

Mapping COVID-19 related research from Saudi Arabia, a scoping review

Between reality and dreams

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ABSTRACT

الأهداف: رسم خريطة الإنتاج البحثي من قبل الباحثين السعوديين لتحديد مجالات القوة والضعف.

المنهجية: لقد اتبعنا إطار عمل أركسلي وأومالي (2005). بحثنا في قواعد بيانات Medline و Cochrane مع التركيز على تحديد المقالات المتعلقة بـ COVID-19 والمملكة العربية السعودية باستخدام بروتوكول PRISMA. أجريت الدراسة في جامعة الملك سعود، الرياض، المملكة العربية السعودية خلال الفترة بين مارس ومايو 2020م.

النتائج: اشتملت الدراسة على 53 مقالة في نهاية المطاف. كان معظم إنتاج البحث من المملكة العربية السعودية عبارة عن مراجعات رأي وسرد تتعلق بالسمات الإكلينيكية لـ COVID-19 بالإضافة إلى التحكم في انتشار الفيروس والوقاية منه.

الخلاصة: تحدد نتائج مراجعة النطاق هذه نقصاً نسبياً في البحث الأصلي، الأمر الذي يتطلب مزيداً من الدراسة.

Objectives: To map research production by Saudi-affiliated investigators in order to identify areas of strength and weakness.

Method: We followed the Arksey and O'Malley (2005) framework. Medline and Cochrane databases were searched with a focus on identifying articles related to COVID-19 and Saudi Arabia following the PRISMA protocol. The study was conducted at King Saud University, Riyadh, Saudi Arabia between March and May 2020.

Results: A total of 53 articles were ultimately included. Most of the research production from Saudi Arabia was opinion and narrative reviews related to the clinicopathological features of COVID-19 as well as control and prevention of virus spread.

Conclusion: The results of this scoping review identify a relative deficiency in original research, which requires further investigation.

Keywords: scoping review, COVID-19, knowledge gap, research production, Saudi Arabia

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The first case of the COVID-19 virus was reported by Chinese authorities in Wuhan on December 31, 2019. As it continue to spread, defying borders of countries and continents, the World Health Organization (WHO) declared a pandemic on March 11, 2020.^{1,2} As of May 5, 2020, 3,600,1063 people have contracted COVID-19, with 251,898 deaths, and the disease has been transmitted to 212 countries and territories worldwide. After just a month,

the total number of patients had reached 30,251 (May 5, 2020) and 200 deaths.^{3,4}

COVID-19 is a non-segmented betacoronavirus comprise of positive-sense single-stranded ribonucleic acid surrounded by a phospholipid bilayer viral envelope.⁵⁻⁷ The exact zoonotic host remains to be identified, although bats might be involved.^{8,9} The case history of the first several cases in Wuhan linked them to the local live animal and seafood market.¹⁰ The person-to-person transmission of the virus mainly occurs via droplet, close contact of healthy persons to infected individuals (examples, talking, sneezing, coughing), and indirect contact with contaminated objects (examples, stethoscope, thermometer) or surfaces.^{11,12} COVID-19 is a highly contagious disease with a relatively high reproductive number (R0) (examples the average number of new infections caused by an infectious person in a totally uninfected population) of 2-3.5.^{10,13,14} The fast-spreading nature of the disease threatens to inundate health care systems worldwide. The disease spectrum of COVID-19 varies from asymptomatic carriers to life-threatening conditions, including myocarditis and acute respiratory distress syndrome (ARDS).^{5,15} The fast-spreading nature of the disease threatens to inundate health care systems worldwide.

The COVID-19 pandemic has created a complex humanitarian emergency; the overwhelmingly high cost of the response is taking a toll on the economy and health facilities of even the developed countries.¹⁶ This leaves academic institutions with a major responsibility to investigate the disease from a holistic prospective, including asymmetric severity distribution, mortality, and spread among different geographical distribution, while avoiding duplicating research topics. Furthermore, national research institutes should focus on the most pressing issues related to COVID-19 on the national level. Hence, we aim in this scoping review to map research publications pertaining to COVID-19 research in Saudi Arabian institutions in order to guide research policies and priorities in the kingdom.

