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The value of China-Africa health development initiatives in strengthening “One Health” strategy

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Abstract

Implementing national to community-based “One Health” strategy for human, animal and environmental challenges and migrating-led consequences offer great opportunities, and its value of sustained development and wellbeing is an imperative. “One Health” strategy in policy commitment, partnership and financial investment are much needed in advocacy, contextual health human-animal and environmental development. Therefore, appropriate and evidence-based handling and management strategies in moving forward universal health coverage and sustainable development goals (SDGs) are essential components to the China-Africa health development initiatives. It is necessary to understand how to strengthen robust and sustainable “One Health” approach implementation in national and regional public health and disaster risk reduction programs. Understanding the foundation of “One Health” strategy in China-Africa public health cooperation is crucial in fostering health systems preparedness and smart response against emerging and re-emerging threats and epidemics. Building the value of China-Africa “One Health” strategy partnerships, frameworks and capacity development and implementation through leveraging on current and innovative China-Africa health initiatives, but also, mobilizing efforts on climatic changes and disasters mitigation and lifestyle adaptations strategies against emerging and current infectious diseases threats are essential to establish epidemic surveillance-response system under the concept of global collaborative coordination and lasting financing mechanisms. Further strengthen local infrastructure and workforce

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capacity, participatory accountability and transparency on “One Health” approach will benefit to set up infectious diseases of poverty projects, and effective monitoring and evaluation systems in achieving African Union 2063 Agenda and SDGs targets both in Africa and China.

Keywords: cooperation; health development initiative; “One Health” approach; preparedness; emergency response; public health emergency; implementation; Africa; China

Introduction

The China-Africa partnership is one of the most important geopolitical and economic relationships of the 21st century that has ushered a new era of investment in mutual health development [1]. China has become the world’s second-largest economy and offered Africa various based on win-win cooperation. Traditionally, China is willing to work together with Africa to achieve mutual benefits by taking advantage of its status as assistance-provider in tackling infectious diseases of poverty [2, 3]. Furthermore, since Africa is home to seven of world’s ten fastest growing economies, Chinese investments in the health sector in the continent can produce substantial financial gains and generate invaluable public health commodities and other goods that are much needed [4, 5]. The need for an African Centre for Disease Control and Prevention (CDC) was recognized at the African Union Special Summit on HIV and AIDS, TB and malaria held in Abuja, Nigeria, in July 2013. The Africa CDC has launched year with the establishment of an African Surveillance and Response Unit, which will include an Emergency Operations Center and exchanges on China’s national disease surveillance and reporting system [4]. Currently, Africa continent is experiencing a rapid economic growth, with a gross domestic product (GDP) of \$ 2.4 trillion USD in 2013 and is estimated to increase to \$ 3.3 trillion USD by 2020. Health-care spending rose from \$ 28.4 billion USD in 2000 to \$ 117 billion USD in 2012 across African countries [6-8]. The fact that Sub-Saharan Africa accounts for 14% of the world’s population and 24% of the global burden of infectious diseases caused by poverty, millions of people could be lifted out of poverty through bilateral trade and cooperation between China and Africa. Increasing and robust new commitments of

governments, investments from international community and other public-private stakeholders on the national health budgets have promoted and actively supported the “One Health” implementation policy and programs in African countries in achieving their health-related sustainable development goals (SDGs). Towards the goal of joint research and education development, the mix of Chinese “One Health” programs and the African vulnerable groups will foster social cohesion in preparedness and response to emerging global challenges [9]. For instance, Chinese and African experts have initiated in revamping new approaches to global health political commitment of implementing universal health coverage, strengthening its primary healthcare system and increasing investment in public health multidisciplinary interventions to reduce the increasingly heavy burden caused by infectious diseases at global level [6, 8]. Disease outbreaks are increasing globally due to environmental degradation, climate change, population growth and increased cross-border movements [1].

