Describing the evolution of Iran's health research system over 50 years, understanding the profile of its publications, and setting the national health research priorities

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Thesis in fulfilment of the requirement of the degree of Doctor of Philosophy

The University of Edinburgh

2018

Abstract

Introduction: Health research is essential towards improvement of population health and development. Hence, it is of much interest to study the low- and middle-income countries (LMICs) that have improved their health research performance. A substantial growth has been reported in the number of Iran's research publications over the past three decades, throughout the times of socio-economic and political instability. Some criticise this growth for having had led to a decline in citation impact of health research in Iran. The overall aim of my PhD was to obtain a better understanding of the changes in different components of Iran's health research system (HRS) over 50 years and investigate different patterns in the growth of its health research publications. As a way to move forward, I also aimed to identify Iran's health research priorities for achieving its long-term health targets. The policy recommendations raised from the findings of this PhD should provide lessons to share with other LMICs. Notably, the priority-setting study provides a model on how to implement a systematic and inclusive method towards improving health research governance at the national level.

Methods: My PhD consisted of four studies. For the first study, I conducted a narrative review of the literature on HRS in Iran. My search strategy was guided by the HRS framework developed by the World Health Organization (WHO). I searched MEDLINE and Google Scholar; after removing the duplicates, 805 articles were retrieved, of which 601 were irrelevant. I categorised and reviewed the remaining 204 records according to the WHO HRS framework. For the second and the third studies, I undertook bibliometric analyses of Iran's biomedical, clinical, and public health research publications for the period 1965-2014. I used Web of Science Core Collection and its different tools for retrieving and analysing the publications and used Journal Citation Reports® to find information about the journals. I also investigated different types of collaborations across the highly-cited papers based on the affiliations, the characteristics of the language of the authors' names, and the authors' study and work backgrounds. In the last study, using the Child Health and Nutrition Research Initiative (CHNRI) method, I engaged 48 prominent Iranian academic leaders in the areas related to Iran's long-term health targets, a group of research funders and policymakers, and 68 stakeholders from the wider society to set Iran's health research priorities.

Results: Iran's number of health research publications has substantially increased since 2000: a surge was seen in 2007, and the figure reached a peak in 2011. The first surge could be the result of an increased visibility, due to the addition of new Iranian medical journals to international bibliographic databases, while the peak could be due to increased financial and infrastructural resources and incentives that had promoted publications. H-index of publications has also increased (almost doubled between 2000 and 2010). 30.9% of the most-cited publications had only relied on Iranian resources (including 48 publications); of which the majority were original basic sciences research; and had been published in journals with impact factors ranging between 0.4 and 8.3. In general, it does not seem that the growth of the quantity and the citation impact of Iran's publications has led to a significant impact on decision making and practice. Iran has made some progress in different functions of its HRS over the last 50 years, such as starting a discourse surrounding health research ethics, priority-setting, and placing monitoring mechanisms while increasing the capacity for conducting and publishing research. However, significant improvements are still required to address the gap between the knowledge producers and users. In the prioritisation study which I conducted, 128 proposed research questions were scored independently using a set of five criteria: (i) feasibility, (ii) impact on health, (iii) impact on economy, (iv) capacity building, and (v) equity. The top-10 priorities were focused on: health insurance system reforms to improve equity; integration of non-communicable diseases (NCDs) prevention strategy into primary healthcare; cost-effective population-level interventions for NCDs and road traffic injury prevention; tailoring medical qualifications; epidemiological assessment of NCDs by geographic areas; equality in the distribution of health resources and services; current and future common health problems in Iran's elderly and strategies to reduce their economic burden; the status of antibiotic resistance in Iran and strategies to promote rational use of antibiotics; the health impacts of water crisis; and research to replace the physician-centred health system with a team-based one.

Conclusions: A great capacity for health research lies in Iran. This capacity can be strengthened with further investment in national priorities; fostering collaboration with Iranian diaspora who have shown interest and capacity in collaboration with peers at home; supporting institutions that are lagging behind while ensuring allocation of adequate resources to academics in Iran with proved capacity; and avoiding excessive use of bibliometrics in health research assessment practices. Furthermore, the findings highlighted consensus amongst various prominent Iranian researchers and stakeholders over the research priorities that require investment to generate information and knowledge relevant to the long-term health targets. Finally, it was concluded that the CHNRI method is an appropriate tool to use in the contexts where participants have limited freedom to express opinions on a panel of experts; and/or

where the macro-level decision-making system is highly centralised and stakeholders from the wider society are rarely engaged in decision-making processes.

Lay summary

Health research is essential towards improvement of population health and development. Hence, it is of much interest to study the low- and middle-income countries (LMICs) that have improved their health research performance. A substantial growth has been reported in the number of Iran's research publications over the past three decades, throughout the times of social, economic, and political instability. Some criticise this growth for having had happened in the quantity without having had any impact on the international scientific community. In my PhD, I aimed to obtain a better understanding of different aspects of this growth, while I also sought to better understand the changes in other components of Iran's health research over 50 years. The aim was to identify the strengths and limitations of health research in the context of Iran, based on which I could propose policy recommendations. I also aimed to implement one of the recommendations which seemed to be essential and effective for improvement of health research in Iran. This was to identify the research questions that Iran should address in order to achieve its long-term health targets.

Drawing on the literature from the field of health policy and system research (HPSR), I aimed to understand how Iran's health research system organised itself in *achieving collective health goals* through research, and how different actors interact in health research policy and implementation process. To achieve these aims, I read and studied publications about health research system in Iran and categorised the information into four groups. I searched through PubMed and Google Scholar databases, through which I could retrieve documents that could be potentially relevant to my research question. After removing the duplicates, 805 articles were retrieved, of which 601 were irrelevant. I categorised and reviewed the remaining 204 records according to the a framework proposed by the World Health Organization (WHO). For the second and the third studies, I undertook bibliometric analyses of Iran's health research publications for the period 1965-2014. I used Web of Science Core Collection online database and its different tools for retrieving and analysing the publications and used Journal Citation Reports® to find information about the journals. I also investigated different types of collaborations across the papers that had been cited the most, based on the affiliations, the characteristics of the language of the authors' names, and the authors' study and work backgrounds. In the last study, using the Child Health and Nutrition Research Initiative (CHNRI) method, I engaged 48 prominent Iranian academic leaders in the areas related to

Iran's long-term health targets, a group of research funders and policymakers, and 68 stakeholders from the wider society to set Iran's health research priorities.

In my studies, I found out that Iran's number of health research publications has substantially increased since 2000: a surge was seen in 2007, and the figure reached a peak in 2011. The first surge could be the result of an increased visibility, due to the addition of new Iranian medical journals to international bibliographic databases, while the peak could be because of increased financial and infrastructural resources and incentives that had promoted publications. H-index of publications has increased too (almost doubled between 2000 and 2010). 30.9% of the most-cited publications had only relied on Iranian resources (including 48 publications); of which the majority were original basic sciences research; and had been published in journals with impact factors ranging between 0.4 and 8.3. In general, it does not seem that the growth of the quantity and the citation impact of Iran's publications has led to a significant impact on decision making and practice. Iran has made some progress in different functions of its HRS over the last 50 years, such as starting a discourse surrounding health research ethics, priority-setting, and placing monitoring mechanisms while increasing the capacity for conducting and publishing research. However, still, significant improvements are required to address the gap between the knowledge producers and users. In the prioritisation study which I conducted, 128 proposed research questions were scored independently using a set of five criteria: (i) feasibility, (ii) impact on health, (iii) impact on economy, (iv) capacity building, and (v) equity. The top-10 priorities were focused on: health insurance system reforms to improve equity; integration of non-communicable diseases (NCDs) prevention strategy into primary healthcare; cost-effective population-level interventions for NCDs and road traffic injury prevention; tailoring medical qualifications; epidemiological assessment of NCDs by geographic areas; equality in the distribution of health resources and services; current and future common health problems in Iran's elderly and strategies to reduce their economic burden; the status of antibiotic resistance in Iran and strategies to promote rational use of antibiotics; the health impacts of water crisis; and research to replace the physician-centred health system with a team-based one.

I concluded that a great capacity for health research lies in Iran. This capacity can be strengthened with further investment in national priorities; fostering collaboration with Iranian diaspora who have shown interest and capacity in collaboration with peers at home; supporting institutions that are lagging behind while ensuring allocation of adequate resources to academics in Iran with proved capacity; and avoiding excessive use of bibliometrics in health assessment practices. Furthermore, the findings highlighted consensus amongst various prominent Iranian researchers and stakeholders over the research priorities that require investment to generate information and knowledge relevant the long-term health targets. Finally, it was concluded that the CHNRI method is an appropriate tool to use in the contexts where participants with limited freedom to express opinions on a panel of experts; and/or where the macro-level decision-making system is highly centralised and stakeholders from the wider society are rarely engaged in decision making processes.

The findings of this PhD should provide lessons to share with other LMICs. Notably, the priority-setting study provides a model on how to implement a systematic and inclusive method towards improving health research governance at the national level.

Declaration

I hereby declare that: (i) this thesis has been composed by me and is entirely my own work; (ii) when any work of this thesis has been conducted in collaboration with a research group, I have clearly indicated how I have made a substantial contribution to the work; and (iii) the work has not been submitted for any other degree or professional qualification.

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October 2018

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Abbreviations

AHC: Ad Hoc Committee

BMGF: Bill and Melinda Gates Foundation

BRICS: Brazil, Russia, India, China and South Africa

CAM: Combined Approach Matrix

CIOMS: Council for International Organizations of Medical Sciences

CHNRI method: Child Health and Nutrition Research Initiative method

COHRED: Council on Health Research and Development

COPE: Committee on Publication Ethics

CONSORT: Consolidated Standards of Reporting Trials

CV: Curriculum vitae

DAH: Development Assistance for Health

DALY: Disability adjusted life years

DARE: Database of Abstracts of Reviews of Effects

DORA: The San Francisco Declaration on Research Assessment

EASE: European Association of Science Editors

ESI: Essential Science Indicators

EMR: Eastern Mediterranean Region

ENHR: Essential National Health Research

EU: European Union

EVIPNet: Evidence Informed Policy Network

GERD: gross domestic expenditure on R&D

GFHR: Global Forum for Health Research

GHPs: General Health Policies

GP: General practitioner

GS: Google Scholar

HRS: Health research system

IAEA: International Atomic Energy Agency

ICMJE: International Committee of Medical Journal Editors

IF: impact factor

IORN: Iranian Osteoporosis Research Network

INDIRAN: Iranian National Diabetes Research Network

IRCT: Iranian Registry of Clinical Trials

ISI: Institute for Scientific Information

JCPOA: Joint Comprehensive Plan of Action

JCR: Journal Citation Reports

KT: knowledge translation

LMIC: low- and middle-income countries

MEHRC: Medical Ethics Research Center

MeSH: Medical Subject Heading

MOHME: Iran's Ministry of Health and Medical Education

MPH: Master of Public Health

MRI: Magnetic Resonance Imaging

NCD: non-communicable disease

NGO: non-governmental organisation

NICE: National Institute for Clinical Excellence

NIHR: Iran's National Institute for Health Research

OECD: Organization for Economic Cooperation and Development

ORCID: Open Researcher and Contributor ID

PHC: Primary Health Care

PCR: Polymerase Chain Reaction

PSP: Priority Setting Partnerships

R&D: Research and Development

RQ: Research questions

S&T: Science and Technology

SCCR: Supreme Council of the Cultural Revolution

SCI: Science Citation Index

SID: Scientific Information Database (Iranian database)

SIGN: Scottish Intercollegiate Guidelines Network

SJR: SCImago Journal Rank

SNIP: Source Normalized Impact per Paper

SRC: Student Research Committees

TUMS: Tehran University of Medical Sciences

SDGs: Sustainable Development Goals

UHC: Universal Health Coverage

UK: United Kingdom

UN: United Nation

UNESCO: The United Nations Educational, Scientific and Cultural Organization

UNICEF: The United Nations Children's Fund

US: United States of America

WAME: World Association of Medical Journal Editors

WHO: World Health Organization

WoS: Web of Science

WoS CC: Web of Science Core Collection

YLD: Years of life with disability

Chapter 1 Introduction

1.1 Overview of the thesis

Health research is increasingly regarded as an essential tool both for improving population health and for development (1-3). Hence, numerous efforts at the national, regional, and global levels have attempted to strengthen health research capacity in low- and middle-income countries (LMICs) (2, 4, 5). However, most LMICs continue to have limited capacity for health research (2, 6, 7). Many have remained largely dependent on international academic institutions and donors: on the former for research-relevant knowledge and expertise, and on the latter for financial resources (2, 6, 8). Evidence shows that many of the barriers impeding improvement of health research capacity are shared across LMICs (2). Thus, studying the approaches that each country takes for overcoming some common obstacles could provide important lessons to other LMICs.

Iran is a middle-income country in which studying the changes in health research could lead to valuable lessons for exchange. A substantial growth in Iran's health research output has occurred over the last few decades (9), throughout the times of social, political, and economic instability, including almost 40 years of international sanctions (10). An increase has been reported both in the quantity and in the citation impact of Iranian publications that are indexed in international bibliographic databases (9, 11-14). There has clearly been a rather significant evolution in the development of Iran's capacity for health research. There is a need to explore and explain the various stakeholders, institutions, policies, the structures, and incentives in the academic community, and funding sources that underlie the observed increase in Iran's health research output.

In my PhD, I aimed to obtain a better understanding of the changes in different components of Iran's health research system (HRS) before and during the time that the growth has happened. I also visualised the landscape of Iranian health research publications that have found their way into international bibliographic databases; identified the profile of the publications; and investigated some of the underlying reasons leading to different patterns of Iran's research publication growth. The findings of the first three studies of my PhD led to several policy recommendations for improvement of HRS performance. To utilise the findings, I implemented one of the recommendations that, according to the existing empirical evidence and the generated knowledge in my PhD, seemed essential and effective in improving different functions of Iran's HRS while being appropriate for the study's context, too.

In this thesis, after presenting the background and the context of this PhD, and reviewing different methods that could be used for this thesis in Chapter 1, I will outline the aims and objectives in Chapter 2. Then, in Chapter 3, the evolution of Iran's HRS over a period of five decades will be described. This overall description will be obtained by reviewing the existing literature and using an established conceptual framework. After that, Chapter 4 illustrates the landscape of Iran's health research publications, identifies the major contributors to the growth, and provides an understanding of the profile of the publications, while Chapter 5 identifies the profile of the most-cited publications that are retrieved in Chapter 4. Chapter 6 aims to assist Iran to move forward, by considering its context, as described in Chapter 1, and the strengths and limitations of its HRS that are identified in chapters 3 to 5. It will present a health research priority-setting exercise that will set national-level priorities in Iran by involving a multi-disciplinary group of prominent Iranian researchers, health research funders and policymakers, and stakeholders from the wider society. Evidence shows that HRSs in LMICs often share many similar constraints. Hence, the recommendations raised from the findings of this thesis should provide lessons to other LMICs, too. Notably, the priority-setting study provides a model on how to implement a systematic and inclusive method towards improving health research governance at the national level.

Chapter 7 of this thesis, firstly, interprets the findings of the four studies in the context of the existing literature. It then integrates and discusses the key findings of the thesis, which provides new insights, summarises the main learning points, and makes recommendations for policymakers and organisations seeking to improve HRSs in LMICs. Lastly, Chapter 8, will reflect on the strengths and limitations of this PhD, draws out the key conclusions, and highlights the data gaps that should be addressed in future research.

1.2 Overview of the Introduction

This introductory chapter provides the background to the thesis, opening with an overview of the definition and the value of health research in the context of global health, and then, summarising evidence from the literature showing the global inequity in health research investments. The goal is to show the relevance of the national-level studies presented in this thesis to global health. After that, systems approach to health research will be explained, and the World Health Organization (WHO) framework for operationalising this approach will be introduced. Then, the main purposes of research assessment practices will be briefly presented. This will be followed by summarising the initiatives that have attempted to address the uneven global health research investments, and their outcomes. Thereafter, using evidence from the literature, the status of HRS in selected LMICs and the contribution of LMICs to global scientific output will be described while the importance of studying Iran's HRS as an emerging scientific nation will be introduced. After that, to assist the reader to better grasp the studies provided in this thesis, the context in which this PhD took place will be described. This introductory chapter closes with a review of the literature that I have conducted on the methods used in chapters 4 and 5, followed by explaining the choice of the priority-setting method which is employed in Chapter 6.

1.3 Definition and value of health research

Health research involves many different types of research (15). It could include studies from biomedical, clinical, epidemiological research to health systems and policy research, socioeconomic and behavioural research, and surveillance and programme evaluations that are relevant to activities of health systems (15). In the report of the Commission on Health Research for Development published in 1990 (1), entitled 'Health Research: Essential Link to Equity in Development', health research was defined rather broadly, as being:

> '*the generation of new knowledge using the scientific method to identify and deal with health problems*' (1).

The report had added that health research is both global and local in nature, concluding that both are essential for effective actions for health (1). While the generated knowledge from research with global indications sets the basis on which new tools, strategies, or approaches possibly applicable to many countries are developed, local knowledge—i.e. specific to the circumstances of one country or even one community—can address the important questions within its particular context (1, 16). The broad definition proposed in the Commission's report was later used by the WHO, too (15, 17).

The Global Forum for Health Research (GFHR)—which was an independent, international organisation committed to demonstrating the essential role of research and innovation for health and health equity (18)—had defined health research as follows:

> '*research undertaken in any discipline or combination of disciplines that seeks to: understand the health impact of policies, programmes, processes, actions or events originating in any sector – including, but not limited to the health sector itself and encompassing biological, economic, environmental, political, social and other determinants of health; assist in developing interventions that will help prevent or mitigate that impact; contribute to the achievements of health equity and better health for all*' (18).

A shorter definition was proposed by the Child Health and Nutrition Research Initiative of GFHR, explaining that,

> '*health research should be regarded as a process that begins with a research question and undertaken to generate new knowledge that will eventually be translated and/or implemented to reduce the existing disease burden (or other health–related problem) in the population*' (19).

Health research generates evidence that can inform policies and contribute to the performance of health systems, leading to improved population health (15); hence, it is a key pillar of the health system (15, 20). It is argued that health systems and health research systems should ideally be mutually dependent (15, 17). Meaning that, on the one hand, a well-functioning health system is crucial to utilise the evidence (e.g.

interventions) that affect public health and health outcomes, while on the other hand, a strong health research system should be in place for effective and efficient performance of the health system (15, 17).

The WHO Report 2013 entitled 'Research for Universal Health Coverage' presented 12 case studies (16), ranging from the new diagnostics for tuberculosis to the provision of healthcare to ageing populations, all of which exemplified how research could lead to universal health coverage (UHC). The presented case studies addressed a diverse range of questions and applied various research methods—from observational and case-control studies to randomised clinical trials, systematic reviews, and meta-analyses (16). The examples highlighted the benefits of having health-related evidence from multiple sources, while they also showed how health research contributes to policy and practice (16).

Finally, health research is increasingly regarded as an essential tool for achieving development goals in LMICs and for reducing global inequity (16, 21). Research helps to understand the root causes of health disparities, for which it can then develop, test, and refine solutions (18). Given the key role that health research plays as a tool for development, clearly, it is essential for LMICs to be active producers and users of health research (1). The contribution of LMICs to the global health research will be further described in the following sections.

1.4 Uneven global investment in health research

In 1987, an independent international initiative—called Commission on Health Research for Development—was formed aiming to improve health of the people in developing countries by focusing on research based on the belief that research plays a huge but too often neglected role to accomplish development and population health (1). This was perhaps one of the earliest international initiatives that aimed to support and coordinate health research globally (22). During three years of intense data collection and analysis, the Commission surveyed the research that was being undertaken on the health problems of the developing countries, identified the strengths and weaknesses, and provided recommendations for improvement (1).

The Commission's report was published in 1990 (1), carrying a striking message: it revealed that 93% of the world's health problems, which overwhelmingly originated in the developing countries, were receiving only 5% of the global health research funds (1). It was indicated that fields such as epidemiology, policy and social sciences, and management were particularly underfunded, although even in biomedical and clinical research which were somehow better funded, significant capacity-building in developing countries was needed (1). The reported mismatch in the allocation of global health research funds that was later known as the '10/90 gap' triggered initiation of multiple efforts towards reducing the gap (20, 22), some of which are described in section 1.7.

1.5 Systems approach to health research

The literature recommends that for assessment of health research, a systems approach should be taken; this section aims to explain why and how.

The report of Commission on Health Research for Development which revealed the 10/90 gap, had stated that '*research is a system involving people, institutions and processes*' (1). Nevertheless, until the early 2000s, not much formal efforts were made to articulate and define the boundaries, goals, and functions of this 'system' (15). The growing interest of governments and funding agencies in evaluating the cost and benefits of their investments in health research brought renewed attention to the concept of HRS (15). A paper published in 2003, entitled 'Knowledge for better health – a conceptual framework and foundation for health research systems' (15), clearly described the need for a systems perspective to health research, and proposed a framework including the main functions and operational components of a HRS. The framework and systems approach to health research were further explained a year later, in the WHO Report 2004, 'World Report on Knowledge for Better Health – Strengthening Health Systems' (17).

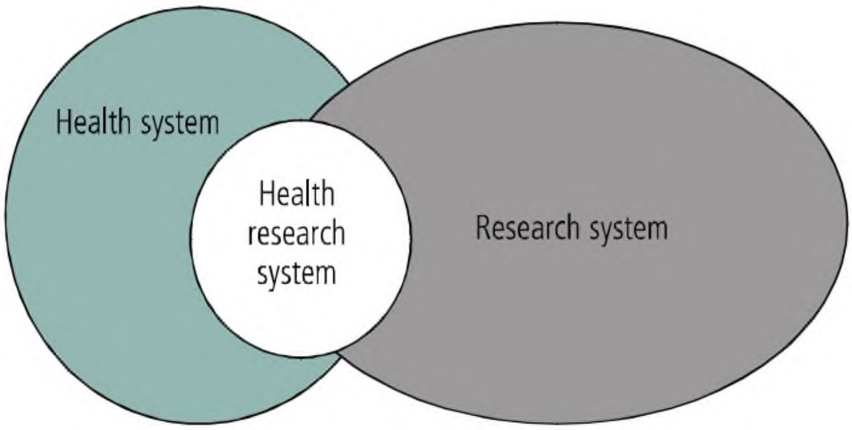
A systems approach to health research recognises that a comprehensive, integrated, and coordinated approach is needed to understand and guide the production and the utilisation of research to improve health outcomes and to decrease inequities in health (2, 15). Such an approach should address many of the problems of health research activities, such as that health researchers often work with minimal effective communication with both the researchers in other disciplines, and the users of health research (i.e. the policymakers, health professionals, and the community) (23). In fact, not much communication exists among researchers within one discipline either, since research has become a highly competitive activity (15).

To achieve a definition for HRS, firstly, a broad definition of health research was used, as described in section 1.3. Then, a 'system' was defined as '*a group of elements operating together to achieve a common goal*' (15). Hence, HRS was defined as follows:

> '*the people, institutions, and activities whose primary purpose is to generate and apply high-quality knowledge that can be used to promote, restore and/or maintain the health status of populations*' (15).

Arguably, a HRS has two fundamental goals: (i) the advancement of scientific knowledge; and (ii) the utilisation of knowledge to improve health and health equity (15). Therefore, a health research system exists at the intersection of two larger, complex systems: the health system and the broader research system, making the health research system a subset of the both (Figure 1) (15).

Figure 1 Locating the health research system at the intersection of the health system and the research system. Figure adapted from reference number (15)



HRS captures the generated health-related knowledge which, when used appropriately, can lead to health impact (15). Clearly, HRS also fits into health policy and systems research (HPSR). HPSR has been described by the Alliance for Health Policy and

Systems Research as a field that: '*seeks to understand and improve how societies organise themselves in achieving collective health goals, and how different actors interact in the policy and implementation processes to contribute to policy outcomes. By nature, it is interdisciplinary, a blend of economics, sociology, anthropology, political science, public health and epidemiology that together draw a comprehensive picture of how health systems respond and adapt to health policies, and how health policies can shape − and be shaped by − health systems and the broader determinants of health* (20)*.'*

From an evaluation point of view, the systems perspective addresses the limitations of methods that had always been used for evaluation of health research activities, which had often seen research process as linear, with an input (e.g. financial and human resources) and output (e.g. publications); an approach which neglected the outcomes of health research, e.g. improved population health (6, 15, 23).

1.5.1 World Health Organization's health research system framework

Understanding the need for a systems approach to health research led the WHO to develop a conceptual framework that values both the generation of knowledge through research and the use of the produced evidence, while provides a platform for effective communication and interaction between all the players and stakeholders in health research (15).

The process of developing the conceptual basis of the framework comprised a comprehensive literature review and an extensive consultation process—ten consultations and forums held between 2001 and 2003, involving more than 100 individuals from over 40 countries (15). The group of participants was very diverse, in terms of expertise and the sector they worked in, and the majority came from LMICs (15). The framework was primarily developed to serve as a base for evaluations, to allow benchmarking, identification of best practices, and lessons to exchange, within and across countries, aiming to lead to improved function of HRSs (15); something that would particularly benefit developing countries.

The framework proposed four main functions for an effective HRS including: (i) stewardship, (ii) financing, (iii) creating and sustaining resources, and (iv) producing and using research (15). Each function is defined by several key operational components as described in **Table 1**.

Table 1 Summary of the functions and components of the WHO health research system framework. Table adapted from reference number (15)

Function	Operational component
Stewardship	• Define and articulate vision for a national health research system (HRS) • Identify appropriate health research priorities and coordinate adherence to them • Set and monitor ethical standards for health research and research partnerships • Monitor and evaluate the HRS
Financing	Secure research funds and allocate them accountably
Creating and sustaining resources	Build, strengthen, and sustain the human and physical capacity to conduct, absorb, and utilise health research
Producing and using research	• Produce scientifically valid research outputs • Translate and communicate research to inform health policy, strategies, practices, and public opinion • Promote the use of research to develop new tools (drugs, vaccines, devices, and other applications) to improve health

1.6 Importance of research assessment practices

In the light of growing attention of governments and funding agencies to research, there is an increasing global demand for assessment of research activities for several purposes, including (i) accountability, (ii) improvement, (iii) advocacy, and (iv) learning (24-26). In addition to these purposes, there exist other reasons to perform research evaluation, particularly in relation to 'selection processes', which are out of the scope of this thesis (25). Examples are evaluations to provide research grants or competitions over publishing in prestigious journals (27).

Evaluation of accountability is often performed by funding agencies to assess whether the outcome of their investment has fulfilled its expected aims, e.g. leading to certain health impacts (26). In terms of improvement purposes, two examples could be mentioned: (i) journal peer review practices to improve the quality of manuscripts through the process of critical appraisal and subsequent revisions by the author(s) (27);

and (ii) evaluation of research units with a view of improving them, rather than only scoring them (25). Research evaluation for advocacy aims to publicise achievements of a research unit in order to encourage further support (26), while evaluation for learning purposes identifies cases of success or failure to understand opportunities and limitations in research units (26). The focus of assessment of research practices in this thesis is on 'advocacy' and 'learning' purposes.

1.7 Initiatives to address the 10/90 gap

- **1990 - Essential National Health Research (ENHR)**

The report published by the Commission on Health Research for Development in 1990 made it clear that any research seeking to contribute to development of LMICs should be based on the local priorities rather than being driven by funders (1). Consequently, to address the '10/90 gap' (as described in section 1.4) and to operationalise 'health research for development', the Commission prepared a step-by-step guide for setting national research priorities called 'the Essential National Health Research' (ENHR) (1). Back then, LMICs were strongly encouraged to undertake the ENHR to define their health research agendas (1, 22).

ENHR focuses on equity in health and development, inclusiveness in participation, and consultations at different levels (5, 28). Participants include researchers, decision-makers, health service providers, and communities (5). The research areas are identified by evidence-based situation analysis, e.g. by looking at the health status, and then, research ideas are collected from different stakeholders, and consensus is built using methods such as brainstorming, multi–voting, nominal group technique, and round–table (5). The criteria that are used for ranking ideas are initially proposed by brainstorming, and are adjusted to the level of each exercise, e.g. global, national, sub-national (5).

- **1993 - Council on Health Research and Development (COHRED)**

Council on Health Research and Development (COHRED) was founded in 1993 to take forward the actions towards addressing the 10/90 gap and, since then, has supported countries in setting national priorities for health research (22).

- **1994 - Ad Hoc Committee (AHC) on Health Research Relating to Future Intervention Options**

In 1994, a rather similar initiative was formed by the WHO, known as the 'Ad Hoc Committee (AHC) on Health Research Relating to Future Intervention Options' (22). The Committee's mission was to identify: (i) priorities for health research and development, (ii) prospects for funding, and (iii) institutional changes that could improve the output of ongoing research and development investments at that time (22). In 1996, the AHC presented a report entitled 'Investing in Health Research and Development' which provided clear arguments for better alignment of research priorities with the global disease burden and building capacity for research, particularly in LMICs (22, 29). The report proposed a five-step process to inform research and development resource allocation: (i) how big is the health problem?; (ii) why does the disease burden persist?; (iii) is enough known about the problem now to consider possible interventions?; (iv) how cost-effective will these interventions be?; and (v) how much is already being done about the problem? (22, 29).

- **1998 - Global Forum for Health Research (GFHR) – 17 Best Buyers**

In 1998, the Global Forum for Health Research (GFHR) was established as an international foundation headquartered in Geneva, Switzerland, again with the aim of addressing the '10/90 gap' through promoting financial and technical support for research on the problems of developing countries and monitoring the progress (18, 22). The forum held annual conferences where experts could share ideas and strategies to address the global health investment inequity (22). GFHR identified 17 research and development priorities—the so-called 17 Best Buyers—and categorised them into three groups of 'strategic research', 'package development and evaluation' or 'new tool or intervention development' (22).

- **2000 - Bangkok, Thailand Conference on Health Research for Development**

In 2000, an international conference on health research for development was held in Bangkok, Thailand (22). The conference was chaired by an international organising committee formed by the representatives of WHO, the World Bank, GFHR and COHRED (22). COHRED presented a review of experiences of ENHR from developing countries. The issues addressed during the conference were systematically categorised into the processes and methods for priority-setting; assessing the results of ENHR; defining who sets priorities and how to get participants involved; the potential functions, roles, and responsibilities of various stakeholders; information and criteria for setting priorities; strategies for implementation; and indicators for evaluation (22).

- **2003 - 'The Grand Challenges', World Economic Forum, Call by the Bill and Melinda Gates Foundation**

Another big step at the global level was taken in 2003 during the World Economic Forum, held in Davos, Switzerland, where Bill and Melinda Gates Foundation (BMGF) announced the allocation of US$ 200 million to support the initiative of 'The Grand Challenges' in global health research. 'Grand Challenge' was defined as '*a call for a specific scientific or technological innovation that would remove a critical barrier to solving an important health problem in the developing world with a high likelihood of global impact and feasibility*' (22). The identification of 'Grand Challenges' was achieved with financial support from BMGF and the National Institutes of Health (22). The initiative gathered a scientific board, including 20 scientists and public health experts from 13 countries—some from developing countries—and made a call for submissions that resulted in 1,000 submissions from scientists and institutions across 75 countries (22). The scientific board reviewed all the ideas, and selected 14 of them which were declared as 'Grand Challenges'. Grants of up to a total of $20 million were then made available by BMGF to overcome these major challenges to progress against diseases that disproportionately affect the developing world (30).

All of the identified 'Grand Challenges' fell into 7 broad categories, as follows: (i) improving childhood vaccines; (ii) creating new vaccines; (iii) controlling insects that transmit agents of disease; (iv) improving nutrition to promote health; (v) improving drug treatment of infectious diseases; (vi) curing latent and chronic infections; and (vii) measuring disease and health status accurately and economically in poor countries (30). Some of these '14 Grand Challenges' addressed very similar problems that the '17 Best Buyers' in 1998 addressed (22). The main difference was that the 'Grand

Challenges' were defined more broadly than the '17 Best Buys', thus they could target several diseases and conditions (22).

- **2004 - Combined Approach Matrix (CAM)**

In 2004, GFHR developed the first specific priority-setting tool: the Combined Approach Matrix known as CAM (28). The aim was to bring together economic and institutional dimensions into an analytical tool with the actors and factors that play a key role in health status of a population (31). CAM tool: (i) helps with classifying, organising, and presenting a large body of information which enters into the priority-setting process; (ii) recognises gaps in health research; and (iii) based on the identified gaps, sets the health research priorities through a process which should include the main stakeholders in health research (31).

- **2004 - James Lind Alliance**

The James Lind Alliance is a British non-profit initiative that was founded in 2004, not only for health research priority-setting, but more broadly to ensure that those who fund health research or decide on health interventions are aware of what matters to patients, carers, and clinicians (32). The method uses a mixture of data collection, quantitative, and qualitative analyses to generate research priorities in areas of treatment uncertainty (32). Participants are identified through Priority Setting Partnerships (PSPs) which brings patients, carers, and clinicians together to reach consensus (32). Treatment uncertainties are defined as situations that either there are no updated and reliable systematic reviews addressing treatment uncertainty, or there are systematic reviews that show such uncertainty exists (32). In the first step, recommendations by PSPs, or through looking at existing literature, creates a list of uncertainties (32). Then, to ensure that they are uncertainties, systematic reviews of databases using Cochrane, DARE, NICE, and Sign will be conducted. Once a reported confidence interval in a systematic review does not cross the line of effect or line of unity, it would be considered as uncertainty (32). Finally, a virtual interim priority ranking, and a final priority-setting workshop will be done to reach consensus on 10 prioritised uncertainties (32).

- **2006 - Child Health Nutrition Research Initiative (CHNRI)**

During the late 1990s and the 2000s, while GFHR continued advocating research by promoting the five-step process proposed by the WHO AHC, it also facilitated the creation of some specific research initiatives (29). One of these initiatives was the Child Health and Nutrition Research Initiative (CNHRI), which was created under GFHR in 1999, and became a Swiss foundation in 2006 (29). The vision of the CHNRI was to improve child health and nutrition in LMICs through research (19). To address the gaps in the then existing research priority-setting methods, CHNRI developed a systematic and inclusive methodology for health research priority-setting, which was introduced in 2007 (19, 33).

CHNRI methodology uses the principle of 'wisdom of the crowds' to score ideas against a pre-defined set of criteria (19). In this method, the research ideas are generated, and scored independently and often through online submission, by researchers (34). The researchers are identified by a management team based on their expertise, e.g. the number of publications, experience in implementation research and programmes (34). After collecting the research ideas, removing the overlapping ones, and improving the clarity of the questions, a compiled list of research ideas will be sent back to the researchers for scoring against a set of criteria (34). The following five standard criteria are often used: (i) answerability; (ii) equity; (iii) impact on burden; (iv) deliverability; and (v) effectiveness, although the criteria could be adjusted based on the context of each exercise (19). Researchers would independently score each research question against each criterion, on a scale of 0, 0.5, and 1 or on a scale of 0 to 100 (34). Different stakeholders, e.g frontline healthcare professionals, patients, caregivers, could also be engaged by being invited to assign weights to the scoring criteria (35).

- **2007 - The Lancet Series to improve maternal and child survival**

Another attempt towards setting health research priorities has been the engagement of *The Lancet* journal into advocacy of international health issues through publication of several series of papers focusing on main priority areas in international health (22). In 2007, *The Lancet* even conducted a Delphi process similar to the one that had led to the 'Grand Challenges' among a wide range of academics and professionals who had work experience in developing countries (22). The coordinators of the process ranked a limited number of very broad research themes in child health, maternal health, health systems, and community development, based on their perceived importance (22).

- **Use of other methods – Delphi process**

In addition to the efforts for introducing initiatives or tools to set health research priorities to ensure the alignment of research investments with the real needs, some already-existing methods were adopted for health research priority-setting (28). Delphi process, developed in the 1950s, is an interactive and systematic forecasting method which uses questionnaires and a panel of experts (28). The participants of a Delphi process should have a relevant background and experience on the target topic, be able to contribute to the process, and be willing to revise their initial judgements in order to achieve consensus (28). The researchers identify and invite participants, ideally through a nomination process, or selection from potential leaders or authors through publication (28). In the first round of the Delphi, an open–ended questionnaire is sent to collect information (28). Investigators will then turn the responses into a well–structured questionnaire to be used as a survey for data collection (28). Through four rounds, experts answer questionnaires; the facilitator summarises anonymously the forecast after the first round and the experts are then asked to revise their earlier answer, thereby decreasing the range of answers and converging towards the correct answer; up to four iterations can be used (28).

1.7.1 Outcome of initiatives to address the 10/90 gap

As described in section 1.7, over the last nearly three decades, several initiatives have attempted to improve the governance of global health research. Some of the attempts have resulted in development of specific tools that can set health research priorities at global, national, sub-national, or institutional levels (28, 36). However, it is yet not clear to what extent the 10/90 gap has been addressed since 1990.

What is clear is that investments in global health research has been growing over the last three decades although the rise has not happened in a coordinated way (37). Over 25 years, the funding available for health research has increased from US$ 50 billion in 1993 to US$ 240 billion in 2009, and financial contributions to international Development Assistance for Health (DAH) has increased from US$ 5.6 billion to US$ 28.1 billion between 1990 and 2012 (38).

There have been several attempts to track and monitor the funding for health research (37), yet, estimates are considerably varied, reflecting methodological challenges in categorising how the money is spent (37, 38). One challenge is in distinguishing research funding from broader development assistance for health (38). Further, there is no agreement on whether the funding invested in high–income countries for studying health problems that could also be relevant to LMICs should be included (37). Example of such research areas are non-communicable diseases, e.g. cardiovascular diseases and cancer, which their burden in LMICs is rapidly on the rise (38).

In terms of priority-setting exercises, despite important steps that have been taken globally towards setting health research priorities, still most LMICs lack systematic and transparent priority-setting exercises (36, 39). A systematic review of all health research prioritisation studies in LMICs, between 1966 and 2014 (36), identified a total of 91 studies, 46% of which had been run at the global level without focusing on LMICs nor on low- and middle-income regions (36). It has also been reported that the majority of health research priority-setting exercises in LMICs have failed in engaging the key stakeholders (e.g. the community) in the processes, and they have heavily relied on the input from the researchers and the representatives from the governments (36, 40). Also, the majority of exercises lack mechanisms for publicising and translating the results, hence most of the exercises have failed in the implementation phase (36, 40). In 2004, WHO surveyed 550 policymakers and 1,900 researchers in 13 LMICs; one third of the participants responded that either there was no rational health research priority-setting process in their country, or if there was, they were unaware of how priorities were being set (17).

Among the methods that have been used and/or developed, a review of 230 health research priority-setting exercises which had been coordinated by the WHO between 2005 and 2010 reported that, at that point in time, there was still no 'gold standard' approach for setting health research priorities (41). In 2010, the WHO's Department for Research Policy and Cooperation held a consultation between experts in developing methodology to identify optimal characteristics of priority–setting methods that could be applicable at the national level (40). The following three methods were recommended: (i) the CAM, (ii) the COHRED, and (iii) the CHNRI (40).

In 2014, a systematic review of the peer-reviewed and non-peer-reviewed studies of health research priority-setting exercises in LMICs (36) reported that the most widely used health research prioritisation process had been holding a workshop or a conference, without any clear specification of established methods (24%) (36). This was followed by the CHNRI method (18%) and a stepwise process that includes literature review, in-depth interviews, and consultation (18%) (36). A review of health research prioritisation studies which were indexed in PubMed database during 2001–2014 found a total of 165 papers (28). The most frequently used tool was CHNRI method (26%), followed by Delphi (24%), James Lind Alliance method (8%), the CAM (2%) and the ENHR (<1%) (28). A further 19% had used a combination of expert panel interview and focus group discussions (consultation), without providing the details, (28). Nine percent had used a combination of literature review and questionnaire to identify research ideas among the participating experts (28).

It is evident that the CHNRI method has received a wide recognition over the last decade (28, 41). The CHNRI method uses the principle of 'wisdom of the crowds' to score ideas against a pre-defined set of criteria (42). This enables funders and policymakers to view the strengths, the weaknesses, and relative ranking of each proposed research idea based on submitted opinions of a larger number of experts (19). This method allows researchers to independently generate and score research questions, thus limits the influence of individuals on the rest of the group (19). Furthermore, it engages the funders and policymakers from an early stage of the process, ensuring their ownership of the final results (43). CHNRI method also provides the essential tools for involving stakeholders from the wider society in the process and receiving their perspectives (35). Other recognised advantages of the CHNRI method include its systematic nature, transparency and replicability, clearly defined context and criteria, a structured way of obtaining information, informative and intuitive quantitative outputs, and studying the level of agreement over each proposed research idea (19, 28, 42).

In the first years after the CHNRI method was introduced, it was primarily used for setting priorities aiming to reduce global child mortality (42). However, since 2012, this method has been applied across various topics (42). It has now been implemented in more than 50 studies led by multilateral organisations (e.g. WHO, UNICEF), national governments, and funders (e.g. The Gates Foundation) to set research priorities in areas ranging from dementia or disability to the efficient execution of national health plans (e.g. in China) (4, 42). While the majority of CHNRI studies have been conducted at the global level, although with a focus on the problems of LMICs (42), national-level CHNRI exercise are on the rise, too (42). They have been conducted in South Africa (44), India (45), Brazil (46), China (47), and one study that included Malawi, Nigeria, and Zimbabwe (42).

1.8 Status of health research system in selected low- and middle-income countries

As discussed in section 1.5, a well-functioning health research system is essential for all countries. Even if every country does not generate research on all health topics, every country needs the capacity to adapt and apply research results to address health challenges (2). This section reviews the literature on the status of HRS in selected LMICs.

An assessment of the state of health research systems across the WHO Eastern Mediterranean Region (EMR) based on publicly available literature and data sources was published in 2013 (6). The review found that – while there have been improvements in terms of research output in the EMR since the early 1990s – the overall research performance remains poor, with critical deficits in system stewardship, research training and human resource development, and data surveillance (6). In terms of use of research, the main barriers to translation of research into policy and practice were reported as weak institutional and financial incentives, and concerns over the political sensitivity of research findings (6). The constraints were mainly linked to the limited expenditure in R&D and the lack of a political will to invest in research (6). It was also highlighted that the publicly available data on research systems in the EMR was very poor, which made meaningful performance assessments of the countries across the region difficult (6). The assessment had called for urgent efforts towards improving the understanding of HRS across the EMR (6).

A recent qualitative study (7, 48, 49) has investigated the strengths and limitations of the HRS in Palestine (conducted in the West Bank and Gaza Strip of the Palestinian territories), through 52 in-depth interviews and six focus group discussions including a total of 104 policymakers, academics, and experts. Moreover, the study has examined the participants' satisfaction with the overall performance of Palestinian HRS (7), in addition to investigating their perceptions about macro-level attention to health research (7). Their analyses have reported that the level of understanding of HRS among health experts in Palestine is inadequate and not sufficiently conceptualised for its application (7). It has also revealed that the HRS in Palestine is remarkably underperforming (7), and the participants perceived the system as ineffective and inefficient, poorly managed, and lacking mechanisms for systematic assessments (7). The reasons behind the under-performance were identified as: (i) an unstructured system which lacks a research culture and a governing body; (ii) health research being regarded as an individualistic activity, not towards development targets, and rarely used in policy decisions; and (iii) significant lack of essential resources, and uncoordinated use of them (7). The latter problem reflected inadequate political support of health research (7).

A review of 28 case studies that had described or analysed health research systems in 26 LMICs was published in 2006 (2). The reviewed studies were sponsored either by the COHRED (including, Cameroon, Egypt, Ethiopia, Hungary, Jordan, Kazakhstan, Lebanon, Lithuania, Mauritius, Oman, Pakistan, Romania, Russia, South Africa, Uzbekistan, and Zambia) or the South-East Asia Regional Office of the WHO (including, Bangladesh, Bhutan, India, Indonesia, Maldives, Myanmar, Nepal, Sri Lanka, and Thailand) or were country monographs of Bangladesh, South Africa, and Uganda (2). Several common challenges facing national health research systems were identified among these countries that were compounded by some fundamental system constraints (2). The main identified challenges facing HRSs included: (i) lack of coordination between research institutions; (ii) inadequate participation of stakeholders in research, policy, and implementation processes; (iii) lack of demand for research; and (iv) inadequate accessibility of research findings (2). The main fundamental system constraints included limited financial, human, and institutional resources and inadequate reliable data (2).

1.9 Status of research publications in low- and middle-income countries and emergence of new scientific nations

In section 1.4, the global disparity in health research investments, which is a key component of one of the main functions of a HRS, was described. The present section informs the reader about the global disparity in the quantity of health research publications, i.e. another component of a HRS.

In recent decades, the number of scientific publications worldwide has substantially grown (9, 50) due to several reasons. One is that the global expenditure on R&D has significantly increased (8), while the number of researchers has risen, too (51). In 2015, there were 7.8 million researchers worldwide, which was 21% more than the figures for 2007 (51). Furthermore, with the emergence and popularity of electronic publishing of journals, online submitting, and online indexing of documents, the quantity and the visibility of publications have grown (50). Consequently, globally, more research is being funded, carried out, and published (51).

Nevertheless, data from international bibliographic databases shows that the overall contribution of LMICs to this large and growing scientific output is still limited (18, 52). The world regions comprising mainly high-income countries, e.g. Western Europe and North America, continue to publish far more than regions including mostly LMICs, e.g. Africa and the EMR (8).

However, in recent decades, a number of LMICs have managed to greatly enhance their research outputs, defined here as the number of peer-reviewed publications in international databases (9). For instance, it has been shown that the BRICS (i.e. Brazil, Russia, India, China and South Africa) have made a considerable scientific progress between 2002 and 2007, while the number of original health research papers from India has also doubled, from 4,494 to 9,066 (38). There is also evidence that the growth has not been restricted to the quantity but also the citation impact of research in some LMICs, e.g. in China and South Africa, has been improving (38).

The literature proposes various factors that could have promoted growth of research publication in different regions or countries, e.g. in Asia (53), China (54), Africa (55) South Africa (56), Brazil (57) and Turkey (58, 59). Overall, the contributing factors included: increased gross domestic expenditure on R&D (GERD) (53-55, 60); increased number of universities and domestic journals that are abstracted in international databases (53-55, 57, 58); establishment of competitive research funding mechanisms which distribute funds among and within universities based on publication counts (54, 55, 57, 58, 60-62); and incentivising publication in journals that are abstracted in international databases (54, 58, 59). In sum, the suggested factors seemed to be mainly a result of the national or institutional policies, particularly policies with direct impact on the higher education capacity and/or the national research capacity, the national budget allocation strategies, and/or research performance assessment systems.

It is argued that the recognition of the role of science in driving social and economic development and in addressing local and global sustainability has led to increased research activity in some LMICs (8). In this regard, the Royal Society Report on Global Scientific Collaborations in 21st Century (published in 2011) quotes Paul Kagame, President of Rwanda, who has been a strong advocate for science for development, as saying:

> '*We in Africa must either begin to build our scientific and technological training capabilities or remain an impoverished appendage to the global economy*' (8).

Among the emerging scientific nations from the LMICs, the rise of China has been particularly remarkable, becoming the second highest producer of research output in the world, just after the US (8, 63). Some have associated China's publications' growth to the exponential increase in GERD; along the significant growth of GDP in China, the proportion of GDP dedicated to R&D has continuously increased (54). It was also reported that since 1997, the contribution of businesses to R&D expenditure has enhanced, and at the same time, China's rapid and sustained economic development has encouraged some of its overseas scholars to return to China (54). Furthermore, the Chinese Government has developed several policies to motivate its overseas scholars to go back home and contribute to development of a knowledge-based economy (54). Another incentive for publishing has reported to be that many Chinese universities, started to add a considerable bonus to academics' salaries once they publish in journals which are indexed in Science Citation Index (54).

In general, several macro-level decisions have contributed to China's scientific growth (54). One example is in the area of nanotechnology where the national support has begun by declaring nanotechnology an important R&D priority in the China's Guidance for National Development in 2001, and issuing of the Compendium of National Nanotechnology Development, which was jointly issued by the Chinese Ministry of Science and Technology, the National Development and Reform Commission, the Ministry of Education, the Chinese Academy of Sciences, and the National Natural Science Foundation (54). Following these, China started publishing two new English-language journals in the field of nanotechnology, which substantially contributed to the global output in nanotechnology research (54).

Turkey is another middle-income country that has improved its scientific output at a pace almost competing that of China (8). Turkey's publication count in Scopus database in 2013 was nearly quadrupled compared to 1996 (64). In the 1990s, the Turkish Government declared research as a public priority and ever since increased its investment on R&D (8). Between 1995 and 2007, Turkey's GERD increased from 0.28% to 0.72% and its number of researchers grew by 43% (8). However, on account of the ongoing reorganisation of higher education in Turkey, led by its President Recep Tayyip Erdoğan, the future of education and research in Turkey is unclear –Turkey's annual number of publications based on the data from Scopus citation database has already declined since 2016 (65).

Önder and colleagues investigated the role of institutional changes in the growth of Turkey's number of publications in social sciences since the 1990s (58). They reported that the old funding schemes in Turkey were exclusively sponsored by the government, which distributed funds among universities based on their general size, defined as the number of students, whereas the new competitive schemes distribute funds according to the research performance scores that each institution earns (58). Another reported change was the increase in the number of funding organisations, which resulted in a competition between institutions and academics to apply for research grants (58). In sum, they had hypothesised that the improvement of the scientific output in Turkey was associated with the institutional changes in Turkish higher education system (58).

Brazil's rank in terms of the number of research documents indexed in Scopus has improved from 21st in 1996 to 13th in 2014 (64). Similar to China and Turkey, the use of bibliometrics (e.g. looking into the number of publications) has become popular among Brazilian funding agencies in evaluating research grant applications, and likewise, they have started to consider publications in journals indexed in leading international databases as the main indicator of scientific productivity (57). Some have criticised the rapid growth of the Brazilian research output, as finding it only a result of the increased number of Brazilian journals abstracted in international databases, the promotion of peer pressure among academics for publishing, and the requirement from the funders' side (62).

