Health innovations in response to the COVID-19 pandemic: perspectives from the Eastern Mediterranean Region

N.M.K. Elden¹, A.M.A. Mandil², A.A. Hegazy¹, N. Nagy³, R.M. Mabry⁴, W.A. Khairy¹

¹Public Health and Community Medicine, Faculty of Medicine, Cairo University, Cairo, 12613, Egypt
²WHO Regional Office for the Eastern Mediterranean, Cairo, 11371, Egypt
³Al-Obour High Institute for Management and Informatics, Cairo, 7050210, Egypt
⁴Independent Public Health Researcher, Muscat, 130, Oman

Address correspondence to RM Mabry, E-mail: rmmabry@gmail.com

ABSTRACT

Background This paper aims to document the numerous health innovations developed in response to the COVID-19 crisis in the Eastern Mediterranean Region (EMR) using a scoping review approach.

Methods A literature search was conducted using PubMed, the Eastern Mediterranean Health Journal, the Index Medicus for EMR to identify peer-reviewed articles between December 2019 and November 2020 and WHO and ministries of health websites for grey literature. Following an initial review, full-text screening identified studies reporting on health innovations in response to the COVID-19 pandemic in the region.

Results This review describes 82 health innovations reported from 20 countries across the region: 80% (n = 66) were digital and technology-based products and services including health care delivery (n = 25), public health informatics (n = 24) and prevention (n = 17); 20% (n = 16) were innovative processes including health care delivery (n = 8), educational programmes (n = 6) and community engagement (n = 2).

Conclusion The speed with which these technologies were deployed in different contexts demonstrates their ease of adoption and manageability and thus can be considered as the most scalable. Strengthened frameworks to protect users’ privacy, documentation and evaluation of impact of innovations, and training of health care professionals are fundamental for promoting health innovations in the EMR.

Keywords COVID-19, Eastern Mediterranean region, health innovations

Introduction

COVID-19 is the first pandemic in human history where innovative digital technologies and social media were used at unprecedented scales to keep people connected, safe and productive while being physically and socially apart. Innovations, not only in tools, products and technologies, but also in systems and processes are key to achieving positive health outcomes. They bring together the diverse and disparate ecosystem of solutions for global health and may be defined as novel methods, models, processes, products, services or a combination to realize gains in public health impact in people, families and communities at large. Innovations attempt to find solutions to problems and overcome resource constraints.¹ Earlier experiences during 2009 and 2014 with the H1N1 influenza and Ebola virus disease outbreaks indicate that the use of appropriate technology played a significant role in response.²

Literature to map health innovations during the COVID-19 crisis in the Eastern Mediterranean Region (EMR) is scarce.³ Our paper aimed to document the health innovations used in the EMR during the COVID-19 pandemic, using a scoping review approach.

Methods

A scoping review is defined as ‘a form of knowledge synthesis that addresses an exploratory research question aimed at mapping key concepts, types of evidence, and gaps in research related to a defined area or field’.⁴ Grant and Booth defined...
Scoping reviews as ‘preliminary assessments of potential size and scope of available research literature’. This scoping review is in line with the PRISMA extension for Scoping Reviews (PRISMA-SCR).

**Search strategy**
A literature search for peer-reviewed publications was conducted between December 2019 and November 2020 using three electronic databases (PubMed, the Eastern Mediterranean Health Journal and the Index Medicus for EMR). A similar search was conducted for grey literature using the Google search engine focusing specifically on WHO, ministries of health and official country websites. The key search terms used were Coronavirus, COVID-19, COVID, SARS-CoV-2, Corona Virus, or Corona and country name of the 22 countries in the EMR plus three Arab countries not part of the EMR, i.e. Algeria, Comoros Islands and Mauritania to obtain articles related to the COVID-19 crises. Search was conducted using both English and Arabic languages.

**Study selection**
After removing duplicate publications, titles and abstracts were reviewed to identify potential studies to be included for full-text screening. Included studies had to pertain to health innovations in response to the COVID-19 pandemic, whereby health innovations were defined as ‘novel methods, models, processes, products, services, or a combination that aims to impact public health; novel refers to “a new method, approach or process or an upscaling of existing processes”.

**Data extraction and synthesis**
A standard template to extract data was developed to gather information on country, description of health innovation, institution and information source. Following a thematic review of the data, innovations were categorized according to the five most common fields (health care delivery, public health informatics, prevention, education and community engagement). Articles were not reviewed for quality because of the diversity of types of articles and methodological approaches and to ensure comprehensiveness of the scoping review. Since all authors are bi-lingual, this ensured consistency in screening/including of documents from both languages. A descriptive approach was used to synthesize information on COVID-19 health innovations in the EMR. All data are incorporated into the article.

