



Current and future clinical research in Sudan: an opportunity for everyone to choose research in medical education, communicable and non-communicable diseases

Mohamed H. Ahmed¹, Musaab Ahmed^{2,3}, Mohamed Hassan Taha⁴, Ahmed O. Almobarak⁵, Wail Nuri Osman⁶, Mohamed Elhassan Abdullah⁷, Azza Zulfu⁸, Elmoubasher Farag⁹, Abubaker Omer¹⁰, Nazik E. Husain⁸

¹Department of Medicine and HIV Metabolic Clinic, Milton Keynes University Hospital NHS Foundation Trust, Eaglestone, Milton Keynes, Buckinghamshire, UK; ²College of Medicine, Ajman University, Ajman, United Arab Emirates; ³Center of Medical and Bio-allied Health Sciences Research, Ajman University, Ajman, United Arab Emirates; ⁴College of Medicine and Medical Education Center, University of Sharjah, Sharjah, United Arab Emirates; ⁵Department of Pathology, Faculty of Medicine, University of Medical Sciences and Technology, Khartoum, Sudan; ⁶Faculty of Medicine, University of Gezira, Sudan; ⁷School of Medicine, University of Limerick, Limerick, Ireland; ⁸Department of Pathology, Faculty of Medicine and Health Sciences, Omdurman Islamic University, Khartoum, Sudan; ⁹Department of Public Health, Doha, Qatar; ¹⁰Faculty of Medical Sciences, Örebro University, Örebro, Sweden

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Correspondence to: Mohamed H. Ahmed. Department of Medicine and HIV Metabolic Clinic, Milton Keynes University Hospital NHS Foundation Trust, Eaglestone, Milton Keynes, Buckinghamshire, UK. Email: Mohamed.Hassan-Ahmed@mkuh.nhs.uk.

Abstract: Sudan is a country with huge natural resources and this may provide a potential for a rich and diverse health research economy especially in medicine. It is important that both basic and applied medical research will be directed and prioritized according to the need of Sudanese communities based on experiments tested in the lab and can be implemented in bedside practice. This can help in facing the health challenges associated with communicable and non-communicable disease. Research in medical education is also needed especially with an increase in the numbers of medical schools. Research for everyone involved in medical education and practice should be adopted as a way forward in Sudan. In other words, research engaged medical force will improve the medical care in Sudan. For instance, doctors can develop expertise, deep learning in their specialties and enhance their chance of developing theories and proposal (satisfy the need for doctors inquiring minds). University hospitals and patients will benefit from recent advancements in medicine in term of diagnostic and treatment. Importantly, research is bringing satisfaction, dynamism and opportunity for doctors to leave a legacy for the next generations of doctors in Sudan. During the pandemic of COVID-19, it is clear that more research is needed in Sudan. Importantly, diabetes, obesity and hypertension are known to have a high prevalence in Sudan and also risk factors for COVID-19. This is a challenging time for the health system in Sudan, and perhaps investing in research will help in keeping people well and open new venues for health service in Sudan. We very much hope that this article will increase understanding and enthusiasm about research in communicable, non-communicable diseases, medical education and social medicine. Therefore, we feel that every doctor in Sudan should engage in research activities so that current and future patients can benefit from the outcomes of these research activities.

Keywords: Clinical research; Sudan; medical education; communicable; non-communicable diseases

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Introduction

Sudan is a large country in north east Africa and surrounded by seven countries. The recent political changes are thought to bring significant changes to the country including medical education and policies about the conduction of medical research and practice. The population of Sudan is a mixture of Nubian, Egyptian, black African Nilotic and Arab. This mixture of different ethnicities meant that there is different types of diseases and genetic structure for different regions in Sudan (1). For instance, in the North of Sudan, there is a high prevalence of noncommunicable diseases like diabetes and hypertension. The admission to hospitals in the North of Sudan showed high admission of non-communicable disease in comparison with a communicable disease. However, the findings of this study were shown in the Atbara Teaching Hospital which is based in the north of Sudan. Therefore, further, research is needed to establish whether this phenomenon is happening in different cities in Sudan (2).