Meo and colleagues conducted a study to investigate some of the predictors of the success in research publishing among forty Asian countries between 1996 and 2011 (53). They investigated the correlations between GDP per capita, GERD, the total number of universities, and the total number of journals indexed in Web of Science Core Collection, with three bibliometric indicators, including the total number of research publications, citation counts per document, and h-index (53). The bibliometric information was retrieved from SCImago which uses Scopus data. The analyses of their study found a positive correlation between GERD, the total number of universities and journals indexed in WoS Core Collection, with the investigated bibliometric indicators in various fields of science and social sciences; no correlation was found with GDP per capita (53).

Another study quantitatively explored determinants of health research publication counts in the WHO African Region between 2000 and 2014 (55). Publications were retrieved from PubMed database and correlations between the number of publications in each country and the following variables was investigated: GDP, adult literacy rate, number of physicians per 100,000 population, the total expenditure on health, private expenditure on health, R&D expenditure and human development index. The only significant predictor of the number of publications was found to be the GDP (55).

1.9.1 Emergence of Iran as a scientific middle-income country

Among all the emerging low- and middle-income scientific nations, Iran has been reported to have had the fastest growth rate of research publications in recent decades (11). The annual number of scientific publications from Iran has increased from only 736 in 1996 to 13,238 in 2008, based on the data retrieved from Web of Science bibliographic database (9). A similar significant increase is evident in other databases, for instance, in Scopus, where the number of Iran's research documents per year in medicine has risen from 151 in 1996 to nearly 9,000 in 2014 (64).

The improvements in the ranking of Iran in scientific publishing confirms that Iran's growth in research publication output has been higher than the world average. For example, Iran's world rank in the production of research articles in medicine has improved from 58th in 1996 to 19th in 2014 (64). Likewise, Iran's contribution to global research output has considerably increased (64). For instance, Iran's contribution to the global production of research articles in pharmacology, toxicology and pharmaceutical sciences has multiplied by 20 times between 1996 and 2014—increasing from 0.1% to more than 2% (64). While Iran had very few research publications in most fields of medical sciences until only 30 years ago, from 2004, it has become a leading producer of research publications in medicine among countries in the EMR (64). Although this PhD focuses on studying health research system in Iran, it should be noted that the growth of research publications in Iran has not been restricted to health-related fields, but has happened across several scientific areas, such as engineering, material sciences, and chemistry (9, 11).

The substantial growth of Iran's health research publications that are indexed in international bibliographic databases has occurred throughout the times of economic, social, and political instability in this country, which are further explained in the section 1.10. It is expected that such instability would lead to reduced resources and less coordination of research activities. Therefore, it is of much interest to firstly, obtain a better understanding of the changes in Iran's health research system over the years that this growth has taken place, and secondly, obtain an overall landscape of the growth and the possible contributory factors to it. Furthermore, some criticise this rapid quantitative growth of Iran's health research publications, arguing that it may have resulted in a decline in citation-based indicators (66, 67). It is essential to investigate whether the growth had been limited to the number of publications or it may have led to improvements based on citation-based metrics, too.

1.10 Study context

1.10.1 Introduction

In this section, the context in which this PhD was conducted will be described. Firstly, having an insight into Iran's context over the years that its health research publications have witnessed a significant growth would assist the reader to better grasp the findings of the bibliometric analyses, provided in chapters 4 and 5. Secondly, knowing the political system and the key decision-making bodies in Iran would answer the following two questions that are further discussed in section 1.12.2 and in the Chapters 7 and 8:

i. Among the problems of Iran's HRS that need to be addressed according to the study that will be presented in Chapter 3, why did I choose to run a health research priority-setting exercise for improving Iran's HRS?
ii. Why is the CHNRI health research priority-setting method appropriate for the context of Iran?

Finally, having a picture of Iran's current and projected challenges would help with better understanding of the findings of the prioritisation exercise, presented in Chapter 6.

1.10.2 General context

Based on the WHO categorisation, Iran is in the Eastern Mediterranean Region. It has a surface area of 1,648,195 km^2, six times the size of the UK, and had a population of 80.6 million in 2017 (68), distributed across 31 provinces (69). The country has great oil and gas reserves, estimated as the 4th and the 2nd largest in the world, respectively (70), in addition to considerable minerals and other natural resources (70). Nonetheless, Iran lacks adequate water resources and has been facing serious water problems since a few years back, i.e. evident by drying lakes and wetlands, frequent dust storms, and water quality deterioration (71).

Iran has witnessed a significant demographic change over the last four decades as a result of a high growth rate between 1976 and 1986 (3.9%), and a substantial decline in fertility rate during its following decade: decreasing from 6.2 births per woman in 1986 to 2.5 in 1996 (72-75). Consequently, today's population of Iran is predominantly composed of working-age adults, for whom the state has failed to create enough jobs (68). The unemployment rate was 11.9% in 2017 (68), and the rate is significantly higher in women and in university graduates: approximately 48% of the female university graduates and 29% of the male ones are unemployed (76, 77). Further information about Iran's demographic transition is provided in section 1.10.5.

The majority of Iran's population has become urban over the last few decades (78). While in 1950, 70% of Iranians lived in rural areas and 30% in urban, the pattern has now reversed (78). This significant urbanisation coupled with insufficient infrastructure has contributed to a rise in the development of informal settlements (slums) in many cities, with more than 10 million population, according to unofficial reports (79).

1.10.3 Geopolitical and economic context

Geopolitically, Iran is part of the Middle East. Unlike many of the countries in this region, Iran is not involved with armed conflicts on its land although it is involved with wars outside its territories, e.g. in Syria. It also hosts over one million refugees, primarily from Afghanistan (80). The last armed conflict within Iranian territories has been the Iran-Iraq war, which began with the invasion of Iraqi military forces in 1980, and led to an eight-year destructive war in which Iraq was supported by the West (81). The war left behind almost one million Iranians killed and or injured, and destroyed much of the country's infrastructure (82).

Iran's international relations have been rather challenging over the last 40 years (83, 84). Since 1979, Iran has continuously been under international sanctions; initially imposed by the US, following the hostage taking of American diplomats in Tehran (83, 84). Over the years, the target sectors of the imposed sanctions and the countries who participate in imposing them on Iran have changed (84). The sanctions were most intensified between 2008 and 2013 as a result of the concerns of the United Nations (UN) Security Council, the US, and the European Union (EU) over Iran's nuclear programme, which Iran insisted it was entirely peaceful (70, 84). The sanctions excluded Iran from the international payments system, restricted imports and export of many items, and isolated the country from global markets (70).

In 2015, following two years of continuous negotiations, an agreement was signed between Iran and the P5+1 (the five permanent members of the UN Security Council—China, France, Russia, UK, US—plus Germany) and the EU, entitled the 'Joint Comprehensive Plan of Action' (JCPOA), commonly known as Iran Deal (85). Under the accord, Iran agreed to limit its nuclear activities and allow in international inspectors in return for the lifting of some of the economic sanctions (85). While the International Atomic Energy Agency (IAEA) has reported that Iran was complying with the terms of the agreement (86), in May 2018, the US President, Donald Trump, announced the withdrawal of the US from the agreement (87). Thus far, this decision has been followed by many non-American companies, too.

A recent systematic review (88) has shown that the imposed sanctions had resulted in a decline in Iran's revenues, devaluation of its national currency, and increased inflation and unemployment rates (88). All of these have contributed to deterioration of the overall welfare of the Iranian population and have reduced their ability to afford the necessities of a healthy life, such as nutritious food, healthcare, and medicine (88). Also, the sanctions on financial system and shipment had led to shortage of essential medicines (88, 89). Vulnerable groups, such as the low-income families, patients, women, and children were reported to have been the most affected (88, 89).

Iran is categorised as a higher middle-income country by the World Bank, with a GDP exceeding $432.5 billion in 2017, and a GDP per capita of approximately $5,452 (68). Iran's industrial sector has grown both in scope and diversity in recent decades, although most of these industries still highly rely on the import of raw material and devices (51).

Iran's economy is rather fragile because of uncertain international relations in addition to social and political instability inside the country, which both increase demand for foreign currency (90). One recent example of the impact of national and international instability on Iran's economy is the devaluation of its currency (i.e. rial) to nearly one fourth since January 2018 (90). The rise in the rial's exchange rate against the US dollar started following some street protests in a number of Iranian cities, which were triggered by economic concerns in the end of December 2017 (90), and the exchange rate was significantly deteriorated following the announcement of the US President regarding the return of the economic sanctions to Iran.

1.10.4 Iran's political system

Since 1979, following the fall of Pahlavi dynasty, the political system in Iran has become a constitutional Islamic republic wherein the position who holds the highest political power is the Supreme Leader (Ali Khamenei, since 1989) (83). The Supreme Leader, who is elected by an Assembly of Experts, is responsible for formulating the general policies, which provide the guidelines for socio-economic, technological, diplomatic, and cultural affairs of the nation (91). The General Health Policies (Appendix 1) are examples of such (91).

As illustrated in Figure 2, the Supreme Leader supervises the three independent branches of power in Iran: the legislative (i.e. the Parliament, consisting of 290 members), executive, and the judicial systems (83). The main responsibility of the Parliament is to evaluate the new proposed legislations that are submitted for ratification (91). Whatever new legislation that is passed by the Parliament should also be evaluated by the Guardian Council (91). The Guardian Council, consisting of six clergymen and six jurists - none of whom is appointed through elections - is a supervisory body which should ensure the conformity of legislations both to the Islamic Law and the constitution of the Islamic Republic of Iran (91). In case of a disagreement between the Guardian Council and the Parliament, the ultimate decision would be made by the Expediency Discernment Council, whose 44 members are appointed by the Supreme Leader (91). It should be noted that the President of the country, members of the Parliament, and members of the Assembly of Experts are appointed through elections. However, since 1991, the eligibility of all the candidates who want to run in the elections, should be first approved by the Guardian Council (83).

The executive branch, headed by the President and consisting of 18 ministries (including Ministry of Health and Medical Education) and several other organisations (e.g. the Plan and Budget Organisation) is responsible for implementing the ratified legislations (91). The executive branch should also propose the national budget plan (i.e. a document where the annual funding for national and provincial agencies is laid out) to the Parliament and allocate the budget once it is approved (91). Additionally, the executive branch is vested with the duty of devising the five-year socio-economic development plans (91). Once the development plan is approved by the Parliament and the Guardian Council, the President would be responsible for its implementation (91).

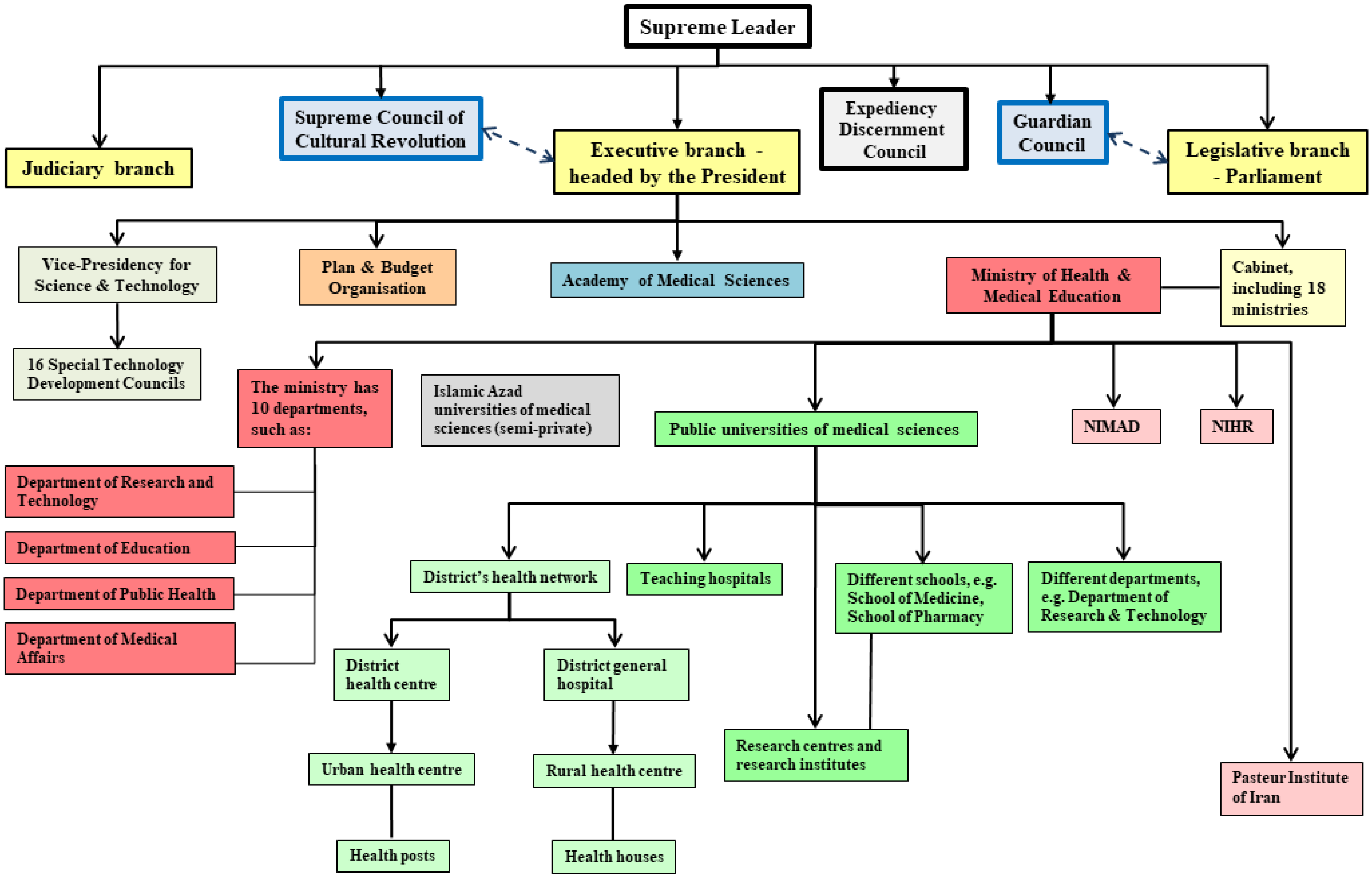
Iran's education and research system is highly centralised and the government plays a significant role in running it (92). A national survey has investigated the views of faculty members in medical schools affiliated with MOHME about academic culture and values (93). The survey had identified politicisation, conservativeness, centralisation, and bureaucracy as the most common features of Iran's public medical schools (93).

Currently, three ministries of the executive branch are responsible for education and research in Iran: the Ministry of Education, i.e. responsible for the 12 years of school education; the Ministry of Science, Research, and Technology, for non-medical higher education and research; and MOHME for medical and health-related disciplines (70, 92). Since 2007, a number of new institutions in relation to funding and policymaking for research have been established; which are again, affiliated to the government, e.g. the Vice Presidency for Science and Technology (70).

It should be noted that an organisation, called the Supreme Council of the Cultural Revolution (SCCR) holds the ultimate authority in formulating policies, decision-making, and provision of guidance on the matters of culture, education, and research in Iran (Figure 2) (91). Furthermore, all the plans and policies that are passed by the science and technology policymaking institutions, including MOHME, should be approved by the SCCR before implementation (91). The SCCR was established in 1980 by the order of Ruhollah Khomeini, the leader of the 1979 Islamic Revolution (91).

As described in section 1.5, and shown in Figure 1, HRS is a subset of both the health system and the broader research system. Therefore, in the following sections, I will describe some of the key changes that both of these systems in Iran have witnessed over the past few decades.

Figure 2 Institutional mapping of Iran's health and health research systems – NIMAD: National Institute for Medical Research Development; NIHR: Iran National Institute of Health Research



1.10.5 Changes in Iran's health system and population health

- **Changes in Iran's population health over the recent decades**

Since recovery from the Iran-Iraq war, Iran has achieved substantial health gains, such as reduction of under-5 mortality from 67.4 deaths per 1,000 live births in 1990 to 18.8 in 2015, and halving maternal mortality within the same period (94). Life expectancy has improved by 8 years since 1990, reaching 78 in women and 72 in men in 2016 (95). Similar to other parts of the developing world, the major causes of death and disability in Iran in the 20th century were communicable diseases (96, 97). Nonetheless, changes such as the improvements in children nutrition, access to clean water and sanitation, improved heating systems, access to oral rehydration solutions, and national vaccination programmes have contributed to reducing the burden of infectious diseases over the past few decades (98-104).

Consequently, Iran's population health problems have transited from being predominantly communicable diseases to non-communicable diseases (NCDs) and the types and the profile of risk factors have changed, too (105). In 2015, NCDs contributed to 74% of disability adjusted life years (DALYs) in Iran (106). The observed leading causes of death were cardiovascular diseases (41.9%), neoplasms (14.9%), and road traffic injuries (7.4%) (105). The leading risk factors were high blood pressure, dietary risks, and high fasting plasma glucose (105).

- **Development of formal structures for the health system in Iran**

Iran's health system has undergone several changes over the last decades (107). After a brief review of the development of formal structures for governance of health system in Iran, the main changes will be reviewed in this section.

In 1920, with the aim of managing the public health and medical affairs, the 'Ministry of Health and Charity Affairs' was founded in Iran; two decades later, charity activities were separated, leading to the establishment of the 'Ministry of Health' (108). In 1975, the 'Ministry of Health' was merged with the 'Ministry of Social Welfare' creating the 'Ministry of Health and Welfare' (109, 110). During all those years, training of the healthcare professionals was the responsibility of the 'Ministry of Higher Education'

(111), and back then, Iran severely suffered from a shortage of healthcare professionals (112). In some parts of the country, there was only one physician to provide services to a population of over 18,000 (112).

A major institutional reform of Iran's health system after the 1979 revolution was the integration of 'medical education and research' into 'health services' in 1985, leading to the establishment of the 'Ministry of Health and Medical Education' (111, 113). The integration had three main aims as follows (111, 113): to (i) increase the number of admitted students to the universities of medical sciences; (ii) improve the quality of curriculum and training by shifting the approach to being more community-oriented; and (iii) pass more responsibility in service provision to medical universities which were being founded all across the country. Since the establishment of MOHME, all of the national-level decisions regarding strategic planning and resource allocation for healthcare and health-related education and research are made by MOHME (114); indeed, decision that are aligned with the parliamentary legislations and approved by higher level entities, as discussed in section 1.10.4 (91).

This organisational reform eventually resulted in that the universities in the provinces take over all the activities related to medical education, research, and provision of health services in the capital of each province, its urban, and rural areas (113). The chancellor of the university in each province became responsible for these activities (113) (as shown in Figure 2). The outcome of the integration and its impact on health research will be further discussed in section 3.5.2.

- **Iran's family planning programme**

One of the most successful programmes implicated by MOHME has been the family planning programme. This national programme had started in 1966, as a health and social policy, but following the 1979 revolution, the authorities renounced the programme for several years (72). It was argued by the religious leaders that use of contraception was inconsistent with Islamic tenets, while instead, family formation was strongly promoted (115). Moreover, the legal minimum age at marriage was declined to only 9 years old for girls and 12 for boys, and married couples were provided with financial incentives by the government to have more children (115).

Further, the Iran-Iraq war (1980-1988) created a nationalistic and pro-birth atmosphere in the country (115). All of this, led to a substantial population growth rate in the 1980s: Iran's population rose from 34 million in 1976 to nearly 50 million in 1986 (72, 116).

The post-war economy and social challenges led the authorities to accept the proposal of MOHME regarding resuming the implementation of the family planning programme (117), and finally, the family planning Act was passed by the Parliament in 1994 (118). Thereafter, using the vast network of primary health care centres all across Iran, MOHME successfully implemented the programme. Population growth reduced dramatically to 1.6% in 2004, (74) and to around 1.2% in 2015; the figure was nearly 4% in 1986 (119). Over the past decade, Iran's population has paced toward an older age structure (75).

- **Primary health care programme**

A significant health system reform in Iran's health system has been the establishment of the so-called 'National Health Network' in 1983 (i.e. a primary health care system - PHC) (120). This network was mainly based on the principles of 'Health for All' as introduced in the conference of Alma-Ata in 1978 (107). In this programme, local 'Health Houses', as shown in Figure 2, were established in rural areas all across the country (120). These local 'Health Houses' are staffed with community health workers who receive two years of training in medical universities (120). During the training, they learn how to provide a range of individual- and population-level primary health services (121). After completing the training, they provide primary-level services to a population of around 1,000 to 1,500 (120, 122). Once required, the community health workers refer patients to the 'Rural Health Centres', where a family physician is present (123). The PHC programme has significantly improved health indicators in rural areas, but it is no longer sufficient to meet the emerging health needs of the whole population in Iran, primarily because of the growing urbanisation (107, 124).

- **Health Transformation Plan**

To address the emerging problems described in the previous section, and other issues in the performance of Iran's health system—e.g. a high out-of-pocket payment—since the early 2000s, there have been initiatives for a healthcare system reform (107). The first attempts started in 2002 by a joint project between Iran and the WHO, which led to allocation of funds to start research about the health system reform, and this was followed in 2004, by a joint project with the World Bank, which resulted in an in-depth situation analysis of Iran's health system, as well as planning for implementing the reform (125). The results of these programmes were included in the 3rd and the 5th national 5-year development plans of Iran (126). In 2014, the General Health Policies (Appendix 1) were announced by Iran's Supreme Leader, drawing the health framework of Iran's Vision by 2025 (127). Finally, in the same year, the Health Transformation Plan towards UHC was launched with the support of the President of the 11th government of the Islamic Republic of Iran (107). The transformation plan is still ongoing and thus far has had successes and challenges (107); there is yet no comprehensive evaluation of its impact.

1.10.6 Changes in Iran's research system

Most analyses of the status of science in Iran highlight the rich heritage of the 'Golden Age' of Islamic civilisation and then, compare and contrast it with the current status (11). However, it should be noted that the majority of the famous Iranian scientists, e.g. Avicenna (the author of Canon of Medicine) or Zakariya al-Razi (who discovered alcohol) lived during only a period between the 9th and 12th centuries (128). According to the literature, this 'Golden Age' was followed by two centuries of decline in scientific activities in Iran and nearly six centuries of 'ignorance' between the 14th and 20th centuries (128). In fact, the history of modern science in Iran is fairly contemporary (128, 129).

Although the first higher education institution in Iran (Jondi-Shahpour medical school), was founded in 271 CE, the first modern higher education institution in Iran, 'Dar al-Fonun' (meaning House of Technologies) was established in 1851 (92, 130, 131). Even that institute was not founded for the purpose of contributing to science, and instead, was only to train new students (129, 132). During the reign of

Mohammad-Reza Shah Pahlavi, in the late 1960s and the 1970s, new universities, e.g. Pahlavi University (renamed to Shiraz University after the 1979 revolution) were established based on American standards (132). The majority of their faculty members were American and some European, but still, not much scientific contribution was made back then (132).

The first years following the 1979 revolution were catastrophic for scientific activities in Iran (132). A process aiming to bring the education system in line with Islamic principles went on during the early 1980s, so-called 'Cultural Revolution', which had different aspects (92, 132). 'Cultural Revolution' caused the expulsion of a large number of faculty members, leading to a huge wave of brain drain during the 1980s (92, 132). Also, all of the universities were closed for three years - two years for medical universities - after which, the power was given to Islamic societies of the universities to monitor activities of academics and students to ensure their conformity with the principles of the Islamic Revolution (132). After the re-opening of the universities, many academics were forced to work in areas irrelevant to their specialty (10). Such events led to a substantial regression in scientific activities in Iran. This regression was further deteriorated by the consequences of the war with Iraq (1980-1988) (10), as it shifted resources from academia towards the more immediate needs of a country in war (10).

On the other hand, it is argued that the Iran–Iraq war and the tight sanctions against Iran—both described in section 1.10.2—may have triggered a drive towards a knowledge-based economy in Iran and may have created support at the macro level for a push towards 'self-reliance' by using nationally-produced science and technology (10, 51). It is argued that the war made Iranian policymakers realise that scientists, such as physicists and mathematicians were needed for developing military technical requirements, which the West supplied to Iraq, but not to Iran (51, 81).

At the same time, since the 1979 revolution was a movement towards egalitarianism, at least in its early years (10), the government sought to improve the healthcare services in rural and deprived areas (111). This required training more healthcare professionals, which was made possible by establishing new medical universities and schools, and recruiting more students (111).

Serious attention to science development in Iran started since 2001, when for the first time, a specific chapter of the 5-year Development Plan was devoted to science and technology (S&T) policies (70, 133). Since then, until 2015, over 50 policies for S&T development, e.g. laws and national documents, have been adopted in Iran (133). As will be described below, three distinguishable periods of S&T policy formulation in Iran since the 1979 revolution have been proposed in the literature (133).

The first period is 1979–1988, when the state significantly invested in development of public elementary education (133). A policy was passed that made elementary education for children tuition-free and mandatory (133). Also, an initiative known as the 'Literacy Movement' was promoted under the order of the then Supreme Leader aiming to provide free education to illiterate adults (133). This resulted in a substantial increase in literacy rate as well as closing the literacy gap between men and women, and between urban and rural populations (92, 133). Between 1955 and 2015, the literacy rate in women and men rose from 10% and 30% to more than 84% and 91%, respectively (133). However, secondary school attendance was still nearly 75% in 2015 (134).

The second period of S&T policy-making in Iran is attributed to the years between 1989 and 2001, when the emphasis was placed on expanding the capacity of higher education (70, 133). Consequently, the number of public universities and the schools within each university increased while also a large number of private universities were established all across the country (70, 133). This resulted in a 10-fold increase in the number of universities and other institutions of higher education (133). In 2015, Iran had 58 public universities of medical sciences, affiliated with MOHME; 154 public universities affiliated with the Ministry of Science, Research, and Technology; 567 semi-private; and 354 non-profit private universities (70).

The policies during the third period, 2005–2015, focused on increasing the number of post-graduate programmes and promoting basic and applied research (133). The number of post-graduate students within this period increased by five times (69). Policies to promote research activities in the emerging fields and technologies and the establishment of advanced technological initiatives were among other activities during that period (133).

Different reasons are proposed in the literature to explain the intentions behind formulating policies for expansion of higher education in Iran. One hypothesis argues that the expansion of higher education has been done with the aim of controlling the high unemployment rate among the youth who had completed high school (135). These young people were the baby-boomers of the late 1970s and the 1980s, as described in section 1.10.5. Another suggested purpose of expanding higher education has been to provide equal opportunities for all; this was in line with the egalitarian values of the 1979 revolution (10). Other proposed reasons were to: respond to the demand of: (i) a generally credential society (92); (ii) a large number of young women who were willing to pursue higher education for gaining a better social status (92); and (iii) young men whose aim for pursuing higher education was to delay recruitment for the 2-year mandatory military service by remaining a 'student' (135). Some also suggest that since the early 1990s, the universities in Iran were commercialised, meaning private and semi-private universities were established only for the purpose of earning money (135).

These S&T policies in Iran have resulted in a large number of educated Iranians, either in Iran or among the diaspora (10, 70). There is even some empirical evidence for the birth of a scientific community in Iran, although Iranian leading scientists have paradoxical opinion about this (10). Some believe that Iran's scientific achievements over the last few decades have solely been products of personal endeavours, while others believe that a scientific community, although a fragile one, exists (10). This PhD will further look into the changes in Iran's health research system during the past five decades. The following section would provide a review of the literature about the methods that will be used for assessment of different patterns of the growth that has occurred in the number of Iran's health research publications.

1.11 Different methods for research assessment

Considering different purposes of research assessment, as described in section 1.6, it is clear that the ways by which research is assessed is a key matter for a wide range of stakeholders, e.g. policymakers and funders, heads of academic institutions, and individual researchers (25). Research assessment includes evaluation of research quality and measuring research inputs, outputs, and impacts (25). It embraces both qualitative and quantitative methods, including the application of peer review judgements, bibliometrics, and alternative indicators (24, 25). These methods are further described in the following sub-sections.

1.11.1 Peer review

Peer review is a process that is used in various research evaluation contexts and responds to different purposes that were summarised in section 1.6. In general, peer review—i.e. peer evaluation in research—is a process in which a jury of equals active in a given research field gather to assess the conduct of a scientific activity or its outcomes (27). The result of the process is often a summarised judgment about suitability for publication or funding, accompanied with comments (27). The prime strengths of peer review are that it is based on specialised knowledge of the subject and methodology, and that relevant literature is available for making evidence-based decisions (24).

The International Committee of Medical Journal Editors (ICMJE) defines peer review as: '*the critical assessment of manuscripts submitted to journals by experts who are not part of the editorial staff*' (136). Indeed, peer review has several contemporary applications in addition to the critical appraisal of papers. Some of its common uses are: (i) assessment of books by publishers; (ii) review of scientific data in the context of publication decisions or data repositories; (iii) measurement of the performance of researchers or research groups in the context of national and international research assessment exercises or awarding scholarly prizes; (iv) assessing fellowship applicants and grant proposals; and (v) evaluations in the context of future studies and the development of national or international research agendas (24, 27, 137). Peer review is increasingly being used for national research assessment exercises (24). Particularly, countries who intend to assess research impact in addition to assessment of research output highly rely on peer review approach; examples are the UK, Italy, France, and Belgium (24).

Despite peer review's strengths and wide use, it has several limitations too, being summarised as follows (24, 27, 138-141): (i) the process is slow, expensive and inefficient; (ii) human judgment is basically subjective; (iii) most of the peer review processes are not transparent; (iv) it is not a consistent process and the lack of inter-rater reliability is reported repeatedly; (v) the process is highly prone to bias, e.g. gender bias regarding career decisions or even publication, bias against publishing negative results, bias in favour of prestigious institutions/countries and vice versa; (vi) the process is vulnerable to be abused, e.g. to block competitors or even insert abusive comments; (vii) it is not very effective at detecting mistakes or even in identifying fraudulent data; (viii) it cannot evaluate the complete research output of a country; (ix) it cannot provide information about the productivity and efficiency of a large research system; and (x) finding peer reviewers is a difficult task, because of potential conflict of interest, lack of experts in emerging and interdisciplinary fields, etc.

Some major areas of improvements of peer review suggested in the literature are to (24, 140): (i) make the process single- or double-blind to overcome potential biases; (ii) replace pre-publication review with post-publication review; (iii) provide open peer review to solve the risk of abuse and to increase accountability; (iv) provide trainings for reviewers to improve the quality of their reviews; and (v) develop new types of peer review, e.g. being more focused on methodology rather than substantive quality criteria as developed by PloS ONE in journals. Pre-prints and post-publication peer reviews are also among the major developments which have become possible with the advent of online networks (142-144). One great advantage of preprints is the ability to disseminate research findings rapidly once the project is complete (143). Faculty1000Research is another novel approach known as post-publication peer review, which provides transparent peer review after publication for materials in life sciences (144).

Two of the disadvantages of peer review that are particularly important in analyses at larger scales are being time-consuming and expensive, which can eventually result in a drop in its quality. For instance, in the 2008 UK research assessment exercise (RAE), each of the members of the review panel for biological sciences had to assess almost 1,000 papers within a few months, and in the fields of social sciences and humanities each member had to review 100 books (24). Clearly, with peer review approach, not all of the submitted research could be reviewed in depth for large-scale research assessments. Furthermore, using peer review for national-level research assessment is very expensive, too. For example, running the UK Research Excellence Framework (REF) exercise in 2014 is estimated to have cost £246 million, comprising almost £232 million in costs to the higher education community and around £14 million in costs for funding bodies (145).

1.11.2 Evolution of research assessment methods

Recognition of the limitations of peer review has encouraged endeavours to replace and or complement it with quantitative metrics, such as bibliometrics and/or Altmetrics. Bibliometrics is further described in the following sub-sections. Altmetrics is 'the study and use of scholarly impact measures based on activity in online tools and environments' (146). The term Altmetrics was proposed in 2010, originating from altmetrics hashtag (#altmetrics), which proposed metrics as alternative or complementary to more traditional metrics, e.g. journal impact factor or h-index (146). Examples of the tools and environments using which Altmetrics tracks research impact are: (i) social media, e.g. Twitter and Facebook; (ii) online reference managers, e.g. Mendeley, CiteULike; (iii) collaborative encyclopaedias, e.g. Wikipedia; (iv) blogs; and (v) scholarly social networks; e.g. ResearchGate (24, 146-150). For instance, counting the number of page/article views, downloads, number of 'retweets' on Twitter or 'shares' on other social networks and any mentions in policy documents or mainstream news outlets could be counted by Altmetrics (146, 148, 149). Such metrics are increasingly gaining attention, particularly on micro levels of assessment, e.g. individual assessment or article evaluation (147).

Another major development that could influence the way citation impact is assessed is in relation to the rise in Open Access publishing (151), meaning publication of journals which provide the full-text versions of articles free of charge (151). The availability of full-texts, and not only the bibliographic information, enables the construction of more advanced citation impact metrics, e.g. indicators that take into account the number of times a publication is referenced in a citing publication, the location where a publication is referenced in a citing document (e.g. introduction, methods, results, or discussion) or even the context in which a publication is referenced (i.e. the sentences in a citing document about the reference to a cited publication) (148, 152). Such new sources of data might be used in the future for obtaining more sophisticated measurements of citation impact (152).

1.11.3 Bibliometric methods

Introduction

As a result of the increased attention to assessment of research performance, bibliometrics has evolved from being an almost obscure statistical sub-field of information science to playing a substantial role within the social and political processes of scientific activities in academia (147, 148, 153). This section first reviews the history of the development of the field bibliometrics. This would help us understand how this field has evolved from formulas and theories to influencing policy, how this contemporary use of bibliometrics can pose problems, and how the limitations can be minimised. Then, different citation databases and bibliometric tools will be introduced, which is followed by a section that compares peer review approach and bibliometrics. Finally, some applications of bibliometrics in large-scale research assessment practices will be reviewed.

History and basic concepts in bibliometrics

Today, the terms *bibliometrics* and *scientometrics* are used interchangeably (154) and this section begins with a brief review of their origins. Both terms were introduced and defined in 1969 (154, 155). The term *bibliometrics* was defined as, '*the application of mathematical and statistical methods to books and other media of communication*'

(148), while *scientometrics* was first defined as '*the quantitative methods of the research on the development of science viewed as an information process*' (148).

However, over the past thirty years, the blurry line between these two specialties has almost been disappeared (154). Today, the originally broader field of bibliometrics is replaced by *informetrics,* while scientometrics and bibliometrics provide equal meanings (154, 156). Therefore, informetrics is like an umbrella that covers scientometrics/bibliometrics as well as the younger related fields, such as altmetrics (156, 157).

The basis of the field of scientometrics or bibliometrics has older origins though, perhaps going back to 1896 when Pareto's principle was introduced (158-160). Pareto's principle stated that for many events, approximately 80% of the effects come from only 20% of the causes (159). Pareto's principle that was initially proposed in economy to describe income distribution was later applied in analysis of citation behaviours in science (153, 158, 160). In 1934, Bradford published his important study on the frequency distribution of papers across journals (154, 155), which showed that if scientific journals would be ranked in terms of their number of articles on a particular subject, there will be a core of journals that publish most of the articles in that subject (148). Bradford's hypothesis was quite similar to Pareto's proposed pattern. Around the same time, a citation-based study was published which had assessed 3,633 citations from 1,926 volumes of the Journal of American Chemical Society (161) to help deciding which chemistry periodicals were better for purchasing by small libraries (154, 155).

A new chapter was opened in practical scientometrics when Eugene Garfield proposed the idea of citation indices for science (162) and officially founded the Science Citation Index (SCI®) at the Institute for Scientific Information (ISI) in 1964 (163). The SCI® was first proposed as a tool for facilitating the dissemination and retrieval of scientific literature (164).

Another historic highlight in development of scientometrics field was the Derek J. de Solla Price 1963 book entitled 'Little Science, Big Science' (165), in which the first quantitative data on the growth of scientific publication covering 1650 to 1950 was provided (165). The book had reported a growth rate of 5.6% per year in the number of journals, and an annual growth rate of 7% for science (165). By analysing the recent systems of science communication of his time, Price established the foundation of modern research evaluation methods (154).

A theory characterising processes of scientific communication was the principle of cumulative advantage proposed by Price (166), which is also known as '*success seems to breed success*' (148). Price explained that a paper that has been cited many times is more likely to be cited again. Similarly, an author of many papers is more likely to publish again than one who has been less prolific.

This idea was initially introduced in 1968 as 'Matthew Effect' by Robert K. Merton (167), who had shown how certain psychosocial processes can influence the allocation of rewards among scientists—an allocation that in return influenced the flow of ideas and findings through scientific communication networks (167). Merton had also been one of the first people who proposed the idea of citations being a reflection of recognition or acknowledgement of a piece of work among peers—i.e. an indicator of the impact of the work on a community of peers (137). He once wrote that '*if one's work is not being noticed and used by others in the system of science, doubts of its value are apt to rise*' (168).

In 1972, Eugene Garfield developed a measure for evaluating and ranking journals—the journal impact factor (IF), which still is in use despite being widely criticised for its flaws (169). In 1978, 'scientometrics' developed as a discipline with the publication of the journal Scientometrics—the first journal specialised in this field (148, 154, 155). Around the same time, the first links between bibliometrics and research evaluation and the use of citation analyses in policymaking took place (148). For instance, the ISI data was included in the US National Science Board's Science Indicators Reports in 1972 and was applied by the Organization for Economic Cooperation and Development (OECD) (148).

- **Levels of aggregation in bibliometrics**

In bibliometric analyses three levels of aggregation are often used. These levels are: (i) micro, e.g. publication output of one author or research groups; (ii) meso, e.g. publication output of institutions, journals, or research fields; and (iii) macro, e.g. publication output of countries, regions, or the world (153, 154). In the literature, micro is considered as the lowest and macro as the highest level of aggregation (154). In performing analyses on any level of aggregation, information about names of the authors, institutions, countries, etc are often obtained from the sections on a publication that include authors' names and affiliations (170).

- **Data quality in bibliometric analyses**

Arguably, the quality of data in bibliometric studies requires significant attention. That is why choosing an appropriate database and cleaning the data is essential (153). Names of authors, institutions, and some countries often have many variations; they may contain spelling errors; or the names might change over time (153, 154, 171). Furthermore, attention should be paid to possible synonyms and homonyms (153). Synonyms are when more than one name exists for one entity—e.g. an author whose name is spelled differently on different publications—while homonym is when one name refers to more than one entity—e.g. different authors who share the same initial and surname (153, 154). Disambiguation and cleaning the names of authors, institutions and even countries is fundamental to performing meaningful bibliometric analyses, particularly in research assessments on micro levels (137, 153, 154, 171).

One strategy to correct identification and disambiguation of authors and institutes in order to improve scientometric analyses on the micro and meso levels is to promote the use of online registries where each researcher can obtain a unique identifier, and link it to his/her publications. In this way, the publications linked to each author could be tracked using their registered identifiers—i.e. IDs (171). This could solve the issues with synonyms and homonyms of authors. Examples of such author ID registries are ORCID (Open Researcher and Contributor ID) and ReseacherID (171). They are both freely available (172), but yet, not widely used for bibliometric analyses. Because firstly, their coverage is still limited and secondly, they are sensitive to human errors, because authors should regularly update their list of publications and maintain publication assignment to their IDs (171).

- **Research area assignment**

Several bibliometric analyses investigate the publication activity in certain research areas. Publications in bibliographic databases are often allocated to research areas, either by subject headings, or based on journals' classification (154). A good example of assignment based on subject headings is the MeSH (Medical Subject Headings) in PubMed (173). PubMed is a bibliographic database for biomedical literature and assigns subjects to documents with a document-based vocabulary thesaurus called MeSH (173). A MeSH term is one of the main topics that is discussed in a document and is assigned to each document based on the decision of subject specialist staff (173). Moreover, these specialists continually revise and update the MeSH vocabulary and may add new major MeSH terms if an important emerging new field is missing (174).

Unfortunately, the main citation databases, i.e. Web of Science and Scopus, allocate research areas to the documents using journal classification (154), meaning they determine the subject of each individual document based on the scope of the journal where the document is published (154). As journals are often not devoted solely to one single topic, the allocation of research fields based on journal assignment is less precise than being based on the subject headings of individual documents (154). In addition, the journal-based subject assignment approach fails regarding the subjects allocated to the documents that are published in multidisciplinary journals such as *Nature* and *Science* (154) or in general medical journals, e.g. *The Lancet*.

Citation databases

Successful quantitative analysis of citations requires accurate and comprehensive bibliographic data sources. There are currently three indexing databases that provide citation information: Web of Science (WoS), Scopus, and Google Scholar (GS) (152). This sections describes and compares these databases with each other. It should be noted that various features of these databases are in constant development. Hence, this review is only valid at this time.

- **Web of Science (WoS)**

Web of Science™ (WoS) citation database was first created at the ISI by Eugene Garfield (163), and since 2016, has been owned by Clarivate Analytics Company (Philadelphia, United States of America) (175). WoS comprises several citation indexes, it is a subscription-based database, and its coverage varies based on the type of subscription (152). Its most famous database—WoS Core Collection—includes Science Citation Index Expanded (covering 8,500 journals), Social Sciences Citation Index (indexing over 3,000 journals), Arts & Humanities Citation Index (full coverage of 1,700 journals) and several other indices, e.g. the Conference Proceedings and Book Citation Indexes, both in science and in social sciences and humanities (148, 176). A more recent addition has been the Emerging Sources Citation, which aims to include scientific literature of regional importance and in emerging fields (152).

- **Scopus**

In 2004, Elsevier introduced Scopus (152), which is another subscription-based citation database rather similar to WoS, covering 21,500 journal titles from 5,000 publishers, over 360 trade publications, over 530 book series, more than 7.2 million conference papers, 116,000 books, and more than 27 million patent records (177). Being younger than WoS, the characteristics of Scopus have been studied less extensively than those of WoS, but there is still a lot of literature comparing these two databases from various aspects, some of which are reviewed in the following sub-sections.

- **Google Scholar (GS)**

In 2004, Google Company launched Google Scholar (GS) as a simple and free-of-charge academic search engine (152); it uses automated software to extract citations from the digital publications that it finds online or that are provided by publishers (148, 152). GS indexes literally any scholarly literature that is available on the web; little is known about its exact coverage (152).

- **Comparing WoS, Scopus, and GS**

Several comparisons of the coverage of WoS and Scopus has been conducted, some of which have reported that Scopus has a better coverage than WoS in various field, although it is suggested that Scopus seems to be covering journals with lower impact factors (178). An analysis of researchers in the field of human-computer interaction showed that Scopus had a better coverage of conference proceedings than WoS (179). An investigation of the overlap of journal titles in Scopus and WoS found the coverage of Scopus to be superior, particularly in science, technology, and medicine (180). However, a study analysed the coverage of publications of two Portuguese universities in WoS and Scopus and concluded that about two third of the documents indexed in any of these databases can be found in both databases, and one third is only indexed in one or the other (181). Furthermore, an analysis of journals in the field of oncology indicated that the journals that are covered by Scopus, but not covered by WoS, tend to have a lower citation impact and are likely to be more nationally oriented (178). The issue of Scopus covering journals with a relatively lower impact was observed in another study, too (182).

Several studies have compared GS against WoS and Scopus to investigate its suitability for research evaluation purposes. A number of studies have reported that GS outperforms WoS and Scopus in terms of coverage of different types of publications (152). For example, it has been observed that GS has a broader coverage of conference proceedings and non-English language journals in the field of library and information science (183). Similarly, GS covers more publications than WoS in the fields of business and management. The mean citation of the research papers of three UK business and management schools in GS were seen to be nearly double the figure for WoS (184). Studies from computer sciences (185) and psychology (186) have also shown broader coverage of GS than WoS. GS might also be a better option for research assessment exercises in the fields where publishing books is more common than publishing journal articles (24). A study compared the citations to 1,000 books submitted to the 2008 UK RAE across seven book-based disciplines and found that both the numbers and medians of GS citations to books were three times as high as Scopus citations (187).

Having said that, GS does not necessarily have a better coverage than WoS and Scopus in all fields. For instance, an analysis documented that coverage of GS compared with WoS and Scopus in the field of energy physics was poor (188). Another study from the field of chemistry reported a lack of convergent validity of the citation analysis based on the GS data and recommended WoS and Scopus as more suitable databases for research assessment in chemistry (189). It should be noted that, some studies have found none of these three databases to be consistently better than the other two in terms of coverage. A comparison of WoS, Scopus, and GS in the fields of oncology and condensed matter physics with the data from 1993 and 2003 indicated that none of these databases consistently outperforms the others (190). A similar conclusion was derived from an analysis of publications in general medical journals (191). Additionally, a comparison of WoS and GS in the field of earth sciences presented a lack of consistent outperformance (192).

GS may be useful for assessment of units that contain a substantial amount of non-English documents, and when pre-prints and or publications in non-conventional platforms must be included (148). However, for a number of reasons, GS should be avoided as the first citation database of choice in undertaking bibliometric analyses. Firstly, GS does not provide transparent information regarding its indexed sources (193). Secondly, GS has no clear quality control over its indexed content (148). It contains many inaccuracies and errors leading to incorrect citation counts (194). Some concerns have also been raised regarding the possibility of manipulating citation counts in GS (195, 196). Finally, cleaning the data from GS could be extremely time-consuming (183).

- **Which citation database to choose?**

In terms of the sensitivity of citation analyses, to choose between WoS and Scopus, suggestions in the available literature are quite mixed. One study ranked different departments of the University of Navarra in Spain based on citation counts from WoS and Scopus and found that they both eventually provided similar rankings (197). Two other studies have indicated that in analysis of small entities—e.g. journals, conference proceedings, or institutions—citation results retrieved from WoS and Scopus are significantly different, whereas for larger entities—e.g. research fields or countries—the yielded figures from two databases could be very similar (198, 199).

The general agreement at this time is that bibliometric data either from WoS or Scopus is sufficient to perform research evaluations in the natural and other sciences where the coverage of publications is high—i.e. excluding social sciences, arts and humanities (24, 148). Particularly, bibliometric analyses in WoS and Scopus on higher levels of aggregation—e.g. national or global levels—seem to yield similar results (199).

The coverage of these three databases has substantially improved over the last recent years, which necessitates further updated comparative studies (24, 200). In particular, WoS has been increasingly expanding the indices that includes, especially in different languages (200). A recent longitudinal comparison of the rate of growth of publications and citations in these databases between 2013 and 2015 found a consistent quarterly growth across all three databases and suggested that all three provide adequate stability of coverage (201).

Bibliometric indicators

Traditionally, the findings of original research are communicated through publications, particularly in certain fields, e.g. biomedical and natural sciences, publishing journal articles is the main way of dissemination of findings (153). Hence publications could be considered as proxies of scientific output of research units (e.g. researchers, institutions, countries) (148, 152, 153). Furthermore, it is assumed that a citation to a document in subsequent articles represent the scholarly impact of the cited document (153, 168). In this way, the number of received citations by a document would somehow reflect scientific impact of that document (137). Consequently, although bibliometrics can, and somehow do, study different aspects of the dynamics of science, in practice, this field has mainly developed around the notion of citations (148, 153), and the majority of indicators developed in bibliometrics focus on citations. Several indicators based on citation counts are available for measuring research impact, which are described in the following sub-sections.

- **General categories of citation impact indicators**

Two main characteristics of citation-based indicators are about: (i) being size-dependent or size-independent (152); and (ii) being normalised or not (153). Size-dependent indicators, aim to provide an overall picture of the performance of one research unit (152), while size-independent indicators aim to provide an average performance measure per publication (152). Example of a size-dependent indicator is the total citations received within a year by publications of an academic institution. This could be helpful for providing an overview of the research performance over time. Indeed, comparing the total citation counts to publications of a large institution with the figures for a small institution is not fair; that is where size-independent indicators, e.g. the average citations per publication come useful. Another well-known example of size-independent indicators is the journal impact factor that aims to calculate the average citation counts to each publication of a journal (24).

In terms of normalising the indicators, the goal is to correct the effect of variables that may influence the outcomes of citation analyses (24). Citation indicators can be normalised by research fields; because of the substantial differences among fields in citation density, i.e. the average citation counts per publication (153, 202). For instance, molecular biology articles have been reported to have ten times as much as citations than publications in computer sciences (203). Also, citation counts should be normalised by the year of publication if they are used for comparison of research units with different ages (152), because an older publication has had more time to get cited than a recent publication (204). Some believe that citation counts should also be normalised by the document type (152), i.e. original article, review article, letter, etc.

An analytical tool offered by Clarivate Analytics Company that normalises the number of citations by research field and the year of publication is Essential Science Indicators^{SM} (ESI), which enables the assessment of researchers, institutions and publications within a given research field and publication year (24, 205). Moreover, InCite is another research evaluation tool provided by the same company that allows assessment of the productivity and citation impact of different research units. One of the metrics in InCite that is normalised by subject category and the year of publication—Percentile in Subject Area—has shown a high correlation with Faculty1000 (i.e. based on peer judgements) ratings (206).

- **General citation impact indicators**

A large number of citation impact indicators have been proposed in the literature, most of which can be seen as variants or extensions of a limited set of indicators that are introduced in the following sub-sections (152). Five main citation impact indicators are the: (i) total number of citations; (ii) average number of citations to publications of a research unit; (iii) number of highly-cited publications; (iv) proportion of the highly-cited publications; and (v) h-index. While the first indicator is self-explanatory, the other four citation-based indicators are described in the following text.