**Results**
The initial literature search resulted in 1528 potential articles from PubMed and other sources; of which 1408 were excluded, as they were not relevant. Following a careful review of abstracts, 120 full text articles were carefully examined, of which 62 met the inclusion criteria including peer-reviewed publications (n = 55), articles on the WHO website (n = 8) and articles from other sources (n = 4). This review describes 82 innovations used at the community and health facility level during the COVID-19 pandemic in 20 countries across the region (Afghanistan, Algeria, Bahrain, Djibouti, Egypt, Iran, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Pakistan, Palestine, Qatar, Saudi Arabia, Somalia, Sudan, Tunisia and UAE). Countries with the largest number of innovations reported were Saudi Arabia (n = 20), Egypt (n = 6), Qatar (n = 6), Iran (n = 5), Jordan (n = 5), Morocco (n = 5) and Pakistan (n = 5). Most of the innovations originated from the public sector (n = 47), including six from public hospitals, and 28 from academia. The remaining were from the private sector (n = 4), entrepreneurs (n = 2) and a non-governmental organization (n = 1). Public sector innovations were mostly related to health care delivery (13, plus all 6 innovations by public hospitals), prevention, including all the mobile applications and public health informatics, largely related to surveillance. Most innovations by academia were related to public health informatics, focusing largely on modelling, projections and health care delivery.

These innovations were grouped in five main fields: health care delivery (n = 33), public health informatics (n = 24), prevention (n = 17), education (n = 6) and community engagement (n = 2). Most health innovations (80%, n = 66) were digital and technology-based products and services (Table 1) including health care delivery (n = 25), public health informatics (n = 24) and prevention (n = 17). The remaining 20% (n = 16) were innovative processes (Table 2) to promote safe continuity of health care services (n = 8), ensure safe tertiary education of health care professionals and in-service training educational programmes (n = 6) and engage the community in mitigating the spread of COVID-19 (n = 2). The digital innovations included: mobile applications (n = 24), teleconsultations through hotlines, social media and video-conferencing (n = 19) and web-based platforms (n = 13). Due to this complementarity, these fields are presented together in the following paragraphs.

**Healthcare delivery**
Healthcare delivery constituted the most common digital health innovations (n = 25, 38%) and innovative processes (n = 8, 50%). Teleconsultations was the most common digital health innovation introduced during the COVID-19 pandemic to ensure continuity of services, especially for patients with chronic diseases (Table 1). Telemedicine included live interactions via telephone calls and messaging through social
| Country (Reference) | Description (#) | Institution |
|---------------------|-----------------|-------------|
| **Health care delivery**<sup>11</sup> | | |
| **Telehealth**<sup>12</sup> | | |
| Egypt<sup>13</sup> | Assessment of patient perception of synchronous (live interactions via WhatsApp and Zoom) and asynchronous (via WhatsApp and emails) use of telemedicine for dermatological consultations in Cairo | Academia |
| Jordan<sup>10</sup> | Establishment of a tobacco cessation hotline for nationals and refugees to provide free consultations and medications | Public sector |
| Lebanon<sup>14</sup> | Use of telemedicine and other telehealth activities such as public awareness, continuing medical education and research during the pandemic | Academia |
| Oman<sup>10</sup> | Introduction of telemedicine and mHealth modalities for people living with NCDs such as instructions on self-management of NCDs, appointments and prescriptions and collection times and a mental health hotline | Public sector |
| Qatar<sup>15</sup> | Establishment of telemedicine via phone calls for post-operative care of acute care surgery patients at Hamad Medical Corporation | Public hospital |
| Jordan<sup>10</sup> | Establishment of a tobacco cessation hotline for nationals and refugees to provide free consultations and medications | Public sector |
| Saudi Arabia<sup>16</sup> | Cura mobile application for teleconsultations | Private sector |
| Saudi Arabia<sup>16</sup> | MayaClinic mobile application for teleconsultations | Private sector |
| Saudi Arabia<sup>16</sup> | Nala mobile application for teleconsultations | Private sector |
| Saudi Arabia<sup>16</sup> | Labayh mobile application for teleconsultations | Private sector |
| Saudi Arabia<sup>16</sup> | Anat mobile application for e-prescription | Public sector |
| Saudi Arabia<sup>16</sup> | Wasfaty web-based platform for the gateway for e-prescription | Public sector |
| Sudan<sup>10</sup> | Establishment of an NCD hotline for consultations, triaging, medication prescriptions, health education, counselling and referrals complemented by WhatsApp to facilitate exchange of prescriptions and lab investigations | Public sector |
| UAE<sup>8,9</sup> | Introduction of tele-pharmacy including health promotion, virtual consultations and dispensing | Academia |
| UAE<sup>10</sup> | Introduction of telemedicine including phone or video consultations, e-prescriptions, home delivery of medications and social media to support people living with NCDs | Public sector |
| **Patient management**<sup>6</sup> | | |
| Jordan<sup>10</sup> | Creation of a web-based tool to gather patient information and assess services for home delivery of medications for NCD patients | Public sector |
| Kuwait<sup>17</sup> | Creation of a prognostic score system to predict severe disease progression of COVID-19 patients at the time of diagnosis to facilitate patient management | Academia |
| Morocco<sup>7</sup> | 3D visualization from CT images of COVID-19 patients to improve diagnosis and management | Academia |
| Saudi Arabia<sup>16</sup> | Utilization of a remote-controlled robot to monitor ICU patients | Public hospital |
| Saudi Arabia<sup>16</sup> | Asefni mobile app developed by the Saudi Red Crescent Authority for emergency services was adapted to provide movement permits during curfew | Public sector |
| Tunisia<sup>18</sup> | Development of web-based platform that evaluates lung X-rays to determine COVID-19 infection | Academia |
| **Mental health support**<sup>4</sup> | | |
| Jordan<sup>10</sup> | Establishment of two mental health hotlines staffed by specialist clinical psychologists | Public sector |
| Oman<sup>10</sup> | Establishment of a mental health hotline | Public sector |