Methods. We formulated our scoping review using the scoping review methodological framework proposed by Arksey and O'Malley¹⁷ and also following the recent scoping review publication by Tricco et al.¹⁸ We mapped

the literature by following 5 key phases: i) identifying the research question; ii) identifying literature relevant to COVID-19 in Saudi Arabia; iii) selecting only those studies; iv) charting the data from the articles; and v) collating, summarizing, and reporting results. We did not consult any stakeholders. The study was conducted at the College of Medicine and Research Center, King Saud University, Riyadh, Saudi Arabia, from March to May 2020.

Research questions. This scoping review was guided by the following questions: "What type of research was carried out in Saudi Arabian institutions on COVID-19? What aspects of the disease and its impact were investigated?"

Data sources and search strategy. A comprehensive electronic database search was performed using PubMed, Ovid-Medline (1946-present), EBM Reviews, and Cochrane databases by an author and another independent reviewer individually. No language, date, or type of article restrictions were applied. Gray literature was not included. Search criteria were developed to capture articles that addressed the literature relevant to research regarding COVID-19 from Saudi Arabian institutions. Search terms used were COVID-19 and Saudi Arabia. Two reviewers independently reviewed extracted articles. Conflicts were resolved by agreement, and in case of dispute a third reviewer was responsible for the decision.

Citation management. Duplicate citations were initially removed in Ovid for citations from Medline, the Editorial Board Member (EMB) reviews, and Cochrane databases.

All studies related to COVID-19 that were conducted in the institutions of Saudi Arabia, both local and in collaboration with scientists from other countries, authored by a Saudi researcher or a non-Saudi researcher representing a Saudi institution were eligible for inclusion. Both published and accepted articles in press that were already published online were also included.

Title and abstract relevance screening. The titles and abstracts of the identified articles were first examined by one author and cross-checked by another author for relevance and inclusion criteria. The reason for omitting each of the excluded papers was recorded.

For selected papers, data were abstracted and charted in Microsoft Excel 2010 using the following categorization: title, first author, Saudi author (if the first author is not Saudi and another coauthor is Saudi), name of the Saudi Arabian institution involved in the study, year and month of the study (in case of published studies), articles in press (for published online articles),

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national or collaborative international, name of the countries in case of multinational studies, type of study (narrative, review/opinion, letter to editor/correspondence, comment/opinion/editorial, short communication, systematic review, guidelines and systematic review, observational including case reports, case series, cohort, cross-sectional, experimental, survey, modeling/epidemiological, and basic science), aim and objectives of the study, and keywords.

Results. Literature search. The initial search in different databases yielded 175 citations, of which 88 were duplicate and deleted. After rescreening, 34 articles did not meet the eligibility criteria; 27 papers mention Saudi Arabia in their abstract or text only as reference, but the researches were conducted in other countries and 7 papers were related to other coronaviruses and had mentioned COVID-19 in their abstract or text. Ultimately, 53 papers met the inclusion criteria. The study selection process is presented in full detail as a Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram in **Figure 1**.

Characteristics of sources of evidence. Among the included 53 papers, authors of 43 articles were Saudi nationals; in 10 articles (19%), Saudi nationals were first authors. Ten articles out of the 53 were authored by non-Saudi nationals affiliated with Saudi institutions. Most of the papers were coauthored by investigators under the affiliation of Johns Hopkins Aramco Healthcare, Dhahran (20 articles; 38%) and King Saud Medical City, Alfaisal University, Riyadh (16 articles; 30%). **Table 1** presents the study characteristics of the included studies.

All the participating hospitals are listed in **Table 2**. All the papers were either published or accepted in 2020. Most of the papers (n=33; 62%) were accepted and published online ahead of print. The majority of the studies (38; 72%) were conducted in collaboration with scientists from other countries. The names of the countries are listed in **Table 3**.

Topics and themes of identified studies. A total of 15 studies (28%) focused on control and prevention of COVID-19, investigating the importance of preventing mass gatherings, including Hajj and Umrah. Three of the 15 control/prevention articles outlined measures to be taken during various surgeries, including dental surgery. The clinicopathological features of COVID-19 (**Figure 2**) were described by 15 studies (28%). Six of the clinicopathological studies included discussion on the management of the infection. Nine papers (17%) focused on the virology and genomics. One paper investigated the mechanism of action of various drugs

Table 1 - General characteristics of studies meeting eligibility criteria.

