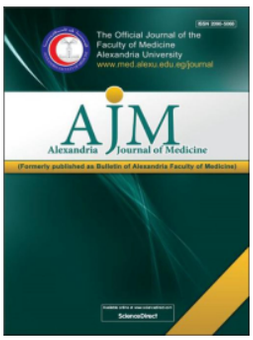

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A view of the health services after COVID-19: an Egyptian perspective

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ABSTRACT

Introduction: Humankind is now facing a global crisis. Perhaps the biggest crisis of our generation. However, national and international health systems failed to avoid millions of morbidities and hundred thousands of mortalities. The decisions people and governments take in the next few weeks will probably shape the world for years to come. They will shape not just our healthcare systems but also our economy, politics, and culture. Aim: The overall aim of this report is just to present an outline skeleton of the main elements of a health plan that may be adopted to achieve a high quality medical care services in the near future. Approach: The approach that will be adopted to present the main elements of the health plan will be through a time frame that includes short term (about one year) and long-term measures (five to ten years).

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COVID-19; medical technology; health services; Egypt; artificial intelligence

1. Background

It seems that the spread of new diseases, such as Ebola, Zika virus, HIV/AIDS, hepatitis C, and dengue hemorrhagic fever, and the resurgence of diseases long since considered under control such as malaria, cholera, and sleeping sickness, were just predicting a new disastrous biological threat. However, considerable attention was not drawn to a possible overwhelming worldwide disaster.

There are continuing threats of large epidemics with widespread mortality like the "Spanish flu" epidemic in 1918–1919 which killed an estimated 40 million people worldwide, or the HIV/AIDS epidemic which has caused widespread morbidity and mortality, and reversed hard-won gains in life expectancy in Africa [1].

On January 8 2020, a novel coronavirus was officially announced as the causative pathogen of COVID-19 by the Chinese Center for Disease Control and Prevention [2]. The epidemics of coronavirus disease 2019 (COVID-19) started from Wuhan, China, December 2019 and have become a major challenging public health problem for not only China but also countries around the world [3]. On January 30 2020, the World Health Organization (WHO) announced that this outbreak had constituted a public health emergency of international concern [4]. The novel coronavirus was initially named 2019-nCoV and officially as severe acute respiratory syndrome coronavirus 2 (SARSCoV-2). As of April 16, COVID-19 has been recognized in all countries, with a total of more than two million laboratory-confirmed cases and more than 135,000 deaths [5].

Humankind is now facing a global crisis. Perhaps the biggest crisis of our generation. The decisions people and governments take in the next few weeks will probably shape the world for years to come. They will shape not just our healthcare systems but also our economy, politics, and culture. We must act quickly and decisively. We should also take into account the long-term consequences of our actions. When choosing between alternatives, we should ask ourselves not only how to overcome the immediate threat but also what kind of world we will inhabit once the storm passes. Yes, the storm will pass, humankind will survive, most of us will still be alive – but we will inhabit a different world. Many short-term emergency measures will become a fixture of life. That is the nature of emergencies. They fast-forward historical processes. Decisions that in normal times could take years of deliberation are passed in a matter of hours. Immature and even dangerous technologies are pressed into service because the risks of doing nothing are bigger. Entire countries serve as guinea-pigs in large-scale social experiments [6].

2. Justification and need for a novel health system

The main justification for the need of both a new national and international concepts of the health system is failure of both the international and national health authorities to avoid millions of morbidities and hundred thousands of mortalities. Even the adopted measures to combat such disaster caused severe undermining of the economic, social, and the current lifestyle of the whole mankind.

The institutions and approaches that have until now enabled health progress across the world are straining under gathering pressures and seem

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outmatched against new risks. Health systems around the world are at risk of becoming unfit for purpose. Changing societal, environmental, demographic, and technological patterns is straining their capacity.

Not only that but, longevity, lifestyle, and climate changes are transforming disease burdens. Health systems need new infrastructure, resources, and skills, but in many parts of the world, they are failing to adapt – even as healthcare spending soars to unsustainable levels [7]. The WHO deems climate change to be "the greatest threat to global health in the 21st century" [8]. Human-induced climate change is already impacting the health of millions and challenging health systems globally [9]. The main concern here about climate change is its association with the incidence of infectious diseases. Warming temperatures are expanding mosquito-friendly habitats beyond the tropics, spreading diseases such as malaria, dengue, yellow fever, West Nile virus and Zika into new regions. Extreme global warming could expose a billion people to mosquito-borne diseases in previously unaffected regions such as Europe and East Africa [10].