(Continued)
| Country (Reference) | Description (#)                                                                                                                                                                                                                                                                                                                                 | Institution |
|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| Qatar[^10]          | Launch of a mental health helpline for children and parents, adults, older people and frontline healthcare workers staffed by mental health professionals who assess and provide support to callers as well as provide referrals to specialized psychiatric services when needed.                                                                                   | Public sector |
| Tunisia[^19]        | Implementation of a psychological crisis intervention hotline as part of the COVID-19 emergency response staffed by volunteer psychiatrists, child psychiatrists and psychologists                                                                                                                                                                           | Public sector |
| **Prevention[^20]** | **Mobile applications[^1]**                                                                                                                                                                                                                                                                                                                   |             |
| Bahrain             | BEAware App official application to assist contain COVID-19 including contact tracing, testing, general guidance and official statistics; [https://play.google.com/store/apps/details?id=bh.bahrain.corona.tracker&hl=en&gl=US](https://play.google.com/store/apps/details?id=bh.bahrain.corona.tracker&hl=en&gl=US) | Public sector |
| Iran[^21]           | Creation of a self-assessment electronic screening system as a mobile application and website to screen for COVID-19                                                                                                                                                                                                                      | Public sector |
| Jordan              | AMAN App, a community-driven mobile application developed by Ministry of Health, Jordan using GPS data to detect exposure to COVID-19 patients; [https://play.google.com/store/apps/details?id=jm.gov.moh.aman&hl=en_US&gl=US](https://play.google.com/store/apps/details?id=jm.gov.moh.aman&hl=en_US&gl=US) | Public sector |
| Oman                | TARASSUD App, a mobile application provides testing results, COVID-19 related statistics and vaccination certificate; [https://play.google.com/store/apps/details?id=om.gov.moh.tarassudapplication&hl=en&gl=US](https://play.google.com/store/apps/details?id=om.gov.moh.tarassudapplication&hl=en&gl=US) | Public sector |
| Qatar               | EHTERAZ App official application to alert exposure to COVID-19 cases, testing, vaccination, official announcements and statistics; [https://play.google.com/store/apps/details?id=com.moi.covid19&hl=en&gl=US](https://play.google.com/store/apps/details?id=com.moi.covid19&hl=en&gl=US) | Public sector |
| Saudi Arabia        | Tetamman App official application for testing, self-assessment and basic information; [https://play.google.com/store/apps/details?id=com.tetamman.home&hl=en&gl=US](https://play.google.com/store/apps/details?id=com.tetamman.home&hl=en&gl=US) | Public sector |
| Saudi Arabia        | Tawakkalna App official contact tracing application. Also used for vaccination and movement permit requests during lockdowns; [https://play.google.com/store/apps/details?id=sa.gov.nic.tawakkalna&hl=en&gl=US](https://play.google.com/store/apps/details?id=sa.gov.nic.tawakkalna&hl=en&gl=US) | Public sector |
| Saudi Arabia        | Tabaud App official application that notifies people if they had contact with a COVID-19 case; [https://play.google.com/store/apps/details?id=sa.gov.nic.tabaud&hl=en&gl=US](https://play.google.com/store/apps/details?id=sa.gov.nic.tabaud&hl=en&gl=US) | Public sector |
| Saudi Arabia[^16]   | Sehaty App official application adapted for COVID-19 testing and vaccine appointments; [https://play.google.com/store/apps/details?id=com.lean.sehaty&hl=en&gl=US](https://play.google.com/store/apps/details?id=com.lean.sehaty&hl=en&gl=US) | Public sector |
| Saudi Arabia[^16]   | Taqasi, a patient tracing application was used to enhance contact tracing-based testing results generated by the existing Health Electronic Surveillance Network                                                                                                                                 | Public sector |
| Tunisia             | E7HMI App official digital tracing application and sends notifications when exposed to COVID-19 patient; [https://play.google.com/store/apps/details?id=tn.onemc.e7m&hl=en_US&gl=US](https://play.google.com/store/apps/details?id=tn.onemc.e7m&hl=en_US&gl=US) | Public sector |
| UAE                 | Al-Hosn App official application for testing and vaccination certification; [https://wwwalhosnapp.ae/en/home/](https://wwwalhosnapp.ae/en/home/)                                                                                                                                         | Public sector |
| **Miscellaneous[^2]** | **Egypt[^12]** Development of a COVID-19 vaccine by the Center for Virology, National Research Center, Egypt                                                                                       | Public sector |
| **Egypt[^13]**      | Creation of a voice activated LED facial mask developed by programmer and game designer to simulate speaking of wearer.                                                                                                           | Individual/Entrepreneur |
| **Egypt[^14]**      | Design of a respiratory facial mask inspired by nanotechnology more efficient than N95 respirators that is also reusable, recyclable, and easy for mass production                                                                                                                       | Academia     |
| **Oman[^25]**       | Utilization of real-time estimation of R to assess implementation of nonpharmaceutical interventions across population sub-groups                                                                                                                                       | Public sector |