Characteristics	n (%)
Publication type	
Experimental studies	2 (3.7)
Survey	1 (1.8)
Reviews	13 (24.5)
Systematic review	2 (3.8)
Editorials/expert opinions	15 (28.3)
Guideline	2 (3.8)
Letter to editor/correspondence	11 (20.8)
Building model	2 (3.8)
Basic Science	4 (7.5)
Short communication	2 (3.8)
Authors	
First authors from Saudi Arabia	10 (18.9)
Studies with coauthors from Saudi Arabia	43 (81.1)
Institutional affiliation	
Johns Hopkins Aramco Healthcare, Dhahran	20 (37.7)
King Saud Medical City	16 (30.2)
Alfaisal University	16 (30.2)
University of Aljouf	3 (5.7)
King Saud bin Abdulaziz University for Health Sciences	6 (11.3)
King Abdulaziz University, Jeddah	6 (11.3)
King Saud University	5 (9.4)
King Faisal University, Al-Ahsa, Hofuf	4 (7.5)
King Faisal Specialist Hospital & Research Centre	1 (1.9)
Other each having 1	14 (26.4)
Studied topics	
Clinicopathologic	15 (28.3)
Control and prevention	15 (28.3)
Virology and genome	9 (17)
Medical management	6 (11.3)
Epidemiology	5 (9.4)
Radiology	5 (9.4)
Economic impact	1 (1.9)

on the viral genome.¹⁹ Surgeons from the city of Al Madinah Al Munawarah, Saudi Arabia were involved in a huge multinational survey of 47 hand surgeons working in 34 countries, including the United States, China, and Canada, that focused on the different measures adopted to combat the pandemic.²⁰ The effect of different drugs on humans were examined in only one clinical trial. Four different treatment options were administered in a multinational randomized trial: antibiotics, antiviral therapy for influenza, host immunomodulation with extended macrolide therapy, and alternative corticosteroid regimens, representing 240 treatment regimens.²¹

Types of studies. Approximately one third of the papers are comment/opinion/editorial (n=15; 28%), one fourth are review articles (n=13; 25%), and one fifth letters to the editor/correspondence (n=11; 21%). **Figure 3** depicts the types of articles included in this

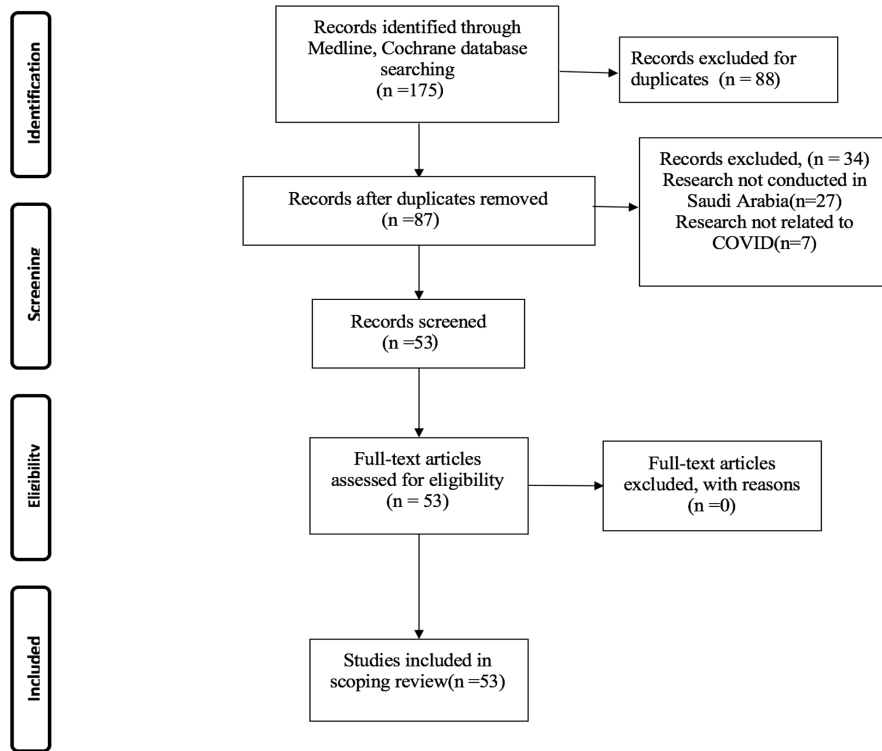


Figure 1 - Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2009 flow diagram

Table 2 - Participating institutions of the included studies.