The unprecedented nature and uncertainties in emerging and existing infectious diseases of poverty, public health threats and epidemics emergencies crises impact linked to human animal and environment interactions are of particular interest from a One Health perspective. The interplay of public health, biosecurity and One Health approach provide immense opportunities for both local and international health actors to address the national/regional public health needs and differential vulnerabilities assessment towards evidence based multifaceted and inter-sectoral programs and interventions. For instance, two major outbreaks of Lassa fever (LF) occurred in 2016 in the two neighbouring West African countries of Nigeria and Benin Republic. Nigeria suffered a larger burden of LF in this recent



outbreak and accounts for about 85% of all deaths recorded (a total of 585 suspected cases, 56 confirmed cases and 73 deaths recorded since disease onset in August 2015). In 2014, US CDC estimated the yearly number of LF cases to be between 300,000 to 500,000 resulting in about 5,000 deaths across West Africa. LF is endemic in most parts of West Africa with sporadic cases occurring in other African countries every year. Studies have predicted approximately 80% of Liberia and Sierra Leone, 40% of Nigeria, and 30% of Benin to be at risk of LF through spatial analysis. In Nigeria, approximately 4883 cases and 277 deaths have been reported from 2012 to date. Due to a paucity of data, the actual number of cases in other West African countries to date is still unknown. However, seroprevalence studies in the past have shown a prevalence of Lassa IgG antibodies in 8% to 52% of the general population in Sierra Leone and in Guinea, and as high as 25% to 55% among inhabitants of tropical rain forest and 29% to 40% in hospital staff of Gueckedou and Lola Prefectures in Guinea. Direct transmission from rodent to humans mainly occurs through inhalation of

primary aerosols from infected rodent urine, ingestion of food contaminated with rodent excreta or by direct contact with broken skin. Regional and nosocomial outbreaks of LF are commonplace in LF endemic countries and played a major role in recent outbreak. In Nigeria, the 2016 LF outbreak has been estimated to have an overall case fatality rate of 48% and 60% in confirmed cases; the impact on healthcare workers due to inadequately equipped, weak preventive measure for hospital associated infections (HAI) and well trained staff and facilities with poor laboratory and clinical management practices were the main reasons for a dearth of data. While there is no known vaccine for LF, early supportive care and treatment with ribavirin. Prevention efforts include isolation of cases, implementing infection control measures such as barrier nursing supplies, rodent control and practicing adequate food hygiene (storing grain and other foodstuffs in rodent-proof containers) and personal hygiene. Although treatment for LF is available, early diagnosis, prevention and prompt management of infection are necessary (Table 1).

Table 1 Prevalence and mortality of existing infectious diseases of poverty and emerging epidemics worldwide

Type	Disease	Year of emergence	Species or disease interface	Number of human species (n)	Global prevalence (number of cases)	Global mortality (number of death)	Vaccine or immunization available
Recent emerging infectious diseases outbreaks	Ebola virus diseases (EVD)	1976	H-A-E	4	27,551	11,236 + 879	Phase III clinical trial
	Zika Virus (ZIKV)	1947 (isolation) 1952 (first evidence)	H-A-E (<i>A. aegypti</i> , <i>A. albopictus</i> & <i>Culex spp.</i>)	2 (over 40 strains including 30 in humans and 10 in mosquito)	Unclear but reported in 74 countries and territories including 44 autochthonous transmission	Unclear--cluster of microcephaly cases and other neurological disorders (15,186 GBS cases)	N. A.
	MERS-CoV	2012	H-A-E	2	1,305	583	N. A.
	Meningitis	>100 years	H-A-E	5	430 million	230,000 per year	Available
	Influenza (Human-animal)	1918	H-A-E	3	200,000	3,300-49,000 per year	Available
	Dengue/Dengue hemorrhagic fever	1988	H-A-E	4	50-528 million per year	25,000	N. A.
	Lassa fever (LF)	1974	H-A-E	-	300,000 to 500,000	5,000	N. A.
	Rift valley fever	1955	H-A-E	2	Over 5,000	>700	Animal vaccinations available
SARS-CoV	2002	H-A-E	2	8,096	775	N. A.	