(Continued)
| Country (Reference) | Description (R)                                                                                                                                                                                                                                                                                                                                                                                   | Institution       |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|
| **Pakistan**       | 10-step pharmacist protection guidelines to raise awareness on personal protection among retail pharmacists                                                                                                                                                                                                                                                                                    | Academy          |
| **Public Health Informatics 17** |                                                                                                                                                                                                                                                                                                                                                                                                          |                   |
| **Mobile applications 6** |                                                                                                                                                                                                                                                                                                                                                                                                          |                   |
| **Algeria**        | Corona Map App official application to stay informed of the evolution of COVID-19 in the country including sending alerts to nearby health structures if symptomatic and notifications if in close contact with a confirmed COVID-19 case; https://play.google.com/store/apps/details?id=com.covid19_algeria&hl=en&gl=US                                                                                                                                            | Public sector     |
| **Kuwait**         | SHLONIK App, an interactive mobile application that provides health updates and a self-check mechanism for quarantined patients; https://play.google.com/store/apps/details?id=com.healthcarekw.app&hl=en&gl=US                                                                                                                                                                                      | Public sector     |
| **Libya 28**       | Adaptation of the Spectar mobile application to support COVID-19 patients in self-isolation in decision if/when to get care                                                                                                                                                                                                                                                                          | Entrepreneur      |
| **Saudi Arabia 16** | Sehla App official application for teleconsultation including live video chat and text messaging; https://play.google.com/store/apps/details?id=com.linkdev.seha&hl=en&gl=US                                                                                                                                                                                  | Public sector     |
| **Saudi Arabia 16** | Mawid App, the main channel for COVID-19 screening and triaging; https://play.google.com/store/apps/details?id=moh.gov.sa.mawid&hl=en&gl=US                                                                                                                                                                                                  | Public sector     |
| **Morocco**        | Wiqayatna App tracking app to detect confirmed cases physically close                                                                                                                                                                                                                                                                     | Public sector     |
| **Web-based platforms and computer programmes 7** |                                                                                                                                                                                                                                                                                                                                                                                                          |                   |
| **Afghanistan 29** | Geographic information system (GIS) software used to generate sub-national COVID-19 incidence, case fatality and recovery rates                                                                                                                                                                                                             | Academy          |
| **Iran 27**        | Development of a web-based COVID-19 registry which could be used to facilitate epidemiological surveys and support evidence-based management of COVID-19 patients across the country’s health system                                                                                                                                                              | Academy          |
| **Iran 10**        | Development of sub-national spatial modelling, risk mapping like heatmaps to support management and control spread of COVID-19                                                                                                                                                                                                            | Academy          |
| **Djibouti 11**    | Adapted DHIS-2 Tracker for COVID-19 surveillance                                                                                                                                                                                                                                                                                                                                                      | Public sector     |
| **Egypt 21**       | Regression modelling analysing first 5 months of COVID-19 in Egypt to predict epidemic peak and final epidemic size                                                                                                                                                                                                                     | Academy          |
| **Kuwait 32**      | Utilization of a deterministic and stochastic modelling approaches to develop prediction models of the size and spread of COVID-19 including simulation scenarios to demonstrate effectiveness of nonpharmaceutical interventions                                                                                                                                                | Academy          |
| **Morocco 33**     | Development of the SIR prediction model to determine COVID-19 evolution in the country                                                                                                                                                                                                                                                                                                               | Academy          |
| **Pakistan 34**    | Development of an artificial neural network to predict evolution of COVID-19 cases, deaths and recoveries                                                                                                                                                                                                                                   | Academy          |
| **Pakistan 35**    | Utilization of regression method with optimized hyper-parameter to develop prediction models of COVID-19 mortality                                                                                                                                                                                                                       | Academy          |
| **Pakistan 36**    | Development of a method utilizing GIS analysis to simulate spatial temporal COVID-19 data that could be used to guide implementation mitigation measures.                                                                                                                                                                                      | Academy          |
| **Palestine 12**   | Adaptation of DHIS-2 Tracker for COVID-19 surveillance                                                                                                                                                                                                                                                                                                                                              | Public sector     |
| **Saudi Arabia 17** | Utilization of autoregressive integrated moving average (ARIMA) model for 4-week prediction of COVID-19 case evolution                                                                                                                                                                                                                          | Academy          |
| **Saudi Arabia 38** | Utilization of the Susceptible-Exposed-Infected-Recovered (SEIR) model to simulate various social distancing scenarios to predict possible outcomes                                                                                                                                                                                              | Academy          |
| **Somalia 11**     | Adaptation DHIS-2 Tracker for COVID-19 surveillance                                                                                                                                                                                                                                                                                                                                                 | Public sector     |