Institutions
Johns Hopkins Aramco Healthcare, Dhahran
University of Aljouf
King Saud Medical City
King Saud bin Abdulaziz University for Health Sciences
King Faisal Specialist Hospital & Research Centre
KingSaud University
Alfaisal University
King Abdulaziz University
King Faisal University, Al-Ahsa
King Abdulaziz Medical City
University of Bisha
Al Ahsa Veterinary Diagnostic Laboratory
Imam Abdulrahman Bin Faisal University, Dammam
Saudi Field Epidemiology, Riyadh, Training Program
Prince Sultan Military Medical City
Riyadh Elm University
National Guard Hospital Medina
Qatif Central Hospital
Jazan University
Majmaah University
King Abdullah Medical City
The Global Centre for Mass Gatherings Medicine, Ministry of Health

review. A similar trend was noted in the publications where the first authors were Saudi nationals. Three out of 10 (30%) were in the category of comment/opinion/editorial and 2 (20%) were review articles. The remainder were categorized as basic science, modeling, and short communications.

Research priorities. To address the gap between the research priorities set by the WHO blueprint and the papers published by scientists affiliated with Saudi institutions, we categorized the papers according to the blueprint, looking at the themes and aims of the studies (Table 4). The table demonstrates the paucity of experimental research with clinical outcomes and vaccine-related research. It also highlights the lack of research on animals and environmental sources of virus origin as well as the human-animal interface.

Discussion. This scoping review of research publication related to COVID-19 in Saudi Arabia identified 53 articles (Table 5). Most of the included studies focused on control and prevention and on the clinicopathological aspects of the disease. The articles focused on the importance of and ways to prevent

Table 3 - Countries in collaboration with Saudi Arabia for included studies.

Australia	Honduras	Netherlands	Spain
Afghanistan	Hong Kong	Nepal	Switzerland
Argentina	Iran	Norway	Turkey
Bolivia	Italy	New Zealand	Taiwan
Brazil	India	Oman	Tunisia
Belgium	Indonesia	Panama	United Arab Emirates
Canada	Israel	Pakistan	United Kingdom
Cameroon	Iraq	Peru	United States of America
China	Ireland	Portugal	Venezuela
Chile	Japan	Qatar	Yemen
Colombia	Jordan	Republic of Congo	Zambia
Denmark	Korea	Russia	
Egypt	Mexico	Sudan	
France	Mali	South Africa	
Germany	Morocco	Singapore	

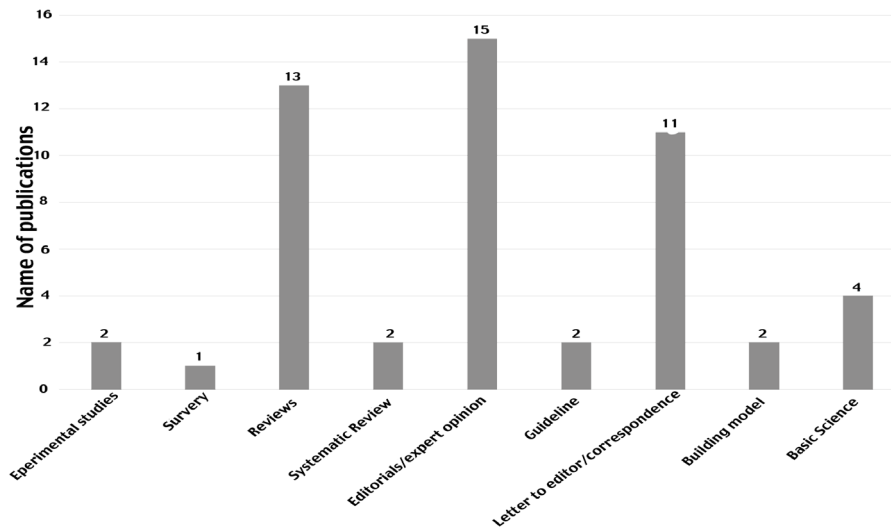


Figure 2 - Identified topics and purpose of disease.