(Continued)

Type	Disease	Year of emergence	Species or disease interface	Number of human species (n)	Global prevalence (number of cases)	Global mortality (number of death)	Vaccine or immunization available
Existing infectious diseases of poverty	Malaria	1880	H-A-E	5	198 million	367,000-755,000 per year (2013)	Phase III clinical trial
	Tuberculosis (TB)	1882	H-A-E	2	9 million	1.5 million (2013)	N. A.
	HIV/AIDS	1983	H-A-E	2	33.2–37.2 million	1.4–1.7 million	N. A.
	Schistosomiasis	1851	H-A-E	4	261 million	20,000 to 200,000 per year (2013)	N. A.
	Cholera	1854	H-A-E	2	3–5 million	100,000–120,000	N. A.
	Poliomyelitis	1908	H-A-E	1	416	–	Available
	Hepatitis	1973 1967 1989 1990	H-A-E	3	A : 1.4 million B: 240 million C: 130–150 million E : 20 million	– 780,000 350,000 to 500,000 56,600	Available
	Yellow fever	1899	H-A-E	1	200,000	30,000	Available
	Leishmaniasis	1903	H-A-E	2	1.3 million	20,000 to 30,000	N. A.
	Typhoid	430–424 B.C.	H-A-E	1	22 million	216500	N. A.

H-A-E: human-animal-environment interface; SARS-CoV: severe acute respiratory syndrome coronavirus; MERS-CoV: middle east respiratory syndrome coronavirus; N.A.: not available

These growing public health emergencies and challenges prompted a memorandum on building the Africa CDC that was signed by the African Union with two parties are including Chinese and US governments. This cooperation exploring ways of further cooperation and lessons learning from China's national disease surveillance and reporting system model [1, 4]. Based on a unified and integrated plan, China and US government are willing to leverage their respective strengths to support the African Union in building this system, which will be the first regional disease surveillance system on the African continent from the Ebola crisis. It is important to strengthen disease surveillance and monitoring efforts at the regional level in providing technical expertise and response coordination in future health emergencies, address complex health challenges, and build needed capacity responses, responsible for disease surveillance, investigations, analysis, and reporting trends and anomalies. This is a landmark event in African ownership of improving health across the continent. The US CDC looks forward to engaging in this partnership for many

years to come to advance public health across Africa and global health security [1, 4]

Results from the First and Second China-Africa Ministerial Health Development Forum held in Beijing, China and Cape Town, South Africa in 2013 and 2015, respectively, showed that China-Africa health development partnership had entered a new collaborative paradigm with great global health opportunities [1, 5, 8]. Chinese and African health ministers have adopted a declaration to increase access to facilities, medication, health workers and training, linking Chinese scholars with those in Africa into shared responsibility and global solidarity [5]. Importantly, China-Africa collaboration in health development will use "One Health" approach to set the collaborative priorities, such as developing innovative information and communication technology for health, building regional surveillance systems, improving the core capacities of international health regulations and enhancing the using regulation of traditional medicines, etc [1, 6, 9].

The significance of Africa-China cooperation health development initiative milestone was the broad consensus



MoU aimed to support the establishment of Africa CDC signed on April 2015, as part of the agreement and of the pledge made at the summit that was held under FOCAC in Johannesburg, South Africa December 2015 [1]. This laudable mutual commitment was realized through the full operationalisation of the Africa CDC in early 2016 supported by the Chinese government, including providing infrastructure construction, equipment, information system, expertise, and professional training, etc. As well fostering continuous strengthening African states public health prevention and control system under the Chinese supports are also provided through comprehensively capacity building (e.g., staff, postdocs and students) and providing technical assistance and technology transferring to Africa CDC sub-regional centres. The benefits of the translation of the immense mutual public health priority aligns “Africa Union health vision 2063” in the fields of infectious diseases of poverty surveillance and elimination, emergency preparedness timely response to early alert and risk communication capabilities against public health emergencies and disaster crises events. Previously, China has already provided two million US dollars cash aid for the Africa CDC in terms of capacity building and the on-site Chinese experts visit for the regional collaboration with other partners’ support [4]. Africa CDC has now developed a five year strategic plan to improve surveillance, emergency response, prevention and resilience against infectious diseases threats and outbreaks, man-made and natural disasters, antimicrobial resistance and chronic diseases public health events of regional and international concerns. Africa CDC focus on strategic priority areas and innovative programs aiming at improving evidence-based decision making and practice in event-based capacity development for surveillance, disease prediction, and improved functional clinical and public health laboratory networks and actions in minimizing health inequalities, and promoting quality care delivery, public health emergency preparedness and response best practices in achieving regional SDGs targets, improved International Health Regulations (IHR), and universal health coverage effectiveness. For example, during the recent Ebola outbreak in the Likati health zone, it activated the Emergency Operational Centre for