| **Genome sequencing 4** |                                                                                                                                                                                                                                                                                                                                                                                                          |                   |
| **Egypt 37**       | Completion of genome sequence of two SARS-CoV-2 isolates                                                                                                                                                                                                                                                                                                                                            | Public sector     |
| **Morocco 40**     | Completion of genome sequence of one SARS-CoV-2 isolate                                                                                                                                                                                                                                                                                                                                            | Public sector     |
| **Saudi Arabia 41** | Development of a diagnostic genome signal processing-based system to detect COVID-19 and distinguish it from other coronaviruses to assist with rapid diagnosis.                                                                                                                                                                                      | Academy          |
| **Tunisia 32**     | Completion of the genome sequence of two SARS-CoV-2 isolates                                                                                                                                                                                                                                                                                                                                      | Public sector     |
| Country          | Description (II)                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Institution            |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| Pakistan 43     | Score Card for rapid assessment of suspect COVID-19 patients at the community level due to limited testing capacity in the country                                                                                                                                                                                                                                                                         | Academia               |
| Sudan 44        | Neighbourhood volunteer system of health professionals and community members to support quarantining people with COVID-19 within the community using a hotline and a community support system                                                                                                                                                                                                             | Academia               |
| Education 6     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                        |
| Jordan 15       | Provision of on-line classes via Zoom during lockdown Faculty of Medicine, University of Science and Technology                                                                                                                                                                                                                                                                                               | Academia               |
| Lebanon 46      | Provision of e-learning using Moodle for access to presentations followed by tests to assess understanding and on-line journal clubs by the Faculty of Medicine, American University Beirut                                                                                                                                                                                                                       | Academia               |
| Qatar 47        | Provision of e-learning by complementing existing on-line access to archive of lectures with updated course material, online discussion forums, live on-line lectures and practical sessions and journal clubs by the College of Pharmacy, University of Qatar                                                                                                                                                      | Academia               |
| Saudi Arabia 16 | Provision of accredited educational webinars on COVID-19 related topics by Saudi Commission for Health Specialties (SCFHS) in collaboration with local and international platforms                                                                                                                                                                                                                                 | Public sector          |
| UAE 50          | Digital learning platform used to build health working capacity to ensure continuity of services for patients with NCDs                                                                                                                                                                                                                                                                                | Public sector          |
| Programmes 1    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Public sector          |
| Qatar 48        | Modification of the orthopaedic surgery department and residency programme that included adapting COVID-19 into clinical practice such as screening and testing for surgical cases, use of PPE, virtual meetings, phone consultations, on-line interactive sessions for didactic training                                                                                                                                                       | Public sector          |
| Health care delivery 15 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                        |
| Bahrain 49      | Introduction of video and telephonic consultations and meetings including sharing WhatsApp numbers with patients to facilitate communication, limited in-person follow-up visits, used variety of PPEs for in-person consultation and bedside assessments, thermal screening of all visitors, COVID-19 screening questionnaires for all OPD patients, Bahrain Oncology Centre, King Hamad University Hospital | Public hospital        |
| Iran 50         | Establishment of a teleconsultation service to provide near real-time diagnostic national and international radiology expertise via WhatsApp for chest CT interpretations for suspect COVID-19 patients by the Iranian Society of Radiology                                                                                                                                                                                                                           | Non-governmental organization |
| Patient management 1 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                        |
| Kuwait 20       | Development of a clinical algorithm-based toolkit for the management of patients with COVID-19                                                                                                                                                                                                                                                                                                                  | Public hospital        |
| Lebanon 51      | Adopting a safety model simulating COVID-19 scenarios for various clinical departments American University Beirut Medical Centre                                                                                                                                                                                                                                                                   | Academia               |
| Morocco 52      | Development of an infection prevention and control strategy to control spread of infection in an oncology unit                                                                                                                                                                                                                                                                                                 | Public hospital        |
| Qatar 53, 69    | Adaptation of anticoagulation management system for patients including extended International Normalized Ratio (INR) recall period, provision of oral drugs, drive-up anticoagulation testing service, home visits, hotline and relocation of warfarin dispensing system to the clinic rather than the general pharmacy                                                                                                                                                     | Public hospital        |
| Saudi Arabia 53 | Adaptation of a range of measures to educate/raise awareness of COVID-19 precautions including approach to dispensing, messaging chronic disease patients about their medications and providing a drive through pharmacy                                                                                                                                                                                                 | Academia               |
| Mental health support 1 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                        |
| Iran 54         | Establishment of a mental health initiative for health care providers involving a small group social networking application, an online platform to screen for additional mental health support, and telephone guidance for caregivers by Tabriz University                                                                                                                                                       | Academia               |
media applications in Egypt, Qatar, Sudan and the United Arab Emirates (UAE) as well as the use of mobile applications by numerous private providers in Saudi Arabia. Some countries supported remote communication between patients and pharmacists using telepharmacy tools, e-prescriptions, home delivery of medical products and drive through services.