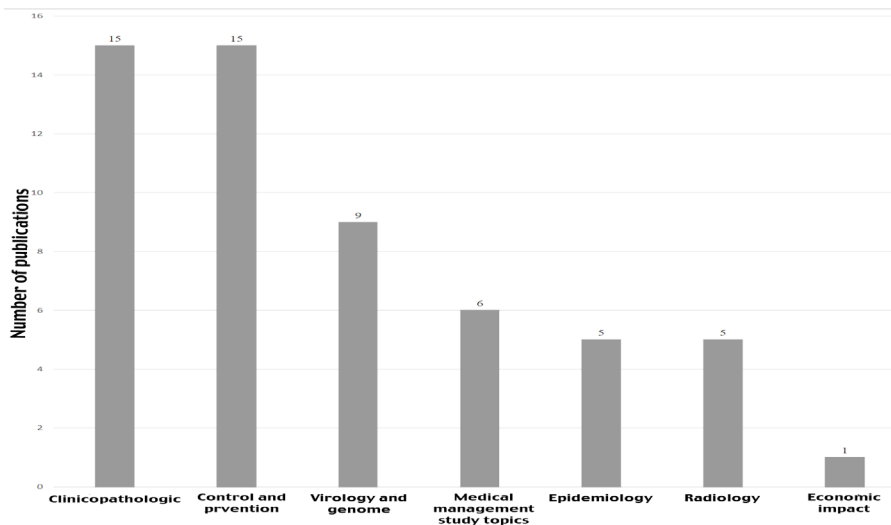


Figure 3 - Identified types of publications.

Table 4 - Research themes of the included articles according to the WHO research priorities for COVID-19.

Research Priorities	Number of articles
<i>Virus: natural history, transmission and diagnostics</i>	
Understand the natural history of the virus and shedding of it from an infected person	1
Support implementation of diagnostics and products to improve clinical processes	4
Develop disease models, including animal models for infection, disease and transmission	7
Develop tools and studies to monitor phenotypic change and potential adaptation of the virus	
Better understand the immune response and immunity	0
<i>Animal and environmental research on the virus origin, and management measures at the human-animal interface</i>	
Identify animal host(s) and any evidence of continued spill-over to humans	1
Understand the socioeconomic and behavioral risk factors for this spill-over	1
Design and test sustainable risk reduction strategies	0
<i>Epidemiological studies</i>	
Understand the transmission dynamics of the virus, including the basic reproductive number, incubation period, serial interval, modes of transmission and environmental factors	8
Define the severity of disease, including risk of fatality among symptomatic hospitalized patients, and high-risk patient groups	3
Understand susceptibility of populations	2
Identify what public health mitigation measures could be effective for control	16
<i>Clinical characterization and management</i>	
Define the natural history of disease to inform clinical care, public health interventions, infection prevention control, transmission, and clinical trials	3
Develop a core clinical outcome set to maximize usability of data across a range of trials	0
Determine adjunctive and supportive interventions that can improve the clinical outcomes of infected patients (examples, steroids, high flow oxygen)	1
<i>Infection prevention and control, including health care workers' protection</i>	
Understand effectiveness of movement control strategies to prevent secondary transmission in health care and community settings	5
Optimize the effectiveness of personal protective equipment (PPE) and its usefulness to reduce risk of transmission in health care and community settings	0
Minimize the role of the environment in transmission	3
<i>Candidate therapeutics (research and development)</i>	
Develop animal models and standardize challenge studies	0
Develop prophylaxis clinical studies and prioritize in healthcare workers	
<i>Candidate vaccines R&D</i>	
Optimize clinical trial design, including for Phase III/ prioritized candidates for testing	0
Understand approaches to evaluate risk for enhanced disease after vaccination	
Develop assays to evaluate vaccine immune response and process development for vaccines, alongside suitable animal models (in conjunction with therapeutics)	
<i>Ethical considerations for research</i>	
Articulate and translate existing ethical principles and standards to salient issues in COVID-2019	0
Embed ethics across all thematic areas, engage with novel ethical issues that arise and coordinate to minimize duplication of oversight	
Support sustained education, access, and capacity building in the area of ethics	

community transmission, which included plans for preventing community gatherings such as Hajj and Umrah along with the Tokyo Olympics.³⁰ Furthermore, issues related to the importance and prevention of cross infection to healthcare workers or different surgical and medical departments were reviewed. A significant number of studies focused on viral genomics and its implication on drug discovery including the potential use of existing drugs to target the virus.¹⁹

Almost all of the articles were narrative, focusing on reported views and experiences. Only 2 were experimental; one of the 2 is a large multicenter, multinational clinical trial, investigating treatment modalities of community-acquired pneumonia and

COVID19. The study was initially launched in European countries and later expanded to Saudi Arabia.