emergency response deployment to coordinate, support and monitor the Ebola outbreak in the DR Congo Team of experts on standby in strengthening of surveillance and investigation including contact tracing reported 11 suspected Ebola cases compared to 66 cases of Ebola including 49 deaths in 2014, 264 cases and 187 deaths were reported in Kasai in 2007, 315 cases and 250 deaths occurred in Kikwit in 1995 in DR Congo in contrast of the 2014-2016 West Africa Ebola outbreaks horror with over 11,300 deaths of 28,600 infected cases [1, 4, 10]. Africa CDC collaborating sub-regional centres in five countries provides an opportunity for effective collaboration, integration and coordination in harnessing existing public health assets, epidemiological surveillance, strengthening existing networks of quality laboratories for early detection and response.

Infectious public health preparedness and emergency response cannot deliver effectively if we do not implement “One Health and biosecurity” approach bringing human, animal and environmental health. Building evidence-based and adequate capacity building need to support integrated “One Health” surveillance, laboratory systems and networks, emergency preparedness and response, and public health research for evidence-based health programming and ample resource allocation. Greater commitment to strengthen local and regional operationalization of integrated disease surveillance and response, public health systems and core capacities have been documented to critically address public health emergencies, biosecurity and disaster risk across the continent. National and regional public health emergencies, biosecurity surveillance, preparedness, rapid response, and recovery policy and strategies are robust and sustainable assets for socio-economic transformation in line with Africa Health Strategy (2016-2030), the Africa Union 2063 agenda and in attaining SDGs [1, 4, 10, 11].

Firstly, developing innovative information and communication technology for health will provide opportunities to avert thousands of deaths and disability by improving access to good-quality essential drugs, by increasing coverage of vaccines immunization and use of other pharmaceutical and medical commodities nationwide [1, 10, 11]. In addition, leveraging on the



unique “One Health” approach to transform health care and health policy and to prioritize collaborative programs can be extended from infectious diseases to maternal and child health and health disparity in the poorest populations in Africa [1, 10-12]. Secondly, building regional surveillance systems is another way to enhance the local health system. The importance of implementing a local and national “One Health” policy and programs holds tremendous prospects, such as co-tackling the epidemiological and environmental challenges, and accelerating in the transition from control to elimination of infectious diseases under China-Africa collaboration [5, 15]. Furthermore, it has potential to revolutionize national health systems, policies and strategic priorities and the patterns in health financing and resources allocation of African countries that require careful understanding of the local context of diverse stressors and drivers [21, 13]. These will continue to dominate the performance and effectiveness of “One Health” in threats and epidemics prevention strategies and policies on healthcare and health outcomes. Thus, assessing health impact especially how greenhouse gas and ozone emissions, rising temperature and environmental pollution resulted in climate change impacts to health ecosystem, such as population movement, animal trading and ecology of vector-borne disease and ill health, aging, chronic disease, drug use and domestic violence, inequity and poverty [16]. Thirdly, improving the core capacities of international health regulations is the sustained efforts to improve the human welfare. For example, China’s response impacting the global health fund (e.g., malaria, HIV/AIDS, schistosomiasis, Ebola, influenza, TB, hepatitis, etc.) has shown robust global health leadership engagement [1, 2, 3]. The leadership reflected in the strategic mobilization and investment of resources fostering more easily accessible, availability and cost effectiveness of prevention and treatment interventions to resources limited countries including African countries [1]. The growing mutual China-Africa win-win collaboration spans to technical expertise, technology transfer and capacity development using scientific and advanced methods to tackle the disease, and have enhanced their commitment to respect the dignity of the people such

as Chinese Ebola outbreak emergency response in West Africa. Fourthly, enhancing the use and management of traditional medicines could improve the community involvement in health care and extend the trade among countries. So far, trade between China and Africa is projected to reach \$ 385 million USD a year by 2015. Increasingly, embracing “One Health” strategy to increase universal coverage of healthcare is significant as sharing China’s rich expertise and lessons learnt in strengthening health systems and tackling public health burden both in China and Africa communities. Thus, Africa has the opportunity to improve capacity of community health workers to reach remotes rural communities living beyond the margins of traditional health care systems [5, 10].