We are standing at an inflection point, with technological progress in a number of areas generating new ideas to solve one of the biggest challenges in our lives today. The Future Health Community necessitates an initiative to stimulate a paradigm change in health care by exploiting the most advanced sensing, computing, and communication technologies to enable high-quality medical care and services in the framework of the Internet-of Humans. Support for Future Health will enable the Egyptian health system to extend and increase its scientific excellence and competitiveness, driven forward by the creation of a cost-effective, sustainable, equitable heath care system [11].

2.1. Importance of high-quality health systems

Good health is the foundation for societal well-being and a dynamic and prosperous economy [12]. Health systems form part of countries' critical infrastructure: they are vital to security, resilience, and growth. At the population level, health underpins productivity. Well-functioning health systems enable countries to respond to, and recover from, natural and human-made disruptions. Health risks pose an expensive and expanding transnational challenge. Health systems need to take a critical look at the fitness of their current approaches and institutions if we are to maintain the progress and tackle emerging threats. When health systems fail to mitigate vulnerabilities and adapt to changing contexts, they increase the likelihood of economic crises, political instability, and social ruptures [7].

3. Aim of the work

The overall goal of the novel health system is to develop the technology, the required infrastructure, and the legal, regulatory, and educational environment for a fully sustainable healthcare system that will offer truly advanced medicine, prevention and wellness for citizens, providing a completely new Quality-of-Life. The main mission of healthcare is to develop the technology, the required infrastructure, and the legal, regulatory, and educational environment for a fully sustainable healthcare system that will offer truly high quality care, prevention, and wellness for the citizens, providing a completely new Quality-of-Life.

The overall aim of this work is just to present an outline skeleton of the main elements of a health plan that may be adopted to achieve a high quality medical care services in the near future. No attempt will be tried to present a complete comprehensive national health plan that includes vision, mission, values, goals and specific measurable objectives, main and subordinate activities, which are time framed and assigned to agencies and individuals responsibilities as well as measurable follow up indicators, as this necessitates:

- Assessment of the current situation of the administered health services
- Time resource
- Team resource
- Administrative resources to facilitate data collection and designing such plans

The approach that will be adopted to present the main elements will be through a time frame that includes short term (about one year) and long-term measures (five to ten years).

4. Short-term activities and practices

4.1. Introduction

The period following control of COVID-19 pandemic is a critical one as disease control in one country does not indicate overall control as imported cases can still occur. Also, up till now, it is not known whether there will be either reactivation of infection or genetic drift or shift of the virus that might cause even more severe waves of the disease. Thus, extreme caution and alertness must be taken into consideration. Also, up till now there no either an effective and efficient drug or vaccine for the management of this pandemic. This situation necessitates multiple measures that must be taken into consideration. The most important measures are:

4.2. Surveillance

It is clear that effective public health surveillance is critical for the early detection and prevention of

epidemics [1]. Continuous Surveillance and scrutinizing of all aspects of the occurrence and spread of COVID-19 must be continued. For this, systematic collection, analysis, interpretation, and dissemination of health data are essential. This includes collecting information about clinical diagnoses, laboratory diagnoses and mortality, as well as other relevant information needed to detect and track the disease in terms of person, place and time. Medical-geography and geographical mapping of the cases is a must. This can be performed through either ready-made software and specially tailored ones. The system should be central with peripheral terminals at each governorate. The system can be initiated immediately and can be tailored and continued later on and can be used to monitor and map other communicable and non-communicable diseases. This can work as an early **health alarm system** to identify communicable diseases and syndromes to take the suitable community and other intervention measures to control these diseases. It would be of great benefit if the system is linked with other similar systems in the Eastern Mediterranean Region and other regions of the world through networks. This will act as an early warning system for predicting cross-world health emergencies.

4.3. Pharmacological management

The unavailability of either a vaccine or an effective drug for COVID-19 disease necessitates that the Egyptian scientists should continue their efforts to find either of them. Also, it should be taken into consideration that the Egyptian health authorities must share in the clinical trials that are carried out to discover either of them. This policy will guarantee either production of these products in Egypt or at least getting them in a subsidized cost.