Different types of tropical diseases are found across Sudan and this in addition to large numbers of neglected diseases. For instances, Malaria is always a big challenge for health authorities in Sudan especially during the rainy seasons and also during the flood of the River Nile (3). The fact that the River Nile is crossing the country from the South to the North and the presence of large irrigations schemes is also another contributing factor for the water-borne diseases. Therefore, communicable diseases are also other important challenges (4). It worth mentioning that during the COVID-19 epidemic many researchers from Sudan have also contributed to medical literature. For instance, they showed how the mitigation efforts of the Ministry of Health in Sudan helped to decrease the impact of COVID-19 (5,6). Researchers from Sudan have showed that different blood groups and living in malaria belt can in part also protect against COVID-19 (7). The burden of COVID-19 cannot be underestimated as many African countries went through difficult crises in decreasing the influence of this epidemic. The research in COVID-19 can benefit from the increase in medical graduates in Sudan. The increase in medical Schools in Sudan within the last two decades has led to an increase in medical graduates, which was also associated with increased brain drain as some of these graduates left the country to work in the Gulf, USA and Europe. There is also an urgent need for research in medical education especially about the social accountability of medical schools and curriculum designs that will be of

international caliber, at the same time this can help to meet the demand of the local health care system in Sudan.

Taking all these factors into consideration, the aim of this review is to highlight the importance of research in communicable, non-communicable diseases and medical education and the need to monitor, coordinate and evaluate the progress of medical research in Sudan. We have provided three sections for all these research themes with detailed explanations for the research opportunities. We much hope this review will provide opportunities for young Sudanese doctors to pursue a career that involves research activities as part time or full time.

Methodology

In this narrative review, we searched Medline (PubMed) and Google Scholar for scientific publications (original and review articles) published in English in the period from the first of January 2015 through the 31st of December 2020 about communicable, non-communicable diseases and medical fields in Sudan. For communicable diseases, we used the keywords Sudan AND communicable diseases OR malaria OR schistosomiasis OR tuberculosis OR antibiotic resistance OR covid-19 OR water-borne diseases. For non-communicable diseases, the search engine includes Sudan AND diabetes OR obesity OR hypertension OR ischaemic heart disease OR maternal mortality OR childhood health OR cancer. While for medical education research, the words: Sudan AND curriculum type OR course design OR learning strategies OR student assessment OR social accountability OR PHD-MD program were used. For social aspects of medicine, the keywords included Sudan AND medical AND habits OR tradition OR customs OR belief, in addition to specific diseases (mycetoma, leishmania, tuberculosis, malaria and cancer).

Non-communicable diseases

like many African countries, the obesity prevalence increased significantly. Ahmed *et al.* showed that the prevalence of obesity among 7,239 Sudanese was 21.2%, and prevalence of overweight was 34.9% with a higher rate of obesity and central obesity in females more than males (8). Therefore, it is not surprising that the prevalence of diabetes was suggested to be around 19%. Diabetes in Sudan was also shown to be associated with a high prevalence of diabetes complications like retinopathy, diabetic foot, neuropathy, stroke and ischaemic heart disease

(9-11). The prevalence of fatty liver was found to be 20% but this level was found to be 52% in Sudanese individuals with diabetes. There is an urgent and dire need for research in the field of metabolic medicine in Sudan (12,13).

Other aspects of the non-communicable diseases are cancer and maternal and child health. There is an increase in maternal and neonatal morbidity and mortality in Sudan. The issue of childhood malnutrition is also an important challenge for the health authorities in Sudan.

The area of non-communicable diseases is fascinating and represents an exciting field especially in a country like Sudan. This can be an area for focus in different research as there are many questions not yet answered. For instance, whether the genetic structure of certain tribes in Sudan will make them more prone to certain diseases such as cancer, hypertension and diabetes or diabetes complications. The prevalence of diabetes and its complications in different parts of Sudan is not well researched. Besides, the delivery of diabetes services needs more research and assessment. This can be an interesting area for further research and one area of innovation is the use of telemedicine to deliver diabetes services in remote areas. The contribution of local Sudanese foods in the high prevalence of obesity and metabolic syndrome need to be investigated, as this will help in giving appropriate dietary advice.