Therefore, China’s advancements in research and development, technical and scientific capacity transferring can support African next generation of proactive scientists to develop more sensitive simplified diagnostic tools and reduce the costs of laboratory diagnosis and medical equipment. Furthermore, Research and Development (R&D) is needed in examining the biological mechanisms of stressors or risk factors exposure and health effects, assessing evidence-based mitigation or adaptation interventions and benefits [1, 11, 12]. Innovative solutions and breakthroughs in human-animal-environment fields would not only enable Africa to meet its own growing needs, but also support integrating health systems, including strengthening the capacities of laboratory diagnostics and medical care, as well as establishing the China-Africa platforms that could generate evidence-based low-cost, available and easy-to-use health packages and solutions for the reduction of public health burden.

The present paper has analyzed the values of implementing national to regional “One Health” strategy for dealing with human, animal and environment related public health threats, diseases outbreaks emergencies and disaster risk challenges, and promote healthy mitigation measures and resilient management approaches in advancing targeted local, national and global health agenda. Also, understanding how to develop, package and implement evidence-based and sustainable “One Health”



approach needs partnerships and investment for strategic priorities and resource mobilization. In addition, it also needs better financing mechanisms and participatory coordination in building capacity and technical assistance, monitoring, performance and effectiveness metrics evaluation for One Health indicators.

Understanding the foundation of “One Health” strategy in China-Africa public health needs and challenges

Although significant progress has been made in improving health and safety of vulnerable population in low and middle-income countries (LMICs), there is growing unprecedented public health emergencies crises due to natural disasters (such as disease outbreaks, floods, climate change, droughts and mud-/land-sliding) and man-made disasters including armed conflict and resulting forced refugees and displaced populations in LMICs and mainly in Africa as well as China. These have been resulting in significant direct and indirect health impacts including limited access to food, clean water, medicines, pre-existing mental health and other health services. Conflict-affected countries have not achieved a single Millennium Development Goal and have significantly higher maternal and infant mortality rates compared to stable and peaceful countries. Natural disasters affect nearly 160 million people each year, with a disproportionate effect on populations and environment. There is also limited quantity of high-quality and integrated research to build evidence “One Health” approach response. For example, recent emerging Zika virus is known to be circulating in Latin America, America, Africa, Asia-Pacific and Middle East regions due to climate change and rapid urbanization, intense regional and global travel and trade impact on Zika virus risk transmission and documented congenital complications on fetal and maternal health. Efforts to strengthen regional and global public health emergencies surveillance and preparedness should be maintained in order to better characterize the intensity of *Aedes* and *Culex* vectorial capacity, asymptomatic or syndromic viral circulation and geographical infection spread, epidemiology and laboratory monitoring of Zika virus related complications in vulnerable settings. We found

that most existing and emerging infectious diseases of poverty and chronic diseases public health programs are based more on top-down and anecdotal experiences rather than accurate research in fostering an integrated human-animal and environment or “One Health” community practice in most vulnerable settings in Africa and China (Table 1).

“One Health” approach was officially adopted by international organizations and scholarly bodies in 1984 in response to the growing global human-animal and environment inter-dependence challenges and issues including climate change which needed new approaches. In such, “One Health” broader interconnections understanding offers tremendous advantages and manifold benefits in tackling emerging zoonotic diseases and chronic diseases to disaster risk consequences, but also in improving safety health of people and animals, and safeguarding environment against pollutants and pollution. It aims to enhance across disciplinary and inter-agencies assessment complex including human-animal health systems vis-a-vis environmental and climatic determinants of health, development of contextual health or disease detection and surveillance-response systems, data sharing and communication; partnerships and mutual learning for positive transformation and behavioral changes outcomes. Hence, strengthening firmer foundation in building evidence-based integrated healthy approach decision making, health programming and actions plans implementation, training and research practice to community-based programs ownership, shared values and experiences in integrated cost effective and beneficial China-Africa “One Health” strategy initiatives for mutual wellbeing and economic prosperity.