4.4. Catch up and rescheduling

The shortage of resources and the increased need for facilities are jeopardizing the usual high standards of elective care to patients [13]. Diagnosis would be delayed for many patients in multiple specialties. Also, time is needed to restore activity and catch up on the backlog. The COVID-19 outbreak made it necessary to suspend or reduce the number of multidisciplinary meetings and other important activities. In the dramatic scenario of intensive care bed scarcity, patients with cancer may need non-invasive options as a compromise (for example, radiotherapy, chemotherapy, or both) yet there may be treatment delays due to the pandemic. The potential disease progression, which is associated with quality of life and costs of care implications [14], has a knock-on effect that may happen with benign disorders too [15] Most health systems continue to focus on reactive care in hospitals – detecting and treating disease – and give too little attention to NCD prevention and control. They have yet to adapt their infrastructure to combine online, remote, and retail care settings to improve information, screening, treatment, and support for patients and caregivers. Health systems – and governments more broadly – will also need better health policies, regulations and promotion strategies to reduce environmental and lifestyle risk factors of NCDs [7].

4.5. Crisis management team

Interaction between intervention measures to control health problems and other aspects like economy, community, energy supply, security, food supply, transportation, communication, real estate, banking, and all other activities affecting daily life of the community necessitates formulation of a multidisciplinary teams for crisis management on the national and local (governorate) levels.

4.6. Universal health system and organizations

It is apparent that the universal health organizations failed to play its main role, namely protecting health and saving lives. It is expected that these organizations will be both restructured and a new formulation process is in its way. The Egyptian authorities must not be only prepared to share in these newly formed organizations, but also to actively participate and look for key positions in these organizations.

4.7. Health in mass media and communication with the population

It can be safely said that the mass media health campaign failed to stimulate the majority of the population either to keep a safe physical distance from others or to stay at home most of the time or wear protective masks. Although it can be argued that there are some lack of resources especially for masks, however, homemade mask could have been produced and used. Also, the majority of the population did not adopt many other safe behaviors that could help lead to control of the pandemic in combination with other preventive measures. This can urge the need to revise mass media health policy and raise the question of strengthening the mutual trust between the health authorities and the population especially in the direction to the population.

Centralized monitoring and harsh punishments aren't the only way to make people comply with beneficial guidelines. When people are told the scientific facts, and when people trust public authorities to tell them these facts, citizens can do the right thing even

without forced monitoring. A self-motivated and well-informed population is usually far more powerful and effective than strictly monitored, ignorant population. Consider, for example, washing hands with soap. Today billions of people daily wash their hands because they understand the facts. They wash their hands with soap because they have heard of viruses and bacteria, they understand that these tiny organisms cause diseases, and know that soap can remove them [6].

But to achieve such a level of compliance and co-operation, you need trust. People need to trust science, to trust public authorities, and to trust the media. Normally, trust needs time to be rebuilt. But these are not normal times. In a moment of crisis, minds too can change quickly. During emergency, a hidden reservoir of trust and amity can be rapidly built. It is not too late to rebuild people's trust in science, in public authorities and in the media. We should definitely make use of new technologies too, but these technologies should empower citizens. Learning to track individual medical condition would raise health awareness and inform the population how to identify healthy behavior that positively contribute to their health. Free access to information will further add to trusting health authorities and their adoption of right policies to combat the epidemic [6].

4.8. Back migration of health workers

As every country now is planning to depend, mainly, on the national workforce; many Egyptians will lose their jobs in foreign countries. It is expected that there is a back migration of many workers and may be health workers in the Arabia Gulf countries and other countries. Plans should be designed and ready to deal with those workers and backstream them to governmental or private work according to the need of each specialty.

4.9. Demands of healthcare workers

Immediately after control of this pandemic; it is seems that some healthcare workers will ask for multiple demands including the restructuring of the healthcare delivery system, reformulation of the medical associations and asking for financial and non-financial benefits among others. Several parties, especially those with political views will be demanding reform and multiple changes to gain leadership in the medical association and attract attention to their parties. Thus, plans must be prepared to deal with these demands and parties.

4.10. Recognition of eminent figures

To raise the morale of the health workers and show appreciation of their efforts during this pandemic; short lists should be prepared of eminent figures that have distinguished roles to combat this epidemic. Moral and psychological appreciation is more important than the financial ones. Model making will encourage the future generation of healthcare workers to do their best to serve their patients and their country.