Different studies showed a high prevalence of cancer in Sudan. For instance, a high prevalence of breast cancer was noted around 25–30% (14,15). There is also an urgent need to understand the prevalence of cancer in Sudan and associated risk factors in community-based studies. The genetic factors and environmental impacts also need to be researched. Therefore, we feel that non-communicable diseases still is an area that will be benefiting from extensive research in the coming years. The examples of research areas we provided are not inclusive for all research areas but are just to provide a glimpse of what can be done in the field of non-communicable disease.

Non-communicable diseases cause 52% of all deaths in Sudan. Cardiovascular diseases account for 28%, cancers 6%, respiratory diseases 3% and diabetes mellitus 2% of all deaths. Injuries 13% and other NCD account for 12%. While, Death from communicable, maternal, perinatal and nutritional conditions accounts for 35% (16).

Communicable disease and social aspects of diseases

Sudan is a country blessed with a significant amount of

fresh water in the forms of rains and different types of rivers and irrigations schemes (the Blue Nile and White Nile meet in Khartoum to form the river Nile which ends in the Mediterranean Sea). This may directly or indirectly affect the spread and transmission of water borne disease like schistosomiasis and transmission of Malaria. Hazardous water conditions in the country due to poor sanitation and climate greatly affect the health of the population, and these issues are responsible for waterborne and foodborne diseases. Aside from diarrheal problems, there is also the issue of schistosomiasis in East and South Darfur states along with other neglected tropical diseases (3).

The most prevalent disease in Sudan is schistosomiasis, which is a parasitic infection strongly tied to freshwater sources (3). Recent surveys have identified presence of both *Schistosoma haematobium* and *Schistosoma mansoni*, being highly transmissible through water. Major risk for these diseases has been known to be frequent contact with bodies of water.

Another disease endemic to Sudan is malaria, caused by single-cell parasitic protozoa *Plasmodium falciparum* and transmitted via female *Anopheles* mosquitoes (17). The transmission ranges from extremely low in Khartoum and the north, to highest in southwest of the country (3). Conversely, *Plasmodium vivax* is an emerging pathogen in Sudan, accounting for 10% of the malaria cases in the nation.

Chikungunya is another mosquito (*Aedes aegypti*) borne disease mainly associated with urban environment which results in fever, rash, and severe joint pain (17). This is also perpetuated by unsanitary conditions that continue to plague the nation.

These are viral diseases that interfere with liver functions and typically spread through water contamination due to contact with fecal matter (17).

Also, leishmania is another important challenge especially in the Eastern part of Sudan. The disease is widespread to the degree that 93% of the population is considered to be at risk of the visceral disease. It has been observed to be restricted to southern, eastern, and central regions of Sudan (3). According to World Health Organization (WHO) there are on average 3000 cases every year for leishmaniasis, which seems comparatively low which might be due to lack of appropriate tools to conduct definitive diagnosis.

Tuberculosis prevalence survey of 2014 revealed a mortality rate of 21 per 100,000 people, a prevalence of 151 per 100,000 people and an incidence rate of 94 per 100,000 people. The main challenges include low detection rate,

rising number of cases of multi-drug resistance TB and poor integration of TB within the health system particularly with HIV (3).

COVID-19 pandemic found the health system in Sudan unprepared to meet with high demand for intensive care admission. COVID-19 has raised significant questions about the need for the country to establish a contingency plan for research especially during the time of the epidemic. There is an urgent need to address different questions about COVID-19 in Sudan. Among these questions, is there any new strains of the virus in Sudan, genome sequencing is not yet established, the social and political impact of COVID-19 and the use of traditional medicinal plants as treatment are not yet explored. It is also extremely interesting to understand and investigate the interaction between infectious diseases such as malaria, schistosomiasis, tuberculosis, and COVID-19.