- **Average number of citations**

Average number of citations of a research unit is the average of citation counts to publications of a research unit. Journal IF that calculates the average number of citations received by publications in a journal is perhaps the most commonly used indicator based on the idea of average number of citations (169). Although average-based metrics are routinely in use, they are widely criticised. The critics rise from the possible skewness of citation distribution in any research publication unit (153). Meaning that the average number of citations of a set of publications can substantially increase by only one or few highly-cited publications, and vice versa (152). Similar to early theories discussed in section 1.11.2, 80% of citations are received by 20% of documents; many publications are even never cited (207). The limitation of average-based metrics on account of unequal distributions has been reported on the level of countries (208), universities (209), and repeatedly on the level of journals (157, 210). Therefore, it is strongly recommended to replace or complement indicators that are based on the average number of citations by other metrics (152). The median has been suggested to be a more robust alternative (211), but as median disregards the highly-cited ones, it also cannot fully represent the citation impact of a research unit (153). Providing the standard deviation with the mean seems more appropriate (153). The following indicators are other examples of alternative metrics for average-based indicators.

- **Number of highly-cited publications**

To calculate this indicator in a research publication unit, firstly, a threshold should be chosen to define the number of citations that are required to call a document 'highly-cited' and then, the highly-cited publications will be identified (24). In recent decades, a number of studies have suggested the use of 'number of highly-cited publications' in research evaluations (212-215). GS and WoS have started using this indicator; GS reports 'i10-index' for authors, which represents the number of their publications with 10 or more citations (24), while WoS offers a tool called ESI, which identifies the highly-cited publications (205). ESI uses WoS data by which identifies a threshold for highly-cited papers as the minimum number of citations received by the top 1% of papers in each research field and in each year.

- **Proportion of highly-cited publications**

This indicator is the proportion of the publications of a research unit that are identified as highly-cited. Citation percentiles, such as the top-5 or the top-1% highly-cited documents have been reported to be appropriate measures of excellence (206, 216).

- **H-index**

In 2005, a more complex indicator was introduced by a physicist called Jorge E. Hirsch to somehow address the limitations of older citation indicators (217). This new metric, the h-index (or Hirsch index) was defined as follows: 'A research unit has index *h* if *h* of its publications each has at least *h* citations and the other publications each has no more than *h* citations' (217).

H-index was the first indicator which—to some extent—intended to capture both the quantity and the citation impact of an individual's research unit in a single number (217). It is now automatically calculated in all three main citation databases (152, 188). H-index can be applied at different levels of aggregation, e.g. authors, institutions, countries (148). Another advantage of h-index is that it disregards the lower down publications, thus it is robust to poor quality data that can be an issue while using GS (148).

However, h-index has several limitations and some of them are inherent limitations of citation indicators, e.g. the problem of using h-index to compare research units in different disciplines with different citation density (148, 203). Two other important limitations of h-index that have provoked many studies for improving this indicator is that h-index is insensitive to firstly, the total number of publications, and, secondly, to the actual number of citations received by the documents included in the h-index—i.e. the h-core. Therefore, research units, e.g. two authors with entirely different number of publications and/or citations could have equal h-indices as long as they both have published *h* papers, each with *h* citations (153). It is also important to mention that, since the maximum of the h-index is the number of publication in the research unit, the h-index is more strongly formed by the number of publications rather than the citation counts (153).

- **Newer variations of h-index**

To overcome the limitations of h-index, a large number of its variants have been proposed in the literature, of which the g-index (218) is probably the one that is best known. G-index, introduced in 2006 by Egghe, was defined as, 'a set of papers has a g-index of *g* if *g* is the highest rank such that the top *g* papers have, together, at least g^2 citations' (218).

The basic idea is that the papers that contribute to h-index—i.e. the h-core—must have at least h^2 citations between them, although in practice, they might have more. G-index attempted to solve the insensitivity of h-index to actual number of citations of the h-core papers (148). The more citations they have, the larger the *g* will be and so it will, to some extent, reflect the total number of citations. However, the disadvantage of g-index is that it is less intuitively obvious than h-index (148).

Another proposed indicator is a-index which is the mean number of citations of the h-core documents (148). The a-index disadvantages better research units, because divides the citation counts by h, which is higher for better research units (148). A further proposal to solve this shortcoming was the r-index that is the square root of the sum of the citations of h-core documents. The ar-index is another variant of the r-index which also takes into account the age of the papers (148). M-index is another indicator which is the median of the citations of h-core documents (148).

In sum, the use of indicators that are based on the total or average number of citations is criticised, because citation distributions are often highly skewed, thus the total or the average citation counts in a set of publications could be very much influenced by only one or a few outliers. Therefore, mean number of citations cannot provide a valid measure of central tendency. Median or providing standard deviations are better alternatives. Indicators based on the idea of counting highly-cited documents have been reported to be a more robust alternative to metrics based on the total or average citation counts. Percentile-based approaches that would determine a threshold and count the number of documents reaching that threshold have shown more promising results. Finally, the h-index has become a well-established indicator and compared to new generations of its variants, it is much more practical as it is now calculated by all main citation databases. However, it is a rather crude simplified indicator to compress the information about both productivity and citation impact into one single number.

Indicators of the citation impact of journals

The previous sub-sections generally described citation-based indicators. This sub-section focuses on some of the most well-known citation indicators that are used for journals.

IF is the most famous journal citation impact indicator (152). It is calculated using two elements: (i) the numerator, which is the number of citations in the current year to documents that were published in the previous two years; and (ii) the denominator, which is the number of substantive original and review articles published in the same two years (169). In a simple example, if a journal has published a total of 100 publications in 2013 and 2014 and if these publications were cited 200 times in 2015, the IF of this journal equals 200/100 = 2. Therefore, IF seems to be a proxy of the average citations to a journal publications in recent years (169). Nevertheless, considering its definition, in the numerator of IF, the citations to all of the publications (all document types) are counted, whereas in its denominator only publications of specific document types—the so-called citable documents—are included (152).

It is also worth highlighting that IF was initially developed by Garfield as a tool to aid them in selecting the most 'relevant' journals among thousands of journals for coverage in SCI with a view of improving the cost-effectiveness of their task (153). Eugene Garfield and his colleagues in ISI had studied the references of the articles in SCI and had shown that the majority of references were citing roughly 500 to 1,000 journals (153, 169). By 1969, they identified 2,200 journals as 'the world's most important scientific and technical journals' and fully indexed them in the SCI (153). Today, the historical background of the creation of IF is often overlooked and IF is extensively used in research assessment contexts (147, 153). This has caused a lot of debate around the use of IF. Part of the debate regarding the IF is not much about the indicator itself, but mainly around the way in which it is used for research assessment purposes, particularly on micro levels, e.g. in assessing articles based on the IF of the journal where they are published or in evaluating researchers based on the IF of the journals where they publish (147, 152, 210).

There is also debate regarding how IF is calculated. Several improvements of and alternatives to IF have been suggested in the literature (24). For example, including citations belonging to a time period longer than two years has been suggested(152), e.g five-year IF which are calculated based on citations to publications in the previous five years rather than two years. The Journal Citation Reports (JCR)—a product of Clarivate Analytics that calculates IFs for journals indexed in the WoS Core Collection—provides both the two-year and the five-year journal impact factors (24).

Some have recommended the use of median instead of the average number of citations of the journal publications (24). Another suggestion is to calculate an h-index for journals as a replacement or complement to IF (24). The concern with the use of h-index for journals is that this indicator unlike most metrics for journals is size-dependent, thus journals with more publications are likely to obtain a higher h-index (152).

Another approach that has received more attention is to normalise journal citation impact metrics for the differences in citation density and citation behaviour among different fields (148). One of these approaches is implemented in the 'Source

Normalized Impact per Paper' (SNIP), which normalises citation impact of journals by their subject and provides the possibility of fair comparisons between journals from different fields (219, 220).

It is also important to mention the attempts to improve journal ranking metrics that have resulted in the creation of Eigenfactor and SCImago Journal Rank (SJR) (152). Eigenfactor that uses the WoS data aims to take into account the prestige of the citing journals (152). This means to add more weight if the citation is received from documents in highly-reputed journals, such as *Nature* and *Science* rather than coming from less known journals. SJR, which relies on Scopus database, uses a similar prestige-based approach as Eigenfactor, but also adds credit to journals when they are cited in sources with a close scientific theme (221, 222). Indeed, determining the prestige of journals is a rather subjective decision, with no clear criteria.

- **Use of journals' citation impact indicators in research assessment contexts**

The IF and other citation impact metrics for journals are very often used not only in the assessment of journals, but also in the assessment of individual publications in a journal or in assessment of the authors of articles in those journals. The use of journal-level metrics for evaluating individual publications is rejected by many (24), because the distribution of citations over the publications in a journal is highly skewed, which means that the IF or any other journal-level metrics are not representative of the citation impact of a single document in a journal.

The San Francisco Declaration on Research Assessment known as DORA (210), which strongly argues against the use of IF in the assessment of individual publications and their authors was published in 2012, and ever since, has received a lot of support from researchers, academic institutions, and even funding bodies (24). Having said that, some would argue that indicators of the citation impact of journals can be useful in assessing very recent publications—meaning for publications that there has yet been no time for them to receive citation (24).

Excluding certain types of publications and citations

In this section, the main issues that are usually considered in selection processes of publications and citations are reviewed. While calculating citation impact indicators, some of the publications may need to be excluded (152). Usually, only publications from a certain time-period are included, thus a selection is made based on the year in which the document was published (152). Another selection of publications is done according to the types of documents; e.g. original articles, editorials (152). Similarly, not all of citations are necessarily included in bibliometric analyses; they could also be excluded depending on certain time-periods after the publication of a document. This time-period is often called 'the citation window' and is discussed further in the following sub-sections. Furthermore, the selection process of citations often addresses the issue of self-citations that will be further explained in this section.

- **Document types**

One of the inclusion/exclusion criteria in bibliometric analyses is the type of the document. In the WoS and Scopus databases, each publication is allocated to a certain document type. Some of the main document types for instance are original article, review articles, editorial, letter, or proceeding abstracts. The underlying reason for excluding certain types of documents from analyses is that usually there is a significant difference in the citation density of different document types (152). Once size-dependant citation indicators are being used, this does not make a huge problem, whereas when size-independent metrics are used, e.g. the average number of citations per publication, the variation of citation counts across different document types can lead to flawed conclusions.

- **Language**

The next selection criterion is the language of documents. Current literature suggests that it is better if non-English documents are excluded from citation analyses, particularly in global comparisons of citation performance of countries (152). The reason is that non-English publications on average receive fewer citations than English publications due to the language barrier. Thus, it is argued that including non-English publications can create a bias against countries where researchers publish a lot in their own language (152).

- **Self-citations**

There are also suggestions regarding exclusion of certain types of citations, e.g. self-citations (152). Self-citations can occur on various levels. For example, on journal level, i.e. when a document in a journal cites other documents published in the same journal or on institutional level, which is when the publications of an institution would cite the publications of authors from their own institution. However, the main focus of the literature about self-citation is on the author level, i.e. an author citing his/her own previous publications.

Several studies have shown that on the macro level, i.e. national, regional, and global analyses, the effect of author self-citations is very insignificant and there is no need to exclude author self-citations on higher levels of aggregation (152). On the other hand, for analyses below the macro level, some suggest excluding self-citations, while others believe it is better to present both, including and excluding author's self-citations (152). On the micro level, there is no agreement about sensitivity of h-index to author self-citations and some have found its sensitivity to be limited, whereas others recommend reporting both h-indices including and excluding self-citations (152).

Although there are strong arguments in favour of excluding self-citations on lower levels of aggregation, this could have shortcomings as well (152). For instance, it could disadvantage highly specialised or emerging fields as well as research groups who are leading larger sub-fields (152). Moreover, excluding self-citation is problematic when publications have a large number of authors, such as articles in global genomic or epidemiologic projects where there may be even more than hundred authors on one paper (152).

- **Citation windows**

In the calculation of citation impact indicators, sometimes only citations within a specific time-period after the appearance of a publication are taken into account (152). This time-period is often referred to as the 'citation window' (152). Using a certain citation window may influence the selection process for both publications and citations (152). For example, if an analysis aims to include publications with a citation window of minimum five years, then recent publications also should be excluded.

A large number of studies have intended to find an optimum citation window (152). The findings are quite mixed, but some points could be highlighted. Several studies have investigated the correlation between shorter and longer citation windows and it seems that in most fields they are correlated (152). Perhaps in areas such as mathematics or the space research (223) longer citation windows provide better results. For instance, an analysis showed that except for publications in mathematics a citation window of two to three years is adequate for providing robust citation impact indicators (224). Another study has suggested that a citation window of at least one full year is essential for all fields (202). The most extensive study performed in this regard has concluded that there is generally no applicable rule for choosing citation windows (152).

Another issue in this context is delayed recognition of influential publications; delayed recognition refers to the lag time before the importance of a publication is recognised (152). One argument that was made based on an analysis of all publications indexed in WoS in the sciences from 1980 is that this phenomenon does not have much influence on citation impact indicators (152). Finally, there is even evidence showing that the documents that are published within the first months of the year are luckier in receiving more citations. This is particularly important to consider while choosing a very short citation window, e.g. a couple of months (225).

Limitations of bibliometric methods in research assessment

While bibliometrics can provide very useful tools to be used in research assessment exercises (147, 210), their limitations should be considered. In terms of limitations in assessment of research output, firstly, bibliometrics heavily rely on information on journal publications, and to some extent books and conference proceedings, and do not retrieve information from other categories of research output, e.g. policy briefs, clinical guidelines, datasets, software, scientific videos (210), particularly if the outputs come in languages other than English.

In terms of use of bibliometrics in research impact assessment, clearly, bibliometrics fail to track the wider impacts of research, such as on population health, policy, and economy (24). Even assessment of scholarly impact using citation-based indicators has limitations. Firstly, since most journals ask for a limited list of references, the list of cited items that appear on a publication is not a complete list of the scientific sources that have influenced the work of the author(s). Secondly, some publications may be used and cited in academic materials other than journal publications, e.g. teaching handouts (24, 147, 210).

Excessive reliance on bibliometrics could lead to goal displacement (24, 58, 226). Meaning, the final goal could change from being a tool of evaluating whether an anticipated level of performance has been achieved to solely trying to attain a high score in research assessment exercises (24). Another issue is in relation to the task reduction (24). Empirical evidence suggests that enforcing publication of certain types of articles can eventually lead academics to spend less time and effort on other activities, such as teaching and or communicating research with its end-users, while only focusing on publishing in English peer-reviewed journals and mainly on certain hot topics (24).

Comparing bibliometrics and peer review in research assessment practices

As discussed in this section so far, there is an intention to use bibliometrics as complementary tools for peer review in different research assessment contexts, particularly at large-scale studies which are too expensive and time-consuming if they rely only on peer review methods. Nevertheless, many concerns have been raised in the literature regarding the use of bibliometricsin research assessment contexts, as described in this section thus far. Due to the limitations of bibliometric methods, some have attempted to investigate the extent to which the results from bibliometric analyses correlate with the results from peer review judgements to see if bibliometrics can complement peer review processes. This sub-section will show that most of the studies have found a positive, but week correlation, although it depends on the level of aggregation and the type of study's indicator (24). A hypothesis for the underlying reason of the imperfect correlation is the variation in peer judgements (24).

One study analysed the relationship between bibliometric indicators and peer review in evaluating the scientific performance of six research groups in economics (227) and found that peer judgments and bibliometric results were generally in agreement (227). Another study analysed 56 research programmes in condensed matter physics which had led to 5,000 publications and nearly 50,000 citations (228). That study found mixed correlations between different bibliometric indicators and the outcomes of a peer assessment: the strongest correlation between peer judgments and bibliometrics was found on the level of research groups, and the correlation for groups doing basic research was stronger than those in applied research (228).

A study of the relationship between citation analysis and peer ratings of books in the field of medical history has also found a high degree of agreement about which books are the best (229). Another comparison that found a positive, but weak correlation between bibliometric indicators and peer review outcomes in a study conducted at a Norwegian university argued that the weak correlation could be due to the shortcomings of the peers' assessments and in the limitations of the indicators (230). A more recent study based on an evaluation of 147 chemistry research groups in Dutch universities covering the work of about 700 senior researchers showed that the h-index related in a quite comparable way with peer judgments (231). However, for smaller groups in the fields with 'less heavy citation traffic', the h-index seemed to be a less of an appropriate measure of research performance.

A paper published in 2011 has reported the analysis of the relationship between peer judgment and a range of citation metrics regarding the impact of researchers in six fields of public health in Australia and has shown a moderate positive correlation in four of the six fields (232). The authors have suggested the reason that there was no or even a negative correlation in other two fields was that in those areas researchers are assessed based on other criteria than visibility in the literature.

Some have compared the results from the Italian qualitative research assessment exercise (VTR 2006) with bibliometric indicators (224, 233) and have concluded that in natural and formal sciences citation-based indicators were better than the VTR 2006 peer review in evaluating the quality (24). The major reported advantage of bibliometrics over qualitative assessment was its ability to measure all the output (24). Also, in national assessments that use bibliometrics, institutes can avoid submitting only a subset of documents, which leads to less error and saves time and costs (24). The Italian peer-based VTR 2006 assessment had only managed to process 9% of the total output of the country (24). While bibliometrics can provide improved robustness and validity in national-level assessments, it fails to capture all scientific outputs (233).

Another study compared the results from informed peer review—i.e. use of peer review and quantitative metrics together—with bibliometrics alone in a random sample of 12,000 publications in economics, business and statistics (234). It showed that informed peer review and bibliometric analysis produced similar evaluations, although they mentioned that the influence of bibliometric information on the reviewers should not be overlooked (234).

In sum, bibliometrics provides helpful tools to inform qualitative judgement processes in research evaluation (147, 235). Furthermore, implication of bibliometrics in evaluating research performance on higher levels of aggregation has opened a wide range of opportunities to researchers, funders, and policymakers (8). Bibliometrics enable investigating where research capacity needs to be enhanced and also allows monitoring the changes in research activities of different units over time (8, 9, 38). However, almost all the studies warn about excessive reliance on bibliometrics in research assessment, particularly on lower levels of aggregation.

1.11.4 Uses of bibliometrics in large-scale research assessment practices

As discussed earlier, bibliometrics are very useful tools to perform large-scale research performance assessments. The results of large-scale bibliometric analyses can easily investigate trendy topics, collaborations, top institutions, and authors, while could identify those who are lagging behind and require further investment or capacity-building (148). By regional and global analyses of research activity, firstly, the countries and institutions that require further attention to enhance their research will be identified (236), and secondly, countries and institutions which can serve as strong and capable hubs of research will be recognised (38). Then it would be easier to legitimately coordinate the investments.

One of the early examples of the use of bibliometrics for global research assessment has perhaps been the 1997 *Science* journal article by Robert May, entitled 'The Scientific wealth of nations' (237). May provided comparisons of scientific research outputs among several countries. He retrieved publications between 1981 and 1994, mainly from the SCI, and reported that the top 15 countries, ranked by their contribution to the world's total scientific publications, accounted for 81.3% of the world's papers. The top seven countries were the world's seven largest economies at the time of study including the US (publishing around 35% of the world's science, receiving nearly 50% of the total citations), the UK, Japan, Germany, France, Canada and Italy (237). May had also matched the number of citations per paper with the GDP of countries and had reported a correlation between GERD and average citations per paper (237). May had also tried to document the changes in the quality of global research publications by using citations per publication and had found India and China as emerging scientific nations (237). He showed how bibliometric methods can be used for exploring the global patterns of change in research publications. For instance, he showed within that 14-year period which he analysed, the world's scientific publication output had increased by 3.7% every year (237).

Another influential global bibliometric analysis was performed by David King, which was published in an article entitled 'The scientific impact of nations' (238). Using bibliometric methods, the article highlighted the global inequalities in scientific productivity by showing that only 31 countries accounted for the top 1% of highly-cited publications; among the 31 countries, South Africa, in 30th place, was the only African nation, and Iran, in 31st place, was the only Islamic country (238).

Such global studies can also be conducted for analysing the research performance in specific fields. One of the fields that attracts attention is medical and health research where investments are increasingly high (38). In anticipation of the 2012 WHO Report 'no health without research', which was eventually published a year later, under the name 'Research for Universal Health Coverage', McKee and colleagues tried to find global gaps in health research using bibliometric methods (236). They used the total number of publications indexed in Scopus to indicate how much health research has been undertaken by each country (236).

A recent study which has investigated the public health research capacity around the world has proposed using h-index instead of the crude total number of publications (38). This study in its methodology has considered some adjustments to minimise the limitations of h-index. Particularly, since the h-indices in that study is calculated for each country within 5-year intervals, to be more careful in choosing an appropriate citation window.

Large-scale bibliometric analyses have also been performed on regional levels: for instance, in different continents, such as Africa (55) and Asia (53), or at national levels, e.g. Australia (226), Turkey (239) and Iran (11), just to name a few. Some of these studies have investigated the patterns of scientific output changes over time only by using basic indicators, whereas some have normalised their results by different variables, for instance they have normalised the number of publications, citation per paper, h-index by population size, GDP, GERD, number of universities, PhD students, or postgraduate programmes. Some of these studies were reviewed in section 1.9.

1.12 Choosing the appropriate priority-setting method

1.12.1 Introduction

As discussed in section 1.7, since the release of the report of the Commission on Health Research for Development in 1990, several global initiatives have attempted to address the so-called '10/90 gap', mainly by proposing tools and methods that would help identifying the research areas where the funders should invest in. The use of these methods have been promoted among LMICs during the last three decades, although as discussed in section 1.7.1, still, appropriate health research prioritisation exercises in many LMICs are non-existent.

In Iran, several priority-setting exercises have been conducted since the early 1990s (240). However, evidence shows that research is yet not guided by the priorities (240, 241), and it has been reported that Iran still lacks a systematic and inclusive mechanism for health research priority setting (241). To choose the most appropriate health research priority-setting method for the purpose of this thesis, I considered a combination of: (i) evidence from the literature on health research priority-setting methods, as described in section 1.7; (ii) context of Iran, as explained in section 1.10; and (iii) the barriers to and the facilitators of health research priority-setting in Iran (240). The latter is further described in this section.

1.12.2 The barriers to and the facilitators of health research priority-setting in Iran

A recent qualitative study, including 23 key informant semi-structured interviews, has identified the constraints on setting health research priorities in Iran, as well as the factors that can facilitate the process (240). In this section, I will justify choosing the CHNRI method as an appropriate health research prioritisation method for improving HRS in Iran by addressing how it can overcome the barriers against priority-setting processes.

One of the main barriers to initiating health-research prioritisation exercises in Iran has been identified as the rapid turnover of people at executive roles, because it makes individuals at such rather temporary positions reluctant to engage with complicated and time-consuming processes (240). Furthermore, the rapid replacement, encourages those at such positions to invest in projects that lead to achievements rather quickly (240). It should be noted that firstly, steps of a CHNRI process are very straightforward and simple, and each study could be completed within a few months (34). Unlike other prioritisation methods, the CHNRI method does not require reviewing the literature for identifying the research gaps, while no meeting arrangements is needed in CHNRI studies, as in this method, all the input can be collected through e-mail or other online platforms (34). A CHNRI prioritisation process, only requires enough time to allow the researchers to generate and score research ideas (34). Secondly, the results of CHNRI priority-setting exercises are easy to be understood and used by decision-makers (43). Particularly, since the end-users of the findings, i.e. policymakers and funders, are already engaged with the process from an early stage, communicating the findings with them would be fairly quick (43). In sum, CHNRI method is suitable to use in the context of Iran, where research directors are changed after short periods, because this method is a relatively simple and quick method and its findings are likely to lead to impact, too.

Another raised concern has been that the majority of research directors in Iran are unfamiliar with priority-setting methods (240). The advantage of the CHNRI method in this regard is that plenty of published information about the application of this method consisting of clear guidance is available in open access journals (34, 35, 42, 43). Research directors with even limited knowledge of priority-setting methods, can easily follow the instructions in the already published CHNRI studies, many of which, are fairly recent and updated (42).

It has been mentioned that one main barrier against the utilisation of health research priority-setting results in Iran is that the decision-making process in Iran's HRS is highly centralised and top-down (240, 241). Merit of the CHNRI method to address this challenge is that it offers specific ways to engage participants from different levels. It collects input from the top (i.e. funders and policymakers who would set the scoring criteria) and the bottom (i.e. stakeholders from the wider society who assign weight to the criteria and the researchers who would generate and score research questions) (19). In this way, since the decision-makers are engaged within the CHNRI process from an early stage, they would have a sense of ownership of the results, even though the results will not be purely their opinion and will also include opinions of researchers and the wider society (19).

The poor stewardship of HRS, including problems such as weak leadership, and insufficient interaction between academia and the end-users of health research, has been identified as the major barrier to health research prioritisation in Iran (240). Priority setting, per se, improves stewardship function of HRSs, as it guides on how to efficiently use the resources to achieve the national health goals (15). Furthermore, CHNRI exercises tend to engage the end-users of research within the process: end-users, including funders, policymakers, and representatives from the industry (e.g. pharmaceutical companies) (43). This improves interaction between academics and the end-users (43).

Another obstacle has been described as the lack of incentives for the researchers who are invited to participate in health research priority-setting exercises (240). It has been argued that most academics in Iran rather investing time and efforts on activities which lead to publications, preferably in journals that are abstracted in international citation databases (240). To incentivise participation of researchers in CHNRI exercises, one recommendation is to provide co-authorship to the researchers who participate in scoring of the research questions, in the publications arising from the exercise (34). The studies that use the CHNRI method seem to have a good chance of getting published in reputable journals. A review of the first 50 applications of the CHNRI method has shown that most of the papers had been published in *PLoS Medicine* (20%), *BMC Public Health* (14%) and *The Lancet* (12%) (42). Indeed, authorship will be given to the researchers only with their permission, and could either take the form of equal co–authorship, or listing under the group co–authorship (34). It should be noted that although to improve transparency, the scoring sheets collected from all the authors would be published as supplementary material of the original articles, the scoring sheets would be anonymised to protect confidentiality of the participants regarding the input they provide individually (34).

It has also been highlighted that perhaps not all the resources should be allocated to the priorities (240). The CHNRI exercises do not aim to provide an exact list of research questions to be used in research grant calls (19). Instead, this methodology allows the funders to see the costs and benefits of investing in each research idea, based on the collective wisdom of the participants of that process (19). It even shows how the research questions are scored against each criterion (19). Therefore, the results of CHNRI exercises would help the funders to predict the potential impacts of investing in each area or research question (19).

Another reported problem of health research priorities in Iran was that the identified priorities are often too general, which can basically include any research question (240, 241). One advantage of the CHNRI methodology is that the researchers are invited to generate research questions that are clear and answerable within the time frame of the study (34). If any generated research ideas/questions fail at these, the researchers would be advised by and assisted with the management team of the study to improve the clarity and specificity of their proposed questions (34).

Another raised concern in the context of Iran was mentioned to be that many stakeholders with decision-making positions would attend the meetings of the prioritisation process as a formality, without providing actual 'intellectual input' (240). The advantage of the CHNRI method in addressing this issue is that as mentioned earlier, the CHNRI process only relies on 'intellectual input' of the participants and does not even involve face to face meetings (35, 43).

Some Iranian key informants about health research priority-setting argue that the community is the main stakeholder in health research, thus despite lacking the basic knowledge of research, the community should be involved in health research prioritisation processes (240). Others believe that instead of directly involving the community during the process, the community should be involved in some surveys which their findings would be later integrated into the results of the priority-setting exercises (240). The CHNRI method provides a creative way of involving the community (35). Since lay people from the community do not hold the knowledge and expertise about research, they cannot indeed propose research questions (35). However, the community would be invited to allocate weight to the criteria, upon which the research questions would be scored (35).

It has been mentioned that in Iran, in certain types of research, such as participatory research, the non-governmental organisations (NGOs) are perhaps better than the state-run organisations (240), thus the NGOs should certainly engage with priority-setting exercises (240). However, the raised concern was that, given the political circumstances in Iran, representatives from the NGOs may not feel free to express their ideas in experts' meetings (240). In the CHNRI process, representatives from NGOs would be invited and involved through individual correspondence and nobody outside the management group of the study would know what input they have provided (35). If the participants from the NGOs are researchers, they would be invited to generate and score research questions, while if they are not researchers, they could participate as stakeholders from the wider society, by adding weight to the criteria (35).

It was argued that the consensus-based prioritisation methods that rely on a panel of experts suffer from the fact that firstly, a louder voice can influence the others, and secondly, once there is a 'powerful' person on the panel, the more junior participants would not feel free to express their opinion (240). As mentioned, the value of CHNRI methodology lies in that, although it seeks consensus of the participants, it collects individual input, and anonymise them in a way that nobody outside the management team of the study, who according to research ethics would keep the information confidential, would know about the individual input of participants (34).

There is general agreement among Iranian health research priority-setting key informants that funders and policymakers should be involved within the process, but cautiously (240). In terms of the concern regarding the involvement of the funders, it was argued that some funders have a 'special relationship' with researchers or would only fund the research that could lead to findings that are desirable to them (240). In terms of involvement of policymakers, it was argued that their decisions could be primarily political rather than scientific (240). These concerns have been tried to be addressed by the vast majority of CHNRI implementers; it is recommended that the funders and policymakers would not be invited to generate nor score research questions (34, 43).

Another recommendation by Iranian key informants has been to create opportunities that the findings of the priority-setting exercises could be further discussed and improved through feedback from stakeholders (240). It was mentioned earlier that the CHNRI results are recommended to be used as a guide rather than a strict list of priorities to fund. The results are simple, thus could be easily provided online and different stakeholders are encouraged to discuss them among themselves (34). For instance, funders are encouraged to calculate new weights for the criteria and re-rank the research questions to adjust them to the needs of their specific group of stakeholders (35).

Chapter 2 Aims and objectives

2.1.1 Aims

The overall aim of my PhD was to obtain a better understanding of the growth of health research publications in Iran by describing the evolution of Iran's health research system and understanding the profile of its publications and the key trends in the growth to provide policy recommendations for Iran and other LMICs.

2.1.2 Objectives

My specific objectives of the PhD were to:

- Conduct a narrative review of the existing literature by using the WHO HRS framework to understand the changes in the following main functions of Iran's HRS over the last 50 years: (i) stewardship; (ii) financing; (iii) creating and sustaining resources; and (iv) producing, disseminating, and using research.
- Study the annual number of Iran's clinical, biomedical, and public health publications over 50 years across different areas, and characterise some of the major trends
- Compute the changes in h-index of Iran's health research publications over 50 years
- Identify the h-core papers of Iran's health research publications in the WoS CC, for the period 1965-2014
- Identify the major contributors to the conduct and publishing of the h-core papers and the most common document types and research areas
- Investigate different types of collaborations among the h-core papers and identify the papers that had only relied on Iranian resources
- Identify the profile of the h-core papers that had only authors from Iranian institutions and investigate the origin of citations to these papers
- Identify Iran's health research priorities for the next five years by adapting the CHNRI method

Chapter 3 Evolution of Iran's health research system over the past 50 years: a narrative review

3.1 Introduction

As reviewed in section 1.3, health research is increasingly regarded as an essential tool both for improving population health and for development (1-3). Hence, numerous efforts at the national, regional, and global levels have attempted to strengthen health research capacity in LMICs (2, 4, 5). Still, most LMICs continue to have limited capacity for health research (2, 6, 7). Many have remained largely dependent on international academic institutions and donors: on the former for research-relevant knowledge and expertise, and on the latter, for financial resources (2, 6, 8). Evidence shows that many of the barriers impeding improvement of health research capacity are shared across LMICs (as described in section 1.8) (2). Thus, studying the approaches that each country takes for overcoming some common obstacles could provide important lessons to other LMICs.

As described in section 1.9.1, a substantial growth in the number of Iran's health research that are published in journals indexed in international bibliographic databases over the last few decades has intrigued many international scholars (9). There has been clearly a significant evolution in the development of Iranian capacity for health research, which has occurred throughout the times of economic, social, and political instability in this country, as described in section 1.10. There is a need to explore and explain the various stakeholders, institutions, policies, the structure, and incentives in the academic community, and funding sources that underlie the observed increase in Iran's health research output.

3.2 Aim

The aim of this chapter was to review the existing literature that could provide a better understanding of the evolution of Iran's health research system over the period of the past five decades to explore and discuss the key factors and events that have contributed to the evolution of Iran's HRS.

3.3 Objectives

The objective of this chapter was to undertake a narrative review of the existing literature and use the WHO HRS framework to understand the changes in the main functions of Iran's HRS over the last 50 years. The HRS functions which I looked into included: (i) stewardship; (ii) financing; (iii) creating and sustaining resources; and (iv) producing, disseminating, and using research.

3.4 Methods

Due to the broad scope of the topic and anticipated heterogeneity of the studies to review, a narrative review approach was employed, as it provides a rather comprehensive coverage (242, 243). Unlike systematic reviews which enjoy established guidelines to ensure rigour of the methods, there are no specific guidelines for conducting and reporting narrative reviews (243); in fact, being tied up to strict rules is somehow against the nature of narrative reviews (242, 243). Having said that, there exists some 'best practice recommendations' to improve transparency and reproducibility of narrative reviews and reducing selection bias (243). This is mainly done by employing an effective bibliographic search strategy and reporting it explicitly (243).

The search strategy and categorisation of the retrieved data in the present chapter were informed by the WHO HRS, as described in section 1.5.1 (15). As summarised in Table 1, the WHO HRS framework proposes four functions for HRS and a number of components for each function.

I conducted the search in April 2018, through PubMed and Google Scholar. PubMed was used to search MEDLINE; relevant MeSH terms in conjunction with 'Iran' in the Title and/or Abstract were used. Since HRS is a broad topic, semantic searchers - both through PubMed and Google Scholar - were also conducted to retrieve further relevant publications, either from journals or from the grey literature. In Google Scholar, no difference was found between the number of search results for 'Iran' and 'Iran'. Hence I only used one variant; I used the term 'Iran' in conjunction with relevant terms based on the four functions of the WHO HRS framework. In PubMed, all the search results were included. In Google Scholar, the results were sorted by relevance and the inclusion of the search results was continued until it became clear that the listed results were no longer relevant. Full details of the search strategy are provided in Table 2.

After removing the duplicates, 805 sources of information remained. After scanning the titles and abstracts, I found 536 of the records irrelevant and excluded them. Then, I scanned the full-text versions of the remaining 269 records. In the end, 204 records were retained as relevant to this narrative review which I reviewed in detail. All types of documents with available full-texts (either in English or Persian) were included.

The included 204 records were organised within Endnote (a reference management software) into the following categories: (i) financial, human, and infrastructural resources; (ii) knowledge networks and collaboration; (iii) medical/research/publication ethics; (iv) HRS monitoring and evaluation; (v) research priority-setting; (vi) national vision and agendas for health research; (vii) research output (general); (viii) bibliometric analyses; (ix) quality of publications; (x) disseminating and using research; and (xi) Iranian journals. I made this categorisation following my initial familiarisation with the themes covered by each record while guided by the HRS framework. After further familiarisation with the data, I categorised the reviewed information into groups as described in Table 3.

Table 2 Search strategy for the narrative review of Iran's health research system

Search through PubMed
1. ('Bibliometrics'[Mesh]) AND iran[Title/Abstract] 2. ('Ethics, Research'[Mesh]) AND iran[Title/Abstract] 3. ('Research'[Mesh]) AND iran[Title/Abstract] 4. ('Scientific Misconduct'[Mesh]) AND iran[Affiliation] 5. ('Periodicals as Topic'[Mesh]) AND iran[Title/Abstract] 6. ('Translational Medical Research'[Mesh]) AND iran[Title/Abstract] 7. (('research system' OR 'research policy')) AND iran[Title/Abstract] 8. ('research capacity') AND iran[Title/Abstract] 9. (('research output' OR 'research product' OR 'research growth' OR 'scientific growth' OR 'scientific output' OR 'scientific product')) AND iran[Title/Abstract] 10. (('research evaluation' OR 'research assessment' OR 'academic assessment' OR 'academic evaluation')) AND iran[Title/Abstract] 11. (('research quantity' OR 'research quality' OR 'research impact')) AND iran[Title/Abstract] 12. (('scientometrics' OR 'scientometric' OR 'bibliometrics' OR 'bibliometric')) AND iran[Title/Abstract] 13. (('research network'[Title/Abstract] OR 'research networks'[Title/Abstract])) AND Iran[Affiliation] 14. (knowledge transfer[Title/Abstract]) AND iran[Affiliation] 15. 'plagiarism' AND 'Iran'
Search through Google Scholar
1. 'iran' AND 'medical research' Up to 50 pages 2. 'iran' AND 'health research' Up to 15 pages 3. 'iran' AND 'research assessment' Up to 10 pages 4. 'iran' AND 'research evaluation' Up to 10 pages 5. 'iran' AND 'research priority' Up to 12 pages 6. 'iran' AND 'research capacity' AND 'medical' Up to 11 pages

Table 3 The categorisation of the retrieved data on Iran's health research system

Stewardship
• Structure and vision for governing health research • Identification of health research priorities and coordinating adherence to them • National-level ethical oversight • Monitoring and evaluating HRS
Financing
• Gross Domestic Expenditure on Research and Development (GERD) • % of Research and Development (R&D) allocated to health • % of health budget allocated to research • Source of the research budget • Mechanisms for distributing funds • Mechanisms for tracking the investments
Creating and sustaining resources
• Figures for human and infrastructural resources • Capacity building – outcome and the barriers to research activities • Collaboration
Producing, disseminating, using research
• Number of research outputs, e.g. research papers, books, patents • Figures for Iranian journals • Figures for citation-based indicators • Underlying reasons for the growth of Iranian research publications • Knowledge translation and research impact

3.5 Results

In this section, I will present the information which I obtained about different components of Iran's HRS since 1970 from the 204 reviewed documents.

3.5.1 Stewardship

Structure and vision for governing health research

Several organisations in Iran are actively involved with health research policy-making, either directly or indirectly (244): (i) The Parliament; (ii) The Supreme Council for Cultural Revolution; (iii) The Department of Research and Technology of MOHME; and (iv) The Plan and Budget Organisation (i.e. responsible for compilation of the annual budget) (244). The Department of Research and Technology of MOHME, and (to a lesser extent) the research departments of the medical universities across Iran, are responsible for executive planning of the policies to achieve the national health research policies (244).

A national evaluation of different functions of HRS in Iran, which was published in 2004 (244), indicated that although an elaborate system existed in Iran to undertake the different operational components of the function 'stewardship', a clear articulation of the vision and the goals of health research was absent (244). Later on, in 2009, a panel of Iranian experts drafted a 'national scientific plan' for health, which outlined Iran's long-term plan by 2025 (245). The plan was based on the Islamic-Iranian values, an agenda known as Iran's Vision for the year 2025, and the general concepts of the National Innovation System (245). This national scientific plan outlined Iran's national vision, goals, monitoring and evaluation indicators, priorities, policies, and strategies for health research (245).

No information was found in the reviewed literature about the extent to which this national scientific plan for health had been followed. It was suggested, as a general conclusion, that perhaps too often the policies are not well implemented in Iran. This may be explained in view of the following constraints (244): (i) inconsistency in policies; (ii) instability in administration; (iii) limited alignment of policies and available facilities; (iv) lack of communication between researchers and policymakers, and (v) the absence of suitable implementers for the policies (244). Regarding the latter, many of the people at executive roles who should implement the policies seem to lack the necessary skills to fulfil their responsibilities. For example, an assessment of individuals in research management positions at 39 Iranian universities of medical sciences found that 40% of them lacked adequate research management skills (246).

Identifying health research priorities and coordinating adherence to them

According to the literature (244), four national-level health research prioritisation exercises have been conducted in Iran. The first two, had been undertaken by the then National Research Council, one exercise in 1993, and another one on three separate occasions in 1991, 1995, and 1999. The last two exercises, were carried out by the Department of Research and Technology of MOHME (in 1996 and 2010-2011) (244). The first three exercises had followed the COHRED (244), as COHRED proposes a process for national-level exercises to show essential steps for priority-setting processes (28). The last exercise had used the ENHR method and had involved all the universities of medical sciences affiliated with MOHME (247): local research priorities were identified by the universities who had also engaged stakeholders within the process. In this last exercise, a total number of 9,607 research ideas were gathered from the universities, which after excluding the irrelevant ones were reduced to a list of 6,723 ideas as 'research priorities'. The research ideas were categorised into nine main areas, e.g. communicable and non-communicable diseases, basic sciences, and health systems research (247, 248).

In terms of institutional-level priority-setting for health research, 45 Iranian medical universities and 53 research centres were surveyed for their status of health research priority-setting in 2002 (244). Twenty-eight of the universities had conducted at least one exercise (244). Those that had not carried out any had stated that their research priorities were the same as the ones identified by MOHME (244). Of the 53 surveyed research centres, 21 had never conducted any priority-setting, and 8 had based priorities upon the health research system's problems (244). Fifteen out of 25 executive departments in the health system had conducted a priority-setting exercise; the remaining 10 had indicated that their priorities corresponded to those set by MOHME (244). The prioritisation exercises had followed COHRED guidelines with some modification (244). Over the last 10 years, several priority-setting exercises had been undertaken in Iran in different areas of health research, and on different levels of national, institutional, or regional, as summarised in Table 4 in.

Table 4 Health research priority-setting exercises in Iran over the last 10 years

Number	Year	Brief description of the retrieved health research priority-setting studies
1	2008	COHRED approach was used to set research priorities in infectious diseases (249). All of the participants were from one university. The study identified 99 'research priorities' in 25 areas with HIV/AIDS, tuberculosis, and drugs being on top.

2	2009	To identify priorities in oncology nursing research, Delphi method was used during a regional conference although the study only involved Iranian nurses (250). Among the 35 proposed areas, the top-3 priorities were as follows: (i) psycho-socio-economic impact of cancer diagnosis on family members; (ii) oral care in patients receiving chemotherapy; and (iii) nutritional needs of cancer patients.
3	2010	A modified version of COHRED was used to set research priorities at an institutional level by engaging 610 faculty members and 220 stakeholders (251). A total of 841 research areas and 1,900 research options were identified as 'priorities'.
4	2010	An institutional-level study used COHRED to set priorities in a research centre of paediatric surgery (252). It identified 7 areas of research and the highest priority was trauma in children, followed by paediatric cancers.
5	2011	Iran's research priorities to reduce burden of cancer were identified (253) by inviting cancer experts from all across Iran to rank a list of topics in cancer research based on the criteria of being necessary, appropriate, practical, and yielding in the Iranian societal context. An electronic system of communication was developed and all scientists were asked to rank each topic from 1 to 5. The results highlighted the need for prioritising studies on infrastructure of cancer control programmes, cancer registration, service delivery, and patient quality of life.
6	2011	The research needs of a health insurance organisation was investigated through semi-structured interviews with 60 healthcare professionals who worked in clinical settings affiliated with the organisation (254). Twelve research topics were proposed, among which 'Designing standard treatment protocols' scored highest.
7	2011	A Delphi study was undertaken for setting priorities in Health Systems Research at an institutional level for each of the departments of a medical university (255). A total of 89 research areas were identified in their study which the top priority for each department varied.
8	2011	Research priorities in healthcare services were set using semi-structured interviews with patients who received services at three hospitals (256). Thirteen research topics were identified of which studying the payment models that vary based on the patients' income and access to services was found as the top-priority.
9	2012	Research priorities in medical education for the countries in the EMR, including Iran were identified (257). Using Delphi method a list of 20 research areas was proposed, of which the top area was 'training physicians to be effective teachers'.
10	2012	A national-level study used the Delphi method for identifying priorities in medical education research (258). A total of 50 research topics were ranked in this national-level study of which the topic 'methods for promoting faculty members' capabilities' was identified as the top priority for further study.

11	2013	Iran participated in a research prioritisation exercise, coordinated by the WHO Alliance for Health Policy and Systems Research (259). The exercise identified research priorities for LMICs in health policy and systems research in the areas of access to medicines and used a mix of literature review, interviews with stakeholders, and reaching consensus. Eighteen research questions were formulated and ranked according to four criteria (innovation, impact on health and health systems, equity, and lack of research). The top research question was: 'In risk protection schemes, which innovations and policies improve equitable access to and appropriate use of medicines, sustainability of the insurance system, and financial impact on the insured?'.
12	2014	Research priorities in the field of patient safety in Iran were identified through a Delphi study where 45 research questions were rated and grouped (260).
13	2014	To identify the institutional-level health research priorities, the following methods were used: (i) semi-structured interviews with managers at a healthcare centre, (ii) questionnaires; and (iii) analytic hierarchy process for ranking the criteria (261). This led to 191 research titles (as priorities) across seven themes.
14	2015	Using COHRED, institutional-level research priorities were identified for a research centre and a total of 31 research areas were identified as priorities (262).
15	2015	Health research priorities were set for one medical university by firstly, extracting a list of research areas from the goals and targets listed in macro policies, and secondly, inviting eight health research experts to rate the research areas based on COHRED criteria (263).
16	2016	Nominal Group Technique and Delphi were used to identify research priorities in the field of medical education at one medical university: Medical Ethics and professionalism gained the highest scores (264).
17	2016	A national-level study (265) invited experts to a workshop and asked them to list their suggestions for preventing invasive cervical cancer in Iran. After merging similar items and removing the duplicates, the experts were asked to rank the list of research suggestions. From the total of 26 suggestions, priorities were: developing national guidelines for cervical screening, and quality control protocol for patients' follow-up.
18	2016	Another study conducted a systematic review on published epidemiologic Iranian studies in HIV/AIDS and reported the knowledge gaps as research priorities (266).
19	2017	Delphi method was also used to determine health research priorities in occupational health in Iran (267). It engaged 22 research centres across Iran and proposed that research in musculoskeletal disorders and injuries should be prioritised in Iran.

In 2002, a study commissioned by the WHO (244) attempted to define how research priorities were being identified in Iranian medical universities, in their affiliated research centres, and executive departments. Moreover, it studied how different stakeholders contributed to the processes, what information sources were used, how consensus was achieved, and what criteria were applied to set priorities (244). The study concluded that '*qualitative and quantitative techniques have not been used in these settings* [Iran] *and the criteria used were diffuse; the one most frequently used was feasibility*' (244). It has also been mentioned that the attempts for setting health research priorities in Iran have so far been mainly relying on the opinion of experts (246).

In a qualitative study that investigated the barriers to evidence-based decision-making in Iran's health system in 2012, participants identified the following challenges: (i) absence of a systematic prioritisation mechanism; (ii) priorities being set by MOHME and not being communicated with academics; and (iii) priorities being too general that fail to guide researchers (241). Another paper had looked into research projects that were approved between 2005 and 2007 by an Iranian university (Golestan University of Medical Sciences) and had found that half of the researchers had chosen the topic of their studies according to their 'personal interest' (268). Finally, a bibliometric study mapped the number of research publications in Iran against the burden of disease in the country and found that the publications did not seem to be aligned with the disease burden (269).

I could not find any study that had matched the investments in health research with research priorities. However, MOHME had stated in 2013 - drawing on the data collected for the annual evaluation of academic performance of medical universities in Iran - that 70% of research projects undertaken at universities were in line with their institutional-level priorities (270). It was also reported that the topic of 60% of the projects conducted in 2007 in Iranian medical universities was aligned with their institutional priorities (271). Nonetheless, adherence to the priorities would matter only once the priorities are identified through systematic, inclusive, and transparent processes.

National-level ethical oversight

In terms of introducing guidelines and regulations regarding medical and biomedical research ethics, Iran has made significant progress over the last 25 years (some major activities are summarised in Table 5). While until the mid-1990s, not much attention was directed towards ethical aspects of medical research in Iran, in the late 1990s, a paradigm shift seemed to have happened (272); some reasons to explain this were suggested, and they will be presented in further text.

Shortly after the release of the first revision of the Declaration of Helsinki (in 1975), Iran went into a turbulent decade: the Islamic Revolution took place in 1979, followed by the Iran-Iraq war (1980-1988) (272). The urgent challenges that Iran was facing during the 1980s and the early 1990s did not allow implementation of the recommendations of the Helsinki Declaration (272). Additionally, following the war in which Iraq seemed to be backed by the West against Iran, a period of hostility between Iran and the West began, which resulted in Iran's isolation, even from the international scientific community (273). It is suggested that this could be a reason that the Iranian academics who were trained during that period became rather unfamiliar with the international research standards (273). This meant that, until the mid-1990s, not only had Iran lacked essential resources to move towards improving research conduct but also there may not have been a sufficient interest in this progress. It is even argued that perhaps the long history of medical sciences in Iran, along with the stress placed on cultural values and religious beliefs in the country, had undervalued the need for a new set of ethical standards (244, 274).

However, when Iran began to publish its research output in international journals, the need for aligning activities with international research standards became lot more apparent (272). For instance, international journals requested Iranian authors to provide information about the ethical considerations of their research upon submitting manuscripts for publication (272). Furthermore, addressing ethical issues became particularly important in biomedical research, where some new areas, e.g. stem cell research, were emerging in which Iran could potentially pioneer (272, 275).

Finally, in the late 1990s, some leading medical researchers in Iran called for an urgent action towards addressing ethical aspects of health research in Iran. In their 1999 paper (272), the need for attention to medical research ethics was highlighted by focusing on the poor status of ethics in clinical trials. The study (272) had assessed 51 clinical trials conducted in Tehran University of Medical Sciences (TUMS), i.e. the leading Iranian medical university—presumably having a better performance than the rest—between

1995 and 1998. Only one had mentioned 'ethical considerations' in its proposal and/or final report; in only six of the 51, human subjects were informed that they were participating in a research. Obtaining informed consent was mentioned in only four of the reports; 13 of the trials had used placebo while in 10 of them the participants were imposed to some risks without having been informed that they might receive placebo. In more than 80% of the trials, the participants had even paid for the intervention, because they thought those were part of their treatment (272).

As evidence of the progress that has taken place since then, a survey of ethics committees of the Iranian medical universities reported that in 2011 all the universities had ethics committees (with 5 to 11 members each); 95% of the committees had a template consent form to provide to the researchers; all would have reviewed research that involved human participants; and in half of the universities, non-compliance with the regulations would have led to penalties (276). Another study reviewed grant applications that had been approved at one university (Urmia University of Medical Sciences) during 2003-2008 (277). Eighty percent of applications for conducting clinical trials had included informed consent. Of the total 324 applications (including all types of research), 85.5% had addressed ethical considerations (277).