5. Long-term activities and practices

During the past few years, The Egyptian Government designed ambitious plans in all fields of life including the health field. Building hospitals, empowering health teams, establishing the basis for comprehensive health insurance coverage, increasing the non-human resources, enhancing the quality of medical care through accreditation measures, in addition to others. However, in view of the impact of COVID-19; it seems that these measures need strengthening. Thus, an outline skeleton to develop and improve the administered health services on the long run (five to ten years) will be uncovered as follows:

6. Financial resources

There is a demand–capacity mismatch of the administered health services. The Egyptian constitution assign at least 3% of the national growth product for the health services that can be increased to match the universal rates. This asset (3%) was only adhered to during the current crisis to cover the urgent needs. As more people live for longer with increasing health and social care needs, and as new drugs and technologies are developed, surging demand and expectations are stretching current approaches to financing care. Health expenditure growth is outpacing inflation in most countries [16]. It has reached an unsustainable 18% of GDP in the United States [17]. To fulfill its commitments to the population and achieve its objectives; the Ministry of Health needs a budget not less than 5% of the GDP [7].

6.1. Community participation

In addition to the governmental financial resources, the non-governmental contribution forms a large proportion of the total health expenditure. However, this contribution is random and opportunistic. If well systematized and organized and can be easily be streamed into the financing health system. Development plans of medical needs must be made widely available for all the population and especially those welling to contribute in this field. This will guarantee proper directions of such contributions to the high priority needs. Fragmented efforts in this direction should be unified. There are multiple successful models that can be followed like the "57,357 Hospital" and others.

7. Health insurance

The current plans for comprehensive insurance of health for all the population of Egypt are still in the experimental plans and just only covering a few governorates that are not heavily populated. Although this seems logic yet, now there is a large demand to immediately extend the coverage to more and more governorates. The adopted plans must be modified to achieve 100% coverage in the shortest possible period (3–5 years). But health systems are finding it difficult to adapt amid questions over who should pay, how high a price can be justified, and what can be given up to afford new therapies. As people's expectations rise, unequal access to better therapies could deepen health inequalities, eroding trust in health systems and societal cohesion.

8. Health services

8.1. Coverage

Health coverage has been fully studied in the sustainable development goals that were launched by the United Nations (UN) and has been ratified by most of the countries of the world. The coverage areas and rates of beds per populations as well as the accessibility of health coverage have been standardized and discussed in details in many documents [18].

8.2. Coordination of health sectors

Currently, health services in Egypt suffer from fragmentation. Multiple parties and agencies have their own health services. The most important major agencies administering health service include governmental (Ministry of Health establishments which has many functional, administrative, and economic classification, University Hospitals, Military hospitals, police hospitals) and private (hospitals, clinics, dispensaries, private companies health services, and contracting). Other types of health services include those provided by different associations for their members, even some governmental agencies provide special healthcare services for its members.

A new system has to be developed to combine most of these fragmented services into one; the most suitable one is the newly established health insurance system for all the governmental and non-governmental establishments. Special consideration should be taken into care regarding the military health services. However, the total capacity of medical care of the country must be well documented to be used during major disasters. A higher committee under the direct order of the prime minister must be activated during the these disasters to command and mange healthcare delivery during these times.

8.3. Levels of health service

8.3.1. Healthcare units

The overall structure of the health services in Egypt is good in terms of geographical covering by primary healthcare units whether in the rural and to some extent in the urban areas. Most of the villages are covered by rural health units; however, primary healthcare units are covering a large number of population in the major cities and towns.

Administratively these units must be linked to the newly established Health Insurance System and form the main core of its function. Each of these health units must be linked to a central hospital as the only way for the patients to be referred to the hospital through the family physicians working in these units. The main specialty in these units must be highly qualified family physicians.

These units must be linked to the central hospital through telecommunication networks that enable the family physicians to have direct consultation with the experts about the clinical, laboratory and imaging findings through broadband networking facilities and the electronic file of the patient and his family. Patient medical files must be linked to National Identity Card to facilitate the health insurance procedures and flow of data.

8.3.2. Home care

One of the main types of newly developed health care is homecare medicine. This should be the responsibility of the family physicians and can be followed by both the physician and the nurse. Homecare providers should have a clear set of standards which cover:

The selection, registration, and discharge of patients, service quality goals, reporting against governance standards including linking into Health Insurance system effectively, e-Transactions, e-homecare and management information requirements/service levels, Patient management, wellbeing safety, experience, outcome, confidentiality, management and monitoring, communications, Compliance with medication and any incidents which relate to this, performance monitoring and management.

e-Transaction mechanisms which set out a common platform for interaction between the patient and homecare provider, to enable effective ordering and management of homecare medicine. Clear systems for reporting and managing risks in homecare medicine between the homecare provider and the healthcare units should be provided [19].