Medical education research

Sudan is a country with a long history of medical education that goes beyond a century. The main leaders in medical education and innovation are Gezira University, Khartoum University and Sudan Medical Specialization Board. A master degree in medical education is one of the best opportunities in medical education research. Importantly, the successful candidates in this master program were able to progress further and obtain PhD in medical education from Gezira University. The medical colleges in Sudan adopted different types of curricula for undergraduate teaching. For instance, curriculum based on problem-based teaching, community-oriented curriculum, hybrid curriculum or traditional teaching curriculum. Therefore, there are many opportunities for research in curriculum design, delivery and assessment. This important as many medical colleges have adopted the system of community-oriented curricula. Hence, there are abundant opportunities for innovation and more development in this area. The use of online teaching is also another area for further research and how new technology can be used as an integral part of curriculum delivery. Competency-based Medical Education Curricula for Improving Practices (SudaniMEDs) is another area for further research and exploration. Professionalism among medical students is also an area that needs continuous evaluation and assessment and this also can be an area for further research. The social aspects of medical education are also another pioneer area for researchers to explore further and to add more to the experience of Gezira

university (18). The social accountability of the medical schools is another pioneer area for medical educationalist in Sudan. For instance, Ahmed *et al.* critically assessed why it is important for medical schools in Sudan to be socially accountable and whether there is a need for a special structure of social accountability in Sudan? (19). Therefore, there is a need for more research about how medical schools in Sudan with different curricula will be able to implement the concept of social accountability. Importantly, there is a need to understand whether socially accountable medical schools will have a positive impact on the community. Implementation of reflection and assessment in Sudan can be an exciting area of research and may generate new ideas and approach in medical education (20).

Medical education and postgraduate can be an exciting field. For instance, Ibn Auf and Ahmed showed that psychiatric training for family physicians in training in Gezira University in Sudan was associated with significant improvement in attitudes towards psychiatry. We have also recently discussed the proposal about the implantation of the postgraduate MD-PhD programme by the Sudan Medical Specialization Board and how this can increase the number of physician-scientists in Sudan. Therefore, further research in training in postgraduate in different fields can involve different aspects of clinical learning and research (21).

Conclusion and the ways forward to strengthen medical research in Sudan

From the above discussion, it is clear that there is a need for more efforts to promote research and the introduction of medical innovations. The main focus will be to train clinician-scientists who can lead in all aspects of medical research in Sudan. The clinician-scientists can also contribute to the development of research programs, including collaborative initiatives with the biomedical and pharmaceutical industry, and expertise on establishing training guidelines for academic research and on the training of clinician-scientists. Therefore, our vision is that an independent professional body in research working in close supervision with Sudan Medical Specialization Board will help in promoting research in Sudan. Collaboration with the regional and international academic and funding organizations will also be necessary. It is expected such initiatives may promote excellence in translational and clinical research and to develop an academic base to improve human health and healthcare services (*Figure 1*), and ultimately this may promote academic medicine in