The findings of this scoping review highlight the collaborative nature of most of the research conducted by Saudi scholars in relation to COVID-19. However, the limited number of Saudi investigator-initiated studies, especially with respect to experimental research, is concerning. These findings highlight the gaps in COVID-19 related research from Saudi research institutes. First, the number of experimental studies focused on new treatment options were very low. Second, the economic impact on specific health resources in Saudi Arabia was not investigated. Moreover, epidemiological studies focused on disease

Table 5 - The types of included studies.

Author(s)	Study title	Types of Articles
Alhazzani et al ¹²²	Surviving sepsis campaign: guidelines on the management of critically ill adults with Coronavirus Disease 2019 (COVID-19)	Guideline
Elfiky ¹⁹	Anti-HCV, nucleotide inhibitors, repurposing against COVID-19	Experimental
Al-Tawfiq ²³	Asymptomatic Coronavirus infection: MERS-CoV and SARS-CoV-2 (COVID-19)	Letter to the Editor
Al-qaness et al ²⁴	Optimization Method for Forecasting Confirmed Cases of COVID-19 in China	Building model
Xu et al ²⁵	Systematic comparison of 2 animal-to-human transmitted human Coronaviruses: SARS-CoV-2 and SARS-CoV	Systematic Review
Bedford et al ²⁶	COVID-19: towards controlling of a pandemic	Opinion
Arabi et al ²⁷	COVID-19: a novel coronavirus and a novel challenge for critical care	Opinion
Nasir et al ²⁸	The role of emergency radiology in COVID-19: From preparedness to diagnosis	Review
Sah et al ²⁹	Complete genome sequence of a 2019 Novel Coronavirus (SARS-CoV-2) strain isolated in Nepal	Basic science/short communication
Gautret et al ³⁰	COVID 19: Will the 2020 Hajj pilgrimage and Tokyo Olympic Games be cancelled?	Letter to the editor
Rodriguez-Morales et al ³¹	History is repeating itself: probable zoonotic spillover as the cause of the 2019 Novel Coronavirus epidemic	Editorial
Arab-Mazar et al ³²	Mapping the incidence of the COVID-19 hotspot in Iran - implications for travellers	Letter to the editor
Kandeel et al ³³	From SARS and MERS CoVs to SARS-CoV-2: moving toward more biased codon usage in viral structural and nonstructural genes	Basic Science
Meo et al ³⁴	Novel coronavirus 2019-nCoV: prevalence, biological and clinical characteristics comparison with SARS-CoV and MERS-CoV	Review
Farooq et al ³⁵	COVID-19 outbreak and its monetary implications for dental practices, hospitals and healthcare workers	Letter to the editor
Al-Tawfiq ³⁶	Middle East Respiratory Syndrome Coronavirus (MERS-CoV) and COVID-19 infection during pregnancy	Letter to the editor
Khurshid et al ³⁷	Human saliva: non-invasive fluid for detecting novel Coronavirus (2019-nCoV)	Opinion
Arabi et al ³⁸	Critical care management of adults with community-acquired severe respiratory viral infection	Review
Ibrahim ³⁹	COVID-19 spike-host cell receptor GRP78 binding site prediction	Basic Science
Rodriguez-Morales et al ⁴⁰	Clinical, laboratory and imaging features of COVID-19: A systematic review and meta-analysis	Systematic review
AlNsour et al ⁴¹	The role of the Global Health Development/Eastern Mediterranean Public Health Network and the Eastern Mediterranean Field Epidemiology Training Programs in preparedness for COVID-19	Opinion
Ralph ⁴²	2019-nCoV (Wuhan virus), a novel Coronavirus: human-to-human transmission, travel-related cases, and vaccine readiness	Basic Science
Al-Tawfiq ⁴³	Viral loads of SARS-CoV, MERS-CoV, and SARS-CoV-2 in respiratory specimens: What have we learned?	Letter to the editor
Ebrahim et al ⁴⁴	Covid-19 and community mitigation strategies in a pandemic	Opinion
Ahmed et al ⁴⁵	The cancellation of mass gatherings (MGs)? Decision making in the time of COVID-19	Short communication
Barry et al ⁴⁶	COVID-19 in the shadows of MERS-CoV in the Kingdom of Saudi Arabia	Opinion