Table 5 Activities for promoting medical ethics, including medical and biomedical research ethics in Iran

Year	Major activities for promotion of medical ethics
1993	MOHME supported the establishment of a research centre focused on medical ethics: Medical Ethics Research Center—MEHRC. In the same year, the centre held the first international conference on medical ethics in Tehran, which saw the collection, organisation, and categorisation of a number of scientific publications on medical ethics, and the publication of proceedings of the conference (244, 278). Over the following years, MEHRC continued promoting medical ethics by holding numerous seminars and courses for health care professionals and academics (244, 278). The centre has published several books, including a comprehensive textbook of medical ethics that is used in Iranian medical schools (244).
1997-1998	National Committee of Ethics in Medical Research was formed in MOHME to: (i) apply Islamic, legal, and moral principles to medical research; (ii) guard human rights and legally protect the participants, the researchers, and the institutions involved; and (iii) promote mandatory inclusion of advisors on ethical issues in all research projects at universities, private research foundations, and industries (279).
1999	Committees of Ethics in Medical Research were formed at the institutional level to monitor the alignment of research that is conducted at universities of medical sciences and biomedical research centres with the national and international ethics principles (244, 248). The committees were asked to follow a uniform guideline, which was written by the Department of Research at MOHME (280). Also, research ethics courses have been held periodically to train the ethics committee members at the universities (281).
2000	MEHRC took the initiative to enact a code of medical research ethics (244). Preparation of these codes was done through a 1.5-year project consisting 46 national ethics committee meetings at MOHME through: (i) a comprehensive review of international codes of ethics, e.g. the Helsinki Declaration and documents of the Council for International Organizations of Medical Sciences (CIOMS); and (ii) customising the international standards for the context of Iran (278, 282). To better understand the context of the Iranian society regarding research ethics, a national survey was conducted, and also the relevant codes in religious laws in *Shia* (the official religion in Iran) were further reviewed (274, 280). Finally, a code of practice of 26 principles was established for research that involves human subjects (244). Examples of the codes were requirement of informed consent; the need to review the risks and benefits of each study; protection of participants' rights; confidentiality of participants' information; compensation for injury; and preservation of the rights of foetus, prisoners, and individuals with mental illnesses (274).

2002	The Department of Research and Technology of MOHME initiated compiling a strategic plan for medical ethics activities in Iran (278). The plan covered areas from management, regulations, education, and training to monitoring and assessment of medical ethics activities at the national level (278). The year 2002 was particularly crucial for biomedical research in Iran, because in that year, Iran's Supreme Leader, Ayatollah Ali Khamenei, released a religious decree (*fatwa*) in which experiments using human embryonic stem (hES) cells were permitted under special circumstances (283). Finally, because in the 26-item codes of medical research, the ethics codes for genetic studies were minimal, some Iranian researchers in 2002 initiated reviewing of the world literature about ethical standards for genetic studies to investigate how they could be adapted for the Iranian context (280).
2005-2006	After rigorous reviewing of relevant literature both on ethics and religious principles, Specific National Ethical Guidelines for Biomedical Research were drafted jointly by (i) MEHRC, (ii) Department of Research and Technology of MOHME, and (iii) the Endocrinology and Metabolism Research Center of TUMS (278). The draft was revised by a group of experts in law, ethics, and medicine as well as the religious authorities (281). Then, the revised guidelines were reviewed, approved, and ratified by the Iranian Parliament and the Guardian Council of the Constitution, and were delivered to all the medical universities and research centres (281, 284). The guideline included 22 items, addressing clinical trials; research involving vulnerable groups; genetic research; research on gamete and embryo; transplantation research; and research on animals (278). It prohibited production of human embryos for research purposes or production of human-animal hybrids, and eugenics (283).

It is of much interest to understand how the processes that have led to the compilation of guidelines in medical and biomedical research ethics in Iran had been facilitated. The literature primarily highlights the pivotal role of one person in this regard: Professor Bagher Larijani, one of the former chancellors of TUMS who also founded MEHRC (272). It is argued that the reason why Professor Larijani was able to initiate and successfully lead discussions surrounding ethics in medical and biomedical research, which is a potentially sensitive issue in most countries (280, 285), is that not only he is a prominent medical practitioner and leading researcher in Iran but also he came from a highly religious and politically influential family; his father was a religious authority and his brothers have always held important decision-making positions in the Islamic Republic of Iran (272). Therefore, Larijani could use the confidence that Iranian authorities had in him as an opportunity (272) and he played a crucial role in (i) developing medical ethics guidelines in Iran; and (ii) promoting the activities of MEHRC both among the policymakers in the health system and among the Islamic scholars (284). Another facilitator of the improvements was suggested to have been the support of political and religious leaders (281). It was assumed that this support could have had partly originated in their interest in advancing Iran's international rank based on science and technology indicators (284).

In terms of the advances, the literature shows that not only Iran has significantly progressed in terms of the development of national medical and biomedical research ethics guidelines and has promoted their use through trainings and by introducing regulations but also research ethics of a diverse range of specific issues have been discussed by Iranian scholars over the past years. For example, ethical aspects of involving Iranian female participants (274); ethical evaluation of research projects that are funded by international organisations (286); ethical issues in clinical trials (287); or research on laboratory animals (288, 289) are all discussed in the literature.

Steps have also been taken towards promoting integrity in research publications. It was mentioned in 2012 that the number of Iranians who were members of the Committee on Publication Ethics (COPE), World Association of Medical Journal Editors (WAME), and or European Association of Science Editors (EASE) has substantially increased (11). Even a survey of 27 Iranian medical journal editors in 2001 had indicated that the majority had an average to high knowledge of the Uniform Requirements for Manuscripts Submitted to Biomedical Journals (290). Moreover, it had been pointed out that in 2011 the first scientific congress of the Iranian Society of Medical Editors was held in Iran, in collaboration with COPE and with a focus on 'publication ethics' (291).

In addition to this, several Iranian journals have been trying to raise awareness among academics about research integrity and publication ethics in recent years (292-295). For example, a paper depicted several examples of good practice (e.g. obtaining permission before reproducing figures protected by copyright) and examples of research and/or publishing misconduct (e.g. data fabrication, ghost and guest authorship) followed by relevant recommendations based on COPE guidelines (296).

The examples were from papers authored by faculty members of a large Iranian university (Mashhad University of Medical Sciences) that had been published in the journals owned by the same university (296). Finally, some universities, e.g. Shiraz University of Medical Sciences, had not only been providing short courses on publication ethics but also had been offering a MS programme on medical journalism since 2008 (297).

Despite such efforts, the literature still calls for greater attention towards research integrity and publication ethics in Iran. In 2008 and 2009, the journal Nature reported several cases of retraction of publications by Iranian senior officials, albeit outside medical fields, due to evident plagiarism (298). A recent paper has identified the retracted papers from Open Access Journals in MEDLINE and has indicated that the majority of the retracted publications were authored by researchers affiliated with institutions in China (n = 199), India (n = 83), US (n = 75), and Iran (n = 50) (299). It was reported that in 2016, 28 retractions from Iranian authors were the result of compromising the peer-review process, plagiarism, and authorship disputes (299). An investigation of the prevalence of publication misconduct in the papers published in Iranian journals indexed in Scopus database during 2009-2011 reported guest authorship (18.10%) and falsification of the methodology (12.65%) as the most common types of misconduct (300). Another study reported that nearly 26% of postgraduate students who graduated from one of the medical schools in Iran in 2015 had done some sort of research misconduct (including plagiarism, fabrication, or falsification of data) in their theses (301). In 2009, an Iranian medical journal studied a sample of 80 of the manuscripts received by their journal and found that 55% of the manuscripts had at least one plagiarised sentence (294).

The findings of a survey in 2012 described the knowledge of medical students at TUMS about plagiarism and self-plagiarism as very low (302). It was reported in another survey that nearly 10% of students at TUMS were not even aware that using a copied paragraph from a textbook or a web page in their academic writing is unacceptable (303). As for postgraduates, a recent study has analysed the curricula of 125 postgraduate programmes in medical sciences in Iran and has found that only 53 programmes (42%) contained ethics training, of which only 17 had specific courses on research ethics, and even that was an elective subject in 25% of the programmes (304). Although it had been thought that medical ethics education had been improved by the launch of MPH (Master of Public Health) courses in 2004 as the programme includes medical ethics subject (278), an assessment of the knowledge of plagiarism did not find a significant difference between the students who were only doing medicine with those who had also been enrolled in MPH courses (303). It is likely that the course does not sufficiently address 'publication ethics'. A survey of 198 students found that medical interns (medical students during the last two years of their studies) seemed to know more about plagiarism than the sub-specialty residents (305).

Several reasons for the emergence of publications containing research/publication misconduct were proposed in the literature as follows: (i) inadequate knowledge of plagiarism and of the regulations in place to deal with cases of plagiarism (273, 294, 302, 303, 305, 306); (ii) poor English language skills and limited writing skills that could lead to plagiarism (273, 297, 303, 306); (iii) requiring faculty members to have publications for academic promotion (67, 273, 294); (iv) requiring PhD students to have publications before graduation (67, 273); (v) requesting certain academic degrees from people who apply for political positions (307, 308); (vi) installing powerful people as the heads of research centres may have led to guest authorships (309); (vii) limited budget that cannot cover all research costs (67); (viii) as a result of the rapid development of postgraduate programmes, some individuals have quickly become faculty members, without having been properly trained to mentor students in research (273); (ix) replacement of competent academics in Iranian universities by less qualified faculty members who were unaware of research activities and ethical regulations (307); and (x) limited interaction between the academics and other sectors, leading to insufficient awareness of academics about the final goal of research, i.e. filling the knowledge gaps to address the problems, rather than solely leading to publications (273).

Monitor and evaluate health research system

In 2000, the Department of Research and Technology of MOHME initiated an annual evaluation of research activities of all the universities and research centres affiliated with MOHME (271); currently including 58 universities of medical sciences and 736 research centres (310). The results of the evaluation of each institution used to be reported to them as a written feedback, while since four years ago, the results have been sharing online (248). The strengths and the weaknesses of the academic performance at the levels of national and institutional are summarised through these evaluations which become the evidence to inform decision making at MOHME and at the institutions towards improving health-related research activities (311).

In this evaluation system that was initially designed based on the WHO HRS framework, research activities are assessed and scored against indicators across three domains: (i) capacity building; (ii) knowledge production; and (iii) stewardship (in recent years, this domain has been renamed to 'leadership') (270, 271, 312). Although the indicators are revised every year based upon the feedback received from research directors of the universities and research centres (311), they generally continue to include the following points described below.

For the assessment of capacity building in each institution, the indicators include the number of: (i) research training courses provided to the academic staff; (ii) national and international organised conferences; (iii) awards that had been achieved by the staff/students at science festivals; (iv) status of the amount and the visibility of the institution's Web contents; and (v) the status of Student Research Committees (SRCs) (313). The second domain, i.e. Knowledge production, is evaluated by the number of: (i) journal publications (the scores allocated to the publications vary according to the databases where the publications are abstracted, e.g. in Scopus, Web of Science Core Collection); (ii) abstracts presented at national and/or international conferences; (iii) published books; (iv) patents; (v) completed research projects that their results had been applied in the health system; and (vi) citations to the published papers in textbooks and peer-reviewed journals (271). Stewardship domain includes the following: (i) having had identified institutional-level research priorities and the status of adherence to them; (ii) having a 5-year strategic plan; and (iii) having an active ethics committee (270).

The universities have been categorised into three groups, and they are ranked within each group based on the total score they receive from the three domains mentioned above (271). The criteria for grouping the universities were not clearly defined in the literature, although it seems to be according to the universities’ general size, without further definition (312). In the first years since the evaluation was introduced, the scores used to be adjusted by the amount of core funding and the number of academic staff at each university (271, 312). In recent reports, the scores do not seem to be adjusted anymore (271, 312). Furthermore, according to the literature, institutions used to receive scores for collaborative research with industry and/or the governmental organisations and for multi-centre projects (244); these seem to have been removed in the recent evaluations, although international collaboration still contributes with additional points (270, 311). Several citation-based indicators had been added to the assessment of ‘knowledge production’ domain in recent years, e.g. citation counts per paper, h-index of institutions, or impact factor of the journals where the papers had been published (312).

Although this system has allowed the annual evaluation of health-related research activities in Iran, it has been criticised for its over-reliance on quantitative indicators; lacking qualitative evaluation by a panel of experts (314); and minimal attention to research outcome and impact (315). A pilot study in 2015 (315) attempted to include assessment of the impact and the quality of research activities in the evaluation of research centres. It evaluated research activities of 5 biomedical and 3 clinical research centres using a peer-review approach (315). Indicators were designed for four domains: governance and leadership, structure, knowledge production, and research impact. The implementers of that pilot study concluded that peer-review model would work for the evaluation of research output, outcome, and impact of medical research centres in Iran (315).

3.5.2 Financing

The reviewed literature generally suggests that investing in health research has not been a priority in Iran. This is reflected in Iran’s Gross Domestic Expenditure on Research and Development (GERD). Iran’s GERD for nine specific calendar years were found in the reviewed literature: it ranged between 0.31% (in 2011 and 2014) (316) and 0.75% (in 2007) (6, 314, 317). Although GERD has remained limited, the annual budget that MOHME had been allocating per research centre had increased more than 80 times between 2001 and 2014 (from 4.8 million to 387.5 million Iranian rials per centre) (318). It was also reported that the amount of research budget per academic member in institutions affiliated to the government had increased by five times between 2002 and 2010 (270). However, these two reports of the increase should be considered cautiously as the amount of investments was not adjusted by the annual inflation rate.

It is also important to note what proportion of GERD is allocated to health research. This figure had decreased from 8.9% in 1999 to 7.6% in 2001 (244). Another publication in 2001 had reported that 5% of GERD was invested in health research (317). Regarding the proportion of GDP that is allocated to health research, the figures ranged between 0.01% to 0.05% between 1991 and 2001 (17), while funding for health research as a proportion of the total health care budget was 0.9% and 2.5% in 1991 and 2001 (244).

No information from the recent years was found in the reviewed documents. It was suggested that the integration of medical education and health research with health care services, which took place in 1985 (as described in section 1.10.5), may have shifted resources away from research to service provision (113). In the short term, the integration has led to the training of a substantial number of healthcare professionals and development of health services across various parts of the country, particularly in deprived areas (114). However, evidence shows that the curriculum of the programmes provided in the universities of medical sciences have not become oriented around the needs of the nation (319, 320). Moreover, in the long term, the integration has increased the universities' workload and responsibilities. It is reported that universities now invest more time and resources on providing service than on research and education (113).

Some minor progress has been made in financial aspects of health research in Iran. For instance, since 1996, GERD began to be specified in Iran's annual national budget plan, which has relatively improved transparency in financing and has allowed monitoring the investments in research (317). Furthermore, several papers have reported that, in recent years, some major macro-policy documents had set targets for substantial rises in R&D expenditure, although the targets were not eventually met (316, 321). An apparent example of failure was the target of increasing GERD to 2.5% by 2015, whereas the last retrieved GERD was only 0.3% (in 2014) (316). It was suggested that the failure in increasing expenditure in R&D is in policymakers' lack of belief in the return of investment in research (321). Finally, it was mentioned that insufficient financial resources for health research have led, at times, to the complete exclusion or underfunding of specific areas in national-level studies, such as mental health research (322).

Transparent information on the mechanisms of distribution of health research funds was absent in the retrieved documents. It was mentioned that, in 2011 (316), more than 80% of GERD was distributed through the universities and institutions affiliated to MOHME but also to the Ministry of Science, Research and Technology; Ministry of Defence; Ministry of Industry; Ministry of Agriculture; Science and Technology Parks; and institutions affiliated to the Vice-Presidency for Science and Technology. The latter is a group of research councils under the supervision of the Presidential Office (316). Firstly, no information to estimate the share of each of these entities of the total funds was provided. Secondly, the sustainability of funding decisions within this model of distribution—which is predominantly through the governmental organisations—was criticisd for being vulnerable to the opinion of politicians who are changed every few years in Iran (66).

In yet another example of insufficient information on how the funds are distributed, in 2015, there were 36 medical research centres earmarked in the national budget plan for receiving funds directly from the public budget (318), but no information regarding the criteria upon which the research centres would be earmarked was provided. Also, it was implied from the reviewed literature that health research funds are somehow distributed equally among academics who work in the institutions affiliated to MOHME (270). Finally, it was reported that in 2013, 40% of health research budget was invested in 'research projects', 70% of which were in line with the institutional-level research priorities (270). It was unclear what the authors meant by investment in 'research projects' and it was not mentioned where the remaining 60% of the health research budget was invested. For the period 1997-2001, it was reported that 5.76% of the total public funding for health research had been allocated to research priorities in the health system (244). In sum, a system for tracking research investments seemed to exist, although its function was not described.

In terms of the source of the research budget, the public sector has remained the primary source of research funds in all fields in Iran, including health (244, 316, 323). In a 2004 report by the WHO, the share of non-governmental sources (i.e. private companies, scientific associations, and NGOs) was estimated to amount to 3-6% of the total funds for health research in Iran, and the figure had decreased from 5.9% in 1991 to 2.7% in 2001 (244). Some have reported that, in recent years, the contribution of the private sector to research investment has increased. For instance, in 1998, less than 1% of investments in R&D was from non-governmental sources (316, 317), whereas in 2009, nearly 31% was the contribution of the private sector (316). Nevertheless, it was reported in 2016 that public funds still constituted 98.5% of the research budget of medical research centres in Iran (318). A paper investigated the status of collaborations in research projects that were conducted between 2005 and 2007 in one of Iran's universities (Golestan University of Medical Sciences) and found that among the 102 included studies, only 12 of them (11.8%) had been co-funded by organisations outside the university (268).

3.5.3 Creating and sustaining resources

Over the last five decades, Iran has largely developed its higher education capacity in medical sciences. This is reflected in the substantial increase in the figures for physical (infrastructural) resources (e.g. the number of schools of medicine) and human resources. The efforts towards expanding the capacity of medical education primarily aimed to increase the number of health care professionals across the country to address the shortage of physicians. However, this already existing human capital was later enabled and encouraged to engage with research activities, too.

Changes in the figures for human and infrastructural resources

While there was inconsistency in the figures across the reviewed documents, all the retrieved data reported a significant rise in the number of academic staff and students at the universities of medical sciences affiliated to MOHME, at different levels of education and training (i.e. primary qualifications, specialty, sub-specialty, and postgraduate programmes) (112, 316, 317). Graph 1 highlights that the literature lacked data on human resources in most years while indicates the significant rise that has occurred in the number of both the students (during 1970-2008) and academic staff (during 1985-2014). The substantial increase in the number of students in disciplines related to medical and health sciences started in the late 1980s (112) and had continued, reaching 56,131 in 2014 (270, 316). It was also mentioned that over the last few decades, the proportion of female students in higher education has greatly increased; for instance, the percentage of female students increased from 42% in 1990 to 68% in 2013 (316).

Investigating the number of faculty members in different years was rather confusing. Certain terms, e.g. 'teaching staff', 'academic researchers', or 'non-academic researchers', were used without being defined (316). Moreover, it was often unclear whether the reported figures for faculty members included or excluded the academic staff of medical universities that are not affiliated with MOHME, e.g. the academics employed by private universities or medical schools affiliated to military organisations. The information summarised here are from the sources that had appropriately described the figures. The number of faculty members in the universities and/or research centres affiliated with MOHME had increased from 3,153 in 1985 (287) to 8,625 in 1999 (317), 11,324 in 2007 (271), and over 13,200 by 2014 (316). It was mentioned that in 1999, there were also 1,158 faculty members in the universities outside the structure of MOHME (317). It was also noted that a new type of academic position was introduced in 2010 as 'research-focused faculty member', meaning some academic staff were recruited for positions which did not involve any teaching; in 2010, 289 of them were recruited (270).

The increases in the number of specialty, sub-specialty, and PhD programmes were also highlighted in the literature. Until 1980, Iranian medical universities offered only a few specialty programmes, no sub-specialty, nor PhD programmes (112). It had been reported that between 1975 and 2008, the annual number of admissions to specialty programmes increased from 401 to 1,732 students, and from zero to 268 in sub-specialty programmes (112). A significant increase in the number of students enrolled in masters and PhD programmes in all disciplines was reported between 1998 and 2013: the first one had increased from 23,303 to 454,978 and the latter from 3,771 to 60,900 (more than 16-fold increase) (316). While the figures for the programmes relevant to health sciences were not specified in that paper, another report showed the rise in the total number of students admitted in doctorate and masters programmes with a health research component for the period 1997–2001 from 44 to 216 (244).

In 2010, MOHME launched a new scheme of PhD programmes, so-called 'PhD-by-research' (316). In 2017, 616 students were enrolled in these PhD programmes across 188 research centres affiliated to MOHME (316). Unlike the conventional type of PhD programmes in Iran, where students are awarded positions only after excellent performance at an annual national entry exam that relies on multiple-choice questions, 'PhD-by-research' students are assessed, recruited, and supervised by faculty members whose eligibility is approved by MOHME (324). Also, while one of the criteria for being offered a 'PhD-by-research' position is having a certain number of publications in international bibliographic databases, graduation from these programmes is also by publication (324).

It was reported that because of the significant increase in university admissions in the 1980s, initially, the ratio of students to faculty members had increased (112). Later on, consequent to the development of postgraduate programmes, the number of individuals who were qualified as faculty members also increased, so that the ratio relatively improved (112, 287): from 17.1 students per faculty member (in 1985) to 8 in more recent years (112, 317). Finally, the number of employed researchers in research centres affiliated to MOHME has risen from 637 in 2001, then 3,828 in 2010, to reach 5,736 in 2014. This translated to an average of 10 researchers per research centre (318) (although the definition of 'researcher' was not fully explained).

Regarding infrastructural resources, the number of academic medical institutions affiliated to MOHME has substantially increased (310, 317, 318). This includes the increase in the number of universities of medical sciences from 34 in 1996 to 58 in 2017 (310). Also, between 1970 and 2008, the number of schools of medicine had increased from 7 to 36; and schools of dentistry and pharmacy from 3 each to 15 and 11, respectively (112). Likewise, the number of schools of nutrition, public health, nursing, midwifery, and several paramedical disciplines has significantly increased (112). Over the last two decades, a substantial increase has taken place in the number of research centres in areas related to medical sciences: from only one centre in 1992 to 53 in 2001, 359 in 2010, and 736 in 2016 (310, 317, 318). The majority of medical research centres are reported to be in the areas relevant to internal medicine, pharmaceutical sciences, and cellular biology (112). Research centre was defined as 'a facility or building dedicated to research, commonly with the focus on a specific area' with no further requirements (310). It was reported that the increase in the number of research centres between 2010 and 2016 occurred without sufficient oversight and led to some challenges (310).

Capacity building

Short-term and long-term strategies have been adopted to build capacity in Iranian academics in areas related to health research. First, many students have obtained research-relevant training during postgraduate studies. Then, numerous training courses relevant to research have been offered since 1990 by the MOHME's affiliated universities and research centres (17). The number and diversity of these courses - from basic research methods to statistics, academic writing, and research methods that are used in specific fields, e.g. in mental health - have been increasing over the last decades (110, 322, 325). The figures had increased from 458 in 2000 to 1,097 in 2007 (271). A survey in 2004 showed that the majority of participants were satisfied with the quality of the courses that had been provided since the early 2000s (244). More recently, research centres have been increasingly providing similar courses; the number of workshops organised by medical research centres increased from 92 in 2001 to 625 in 2014 (318). Furthermore, some research hubs that have achieved a reasonable capacity for research in specific areas are now building capacity in their peer institutions. For instance, Royan, a leading Iranian stem cell research centre, now provides courses related to research in stem cell and tissue engineering (283).

The role of Student Research Committees (SRCs) was also noted in the literature in developing research capacity. SRCs are run by students and they promote research among the students of medical sciences primarily by: (i) offering research methods training; (ii) conducting research; (iii) writing papers; and (iv) presenting at conferences (271). Some SRCs even raise funds to sponsor travels of the committee members to international conferences (326). Finally, SRC members try to acquire other essential skills for research, e.g. communication, management, and teamwork (327). The first SRC was established in TUMS in 1993 by a group of enthusiastic undergraduate students who aimed to create a supportive and enabling research environment at universities (327). Later on, under the supervision of the Department of Research and Technology of MOHME, SRCs were formed in all universities (271, 326).

It was reported that a significant capacity has been built in certain disciplines, such as gastroenterology and hepatology, which have advanced substantially in educating and training clinical and research fellows (112). It was suggested that such success could be related to the hard work and the determination of some devoted academics in those fields, who were also supported and provided with resources both by the governmental and non-governmental entities (112).

Barriers to research activities

Despite efforts to improve the capacity of Iranian academics in research and publishing, the number of skilled researchers in the country is still limited (17). An assessment of the knowledge, attitude, and practice of 436 students in an Iranian university of medical sciences in 2013 found that students' skills in using research methods were considered moderate; the majority had no positive attitude towards research activities; and their research performance was graded as weak (328). Several papers have touched on the possible reasons. One hypothesis is that many motivated young graduates who have acquired research skills by attending courses and/or through working in SRCs during undergraduate studies would immigrate to developed countries soon after publishing a few papers and improving their academic CV (6, 85). Another proposed reason is that the students who join SRCs, or the faculty members who attend research-related courses, are likely to be already willing to improve their research skills (303). Hence, research capacity in those with less interest in research may never improve much because research methods are not included in the core curriculum of programmes in medical sciences and are only offered as optional courses (327).

Furthermore, the literature highlighted that the education curriculum in Iran does not equip graduates with the necessary skills for research. The medical education curriculum was particularly criticised for being too oriented towards the students passively learning facts (329), rather than looking for critical thinking or creative problem-solving. The model of admittance to Iranian universities was criticised, too, for being largely dependent on the performance of applicants on a competitive multiple-choice annual exam, which trains students to memorize facts instead of being critical thinkers (246).It was also emphasised that students in Iran's higher education programmes do not receive training to develop skills in communication, writing, management, or teamwork, which are requisite for becoming a competent researcher (246, 329).

Another critical barrier to more enthusiasm for research are lower financial incentives for research compared to teaching or clinical activities. In an assessment of 186 academics from one Iranian university (Guilan University of Medical Sciences), 70% reported limited financial reward as a major constraint on doing research (246). On the other hand, the extra payment that academics receive for additional teaching hours is often higher than earnings from their time invested in research (246). Importantly, since in Iran, medical education and research are merged with health care services provision, many of the academics in the universities affiliated with MOHME are clinicians too. These clinical academics are paid greater salaries by working in teaching hospitals (246). They even receive extra payment per patient that they visit in university clinics (246). Therefore, they can have a much higher income through providing clinical services instead of investing in research activities (246). A

Commentary had suggested that many Iranian clinical academics still think of research as *a luxury good* while considering clinical activities as *a necessity good*. Thus, they engage with research only to get academic promotion, rather than contributing to the society or to the industry (330). Also, one of the reported constraints cited the researchers' own low expectation that their findings would be applied in practice (244).

Other constraints reported in a number of studies are summarised as follows: inability or unwillingness for collaborative work; lack of essential means and facilities to conduct research; restrictive administrative regulations; lack of university autonomy; limited organisational support and poor cooperation between executive offices within the universities; weak project management skills; inadequate number of qualified senior researchers to provide effective supervision; and limited number of qualified librarians (244, 331-333). On the individual level, heavy workload and limited time for research; poor knowledge of research methods and statistics; insufficient incentives; and inadequate support for academics with family commitments were mentioned as some of the barriers to medical and health sciences researchers in Iran (331, 333).

Some literature argue that the international trade sanctions against Iran, which aimed to restrict Iran's nuclear programme by targeting its oil and gas export, banking, and financial sectors, had posed another constraint on research activities of Iranians (85, 334-336). The reasons behind this argument are that the sanctions had (i) restricted exchange of Iranian students and faculty members with international academic institutions; (ii) made purchase of laboratory equipment and material difficult; (iii) negatively affected international collaboration; and (iv) at times led to the outright rejection of Iranian research papers by some journals (85, 334-336). In terms of the last one, in April 2013, Elsevier advised its US editors against handling any papers authored by employees of the Iranian government, which could include any academic working at the universities affiliated with MOHME, and this 'advice' was followed by some journal editors (335, 336).

On the other hand, although sanctions must have had made it harder for Iranians to conduct research and to partake in the international scientific community, data retrieved from international bibliographic databases show that the quantitative growth of Iran's research publications had continued during the sanctions (85). Also, as for publishing research papers with international collaborators, between 2005 and 2014 (i.e. during tight trade sanctions), the rate of the growth of international collaboration in Iran was similar to that in Egypt and Israel, and higher than that in Turkey, suggesting that sanctions against Iran did not much affect its international scientific collaborations (337). Likewise, the number of collaborations with the UN agencies showed no significant change during this period (318). It was explained that the development of Iranian journals might have alleviated some of the consequences of sanctions on Iranian research publications (337). Also, *The Lancet* editors claim that, as one of the main actors of the international health research community, their support may have had a positive impact on reducing consequences of sanctions (337).

Finally, it was argued that one barrier against innovative and high-quality original research in Iran is that higher education opportunities are still not equally provided to all Iranians (338). As an example of inequality, it was mentioned that in Iran women are banned from studying 77 disciplines (without providing the list) and that equal opportunities may not be provided to all religious minorities (338).

Collaboration

Collaborations and coordinated activities are key to sustaining and strengthening research resources (6). In the early 2000s, the Department of Research and Technology of MOHME introduced several initiatives to promote collaboration in research. One initiative was that, between 2001 and 2011, MOHME signed official memorandums for collaboration between Iran and academic institutions in Sweden, Germany, South Africa, Belarus, Malaysia, Indonesia, and the Eastern Mediterranean Regional Office of the WHO (339). These memorandums led to the joint training of 20 students; 18 collaborative projects; 26 publications; and co-organising 17 workshops (339). The second initiative, beginning in 2001, was for expansion of collaboration between researchers and the community (244, 340). This initiative was implemented through the establishment of community-based participatory research centres in several medical universities across Iran. These centres supported the conducting of projects that could lead to capacity-building in the community, so that the community's knowledge could be used for addressing health problems, particularly those regarding the social determinants of health (340).

The third initiative of MOHME towards promoting collaboration was the development of knowledge networks, aiming to organise, lead, empower and coordinate efforts made by health researchers and key stakeholders to: firstly, prevent repetitive and/or parallel health research in Iran; and secondly, strengthen knowledge translation (244, 341, 342). By 2012, Iran had 27 knowledge networks in medical and health sciences (342). However, it was shown that the approaches used in the management of those networks was not very transparent, and that the majority lacked clearly defined goals and faced multiple administrative problems (341). Still, according to the literature, some networks - e.g. Iranian Osteoporosis Research Network (IORN) and Iranian National Diabetes Research Network (INDIRAN), both established in 2002 - made significant contributions. IORN, by 2008, had linked 21 Iranian universities and research centres and had: established osteoporosis clinics; initiated a multi-centre osteoporosis study and a hip fracture registry project; and run education and prevention programmes (343). By that time, INDIRAN had also completed and/or initiated multiple projects, e.g. estimating the prevalence and the burden of diabetes in Iran; evaluation of the quality of life in diabetic patients; and running diabetes education and prevention programmes (344). It was mentioned that, despite accomplishments of INDIRAN, a number of provinces still required research facilities, trained researchers or research centres in diabetes that could collaborate on national projects (344).

To further promote collaborative research, the Department of Research and Technology of MOHME that runs a national, annual academic assessment, by which it ranks the Iranian medical universities and their affiliated research centres, allocated points to collaborative research projects that engaged several institutions (246). However, the regulations that were in place for evaluation of academics still provided more points to single-authored papers; this obviously discouraged collaboration. The regulations for academic promotion requirements are made by a different organisation.

This conflict in regulations suggests that further coordination is required for the success of initiatives that promote collaboration (246).

Despite the abovementioned efforts, the literature suggests that the status of research collaboration is not satisfactory. A paper investigated the status of collaborations in research projects that were approved between 2005 and 2007 by an Iranian medical university (Golestan University of Medical Sciences) (268). Among the 102 assessed studies, only 10 projects (9.8%) had been performed in collaboration with other organisations; only one project was commissioned by a non-governmental organisation; and half of the researchers had chosen the research topic according to their personal interest (268). Another study showed that of the 208 research projects conducted in TUMS in 2004, only 2.2% had a collaborator from non-academic organisations and 51 researchers (24.5%) stated the users had not contributed to any stage of the research (345). A qualitative study in 2004 investigated the status of collaboration between universities of medical sciences and their affiliated research centres with either the community or the executive organisations and found the following: 20% of the academic institutions had no link with the private sector, while collaboration with the community as well as with executive entities was weak too, particularly in knowledge utilization and identification of research priorities (346).

3.5.4 Producing, disseminating, and using research

Producing and disseminating research

A substantial rise over the last few decades has been reported in the number of Iranian health-related research papers in international bibliographic databases (313, 316). For instance, it was reported that the number of Iranian documents in MEDLINE had increased from only 273 in 2000 to 14,511 in 2014 (316). This review retrieved 34 papers that had reported the quantitative growth of Iranian publications in different biomedical, clinical, and/or public health research areas (Summarised in Table 6). It was also noted that the rise in research output had occurred regardless of the population growth. For instance, the number of publications per million Iranian inhabitants had increased from 155 in 2008 to 326 in 2014 (12, 316), while the number of publications per academic has risen too (271). The growth had also been observed in the figures for the Iranian papers in Persian (a 30-fold rise between 1979 and 2003) (112), and the number of Iranian books that have used the findings of national research had increased as well (313).

In terms of citation-based indicators, the reports are paradoxical. While some have reported a decline in the average number of citations per document (67), it has been shown that the number of citations that Iranian research papers have been receiving in medical textbooks (313) and the citation counts per academic have increased (316). Also, Iranian papers are being published in journals with higher IFs than before (112, 244).

Likewise, the number of Iranian medical journals, both national and international, has increased over the last few decades (271). Only between 1990 and 2010, 155 new medical journals were approved by Iran's MOHME and many of them have found their way into international bibliographic databases (66). Improvements have also been reported in the citation-based indicators of the Iranian medical journals that are indexed in the WoS Core Collection: e.g. between 2012 and 2014, their average IF had increased from 0.40 to 0.68 and the average number of citations that each of the documents in these journals has been receiving from international authors had risen from 0.19 to 0.49 (347). However, Iranian journals have been criticised for being predominantly published by the universities; it was argued that this closeness of journals to where the research originates could have been negatively affecting the independence of peer review processes (66, 348).

Table 6 A summary of the reported increase in the number of Iran's research publications in various research areas, using different data sources, and within different periods

Rank	Area	Data source(s)	Time period(s)
1	Medical education (325)	Index Medicus	1982-1998
2	Transplantation research (349)	Data from 91 Iranian journals abstracted in IranMedex	1993-2003
3	Nephrology (350)	Medline and IranMedex	1997-2007
4	Nephrology and urology (351)	PubMed	1993-2013
5	Psychiatric disorders (352, 353)	The national mental health data bank (IranPsych)	1973-2002
6	Substance use and addiction (354)	Web of Science, Medline, Scopus, SID, and Iranmedex	2008-2012
7	Epilepsy (355)	Scopus	2000-2014
8	Dental research (356)	Data from electronically accessible national journals and also through PubMed	1982-2006
9	Dental research (357)	Medline and IranMedex	1990-2009
10	Dentistry (358)	Web of Science	1993-2012
11	Dental research (359)	PubMed	2005-2014
12	Endodontic (360, 361)	Pubmed	1992-2011
13	Orthodontic research (362)	PubMed, IranMedex, and SID	1997-2012
14	Mineral trioxide aggregate (363)	Pubmed	1993-2012
15	Trauma (364)	Using the database of one of the largest trauma centres in Iran (Sina Trauma Data Bank)	2000-2006
16	Ophthalmology (365)	MEDLINE/PubMed	1981-2010
17	Paediatrics (366)	PubMed	2002-2007

Rank	Area	Data source(s)	Time period(s)
18	Rationale use of medicine (367)	PubMed, Web of Science, Google Scholar, CINAHL, Proquest, International Pharmaceutical Abstract and Persian databases including SID, Iran Medex and MagIran	1975-2012
19	Neuroscience (368)	Science Citation Index Expanded (SCIE) via Web of Science database	2005-2008
20	Parasitology (369)	Web of Science	2002-2010
21	Stem cell (370)	Science Citation Index (SCI) Expanded	1996-2012
22	Stem cell (283)	Web of Science	2004-2010
23	Stem cell (371)	Web of Science	1996-2013
24	Health policy (372)	Web of Science	1898-2013
25	Cardiovascular diseases (373)	Medline	2003-2012
26	Obesity/overweight (374)	Scopus	1990-2013
27	Health impacts of mustard gas exposure in Iran-Iraq war (375)	Scopus, Medline, and Web of Science	1988-2012
28	Diabetes (376)	Scopus, Medline, and Web of Science	1990-2012
29	Diabetes (377)	Scopus	1968-2014
30	Reproductive health (378)	Scopus	2010-2014
31	Public health (379)	Web of Science and PubMed	1975-2014
32	Hepatitis (380)	Web of Science	2005-2014
33	Breast cancer (381)	Scopus	1991-2015
34	Neurosurgical research (382)	PubMed and IranMedex were searched for the publications of all Iranian neurosurgeons and also the neurosurgeons were invited to send the list of their publications	Before 1990; 1991-2000, and after 2000

While the increasing number of Iranian journals that are indexed in international databases has significantly improved the visibility of Iranian publications (11), the publications in the national journals do not yet seem to be very applicable by the international readers (383). An assessment of the web-based databases where Iranian journals were indexed has found that none had a complete coverage of Iranian journals; the search features were sub-optimal; English translation of the titles of the Persian papers, authors' names, keywords, and abstracts were not aligned with standard formatting styles; there were numerous typos in the English content; and some websites did not even provide English abstracts (383). This assessment had included the following websites: IranDoc; IranMedex; MagIran; Scientific Information Database (SID); and Shiraz Regional Library of Sciences and Technology (383).

In terms of the substantial growth of Iranian health-related research publications, although no explanatory study had investigated the national-level contributors to the growth, several possible reasons were hypothesised in the reviewed papers as follows: (i) increased investment of the government in R&D (11, 12, 311) and increased investment in the health sector (246); (ii) increased number of research centres and medical universities (12, 246, 308); (iii) increased number of faculty members (11, 246); (iv) providing academics and students with training courses in research and publishing (311); (v) introduction of regulations that required faculty members to have papers for academic promotion (66, 297, 330); (vi) increased number of students (11); (vii) the large number of young and talented researchers who mostly publish papers to improve their academic CVs (85); (viii) introduction of regulations that required PhD students to have papers abstracted in international bibliographic databases (11, 273); (ix) improved quality of Iranian journals and increased number of Iranian journals that are indexed in international citation databases, e.g. Scopus (11); and (x) increased international collaboration, which may have been for bypassing the international sanctions (308, 337).

Regarding the institutional-level underlying reasons for the growth, one paper in 2014 studied the success of implemented policies in one major Iranian university (Shahid Beheshti University of Medical Sciences) towards promoting research and publication among its academics (384). They found the following interventions that seemed to have had contributed to improving the quantity, the quality, and utilization of research (384): (i) providing research courses for administrative staff so that they could speed up the research grants' allocation processes; (ii) expanding subscription to international journals and bibliographic databases; (iii) equipping a laboratory with facilities to run PCR (i.e. polymerase chain reaction) tests and do MRI on lab animals; (iv) establishing a centre to serve as an intermediary between the departments of pharmacy and pharmaceutical manufacturers to help with knowledge translation and raising research funds from the industry; (v) replacing the paper-based administrative processes of research with online forms; (vi) identifying research priorities and encouraging adherence to them; (vii) increasing (more than doubling) the number of research centres of the university; (viii) introducing grant schemes specific to prolific authors (the amount of the awarded grants was dependent on the indexing and the IF of the journal where the previous papers of the academics had been published); and (ix) introducing a regulation that research publications were requisite for remuneration (384).

Regarding the quality of research, the literature suggests that still most of the output is not of high quality (17) although in most cases the quality was only assessed by citation-based indicators (67), a practice which is widely criticised (147, 210, 385). A quality assessment of 509 Iranian clinical trials published during 2008-2010 in national journals reported that the adherence of 43.8% of the publications to the standard CONSORT checklist was inadequate (386). Nonetheless, regarding reporting, an analysis of 795 clinical and/or health systems research articles published between 2001 and 2006 that had included Iranian populations on maternal care, diabetes and tuberculosis (indexed in national and international databases) found that 98.5% of the papers contained a clear message (387). One study used two standard tools for quality evaluation of the methodology and reporting in Iranian papers in medical education research (2003-2008) that were abstracted in MEDLINE, and/or SID (388). The study suggested that the quality of publications was suboptimal, particularly the validity of research methods and the reporting of study limitations (388).

Using research

In terms of knowledge translation (KT), according to the literature, several steps have been taken in Iran over the last recent decades which seem to have been effective in the promotion of KT. The activities could be grouped into the categories of *Supply* of knowledge that is relevant to the users; *Demand* for knowledge; and *Exchange*—which includes the interaction between knowledge producers and users (6, 323). In the *Supply* category, while capacity has been built in academia to increase needs-based research, KT activities had also been incentivized (323). Regarding capacity building, representatives from almost all Iranian medical universities participated in a KT training course in 2009 that was organised by the WHO EMR Office; the course covered topics from the basics of KT to the passive and active KT strategies (323). In terms of incentives, the annual evaluation of academic institutions that is undertaken by MOHME allocates points to the implementation of research findings (271) and—likewise—according to the 2008 revision of the regulations for academic promotion, medical universities' faculty members could receive points by KT activities (323).

In the *Demand* category, although some assume that the integration of medical education and research into the health care services has closed the gap between the knowledge producers and users in Iran's health system provision (6, 244), evidence suggests that this model has not much succeeded in this regard (Further details in section 3.5.2) (113). On the other hand, an attempt that seems to have been successful is that in recent years, the executive departments of medical universities were asked to allocate nearly 2% of their budget to 'applied research'(244, 323). Hence, the university executive departments commission the academics and provide them with funds to address the needs of the executive departments through research (244, 323). Moreover, since 2005, MOHME has been calling for applied research grants, e.g. in Health Systems Research. Finally, great efforts have been made to promote using the findings of systematic reviews and clinical trials and, in general, 'evidence-based decision-making and practice' among service providers and policymakers (287, 323).

Another attempt that improved *Demand* in KT was the development of the Iranian Registry of Clinical Trials (IRCT) in 2008 which increased the public accessibility to the ongoing and/or the findings of completed clinical trials in Iran (287). The number of registered clinical trials in IRCT rapidly increased. It was more than quadrupled between 2009 and 2010 (rising from 181 to 772), presumably as a result of the regulations introduced by the Iranian medical journals that requested authors to include IRCT codes in their submitted manuscripts (389). This regulation indeed led to a substantial number of trials getting registered retrospectively, particularly after completing the recruitment of participants; 62% of the registered trials in 2011 had been submitted after the end of patients' recruitment (389).

In the *Exchange* category of KT activities, significant efforts have been made to identify health research priorities at the national and institutional levels with the engagement of the academics and the key stakeholders (323). Further information on this subject is provided in section 3.5.1 and Table 4. Also, as described in section 3.5.3, in the sub-section of Collaboration, community-based participatory research centres were established to facilitate interaction of the academics and the community in the process of research (323). A major attempt in the *Exchange* category has been the establishment of 'incubation centres' where researchers could present their ideas and/or findings that have a potential of commercialisation to the businesses and could receive seed funding to further develop their work (316, 323). Moreover, establishing Science and Technology Parks and supporting young graduates to found knowledge enterprises have been among the strategies towards improving *Exchange* in KT (316, 323).

Between 2010 and 2013, the number of incubation centres increased from 98 to 148, while the figures for knowledge enterprises had also risen from 2,169 to 3,400, and the number of Science and Technology Parks had reached 33, from 28 (316). The figures for research staff of the parks had increased from 16,139 to 22,000 within the same period (316). According to the UNESCO Science Report, the number of Iranian patents, in all areas, submitted to the United States Patent and Trademark Office, had increased from only 3 in 2008 to 43 in 2013 (357).

Few studies have attempted to assess the status of KT in health-related fields in Iran. Two assessments of medical universities and research centres have reported the lack of an appropriate KT environment in Iran's academia; insufficiency of financial incentives; supportive regulations and facilities for KT activities; and limited opportunities for interaction between the academics and the knowledge users (390, 391). KT activities in diabetes were assessed in 2015 and the overall status had been described as 'lower than ideal', and several barriers at the macro and the meso levels were found against improvement of the status quo (392). It was reported that the most commonly used KT activity by Iranian medical academics has been publishing research in journals, i.e. a passive KT strategy (323), although engagement in active KT strategies was reported to be significantly higher in Health Systems Research projects (393).

A survey of medical interns at a teaching hospital affiliated with TUMS described the knowledge of the basic concepts of Evidence-Based Medicine in the majority of the respondents as insufficient although the interns were willing to receive training to learn about it (394). Another survey enquired 319 general practitioners (GPs) in 2008 about whether they had updated their knowledge of diabetes over the preceding two years, and if so, which sources of information they had been using (395). It was reported that a total of 38% of the GPs had not updated their knowledge, and the ones who had, mainly relied on Iranian journals in Persian, showing that clinical guidelines did not have any place as a source of information and/or practice (395). The main barriers to the development and to the use of clinical practice guidelines in Iran were reported to be the lack of an evidence-based health care system and insufficient political support at the macro level (396).

A survey of 304 nurses working in teaching hospitals in 2003 reported the following: 80.6% had not been involved with the conduct of any research since qualifying as a nurse; 70% of those who had undertaken some research had done it as part of a course; about 30% had never used research in their practice; 44.3% read research once every 2 or 3 months or more frequently; and the main information sources that the majority relied on for practice were nursing textbooks and/or asking the nurse supervisors (397). The barriers to research utilisation in nursing practice in Iran had been identified as follows: (i) insufficient time to read papers; (ii) inadequate facilities and time to implement research; (iii) limited authority of nurses to change practice and limited cooperation of medical doctors in this regard; (iv) inaccessibility of scientist by whom the nurses could discuss relevant topics; and (v) inadequacy of relevant research (397-399).

The importance of 'relevant research' was also highlighted in an editorial in 2007, where it was noted that, despite the substantial growth of mental health research publications in Iran between 1997 and 2002, the country still lacked the required evidence for national-level decision-making in mental health (400). It was argued that this problem originated in the lack of a national policy that guides research investments towards mental health research priorities. Back then, conducting several systematic reviews was initiated to identify (i) the knowledge gaps, and (ii) the weaknesses in the quality of the earlier research that needed to be addressed (400). Furthermore, an investigation of the views of 131 researchers and health research policymakers on how the development and the usage of evidence from systematic reviews could be promoted in Iran had recommended: (i) the introduction of national-level initiatives for making systematic reviews 'wanted', and (ii) improving the capacity to conduct high-quality research (401).

Regarding the impact of medical and health research in Iran, most of the retrieved documents in this review - even the analyses that were commissioned by MOHME - (315) seemed to have been assessing the research impact solely by considering citation-based indicators. Only one study was found that had used a multi-dimensional approach; it had used the Payback Framework for impact assessment of a sample of 238 research projects that had been completed by 2008 (321). The findings were as follows: half of the studies had published no articles in journals indexed in Scopus; the results of 12% of the studies had been used in systematic reviews; 12% had been used in clinical or public health guidelines; findings of only 5.3% had been used by MOHME in policy making; 62% were expected to directly lead to health impacts, of which only 38% had been implemented, and 60% had achieved the anticipated result; and of those with a potential of making an economic impact, nearly 36% had been implemented, of which 61% had made an economic impact, e.g. by reducing the cost for the person and/or on the health system, and/or by reducing the number of work days missed due to illness/disability (321). A rare example of research with an impact found in the literature was from Royan Institute, an Iranian stem cell research centre approved by MOHME in 1998, where research is translated into medical services. It was reported that the centre provides stem cell therapy for skin and cartilage disorders (402). Finally, in 2003, it was reported that 13 national research studies had led to an improvement or change in the health system, while about 20 national guidelines for use in the health system had been reformulated based on the outcomes of locally conducted research (references to specific studies were not given) (244).

Chapter 4 Bibliometric analysis of Iran's health research publications (1965-2014)

4.1 Introduction

As described in section 1.9.1, Iran is a remarkable example of emerging middle-income scientific nations. Iran's number of research publications has witnessed the fastest growth during recent decades, from publishing only 736 in 1996 to 13,238 in 2008 (9). It was mentioned in section 1.10.5 that since 1985, the governance of medical education and research in Iran has been entrusted to MOHME (114). Therefore, it is important to study Iran's publications in health research separately from other fields of science. It should be noted that in the bibliometrics studies that are presented in this chapter and in Chapter 5, health research publications are defined as publications that include clinical, biomedical, and or public health research.

It has already been discussed in section 3.5.4, and summarised in Table 6, that multiple studies have thus far reported the quantitative increase in Iran's health research publications in various areas, from general fields, e.g. paediatrics (366) or dental research (357) to more specific areas, e.g. breast cancer (381), diabetes (377), or the rationale use of drugs (367). However, an overall landscape of the changes across all fields of clinical, biomedical, and public health research is still lacking. Furthermore, some criticise Iran's research publications for having a very low citation impact and for having had increased only in the quantity (66, 67), and this matter requires further investigation.

In this chapter, I will seek to obtain a better understanding of Iran's growth in health research, both in terms of the quantity and citation impact. This could firstly inform the national research policymakers about that which researchers, institutions, and fields have achieved an acceptable capacity to perform and publish health research, thus are worthy to be funded; and that which ones have lagged behind and could benefit from further capacity-building and/or investment. Secondly, the findings should help stakeholders from international organisations, e.g. the WHO, to better understand the local research capacity of Iran, which could be used in regional and global projects.