Prioritizing “One Health” approach in emerging and current infectious diseases public health emergencies and disaster risk reduction is essential in attaining the regional Africa Union and global health agenda promises and benefits. It requires promoting and implementing evidence-based, effective and sustainable national “One Health” strategy advocacy and mitigation strategies in most Africa countries and worldwide [5-7]. Strengthening evidence-based, consistent and reliable community, national and regional ‘One Health’ and biosecurity



partnerships, leadership, road maps commitment, approaches and strategies is a crucial for zoonotic diseases threats and outbreaks public health emergencies and other disasters risks humanitarian crises. Integration “One Health” principles and frameworks in health and relating multisectorial units or agencies planning and actions plans in generating comprehensive, consistent and real time knowledge and information in guiding evidence-based decision-making policy and participatory commitment and investment [6, 7, 10]. Articulated interest and reliance of all stakeholders will cover communities and public articulated actions in preparedness and response to climate changes, infectious and zoonotic threat and epidemics public health burden has provided [10, 17, 18].

The extent and nature of “One Health” approach through political engagement and funding is critical in advancing community social mobilization and awareness on “One Health” strategy integration in public health systems and primary health care. The needs and value is prerequisite in sustainable public emergencies and disaster risk reduction priorities, preparedness, preventive and control programs and activities. While, providing the enabling health-animal and environment interface biosecurity and protection of legislative and technical assistance support to policy makers, planners and implementers including the local vulnerable communities in transforming contextual positive knowledge, behavioural and attitudes changes [4, 6].

Understanding the climate change, global migration and country-specific complexities of emerging and current infectious diseases of poverty is needed in tackle operational programs challenges and bottlenecks, improved sustained control into elimination. For example national immunization programs hesitancy and resistance issues, such as misconceptions and mistrust or fear, weak coverage and non-adherence, persistent resurgence of zoonotic threats and emerging epidemics, continue to place a huge toll of maternal and child health morbidity and mortality on burden and coupled with the rising trend of chronic diseases related inequities and poverty vicious cycle [8, 9, 10, 13, 15].

Building China-Africa “One Health” strategy partnerships, frameworks and capacity development

China’s global health approach is an unique and distinctive path. This approach based on contextual policies and realities-based on their history, driven-inter sectoral and multidisciplinary government related ministries strengthen health systems in different African countries [1, 7, 9, 19, 20]. There is a steadily growth in depth and strength of China’s global engagement and collective participation in fostering global health agenda through China-Africa health development strategies. Event-based preparedness and transparent support management and technical assistance on transferable Chinese lessons in infectious diseases elimination and eradication including measles, filariasis, schistosomiasis, malaria, SARS and Ebola, etc. For example, the China-Tanzania pilot project of community-based and integrated malaria control strategy and applications funded by China-UK partnership aimed at assessing the feasibility and transferability of Chinese malaria skills in strengthening malaria health education, awareness knowledge and access to vector control interventions (e.g., RDT, LLIN, ACTs) to reduce the risk of malaria infection in Tanzania [1, 20]. Moreover, in the absence of specific Ebola infection treatment, the partners or organizations, including African governments, WHO, The GAVI Alliance and “Ebola ça Suffit Ring Vaccination Trial Consortium” should accelerate on joint consensus for the adoption and “expanded access” to proven efficacious and safe rVSV-ZEBOV vaccine ring Ebola immunization strategy implementation to boost immune response and protect vulnerable populations and global travelers from potential Ebola outbreaks [1, 10, 11].