Various telemedicine approaches were used to improve patient management, such as developing tools for predicting disease severity, 3D visualization of computerized tomography (CT) images and a web-based platform to evaluate lung X-rays to determine COVID-19 infection. Innovative processes helped support continuity of care through establishing a network of radiology experts at the national and internal levels to support CT chest interpretations of suspected cases, develop a clinical algorithm-based toolkit for management COVID-19 patients and drive through anticoagulation testing services. Similarly, innovative processes were introduced to prevent the spread of disease among cancer patients including adopting infection and control strategies in oncology units in Bahrain and Morocco.

Multiple centralized psychological support interventions were developed during the pandemic to manage the urgent psychological need of the population through helplines in Jordan. The most innovative process with the psychological crisis intervention hotline in Tunisia was integrated as part of the COVID-19 emergency response and staffed by volunteer psychiatrists, child psychiatrists and psychologists. Another mental health initiative targeted health care providers in Iran and involved the creation of small group social networking application, an online platform to screen for mental health support and telephone guidance for caregivers.

Public health informatics

One of three digital health innovations were related to public health informatics. Smartphone apps were the most commonly reported and were used to notify users if they came in close contact with confirmed COVID-19 cases in 11 countries of the region, including Algeria, Bahrain, Egypt, Iran, Jordan, Kuwait, Morocco, Qatar, Saudi Arabia, Tunisia and UAE. The applications reportedly follow the international Google and Apple guidelines on data privacy and provided additional services such as sharing official statistics and COVID-19 information.