4.2 Aim

The aim of this chapter was to obtain a better understanding of the changes in Iran's health research publications over 50 years, both in terms of the quantity and citation impact, and identify the major contributors and key factors that have led to the changes.

4.3 Objectives

Using bibliometric methods in this chapter, I seek to (i) study the annual number of Iran's clinical, biomedical, and public health publications over 50 years across different areas, and characterise some of the major trends; and (ii): compute the changes in h-index of publications over this period to investigate whether the growth has been limited to the quantity.

4.4 Methods

4.4.1 Methods to study the landscape of publications

Given the advantages that the use of bibliometrics has over peer review and altmetrics in large-scale research assessment studies (as described in section 1.11.3), I used bibliometric methods for the purpose of this study. Then, after considering the strengths and limitations of different international databases that are explained in section 1.11.3, I chose WoS CC for the purpose of this study. As indicated in section 1.11.3, the general consensus is that large-scale bibliometric analyses in WoS and Scopus seem to yield similar results (199). I chose WoS CC over Scopus as it offered better tools to refine and analyse search results at the time the study was conducted. It is likely that Scopus has developed some similar features by now. I accessed WoS via the University of Edinburgh Library.

On February 28, 2018, I performed a search in WoS CC of all the publications from Iran between 1965 and 2014 by running an 'Advanced Search' with the country field tag: i.e. CU=Iran. To include papers with a topic relevant to clinical, biomedicine, and/or public health, I refined the search results by selecting 48 relevant items listed under the 'Research Areas' option on the refine panel. List of the included 'research areas' is provided in Appendix 2.

My goal was to study the longest possible period. The reason for which 1965 was chosen as the start year is that WoS currently only indexes the authors' affiliations of publications since 1966, hence, articles published in earlier years cannot be captured by searching the country subfield (403). Year 2014 was chosen for the end of the period because once a new journal is indexed in WoS CC, the most recent three years of the journal's back issues will be obtained by WoS (404), which increases the figures. Thus, it is better to exclude the publications of the last three years in such bibliometric analyses. I obtained information about IF and country of origin of the journals on Journal Citation Reports® (JCR).

I used the 'Results Analysis' feature of the WoS CC for analysing the retrieved records, and then, ranked them in a descending order in the following fields: 'Countries/Territories'; 'Organization-Enhanced'; 'Source Titles'; 'Research Areas'; 'Authors'; and 'Document Types'. While most of these fields are self-explanatory, it is worth mentioning that 'Organization-Enhanced' that indicates authors' affiliations, comprises the unified and the most accurate name variant of addresses (405). It should also be noted that regarding prolific authors, it is possible that some publications that belong to authors with the same surname and initial are incorrectly attributed to one author. Therefore, I performed an 'Advanced Author Search' to ensure the publications linked to prolific authors belonged to one person.

To obtain the landscape of the growth across different research areas, I counted the number of publications in each year and in each research area by firstly, retrieving the publications in every year and secondly, analysing them for research areas. Finally, I exported the data to a Microsoft Excel (Microsoft Inc, Seattle WA, USA) file for calculations.

4.4.2 Method to investigate the changes in h-index

As described in section 1.11.3, h-index is a bibliometric indicator which was originally developed to measure the quantity and the impact of an individual's research output, trying to capture both in a single number (217). However, h-index can be adapted to assess the characteristics of research from both institutions and countries and provide an understanding of their capacity for research (406); in such indications, it can be called h-core (407). This analysis only included citations from sources that were indexed in WoS CC. The approach used to identify the 5-year h-indices is explained in the following text.

Approach to identify the 5-year h-indices

To assess the changes in h-index of publications over time, I employed a method that was co-developed by Anna Badenhorst (a student of Master of Public Health at the Centre for Population Health Sciences, The University of Edinburgh), Dr Kit Yee Chan (my principle supervisor), and myself (38). It should be noted that the methodology development was not part of my PhD although I contributed to that study. We had introduced the methodology for assessing the global public health research capacity (38). I followed the same method to calculate the 5-year h-indices of Iran's health research publications as follows.

I calculated h-indices over ten 5-year periods: 1965-1969; 1970-1974; 1975-1979; 1980-1984; 1985-1989; 1990-1994; 1995-1999; 2000-2004; 2005-2009; and 2010-2014. To minimise the expected lag between publications and getting cited (408), I added a 'citation window' of three years following each 5-year period (38). This means that, for instance, when calculating the h-index for the 5-year period between 2000 and 2004, publications with dates 2000-2004 were included, while all the citations that those publications had received in the period 2000-2007 were taken into account in calculating the h-index. The search criteria were the same as the ones described in the previous section (section 4.4.1), except for the time span.

Once the search was complete for each 5-year period, I found the citation information of the articles using the 'Citation Reports' feature of WoS CC. 'Citation Reports' shows the number of citations that every search result has received every year. To include the 8-year citations, I set the time span of the search for the 8-year period, while after running the search and before creating the 'report', I refined the publication years to only include the documents that were published within my desired 5-year period. To calculate the h-index, all the citation data was exported to a Microsoft Excel file, then the total citation counts of each document in an 8-year period was calculated, and the documents in each 5-year period were ranked by citation counts in a descending order and documents were numbered accordingly. I computed the h-index by finding where the rank was lower or equal to its corresponding citation count.

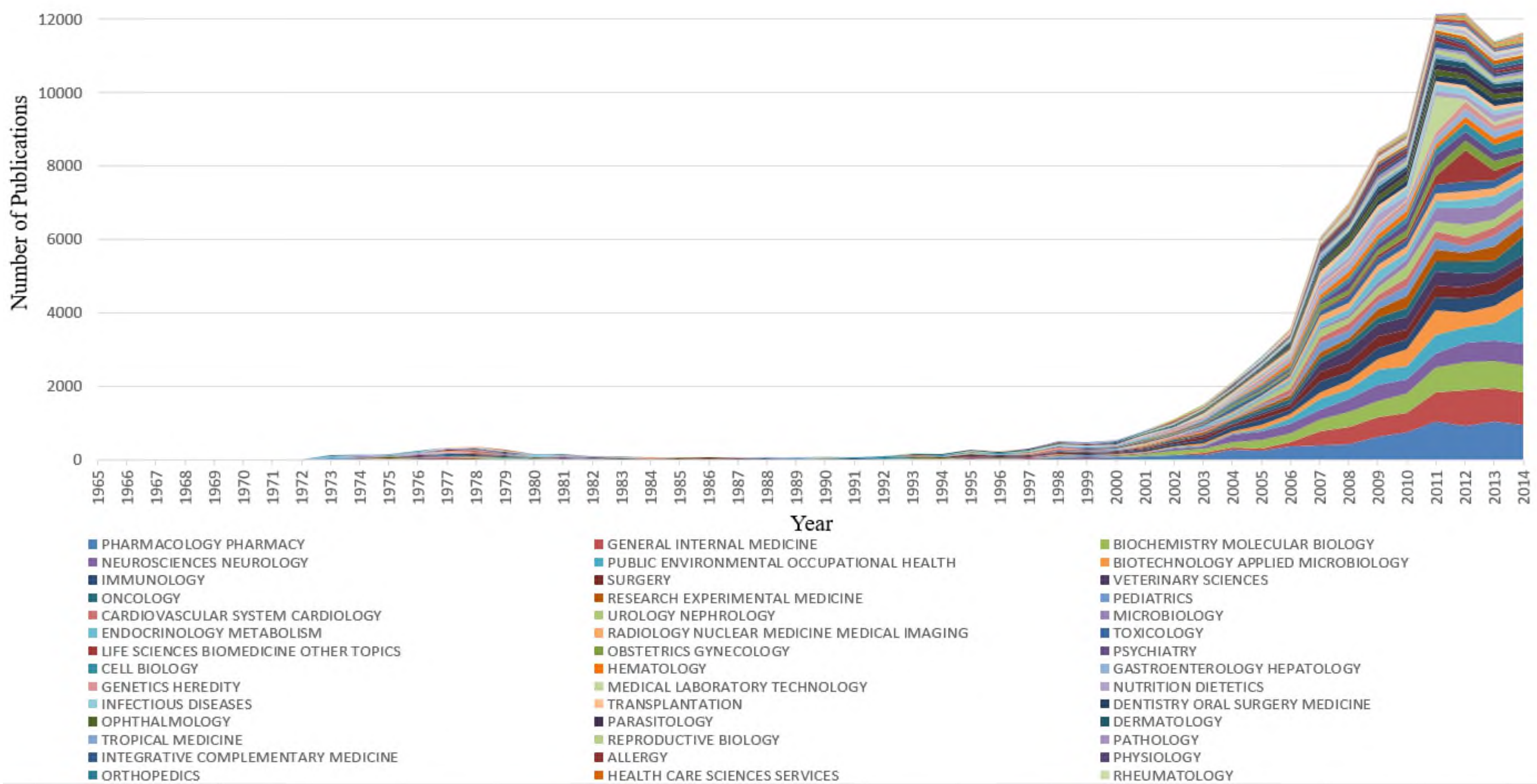
4.5 Results

4.5.1 A landscape of Iran's health research publications (1965-2014)

On February 28, 2018, there were 244,290 research publications indexed in WoS CC with at least one author with an Iranian affiliation for the period 1965-2014; a total of 72,686 (29.7%) were in clinical, biomedical, and/or public health. The absolute number of publications in each year, and the annual and the total number of publications in each research area are provided in Appendix 3. Figure 3 illustrates the landscape over 50 years.

A substantial increase is evident in the quantity of publications over 50 years, rising from only 1 publication per year in the late 1960s to a total of 8,984 in 2014. An overall increase has started since 2000, and has become more substantial between 2006 and 2007 (increasing from 3,587 to 6,058), and another surge has occurred between 2010 and 2011. The growth peaked in 2011, reaching 9,646 publications, remained relatively steady in 2012, while decreased to 8,616 in 2013. It should be noted that the number of publications that are illustrated in Figure 3 are the summed up number of publications in different research areas, meaning that if a record had been assigned to multiple research areas by WoS, it had been counted more than once. That is why the number of publications indicated in Figure 3 are higher than the annual number of publications.

Figure 3 Iran's publications across clinical, biomedical, and public health research areas (1965-2014, indexed in Web of Science Core Collection)



Results of analyses of the publications and information about the journals where the highest proportions of papers have been published are summarised in Table 7. IF of the 10 journals where the majority of papers were published ranged between 0.57 and 2.4; six of them were Iranian journals; and one of these 10 journals is no longer indexed in WoS CC (i.e. Life Science Journal - Acta Zhengzhou University Overseas Edition). Ten percent of the international collaborations has been with the USA, the UK, and Canada. The majority of publications were original articles (69.0%), followed by meeting abstracts (20.4%), letters (4.0%), and review articles (2.7%). The full analysis results is available in Appendix 3.

Table 7 Results of analysis of 72,686 Iranian health research publications (1965-2014), indexed in WoS CC, representing: research areas with most publications, the most prolific organisations and authors, journals that had published the majority of publications, and countries with which Iran has had the most collaboration*

Rank	Research areas with most publications	Prolific organisations†	Prolific authors‡	Journals that had published the most	Countries with most collaborations§
1	Pharmacology pharmacy (8,167)	Tehran University of Medical sciences (17,401)	Abdollahi, M (558)	Iranian Journal of Public Health (1,442) – From Iran –IF in 2016: 0.76	US (3,684)
2	General internal medicine (6,075)	Shahid Beheshti University of Medical sciences (6,728)	Azizi, F (491)	Iranian Red Crescent Medical Journal (1,146) – From Iran – IF in 2016: 0.86	UK (2,331)
3	Biochemistry molecular biology (5,844)	University of Tehran (6,086)	Larijani, B (447)	Journal of Research in Medical Sciences (1,005) – From Iran – IF in 2016: 1.2	Canada (1,317)
4	Neuroscience neurology (4,638)	Shiraz University of Medical Sciences (5,241)	Rezaei, N (429)	Life Science Journal - Acta Zhengzhou University Overseas Edition (1,001) – From China – Indexed between 2008-2012	Germany (1,050)
5	Public environmental occupational health (4,353)	Isfahan University of Medical Sciences (3,876)	Dehpour, AR (428)	Clinical biochemistry (999) – From Canada – IF in 2016: 2.4	Australia (1,020)
6	Biotechnology applied microbiology (3,712)	Pasteur Institute of Iran & Le Réseau International des Instituts Pasteur (RIIP) combined (3,807)	Zarrindast, MR (378)	Archives of Iranian Medicine (931) – From Iran – IF in 2016: 1.2	Sweden (736)
7	Immunology (3,321)	Tarbiat Modares University (3,732)	Malekzadeh, R (353)	African Journal of Biotechnology (694) – From Kenya - IF in 2016: 0.57	France (693)
8	Surgery (3,256)	Mashhad University of Medical Sciences (3,588)	Alavian, SM (345)	European Psychiatry (642) –From France - IF in 2016: 3.1	The Netherlands (675)
9	Chemistry (3,182)	Tabriz University of Medical Sciences (3,331)	Zali, MR (344)	Iranian Journal of Pharmaceutical Research (619) - From Iran – IF in 2016: 1.5	Italy (666)
10	Veterinary sciences (3,017)	Iran University of Medical Sciences (2,372)	Ghavamzadeh, A (340)	Iranian Journal of Pediatrics (597) - From Iran – IF in 2016: 0.7	Malaysia (626)

IF – impact factor; WoS CC: Web of Science Core Collection
*The numbers in brackets show the number of the documents, based on the data from 72 686 publications in clinical, biomedical, and public health research areas (1965-2014) with at least one Iranian affiliation; †7474 documents were attributed to the Islamic Azad University, a very large private university with many branches all across Iran, which all seem to be using the same affiliation. It was impossible to distinguish the publications that originate in each branch, therefore, the Islamic Azad University was excluded from the results. Furthermore, in addition to Pasteur Institute of Iran, Le Réseau International des Instituts Pasteur (RIIP) was among the most productive organisations. Since the publications attributed to both of these two institutions belonged to one organisation, the number of their publications were summed up; ‡The names of two authors from the top list were excluded: Amini, M; and Karimi, M, which are both a very common combination of a surname and an initial among Iranians. The reason for exclusion was that an 'Advanced Author Search' revealed the records that were attributed to these two authors included publications of multiple authors with the same surname and initial; §Web of Science reports publications affiliated with England, Scotland, Northern Ireland, and Wales separately. Here, the summed up figure is reported for the UK.

4.5.2 Changes in h-index of publications (1965-2014)

Table 8 summarises the changes in h-index. In general, the 5-year h-index has had a growing trend over the last 5 decades, and it has become ~1.5 times greater every 5 years between 1990 and 2004. The 5-year h-index of publications between 2005 and 2009 was more than doubled compared to the figure for publications between 2000 and 2004 (rising from 35 to 78). The h-index of documents published during 2010-2014 reached 105, meaning that within this period 105 documents were published that each one had been cited at least 105 times until the date of conduct of this study.

Table 8 Five-year h-indices of Iranian clinical, biomedical, and public health publications (1965-2014), indexed in Web of Science Core Collection

Period Number	5-Year Period	Year H-Index
1	1965-1969	0
2	1970-1974	9
3	1975-1979	16
4	1980-1984	13
5	1985-1989	10
6	1990-1994	14
7	1995-1999	21
8	2000-2004	35
9	2005-2009	78
10	2010-2014	105

Chapter 5 Identifying the profile of Iranian h-core health research publications

5.1 Introduction

Chapter 4 reported that the number of health research publications, with at least one Iranian author and abstracted in the WoS CC database had reached 72,686 by 2014. It also found some improvements in the h-index of the publications over the period that the quantitative growth has taken place. It is essential to identify the publications that contribute to the h-core of these publications and investigate who are supporting and conducting the research that have become highly-cited. Particularly, it is of much interest to characterise the publications that had only relied on Iran's resources while have found their way into the h-core publications of the country.

5.2 Aim

In this chapter, I aimed to identify the h-core health research publications of Iran that were indexed in the WoS CC, during 1965-2014, and investigate their profile.

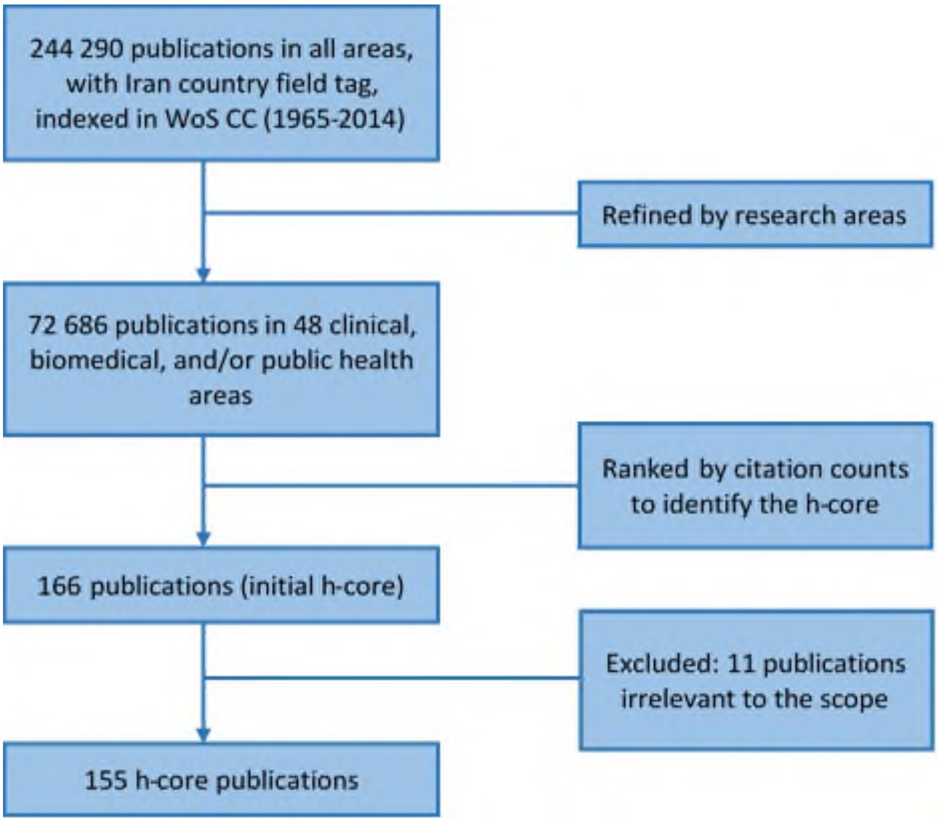
5.3 Objective

In this chapter, I sought to: (i) identify the h-core papers of Iran's health research publications in the WoS CC, for the period 1965-2014; (ii) identify the major contributors to the conduct and publishing of the h-core papers and the most common document types and research areas; (iii) investigate different types of collaborations among the h-core papers and identify the papers that had only relied on Iranian resources; and (iii) identify the profile of the h-core papers that had only authors from Iranian institutions and investigate the origin of citations to these papers.

5.4 Methods

Firstly, the same search strategy described in section 4.4.1 was applied, and then, the retrieved publications were ranked by citation counts in a descending order for identification of h-index (Figure 4). Citations were counted until the time of conducting the search (February 28, 2018). By using the 'Marked List' feature of WoS, the h-core papers were selected for further analysis. In WoS, the allocation of articles to research areas is done automatically based on the scope of the journals where the articles are published. Hence, through refining the search results by 'Research Areas' some articles may appear that were published in clinical, biomedical, and/or public health journals, while their content may not be fully relevant. To ensure that the research area of the included h-core papers was in clinical, biomedical, and/or public health, the titles, abstracts, and when necessary the full-texts of the records were screened and the ones with irrelevant topics were excluded. Excluded papers were replaced with their following publications, and this was done until the rank was lower than or equal to the citation counts (i.e. the h-index). Initially, there were 166 records which finally reached 155 records after excluding the irrelevant papers: h-core=155.

Figure 4 Search strategy to identify the h-core publications



I investigated different types of collaborations in the h-core papers by looking at the affiliation of the authors and their country of origin (to identify whether it was Iran or not). Author affiliations were found in the full-text of papers, while to explore the country of origin of authors, language of their names and also study/work background of the authors were investigated by searching the Web. Most Iranian names have distinguishable characteristics. As a native Persian speaker, I investigated the language of the names and categorised the articles as explained below.

- Authors with Persian names who only had Iranian affiliation(s) were considered as 'Iranian in Iran'.
- Authors with Persian names who only had non-Iranian affiliation(s) were considered as 'Iranian abroad'. Since there might be people with Persian first and surnames who had never studied nor worked in Iran, education and work background of authors with Persian names but international affiliation(s) were also searched on the Web.
- Publications of authors with Persian names but with dual affiliations (Iranian and international affiliations) were considered as a collaboration of 'Iranian in Iran and Iranian abroad'.
- Authors with non-Persian names and non-Iranian affiliation(s) were considered as 'International'.
- Authors with non-Persian names, but with Iranian affiliation were considered as 'Foreigner in Iran'.
- Articles which were clearly part of a large international collaborative project, funded by international organisations, and/or with collaborators from various parts of the world, and/or on topics that international collaboration was inevitable were considered as 'Consortium'.

The 155 h-core papers were analysed for: (i) authors; (ii) organization-enhanced; (iii) journals; (iv) document types; (v) research areas; and (vi) collaborating countries. A subset of the h-core papers comprising 'only Iranian' publications, meaning papers which solely had Iranian authors affiliated with Iranian institutions, was analysed for the first five abovementioned fields. These papers were also categorised into basic, clinical, and public health research according to their content. The journals where the 'only Iranian' papers had been published were further analysed using JCR. To identify what proportion of the citations to each of the 'only Iranian' h-core papers originated in Iran, firstly, a 'Cited Reference Search' was performed to find items that had cited each of the papers. Secondly, by running an 'Advanced Search' with the country field tag, all the publications with at least one author based in Iran were retrieved. A combination of these two search provided the citing documents that had at least one author in Iran, and the proportion of these publications to all citations was computed.

5.5 Results

Bibliographic information of the 155 h-core publications with their citation counts are provided in Appendix 4. Citation counts ranged between 156 and 3,959. The most-cited paper was a systematic analysis for the Global Burden of Disease (GBD) Study 2010, with contribution from 118 institutions (two of which were Iranian) and was published in 2012 in *The Lancet*. The oldest highly-cited record (published in 1973) was authored by three Iranians affiliated with Namazi Hospital of Pahlavi University, and one non-Iranian person with the same Iranian affiliation. Table 9 summarises the major results from analysis of the 155 h-core papers and the full results are provided in Appendix 5. Twelve international institutions appeared among the top contributors to the h-core papers, while the three Iranian ones included Tehran University of Medical Sciences—TUMS (51 papers), Shahid Beheshti University of Medical Sciences (19 papers), and Isfahan University of Medical Sciences (13 papers).

Table 9 The top contributors to the 155 Iranian clinical. Biomedical, and public health h-core publications (1965-2014), indexed in Web of Science Core Collection*

Rank	Research Areas with ≥6 h-core papers	Organisations† contributed to ≥13 h-core papers	Authors (from Iran, contributed to ≥5 h-core papers)	Journals that have published ≥3 h-core papers	Collaborating Countries
1	General Internal Medicine (31)	Tehran University of Medical Sciences (51)	Farzadfar, F (9)	The Lancet (17)	UK (74)
2	Pharmacology Pharmacy (18)	University of London (29)	Naghavi, M‡ (8)	Journal of Endodontics (7)	US (65)
3	Oncology (13)	Harvard University (24)	Forouzanfar, MH‡; Torabinejad, M‡ (7)	New England Journal of Medicine (5)	Canada (35)
4	Biochemistry Molecular Biology (12)	University of California System (22)	Abdollahi, M; Azizi, F; Ezzati, M‡; Kelishadi, R; Pourmalek, F‡ (6)	Advanced Drug Delivery Reviews; American Journal of Clinical Nutrition; Biosensors Bioelectronics; Diabetes Care; Journal of Allergy and Clinical Immunology; Nature Genetics (3)	People's Republic of China; Sweden (27)
5	Biotechnology Applied Microbiology; Endocrinology Metabolism; Nutrition Dietetics (9)	University College London (20)	Azadbakht, L; Esmailzadeh, A; Malekzadeh, R; Mehrabi, Y (5)		Australia; Brazil; France; Germany; India (24)
6	Public Environmental Occupational Health (8)	Shahid Beheshti University of Medical Sciences (19)			The Netherlands (22)
7	Cell Biology; Chemistry; Dentistry Oral Surgery Medicine; Genetics Heredity (7)	Karolinska Institutet (18); National Institute of Health (NIH USA) (18)			Italy; Japan; South Africa; Switzerland (21)
8	Immunology; Neuroscience Neurology; Psychiatry; Science Technology other Topics (6)	Imperial College London; University of Washington (17)			Spain (20)
9		University of Oxford; University of Toronto; (15)			Argentina (18)
10		Isfahan University of Medical Sciences; Monash University; University of Sydney (13)			Colombia; Turkey (16)

*The names grouped in one cell have had equal number of contributions, as presented in brackets; †The same numbers were double reported for 'University of Washington' and 'University of Washington Seattle'. Here, the figures are reported for 'University of Washington' as its preferred name variant; ‡Authors who at least in one of their publications were affiliated with international institutions.

Using the approach described in section 5.4, different types of collaborations were identified. As indicated in Figure 5, of the total 155 records, 48 (30.9%) were 'only Iranian' and the rest, included some sort of international collaboration.

Figure 5 Distribution of different types of collaborations across the 155 Iranian clinical, biomedical, and public health h-core publications (1965-2014), indexed in Web of Science Core Collection

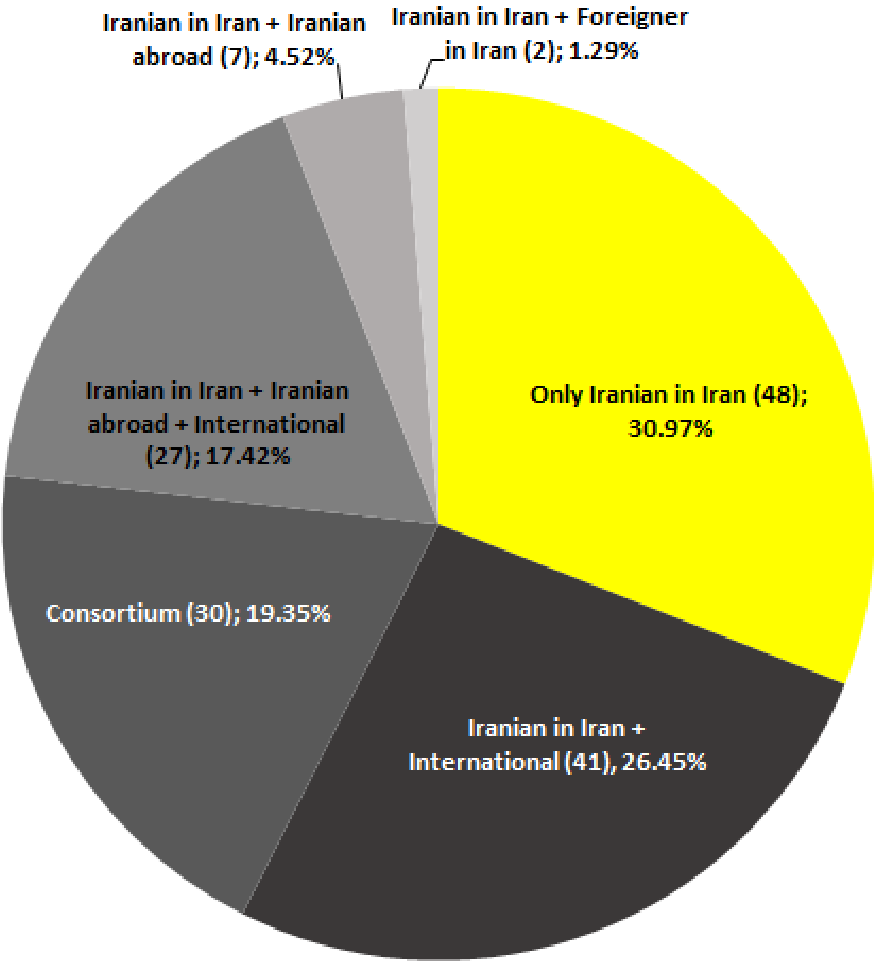


Table 10 summarises the titles and bibliographic information of the 48 'only Iranian' publications, the citation counts (until 28 February, 2018), and the proportion of citations to each that had originated in Iran. As explained in section 1.11.3, citation counts depend on the year of publication and the research field. Hence, higher or lower number of citations to the articles listed on Table 10 does not represent any superiority/inferiority. Distribution of document types and research categories across the 48 'only Iranian' publications is presented in Table 10.

The majority of the 'only Iranian' h-core papers were basic research (64.5%). Also, 62.5% of the 48 papers were original articles; and the remaining were review articles (Further details in Table 11). The 48 'only Iranian' papers were published across 43 journals. IF of these journals ranged between 0.4 and 8.3 with a median of 2.3 (based on the IF in the year when each paper was published). A full list of the 43 journals where the 'only Iranian' papers had been published and the IFs are available in Appendix 6.

The research areas, institutions, and authors with most contribution to the 48 'only Iranian' papers and the journals which have published at least two of these papers are listed in Table 12. The most-cited 'only Iranian' paper was a review article in basic sciences entitled 'Hydrogel nanoparticles in drug delivery', published in 2008 in *Advanced Drug Delivery Reviews*. The paper was a collaboration between three authors affiliated with Shiraz and Zanjan universities of medical sciences. It was cited 778 times, and only 9.1% of its total citations were from sources affiliated to Iranian institutions. In general, the proportion of citations that originated in Iranian institutions ranged between 0.8% and 97.7%. All of the six papers which over 80% of their citations was Iranian were in public health. While five of them were national and sub-national epidemiologic studies (addressing cancer; mental health; non-communicable diseases; cardiovascular risk factors; and metabolic syndrome), one was the preliminary results of a community-based programme for prevention and control of cardiovascular diseases. The papers which had less than 10% of their citations originated in Iran (including 17 papers) were predominantly in basic sciences (16 out of 17).

Table 10 List of the 48 'only Iranian' h-core health research publications (1965-2014), indexed in Web of Science Core Collection, ranked by their year of publication, and then by citation count within each year

No.	Authors	Title	Publishing journal and year	% of Citations Originating in Iran	Citation Count	Research Type	IF in the Publication Year
1	Salehizadeh H, Shojaosadati SA	Extracellular biopolymeric flocculants - Recent trends and biotechnological importance	Biotechnology Advances 2001	1.1%	264	Review - Basic	1.568
2	Azizi F, Rahmani M, Emami H, et al.	Cardiovascular risk factors in an Iranian urban population: Tehran Lipid and Glucose Study (Phase 1)	Sozial- und Präventivmedizin 2002	95.6%	269	Public Health	0.639
3	Azizi F, Salehi P, Etemadi A, et al.	Prevalence of metabolic syndrome in an urban population: Tehran Lipid and Glucose Study	Diabetes Research and Clinical Practice 2003	69.3%	275	Public health	1.68
4	A Vessal M, Hemmati M, Vasei M	Antidiabetic effects of quercetin in streptozocin-induced diabetic rats	Comparative Biochemistry and Physiology - Part C: Toxicology & Pharmacology 2003	8.5%	238	Basic	1.469
5	Akhgari M, Abdollahi M, Kebryaeezadeh A, et al.	Biochemical evidence for free radical-induced lipid peroxidation as a mechanism for subchronic toxicity of malathion in blood and liver of rats	Human & Experimental Toxicology 2003	18.4%	182	Basic	0.99
6	Sarraf-Zadegan N, Sadri G, Afzali HM, et al.	Isfahan Healthy Heart Programme: a comprehensive integrated community-based programme for cardiovascular disease prevention and control. Design, methods and initial experience	Acta Cardiologica 2003	89.4%	157	Public health	0.38
7	Abdollahi M, Ranjbar A, Shadnia S, et al.	Pesticides and oxidative stress: a review	Medical Science Monitor 2004	21.5%	312	Review – Public Health	1.595
8	Almasirad A, Tabatabai SA, Faizi M, et al.	Synthesis and anticonvulsant activity of new 2-substituted-5-[2-(2-fluorophenoxy)phenyl]-1,3,4-oxadiazoles and 1,2,4-triazoles	Bioorganic & Medicinal Chemistry Letters 2004	7.9%	224	Basic	2.333
9	Noorbala AA, Yazdi SAB, Yasamy MT, et al.	Mental health survey of the adult population in Iran	British Journal of Psychiatry 2004	82.6%	165	Public health	4.175
10	Rahimi R, Nikfar S, Larijani B, et al.	A review on the role of antioxidants in the management of diabetes and its complications	Biomedicine & Pharmacotherapy 2005	31.3%	411	Review – Clinical	2.069
11	Azadbakht L, Mirmiran P, Esmailzadeh A, et al.	Beneficial effects of a Dietary Approaches to Stop Hypertension eating plan on features of the metabolic syndrome	Diabetes Care 2005	18.9%	251	Clinical	7.844
12	Azadbakht L, Mirmiran P, Esmailzadeh A, et al.	Dairy consumption is inversely associated with the prevalence of the metabolic syndrome in Tehranian adults	American Journal of Clinical Nutrition 2005	26.4%	222	Public health	5.853
13	Safavi A, Maleki N, Moradlou O, et al.	Simultaneous determination of dopamine, ascorbic acid, and uric acid using carbon ionic liquid electrode	Analytical Biochemistry 2006	33%	301	Basic	2.948
14	Bonab MM, Alimoghaddam K, Talebian F, et al.	Aging of mesenchymal stem cell in vitro	BMC Cell Biology 2006	3.4%	360	Basic	2.742
15	Pourmorad F, Hosseinimehr SJ, Shahabimajd N	Antioxidant activity, phenol and flavonoid contents of some selected Iranian medicinal plants	African Journal of Biotechnology 2006	13%	266	Basic	0.45

16	Eidi A, Eidi M, Esmaeili E	Antidiabetic effect of garlic (Allium sativum L.) in normal and streptozotocin-induced diabetic rats	Phytomedicine 2006	13%	163	Basic	1.403
17	Hamidi M, Azadi A, Rafiei P	Pharmacokinetic consequences of pegylation	Drug Delivery 2006	3.1%	161	Review - Basic	1.424
18	Shahverdi AR, Fakhimi A, Shahverdi HR, et al.	Synthesis and effect of silver nanoparticles on the antibacterial activity of different antibiotics against Staphylococcus aureus and Escherichia coli	Nanomedicine: Nanotechnology, Biology and Medicine 2007	8.9%	532	Basic	5.44
19	Moradali MF, Mostafavi, H, Ghods S, et al	Immunomodulating and anticancer agents in the realm of macromycetes fungi (macrofungi)	International Immunopharmacology 2007	0.8%	240	Review - Basic	2.066
20	Kelishadi R	Childhood overweight, obesity, and the metabolic syndrome in developing countries	Epidemiologic Reviews 2007	41.3%	308	Review - Public health	5.429
21	Shahverdi AR, Minaeian S, Shahverdi HR, et al.	Rapid synthesis of silver nanoparticles using culture supernatants of Enterobacteria: A novel biological approach	Process Biochemistry 2007	8.5%	279	Basic	2.336
22	Atlasi Y, Mowla SJ, Ziaee SA, Bahrami AR	OCT-4, an embryonic stem cell marker, is highly expressed in bladder cancer	International Journal of Cancer 2007	11.6%	173	Basic	4.555
23	Hosseinimehr SJ	Foundation review: Trends in the development of radioprotective agents	Drug Discovery Today 2007	13.9%	226	Review - Basic	6.671
24	Akhondzadeh S, Tabatabaee M, Amini H, et al	Celecoxib as adjunctive therapy in schizophrenia: A double-blind, randomized and placebo-controlled trial	Schizophrenia Research 2007	14.2%	169	Clinical	4.24
25	Mohamadnejad M, Alimoghaddam, K, Mohyeddin-Bonab M, et al.	Phase 1 trial of autologous bone marrow mesenchymal stem cell transplantation in patients with decompensated liver cirrhosis	Archives of Iranian Medicine 2007	12.6%	165	Clinical	IF started since 2009 with 0.874
26	Hamidi M, Azadi A, Rafiei P	Hydrogel nanoparticles in drug delivery	Advanced Drug Delivery Reviews 2008	9.1%	778	Review – Basic	8.287
27	Asl MN, Hosseinzadeh H	Review of pharmacological effects of Glycyrrhiza sp and its bioactive compounds	Phytotherapy Research 2008	5.4%	433	Review – Basic	1.772
28	Montazeri A	Health-related quality of life in breast cancer patients: A bibliographic review of the literature from 1974 to 2007	Journal of Experimental and Clinical Cancer Research 2008	3.9%	274	Review – Public health	1.184
29	Jouyban A	Review of the cosolvency models for predicting solubility of drugs in water-cosolvent mixtures	Journal of Pharmacy and Pharmaceutical Sciences 2008	44.7%	239	Review – Basic	1.887
30	Imanshahidi M, Hosseinzadeh H	Pharmacological and therapeutic effects of Berberis vulgaris and its active constituent, berberine	Phytotherapy Research 2008	14.8%	225	Review – Basic	1.772
31	Gill P, Ghaemi A	Nucleic acid isothermal amplification technologies - A review	Nucleosides Nucleotides & Nucleic Acids 2008	3.6%	195	Review – Basic	0.571
32	Beitollahi H, Mazloum-Ardakani M, Ganjipour B, et al.	Novel 2,2 '-[1,2-ethanediylbis(nitriloethylidyne)]-bis-hydroquinone double-wall carbon nanotube paste electrode for simultaneous determination of epinephrine, uric acid and folic acid	Biosensors & Bioelectronics 2008	65.6%	168	Basic	5.149
33	Soleimani M, Nadri S	A protocol for isolation and culture of mesenchymal stem cells from mouse bone marrow	Nature Protocols 2009	6.4%	317	Basic	6.335
34	Mousavi SM, Gouya MM, Ramazani R, et al.	Cancer incidence and mortality in Iran	Annals of Oncology 2009	93.7%	223	Public health	5.647

35	Safavi A, Maleki N, Farjami E	Fabrication of a glucose sensor based on a novel nanocomposite electrode	Biosensors & Bioelectronics 2009	14.3%	218	Basic	5.429
36	Azizi F, Ghanbarian A, Momenan AA, et al and the Tehran Lipid and Glucose Study Group	Prevention of non-communicable disease in a population in nutrition transition: Tehran Lipid and Glucose Study phase II	Trials 2009	97.7%	277	Public health	2.02
37	Delavari A, Forouzanfar, MH, Alikhani S, et al.	First Nationwide Study of the Prevalence of the Metabolic Syndrome and Optimal Cutoff Points of Waist Circumference in the Middle East The National Survey of Risk Factors for Noncommunicable Diseases of Iran	Diabetes Care 2009	81.4%	181	Public health	6.718
38	Akhondzadeh S, Jafari S, Raisi F, et al.	Clinical trial of adjunctive celecoxib treatment in patients with major depression: a double blind and placebo controlled trial	Depression and Anxiety 2009	12.9%	171	Clinical	2.926
39	Ranjbar B, Gill P	Circular Dichroism Techniques: Biomolecular and Nanostructural Analyses- A Review	Chemical Biology & Drug Design 2009	16.3%	166	Review – Basic	2.473
40	Ghasemi K, Ghasemi Y, Ebrahimzadeh MA	Antioxidant activity, phenol and flavonoid contents of 13 citrus species peels and tissues	Pakistan Journal of Pharmaceutical Sciences 2009	25.3%	161	Basic	0.588
41	Esmaeili M, Mohabatkar H, Mohsenzadeh S	Using the concept of Chou's pseudo amino acid composition for risk type prediction of human papillomaviruses	Journal of Theoretical Biology 2010	6.6%	258	Basic	2.371
42	Mohabatkar H	Prediction of Cyclin Proteins Using Chou's Pseudo Amino Acid Composition	Protein and Peptide Letters 2010	4.7%	215	Basic	1.849
43	Mohabatkar H, Beigi MM, Esmaeili A	Prediction of GABA(A) receptor proteins using the concept of Chou's pseudo-amino acid composition and support vector machine	Journal of Theoretical Biology 2011	6.6%	183	Basic	2.208
44	Jadidi-Niaragh F, Mirshafiey A.	Th17 Cell, the New Player of Neuroinflammatory Process in Multiple Sclerosis	Scandinavian Journal of Immunology 2011	16.6%	164	Review – Basic	2.230
45	Dinarvand R, Sepehri N, Manoochehri S, et al.	Polylactide-co-glycolide nanoparticles for controlled delivery of anticancer agents	International Journal of Nanomedicine 2011	13.6%	156	Review – Basic	3.13
46	Nabavi SM, Nabavi SF, Eslami S, et al.	In vivo protective effects of quercetin against sodium fluoride-induced oxidative stress in the hepatic tissue	Food Chemistry 2012	55%	156	Basic	3.334
47	Mostafalou S, Abdollahi M.	Pesticides and human chronic diseases: evidences, mechanism, and perspectives	Toxicology and Applied Pharmacology 2013;268(2):157-177	15.8%	255	Review – Public health	3.975
48	Karimi-Maleh H, Biparva P, Hatami M.	A novel modified carbon paste electrode based on NiO/CNTs nanocomposite and (9, 10-dihydro-9, 10-ethanoanthracene-11, 12-dicarboximido)-4-ethylbenzene-1, 2-diol as a mediator for simultaneous determination of cysteamine, nicotinamide adenine dinucleotide and folic acid	Biosensors and Bioelectronics 2013	63.5%	192	Basic	6.541

Table 11 Distribution of document types and research categories across the 48 'only Iranian' h-core publications

	Original Article	Review Article	Total
Basic	18	13	31
Clinical	4	1	5
Public Health	8	4	12

Table 12 The top contributors to the 48 'only Iranian' h-core health research publications (1965-2014), indexed in Web of Science Core Collection

No.	Research areas with ≥3 papers	Organisations contributing to ≥3 papers	Authors contributing to ≥3 papers	Journals that have published ≥2 papers
1	Pharmacology pharmacy (14)	Tehran University of Medical sciences (17)	Azizi, F (5)	Biosensors Bioelectronics (3)
2	Biochemistry molecular biology (7)	Shahid Beheshti University of Medical sciences (9)	Abdollahi, M; Mirmiran, P (4)	Diabetes Care; Journal of Theoretical Biology; Phytotherapy Research (2)
3	Biotechnology applied microbiology; Chemistry (6)	Tarbiat Modares University (7)	Kelishadi, R; Mohabatkar, H (3)	
4	Neuroscience neurology (4,638)	Shiraz University (5)		
5	Science Technology other Topics (5)	Mazandaran University of Medical Sciences (4)		
6	Endocrinology Metabolism; Research Experimental Medicine (4)	Isfahan University of Medical Sciences; Ministry of Health and Medical Education; Shiraz University of Medical Sciences (3)		
7	Biophysics; Electrochemistry; Oncology; Psychiatry; Toxicology (3)			

Chapter 6 Iran's health research system moving forward: a national-level health research priority-setting exercise

6.1 Introduction

As explained in section 1.12, and chapters 3, 4, and 5, although Iran has significantly progressed in terms of expanding its capacity to conduct health research and even to set health research priorities over the last three decades, it still lacks systematic and inclusive mechanisms to set the national health research priorities. Furthermore, as described in section 3.5.2, Iran's investment in research, particularly in health research has remained limited, and even has declined over the last decade (409). There seems to be a substantial need to a proper prioritisation process to clarify the research priorities and align them with Iran's national and international health agendas.

6.2 Aim

This chapter aimed to adapt the CHNRI method to identify health research priorities in Iran to assist with the efficient use of resources towards achieving the long-term health targets. It should also provide a model to other low- and middle-income countries on how to effectively adapt this prioritisation process to improve funding allocation for health research.

6.3 Objectives

- Create an appropriate management group to run the exercise
- Identify and invite the group of policymakers and funders
- Identify and invite the group of prominent Iranian researchers with expertise relevant to the scope of the study
- Identify and invite the wider group of stakeholders
- Identify the context of the study, e.g. the timeframe, the topic, the level
- Compile a list of research questions after collecting the generated questions from the researchers
- Identify the scoring criteria with clear definitions

- Calculate the scores obtained by each research question against every criterion and the total score, before and after the assignment of the input from stakeholders
- Calculate the average level of agreement among the researchers on each research question

6.4 Methods

I conducted this study between July-December 2017, using the CHNRI method, as described in sections 1.7 and 1.12. All of the original materials and correspondences with participants in this exercise were in Persian, and I translated the ones which required further discussion within the steering committee into English.

6.4.1 Defining the context of the health research priority-setting study

In the first step, I formed a steering committee for running the CHNRI exercise in Iran. As the coordinator of the steering committee, I invited four people to sit on the committee as follows: (1) Professor Igor Rudan (IR); (2) Dr Kit Yee Chan (KYC); (3) Professor Reza Majdzadeh (RM); and (4) Dr Zhaleh Abdi (ZA). IR and KYC were invited for their expertise in the CHNRI methodology and extensive experience in its implementation in multiple national and global exercises. RM and ZA were invited for ensuring that the CHNRI method was adapted properly within the context of Iran. They also facilitated identification of and access to the study participants. I was based in Tehran, Iran during the conduct of this study and coordinated communications between the members of the steering committee through e-mail correspondences and WhatsApp group calls.

Through several meetings and discussions within the steering committee, different components of the context of the exercise were defined, including, (i) health targets on which the exercise focused and the agendas where the targets were outlined (i.e. Iran's long-term health targets as outlined in Iran's GHPs and in the Sustainable Development Goals (SDGs), listed in appendices 1 and 7, respectively); (ii) geographic limits (i.e. national); and (iii) the time scale within which the research is expected to be funded and conducted (i.e. the next 5 years). In terms of the time scale of the exercise, a short-term period was aimed, because most of the national plans in Iran are made for 5-year periods. Furthermore, as described in section 3.5.2, the majority of health research funding bodies in Iran are run by the government, thus their funding policies often change every four to eight years with the change of the President of the country and/or his Cabinet.

In terms of the long-term health targets, it should be noted that currently Iran has two major commitments for improving population health: one national and one international commitment. Aligning the national and international commitments facilitates the monitoring and evaluation of the progress towards achieving the long-term targets. Therefore, in this exercise, Iran's health targets as outlined in both its national and international major commitments were included.

Iran's national commitment for improving health is to achieve the GHPs by 2025. The English translation of the GHPs is presented in Appendix 1. The GHPs are a set of 14 long-term health targets that were announced in 2014 by Iran's Supreme Leader, who as explained in section 1.10.4, is responsible for outlining the general policies for the country. The GHPs aim to provide Iran with a framework to achieve the health-related goals of Iran's Vision 2025. The Vision 2025 is a 20-Year national strategic plan that was released in 2004 and outlines political, economic, and social goals, which achieving them presumably could facilitate Iran's broader ambition, i.e. 'becoming the Middle East's top power by 2025' (310, 410).

One of the major international commitments of Iran is to deliver the SDGs by 2030, and this also includes achieving the health targets that are outlined in the SDGs. The SDGs were adopted by the UN General Assembly in 2015, and Iran is one of its signatories. The SDGs are a set of interconnected goals that build on the successes of the Millennium Development Goals, while introducing new areas, such as climate change, economic inequality, and sustainable consumption (411). Among the 17 goals that are proposed in the SDGs, Goal 3 specifically addresses health issues and is described as a goal for '*ensuring healthy lives and promoting the well-being of all at all ages*' (411). In this study, in addition to the 13 targets outlined under Goal 3 (i.e. 3.1-3.9, and 3.a; 3.b; 3.c; and 3.d), eight additional SDG health targets were included from goals other than Goal 3. This consists of the targets that were proposed in the 2016 report of the WHO on Monitoring Health for the SDGs (412). The full list of the SDG targets that were included in this study is provided in Appendix 7.

In reviewing the content of the GHPs and the health targets of the SDGs, I found a high degree of overlap between the targets across the two agendas. Only five of the GHPs are not covered by the SDGs due to being quite specific to the context of Iran, including GHP 1, GHP 2, GHP 12, GHP 13, and GHP 14 (Further details in Appendix 1).

6.4.2 Identification, invitation, and participation of the experts

I identified a total of 70 experts—in the fields relevant to the health targets that were included in this exercise—across a reasonably wide range of disciplinary backgrounds and views. To identify experts, I searched the Web of Science and Scopus databases for the most prolific researchers in Iran in the areas related to the included health targets in this study. To do so, I went through a random sample of the publications of the most productive authors to identify whether the papers were original research and could confirm that their authors were real experts in the field (Further details is provided in Appendix 8). I also searched the web in Persian for experts who have held leading academic roles in Iranian scientific societies and or universities, or have held scientific roles in executive organisations, e.g. MOHME and or NGOs. I gave careful consideration to ensure that the invitees had a good understanding of research in their field, and were not solely holding executive roles. The final list of experts were checked and overseen by RM and ZA to ensure that the list had a comprehensive coverage of experts.