8.3.3. Hospitals

The COVID-19 crisis revealed that the major defect lied in the secondary hospitals as it was not equipped or manpowered both qualitatively and quantitatively enough to deal with the crisis in view of affection of

a considerable percentage of medical staff. Even before the crisis most of these hospitals were suffering from low bed occupancy.

As shown previously, these hospitals must be linked with healthcare units. To raise the quality level of administered medical care, it is suggested that close cooperation is needed with the university medical staff to share the responsibility with their colleagues in these hospitals through clear protocols that exactly define their duties and relation with the present medical staff. If correctly arranged; this system will help improve quality of administered medical service, provide clinical education of the postgraduate students in their own workplace and thus decrease the burden of the tertiary care hospitals (university hospitals) which should only receive patients referred by these secondary hospitals. Hours of work, financial incentives and duties as well as responsibilities can be managed through a well prepared protocols between the ministry of health and the universities.

8.3.4. Academic and research medical centers

The cost of high-quality university education is very expensive; even research activities are more expensive and consume an enormous amount of financial and non-financial resources. Keeping a high-quality level of more than 20 universities in Egypt is too difficult. The private universities although share in the educational goals of the country, yet their ultimate goals are making profit and can not afford the huge required budget for highly distinguished academic/research centers (ARC) that are beyond their capacities.

The specialty will be determined according to the already present one (that will be strengthened), need and demand by the locality, trained manpower available. These centers will receive its patients from all over the country as the substitute is getting such service abroad. These centers will also attract patients from the surrounding countries. They can act as both research and training centers in addition to the highly advanced medical service.

Thus, it seems reasonable to have 8–10 highly advanced academic/research centers. Each center will be dealing with a field perspective different from the other one. It is suggested that these centers should cover the most important field related to the future expected medical technology and including, but not limited to, genomic perspective, biomedical technology, pharmacogenetics, bioengineering and artificial intelligence.

Primary, these centers can be located to cover and serve the whole country. In view of the economic and demo-geographical characteristics of Egypt; these centers can be located in Great Cairo (New Capital), Suez Canal region, Alexandria and one in Upper Egypt (Assuit) and other selected areas to reach the required number (8–10 centers). There are already some distinguished models in Egypt like the "Mansoura Nephrology Center" and the "Aswan Cardiac Center of Magdy Yakoub." The success stories of these canters can be replicated in other areas.

These centers must be linked to the related mega factories and agencies that are expected to be localized in Egypt or the Middle East in general as their outcome applied research will be available for these factories. This will, to some extent, provide a source for financial needs of these centers. Multiple sources should be searched for financing these centers including governmental and non-governmental ones. These centers must be unique whether in their specialty field or flexible and independent rules and policies of administration

The main features and roles of these centers can be summarized as follows:

To empower the researchers to find new cures, disseminate knowledge, and improve health for all people. Shaping the Future of Medicine will strengthen and accelerate the medical impact by enhancing the essential attributes of the integrated Academic Medical Centers (AMC): Championing a culture of innovation, excellence, inclusion, and collaboration; attracting and supporting the most talented faculty and effective leaders of departments, centers and institutes, and the health system; leading in the use of informatics to catalyze discovery and integrate research and clinical care; ensuring strong financial performance with balanced support across missions; and being among the world leader in all mission areas. The main mission is to advance knowledge and improve health through research, and the education of trainees in an inclusive culture that embraces diversity, fosters innovation, stimulates critical thinking, supports lifelong learning, and sustains legacy of excellence.

Recommend-Centric Care of the Future, by driving innovation in the delivery of high quality and high-value care; providing a world-class inpatient care guidelines; and harnessing the power of data science to provide precision diagnostics and therapies that will result in better health and fewer hospitalizations.

Pioneer New Discoveries and Therapies for Patients by developing new methods and technologies to transform biomedical research; advance first in human trials based on these discoveries; catalyzing entrepreneurship and new commercial partnerships to advance health and cure disease; fostering a culture of interdisciplinary collaboration; and applying public health scholarship and healthcare delivery science to achieve both regional and global impact on health.

Foster Inclusion, Engagement, and Professional Development by championing inclusion and diversity across the health system; launching innovative personal and professional development programs to foster engagement and advancement; and driving individual and organizational change initiatives to promote

wellness and resilience in a rapidly evolving biomedical research and healthcare environment.

Promote Lifelong Learning by developing innovative methods for on-line education and experiential learning; fostering engagement of all trainees (PhD, MS) in cross-training activities; and enhancing personal and professional development.