Web-based platforms were used to monitor the COVID-19 pandemic. Web-based registries were developed in Iran and Saudi Arabia and became reliable tools for COVID-19 data. Open-source, web-based applications, that support data collection, and analysis, namely the District Health Information Software 2 Tracker, was used in Djibouti, Palestine and Somalia. Two countries (Pakistan and Afghanistan) used GIS analysis techniques, resources and methods to trace the number of cases, locate the highly affected areas to guide the health authorities to take appropriate actions. At the same time, seven countries (Egypt, Iran, Kuwait, Morocco, Oman, Pakistan and Saudi Arabia) used machine learning and statistical modelling approaches to predict the rate of spread of COVID-19.

Four countries (Egypt, Morocco, Saudi Arabia and Tunisia) published the complete genome sequence of a novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) strains.

Prevention

Seventeen innovative digital technologies were used for prevention measures. Various mobile applications were used to support testing, contact tracing, self-assessment and vaccination status in eight countries (Bahrain, Iran, Jordan, Oman, Qatar, Saudi Arabia, Tunisia and UAE). Saudi Arabia reported using a mobile app to obtain movement permits during lockdowns.

New designs with innovative solutions for facial masks were developed in Egypt for population-based prevention and health care workers. Robots were used for monitoring intensive care unit patients in Saudi Arabia. Pharmacists in Pakistan developed a 10-step pharmacists’ protection guidelines in English and Urdu languages, for protection of pharmacists as they are the first line of contact for the public in this COVID-19 pandemic.

Education

Five countries (Jordan, Lebanon, Qatar, Saudi Arabia and UAE) described innovative approaches to ensure continuity of tertiary level education and workforce development during the pandemic. Educational institutions transitioned to online teaching through individual institute-based platforms and commercial platforms like Zoom and Google platforms. In Jordan, the Faculty of Medicine, University of Science and Technology, a well-regarded government supported university established in 1986, moved to on-line classes via Zoom during the lockdown. The Faculty of Medicine, American University Beirut, Lebanon, a private university founded in 1866, provided on-line access to presentations using Moodle and gave tests to assess understanding and established on-line journal clubs.
sity of Qatar, the country’s main university established in 1977 (http://www.qu.edu.qa/), complemented existing online access to archive of lectures with updated course material, established online discussion forums, provided live on-line lectures and practical sessions and journal clubs.47 The Saudi Commission for Health Specialties (SCFHS), the professional body overseeing professional training of health practitioners in Saudi Arabia since 1992 (https://scfhs.org.sa/), provided accredited educational webinars on COVID-19-related topics in collaboration with local and international platforms in Saudi Arabia.16

Digital learning platforms and websites were introduced to train and build capacity of health care workers.10 Virtual settings were used for progress updates, case discussions and review of imaging as an evolving educational strategies for the orthopaedics residency program at Hamad Medical Corporation, Qatar,48 the main secondary and tertiary health care provider in the country (https://www.hamad.qa/). A hospital-wide quality improvement initiative for the multidisciplinary health team on the identification of safety threats and preparedness for COVID-19 took place at an academic tertiary healthcare facility located in Beirut, Lebanon.51

Community engagement

Two innovative processes were introduced to engage the community in controlling the spread of COVID-19. In Pakistan, a simple score card was developed for community members to conduct a rapid assessment for suspected COVID-19 patients.43 A neighbourhood volunteer system of health professionals and community members were empowered to support the quarantining of COVID-19 cases within the community using a hotline service and creating a community support system to care for people isolated in community buildings.44

Discussion

Main findings

This scoping review shows how the COVID-19 pandemic allowed rapid design and adoption of health innovations in the EMR by ministries of health and academic institutions in the areas of public health informatics, health care delivery, education and community engagement. A large majority of the 82 innovations identified were digital and technology based. They were key to expanding health care delivery, strengthening health informatics and promoting prevention including innovative processes promoting continuity of health care services and improving access to education/training of the health workforce. Although this review does not evaluate user experience, the wealth of innovations identified demonstrates the crucial role innovations, particularly digital technologies, played in responding to the COVID-19 pandemic in the region. A systematic review of COVID-19 health innovations in the EMR could build on this initial effort and aim at a detailed assessment.