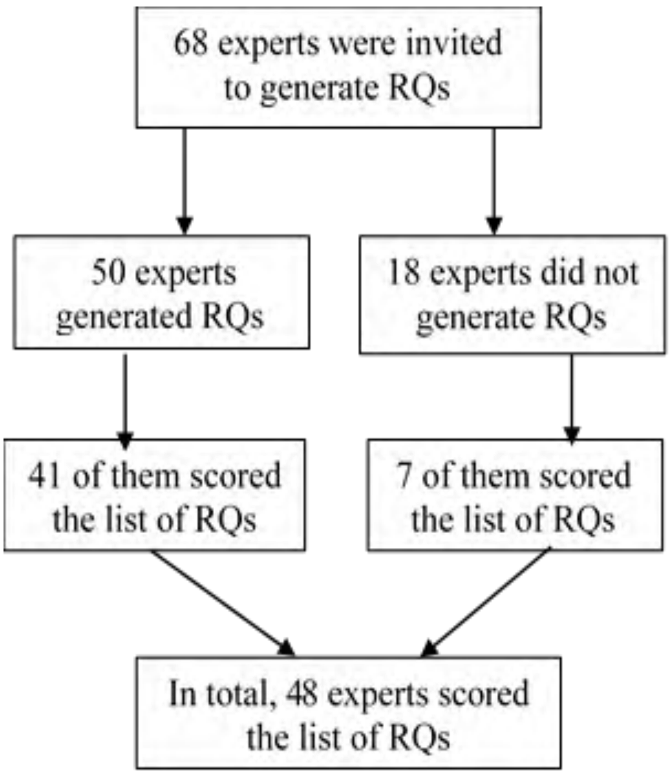
To diversify the range of expertise of identified researchers, which was predominantly from medical sciences backgrounds, I used snowballing, by asking the identified experts in less represented areas (e.g. in social sciences, humanities, environmental sciences) to nominate other experts in their field. Despite such efforts, education background of the majority of the invitees (70%) was clinical, biomedical, and/or public health sciences. This figure for those who contributed to generating RQs and to the scoring of the RQs was 74% and 75%, respectively.

I sought contact information of the identified experts through combined searches in PubMed, Google, and in accessible contact and mailing lists. Of the 70 identified experts, I could not find updated contact information for two (one anthropologist and one lawyer who were both based outside Iran). Therefore, eventually, 68 experts were invited to the exercise. To encourage participation, I prepared individualised inviting letters on Iran's

NIHR letterheads, got them manually signed by RM, the then Head of the NIHR, scanned the signed letters, and attached the digital invitations to individualised inviting e-mails which RM sent to the invitees and copied me in. The English content of the letters and a sample of an original inviting letter are provided in Appendices 9 and 10, respectively. The e-mails also included the instructions for generating RQs (Appendices 11 and 12) and the list of the health targets based on which the researchers were asked to propose research questions. The list included the GHPs (Appendix 1) and the health targets of the SDGs (Appendix 7). All the original material were in Persian, including the health targets.

Figure 6 summarises how many experts participated at each stage of the exercise. An overview of experts' background information and participation is provided in Appendix 13.

Figure 6 Experts' participation in the health research priority-setting exercise



6.4.3 Generating research questions

In the first instance, the identified experts were invited to participate in the exercise by independently generating three to five RQs. Fifty experts (73.5% of all 68 invitees) agreed to participate and generated a total of 251 RQs. The steering committee of this exercise (including myself, IR, KYC, RM, and ZA) retained 128 RQs after removing apparent duplicate questions and merging very similar ones. This stage included several rounds of translating and back translating between Persian and English, because the original RQs were in Persian, while the list should have been discussed among the committee members, who two of them were non-Persian speakers. Finally, the agreed list of RQs had to be translated into Persian to share with the Iranian experts for scoring. The consolidated list of 128 RQs, the five criteria, and scoring instructions were sent to the original 68 experts with an invitation to score the RQs. The 5 scoring criteria (presented in Table 13) were chosen and defined specifically for this exercise using input from a management group of nine persons which included Iranian health research policymakers and funders, and the steering committee. The process through which the criteria were selected is described in the following section.

6.4.4 Selecting and defining the criteria

The CHNRI method introduces a transparent set of criteria that could discriminate between many competing research options. CHNRI's 'standard' criteria include (i) answerability, (ii) effectiveness, (iii) deliverability, (iv) potential for a substantial reduction of disease burden, and (v) impact on equity (42). However, the CHNRI method provides flexibility to modify the criteria according to the context (42). Using this flexibility, the selected criteria and their definitions were modified for this exercise, based on the input from a management group. The management group comprised the steering committee members (including myself, IR, KYC, RM, and ZA) and four other people who held positions that allowed them to influence Iran's major health research policy making and/or funding decisions.

On the first step, I coordinated discussions among the steering committee regarding the context suitability of the 'standard' CHNRI criteria and the other criteria that have been used in previous CHNRI exercises. Two new criteria were proposed as they seemed to fit within the context of Iran. After several discussions where each of the members of the steering committee argued for inclusion and/or exclusion of any of the criteria, a consensus on a shortlist of 9 criteria and a definition for each was achieved (Appendix 14). The shortlist included the following: (i) feasibility; (ii) impact on health; (iii) impact on economy; (iv) capacity-building; (v) equity; (vi) impact on Iran's scientific rank; (vii) potential for translation; (viii) impact on creating wealth; and (ix) long-term impact.

On the second step, the other four members of the management group were invited to independently rank the nine criteria, choose the top-five, and provide comments that could improve the proposed definitions of the criteria. These participants were invited from the Academy of Medical Sciences; Department of Research and Technology of MOHME; Department of Curative Affaires of MOHME; and Department of Research and Technology of Tehran University of Medical Sciences. Except for the first invitee who represented the Academy of Medical Sciences, the other three chose to express their personal opinion.

On the third step, each of the steering committee members ranked all the nine criteria too. By counting the total votes for each criterion as well as counting the scores that each criterion had received (based on the ranking system), the top-five criteria were selected as follows: (i) feasibility; (ii) impact on health; (iii) impact on economy; (iv) capacity-building; and (v) equity. The top-five criteria turned out to be the same using both approaches (counting the votes or counting the value based on ranking). Finally, to obtain the definition for each criterion, I summarised the comments from all. At this step, I also asked a colleague from the Knowledge Utilization Research Center at Tehran University of Medical Sciences who has extensive knowledge and experience in health research impact assessment in Iran to assist with improving the final definitions.

Table 13 List of the included five criteria and the agreed definition for each

Number	Criterion	Definition
1	**Feasibility**	(i) There is sufficient capacity (e.g. data infrastructure, laboratory equipment) to carry out this research; (ii) It is possible to provide training for the staff who would undertake this research; (iii) This research can be conducted in an ethical way and produce informative results within the next five years
2	**Impact on Health**	Results of this research have high potential to improve health by: (i) reducing disease incidence and/or prevalence;(ii) reducing social, environmental, and/or individual risk factors of ill-health; (iii) shaping future health planning and implementation; (iv) improving health services delivery by improving acceptability, accessibility, suitability, efficiency, efficacy, effectiveness, and/or safety of treatment or service; and/or (v) improving societal and system preparedness for future health challenges
3	**Impact on Economy**	Results of this research have high potential in: (i) having direct effect on the production of materials or consumer services; (ii) optimising the earlier goods and/or products (increasing quality and/or reducing production costs); (iii) creating knowledge-based entrepreneurship; (iv) decreasing days of work missed due to illness or disability for patients and caregivers; (v) reducing opportunity costs for patients and caregivers; (vi) reducing impact on direct patient costs as well as health and welfare systems; and/or (vii) reducing caregiver burden and its associated financial costs (including healthcare costs for caregivers)
4	**Capacity Building**	Results of this research have high potential to lead to: (i) education and training in Iran's human resources; (ii) the acquisition of new skills by the research team; and/or (iii) investment to improve research facilities/amenities where the study will be undertaken, e.g. purchasing software/equipment
5	**Equity**	Results of this research have high potential to: (i) lead to interventions or services that will be accessible and affordable to everyone, including members of vulnerable groups; (ii) lead to policy, plans, interventions or services that could reduce health inequality. This could be achieved by policies or interventions that target and empower vulnerable groups to reduce risk and disease exposures and/or improve access to services or interventions.

6.4.5 Scoring research questions

On the scoring step, I prepared individualised scoring sheets for each researcher in Microsoft Excel where all the 128 RQs were listed against the 5 criteria. The RQs were sorted randomly on each scoring sheet so that all of the RQs would have an equal chance of standing on higher or lower rows on the list. Similar to the initial invitation, I prepared individualised inviting letters on Iran’s NIHR letterhead, got them manually signed by RM, scanned the letters (Appendices 15 and 16), and attached them to the scoring inviting e-mails and along with the scoring instructions (Appendices 17 and 18) sent to the researchers. After sending out the e-mails, the researchers were initially given 2 weeks to send back their responses. After 2 weeks, I followed up the invitees on a weekly basis and the majority responded within the following 2-3 weeks. To the researchers who wanted to decline participation due to time constraint, an option of scoring RQs against fewer criteria—instead of all the 5 criteria—was given. Of this group of researchers, only one of them accepted this offer and scored the RQs for only one criterion, and the rest of invitees who initially wanted to decline scoring due to time constraint scored the RQs against all the 5 criteria. One of the scorers argued that it was only possible to score the RQs for ‘Feasiblity’, therefore he was encouraged to do so. In sum, 46 of the experts scored the RQs against the 5 criteria and two experts scored the RQs only for ‘feasibility’. The scoring sheets on Microsoft Excel did not read well for two of the researchers (possibly because of the incompatibility of Arabic fonts with Mac systems), for whom I prepared the scoring sheets in Google Docs.

The CHNRI method provides four response options for scoring: 0; 0.5; 1; or leaving blank in case the expert does not feel sufficiently informed to respond. However, within the steering committee of this exercise, it was agreed that typing a 3-digit response—i.e. ‘0.5’— may not seem convenient. Hence the instructions were adapted as follows: scoring ‘3’ for ‘yes’; ‘2’ for ‘informed but undecided’; ‘1’ for ‘no’; and ‘0’ for ‘insufficiently informed’. For calculating the results, all responses were re-coded to the standard CHNRI scoring system. In total, 48 of the initial 68 invited experts (70.6%) completed scoring. To ensure that the researchers felt free to express their opinions while generating and/or scoring RQs, they were informed that nobody outside the steering committee of the exercise would be able to link their input to their real names.

6.4.6 Engaging stakeholders from the wider society

To ensure that the prioritisation exercise considered views of a wider group of stakeholders, relative weights for each of the five criteria were calculated using the input from a larger reference group as explained below.

Engaging laypersons, frontline health workers, and patients in health research prioritisation processes is highly recommended because these people have their own specialised knowledge and a real stake in the outcome of the process (35). I identified participants in the stakeholders' group using snowballing in addition to sharing a public invitation in online forums of patients and healthcare professionals in Iran. The online platform that I used for this purpose was an instant messaging service: i.e. Telegram app. Telegram app which was widely used among Iranians at the time the study was conducted allows easy sharing of information across various online forums. The stakeholders were given a brief summary of the aims of the exercise and the definition of the criteria in plain language, and were invited to rank the five criteria in a descending order based on their system of values and send back their response to an account (called @health_research_priorities in English) which I had created for this purpose. The English translation of the inviting message and the original message in Persian are provided in appendices 19 and 20, respectively. The inviting message was 'seen' by a total of 4,000 people. In total, sixty-eight stakeholders from the following groups participated: 16 patients with chronic diseases; 14 caregivers; 23 healthcare professionals (including 12 medical doctors, 6 nurses, 3 pharmacists, 1 dentist, and 1 midwife); 3 social workers; 9 social and environmental activists; and 3 pharmacists from industry. Once I would have received a response from participants, I would have asked them (via text messaging in the online application), if they could indicate the group which they wanted to represent. This was important because one person could belong to several groups, e.g. a medical doctor with a chronic disease who was a social activist too. Indeed, at the end, the precise categorisation of the stakeholders' group was not possible and was outside the scope of this study. I only wanted to have a rough idea to ensure a reasonable coverage of a wide range of stakeholders. Appendix 21 provides further information on the profile of the engaged stakeholders.

The group of stakeholders collectively allocated the highest average score to the criterion impact on health (4.13). This was followed by feasibility (3.44), impact on economy (2.71), equity (2.56), and capacity building (2.19). To calculate the weight of each criterion, these average scores were divided by 3.00; i.e. the average score in case of equal value of all the five criteria. The amount of average scores to each criterion is provided in Table 14.

Table 14 Stakeholders' input calculation

Criteria	Mean score (1-5)	Mean suggested weight
Impact on Health	4.13	1.38
Feasibility	3.44	1.15
Impact on Economy	2.71	0.90
Equity	2.56	0.85
Capacity Building	2.19	0.73

To rank the RQs, 'weighted research priority scores' were calculated. This score took into account the average score provided by the experts to each RQ across the 5 criteria, and the weights assigned by the stakeholders to each criterion. The average scores—that initially were between 0 and 1—were multiplied by 100 to provide scores in a range between 0 and 100. The RQs were also ranked based on the scores for each criterion. Average expert agreement (AEA)—i.e. the level of agreement among the scorers—on each RQ was also computed as the frequency of the mode (i.e. the most common score divided by the total number of scores). All the independent responses of scorers, calculations that led to the final scores, weights, and AEA are provided in Appendix 22.

6.4.7 Ethics

The CHNRI method relies on input from human subjects. Hence, ethical aspects of conducting CHNRI exercises should be considered. After the CHNRI method was developed and proposed for implication, the method itself, underwent ethical assessment at the institution where it was developed–i.e. the Croatian Centre for Global Health at the Faculty of Medicine of the University of Split, Croatia. That ethical assessment of the method resulted in a list of recommendations by following which, alignment of CHNRI studies with research ethics would be ensured. The recommendation are extensively explained elsewhere (34), and in short, they address the issues regarding voluntary participation and consent of the participants if the findings are shared without anonymisation (34). I ensured to address all the ethical concerns and recommendations regarding implementation of the CHNRI method. Still, I had to seek for ethics approval from Iran, because all research applications related to health sciences should obtain ethics approval, according to a new regulation in Iran. Following the Iranian academic regulations, I sought for and received ethics approval from the Ethics Committee of Iran's National Institute of Health Research (NIHR) for conducting the CHNRI exercise. A copy of the approval letter is provided in Appendix 23.

In terms of anonymity of participants of the CHNRI exercise, the researchers were informed that their real name will appear on the reports and or manuscripts resulting from this exercise, unless they wish not to (two of the researchers requested anonymity). However, the researchers were informed that nobody except the study's steering committee members could link the individual generated research questions and the individual allocated scores to research questions to the real names of the researchers. Meaning that they were informed that only the collective results will be reported. To ensure confidentiality, I created a key list where a code was assigned to each researcher, and I kept the key list in an electronic file to which only I had access. The key list was kept separated from where the files including the real names of the researchers was kept.

6.5 Results

As described in **section 6.4**, in total, 128 RQs were systematically scored by 48 experts against five criteria, and 68 representatives from stakeholder groups provided weights to the five criteria. The weighted Research Priority Scores (wRPS) ranged from 84.5% to 28.5%. Table 15 shows the top 10 priorities, the wRPSs, the score that each priority has received for each criterion, and the AEA. Full list of the ranked 128 RQs is provided in Appendix 22.

Ninety-two of the 128 RQs (71.8%) fell entirely or partially under health policy and systems research (HPSR). To identify HPSR questions, the definition proposed by the

Alliance for Health Policy and Systems Research was followed (20), which describes HPSR as a field that: '*...seeks to understand and improve how societies organise themselves in achieving collective health goals, and how different actors interact in the policy and implementation processes to contribute to policy outcomes. By nature, it is interdisciplinary, a blend of economics, sociology, anthropology, political science, public health and epidemiology that together draw a comprehensive picture of how health systems respond and adapt to health policies, and how health policies can shape − and be shaped by − health systems and the broader determinants of health* (20)*.'*

Forty-five RQs addressed specific causes of morbidity, mortality, and or interventions for their diagnosis, prevention, and or management. Sixteen RQs fell into the category of 'Planetary Health'—i.e. addressing human health effects of accelerating environmental changes– the term was coined in 2014 (414). Other themes that were found across the 128 RQs were traditional Iranian medicine and Iranian-Islamic values (9 RQs), medical education, science, and innovation (6 RQs), and community participation (5 RQs).

6.5.1 Top-10 health research priorities

The top 10 priorities comprised a wide range of RQs: 9 contained HPSR components with one RQ being focused on medical education; 6 entirely or partially fell into the scope of epidemiological research; and one addressed planetary health. The top priority RQ 'How do we reform Iran's health insurance system to improve equity?' also scored highest for impact on economy (RPS= 90.7) and equity (RPS= 91). The second, the third, and the fifth priorities all addressed NCDs: two HPSR and one epidemiological question. They focused on NCD prevention strategy for Iran and its integration into the primary health care; seeking effective and cost-effective population-level interventions for reducing and managing NCDs and road traffic injuries; and an epidemiological assessment of NCDs and their underlying causes across Iran and making projections for 2030. Both of the HPSR questions that addressed NCDs have also scored highest for impact on health.

The 4th priority focused on tailoring medical qualifications to better serve the needs of the nation, and it was agreed among the experts that this RQ would provide the greatest opportunity for capacity building. The experts collectively proposed that the 6th priority, which focused on ways to achieve UHC, was identified as a rather feasible question to address (ranked 8th for feasibility) and with a good potential for making an impact on health (ranked 4th). This priority was followed by proposing investigation of the current and the future common health problems in Iran's elderly population and identifying strategies to reduce their economic burden. The consensus of experts suggested that this question is the most feasible among all the 128 RQs.

One planetary health question that was identified as a top-10 priority addressed health impacts of water crisis in Iran and how the health system should respond to it. Another priority suggesting a health systems research to replace physician-centred system with a team-based one was found to provide a great opportunity for capacity building. Another top-10 priority proposed assessing the status of antibiotic resistance in Iran and investigating ways to promote rational use of antibiotics.

Table 15 Top 10 health research priorities in Iran, ranked by wRPS

Rank	Proposed RQ	wRPS	AEA	CV	Feasibility	Impact on Health	Impact on Economy	Capacity Building	Equity
1	How do we reform Iran's health insurance system to improve equity?	84.5	68	14.63	81	91	91	63	91
2	What should be Iran's non-communicable diseases prevention strategy? How could it be integrated into primary health care?	84.2	66	10.54	86	93	83	69	83
3	What are the most effective and cost-effective population-level interventions for reducing and managing non-communicable diseases (e.g. ischemic heart diseases, diabetes, stroke, hypertension, and dementia) and road traffic injuries in the Iranian context?	84.2	65	13.14	84	91	88	64	88
4	How do we tailor our primary qualifications (e.g. Doctor of Medicine, and Doctor of Pharmacy) and higher qualifications (e.g. specialist training in psychiatry) in medical and health sciences in Iran to better serve the needs of the nation?	81.2	60	2.90	84	83	79	80	79
5	What are the leading non-communicable diseases (e.g., diabetes, stroke, cardiovascular disease, hypertension, and cancer) in Iran now and in 2030? How are they distributed across the country and what are their underlying causes?	79.6	60	15.61	86	87	79	57	79
6	To what extent are health resources and services equally distributed across the country? To what extent do they meet the needs of the people? How do we reduce inequality in health service access in Iran and achieve Universal Health Coverage?	79.2	65	14.46	85	89	76	60	76
7	What is the health status and common health problems in Iran's elderly population? How will these change by the year 2030? What is the economic burden of these problems and how can we reduce this burden?	78.6	58	16.31	87	89	74	58	74
8	What is the current status of antibiotic resistance in Iran and future predictions? What is the current antibiotic prescription pattern(s) of medical practitioners in Iran? What can we do to promote more rational use of antibiotics?	78.1	53	19.30	85	88	77	51	77
9	What are the health impacts of Iran's water crisis? For example, how has the Lake Urmia water crisis impacted the health of residents in nearby provinces? What can the Ministry of Health and Medical Education and health centres across the country do to respond to water crises?	78.0	58	13.14	75	86	81	60	81
10	How can we replace the current physician-centred system with a team-based care approach (i.e. the provision of health services by at least two health professionals including medical doctors, clinical pharmacists, nurses who work collaboratively with patients, family caregivers, and community service providers to achieve care)?	77.8	60	6.23	73	84	78	72	78

RQ: research question; wRPS: weighted research priority score; AEA: average expert agreement; CV: coefficient of variation

6.5.2 Top-quartile health research questions

Other questions that were ranked among the top quartile of the 128 RQs (including 33 RQs with wRPS≥74.3) focused on a range of issues in the Iranian context, as follows: optimising resources to produce the 18 vaccines specified in the national programme (wRPS=76.4); epidemiological assessment of the current and the future leading causes of death and morbidity (wRPS=77.1) and estimating the economic burden of the leading NCDs (wRPS=75); evaluating the existing national programmes for improving nutrition (wRPS= 75.9), and developing urban spaces that promote healthy lifestyles (wRPS= 75); impact of climate change on air quality and on population health (wRPS= 75.1), and community-based strategies to reduce energy consumption and environmental pollutants (wRPS= 74.3); socioeconomic risk factors of addiction (wRPS= 75.8); community-based interventions for reducing high-risk behavior (e.g. intravenous drug use, unprotected sex) amongst adolescents in deprived areas (wRPS= 74.3); engagement of private sector in health services provision (wRPS= 77.2) and health promotion (wRPS= 75.9); achieving sustainable health financing (wRPS= 75.3); roles of the public and private health insurance towards achieving the GHPs (RPS= 75.5); the cost–effectiveness threshold and criteria for making health interventions decisions (wRPS= 75.6); application of Health Technology Assessment for incorporating new therapeutic interventions (wRPS= 75.6); identifying the rates and patterns of health services usage (wRPS= 75.3); best model for providing pharmaceutical services (wRPS= 74.8); best healthcare payment models to use at different levels of Iran's health system (wRPS= 74.6); reforming the health system to cope with rapid urbanization (wRPS= 76.1); identifying the major gaps in Iran's health surveillance and information systems (wRPS= 76.2); establishment of a national data platform for informing evidence-based policy making across different ministries to tackle major health issues (wRPS= 75.1); and reforming Ministry of Health and Medical Education's organisational structure and culture (wRPS= 74.7). The AEA for these proposed priorities (RQs ranked between 11th and 33th) ranged between 62% and 48%.

6.5.3 Research questions which received the lowest scores

Among the 10 RQs from the bottom of the ranking (wRPS range= 52.5-28.4), 8 addressed traditional Iranian medicine and Islamic-Iranian values, while two were very specific questions related to dementia. Examples of low-scoring RQs related to dementia were ‘How do behavioural and psychiatric symptoms of dementia patients differ between Iran and other countries?’ (wRPS= 41.4); or ‘At which stages of dementia do people seek medical assistance in Iran, and how does this vary between groups with different levels of education?’ (wRPS= 52.5). The RQ that received the lowest score (wRPS= 28.4) was: ‘How should we remember and honour the most influential medical scientists in Iran's history?

6.5.4 Average expert agreement

In general, the level of agreement among the experts was between 67.5% and 34.58%. The RQs for which the greatest level of expert agreement was observed were generally those that received the highest RPS (Correlation: 0.79). Seven of the top 10 priorities had the greatest agreement scores, with the top-3 RQs having had received the highest AEA (65%, 66%, and 68%). On the other hand, RQs that had been the most controversial were those that ranked lower than the median based on the expert scoring (<68.3).

Chapter 7 Discussion

7.1 Introduction

In this chapter, I will discuss how my findings address the knowledge gaps about health research in Iran by interpreting the findings of my studies. To achieve this outcome, I sought for similarities and contrasts of my findings with those reported in the existing literature, while also explained the findings within the context of Iran, as described in Chapter 1. I will then make recommendations for policymakers and organisations seeking to improve HRSs in LMICs.

7.2 Interpretation of findings in light of the existing literature

7.2.1 Evolution of Iran's health research system

The narrative review presented in Chapter 3 showed that Iran has successfully developed necessary structures for both formulating and implementing health research policies. However, perhaps too often the policies are not well implemented because of several constraints, such as the absence of qualified people at executive roles. Stewardship seems to be the Achilles heel of the HRS of other countries in the WHO EMR too (6). In 2008, it was reported that (415) in a sample of 10 EMR countries, only four had structures for national governance of HRS, and just two countries had national health research policies (415). The review presented in Chapter 3 indicated that although Iran seems to be at a better position regarding having the structures, national policies, and mechanisms for oversight in place, as well as some familiarity with health research priority-setting approaches, it does not seem to function much better in terms of effective use of this capacity.

The narrative review also found multiple exercises that had attempted to identify the health research priorities although a need for more systematic, inclusive, and less time-consuming approaches to research prioritisation was evident. Some of the barriers to initiation of health research prioritisation exercises in Iran and to the utilisation of their findings have been identified in the literature as follows: (i) the rapid turnover of people at executive roles, which makes individuals at such relatively temporary positions reluctant to engage with time-consuming processes (240); (ii) poor knowledge of the majority of research directors of priority-setting methods (240); (iii) the highly centralised and top-down decision-making process in Iran's HRS (240, 241); (iv) inadequate interaction between academia and the end-users of health research (240); (v) lack of incentives for the researchers who are invited to participate in priority-setting exercises (240); (vi) the identified priorities often being too general (240, 241); (vii) most decision-makers attending the meetings only as a formality, without providing any 'intellectual input' (240); (viii) in consensus-based prioritisation exercises, 'powerful' individuals with louder voices influencing the opinion of others, including the representatives from NGOs (240).

Global literature shows that lacking systematic and transparent priority-setting exercises is a mutual problem of the HRSs in most LMICs (36, 39). Moreover, it has been reported that the majority of health research priority-setting exercises in LMICs have failed to engage the key stakeholders (e.g. the community) in the processes, and they have heavily relied on the input from researchers and representatives from the governments (36, 40). For the context of Iran, there seems to be a need to seek for prioritisation methods that, firstly, obtain actual intellectual input from decision-makers rather than having them invited to meetings only as a formality, and secondly, methods that can provide adequate freedom to the participants to express their opinions.

The reviewed evidence show that research and publication integrity in Iran's academia still require significant improvements. Of the identified obstacles for improvement, overcoming some of them requires fundamental changes. Examples of this category of obstacles are to improve meritocracy in recruiting faculty members, because faculty members train the future academics; or changing the education system, perhaps from primary school to higher education, to improve the level of English and writing skills of the graduates. On the other hand, addressing some other constraints seem more feasible in medium term, such as modifying the regulations that mandate academics and students to publish papers; provision of further training on how to avoid and address plagiarism; and improving interaction between academia and the end-users of research.

It has been reported that the majority of EMR countries have established national-level structures to oversight health research ethics. However, they often lack administrative support and financial resources to work effectively (6). A survey published in 2009 (416) found that only 21% of respondents from national ethics committees all across the EMR had received any formal training on ethics (416). A retrospective analysis of proposals from the EMR, published in 2008, had called for increased training of researchers in the EMR about the concepts of research ethics as well as development of further guidelines for strengthening ethical review systems (417).

Finally, it is promising that a system is in place for monitoring health research activities of medical academic institutions in Iran although for ranking purposes there seems to be a demand for: adjustment of the scores by the input of each unit (e.g. the core funding); less reliance on bibliometric indicators; further attention towards the quality and the impact of research; and additional rewards for collaborative projects between academia and the users of research.

Another key function of a HRS is financing which includes: (i) securing of research funds from different sectors, i.e. public and private, both national and international; and (ii) allocating the funds efficiently and transparently (15). One basic step towards improving financing of the HRS, which Iran has already taken, should be to ensure that the official budget plans allocate a proportion to R&D – no matter how small. Although since 1996, GERD has been specified in Iran's annual national budget plan, there is still a huge gap in data on financing, particularly about the proportion of GERD that is invested in health, or the share of research budget from the total health expenditure. Having limited and fragmented data on financial resources for health research is quite universal across LMICs and countries of the EMR (6, 15).

A seemingly successful attempt has been requiring executive entities in the health sector to allocate a certain percentage of their annual budget to health research (for the case of Iran it was around 2%).

The 1990 report of the Commission on Health Research for Development (1) had recommended that developing countries should allocate at least 2% of their health budget to research. The reviewed literature suggested that investing in health research has never become a priority in Iran. Iran's R&D expenditure has even been decreasing in recent years (reaching only 0.3% in 2014). This downward trend is in contrary to the ambitious figures that are envisioned for GERD in some of Iran's major macro-policy documents. Allocating limited financial resources to research is a common problem across the majority of LMICs (2) and most parts of the EMR (having an average GERD of 0.3%, 97% of which is publicly funded) (6). Exceptions in the EMR are a few Gulf countries that have been increasing their research investments in recent years (6). For instance, GERD in Saudi Arabia suddenly increased from only 0.04% in 2008 to 0.8% in 2010 (409). However, these countries have a quite weak national capacity for health research and, hence, their research highly depends on international academics (6). For example, according to the data abstracted in Scopus database, 75.8% of Saudi Arabia's publications in 2017 had international collaborators (64).

In terms of resource allocation mechanisms, it is proposed that the allocation of research funds should be decided based on a transparent peer review-based processes (15). While transparent information on the mechanisms of distribution of research funds was absent in the retrieved documents in Chapter 3, it was implied that health research funds are somehow distributed equally among academics. Such a mechanism does not seem appropriate in a country where research budget is limited and mainly dependent on the government, while receiving funds from international sources is rare too. However, distributing equal funds among academics seems aligned with the egalitarian values of the 1979 Islamic Revolution which perhaps had aimed to make education and research universal all across the universities (10). While this approach could provide equal opportunities for all to partake in research activities, distribution of equal funds within this system could leave insufficient resources for the academics with potentials to conduct high-quality research which often demand larger funds. Furthermore, in medical fields, it seems that the individual-level financial incentives for clinical and or teaching activities are far more than that for health research activities in Iranian universities of medical sciences. An investigation of the institutional constraints on the Iranian academics in non-medical science fields had reported that the outstanding academics were the most frustrated ones, while the mediocre researchers seemed rather satisfied with their career in Iran (129).

Another essential function of a HRS is to create and sustain human resources and infrastructural resources (15). This review showed that over the last five decades, Iran has largely developed its higher education capacity in medical sciences, as reflected in the increased number of universities of medical sciences and schools and research centres within the universities, as well as the substantial rise in the figures for academic staff and students. Nevertheless, it was reported that some of these increases have occurred without sufficient oversight or without having had the essential capacity and facilities for expansion. An analysis of the structure of scientific community in Iran, in non-medical fields, during 2002 and 2004 had identified insufficiency of facilities in academic institutions as one of the major difficulties of Iranian academics (129).

The literature also emphasises that this function of HRS is not only regarding recruiting and training new researchers or founding new institutions, but also is concerned about sustaining the existent capacity to conduct, absorb, and utilise health research (15). In terms of capacity-building, numerous training courses relevant to health research have been offered since 1990. However, the literature suggested that the number of skilled researchers in the country is still limited. Some have corresponded this issue to Iran's high rate of the so-called 'brain drain': approximately 150,000 Iranian specialists emigrate every year (418). Many LMICs, despite having research-intensive universities, lose their trained human resources to brain drain (6, 15). This is because in addition to availability of good academic institutions and facilities to undertake health research, a favourable research environment, encouraging remuneration and career prospects, sufficient research funds, and opportunities to openly discuss research should exist to encourage talented individuals to stay (6, 15).

An investigation of the institutional constraints on the emerging scientific community in Iran (in non-medical fields) had reported that the outstanding scientists in Iran were the most frustrated, thus more vulnerable to emigrate, while the mediocre researchers seemed rather satisfied with their academic institutions (129). Furthermore, in terms of medical sciences, the review presented in Chapter 3 found that, in general, the individual-level financial incentives for clinical and/or teaching activities in Iran seem to be far more than that for health research activities. This could discourage academics with expertise and interest in conducting research. Some universities in the EMR, e.g. the King Abdullah University of Science and Technology in Saudi Arabia are attempting to invite researchers back to the region, by offering financial incentives, including enormous research grants and high salaries. However, these institutions are concentrated in the Gulf States where the existing research base is rather weak (6).

To encourage the return of the Iranian diaspora, particularly in science, the current President (2013 – present) has made several efforts (418). Although figures on the outcome of the government's efforts are unavailable, sporadic reports show no significant success in this regard (419). One rather recent example was a prominent Iranian environmental scientist at Imperial College London, who was invited by the President's administration to return home to serve as the Deputy Head of Iran's Department of Environment (419). Although he did accept the invite, less than a year later, he decided to step down and leave the country consequent to receiving substantial pressure from hardliners in Iran (419).

It should be highlighted that inviting back the diaspora is only one way to address brain drain. Finding other ways to connect with diaspora and their international networks is critical. Many emigrated scientists are often willing to 'informally' collaborate with their peers back home, by providing intellectual, technical, or material assistance (8, 15). I have provided some examples of successful collaborations of Iranian diaspora with academics based in Iranian institutions in Chapter 5 (14). Given the international isolation of Iran which has declined 'formal' exchange of academics between Iran and international institutions and has restricted Iranians' access to international research grants, establishing and maintaining 'informal' collaborations with the Iranian abroad seems more feasible.

Drawing on the data provided in the reviewed literature in Chapter 3, another hypothesis to explain the limited number of skilled researchers in Iran is that students in Iran's higher education programmes do not receive training to develop skills in communication, writing, management, or teamwork, which are necessary for becoming competent researchers. Assessments of health research-relevant skills among researchers in the EMR have identified weak knowledge of research methods, poor understanding of data analysis techniques, limited communication and computer skills (6).

Furthermore, research-relevant courses are optional and are not included in the core curriculum of programmes in medical sciences. Hence, only those with an interest in research would attend such courses and acquire research skills. The literature also criticises the medical education curriculum and even the national entry exam by which university seats are reserved for students for being too oriented towards the students passively learning facts, rather than looking for critical thinking or creative problem-solving. It was also emphasised that Iran's higher education programmes do not provide training to develop skills in communication, writing, management, or teamwork, which are requisite for becoming competent researchers.

More importantly, it seems that the majority of the research trainings have focused on research methods, and or on teaching some mere 'techniques' to write and publish research papers. There is a lack of an environment which educates students and academics about why to do research and why to publish it.

The reviewed literature also described the collaboration among Iran's medical researchers and research institutes as rather poor in Iran. An investigation of collaborations in non-medical fields in Iran has found that the majority of the collaborations are between the academics and their PhD students (129). Limited coordination and collaboration in research activities is a universal problem in LMICs, which leads to the waste of a large proportion of the already scarce resources (15).

The fourth function of HRS is regarding producing, disseminating and using valid research (15). The publication of research findings is considered to be the primary output of the research process. Therefore, dissemination could be publications in peer-reviewed journals, policy briefs, reports, books, discussion papers, etc. Utilisation of research could be either for developing new tools, e.g. new drugs, devices, applications, or for contributing to improvement of policy and practice, particularly within health systems (15). While several factors, such as the increases in infrastructural and human resources, the introduction of policies that promote research, and the improved facilities for disseminating research have led to a substantial growth of health research publications in Iran, a vast amount of these publications seem irrelevant to the needs of the end-users of research. Furthermore, limited use of research is reflected in the poor evidence-based decision-making and practice. Particularly use of research findings that are published in international journals seemed insignificant in practice.

Inadequate use of knowledge has been reported in other LMICs too. Some of the constraints on knowledge translation in the EMR are identified as: (i) limited opportunities for engagement of researchers during the policy making processes; (ii) lack of institutional and financial incentives that support knowledge translation; and (iii) concerns over the political sensitivity of research findings (6). The first two, are similar to the problems that were identified for Iran in Chapter 3.

To improve KT in the EMR, in 2009, the WHO EMR Office established a regional Evidence Informed Policy Network (EVIPNet) to host workshops that bring together researchers and policymakers (420); Iran has been one of the active members of the network (420). In general, compared to the other countries in the EMR, Iran has a higher output of systematic reviews and clinical trial registration (6). It has even been reported that the rise that is evident in the number of clinical trial registrations from the EMR since 2004, is largely due to the output from Iran (6).

Still, the existing capacity in Iran's HRS could be better used with an improved research governance. There seems to be a need for educating the students and academics about the role of research for better health rather than solely teaching them research-relevant methods. Furthermore, fundamental changes are required to address the existing gap between the knowledge producers and users and to improve the use of research in policy and practice.

7.2.2 Bibliometric analysis of Iran's health research (1965-2014)

The study presented in Chapter 4 was successful in providing a 50-year overview of Iran's health research publications that are indexed in WoS CC. Health research publications for this bibliometric study were defined as publications in the areas relevant to clinical, biomedical, and or public health research. This bibliometric analysis also identified the year in which the growth of health research publications in Iran peaked; and characterised main trends across the publications. Furthermore, it suggested that the rise in the quantity to some extent has led to improvements in citation impact.

Several bibliometric studies had previously reported the substantial quantitative growth of Iranian research publications over the last three decades, as summarised in Table 6 (9, 11-13). In Chapter 4, I visualised the changes in the number of Iranian clinical, biomedical, and public health research publication over 5 decades and found a significant rise until 2011 and a drop afterwards. Some of the proposed possible contributory factors to the quantitative increase in Iran's research publications are the following: improved economy after recovery from the Iran-Iraq war (1980-1988) (66, 421); increased number of universities, research centres, students and faculty members; multiplication of postgraduate programmes (11, 66, 422); requiring students to have publications; providing academics with financial rewards per publication (66, 423); increased number of Iranians who study abroad and maintain international collaborations after returning to Iran (421); or improved access to data sources (424).

Even if such assumptions justify the overall research growth in Iran, still the accelerated increases in certain periods require further explanation. For example, one surge is evident in 2007 which could partially be explained by the addition of a significant number of regional journals to the WoS CC between 2005 and 2010 (200). Regional journals were defined as journals publishing outside the US or the UK and containing the scholarship of authors from a particular region or country, and covering topics of regional interest (200). Within that 5-year period, Thomson Reuters—the former owner of the WoS—indexed 1,600 new regional journals that met the standard editorial criteria of the WoS (200), while concurrently, MOHME was supporting Iranian medical journals to improve their quality to meet international editorial and publishing standards (425). Consequently, between 2005 and 2010, the number of Iranian journals indexed in WoS CC increased from only five to 41; 15 of the new additions were in clinical medicine (200). Furthermore, once a new journal is indexed in WoS CC, the most recent three years of the journal's back issues would also get indexed (404), and this suddenly adds up to the number of indexed documents. Finally, looking at the top-10 journals where the majority of Iranian clinical, biomedical, and public health papers have got published, six of the journals were Iranian. Parallel increases in the number of research publications and the number of journals that are indexed in international databases had been reported from other countries, e.g. Brazil (426). In sum, the addition of Iranian journals to WoS CC seems to have had contributed to the 2007 surge.

Another substantial rise in research output occurred between 2010 and 2011. Considering an often three- to four-year time lag between the initiation of research projects and their publication, the contributory factors to the 2011 peak should be traced back in a few years earlier. For instance, the surge could possibly be associated with that Iran had its highest GERD—i.e. 0.75%—in 2007 (316). This may had led to increased resources allocated to health research. Furthermore, in 2009, a policy document entitled 'Iran's Comprehensive Scientific Map' was developed and released by 'Iran's Supreme Council of Cultural Revolution' (245, 410). As shown in Figure 2, this council holds the highest level of authority for setting education and research policies in Iran. The so-called 'Scientific Map' provided a set of goals, policies and requirements for development of science, technology and innovation system in Iran (245). It partially outlined the targets by meeting which Iran presumably could achieve its broader ambition: i.e. becoming the Middle East's leading country by 2025 based on scientific and technological indicators (310, 410). Examples of targets included increased number of research centres, faculty members, and PhD students (316).

Some correspond the drop in publication counts in 2013 to the tightening up of the economic and banking sanctions imposed on Iran (427). Regarding the peak that was seen in 2011, it should be noted that this study included the publications by the end of 2014 and it is likely that publication counts have already exceeded the figures for 2011, or may exceed it in the future. Analyses of the data retrieved from PubMed show a continued growing trend until 2015 (316).

In terms of the most prolific institutions, TUMS stands on top with nearly three times as many publications as the next institution, i.e. Shahid Beheshti University of Medical Sciences (also located in the capital city, Tehran). As bibliometric analyses' results are often not adjusted by size of the unit (e.g. by the number of students or academics), it is anticipated that TUMS—i.e. the largest Iranian university of medical sciences—would lead the national ranking tables for output (312). More importantly, TUMS, has an excellent reputation for medical education and research among most Iranians. Hence, many top students and competent early-career academics intensively compete for admission in TUMS (428), therefore it is possible that the researchers at TUMS are potentially more productive than their peers. It could also be hypothesised that TUMS—which is based in the capital city Tehran and in many periods has been directed by leading scientists with strong networks inside and outside academia—may have been closer to the sources of funding. It is worth mentioning that the top-3 prolific Iranian universities of medical sciences also have the highest number of research centres, which could be another contributory factor to greater research publication productivity (310).

This is similar to the global pattern that research hubs are increasingly becoming the states, cities, or even certain academic institutions rather than countries. Meaning in most countries there is a degree of concentration of research activity in certain places. For instance, in 2004, more than 60% of the US R&D expenditure was invested in only ten states—with California alone accounting for over 20% (8). Another example is that half of Russian research publications originate in its capital city, Moscow (8). Likewise, other capital cities, e.g. Buenos Aires, Budapest, and Prague each account for more than 40% of their national research outputs, and the figure for London, Beijing, Paris and Sao Paolo is also over 20% each (8). Examples of research-intensive institutions who dominate the ranking tables are Harvard University in the US which its publication output in 2004 to 2008 was greater than that of the whole of Argentina, or The University of Cambridge where 98 of its affiliates have thus far been awarded a Nobel Prize (429).

Having known the work background of the prolific authors, it seems that the majority of the top-10 are either (i) well-reputed mentors who attract many student projects that could lead to publications; and/or (ii) had held executive roles that has either facilitated access to resources, and/or has provided them with necessary skills to initiate and effectively manage teamwork. Among the top-5 prolific authors two are pharmacologists, another two are clinicians in endocrine and metabolic disorders, and one is a paediatric immunologist. The landscape for research areas with most publications has been fairly similar. Pharmacology was the research area with the largest proportion of publications (11%), followed by General Internal Medicine, and Biochemistry Molecular Biology, each comprising ~8% of the total publications.

It could be suggested that Pharmacology and Biochemistry Molecular Biology are fields that most of their publications originate in schools of pharmacy. Schools of pharmacy in Iran seem to be more research-oriented than schools of medicine. This assumption is partially made based upon the structure of MOHME (as described in section 1.10.5), where the schools of medicine are not only responsible for medical education and research, but also for providing healthcare services (113). It has been suggested that the workload of medical faculty members and students within this structure does not leave sufficient time for research (113).

In terms of document types, it is interesting that following original articles (comprising ~69.0% of total publications), the second most common document type was 'meeting abstract' (over 20.4%). This could be a result of the support and incentives that MOHME has been providing to promote participation of Iranian academics in international conferences (318). In the research performance assessment of the universities of medical sciences that MOHME runs annually, accepted abstracts in international conferences contribute to extra points (271).

It is noticeable that the journals where larger proportions of Iranian research had been published generally had relatively low IFs (0.57-2.4). It could be hypothesised that Iranians have found easier ways for publishing papers, e.g. submitting to Iranian and/or international journals with possibly higher acceptance rates. Other countries, e.g. Turkey and Australia, had previously reported a decrease in the average IF of the journals where the total national publications were getting published after implementation of policies that strongly emphasised the value of the quantity of publications (430, 431).

On the one hand, some criticise Iranian publication growth on account of the fact that a large proportion of the papers were published in journals with relatively low IFs (67). On the other hand, it could be argued that increased visibility of publications in Iran, even if achieved by publishing in mediocre journals, could have benefits. Firstly, partaking in the international scientific community by publishing could provide a sense of accomplishment to the young researchers and encourage the competent ones to improve their research activities. Secondly, it assists international institutions and researchers to identify potential Iranian collaborators, which could lead to opportunities for exchange of knowledge, expertise, and resources (312). Last but not least, visibility of publications to a larger group of peers attracts wider criticism which could lead to early detection of possible problems. For instance, the international criticism that the alleged Iranian cases of research misconduct have received urged the national science policymakers to take further steps for addressing issues regarding research and publishing integrity in Iran's academia (67, 432). It would also promote a discourse on research ethics in Iran, which in the long term could strengthen its growing scientific community (432).

Similar to the global patterns where intra-regional collaboration is not dominant, Iran's major collaborators have all been outside the EMR (8). Generally, collaboration between LMICs is globally small (8). An investigation of the collaborations in production of biomedical research papers from Africa between 2004 and 2008 found that while 77% of the publications involved international collaborators, only 5% were the output of collaborations with another African country (433).

The majority of international collaborations of Iran, has been with the USA, the UK, and Canada, which—interestingly—all the three have had fairly challenging international relations with Iran over the last four decades. While the negative impacts that the imposed trade sanctions have had on Iran's research activities should not be overlooked (427, 434-436), it seems that international scientific collaborations had been established and/or maintained regardless of the political atmosphere (337). Also, these countries are three of the most common destinations that Iranians choose for studying and/or immigration (437). The ones who return to Iran after completion of their academic programmes may continue collaboration with their former supervisors, or with the international network which they have established (421), while those who emigrate may continue collaborating with colleagues back home. Another point is that many of research consortiums are led by American and/or British institutions, and publications arising from such projects, if having Iranian collaborators too, would be counted as collaborative publications between

Iran, the US, and/or the UK. Globally, the US is the dominant collaborator in research publications (17% of all internationally collaborative papers are in partnership with the US) (8). European collaborations have increased since the 1990s, mainly as a result of the EU funding initiatives, but the US remains the major partner for most European countries too (8).

The bibliometric analysis presented in Chapter 4 indicated that h-index of Iran's publications has had a growing trend over ten 5-year periods. This means that along the substantial quantitative growth of publications, citation counts have increased to a certain degree, which confirms some previous reports on this (313, 318, 385). My colleagues and I had previously reported on similar significant growing trends of 5-year h-indices of public health research publications in some other LMICs (38). For instance, it was shown that the 5-year h-index of public health research publications of China had increased from 36 in the period 1996-2000 to 100 during 2006-2010. This figure for South Africa was 30 in the first 5-year period and was 32 for Brazil, while it increased to 78 publications in both countries for the period 2006-2010 (38).

As described in section 1.11.3, some may criticise the use of h-index for assessing citation counts (438). Firstly, one argument could be that since the maximum of h-index is the number of publications in a research unit, h-index is more strongly formed by publication counts rather than citation counts (153). However, if the rise had been restricted to the quantity, it would have been impossible to see any improvements in the h-index over time. Secondly, another objection could be that h-index is insensitive to the total number of publications, thus it does not provide any information about the large proportion of publications that possibly have received minimal or zero citations (153). This is a valid point and this study did not aim to investigate improvements in the average citation counts, nor in citations per document. Nevertheless, what this paper could suggest is that in the long term, the increase in the quantity has promoted the number of the publications that had a potential to receive a 'reasonable' number of citations. Thirdly, many of the papers contributing to 5-year h-indices might be a result of international collaborations; even so, this is an achievement for a country that has been internationally isolated for four decades (337). In fact, international collaboration is crucial for scientists in LMICs as they enable access to facilities, funding, equipment and networks that are often limited in LMICs. Finally, some may criticise the improved citation counts of the publications for having been self-citation in most cases. But the effect of author self-citations on global or national analyses is so insignificant that there is no need to exclude them (152).

7.2.3 Identifying the profile of Iranian h-core health research publications

The study presented in Chapter 5 identified a set of 155 most-cited Iranian clinical, biomedical, and or public health publications and highlighted where the capacity for producing highly-cited papers lies.

I analysed the 155 h-core publications, among which nearly 70% were the product of an international collaboration. In general, papers with multi-national contribution often receive more citations (152). This could be because a multi-national paper will probably be seen by people in various networks, due to the so-called network effect. Analysis of Elsevier data had previously shown a three-fold increase on the publication's citation counts of publications that include international authorship compared to a standard domestic publication (8). For instance, the most-cited publications from Mexico have reported to be their collaborative publications with Germany and Italy (8). Chinese publications in collaboration with Russia receive 4 times more citations than publications with authors only affiliated to China (8). Russian publications also receive a significantly higher number of citations while being written collaboratively with each of the country's G8 partners or with China (8). The fact that the leading collaboration hubs such as US, UK, France and Germany have an impact on citation rates is perhaps not surprising, particularly given the size of the scientific communities and the citation rates generated within these countries. Other collaboration pairs bring a noticeable increase in citation impact. Australia's collaborations with Spain and China benefit from the strength of research in those countries in medicine (mostly clinical drug studies) and genetics/genomics respectively (8).

Moreover, through international collaborations, scientists can enhance the quality of their work, increase the effectiveness of their research, and overcome logistical obstacles by sharing costs, tasks and expertise (8)

Thirty-four of the identified most-cited papers in the bibliometric study presented in Chapter 5, had at least one Iranian co-author who was affiliated with international institutions. Iran has a high rate of brain drain as described in section 7.2.1, which is difficult to control given the country's increasing unemployment rate among the educated population, the social and economic instability, and political challenges (437).

This study highlighted that one way to use the capacity of the Iranians abroad could be provision of further opportunities for collaboration with them. Over the past decade, the focus of debates over 'brain drain' have shifted from preventing 'brain drain' to turning it to 'brain gain', and in a way calling the phenomenon 'brain circulation'. Meaning that this phenomenon could even benefit developing countries, rather than only being a loss. Some governments appreciate the value of 'brain circulation' and allocate resources for attracting national talent back home to start a new business or take up a senior position in academia, while maintaining useful links back to the US or Europe (8).

Few examples are China, India, and Malaysia (8). Over 70% Of the 1.06 million Chinese who studied abroad between 1978 and 2006 did not return home. To attract these emigrated academics, in 2008, China initiated a programme called 'The Thousand Talents', which provided personal and professional facilities and incentives. This programme had brought back 600 Chinese academics abroad to return to China by 2011 (8).

India established a specific ministry, i.e. the Ministry of Overseas Indians, to organise policies related to remittances and investment flows, and eased the previously strict citizenship requirements to make it easier for potential returnees (8). Elsewhere, Malaysia established a new 'Talent Corporation' which will be charged with connecting with diaspora communities. Ecuador's President also announced a US$1.7 million 'Prometheus Old Wiseman' plan to attract senior scientists who see Ecuador as 'the retirement destination of brilliant minds' (8).

As discussed in section 7.2.2, attracting back the overseas is only one way of using the capacity of emigrated academics, and may not necessarily work for Iran given the ongoing challenges. Still, benefiting from the global networks of the Iranian diaspora can be critical. 'Nomadic scientists' are often keen to maintain scientific and informal links with their home countries. Many are eager to contribute but are unsure where to start. In supporting international collaboration, these diaspora communities are an untapped resource (8).