8.4. Human resources

One important element of the capacity building process is empowering the medical staff (physicians, nurses, technicians, and all medical team members) to be able to adopt and safely practice all the required clinical and other skills in addition to the newly introduced technological medical techniques. Information technology, artificial intelligence, and digitalization concepts should be an essential part of preparing both the future medical staff and on job training of those enrolled at work.

Calculation of the ratios of physicians/population, nurses/population and other staff should be compared with both universal and similar countries figures. The outcome of these calculations must be linked to both and undergraduate and postgraduate number of students (by specialty). All factors affecting job satisfaction, low morale and burnout (number quitting the job by migration out or other reasons) of medical staff must be taken into consideration when deciding on the final numbers. The brain drain of health workers places further strain on health services. Adopting these approaches could provide sufficient numbers of well-trained staff that contribute to required quality of medical services.

8.4.1. On job continuous medical education

On job training should be planned as an integrated part of capacity building of the medical human resources. Multiple methods and approaches can be utilized for on demand skill building. Programs and plans of continuous medical education should be prepared to include task building activities and clinical skills that match the need according to the specialty. Training programs should include all members of the medical staff and not just only physicians. Plans for training of nurses, technicians, and allied personnel should be prepared and implemented all-round the year. Methods and educational content will be discussed in detail under education of medical students.

8.5. Non-human resources

Non-human resources does not only include supplies and equipment but also the legislation, policies, regulations, and guidelines that govern the whole process of administering high-quality care to maintain and improve the health of the patients. Sufficient budget must be provided to guarantee all the required essential equipment and tools and continuous supply of the required dispensable and supplies. Policies and regulations should be enhanced to match the planned progress in view of the updated medical technology and artificial intelligence and medical digitalization.

9. Digital healthcare technology [20]

The experiences gained from the COVID-19 pandemic should be thoroughly analyzed in order to inform future policies across the entire spectrum of the digital domain. In particular, fields such as "e-Health, digital education, e-Government, data sharing and broadband connectivity," should receive particular attention following the current coronavirus crisis.

Healthcare will not just be altered by the proliferation of new medical technologies coming up from research labs. As the COVID-19 disease spread was exponential; healthcare change will also be driven by the exponential growth in computing technologies, as well as long-term sociodemographic trends [21].

Digital healthcare technologies should not just be seen as increasing costs, but rather as a new means of addressing the big healthcare challenges. The next decade presents an opportunity to address data governance and cyber security concerns, agree ethical frameworks and develop staff/organizations to implement digital technologies in the workplace. The complexity of data governance requirements should not be a reason for inaction. Most importantly, there must be mechanisms in place to ensure advanced technology does not dehumanize care. While automation will improve efficiency, it should not replace human interaction.

Genomics, digital medicine and artificial intelligence (AI) will have a major impact on patient care in the future. A number of emerging technologies, including low-cost sequencing technology, telemedicine, smartphone apps, biosensors for remote diagnosis and monitoring, speech recognition and automated image interpretation, will be particularly important for the healthcare workforce.

9.1. Top technology descriptions [22]

9.1.1. Telemedicine

Telemedicine deals with providing direct consultations to the patients using both audio and video approach [23]. It can easily reach patients and avoid dropouts. Home care constitutes another area where telemedicine can be beneficial to both residents and staff [22]. However, a main disadvantage of telemedicine is its inability to replace physical examination and

the mutual communication between the healthcare givers and the recipients of this care. Privacy and security of obtained medical information have to be taken into consideration as well as the cost of the service [24].

9.1.2. Smartphone applications

Multiple smartphone applications are becoming available. Monitoring of vital signs, checking scheduled medical checkups and asking for delivery of prescriptions all can be practiced through phone applications [22].

9.1.3. Sensors for monitoring

Medical management depends mainly on laboratory and non-laboratory investigations [25,26]. Multiple types of patient monitoring are available including self-tests as those of HIV and diabetes [27]. Many others are being developed to measure vital signs and can provide fast linking to health services [20,28,29]. Video-cameras can be used in elderly home-care and psychiatric hospitals to monitor high-risk situations [30,31].

9.1.4. Speech recognition

Speech recognition programs can save time for writing reports and even writing clinical notes through clinical digital records. Most of the time assigned for administrative tasks can saved and used for clinical practice [32].

9.1.5. Automated image interpretation

Automated image interpretation can provide rapid and accurate diagnosis. It can save time and reduce cost of expertise [33,34]. Specialties like radiodiagnosis, pathology, and dermatology can make great benefits of such technology. With progress of smartphone cameras; images can help in early diagnosis [35].