What is already known on this topic

Digital technologies, especially smart phone applications were ubiquitous, even in the early stages of the pandemic.56,57 Many EMR countries released GPS-enabled smartphone apps to monitor and restrict their citizens’ movement during curfew hours. Mobile apps and web-based applications for prevention, surveillance, health communication including self-assessment and contact tracing features were launched. Digital apps have demonstrated their effectiveness during the pandemic56 such as improving linkages between data sources and increasing information transparency.16

What this study adds

This review found a rapid expansion and optimization of digital technologies and innovative approaches used to ensure the continuity of health services including access to essential medicines. Telehealth technologies through live conferencing, phone calls and social media were used to increase patient adherence to treatment, for radiological diagnoses and to reduce unnecessary exposure to infection. Home delivery of medications and drive-through services were useful solutions to support mitigation measures especially during the lockdowns.53,55,58 Creating a people-centred digital health service delivery requires numerous critical factors including raising public awareness of digital health, building capacity of the health workforce and using inclusive approaches in their adoption and management.35,60 The WHO digital health strategy 2020–2025 is an important tool for achieving the health-related SDGs.60,61 The rapid adaptation of health systems to respond to the COVID-19 pandemic was only possible because of the creativity and innovation of health care workers and managers in different parts of the world, including the EMR. Assessing the positive and negative impact of the use of technology by health service users and providers can help determine how best they can be used to expand Universal Health Coverage (UHC) and ensure quality of care.60,62–64

Moreover, the COVID-19 pandemic highlighted the importance of mental health services, an often-neglected field in public health and clinical health care delivery. Various approaches were used to address mental health, including mental health hotlines adopted in numerous countries to
support the community\textsuperscript{10,19} and health professionals.\textsuperscript{10} Examining the utility, perceptions and impact of these services would be useful in determining how best mental health programmes could be fully integrated into health systems in EMR countries.\textsuperscript{65}

Public health informatics, including mobile applications to monitor the evolution of the COVID-19 outbreak, to screen and triage, web-based platforms for COVID-19 surveillance and computer programmes to predict COVID-19 disease evolution were some of the most common uses. They were used for documenting prior infection, vaccination status, providing testing results (e.g. polymerase chain reaction (PCR), rapid testing, etc.) and contact tracing. However, digital health technologies raises legal, ethical and privacy concerns, potentially threatening human rights in the attempt to protect public health,\textsuperscript{56,57,66} strengthen the legal and regulatory governance framework and ensure data protection and privacy are a critical step in promoting security, privacy and ethical use of data.\textsuperscript{50}

In the context of this unprecedented public health emergency, e-tools and distance learning platforms were used for higher education and health workforce capacity building. Health professionals and academics demonstrated their resilience in a time of crisis by being proactive in adapting virtual learning environments. The extent of their use in this region appeared to be dependent on institutional capacity and were possibly more successful where infrastructure and programming existed prior to the pandemic. Flexibility in information delivery and approach and ability to take advantage of available technologies to promote student engagement and provide practical learning experiences through a virtual platform are some of the lessons learned and these have the potential to expand health workforce capacity in the region.\textsuperscript{67,68}

**Limitations**

The attempt to document health innovations in EMR during the pandemic is challenging and shortcomings are expected. A single innovation could be classified under more than one field of innovation. This study did not evaluate the innovations or check for user experience. It did not identify innovations related to ventilators, vaccines, respirators and other technological advances, which have been of critical importance during the pandemic.\textsuperscript{3} Supporting future research that will investigate the success and challenges of digital experience during this pandemic is a key for constructive cumulative knowledge and up-scaling.

**Conclusion**

Despite the negative consequences, the COVID-19 pandemic provided the opportunity for rapid adoption of digital solutions with advanced technology tools in health care. In the EMR, digital technologies were introduced mainly in the fields of surveillance, prevention, diagnosis and service delivery. The speed with which these technologies were deployed in many different contexts demonstrates their ease of adoption and manageability and thus can be considered as the most scalable. New digital models of care should be integrated into public health preparedness guidelines. However, ethical frameworks to protect user’s privacy, training of health care professionals and educating the community are fundamental issues. A follow-up systematic review of COVID-19 health innovations in the region along with research assessing their effectiveness and impact would provide a more comprehensive picture useful to guide policy makers in strengthening emergency preparedness, response and recovery as well as in expanding UHC.

**Author Contributions**

N.M.K.E.: conceptualization, methodology, data collection, writing, review and editing.
A.M.: conceptualization, overall coordination, validation, review and editing.
A.A.H.: methodology, data collection, writing original draft.
N.N.A.: conceptualization, data collection, validation.
R.M.M.: conceptualization, methodology, formal analysis, writing, review and editing.
W.A.K.: conceptualization, methodology, data collection writing, review and editing.

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**Declaration of interests**

None.

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