Two of the highly-cited papers had an international author affiliated with an Iranian university: Pahlavi University, which was renamed to Shiraz University of Medical Sciences following the 1979 Islamic Revolution. This university was modelled after American schools, and used several international academics aiming to educate Iranian medical doctors (437). The majority—if not all—of international academics left Iran following the 1979 Revolution (as described in section 1.10.6).

Studying the most-cited papers suggests that the GBD studies had a significant share in Iran's h-core papers. The majority of these papers had an internationally well-known Iranian collaborator affiliated with TUMS, and were published in *The Lancet*. In terms of the research area, GBD papers should be attributed to 'public health' area, but WoS attributes the papers that are published in general medical journals—e.g. *The Lancet*— to 'General Internal Medicine'. Across the 155 h-core papers, five prolific Iranian authors who are based abroad were identified. It appears that these academics have interest and ability in establishing successful collaborations with their peers in Iran; thus, further collaboration with them should be encouraged.

In terms of authors of the 48 'only Iranian' papers, five researchers had contributed to publishing at least three impactful papers (by relying on Iranian research resources). It should be ensured that these academics would receive adequate resources to continue their research activities.

Regarding where the 48 'only Iranian' papers were published, it should be highlighted that they were not published in journals with very high IFs (IF ranged between 0.4 and 8.3 with a median of 2.3). As explained in section 1.11.3, the use of journal-level metrics for evaluating individual publications and their authors is rejected by many, because the distribution of citations over the publications in a journal is highly skewed (439). However, still many decisions by funding bodies or academic employers are made upon IF (152). This study showed that at least in the case of clinical, biomedical, and public health research publications that had only relied on Iranian resources, the likelihood of getting cited in the future was independent of the IF of the journals where they were published. Another finding worth noticing is that while the proportion of review articles among the total publications of Iran was small (2.7%), 37.5% of the 'only Iranian' highly-cited papers were review articles. In general, review articles tend to attract more citations than other document types (152). Perhaps countries or institutions who wish to contribute to the global science and get recognised, while lack sufficient resources for conducting high-quality original research could promote publication of review articles.

The 48 'only Iranian' h-core papers were categorised into basic, clinical, and public health research and the majority were in basic sciences. This should trigger further thinking in Iranian medical research policymakers regarding how best the financial and human resources in clinical, biomedical, and public health research should be distributed. For instance, one approach could be to always allocate a certain proportion of resources to basic sciences, where some potential for attracting recognition seems to exist. Particularly, supporting publication of review articles in basic sciences could be a strategy when resources are scarce. Then, in deciding where to invest the rest, one approach could be identifying the neglected research areas across the total publications and investigate whether research in some areas is less promoted or less supported.

7.2.4 The national-level health research priorities

The priority-setting exercise described in Chapter 6 identified the research priorities that have a potential to assist Iran in addressing the knowledge gaps to achieve its long-term health targets as outlined in the National GHPs by 2025 and the SDGs by 2030. This was the first national-level health research priority-setting exercise in Iran that aggregated independent input from prominent Iranian researchers, policymakers and funders, and a group of stakeholders from the wider society. While the identified research priorities covered a diverse range of issues related to health, the majority of the proposed RQs, as well as 90% of the top-ranked questions, had aspects of HPSR. This is not surprising given the context of this study, which addressed a set of broad national health targets within a relatively short period (i.e. the next 5 years) (42).

The HPSR questions that ranked among the top quartile of the 128 RQs predominantly related to financing, governance, and/or service delivery. This corresponds quite well with Iran's ongoing Health Transformation Plan—launched in 2014—which aims to provide UHC by 2025, improve the quality of healthcare services, and achieve financial protection (described in section 1.10.5) (107). Furthermore, seeking ways to improve efficiency of the health system was reflected in several of the top-10 RQs, e.g. reform of the insurance system; prevention and management of NCDs at different levels of the health system; and replacing the physician-centred healthcare system with a team-based one. This may suggest that, although Iran's investment in healthcare has substantially increased since 2015 (107). the system has not yet succeeded in efficiently using its resources, either financial or human resources.

The priorities also clearly highlighted the significance of addressing questions that seek cost-effective population-level interventions and health system strategies to prevent NCDs and road traffic injuries in Iran. It was also agreed that studying the current and the estimated future distribution of NCDs and their underlying causes across Iran as well as the common health problems in Iran's elderly population should be prioritised. Such results reflect the need for further investment in addressing the knowledge gaps in a country facing a rapidly increasing burden of NCDs (106) with an ageing population (described in section 1.10.5) (440). Such challenges reinforce the need for improving efficiency of the health system.

Although Iran continues to struggle with infectious diseases (441), as described in 1.10.5, the greatest contemporary challenge is the transition to NCDs (106). According to a national NCD Survey conducted in 2011, 20% of Iranian men and women were hypertensive. During the last four decades, the prevalence of adult obesity has increased from 13% to 30% in women and from 4% to 17% in men (442), which may have been the contributor to the doubling of the prevalence of diabetes prevalence between 1980 and 2015, from 5% to 10% (443).

Consensus of the participants also indicated that Iran's success in achieving its long-term health targets requires investment in studying the health impacts of environmental challenges, e.g. water crisis. It has been argued previously that securing sustainable water resources in Iran requires immediate coordinated multi-sectorial action (444). Another top-10 priority highlighted the importance of tailoring medical education to better serve the needs of the society. This question was raised for the primary qualification (e.g. Doctor of Medicine) and was also specified for the curriculum of specialist training in psychiatry.

The questions related to the values embedded in the rich history of medical sciences in Iran were relatively prevalent among the originally proposed RQs (9 out of 128). However, the majority of them were ranked near the bottom of the list. This could suggest that, although a number of Iranian academics agreed that knowledge gaps regarding these issues should be addressed, it seems that it was difficult for these questions to meet the criteria of this exercise. It is likely that in a prioritisation exercise within a different context, e.g. considering a longer time scale, or using a different set of criteria, these questions could receive a higher average score.

It is worth mentioning that since 2000, Iran's MOHME has been building capacity in medical universities across the country and in different departments of the Ministry to carry out research prioritisation exercises (271). Research priorities had been identified either at the national level in specific areas, e.g. prevention of cervical cancer (445), HIV and AIDS (446), and patient safety (447), or at the institutional level, e.g. in health systems research (448), or medical education (449). However, none of these studies had engaged stakeholders from the wider society; the majority lacked a clearly-defined context; and all had used methods that included a panel of experts, rather than a structured and replicable approach.

Furthermore, while efforts to improve governance of health research in a developing country are admirable, it is unclear how the priorities were being set at the national level. It was reported in 2016 that a total of 6,723 'research priorities' were collected from Iran's medical universities (248), but this number is too large to consider each idea a 'priority'. The report (248) continued that the collected research questions were grouped into nine 'main areas', but those were also too broad to be considered priorities that could direct national health research investments. A qualitative study investigated the barriers to evidence-based decision-making in Iran's health system in 2012 (241). The participants identified the following issues: (i) lack of a systematic prioritisation mechanism; (ii) priorities being identified by MOHME and not being communicated with academics; and (iii) priorities being too general, thus failing to guide researchers.

My study adapted the CHNRI method, which has several advantages discussed in Chapter 1 (4, 19, 28, 42). Compared to previous national-level CHNRI exercises conducted in South Africa, India, Brazil, China, and one study that included Malawi, Nigeria, and Zimbabwe (42, 45), this study had a relatively similar time scale, i.e. 5-10 years. Perhaps this shows that it is of more interest for national-level studies to set the priorities with shorter periods in mind. This study had several strengths compared to previous CHNRI exercises. As the method has already been applied in over 50 exercises (42), plenty of published guidance was available to help adapt the method to our needs. The management group considered the modifications in the previous CHNRI studies (42) and this helped to easily reach a consensus over the five criteria most relevant to the present study. Furthermore, previous CHNRI exercises had a response rate between 30-70%, (42) while in this exercise more than 70% of contacted participants responded both to a request to generate RQs and to score them. This shows that the exercise has been successful in engaging the experts with the process and the results are less likely to be biased. Moreover, the wide range of final research priority scores (84.5-28.5%) indicated a good level of discrimination between the RQs in meeting the five criteria. Finally, only about 20% of previous CHNRI exercises had managed to engage an appropriate group of stakeholders in the process (35).

I explored the impact that the stakeholders' assigned weights had on the final ranking of the RQs. Their input led to minor changes in the order of the questions, and also promoted two new RQs among the top-10 priorities, one addressing the common health problems in the elderly and another regarding antibiotic resistance. In the top quartile, notable examples of questions that were helped by the stakeholders' input were: (i) impact of climate change on air quality of Iranian cities and its health effects; (ii) community-based strategies to reduce energy consumption and environmental pollutants to improve health; and (iii) community-based interventions for reducing high-risk behaviours (intravenous drug use, unprotected sex) amongst adolescents living in deprived areas. In summary, the stakeholders' input did not lead to a drastic change in the final ranks, but it helped several RQs with a focus on community participation to improve their ranks.

In terms of the level of agreement among experts, the AEA ranged between 67.5 and 34.5%. All of the RQs that were the most controversial were RQs that have ranked lower than the median RPS of 68.3. The greatest level of controversy seems to have been observed among the questions that were either too broad or too specific.

The identified priorities seem plausible within the context of the study, which involves a country with an ageing population, facing a high burden of NCDs and road traffic injuries while in parts still struggling with endemics of infectious diseases, experiencing accelerated environmental changes, having a large number of students at universities of medical sciences, and undergoing a Health Transformation Plan to achieve UHC. On the other hand, we should analyse why the majority of questions addressing mental health, substance abuse, or dementia did not score highly despite a high burden of disability and death which they cause in Iran (105).

Mental and behavioural disorders have become the main group of diseases causing years of life with disability (YLDs) in Iran (450). Furthermore, substance abuse imposes a large burden among the youth and opium use is still the most prevalent drug use disorder among Iranian adults (451).

It is possible that firstly, the way in which the questions in those areas were framed did not seem feasible enough to the scorers. Secondly, the low scores that these questions have received for impact on economy may suggest insufficient awareness of the majority of the engaged experts about the burden that non-physical health conditions could cause. It is also worth mentioning that while the consensus of experts in this exercise strongly supported the need for investment in further studies on NCDs, one of the top-10 priorities addressed antimicrobial resistance. This highlighted that although communicable diseases are contributing to less DALYs in Iran, they continue to remain important. Diseases such as influenza, brucellosis, and tuberculosis are still major endemics in Iran (452), and the country's capacity in studying and controlling outbreaks of neglected, emerging, and/or re-emerging infectious diseases requires improvements (452).

7.3 Implications for policy

Drawing on the findings from this PhD, Iran's endeavours towards improving the quantity, impact, and quality of health research publications is admirable (312, 315). What requires further attention is to firstly, be aware of the challenges posed by using bibliometric tools in assessment of research activities. Chapters 4 and 5 pointed out the misleading allocation of research areas of documents in WoS; and highlighted that journal IFs cannot be representative of the citation impact of individual papers. Secondly, the limitations of bibliometric tools in assessment of research output and/or impact should be considered (147, 210). One inherent limitation of relying only on bibliometrics is that scientific outputs other than papers—e.g. clinical guidelines, policy documents, or datasets—could be neglected (147, 210, 439). Similarly, it is likely that studies with less chances of publication in prestigious journals—despite having great potentials of leading to societal, economic, or health impacts—would be undervalued, both by the funders and by researchers.

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Furthermore, drawing on the findings of this thesis, the following suggestions could be shared with other LMICs who are to improve their health research output: (i) invest in developing national journals and in supporting them to get indexed in international citation databases for increased international visibility of publications (11, 313). This could help with early identification of potential existing problems in research practices, thus would help with addressing the problems in time; (ii) provide opportunities for collaboration with academic nationals who have emigrated to developed countries, particularly support collaborations with those who have already proved competency and interest in establishing successful collaborations with peers back home; (iii) identify and support researchers who are able to produce high-quality research output while relying only on resources from LMICs; (iv) while resources for conducting high-quality original basic research is limited, promote publication of review articles which could receive international recognition; and finally, (v) avoid over-relying on bibliometrics in academic assessment practices, particularly be aware of the challenges of using journal IF for evaluation of individual papers, and/or researchers.

While increased health research investment is recommended to better use the existing health research capacity in Iran, the investments should be governed in a way that resources would be used efficiently. The identified priorities described in Chapter 6 guide research that is likely to be feasible to be conducted within the next five years, and bear a higher impact on health and economy and lead to capacity building and equity. I hope that this paper will firstly contribute to the field of health research priority-setting as one of the most recent applications of the CHNRI method at a national level. Secondly, this was the first application of the CHNRI method in Iran and we hope that the findings of this study will be utilised in making funding decisions within the next five years. Iran's NIHR has already expressed willingness to use the identified priorities in its upcoming grant application calls. Further advocacy of the findings could be done through holding meetings with decision-makers at different departments of MOHME, the Islamic Parliament Research Center, Academy of Medical Sciences, and research departments of major Iranian universities of medical sciences. Summaries of the results should become available online for open and easy access of all researchers and stakeholders. We also encourage different funding agencies to compute the weights for the criteria using the input from their own major stakeholders to adjust the priorities with their organisations' targets.

It is worth comparing the research papers that were identified as the most impactful research publications, based on the number of citations, with the RQs that were identified as the top priorities. While the identified research priorities covered a diverse range of issues related to health, 90% of the top-ranked questions, had aspects of HPSR. Except the GBD-relevant questions, the rest do not seem to be RQs with a high potential for leading to a large number of citations. Even so, the "crowd wisdom", i.e. the collective input of different researchers, funders and policymakers and other stakeholders who got engaged with the prioritisation study presented in this thesis – identified these research as unmet questions that should be addressed within the next 5 years. This disconnect between the macro investments of countries in research that potentially leads to higher impact based on bibliometric indicators, with research that addresses the real needs of the country is not limited to Iran and is evident in many other LMICs. Therefore, the recommendations from this study has implications in other countries, too.

In Iran, investing and formulating education and research policies towards improvement of bibliometric indicators has been the result of a political will at the macro level. This could be the same case in other countries given the contemporary global competition around scientific achievements as measured by bibliometric indicators. I would recommend that in a similar situation, a proportion of the resources could be allocated to research and research units which have proved that can lead to publications with a potentially high bibliometric impact, while a certain amount of the resources should be allocated to research that would be identified as priorities in a systematic, inclusive, and transparent prioritisation processes. Using a method such as CHNRI has the merit of engaging high-level decision-makers at an early stage which would increase the chances of the results being used by them.

Iran has got a substantial health research capacity (385) and proved interest in prioritising research (271). Now that the CHNRI method has been successfully introduced in Iran, I recommend its application to identify the research priorities in more specific domains, e.g. for certain health conditions with a high burden in Iran, or for specific target populations. It is also recommended to conduct the CHNRI studies at a sub-national level. The development of a Massive Open Online Course (MOOC) for the Iranian audience could facilitate implementation of the method at a larger scale. I also recommend this national-level exercise to be repeated every five years to be aligned with Iran's 5-Year Development Plans. Finally, this exercise was the first implication of the CHNRI method in the WHO EMR. I would encourage Iranian health research policymakers to pursue efforts to share the results with the WHO EMR Office that may assist conduct of the exercise in countries with a similar context to Iran and or at the regional level.

Chapter 8 Concluding remarks

In this chapter, I will firstly reflect on the strengths and limitations of this PhD, will then draw out the key conclusions, and highlight the data gaps that should be addressed in future research.

8.1 Reflections on strengths and limitations

- **Strengths**

The narrative review presented in Chapter 3 was thus far the most comprehensive review of the changes in Iran's health research system over 50 years. The transparent and systematic bibliographic search and the use of an established framework for categorising the retrieved information minimised the limitations of a narrative review while served the advantages of a comprehensive review.

The bibliometric studies presented in chapters 4 and 5 had several advantages as follows: (i) careful inclusion of research areas to increase the coverage, while maintaining the specificity; (ii) using the 'country filed tag' rather than the 'address' filter, which is more specific; (iii) using 'organization-enhanced' for analysing the institutions instead of 'organization', which the former searches the unified name variant of affiliations; (iv) using a novel approach to find different types of collaborations across the Iranian h-core papers; and (v) studying the publications over half a century.

Finally, the health research priority-setting study presented in Chapter 6 was a good example of a national-level health research priority-setting process and a rare example where a national research funding body adapted the process to decide on health research funding in a holistic way. This helped to overcome problems of previous research priority-setting exercises that were described in section 1.12.2, with further implementation now underway in Iran. This exercise also provides a model to public research funding bodies in other countries that could be adapted to improve decision-making on funding allocation for health research, especially in low resource settings.

- **Limitations**

The review of the literature on Iran's HRS (presented in Chapter 3) is subjected to the inherent limitations of a narrative review. One main limitation is that unlike systematic reviews for which there exist established guidelines to ensure rigor of the methods, there are no specific guidelines for conducting and reporting narrative reviews (243). Nonetheless, there are some 'best practice recommendations' to improve transparency and reproducibility of narrative reviews and reducing selection bias (243). This is mostly done by employing an effective bibliographic search strategy and reporting it explicitly (243), which was performed in Chapter 3 of this thesis. In terms of reporting, the structure of section 3.5 was guided by the established HRS framework of the WHO, as described in section 1.5.1.

Still, narrative reviews remain prone to bias as they represent the interpretation of the author from the existing literature. Some potential biases in Chapter 3 could result from my past experiences as follows. Before moving to the University of Edinburgh, I had obtained my first degree from TUMS, had attended several research-relevant courses offered outside the main curriculum at my school, and had contributed to a number of clinical trials. Also, at a smaller Iranian medical university, Mazandaran University of Medical Sciences, I had served both as a Research Associate and a medical journal editorial assistant (published in English). Although I have made substantial efforts to remain committed to the reviewed documents and evidence, my education and work background could have potentially led to some biases.

Finally, it should be noted that although the review presented in Chapter 3 conducted the search only in two databases, this should not be a dramatic limitation as one of the two databases was Google Scholar. As explained in section 1.11.3, Google Scholar indexes literally any scholarly literature that is available on the web (152). Another concern could be that the search only used English keywords, which could have excluded the documents that were fully in Persian. One could argue that this might be the reason for the identified data gaps in many areas. However, it should be mentioned that several of the retrieved and reviewed documents were studies commissioned by MOHME, to evaluate Iran's HRS; this makes it quite unlikely that further relevant information could have been found in the public domain. A more comprehensive review may be possible through a documentary analysis which was outside the scope of this thesis.

The bibliometric studies presented in chapters 4 and 5 had limitations, too. One limitation originates in the way WoS attributes research areas to each document, which is done automatically based on scope of the journals where the documents are published. One consequent problem is that some documents may be included because of having been published in journals with a clinical, biomedical, and/or public health scope while the articles' content may be irrelevant. For the same reason, the retrieved number of publications in each research area could be misleading. It should also be noted that this study only included publications from WoS CC, which are not representative of all the publications arising from Iran. Finally, although careful considerations were made in investigation of the country of origin of the authors (based on the language of the names and/or searching the study and work background of the authors on the Web) and in understanding different types of collaborations (e.g. deciding on whether a project was a consortium) across the h-core papers, this approach could be susceptible to subjective assessment.

Regarding the limitations of the priority-setting study presented in Chapter 6, in general, the findings of the CHNRI exercises may represent a biased opinion of a limited group of involved experts. In terms of the initially proposed RQs, some valid RQs will not be proposed and this is an inherent limitation. In terms of scoring, it has been shown that the collective opinion of the experts in CHNRI processes stabilises with involving 45-50 participants (453). Thus, the number of experts in this study (48 persons) was sufficient to produce robust results, which would be highly unlikely to change with adding further scorers. Regarding diversity of the sample, a considerable effort was made to include experts with a wide range of disciplinary backgrounds and views. Even so, more than 70% of the identified experts had a background in medical sciences. It appears that health research in Iran is very much dominated by medical scientists, even though some may have focused their research on areas that are not purely medical. There does not seem to be a significant difference between the disciplinary backgrounds of the initial invitees, those who generated RQs, and/or the scorers, while the high response rate makes such a bias less likely.

The potential bias in this priority-setting exercise could result from the process through which the experts were identified, because this relied on the input from three members of the steering committee (RM, ZA, and myself), with a snowballing for less represented fields. Following the standard CHNRI guidelines (34), one third of the experts were identified by searching for the most prolific researchers in the fields relevant to the health targets of this exercise. No time limit was considered in the search strategy. The experts were found among the most productive 50 authors in research areas relevant to the scope of this study through searching in Web of Science and Scopus. As described in Appendix

8, I went through a random sample of the publications of the most productive authors to identify whether the papers were original research and could confirm that their authors were real experts in the field. Another applied approach was to identify people who have held scientific roles in Iranian scientific societies, universities, or executive organisations. Careful consideration was given to ensure that the invitees had a good understanding of research in their field, and were not solely holding executive roles.

In total, 11 invitees to the CHNRI exercise presented in Chapter 6 did not participate in generating RQs, nor in the scoring of RQs. Only one invitee declined participation due to concerns over the CHNRI methodology, questioning its ability to replace debate. Of the 50 experts who participated in generating RQs, but did not score them, only one declined for a specific reason, believing that the RQs needed a more comprehensive assessment rather than numerical scores against a set of criteria. The most likely reason for others to decline was time constraint, i.e. failing to meet the deadline for responding.

A review of 50 CHNRI studies has found that the redundancy rate in the initial list of proposed RQs is nearly over 50% (42). In this study it was almost the same: a total of 251 RQs was reduced to 128. During this step, some of the initially proposed descriptive RQs were merged with interventional RQs that addressed the same health problem, and this could have led to biased responses towards one part of the question. Another issue worth mentioning was that, although the compiled list of RQs was refined and revised multiple times by the steering committee before sending out to the scorers, there were still RQs that had some degree of overlap, which was very difficult to avoid completely. Finally, it should be noted that all RQs were initially proposed in Persian, then translated into English by myself to be discussed in the steering committee, and then the compiled list of 128 RQs was back-translated into Persian. Within this process, very careful consideration was taken for translations being well-representative of the original meaning.

8.2 Conclusions

This PhD reviewed Iran's evolution of HRS during the past 50 years. It bears essential lessons to share with three audiences: national-level health research decision-makers in Iran and in other LMICs, as well as international stakeholders, e.g. the WHO - to guide future health research capacity strengthening initiatives. The findings emphasised that improvement of HRS functions requires addressing context-specific problems. For instance, while formulating policies for the governance of health research is a critical component of the stewardship function of the HRS, having the policies in place will not suffice unless the barriers to the implementation of the policies are addressed. In this review, multiple examples were given of success stories regarding different functions of Iran's HRS, that for instance, how one individual with links to influential decision-makers could promote medical research ethics in Iran. Or that how specific regulations in Iranian medical journals increased online accessibility to Iranian clinical trials. Several examples of context-specific challenges were found too, such as the barriers to research priority setting processes, and the obstacles that impede improving publication integrity.

Reviewing the documents in the light of the world literature particularly triggered further thinking about possible approaches that can effectively strengthen HRS in contexts that struggle with the following: (i) high dependence on very few sources of research funds; (ii) centralised decision-making in HRS; (iii) sub-optimal meritocracy in the recruitment of academics and or in appointing individuals to research-relevant executive roles; (iv) a high rate of brain drain and failure in attracting back the diaspora; and (v) limited transparency in resource allocation processes. Indeed, these problems are not exclusive to Iran, EMR, or LMICs, but could be found across the developed world, too.

It was also concluded that Iran has built a great human resource capacity for research, a large number of research centres, and several medical journals that disseminate research originating in Iran and beyond. Nonetheless, the reviewed literature confirmed that research-intensive institutions should also offer an enabling and favourable environment and career prospects to encourage the trained academics to stay in the country. Some recommendations for improvement were increasing health research funds along with accountable allocation mechanisms; ensuring that the competent researchers receive enough resources to pursue high-quality research projects; and incentivising research activities in medical universities as much as the clinical and teaching activities are supported. Finally, it was concluded that the identified barriers to knowledge utilisation should be addressed so that high-quality and need-based research could be translated into policy and practice.

This PhD also indicated that the number of clinical, biomedical, and public health research publications in Iran has significantly increased over the last 5 decades. The output in certain fields, such as pharmacology research has been greater. It seems that in the long term, the quantitative increase has led to an increase in the citation impact. The majority of the highly-cited papers from Iran have been the product of international collaborations, many of the collaborations had become possible with the contribution of Iranian academics abroad. Regarding the Iranian papers that had only relied on national resources, the likelihood of getting cited in the future had been independent of the IF of the journal where the papers were published. The Iranian science policymakers are encouraged to (i) support the researchers and institutions that have proved research capacity; (ii) direct further resources towards research areas and/or institutions that are lagging behind; (iii) facilitate further international collaboration with the academics and/or institutions that have shown the capacity for conducting successful research projects with Iran.

The main messages of the priority-setting study presented in this PhD were that addressing equity by reforming insurance system and improving equality in health services access should be prioritised in Iran. Furthermore, research on preventive strategies for the leading NCDs and road traffic injuries are needed, as well as further epidemiological research on NCDs and the health problems of the elderly population. This should happen in parallel to a tailored curriculum of qualifications in the universities of medical sciences, where a team-based healthcare system should be promoted. Research is also needed on over-/mis-use of antibiotics and the health impacts of water crisis.

8.3 Recommendations for future research

Considering the data gaps that were identified in Chapter 3 regarding the financial, infrastructural, and human resources, a documentary analysis of the health research system in Iran is recommended. Such a study should have access to official documents that may contain unpublished data and or policies regarding health research in Iran. Furthermore, a qualitative investigation of the contributory factors to the growth of health research publications in Iran could provide a more in-depth insight into the underlying reasons of the growth.

As highlighted in the findings of chapters 3, 4, and 5, given the continued international isolation of Iran due to political circumstances, strengthening formal and informal research collaborations between Iranian diaspora and academics in Iran is key to improvement of health research in the country. Therefore, future research in health research system in Iran should investigate the facilitators of and the barriers to scientific international collaboration between academics in Iran and Iranian diaspora. Such a study should lead to recommendations on how the capacity of Iranian academics abroad could be used more effectively.

Regarding health research priorities, now that the CHNRI method has been successfully introduced in Iran, I recommend its application to identify the research priorities in more specific domains, e.g. for certain health conditions with a high burden in Iran, or for specific target populations. I would also recommended to conduct the CHNRI studies at a sub-national level. This would assist with identifying the priorities based on the needs of each region of this relatively large and populous country, where each part deals with particular health challenges ranging from water scarcity and air pollution to substance abuse or challenges imposed by sharing borders with countries in conflict. I would also recommend this national-level exercise to be repeated every five years to be aligned with Iran's 5-Year Development Plans.

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Appendix 1. English translation of the General Health Policies of the Islamic Republic of Iran (GHPs)

GHP 1: Providing health services (including medical and health sciences education and research services, and preventive, curative, and rehabilitative care services) based on human and Islamic principles; and institutionalising such principles in the society as follows:

Improving the system of recruitment, assessment, teaching, and training of the students, faculty members, and directors in scientific and academic environments according to the Islamic, professional and medical codes of ethics

GHP 1.1: Raising awareness in the public about their [health-related] social rights and responsibilities and use the capacity of the healthcare centres to promote spirituality and Islamic ethics in the society

GHP 2: Fulfilling Universal Health Coverage (UHC) in all the laws, regulations, and policies through:

GHP 2.1: Prioritising prevention over treatment

GHP 2.2: Updating national medical and health plans

GHP 2.3: Reducing environmental health hazards and the relevant risk factors based on credible scientific evidence

GHP 2.4: Preparing 'Health Attachments' for the national development projects ['Health Attachment' was a term proposed for the first time in the 5th National Development Plan of Iran—in Section B of Article 32—stating that the national development projects should have an attachment that would discuss the potential health impacts of the project]

GHP 2.5: Improving the health indexes for becoming the first country of the Southwest Asia

GHP 2.6: Improving and complementing the current assessment and monitoring systems to protect [health-related] rights of the patients and the nation and to ensure the proper implementation of the GHPs

GHP 3: Improving mental health of the nation by: promoting the Islamic-Iranian lifestyle; strengthening family foundation; removing factors that cause tension in individual and social life of the people; promoting moral and spiritual teachings; and improving mental health determinants

GHP 4: Establishing and strengthening the required infrastructure for manufacturing pharmaceutical active ingredients and products, vaccines, biologic drugs, and medical devices and equipment that meet the international quality standards

GHP 5: (i) Inhibiting induced demand; (ii) Inhibiting prescription of medications that are outside the clinical guidelines and the Generic National Pharmaceutical System of

Iran; (iii) Policymaking and efficient oversight on manufacturing, use, import of pharmaceuticals, vaccines, biologic drugs, and medical devices aiming to support domestic production and increasing national capacity for export

GHP 6: Supplying food security; and equitably providing healthy and adequate food, clean air and water, public sports facilities, and safe sanitary products that are all approved by the national, regional, and international standard criteria

GHP 7: Sharing the duties regarding stewardship, financial supplying, and providing health services with the aim of responding to the needs, achieving equity, and providing appropriate medical services to the community as follows:

GHP 7.1: Stewardship of the health system by the Ministry of Health and Medical Education (MOHME), including policymaking, designing and implementing plans, designing strategies, evaluation, and oversight of the plans

GHP 7.2: Management of resources in the health sector through the insurance system with the central role of MOHME and the cooperation of other organisations and entities

GHP 7.3: Providing services by resources from the government [e.g. the ministries], the public resources [e.g. the municipalities] and the private sector [e.g. charities]

GHP 7.4: Organising the abovementioned tasks based on the mechanisms that are determined by law

GHP 8: Increasing and improving the quality and the safety of the [health] services and developing a comprehensive and integrative healthcare [system] that focuses on equity and is responsive [to the nation's needs] and emphasises transparent informing, efficacy, efficiency, and productivity within the Primary Health Care (PHC) and is in line with the referral system by:

GHP 8.1: Promoting decision-making and operation based on scientific evidence; and codifying standards and guidelines; undertaking Health Technology Assessment; establishing the referral system by prioritising prevention and health improvement and integrating them with the medical education system

GHP 8.2: Increasing the quality and the safety of healthcare services by promoting clinical authority and determining standards

GHP 8.3: Codifying a comprehensive healthcare plan to support disabled people and disabled Iranian veterans aiming to improve their health status and to empower them

GHP 9: Improving the quantity [the number of people who are covered] and the quality of health and medical insurance aim to:

GHP 9.1: Achieving universal public health insurance

GHP 9.2: Achieving full coverage of basic medical needs by insurance companies for all to reduce the patients' share in medical expenses

GHP 9.3: Providing services beyond the basic insurance by complementary insurance that follows transparent regulatory frameworks

GHP 9.4: Preparing packages of comprehensive health and medical services at the levels of basic and complementary insurance by MOHME

GHP 9.5: Strengthening a competitive market for medical insurance companies

GHP 9.6: Codifying tariff policies based on evidence

GHP 9.7: Modifying the payment models, in a way that it would be based on the quality of services, be more efficient, and would pay special attention to health promotion activities and to prevention in deprived areas

GHP 10: Sustainable health financing

GHP 10.1: Making the amount of expenses, activities, and earnings [within the health system] transparent

GHP 10.2: Increasing the proportion of the Gross Domestic Product (GDP) and the public budget that is invested in health. In this way Iran's investment in [healthcare] should exceed the average investment of the countries in the region [The Middle East], thus it would fulfil the targets as set in the Vision policy [Iran's 20-year national strategic plan by 2025].

GHP 10.3: Adding taxes on products that can be harmful to health

GHP 10.4: Improving the equitable distribution of government healthcare subsidies

GHP 11: Raising awareness, responsibility, capability, and systematic and active participation of individuals, families, and the community in supplying, maintaining, and improving health by using the capacity of different cultural and educational entities as well as the media, under the supervision of MOHME.

GHP 12: Studying, understanding, developing, promoting, and institutionalising traditional Iranian medicine

GHP 12.1: Prompting cultivation of medicinal plants under the supervision of the Ministry of Agriculture Jihad and supporting the development of technical and scientific innovations in manufacturing traditional medicines under the supervision of MOHME

GHP 12.2: Standardising and updating the diagnostic and curative methods that are recommended in traditional Iranian medicine

GHP 12.3: Exchanging knowledge with other countries regarding traditional medicine

GHP 12.4: MOHME supervising the provision of health services and products that use traditional Iranian medicine

GHP 12.5: Establishing links between traditional Iranian medicine and modern medicine

GHP 12.6: Modifying people's lifestyle, particularly their diet [by using traditional Iranian medicine]

GHP 13: Improving the quantity [increasing the capacity] and the quality of the medical education system [in Iran] to make it become targeted, health-oriented, and based on the needs of the nation; and efficiently training human resources to respond to the needs in an equitable manner, and [training people in a way that they] would be committed to the Islamic and professional ethics and would have essential skills to respond to population health needs across different parts of the country

GHP 14: Revolutionising medical research [medical research system in Iran] strategically with an approach to [promote] innovation system and planning for making Iran a pioneer in science, technology, and in the provision of medical services and making Iran to become a medical hub in Southwest Asia and in the Islamic world

Appendix 2. List of the 48 included biomedical, clinical, and public health research areas

'Research Areas' is a classification scheme aiming to be the indexing backbone by which all WoS products have their content classified. The forty-eight included research areas were the following:

Pediatrics or tropical medicine or urology nephrology or endocrinology metabolism or pathology or reproductive biology or radiology nuclear medicine medical imaging or toxicology or pharmacology pharmacy or life sciences biomedicine other topics or allergy or research experimental medicine or obstetrics gynecology or physiology or general internal medicine or microbiology or biochemistry molecular biology or psychiatry or hematology or neurosciences neurology or medical laboratory technology or gastroenterology hepatology or health care sciences services or orthopedics or cell biology or virology or public environmental occupational health or genetics heredity or rheumatology or biotechnology applied microbiology or respiratory system or infectious diseases or immunology or transplantation or nutrition dietetics or mycology or veterinary sciences or surgery or dentistry oral surgery medicine or ophthalmology or otorhinolaryngology or dermatology or rehabilitation or nursing or integrative complementary medicine or oncology or parasitology or cardiovascular system cardiology

Appendix 3. Analysis results of all the 72,686 retrieved Iranian biomedical, clinical, and public health research, indexed in Web of Science Core Collection, published 1965-2014

Sheet 3 of the Microsoft Excel (Microsoft Inc, Seattle WA, USA) file available at: http://www.jogh.org/documents/issue201802/jogh-08-020701-s001.zip

Appendix 4. List of the 155 Iranian h-core publications (1965-2014), indexed in Web of Science Core Collection, ranked by their year of publication, and then by citation count within each year

Table S2 of the Microsoft Word (Microsoft Inc, Seattle WA, USA) file available at:

http://www.jogh.org/documents/issue201802/jogh-08-020701-s001.zip

Appendix 5. Analysis results of the 155 h-core Iranian biomedical, clinical, and public health publications indexed in Web of Science Core Collection (published 1965-2014) - Citations counted by the end of 2017

Sheet 4 of the Microsoft Excel (Microsoft Inc, Seattle WA, USA) file available at:

http://www.jogh.org/documents/issue201802/jogh-08-020701-s001.zip

Appendix 6. Journals that had published the 48 'only Iranian' h-core papers, information retrieved from Journal Citation Reports

Sheet 5 of the Microsoft Excel (Microsoft Inc, Seattle WA, USA) file available at:

http://www.jogh.org/documents/issue201802/jogh-08-020701-s001.zip

Appendix 7. Health-related targets of the United Nations' Sustainable Development Goals (SDGs)

SDG (3.1) By 2030, reduce the global maternal mortality ratio to less than 70 per 100,000 live births

SDG (3.2) By 2030, end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1000 live births and under-5 mortality to at least as low as 25 per 1,000 live births

SDG (3.3) By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases.

SDG (3.4) By 2030, reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being.

SDG (3.5) Strengthen the prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol.

SDG (3.6) By 2020, halve the number of global deaths and injuries from road traffic accidents.

SDG (3.7) By 2030, ensure universal access to sexual and reproductive healthcare services, including for family planning, information and education, and the integration of reproductive health into national strategies and programmes.

SDG (3.8) Achieve universal health coverage, including financial risk protection, access to quality essential healthcare services and access to safe, effective, quality and affordable essential medicines and vaccines for all.

SDG (3.9) By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution, and contamination.

SDG (3.a) Strengthen the implementation of the WHO Framework Convention on Tobacco Control in all countries (including controlling production and consumption)

SDG (3.b) Support the research and development of vaccines and medicines for the communicable and non-communicable diseases that primarily affect developing countries, provide access to affordable essential medicines and vaccines, in accordance with the Doha Declaration on the TRIPS Agreement and Public Health, which affirms the right of developing countries to use to the full the provisions in the Agreement on Trade-Related Aspects of Intellectual Property Rights regarding flexibilities to protect public health, and, in particular, provide access to medicines for all.

SDG (3.c) Substantially increase health financing and the recruitment, development, training and retention of the health workforce in developing countries

SDG (3.d) Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks.

SDG (2.2) By 2030 end all forms of malnutrition, including achieving by 2025 the internationally agreed targets on stunting and wasting in children under five years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women, and older persons.

SDG (6.1) By 2030, achieve universal and equitable access to safe and affordable drinking water for all

SDG (6.2) By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations

SDG (7.1) By 2030, ensure universal access to affordable, reliable and modern energy services (Clean household energy to use for cooking, heating and light)

SDG (11.6) By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management

SDG (13.1) Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries

SDG (16.1) Significantly reduce all forms of violence (i.e. physical, mental, or sexual violence) and related death rates and conflict-related deaths

SDG (16.2) End abuse, exploitation, trafficking and all forms of violence against and torture of children

Appendix 8. The bibliometric method for identification of experts to invite to the priority-setting study

I searched through two international bibliographic databases (Web of Science and Scopus) for prolific authors who could potentially be identified as experts. Instead of searching keywords, I first retrieved all the publications with at least one author affiliated to Iranian organisations. This was done by the 'Advanced Search' feature on Web of Science and running the search for 'CU= Iran', while in Scopus's 'Advanced Search', I searched 'Iran' as the 'Affiliation Country'. In this way, in both databases, all the publications with at least one Iranian author were retrieved. Then, I refined the search results by research areas to get closer to the health targets included in this prioritisation exercise. Refining the results in Web of Science was back then carried out by the option 'Research Areas', which pretty much serves the same purpose of 'Subject Category' in the current version of the product. In Scopus, the research areas were represented by 'Subject Area', which is a less elaborated version of the refine panel on Web of Science. Meaning that it has fewer options, thus I looked into all of them. In Web of Science, at the first step, to broadly identify any publication relevant to biomedical, clinical, and public health, first, the search results were refined by the following areas:

'pediatrics or tropical medicine or urology nephrology or endocrinology metabolism or pathology or reproductive biology or radiology nuclear medicine medical imaging or toxicology or pharmacology pharmacy or life sciences biomedicine other topics or allergy or research experimental medicine or obstetrics gynecology or physiology or general internal medicine or microbiology or biochemistry molecular biology or psychiatry or hematology or neurosciences neurology or medical laboratory technology or gastroenterology hepatology or health care sciences services or orthopedics or cell biology or virology or public environmental occupational health or genetics heredity or rheumatology or biotechnology applied microbiology or respiratory system or infectious diseases or immunology or transplantation or nutrition dietetics or mycology or veterinary sciences or surgery or dentistry oral surgery medicine or ophthalmology or otorhinolaryngology or dermatology or rehabilitation or nursing or integrative complementary medicine or oncology or parasitology or cardiovascular system cardiology'.

This refinement resulted in retrieving the Iranian publications with some relevance to health research. Then, once again, I narrowed down the results by excluding the irrelevant and including some further relevant areas, as listed in the table on the following page (ordered alphabetically).

Number of the area	Included research areas	Number of the area	Included research areas
1	Anthropology	36	Pathology
2	Cardiac & Cardiovascular Systems	37	Pediatrics
3	Clinical Neurology	38	Peripheral Vascular Disease
4	Critical Care Medicine	39	Pharmacology & Pharmacy
5	Demography	40	Plant Sciences
6	Ecology	41	Primary Health Care
7	Economics	42	Psychiatry
8	Education & Educational Research	43	Psychology
9	Education, Scientific Disciplines	44	Psychology, Applied
10	Emergency Medicine	45	Psychology, Clinical
11	Endocrinology & Metabolism	46	Psychology, Multidisciplinary
12	Environmental Sciences	47	Public, Environmental & Occupational Health
13	Family Studies	48	Rehabilitation
14	Gastroenterology & Hepatology	49	Religion
15	Genetics & Heredity	50	Reproductive Biology
16	Geriatrics & Gerontology	51	Respiratory System
17	Gerontology	52	Rheumatology
18	Health Care Sciences & Services	53	Social Sciences, Biomedical
19	Health Policy & Services	54	Social Sciences, Interdisciplinary
20	Hematology	55	Social Work
21	Immunology	56	Sociology
22	Infectious Diseases	57	Substance Abuse
23	Integrative & Complementary Medicine	58	Surgery
24	Management	59	Toxicology
25	Marine & Freshwater Biology	60	Transplantation
26	Medical Informatics	61	Transportation
27	Medicine, General & Internal	62	Tropical Medicine
28	Medicine, Research & Experimental	63	Urology & Nephrology
29	Neurosciences	64	Virology
30	Nursing	65	Water Resources
31	Nutrition & Dietetics	66	Women's Studies
32	Obstetrics & Gynecology		
33	Oncology		
34	Orthopedics		
35	Parasitology		

In both databases, I retrieved the publications in each 'research area' and analysed them for 'authors' to get the authors' names ranked based on publication counts. What should be highlighted in this regard is that in the refine panel of the Web of Science, there is a limit for the number of 'shown' research areas. Therefore, I had to exclude irrelevant research areas, (e.g. nanomedicine nanotechnology, anesthesiology, sport sciences, radiology nuclear medicine medical imaging, biochemistry molecular biology) to ensure that relevant areas with possibly fewer number of publications (e.g. geriatrics gerontology, sociology) would not be missed. I repeated this exclusion up to the point where the areas with less than 20 records appeared in the refine panel. In terms of the research areas that I looked into, as it is shown in Table 1 in this letter, in addition to certain areas that seemed very relevant (e.g. public environmental occupational health; health care sciences services), I analysed the results for any area that could possibly be relevant. For instance, any area that could cover communicable or non-communicable diseases, or could provide publications of studies with aspects other than medical sciences, e.g. sociology, economics. It should be emphasised that the records in each area were analysed for authors separately, instead of looking for the most productive authors in the total publications.

Regarding the strategy for going through the publications, I screened the titles and abstracts of nearly 25-50% of a random sample of the records by the top 20 authors (with seemingly Iranian names) in each area to ensure that the publications were original research in the respective fields of our interest. In the areas with fewer number of publications, I went through more than 25% of the records.

Appendix 9. English translation of letters to the experts for invitation to generating research questions for the priority-setting study

Dear [Title and Surname],

Greetings and respect [This is how formal Iranian letters begin],

As you know, there are two major commitments in the country for health that the first one is the General Health Policies, **notified by the Grand Supreme Leader** and the second one are Sustainable Development Goals that include targets to ensure healthy lives and to promote well-being for all at all ages, which is of prime concern to all of the people who work in the health field. Undoubtedly, our success in achieving the targets as set by these two documents depends on the strategic and effective use of our country’s resources, such as in the use of available resources for health research. To assist with this process, we would like to invite you **as one of the 40 distinguished experts in the relevant research fields** to take part in a **health research priority** setting exercise; an exercise that brings together funders, researchers and stakeholders in deciding the most targeted, yet feasible research ideas or questions in the next five years that could help Iran meet its longer term health targets. For example, the National Institute of Health Research has decided to use the results of this prioritisation to inform funding decisions in its future funding cycles.

In this exercise, the Child Health and Nutrition Research Initiative’s (CHNRI) method is used; a method that has been co-developed by Professor Igor Rudan and Associate/Professor Kit Chan. Dr Mansoori, who is undertaking her PhD thesis under the supervision of Ass./Prof. Chan, Prof. Rudan and me is keen on implementing this method **for the first time in the Middle East**, in our country Iran. The CHNRI method has so far been used to identify health research priorities in over 50 studies led by multilateral organisations (e.g. WHO, UNICEF), national governments (e.g. Chin, India and South Africa) and various funding agencies [1-5]. Unlike the older methods, CHNRI uses a systematic and transparent approach to priority setting and it allows researchers complete independence in the generation and scoring of the collected research questions.

Furthermore, it involves funders and other stakeholders early in the process to ensure relevance and ownership of the findings [6]. Should you be interested in reading more about the CHNRI method and its applications, at the end of this email various links to the relevant publications are kindly provided. It should be mentioned that many CHNRI exercises **have thus far been published in prestigious journals including The Lancet, Lancet Neurology, and PLoS**

Medicine, and are often open-access to encourage broad readership [2-4]. While we cannot guarantee the journal in which the paper resulting from this exercise will be published, we do intend to submit the manuscript to a relevant journal of the same prestige, and would like to invite all research participants to join us in corporate or group authorship.

If you are willing to participate, in the first instance, please complete the attached Instruction file by jotting **down 3 to 5 research questions or ideas** that in your opinion, if they are carried out within the next 5 years would assist Iran in achieving its long term targets as set by the abovementioned documents. As right now is an exceptional time to conduct this exercise, we would be extremely grateful if you could kindly email the questions/ideas by **[insert date]** to **me or to Dr Mansoori at (parisamansouri87@gmail.com)**. Should you have any questions, please do not hesitate to contact me or her by email or by phone at (0098)912-3135299.

The success of this priority-setting exercise completely depends on the collective inputs of the most distinguished health researchers of the country particularly yourself. Hence, we hope you will participate in this endeavour.

Yours sincerely,

Dr Seyed Reza Majdzadeh

Head of the National Institute of Health Research [signed manually]

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-cc: Dr Parisa Mansoori

Appendix 10. A sample of an original letter to the experts for invitation to generating research questions for the priority-setting study

تاریخ: ۱۳۹۶/۳/۳۱

جمهوری اسلامی ایران
وزارت بهداشت و درمان وآموزش پزشکی
موسسه ملی تحقیقات سلامت

دانشگاه علوم پزشکی و خدمات بهداشتی،درمانی تهران

بسمه تعالی

جناب آقای دکتر منتظری
ریاست محترم پژوهشکده علوم بهداشتی جهاد دانشگاهی
با سلام و عرض ادب

همان‌گونه که مستحضرید، دو تعهد مهم برای سلامت کشور وجود دارد که نخستین آن سیاست‌های کلی سلامت، **ابلاغیِ مقام معظم رهبری** و دومین آن **آرمان‌های توسعه‌ی پایدار** است که اهدافی را برای تضمینِ زندگیِ سالم و ترویج زندگی مطلوب برای همه و در تمامی سنین شامل می‌شود که همانا دغدغه‌ی اصلی همه‌ی کسانی است که در حوزه‌ی سلامت فعالیت می‌کنند. بی‌تردید، موفقیت کشورمان در دستیابی به اهداف اسناد ذکرشده در گروی استفاده‌ی راهبردی و کارآمد از منابع کشور از جمله در پژوهش است. برای کمک به این فرآیند، از جنابعالی به **عنوان یکی از ۴۰ صاحب‌نظرِ برجسته در حوزه‌های پژوهشی مرتبط** دعوت به عمل می‌آید که در پیشبرد فرآیند **تعیین اولویت پژوهشی** در سلامت مشارکت نمایید؛ فرآیندی که نهادهای بودجه‌دهنده، پژوهشگران و ذی‌نفعان را برای شناسایی هدفمندترین سوالات پژوهشی که در عین حال قابل پاسخ‌گویی طی ۵ سال آینده هستند گردهم می‌آورد تا ایران را در دستیابی به اهداف درازمدت سلامتش یاری بخشد. از جمله اینکه، موسسه ملی تحقیقات سلامت تصمیم دارد از نتایج این اولویت‌بندی در برنامه‌های آتی خود برای تخصیص منابع پژوهشی استفاده نماید.

در این فرآیند اولویت‌بندی از روش Child Health and Nutrition Research Initiative (CHNRI) استفاده می‌شود؛ روشی که توسط دکتر Igor Rudan و دکتر Kit Chan طراحی شده و خانم دکتر منصوری که پایان‌نامه‌ی مقطع PhD خود را زیر نظر بنده، دکتر رودان و دکتر چان انجام می‌دهند تمایل دارند این روش را **برای نخستین بار در منطقه‌ی خاورمیانه**، در کشورمان ایران، اجرا کنند. روش CHNRI تاکنون در بیش از ۵۰ مطالعه برای تعیین اولویت‌های پژوهشی سلامت از طرف سازمان‌های بین‌المللی از جمله WHO و یونیسف، از طرف دولت‌های چین، هند و آفریقای جنوبی و نیز نهادهای بودجه‌دهنده‌ی مختلف استفاده شده است [۱-۵]. برخلاف روش‌های قدیمی‌تر، روش CHNRI رویکردی نظام‌یافته و شفاف داشته و به پژوهشگران امکان می‌دهد به صورت کاملاً مستقل ایده‌های پژوهشی‌شان را نوشته و به فهرستی از ایده‌های جمع‌آوری‌شده امتیاز دهند. همچنین، نهادهای بودجه‌دهنده و ذی‌نفعان را از مراحل ابتدایی مطالعه درگیر می‌کند، به گونه‌ای که این افراد و نهادها یافته‌های مطالعه را از آنِ خود دانسته و از نتایجش استفاده کنند [۶]. چنانچه تمایل دارید بیشتر در مورد روش CHNRI و کاربردهای آن مطالعه بفرمایید، در انتهای این دعوت‌نامه فهرستی از پیوندهای مقالات مرتبط خدمتتان تقدیم شده است. لازم به ذکر است که **نتایج بسیاری از مطالعات پیشین CHNRI تاکنون در مجلات بسیار معتبر از جمله The Lancet، Lancet Neurology و PloS Medicine** که عموماً هم با دسترسی رایگان هستند و مخاطب گسترده‌ای دارند منتشر شده‌اند [۲-۴]. اگرچه ما نمی‌توانیم تضمین کنیم که نتایج این مطالعه در چه مجله‌ای چاپ خواهد شد، هدفمان این است که مقاله‌ی حاصل از این مطالعه را به مجلاتی با اعتباری در حد مجلات مذکور ارسال نموده و تمایل داریم تمام پژوهشگرانی که در این مطالعه شرکت می‌کنند در فهرست نویسندگان به صورت **corporate** یا **group authorship** حضور یابند.