Ebrahim et al ⁴⁷	COVID-19 - the role of mass gatherings	Review
Al-Tawfiq et al ⁴⁸	Diagnosis of SARS-CoV-2 infection based on CT scan vs. RT-PCR: Reflecting on experience from MERS-CoV	Opinions
Al-Tawfiq ⁴⁹	Remdesivir as a possible therapeutic option for the COVID-19	Letter to the editor
Petersen et al ⁵⁰	Li Wenliang, a face to the frontline healthcare worker. The first doctor to notify the emergence of the SARS-CoV-2, (COVID-19), outbreak	Editorial
Ebrahim et al ⁵¹	COVID-19: preparing for superspreader potential among Umrah pilgrims to Saudi Arabia	Correspondence
Ebrahim et al ⁵²	Saudi Arabia's measures to curb the COVID-19 outbreak: temporary suspension of the Umrah pilgrimage	Opinion
Zumla et al ⁵³	Reducing mortality from 2019-nCoV: host-directed therapies should be an option	Correspondence
Hui et al ⁵⁴	The continuing 2019-nCoV epidemic threat of novel coronaviruses to global health - The latest 2019 novel coronavirus outbreak in Wuhan, China	Editorial
Hemida et al ⁵⁵	The SARS-CoV-2 outbreak from a one health perspective	Review
Islam et al ⁵⁶	Emergence of deadly severe acute respiratory syndrome coronavirus-2 during 2019-2020	Review
Meo et al ⁵⁷	Biological and Epidemiological Trends in the Prevalence and Mortality due to Outbreaks of Novel Coronavirus COVID-19	Review
Alharbi et al ⁵⁸	Guidelines for dental care provision during the COVID-19 pandemic.	Guideline
Ducournau et al ²⁰	COVID-19: Initial experience of an international group of hand surgeons.	Survey
Al-Tawfiq J et al ⁵⁹	Super-spreading events and contribution to transmission of MERS, SARS, and COVID-19.	Review
Rabaan et al ⁶⁰	SARS-CoV-2, SARS-CoV, and MERS-COV: A comparative overview	Review
Rodriguez-Morales A et al ⁶¹	Genomic epidemiology and its importance in the study of the COVID-19 pandemic.	Editorial
Hasan et al ⁶²	A review on the cleavage priming of the spike protein on coronavirus by angiotensin converting enzyme-2 and furin.	Review
Phua et al ⁶³	Intensive care management of coronavirus disease 2019 (COVID-19): challenges and recommendations.	Review
Angus et al ²⁰	The randomized embedded multifactorial adaptive platform for community-acquired pneumonia (REMAP-CAP) study: rationale and design.	Clinical trial
Al-Tawfiq et al ⁶⁴	COVID-19 in the Eastern Mediterranean Region and Saudi Arabia: prevention and therapeutic strategies	Review
Kandeel et al ⁶⁵	Virtual screening and repurposing of FDA approved drugs against COVID-19 main protease	Building model
Mallineni et al ⁶⁶	Coronavirus disease (COVID-19): Characteristics in children and considerations for dentists providing their care	Editorial
Memishet al ⁶⁷	No time for dilemma: mass gatherings must be suspended.	Correspondence
Whiteside et al ⁶⁸	Redesigning emergency department operations amidst a viral pandemic	Review
Yezli et al ⁶⁹	COVID-19 social distancing in the Kingdom of Saudi Arabia: Bold measures in the face of political, economic, social and religious challenges	Short communication
Atique et al ⁷⁰	Hajj in the time of COVID-19	Letter to the editor
Petersen et al ⁷¹		Editorial

transmission or modeling of important outcomes such as health resources utilization were lacking. Furthermore, the current published research seems to be discordant from the WHO research and development blueprint for epidemic research that was established in 2015 and updated in 2017 by international experts.⁷² The blueprint was developed to ensure research preparedness during outbreak crises with a special focus on vaccine development, diagnostic testing, and therapeutic testing.⁷⁴ While it is possible that some of the national research projects are still ongoing and were not captured by the time we prepared this article, clearly, the current publications do not reflect strong national research preparedness to adequately address epidemics and pandemics.