9.1.6. Interventional and rehabilitative robotics

Robots are currently used in many disciplines of medicine particularly general surgery, orthopedics and urology and gastrointestinal surgeries [36–38]. Repetitive tasks also may make benefit from robotics [39].

9.1.7. Predictive analytics

Mathematical modeling is more and more used specially in epidemiological studies. However, risk analysis using these models can be used to predict other medical events such as unexpected deterioration of hospitalized patients and predicting multiple events in more than one center [33,34,40–42].

9.1.8. Writing the genome

Genome-editing can help patients through writing and reading genomic information. Clinical trials are currently carried out to use of gene editing in hemophilia and cystic fibrosis which are rare diseases. Genomic editing can provide personally tailored treatments [43].

9.2. Limitations of technology

New technologies may carry the risk of jeopardizing both patient safety and privacy. While errors of a single healthcare worker may affect few patients; errors of modern technology may affect a large number of patients [44]. Also the risk of cyberattacks is a real threat [45].

Another limitation of modern technology is the ethical problems about birth and death. A fetus can be removed from the uterus to an incubator several weeks before delivery. Also, resuscitation measures and use of mechanical ventilators raised multiple problems about the decision to stop its use [46].

10. Training of medical students

10.1. Background

The capabilities of all medical team members need to be enhanced to offer the highest possible quality of medical care to their patients. Medical schools must be stimulated to improve the level of education and adopt recent approaches of education. Introducing new curricula and improving the already present one are needed. Emphasis has to be upon integrating technology into the practice of medicine, and building leadership and communication skills. Dealing with “big data” should be stressed [47].

New methods of training for all the medical staff, especially undergraduate and postgraduate medical students should be adopted. With the wide spread of the telecommunication methods and the increasing use of digital technology, phone application, and the easy accessibility to information on the worldwide web; professional and clinical skills should be the main target of learning.

Online learning and uploading of educational materials through well-designed educational courses should be used for knowledge. It should also cover the first stage of skill building (core knowledge and demonstration) through electronic educational materials. Physical and psychomotor (mainly clinical and laboratory) skills can only be built in the hospitals and laboratories.

This approach has many advantages and can solve serious problems that the medical learning process is suffering. Obstacles like overcrowding, large number of students, long time required for learning, saving time of university staff (will have more time for clinical

practice), in addition to decreased cost on the long run (no need for large lecture rooms, etc.)

10.2. Postgraduate medical training

Postgraduate medical training, in Egypt, suffers from multiple problems and generally speaking does not satisfy the large hopes of these students. Currently, there are multiple educational certificates under the auspices of multiple agencies. Recently, some efforts are practiced to coordinate these agencies. This crisis necessitates that a single educational certificate based mainly on acquiring well planned defined clinical skills is required. Coordination between the universities from one side and the Ministry of Health (currently the main employer of the medical staff) from the other side in collaboration with military medical academies can result in well-defined programs and medical curricula. The already present program can be used as a starting point and make the necessary changes.

Through the generic professional capabilities framework, we will expect all postgraduate curricula to reflect essential generic professional capabilities crucial to safe and effective patient care, such as communication, leadership, and patient safety. This framework will strengthen the emphasis on training all doctors to be future leaders and to work well in multidisciplinary teams. All doctors, regardless of their specialty, will have to demonstrate they have achieved these capabilities by the time they complete training [48].

The main obstacle that face postgraduate medical training in Egypt can be avoided through transferring clinical skill building to their own workplaces. As we discussed before; moving of the university staff to the central secondary hospitals will serve double purpose; improving the level of the medical care and learning of the postgraduate medical students through actual clinical practice with a reasonable ratio of student to learner indicator. Well-designed logbooks containing both quantity and quality of the required clinical skills will act as an important indicator of achieving the learning objectives.

Perhaps the main advantage of the current postgraduate medical education system is the five years of training which seems to be sufficient period to acquire the targeted skills. However, the overall content that may need change. The newly developed comprehensive care model and teamwork necessitates that the training program should include one year training designed for acquiring some general clinical skills that are necessary to deal with the patient in this comprehensive concept. Also, this crisis showed that with losing a considerable portion of the medical teams (by infection) necessitates shifting physicians from other specialties to dover the defect. This means that emergency and life-saving skills, other clinical skills like general medicine for very specified medical ones as well as general surgery skills for the special surgeons, are very important.

This modification of the training will lead to better cross specialty understanding and recognition, a more flexible medical workforce. More general training within and across specialties will help in its development, Flexibility in training arrangements that consider how and where doctors train, such as less than full-time training, and Flexibility in working practices to adapt to patient and health service needs.