چنانچه تمایل به مشارکت در این مطالعه دارید، برای شروع، لطفاً در فایل دستورالعملِ پیوست **۳ تا ۵ سوال یا ایده‌ی پژوهشی‌ای** را که از دیدگاه جنابعالی، در صورت انجام طی ۵ سال آینده، کشورمان را در دستیابی به اهداف درازمدتش با توجه به اسنادِ اشاره‌شده یاری می‌بخشند، بنویسید. از آنجایی که اکنون زمانی استثنایی برای انجام این کار است، از شما بینهایت سپاس‌گزار خواهم بود، چنانچه سوالات یا ایده‌های پژوهشی‌تان را **تا تاریخ ۱۳۹۶/۴/۷ برای اینجانب و یا خانم دکتر منصوری** به آدرس

نشانی پستی: تهران- بلوار کشاورز –خیابان وصال شیرازی – خیابان بزرگمهر شرقی – پلاک ۷۰
تلفنهای تماس: ۶۲۹۲۱۱۵۹-۶۶۴۰۷۸۲۲نمابر: ۶۶۴۰۷۷۵۴کد پستی : ۱۴۱۶۸۳۳۴۸۱

جمهوری اسلامی ایران
وزارت بهداشت و درمان وآموزش پزشکی
موسسه ملی تحقیقات سلامت

تاریخ: ۱۳۹۶/۳/۳۱

:انشگاه علوم پزشکی و خدمات
بهداشتی،درمانی تهران

parisamansouri87@gmail.com ایمیل بفرمایید. برای طرح هر سوالی در مورد این مطالعه نیز خواهشمند است با بنده یا ایشان از طریق ایمیل و یا شماره‌ی ۰۹۱۲۳۱۳۵۲۹۹ تماس حاصل فرمایید. موفقیت این فرآیند تعیین اولویت پژوهشی کاملاً وابسته به مشارکت پژوهشگران برجسته‌ی کشور در حوزه‌ی سلامت، به‌خصوص جنابعالی است. بنابراین، امیدواریم که جنابعالی در پیشبرد این فعالیت مشارکت نمایید.

با احترام

دکتر سیدرضا مجدزاده
رییس موسسه ملی تحقیقات سلامت جمهوری اسلامی ایران

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رونوشت: دکتر پریسا منصوری

نشانی پستی: تهران- بلوار کشاورز –خیابان وصال شیرازی – خیابان بزرگمهر شرقی – پلاک ۷۰
تلفنهای تماس: ۶۲۹۲۱۱۵۹-۶۶۴۰۷۸۲۲نمابر: ۶۶۴۰۷۷۵۴کد پستی : ۱۴۱۶۸۳۳۴۸۱

Appendix 11. English translation of the instructions sent to the experts for generating research questions for the priority-setting study

Instructions

Greetings and respect [This is how formal Iranian letters begin]

Thank you very much for your interest to participate in setting health research priorities
Your participation involves 2 steps, both of which will be completed **only via email correspondences** and there is no need to attend meetings

In the first instance, we would ask you to write down, in the next page, **3 to 5 distinct research questions that are answerable in the next five years** and could help Iran achieve its General Health Policies and health-related targets of the Sustainable Development Goals (The General Health Policies and a list of health-related targets of the Sustainable Development Goals are attached in a PDF file for your kind reference). We would ask you to kindly next to each one of your proposed research questions/ideas write down the number of policy/policies and/or target/targets that your question is covering. Indeed, it is likely that one research question would cover several policies and/or targets at the same time. [We expected that the researchers might propose research questions without being attentive to their relevance to the health targets that are considered in this study. That is why they were asked to specify which target/targets each of their proposed research idea/question was covering].

We would be grateful if you could kindly email back your research questions/ideas by [insert date] to me or to Dr Mansoori

Once we have received research questions/ideas from all our participants, we will compile the questions into a list, and ask you to score the questions against a set of pre-determined criteria.
If, for any reason, you would not be able to provide us with your research questions at this stage but would like to participate in the scoring of the research questions, please kindly inform me or Dr Mansoori by email or by phone at (0098)9123135299.

We sincerely appreciate your attention to this study.

Best wishes,

Seyed Reza Majdzadeh [with no signature]

Research Questions/Ideas

____

____

Research question/idea number 1 covers policy/policies/target/targets number/s____

____

____

Research question/idea number 2 covers policy/policies/target/targets number/s ____

____

____

Research question/idea number 3 covers policy/policies/target/targets number/s ____

____

____

Research question/idea number 4 covers policy/policies/target/targets number/s ____

____

____

Research question/idea number 5 covers policy/policies/target/targets number/s ____

Appendix 12. A sample of an original instruction sent to the experts for generating research questions for the priority-setting study

دستورالعمل

با سلام و عرض ادب

از تمایل سرکار عالی برای مشارکت در تعیین اولویت‌های پژوهشی سلامت بسیار سپاس‌گزاریم. مشارکت شما شامل دو مرحله خواهد بود که هر دو مرحله **تنها از طریق مکاتبات ایمیلی** صورت گرفته و نیازی به شرکت در جلسات حضوری نیست.

در مرحله‌ی نخست، از سرکار عالی خواهش می‌کنیم **۳ تا ۵ سوالِ پژوهشیِ مشخص و قابل پاسخگویی طی پنج سال آینده را** که می‌تواند به ایران در تحقق سیاست‌های کلی سلامت و اهداف مربوط به سلامت در آرمان‌های توسعه‌ی پایدار یاری بخشد، **در صفحه‌ی بعد** بنویسید. سیاست‌های کلی سلامت و نیز فهرست اهداف مربوط به سلامت در آرمان‌های توسعه‌ی پایدار در فایل PDF پیوست جهت مطالعه خدمتتان تقدیم می‌شود. از سرکار عالی خواهشمندیم کنار هر یک از سوالات یا ایده‌های پژوهشیِ پیشنهادیِ خود **شماره‌ی هدف/اهداف و یا سیاست/سیاست‌هایی** را که سوال مورد نظرتان پوشش می‌دهد ذکر بفرمایید. قطعاً احتمال دارد یک سوال پژوهشی هم‌زمان چندین هدف و یا سیاست را پوشش دهد.

چنانچه لطف بفرمایید و تا تاریخ ۱۳۹۶/۴/۷ سوالات یا ایده‌های پژوهشی‌تان را به اینجانب یا به خانم دکتر منصوری به آدرس parisamansouri87@gmail.com ایمیل بفرمایید از شما بسیار ممنون می‌شویم.

پس از آنکه سوالات و ایده‌های پژوهشی را از تمام پژوهشگرانی که با این مطالعه همکاری می‌کنند دریافت کردیم، فهرستی از سوالات تهیه کرده و خدمتتان می‌فرستیم که لطف فرموده و بر اساس معیارهایی از پیش‌تعیین‌شده به هر سوال امتیاز بدهید.

چنانچه در این مرحله به هر دلیلی نتوانید سوالات پژوهشی‌تان را در اختیارمان قرار دهید ولی تمایل به شرکت در مرحله‌ی دوم (امتیازدهی به سوالات) دارید، لطفاً به بنده یا خانم دکتر منصوری به آدرس ایمیل **parisamansouri87@gmail.com** و یا شماره‌ی ۰۹۱۲۳۱۳۵۲۹۹ اطلاع دهید.

از توجه شما به این مطالعه سپاس‌گزاریم.

با احترام

دکتر سیدرضا مجدزاده

سوالات یا ایده‌های پژوهشی

(۱) ____________________

ایده یا سوال پژوهشی شماره‌ی ۱ سیاست/سیاست‌های/هدف/اهداف شماره‌ی/شماره‌های ____________________ را پوشش می‌دهد.

(۲) ____________________

ایده یا سوال پژوهشی شماره‌ی ۲ سیاست/سیاست‌های/هدف/اهداف شماره‌ی/شماره‌های ____________________ را پوشش می‌دهد.

(۳) ____________________

ایده یا سوال پژوهشی شماره‌ی ۳ سیاست/سیاست‌های/هدف/اهداف شماره‌ی/شماره‌های ____________________ را پوشش می‌دهد.

(۴) ____________________

ایده یا سوال پژوهشی شماره‌ی ۴ سیاست/سیاست‌های/هدف/اهداف شماره‌ی/شماره‌های ____________________ را پوشش می‌دهد.

(۵) ____________________

ایده یا سوال پژوهشی شماره‌ی ۵ سیاست/سیاست‌های/هدف/اهداف شماره‌ی/شماره‌های ____________________ را پوشش می‌دهد.

Appendix 13. Overview of the experts' background, participation in the priority-setting exercise, and responses

Table S5 of the Microsoft Word (Microsoft Inc, Seattle WA, USA) file available at:

http://www.jogh.org/documents/issue201802/jogh-08-020702-s001.zip

Appendix 14. The initial nine agreed criteria for the priority-setting study

No.	Potential Criteria	Definition
1	**Impact on health**	*Results of this research have a high potential to improve health by:* (1) reducing disease incidence and/or prevalence; (2) reducing social, environmental and individual risk factors of ill health; (3) shaping future health planning and implementation; (4) improving health services delivery by improving acceptability, accessibility, suitability, efficiency, efficacy, effectiveness, and/or safety of treatment or service; and/or (5) improving societal and system preparedness for future health challenges.
2	**Impact on economy**	Results of this research have high potential in: (1) having direct effect on the production of materials or consumer services; (2) optimising the earlier goods and/or products (increasing quality and/or reducing production costs); (3) creating knowledge based entrepreneurship; (4) decreasing days of work missed due to illness or disability for patients and caregivers; (5) reducing opportunity costs for patients and caregivers; (6) reducing impact on direct patient costs as well as health and welfare systems; and (7) reducing caregiver burden and its associated financial costs (including health care costs for caregivers).
3	**Impact on Iran's scientific rank**	*Results of this research have high potential to lead to:* (1) multiple publications in peer-reviewed journals; (2) publications in prestigious journals; and/or (3) highly cited publications.
4	**Capacity building**	*Results of this research have a high potential to lead to:* (1) education and training in Iran's human resources; (2) the acquisition of new skills by the research team; and/or (3) investment to improve research facilities/amenities where the study will be undertaken, e.g purchasing software/equipment
5	**Feasibility**	(1) There is sufficient capacity to carry out this research; (2) It is possible to provide training for the staff who would undertake this research; (3) The research is doable in an ethical way within the next 5 years.
6	**Equity**	*Results of this research have high potential to:* (1) lead to interventions or services that will be accessible and affordable to everyone, including members of vulnerable groups; (2) lead to policy, plans, interventions or services that could reduce health inequality. This could be achieved by policies or interventions that target and empower vulnerable groups to reduce risk and disease exposures and/or improve access to services or interventions.
7	**Potential for translation**	Results of this research have high potential to be used in Iran
8	**Impact on creating wealth**	*Results of this research have high potential to lead to:* (1) production of new products/services; (2) improvement of existing products, i.e. by increasing their quality/reduction of manufacturing costs; and/or (3) knowledge-based entrepreneurship.
9	**Long-term impact**	Results of this research have high potential to lead to impact in the long run.

Appendix 15. English translation of letters to the experts for invitation to scoring research questions for the priority-setting study

[Version 1: To those who participated in generating research questions]
[The letter was written in the NIHR letterhead].

In the Name of God

Dear [title and name],
Greetings and respect [this is how Iranian formal letters begin],
Thank you again for your continuous interest and support in participating in the first step of the national health research priority setting exercise in Iran.

Fifty distinguished researchers (see file attached) have participated in generating a total of 251 research questions/ideas for funding in the next five years that could help our nation achieve the health targets set out in our General Health Policies and SDGs. As many of the research questions overlapped, we have consolidated them into a list of **128 research questions**. All research questions were reworded to provide consistency in style and format. We have invested a lot of effort to ensure the consolidated questions remain truthful to the ideas and meaning of the original research questions, but sincerely apologise for any unintended oversights.

We would now like to invite you to extend your support by participating in the next step of the exercise by independently **scoring the consolidated list of research questions in the attached Excel file**. The task could take a couple of hours of your time. You will not be required to attend any meetings. If you choose to participate (which we hope you do), we would like to invite you to be a corporate/group author on the publication resulting from this exercise.

We have taken the liberty of attaching with this email the 'Instructions for Scoring', 'The Criteria Sheet', and the 'Scoring Sheet' in three separate files.

We would be extremely grateful if you could kindly return the completed Scoring Sheet **tome** by **[insert date]**. Should you have any questions regarding scoring, please do not hesitate to contact me or her.
We sincerely hope to have your support in for this extremely important study that could help shape our nation's health research investment.

Yours sincerely,

Dr Seyed Reza Majdzadeh [He is a professor, but the title 'Professor' is not used in Iran**]**
Head of the National Institute of Health Research
[Signature]

-cc: Dr Parisa Mansoori

[Version 2: To those who did not generate research questions]

In the Name of God

Dear [title and name],
In the first step of the health research priority setting exercise in Iran, fifty distinguished researchers (see file attached) have participated in generating a total of 251 research questions/ideas for funding in the next five years that could help our nation achieve the health targets set out in our General Health Policies and SDGs. By investing a lot of effort in merging overlapping questions, we have consolidated them into a list of **128 research questions, which each should be scored independently against 5 criteria. The research questions that score higher would be identified as the research priorities.**

We would now like to invite you to participate in the second step of this exercise by independently **scoring the consolidated list of research questions in the attached Excel file**. The task could take a couple of hours of your time although it does not require attending any meetings. If you choose to participate (which we hope you do), we would like to invite you to be a corporate/group author on the publication resulting from this exercise. Unfortunately, at this step adding new research questions/ideas to the list is not possible.

We have taken the liberty of attaching with this email the 'Instructions for Scoring', 'The Criteria Sheet', and the 'Scoring Sheet' in three separate files.

We would be extremely grateful if you could kindly return the completed Scoring Sheet by **[insert date]**. Should you have any questions regarding scoring, please do not hesitate to contact me or her.
We sincerely hope to have your support in for this extremely important study that could help shape our nation's health research investment.

Yours sincerely,

Dr Seyed Reza Majdzadeh [He is a professor, but the title 'Professor' is not used in Iran**]**
Head of the National Institute for Health Research
[Signature]

-cc: Dr Parisa Mansoori

Appendix 16. A sample of an original letter to the experts for invitation to scoring research questions for the priority-setting study

[Version 1: To those who participated in generating research questions]

جمهوری اسلامی ایران
وزارت بهداشت و درمان وآموزش پزشکی
موسسه ملی تحقیقات سلامت

دانشگاه علوم پزشکی و خدمات بهداشتی،درمانی تهران

تاریخ : ۱۳۹۶/۰۷/۱۹
شماره : ۹۶/ص/۲۴۱/۴۹۱
پیوست : دارد

بسمه تعالی

جناب آقای دکتر منتظری

رییس محترم پژوهشکده علوم بهداشتی جهاد دانشگاهی

با سلام و عرض ادب

یک بار دیگر از مشارکت ارزشمند جنابعالی در مرحله‌ی نخست فرآیند تعیین اولویت‌های پژوهشی کشور در حوزه‌ی سلامت صمیمانه قدردانی می‌نمایم.

به طور خلاصه، به دنبال مشارکت **۵۰ نفر** از پژوهشگران برجسته‌ی کشور (فهرست اسامی پیوست شده است) مجموع ۲۵۱ سوال و ایده‌ی پژوهشی برای انجام طی ۵ سال آینده به منظور کمک به کشور جهت دستیابی به سیاست‌های کلی سلامت و اهداف مرتبط با سلامت در آرمان‌های توسعه‌ی پایدار گردآوری شد. از آنجایی که بسیاری از سوالات ارسال‌شده هم‌پوشانی داشتند، گروه پژوهش با ادغام سوالاتِ مشابه فهرست نهایی را به **۱۲۸ سوال پژوهشی** رسانده است. اگرچه برای حفظ اصالت ایده‌های دریافت‌شده تلاش بسیار زیادی شده است، امکان دارد به دنبال ادغام ایده‌ها و تغییر در واژه‌گزینی به منظور یکسان‌سازیِ ساختارِ سوالات نحوه‌ی بیان آن‌ها متفاوت از آنچه باشد که برای طرح ارسال شده بود. امید است پوزش ما را بابت هر گونه کوتاهی در این امر صمیمانه بپذیرید.

اکنون، از جنابعالی برای مشارکت در مرحله‌ی دوم این طرح با **امتیاز دادن به فهرست ۱۲۸ سوال پژوهشیِ پیوست** (فایل اکسل با عنوان صفحه‌ی امتیازدهی) دعوت به عمل می‌آید. لطفاً توجه فرمایید فرآیند امتیازدهی ممکن است چند ساعتی (حدود ۲ الی ۳ ساعت) زمان ببرد اگرچه از افراد گروه ماکمتر از ۴۰ دقیقه زمان برد. البته با سوالاتِ صفحه‌ی امتیازدهی آشنا بوده‌ایم. چنانچه تصمیم بگیرید در این مرحله از طرح مشارکت بفرمایید، که امیدواریم چنین باشد، از جنابعالی دعوت می‌شود نامتان در فهرست نویسندگان مقاله‌ی حاصل از این طرح به صورت **corporate** یا **group authorship** بیاید.

«صفحه‌ی امتیازدهی» که شامل سوالات پژوهشی است، **«دستورالعمل امتیازدهی»** و **«برگه‌ی معیارها»** در ۳ فایل جداگانه به پیوست خدمتتان تقدیم می‌گردد.

از جنابعالی بینهایت سپاس‌گزار خواهم بود، چنانچه صفحه‌ی امتیازدهی را پس از پر کردن **تا تاریخ ۱۳۹۶/۸/۱ برای اینجانب و یا خانم دکتر منصوری** به آدرس parisamansouri87@gmail.com ایمیل بفرمایید. برای طرح هر سوالی در مورد امتیازدهی نیز خواهشمند است با بنده یا ایشان تماس حاصل فرمایید.

مشتاقانه امیدواریم از مشارکت جنابعالی در این مرحله از طرح که می‌تواند گامی در جهت حرکتی هدفمند برای پاسخ به نیازهای کشور باشد بهره‌مند شویم.

دکتر سید رضا مجدزاده
رئیس موسسه ملی تحقیقات سلامت

رونوشت: دکتر پریسا منصوری

نشانی پستی: تهران- بلوار کشاورز -خیابان وصال شیرازی - خیابان بزرگمهر شرقی - پلاک ۷۰
تلفنهای تماس: ۶۶۹۲۱۱۵۹-۶۶۴۰۷۸۲۲ نمابر: ۶۶۴۰۷۷۵۴ کد پستی : ۱۴۱۶۸۳۳۴۸۱

[Version 2: To those who did not generate research questions]

دانشگاه علوم پزشکی و خدمات بهداشتی،درمانی تهران

جمهوری اسلامی ایران
وزارت بهداشت و درمان وآموزش پزشکی
موسسه ملی تحقیقات سلامت

تاریخ : ۱۳۹۶/۰۷/۱۹
شماره : ۹۶/ص/۲۴۱/۴۹۲
پیوست : دارد

بسمه تعالی

جناب آقای دکتر مکری گرامی

با سلام و عرض ادب

جهت دعوت از جنابعالی برای مشارکت **در مرحله‌ی امتیازدهی** طرح تعیین اولویت‌های پژوهشی کشور در حوزه‌ی سلامت مزاحم می‌شوم.

در مرحله‌ی نخست طرح که افتخار نداشتیم از نظرات جنابعالی بهره‌مند شویم به دنبال مشارکت **۵۰ نفر** از پژوهشگران برجسته‌ی کشور مجموع ۲۵۱ سوال و ایده‌ی پژوهشی گردآوری شد. سوالات و ایده‌ها برای انجام طی ۵ سال آینده به منظور کمک به کشور جهت دستیابی به اهداف درازمدت سلامت که در سیاست‌های کلی سلامت و آرمان‌های توسعه‌ی پایدار ذکر شده است مطرح شدند. گروه پژوهش با تلاش و دقت بسیار با ادغام سوالات مشابه، فهرست نهایی را به **۱۲۸ سوال پژوهشی** رسانده است و سوالاتی از این فهرست که امتیاز بالاتری دریافت نمایند به عنوان اولویت‌های پژوهشی انتخاب خواهند شد.

اکنون، از جنابعالی برای مشارکت در مرحله‌ی دوم این طرح که شامل **امتیاز دادن به فهرست ۱۲۸ سوال پژوهشی پیوست** (با عنوان صفحه‌ی امتیازدهی) است دعوت به عمل می‌آید. لطفاً توجه فرمایید که فرآیند امتیازدهی ممکن است چند ساعت (حدود ۲-۳ ساعت) زمان ببرد اگرچه نیازی به شرکت در جلسات حضوری ندارد. چنانچه تصمیم بگیرید در این مرحله از طرح مشارکت بفرمایید، که امیدواریم چنین باشد، از جنابعالی دعوت می‌شود نامتان در فهرست نویسندگان مقاله‌ی حاصل از این طرح به صورت **corporate** یا **group authorship** بیاید. متاسفانه در این مرحله دیگر امکان افزودن سوالات یا ایده‌های پژوهشی جدید وجود ندارد.

«صفحه‌ی امتیازدهی» که شامل سوالات پژوهشی است، **«دستورالعمل امتیازدهی»** و **«برگه‌ی معیارها»**، و فهرست اسامی پژوهشگرانی که در مرحله‌ی نخست طرح مشارکت کرده‌اند (جهت اطلاع) در ۴ فایل جداگانه به پیوست خدمتتان تقدیم می‌گردد.

در صورتی که تمایل به مشارکت در این مرحله از طرح را دارید، از جنابعالی بینهایت سپاس‌گزار خواهم بود چنانچه صفحه‌ی امتیازدهی را پس از پر کردن **تا تاریخ ۱۳۹۶/۸/۱ برای اینجانب و یا خانم دکتر منصوری** به آدرس **parisamansouri87@gmail.com** ایمیل بفرمایید. برای طرح هر سوالی در مورد امتیازدهی نیز خواهشمند است با بنده یا ایشان تماس حاصل فرمایید.

مشتاقانه امیدواریم از مشارکت جنابعالی در این مرحله از طرح که می‌تواند گامی در جهت حرکتی هدفمند برای پاسخ به نیازهای کشور باشد بهره‌مند شویم.

دکتر سید رضا مجدزاده
رئیس موسسه ملی تحقیقات سلامت

رونوشت: دکتر پریسا منصوری

نشانی پستی: تهران- بلوار کشاورز -خیابان وصال شیرازی - خیابان بزرگمهر شرقی - پلاک ۷۰
☎ تلفنهای تماس: ۶۲۹۲۱۱۵۹-۶۶۴۰۷۸۲۲ نمابر: ۶۶۴۰۷۷۵۴ کد پستی : ۱۴۱۶۸۳۳۴۸۱

Appendix 17. English translation of the instructions sent to the experts for scoring research questions in the priority-setting study

Scoring Instructions

Please kindly follow the following steps:

1. Open the PDF file **<Criteria>**. You will find definitions of the 5 criteria you will need for scoring the research questions. Please print this out for easy reference while scoring.

2. Now open the Excel file **<Scoring Sheet>**. You will see a list of 128 research questions in **Column C**, and the 5 criteria in **Row 2**. Please score each research question against the 5 criteria by placing '1' for 'no', '2' for 'informed but undecided','3' for 'yes', and '0' if you feel you are 'not sufficiently informed' to score a specific research question against a specific criterion.

For example:

Research Questions	Feasibility	Impact on Health	Impact on Economy	Capacity Building	Equity
1. RQ1	2	3	2	3	3
2. RQ2	2	2	2	2	2
3. RQ3	3	3	2	1	1

Please note:

a. **Each research question should be scored independently**, without being compared to other research questions.
b. Do **not** leave any cells **blank**.
c. If you enter an invalid score (e.g. if you accidentally type '11' instead of '1'), an error message box will appear.

3. As a participant of this CHNRI exercise, we would like to invite you to be a group/corporate author on the manuscript resulting from the exercise. If you would like to accept this offer, please kindly with your reply send us your **full name**, **affiliation** and **contact information** in the way that you would like the information to appear on the manuscript, **using Latin spelling. If you would rather, please send the information in a separate email**.

Please be assured that:
(i) **Nobody outside the research team will be able to link your name to the scores you provide**; and
(ii) You will have no further responsibility in the writing or submission of the paper, unless you would like to.

4. Please kindly email back the completed scoring sheet **by 27/Oct/2017** to me or to Dr Mansoori at . Should you have any questions about this exercise, do not hesitate to contact me or Dr Mansoori.

We highly appreciate your support for this exercise.

Seyed Reza Majdzadeh

Appendix 18. A sample of an original instructions sent to the experts for scoring research questions in the priority-setting study

دستورالعمل امتیازدهی

مشارکت جنابعالی نیازی به شرکت در جلسات حضوری ندارد. فقط خواهشمندیم مراحل زیر را دنبال بفرمایید:

۱) لطفاً ابتدا فایل PDF پیوست را با عنوان «**برگه‌ی معیارها**» باز بفرمایید. در این برگه تعاریف هر ۵ معیاری را که برای امتیاز دادن به سوالات پژوهشی لازم دارید می‌بینید. پیشنهاد می‌شود یک نسخه از «برگه‌ی معیارها» را پرینت گرفته و هنگام امتیاز دادن برای رجوع به تعاریف، آن را همراه داشته باشید.

۲) اکنون، فایل اکسل پیوست را با عنوان «**صفحه‌ی امتیازدهی**» باز بفرمایید. فهرست ۱۲۸ سوال پژوهشی را در ستون C و معیارهای امتیازدهی را در ردیف ۲ مشاهده می‌فرمایید. لطفاً به هر یک از سوالات مقابل هر معیار، با اختصاص **«۱» به خیر، «۲» به با وجود داشتن اطلاعات تردید دارم، «۳» به بله** و **«۰» به اطلاعات کافی برای پاسخ به سوال ندارم**، امتیاز دهید.

مثال:

سوالات پژوهشی	قابلیت اجرایی	اثر بر سلامت	اثر بر اقتصاد	ظرفیت‌سازی	عدالت
سوال شماره‌ی ۱	۳	۳	۳	۳	۱
سوال شماره‌ی ۲	۳	۳	۲	۱	۳
سوال شماره‌ی ۳	۰	۱	۱	۳	۲

لطفاً توجه بفرمایید که:

الف) هر سوال پژوهشی باید به صورت مستقل **و بدون مقایسه** با سوالات پژوهشی دیگر امتیاز داده شود.

ب) هیچ خانه‌ای در فایل اکسل **نباید خالی بماند**.

ج) چنانچه اشتباهاً اعدادی به غیر از ۰، ۱، ۲ یا ۳ در خانه‌های اکسل تایپ شوند یک پیام خطا بر صفحه پدیدار می‌شود.

۳) از آنجایی که به دنبال مشارکت در این مرحله در صورت تمایل جنابعالی نامتان در فهرست نویسندگان گروهی مقاله‌ی حاصل از این طرح خواهد آمد خواهشمند است همراه پاسخ به این ایمیل یا در صورت تمایل در ایمیلی جداگانه نام و نام خانوادگی، وابستگی سازمانی و اطلاعات تماس خود را به گونه‌ای که تمایل دارید در مقاله عنوان شود (با دیکته‌ی دقیق لاتین) برایمان بنویسید.

لطفاً آسوده‌خاطر باشید که:

الف) امکان ارتباط دادن نام شما به امتیازدهی‌ای که انجام می‌دهید برای هیچ کس غیر از گروه پژوهش ممکن نخواهد بود.

ب) در نوشتن و یا سابمیت مقاله مسئولیتی بر عهده‌ی جنابعالی نخواهد بود، مگر اینکه تمایل داشته باشید در آن مراحل نیز مشارکت فرمایید.

۴) چنانچه لطف بفرمایید و **تا تاریخ ۱۳۹۶/۸/۱** صفحه‌ی امتیازدهی پرشده را **برای اینجانب یا به خانم دکتر منصوری** به آدرس parisamansouri87@gmail.com ایمیل بفرمایید از شما بسیار ممنون می‌شویم. برای پاسخ به هر سوالی در مورد طرح لطفاً با بنده یا خانم دکتر منصوری تماس حاصل فرمایید.

از توجه شما به این مطالعه سپاس‌گزاریم.

سیدرضا مجدزاده

Appendix 19. English translation of the inviting message to the stakeholders from the community to the priority-setting study

Hello,

As an Iranian citizen who is either providing healthcare services, or using health services (either yourself or family members), you are invited to participate in a research priority-setting study. If you agree to participate, please rank the 5 criteria that are listed below and send back your results by Thursday, 25/Nov/2017 to the following ID: @health_research_priorities

The question is that if our country wants to investigate what are the research that should be funded within the next 5 years, in your opinion, how should the five criteria, including, feasibility; impact on health; impact on economy; capacity building; and equity be ranked, once ordered by importance.

Please put the criterion which you find the most important on the first line, and rank the remaining 4, below it, ordered by their importance based on your opinion.
Definition of the criteria:

- Feasibility: The study can be conducted using the facilities and resources in Iran.
- Impact on health: The findings of the study can lead to prevention and or treatment of diseases.
- Impact on economy: The findings of the study can lead to reduced financial costs on patients and or the health system.
- Capacity building: The conduct of the study would lead to capacity building, such as increasing the skills in students and or development of laboratories in the universities.
- Equity: The findings of the study would lead to services to which are accessible and affordable for all people.

Appendix 20. Original inviting message to the stakeholders from the community to participate to the

سلام،

از شما دعوت می‌شود به عنوان یک شهروند ایرانی که به ارائه‌ی خدمات سلامت مشغول هستید، و یا خود یا اطرافیانتان از خدمات بخش سلامت استفاده می‌کنید در یک طرح تعیین اولویت پژوهشی مشارکت بفرمایید. در صورت تمایل به مشارکت، لطفاً ۵ معیاری را که در پایین نوشته شده به ترتیب اهمیت، مرتب بفرمایید و پاسخ‌تان را تا پنجشنبه، پنجم بهمن برای آی‌دی زیر بفرستید.
@اولویت_پژوهش_سلامت

- سوال این است که اگر کشورمان بخواهد بداند در پنج سال آینده بهتر است برای چه پژوهش‌هایی در حوزه‌ی سلامت سرمایه‌گذاری کند، به نظر شما پنج معیار قابلیت اجرایی، اثر بر سلامت، اثر بر اقتصاد، ظرفیت‌سازی، و عدالت به ترتیب اهمیت باید چگونه قرار بگیرند؟

لطفاً معیاری را که به نظرتان مهم‌ترین است در خط اول و چهار معیار دیگر را زیر آن به ترتیب اهمیت بنویسید.

تعریف معیارها:

- قابلیت اجرایی: پژوهش با امکانات موجود در کشور قابل انجام باشد
- اثر بر سلامت: یافته‌های پژوهش در پیشگیری و یا درمان بیماری‌ها موثر باشد
- اثر بر اقتصاد: یافته‌های پژوهش منجر به کاهش هزینه‌های مالی وارد بر بیمار و یا نظام سلامت شود
- ظرفیت‌سازی: انجام پژوهش منجر به ظرفیت‌سازی، از جمله افزایش مهارت در دانشجوها و یا توسعه‌ی آزمایشگاه‌های دانشگاه‌ها شود
- عدالت: یافته‌های پژوهش منجر به خدماتی شود که همه‌ی مردم به آن‌ها دسترسی داشته باشند و از عهده‌ی هزینه‌هایش برآیند

از مشارکت شما بسیار سپاس‌گزاریم.

Appendix 21. The profile and the responses of the stakeholders who participated in the priority-setting study

Table S6 of the Microsoft Word (Microsoft Inc, Seattle WA, USA) file available at:

http://www.jogh.org/documents/issue201802/jogh-08-020702-s001.zip

Appendix 22. All the individual scoring responses to the research questions in the priority-setting study

Sheet 1 of the Microsoft Excel (Microsoft Inc, Seattle WA, USA) file available at:

http://www.jogh.org/documents/issue201802/jogh-08-020702-s001.zip

Appendix 23. Ethics approval from the Ethics Committee of Iran's National Institute of Health Research (NIHR) for conducting the priority-setting study in Iran

Islamic Republic of Iran
Ministry of Health & Medical Education
Research Ethics Committee

Ref. No.	**IR.TUMS.NIHR.1396.27**	**Receipt date**	27.08. 2017
Name of Committee	Research Ethics Commitee of National Institute of Health Research – Tehran University of Medical Siences	**Meeting Date**	24.09.2017
Decision	Approved		
Approval Statement	The project was found to be in accordance to the ethical principles and the national norms and standards for conducting Medical Research in Iran.		
Research Title	Setting priorities in health system research for Iran using the CHNRI method		
Investigator's profile	**Name:** Parisa **Place of work:** Mansoori **Phone number:** 00(98) 9123135299 **Email address:** parisa.mansoori@ed.ac.uk		

Chairman/ Secretary
National Institute of Health Research
Research Ethics Commitee

Zhaleh Abdi

Address:NO 70- Bozorgmehr Ave – Tehran- I.R.IRAN
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Web: http:/nihr.tums.ac.ir

Appendix 24. The scores and ranks of all the research questions against the 5 criteria of the priority-setting study

Sheet 2 of the Microsoft Excel (Microsoft Inc, Seattle WA, USA) file available at:

http://www.jogh.org/documents/issue201802/jogh-08-020702-s001.zip

Appendix 25. Publications rising from this PhD

Publication 1: Full text version available at:

https://www.sciencedirect.com/science/article/pii/S0140673617302349?via%3Dihub

5 Huber-Wagner S, Biberthaler P, Haberle S, et al. Whole-body CT in haemodynamically unstable severely injured patients—a retrospective, multicentre study. PLoS One 2013; 8: e68880.
6 Saltzherr TP, Bakker FC, Beenen LF, et al. Randomized clinical trial comparing the effect of computed tomography in the trauma room versus the radiology department on injury outcomes. Br J Surg 2012; 99 (suppl 1): 105–13.
7 Stengel D, Ottersbach C, Kahl T, et al. Dose reduction in whole-body computed tomography of multiple injuries (DoReMI): protocol for a prospective cohort study. Scand J Trauma Resusc Emerg Med 2014; 22: 15.
8 Ioannidis JP. This I believe in genetics: discovery can be a nuisance, replication is science, implementation matters. Front Genet 2013; 4: 33.

Authors' reply

With great respect we read the correspondence of Stefan Huber-Wagner and colleagues. The REACT-2 trial[1] included many patients without polytrauma (Injury Severity Score [ISS] <16), possibly not the population benefitting most from total-body CT scanning. Sole inclusion of patients with an ISS of 16 or more would be preferable, but in daily practice ISS scores are partly based on imaging—the very subject of our randomised controlled trial. We cannot use the results of imaging before we decide which imaging to use, therefore 35% of patients not having polytrauma is the reality to deal with. We continue our work in refining patient selection by clinical parameters and challenge the authors to join us.

The authors refer to dose-reduction algorithms to lower radiation doses as proposed in a study protocol by Stengel and colleagues.[2] However, the dose reduction of 50% without loss of diagnostic value still has to be proved. The total radiation dose is multifactorial and variable in individual patients despite equal scanning parameters. For this reason, we chose to calculate representative radiation doses as described in our Article. If we had used a lower radiation dose, it would have affected both groups. Because the difference between groups was tested for significance with the sum of ranks of the radiation doses, we think that the reported results are rather robust.

The absolute 5% reduction of mortality risk from an estimated 12% baseline level at the time of study design was a defendable margin for clinicians, researchers, health economists, patient representatives, and insurer representatives who were invited as reviewers of our study proposal by the Netherlands Organisation for Health Research and Development, the public funding agency behind our trial. Total-body CT scanning increases the minimum radiation dose in almost all patients and insufficient reduction of mortality raises the debate whether Dutch society would be better off spending limited health-care resources on other promising topics in health care with even more potential for health improvements or saving of lives.

The authors address the many total-body CT scans performed in the standard work-up group, which will indeed have reduced the difference between groups. We kindly refer to the first paragraph of the limitations section of our Article. In the second paragraph, we describe alternatives for our study design, all including drawbacks. Doctors indeed happen to regard total-body CT scanning as an integral part of trauma management, which is exactly why we think our study was needed. When we started our trial in 2010, total-body CT scanning was rapidly finding its way into daily clinical practice without level 1 scientific evidence. The important lesson from REACT-2 is that we ought to be selective with this procedure to prevent unnecessary high radiation doses.

We declare no competing interests.

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1 Sierink JC, Treskes K, Edwards MJ, et al. Immediate total-body CT scanning versus conventional imaging and selective CT scanning in patients with severe trauma (REACT-2): a randomised controlled trial. Lancet 2016; 388: 673–83.
2 Stengel D, Ottersbach C, Kahl T, et al. Dose reduction in whole-body computed tomography of multiple injuries (DoReMI): protocol for a prospective cohort study. Scand J Trauma Resusc Emerg Med 2014; 22: 15.

Iran's research needs to be more noticed

Mohammad Saeid Rezaee-Zavareh and colleagues (July 2, p 29)[1] criticised the quality of Iranian scientific publications during international trade sanctions against Iran, which aimed to restrict Iran's nuclear programme by targetting Iran's oil and gas export, banking, and financial sectors. Although we share the authors' concerns regarding research misconduct, our analyses portray the situation differently and encourage taking further in-depth approaches.

To investigate Iran's citation impact, we compared citation counts in Scimago between 1996 and 2014, and found an improvement in Iran's global ranking from 56th to 22nd. Furthermore, using a method explained elsewhere,[2] we assessed Iran's publication performance in biomedical and public health research and our preliminary findings showed that Iran's h-index in these fields was nearly doubled every 5 years between 1996 and 2010, rising from 23 to 82.

For more on citation counts in Scimago see http://www.scimagojr.com/countryrank.php

Iranian research publication count was low in Scopus during the early years of the period that Rezaee-Zavareh and colleagues studied (1996–2014). Subsequently, the mean number of publications was reduced, and therefore the conclusions based on average citations and h-indices from the whole period were flawed. More importantly, use of citation-based bibliometrics to measure research impact is disputable, let alone its use to assess quality.[3] There is evidence that using journal impact factors for quality assessment should be avoided.[4] It would be better that research growth is assessed by a combination of indices, and not being limited to citations.

Publication 2: Full text version available at:

http://www.jogh.org/documents/issue201802/jogh-08-020701.htm

Electronic supplementary material:
The online version of this article contains supplementary material.

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RESEARCH THEME 3: GLOBAL HEALTH RESEARCH PRIORITIES

50 years of Iranian clinical, biomedical, and public health research: a bibliometric analysis of the Web of Science Core Collection (1965-2014)

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Background A substantial growth has been reported in Iran's number of clinical, biomedical, and public health research publications over the last 30 years. It is of interest to investigate whether this quantitative growth has also led to a larger number of papers with a high citation impact; to explore where the capacity for performing research lies; and which fields/institutions are lagging behind.

Methods This was a bibliometric study. Web of Science Core Collection and its different tools were used for retrieving and analysing the publications. Information about the journals was found on Journal Citation Reports®. Different types of collaborations across the highly-cited papers was investigated based on the affiliations, the characteristics of the language of the authors' names, and the authors' study and work backgrounds.

Results Iran's number of clinical, biomedical, and public health research publications has substantially increased since 2000, a surge was seen in 2007, and the figure reached a peak in 2011. 11% of the publications were in Pharmacology Pharmacy; and the majority originated in Tehran University of Medical Sciences. Six of the 10 journals that had published the most were Iranian journals. H-index of publications had also increased over time (almost doubled between 2000 and 2010). 30.9% of the most-cited publications had only relied on Iranian resources (including 48 publications); had been published in journals with impact factors ranging between 0.4 and 8.3; and the majority were original basic sciences research.

Conclusions In Iran, a great capacity for research lies in clinical, biomedical, and public health fields which can be strengthened with further investment. It is important to use this capacity in a way that would align with the national population health needs. It is also essential to consider the limitations of only relying on bibliometric tools for assessing health research activities. Finally, the Iranian science policy-makers are encouraged to (i) support the researchers and institutions that have proved research capacity; (ii) direct further resources towards research areas and/or institutions that are lagging behind; (iii) facilitate further international collaboration with the academics and/or institutions that have shown the capacity for conducting successful research projects with Iran.

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In recent decades, several low- and middle-income countries (LMICs) have become prominent contributors to the global scientific output [1]. For instance, although the largest proportion of public health research output continue to originate in North America and Western Europe, contribution of several countries from Eastern Mediterranean Region (EMR) and South-East Asia has greatly increased [2]. Iran is a remarkable example of such emerging scientific nations

Publication 3: Full text version available at:

http://www.jogh.org/documents/issue201802/jogh-08-020702.htm

Electronic supplementary material:
The online version of this article contains supplementary material.

journal of global health

RESEARCH THEME 3: GLOBAL HEALTH RESEARCH PRIORITIES

Setting research priorities to achieve long-term health targets in Iran

Parisa Mansoori[1,2*], Reza Majdzadeh[2,3,4*], Zhaleh Abdi[5], Igor Rudan[1], Kit Yee Chan[1,6*]; The Iranian CHNRI Health Research Priority Setting Group; Mohsen Aarabi[7,8], Elham Ahmadnezhad[5], Shirin Ahmadnia[9], Shahin Akhondzadeh[10], Ali Azin[11], Fereidoun Azizi[12], Reza Dehnavieh[13], Hassan Eini-Zinab[14], Farshad Farzadfar[15], Mohammad Hosein Farzaei[16], Mostafa Ghanei[17], AliAkbar Haghdoost[18], Sedigheh Hantoushzadeh[19], Gholamreza Heydari[20], Hassan Joulaei[21], Naser Kalantari[22], Roya Kelishadi[23], Ardeshir Khosravi[24], Bagher Larijani[25], Amir Hossein Mahvi[4,26], Ali Reza Massah Bavani[27], Alireza Mesdaghinia[28], Azarakhsh Mokri[29], Ali Montazeri[30], Ehsan Mostafavi[31], Seyed Abbas Motevalian[32], Kazem Naddafi[33,34], Shekoufeh Nikfar[35], Seyed Ali Nojoumi[36], Maryam Noroozian[37], Alireza Olyaeemanesh[5,38], Nasrin Omidvar[39], Abbas Ostadtaghizadeh[40], Farshad Pourmalek[41], Roja Rahimi[42], Afarin Rahimi-Movaghar[29], Arash Rashidian[43], Emran Razaghi[44], Homayoun Sadeghi-Bazargani[45], Gholamhosain Salehi Zalani[46], Hamid Soori[47], Jafar Sadegh Tabrizi[48], AbouAli Vedadhir[49,50], Bahareh Yazdizadeh[2], Masud Yunesian[51], Mehdi Zare[52]

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Background In 2015, it was estimated that the burden of disease in Iran comprised of 19 million disability-adjusted life years (DALYs), 74% of which were due to non-communicable diseases (NCDs). The observed leading causes of death were cardiovascular diseases (41.9%), neoplasms (14.9%), and road traffic injuries (7.4%). Even so, the health research investment in Iran continues to remain limited. This study aims to identify national health research priorities in Iran for the next five years to assist the efficient use of resources towards achieving the long-term health targets.

Methods Adapting the Child Health and Nutrition Research Initiative (CHNRI) method, this study engaged 48 prominent Iranian academic leaders in the areas related to Iran's long-term health targets, a group of research funders and policy makers, and 68 stakeholders from the wider society. 128 proposed research questions were scored independently using a set of five criteria: feasibility, impact on health, impact on economy, capacity building, and equity.

Findings The top-10 priorities were focused on the research questions relating to: health insurance system reforms to improve equity; integration of NCDs prevention strategy into primary health care; cost-effective population-level interventions for NCDs and road traffic injury prevention; tailoring medical qualifications; epidemiological assessment of NCDs by geographic areas; equality in the distribution of health resources and services; current and future common health problems in Iran's elderly and strategies to reduce their economic burden; the status of antibiotic resistance in Iran and strategies to promote rational use of antibiotics; the health impacts of water crisis; and research to replace the physician-centered health system with a team-based one.

Conclusions These findings highlight consensus amongst various prominent Iranian researchers and stakeholders over the research priorities that require investment to generate information and knowledge relevant to the national health targets and policies. The exercise should assist in addressing the knowledge gaps to support both the National General Health Policies by 2025 and the health targets of the United Nations' Sustainable Development Goals by 2030.

www.jogh.org • doi: 10.7189/jogh.08.020702 1 December 2018 • Vol. 8 No. 2 • 020702

Appendix 26. Accepted manuscript rising from this PhD

Electronic supplementary material:
The online version of this article contains supplementary material.

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RESEARCH THEME 3: GLOBAL HEALTH RESEARCH PRIORITIES

Evolution of Iran's health research system over the past 50 years: a narrative review

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Background A substantial growth has been reported in Iran's health research output over the last recent decades, throughout the times of economic, social, and political instability. This study reviewed the existing literature to provide a better understanding of the evolution of Iran's health research system over this period.

Methods A narrative review of studies addressing health research system (HRS) in Iran was performed. The search strategy and categorization of the retrieved data was informed by the HRS framework of the World Health Organization (WHO). This framework proposes four functions for HRS: (i) stewardship; (ii) financing; (iii) creating and sustaining resources; and (iv) producing and using research. Searches in MEDLINE through PubMed (using MeSH terms) complemented with semantic searches through PubMed and Google Scholar were conducted.

Results After removing the duplicates, 805 articles were retrieved, of which 601 were irrelevant, and 204 were reviewed.

Conclusions Iran has made substantial progress in different components of its HRS over the last few decades, such as starting a discourse surrounding health research ethics, priority-setting, and placing monitoring mechanisms while increasing the capacity for conducting and publishing research. However, there is still room for improvements, or even a need for fundamental changes, in several components, such as regarding increasing the research budget and improving the funding allocation mechanisms; improving the education curriculum; and promoting the use of evidence. The findings emphasized that improvement of HRS functions requires addressing context-specific problems. This review provides essential lessons to share with other low- and middle-income countries and international organizations, eg, the WHO.

Health research is increasingly regarded as an essential tool both for improving population health and for development [1-3]. Hence, numerous efforts at the national, regional, and global levels have attempted to strengthen health research capacity in low- and middle-income countries (LMICs) [2,4,5]. However, most LMICs continue to have limited capacity for health research [2,6,7]. Many have remained largely dependent on international academic institutions and donors: on the former for research-relevant knowledge and expertise, and on the latter for financial resources [2,6,8]. Evidence shows that many of the barriers impeding improvement of health research are shared across LMICs [2]. Thus, studying the approaches that each country takes for overcoming some common obstacles could provide important lessons to other LMICs.

Iran is a middle-income country which studying the changes in its health research could lead to valuable lessons for exchange. A substantial growth in Iran's

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www.jogh.org • doi: 10.7189/jogh.08.020703 1 December 2018 • Vol. 8 No. 2 • 020703

Appendix 27. Publication rising from a collaboration that led to methodology development used in Chapter 4

Full text version available at: http://www.jogh.org/documents/issue201601/jogh-06-010504.pdf

Electronic supplementary material:
The online version of this article contains supplementary material.

journal of global health

PAPERS

Assessing global, regional, national and sub–national capacity for public health research: a bibliometric analysis of the Web of Science™ in 1996–2010

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Background The past two decades have seen a large increase in investment in global public health research. There is a need for increased coordination and accountability, particularly in understanding where funding is being allocated and who has capacity to perform research. In this paper, we aim to assess global, regional, national and sub–national capacity for public health research and how it is changing over time in different parts of the world.

Methods To allow comparisons of regions, countries and universities/research institutes over time, we relied on Web of Science™ database and used Hirsch (h) index based on 5–year–periods (h5). We defined articles relevant to public health research with 98% specificity using the combination of search terms relevant to public health, epidemiology or meta–analysis. Based on those selected papers, we computed h5 for each country of the world and their main universities/research institutes for these 5–year time periods: 1996–2000, 2001–2005 and 2006–2010. We computed h5 with a 3–year–window after each time period, to allow citations from more recent years to accumulate. Among the papers contributing to h5–core, we explored a topic/disease under investigation, "instrument" of health research used (eg, descriptive, discovery, development or delivery research); and universities/research institutes contributing to h5–core.

Results Globally, the majority of public health research has been conducted in North America and Europe, but other regions (particularly Eastern Mediterranean and South–East Asia) are showing greater improvement rate and are rapidly gaining capacity. Moreover, several African nations performed particularly well when their research output is adjusted by their gross domestic product (GDP). In the regions gaining capacity, universities are contributing more substantially to the h–core publications than other research institutions. In all regions of the world, the topics of articles in h–core are shifting from communicable to non–communicable diseases (NCDs). There is also a trend of reduction in "discovery" research and increase in "delivery" research.

Conclusion Funding agencies and research policy makers should recognise nations where public health research capacity is increasing. These countries are worthy of increased investment in order to further increase the production of high quality local research and continue to develop their research capacity. Similarly, universities that contribute substantially to national research capacity should be recognised and supported. Biomedical journals should also take notice to ensure equity in peer–review process and provide researchers from all countries an equal opportunity to publish high–quality research and reduce financial barriers to accessing these journals.

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www.jogh.org • doi: 10.7189/jogh.06.010504 1 June 2016 • Vol. 6 No. 1 • 010504