China-Africa mutual and comprehensive partnership in health and pharmaceutical has been encouraging and promoting the use of community-based health services; and increasing government investment in public health interventions [7, 19, 21]. China has been very supportive on African countries’ efforts in building medical facilities and health service. For example, in 2013, the Chinese government constructed 38 medical facilities and



provided 50 batches of medical equipments and supplies to African countries. Chinese enterprises and non-governmental organizations have helped African people get quality medical services by means of building and running hospitals, investing in pharmaceutical factories and localizing medicine production in improving health management and well-being, including maternal and child health, and emerging pandemic threat programs, etc. Moreover, Chinese medical assistance to Africa has been sustained and operative win-win mutual support tailored to local settings, which could enhance research priorities in dynamic mapping of vectors and infectious diseases transmission with interaction of human-animal-environment, and provide evidence-based strategies in national or regional diseases control programmes and effective response packages [7, 8, 19-21].

Good progress remains in developing and implementing these policies and strategies coupled with shared lessons learnt and experiences against unprecedented infectious diseases public health emergencies and rising non-communicable diseases (NCDs) challenges, such as obesity, cardiac arrest and stroke, hypertension, diabetes, cancer, kidney disorders and mental health, etc. There is a shortage of qualified health professionals at grass-roots health facilities. It is also shortage in accessing to basic health control and elimination packages and service delivery including vaccine preventable diseases immunization programs coverage inadequacies in most rural and remote settings across Africa compared to China, insufficient public and private sector funding to R&D on safety and effective vaccines or drugs against most emerging coupled with unattended public health diseases threats and epidemics impact preparedness, and strategies mutually gains and economic benefits [12].

Leveraging on current and innovative China-Africa health development initiatives

Remarkable results and outcomes have been documented from Chinese medical assistance in 51 of 57 African countries, ranging from health workers, implementers and policy-makers. Capacity development and skills acquisition were achieved in over 115 health-related

training courses to 2,200 health implementers and health workers since 1963. Chinese medical teams friendship and health cooperation, including construction of ophthalmic center where more than 2,000 free cataract surgeries were completed in four African countries and construction of more than six other Chinese medical hospitals in the last 2 decades [3, 5, 23]. It is also worth noting the robust and efficient participation and contribution of twenty-seven Chinese provinces, autonomous regions and municipalities with accumulated more than 24,000 Chinese medical workers in 120 medical centers since 1963, and currently over 1,200 medical workers are working in 51 African countries. Continuous support in building medical facilities, Africa CDC reference laboratories per excellence and health service capacity has been appraised in embarking on assessing public health emergencies needs, risk factors and determinants in understanding the perception, knowledge, attitude and practice in evidence-based promotion of integrated “One Health” approach and biosecurity decision-making approach. This also provide priority and targets, methodologies and programs through effective indicators surveillance and monitoring. For examples, Chinese government dispatched over 38 medical facilities and over 50 batches of comprehensive medical equipment for early diagnostics and prompt treatment or response, and supplies across Africa since 2013 [3, 9]. Chinese partnerships with local firms and communities have helped medical services delivery to remote and rural vulnerable populations through joint activities in building and running hospitals, investing in improving and scaling up localized production in pharmaceutical and biotechnologies industries in Africa. In addition, we also recorded the establishment of more than 10 clinics of standard traditional Chinese medicine (TCM) integrated to Africa traditional medicine (ATM) [8, 24].

In achieving universal coverage and healthcare for all, upgrading China-Africa mutual health development cooperation and collaboration through independent and joint institutional research project and capacity development in health services delivery and in promoting science and technology capabilities, joint projects and activities have been increasingly developed and