10.3. Factors to be considered for preparing and training medical students [49]

(1) Leadership skills and to be a team player.
(2) We can retrieve a lot of things now and reduce some of the burden on learning and memory, because non-emergency knowledge can be "pulled" when needed.
(3) An underlying sense of responsibility toward our community and the patients we serve, strong sense of values and ethos.
(4) Generalist skills: family medicine, general medicine, geriatrics, health promotion, and prevention.
(5) Skills for lifelong learning.
(6) We need to deliver cost-effective care, and understand our health system, its costs, finances, and economics.
(7) Skills for quality improvement and innovation. We need to be comfortable with technology, data, and analytics, in how to use medical data in our IT systems to improve our care, and for digital medicine.
(8) Doctors will need a high degree of adaptability given the complexity and change in systems.
(9) Continued trust and support from the community. We must always maintain trust because that underlies everything we do and our ability to serve our patients.

11. Fields and scopes of medicine

It is not just only the approach of teaching that has to be changed but also new fields of medicine are arising and the relative need to some fields and scopes are emphasized.

11.1. Emergency medicine

This specialty must be strengthened and its curricula should be modified to cope with the newly developed technological methods. **Disaster medicine** curriculum must be added to the learning courses.

11.2. Family medicine

Nearly four decades ago, the specialty of family practice was created to fulfill the generalist function in medicine. This specialty was established to reverse the decline of general practice [50,51] and provide personal, frontline medical care to people of all socioeconomic strata and in all regions. In fact and unexpectedly; family physicians had a minor role during this crisis. Multiple factors might be behind this deficient role; lack of training and clearness of duties and responsibly can be spotted. Yet, an evaluation study is recommended to assess the extent of achievement of its objectives. This specialty is of utmost importance and should have a leading role as a first-line care deliverer. Restructuring of curricula is required and a community preventive intervention curriculum should be added.

11.3. Tropical medicine

It is the time to improve this very important specialty which could have played a pivotal role during this crisis. Clinical diagnosis and management of all forms of communicable diseases (not only endemic ones) must be integrated with educational courses in addition to increasing the credit hours assigned to general epidemiology, biostatistics and evidence-based medicine. This specialty should be prepared to be a pioneer in the scope of infectious diseases.

11.4. Genetics

Clinical and laboratory genetics should be closely associated and fully coordinated. Advanced molecular genetics is expected to be the leading specialty in the very near future. Currently, at least in Alexandria Faculty of Medicine, there is no clinical department of genetics. Although the clinical service is present; however, it is fragmented among the different specialties.

11.5. Elderly medicine

With expected increase in the life span of the Egyptians; the elderly will form a conservable percentage of the population. This group of age is at higher risk of non-communicable diseases as well-communicable diseases due to their lowered body immunity. More specialized physicians in this field are needed to cover this expected increased demand.

11.6. Medical imaging

We should be prepared to the great expected advancement in technology of body imaging. It seems that body imaging will be one of the major diagnostic tools of most kinds of diseases.

12. Mega high technology biomedical industry

Egypt is qualified to attract and localize mega biomedical industries and artificial intelligence technology. With the expected shift of the major universal industries from the far east and specifically China; Africa, in general, and Egypt in special should offer generous facilitation to localize these industries. However, this necessitates a strong infrastructure not only including the trained cheap manpower but also an advanced network of roads, sufficient energy with reasonable cost and efficient network of municipality. Not only that but an efficient network of telecommunication covering the whole country is a must. Encouraging policies and procedures is the key factor for attracting such industries. Egypt can be the main center of high technology biomedical industry in the Eastern Mediterranean Region (EMR).

The high priority industries that are related to the healthcare industry include pharmacogenetics, biomedical engineering, medical equipment and supplies in addition to many other small industries artificial intelligence technological industries that will support and continuously supply the needs of these mega universal industries.

These industries must be linked to the Academic and Research Centers (ARC). These centers will serve as a counselor for these industries and can work as an experimental field and research centers. This will guarantee a considerable financial resource for the ARC.

In addition to the multiple economic, social, educational, and community benefits of these industries is the medical ones. These industries will provide most of the needs of medical supplies required by the different health facilities and will provide most of the medicines and medical supplies required by the health system not only in Egypt but in the whole Eastern Mediterranean Region.

Cost benefit analysis studies are definitely required for each type of industry including all the factors required for localizing such industries.

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