Table 1 Proposed steps that will enhance and strengthen research in Sudan

Pillars to strengthen medical research in Sudan	Explanation
1. Design of research and policy	The main aim is to develop sustainable scientific medical research policies, strategies and innovation based on appropriately regulated research environment that will contribute to the health and wealth of Sudan. Adoption of the policy of collaboration with national and international academic institutes to harness the culture of research and innovation and attraction of national and international funding
2. Achieving high standard and excellence in research	The first step in achieving excellence in research is an investment in people conducting and leading research. Universities and medical schools should recruit the brightest and best medical graduates. Supporting them during their research journey and promoting and celebrating their achievements and harnessing their expertise to attract more young medical graduates. Encourage Sudanese researchers to publish in international journals and promote international research collaboration
3. Invest in developing talented researchers with aim of retention and recruitment and to prevent brain drain	The need to establish a clear academic research career pathway. For instance, we have recently proposed the PhD-MD program as one way of increasing the number of Sudanese clinical scientist. The opportunity for an international research fellowship will come with considerable benefit for the researcher. A clear policy is needed in term of training and career pathways and personal support for early-career biomedical researchers
4. Encourage patients and public contribution in medical research	It is important to use different resources in the media to promote the importance of research and how this can help in the development of the health and wealth of Sudan. Such a positive perception of research will increase and motivate young generations of doctors to join the research. Awareness of the public about research will increase the engagement in clinical trials and willingness to participate in research
5. Providing further opportunities and support for PhD holders and independent researchers	Providing opportunities for national and international research. Increase research funding and allow the clinician to have dedicated time for research. Harnessing networking activities and be part of sustainable global health development programs to build a reputation based on excellence and cutting-edge research
6. Promotion of collaboration with diverse disciplines like biomedical scientists, statisticians and medical diaspora	Every effort should be directed to encourage full diversity of the biomedical and health community, showcasing talent from all areas and different backgrounds. It is vital that success achieved is recognized and rewarded as will lead to more success in life and work
7. Huge investment is needed in management courses and promoting emotional intelligence	Sustainability of success in research output in limited resources countries is largely dependent on excellent management and team with a high level of emotional intelligence
8. System of monitoring of progress and achievement	Continuous monitoring of research progress and impact is vital to address the impact on the health of Sudanese people

Sudan. In *Table 1* we have listed possible pillars for the main work that needs to be done to strengthen medical research in Sudan. Importantly, research is much depending on the excellent collaboration and teamwork. Promotion of collaboration with diverse disciplines like biomedical scientists, statisticians, and medical diaspora, should be part of the policy for success in research. Every effort should be directed to encourage full diversity of the biomedical and health community, showcasing talent from all areas and different backgrounds. It is vital that success achieved is recognized and rewarded as this will lead to more success in

life and work. Huge investment is needed in management courses and promoting emotional intelligence. Sustainability of success in research output in limited resources countries is largely dependent on excellent management and team with a high level of emotional intelligence.

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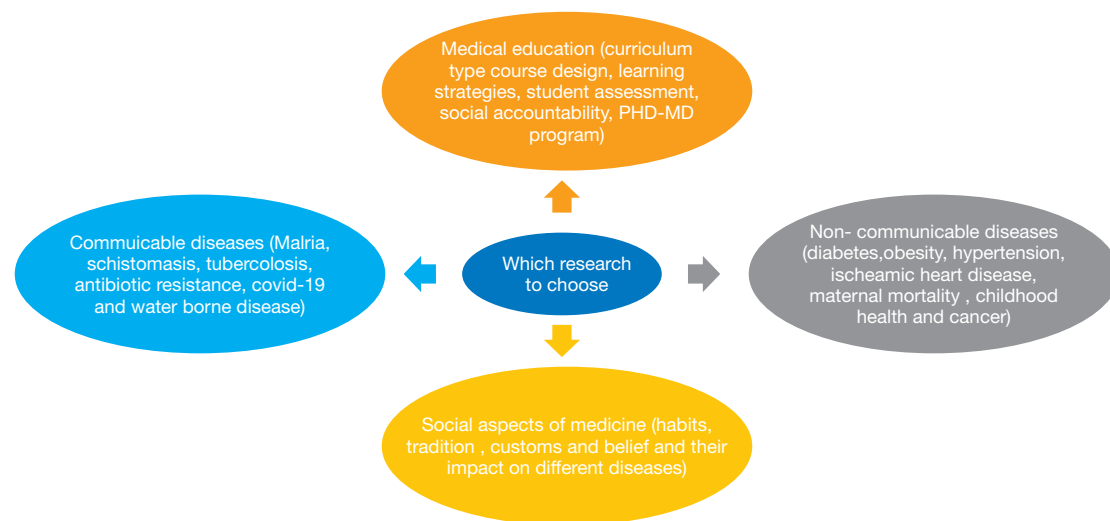


Figure 1 showing opportunities for research in communicable, non-communicable diseases, social medicine and medical education in Sudan.

Footnote

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