This scoping review is useful in the context of fund allocation from the government through various institutions to support health care and COVID-19-related research on a national and international level. Interestingly, if we examine previous efforts from the Saudi Ministry of Health in the era of the MERS-Cov epidemic, we can find a road map that addressed similar issues related to emerging infection research, particularly in the field of vaccine development.⁷³ The international workshop hosted by the Saudi government called for a paradigm shift establish clear goals of public health interest that guide epidemic research. The government, represented by the Ministry of Health, and academic institutions, in collaboration with international stakeholders, including the WHO, should work together to achieve this goal.⁷⁵ Unfortunately, most of the published research during this pandemic seems to stray from the previously addressed road map and instead focuses on opinions and narrative reviews rather than original research. This calls for careful and in-depth analysis to identify the factors contributing to the current state of research. The research gap related to COVID-19 identified by the WHO that needs to be addressed by the global community are: i) Understand the natural history of infection, identify animal host, infection and transmission of infection including asymptomatic infection and susceptible population. ii) Determine the most effective standard of care approach using data from China and other countries. iii) Research on adjunctive and supportive therapies. iv) Research on rapid point of care diagnostics. v) Clinical trials for development of vaccine and investigating therapeutics. This can be utilized for planning future research steps.

This scoping review also identifies that Saudi Arabia scholars' research is mainly focused on the pathogenesis of the COVID-19 infection and opinions related to

viral control and prevention. This is important, since the priority of research at the level of funding agencies and even national strategy should take this into account in order to improve the knowledge gap in understudied and important fields such as epidemiological studies, diagnostic testing, immune response, genetic predisposition to sever phenotypes and experimental treatment interventions.

Study limitation. We did not search the gray literature or the EMBASE. Also this study did not capture unpublished ongoing research projects, particularly in areas of molecular and basic science, at the time of this manuscript preparation.

Finally, the aim of this scoping review was to map our COVID-19-related research on a national level in order to identify areas of strength and weakness. The results of our knowledge mapping should be followed by coordinated efforts from all stakeholders in our national health research, including the Ministry of Health, Ministry of Higher Education, academic and research institutes, National Institutes of Health, and the Center of Chronic Disease Prevention in order to identify a national strategy that invests in building capacities inspired by Saudi Vision 2030 and in alignment with the WHO epidemic research and development blueprint. In particular, we call for clear national strategy for health research that takes inconsideration emerging epidemics along with other public health priorities. We urge all national research institutes to identify research infrastructure capacity in order to maximize the utility of these infrastructures and help overcome their shortcomings. In addition, we suggest establishing national capacity for regular laboratory research materials through the investment in national companies for laboratory materials. Furthermore, we strongly encourage the investment in public health schools especially in leading national universities which are entailed to handle public health crises while provide guidance to the government in the most scientific and evidence-based approach.

In conclusion, this scoping review was a first step by the authors toward contributing to the development of a national COVID-19 pandemic research agenda for decision-makers concerned with the role of national health research in priority setting and resource allocation. Many decision-makers are seeking research support and guidance in moving forward during this critical time.

Ultimately, the intention of the national research activities should be to maximize the impact and usefulness of national public health interventions and policies. The decision-makers are facing the constraints

of national COVID-19 pandemic research to inform priority setting and resource allocation decisions. The next step is to produce a national research framework for COVID-19 with specific research projects to address critical gaps identified through this scoping review. This can be achieved through collaboration between decision-makers and researchers with interests in this field.

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Statistics

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Describe statistical methods with enough detail to enable a knowledgeable reader with access to the original data to verify the reported results. When possible, quantify findings and present them with appropriate indicators of measurement error or uncertainty (such as confidence intervals). Avoid relying solely on statistical hypothesis testing, such as the use of *P* values, which fails to convey important information about effect size. References for the design of the study and statistical methods should be to standard works when possible (with pages stated). Define statistical terms, abbreviations, and most symbols. Specify the computer software used.