implemented. These projects and activities aim at tackling the persistent and growing burden of infectious diseases of poverty, maternal and child morbidity and mortality, and responding timely to the global health concerns and emergency response called on emerging threats and epidemics in the continent. Some examples of the landmark achievements include the China-Zanzibar and China-Tanzania projects on sharing Chinese lessons and experiences in infectious diseases to support schistosomiasis and malaria prevention and control in African countries respectively, as well as Chinese maternal-child health safety and children nutrition, dissemination and transfer experiences in Ghana [9, 25, 26]. Furthermore, China-Comoros support to national malaria elimination that led to interruption of transmission and reducing in malaria mortality to zero in the last eight years in Comoros [8, 9, 10]. Likewise, understanding strategic public health financing and human resources systems capacity is necessary in promoting uptake and efficiency of Chinese global health initiatives and innovations in strengthening healthcare delivery system and quality outcomes in LMICs including Africa, Asia-Pacific, Middle East and Latin American countries. Strikingly again, during the West Africa Ebola outbreaks in 2014-2015, the Chinese assistance in response valued at \$ 120 million USD and more than 1,200 experienced medical professionals were deployed in the frontline affected and neighboring communities to combat and contain the rapid spread of the Ebola virus epidemics [8]. In addition to the mobile biosafety laboratory, China also built permanent and well-equipped public biosafety laboratory in Sierra Leone and DR Congo to improve the national capacity to detect, prevent and respond to future threats and epidemics. Over 30 batches of public health, clinical medicine and laboratory experts were dispatched in 11 African countries in scaling up public healthcare delivery capacity and training of health workers and communities in risk assessment, communication, and response measures in effective Ebola, malaria, schistosomiasis prevention and containment, amongst other shared responsibility and mutual commitment [1, 4, 8, 9, 25-27].

Future expansion of China-Africa health development initiatives offers immense opportunities

in increasing mutual benefits and growth to both continents' several domains not only limited to health, technology and trade. The scale and sustainability of existing and forthcoming programs and plan of actions will require aligning of national priorities and defining contextual performance and effectiveness indicators, but also mutual respect and trust, accountability and transparency with good governance and proactive stewardship. It is imperative that efforts should also be made in strengthening evidence-based translation to the benefits of vulnerable populations and global community through sharing of lessons learnt and care knowledge experiences and information for all generations in combating infectious diseases and rising burden of non-communicable diseases.

Fostering health systems preparedness and smart response against emerging and re-emerging threats and epidemics

Chinese and African rapid economic growth and the importance of strengthening the local and national public health laboratory systems in both continents have been recognized in tackling the rising healthcare needs, challenges and issues [1, 2, 26]. Globalization of travel and trade is ever increasing local, national and global emerging and re-emerging infectious diseases threats and their impacts on human and animal health. Resolving the persistent and unprecedented rising of emerging and re-emerging epidemics, and new priorities of Ebola, Zika, HIV/AIDS, tuberculosis, malaria and neglected tropical diseases (NTDs) requires collaborative and mutual cooperation with governments, bilateral and multilateral initiatives, including boosting private-public partnerships, regional and international organizations in achieving the global health security threat and agenda 2030 [2, 3, 5, 6, 7]. For example, China has dispatched more than 1,000 medical experts to resist West Africa Ebola epidemics through contributions to coordinated international emergency response efforts that helped to contain Ebola virus transmission dynamics and spread that retrieved lives of over 12,200 people [1, 5, 6]. Similarly, Zika virus belongs to the family Flaviviridae, genus *Flavivirus*, and includes Africa subtype and Asia subtype. It is a mosquito-borne virus primarily transmitted by *Aedes aegypti*



mosquitoes, sexual transmission; blood transmission and mother-to-fetus transmission have been also reported. Zika virus can go through blood-brain barrier and infect central nervous system. Symptoms are generally mild and self-limited, but recent evidence suggests a possible association between maternal Zika virus infection and adverse fetal outcomes, such as congenital microcephaly, as well as a possible association with Guillain-Barré syndrome. In absence of safe vaccine or effective antiviral Zika medication for prevention and control Zika virus infection, early laboratorial diagnosis includes nucleic acid detection, serological test, and isolation of virus and epidemiology and clinical risk assessment and syndromic surveillance is crucial [1, 3, 13]. Nevertheless, there remains a need to build a platform with function of effective surveillance, recovery, preparedness, consultation and communication, and to share surveillance based on the principle of sincerity, real time problem-solving and results-giving, and good faith towards collaborative global health solutions [4, 14-16].

Fostering surveillance capacity in laboratory, clinical, veterinary and allied health sciences in the Africa continent are critical to overcoming the growing burden of diseases and ensuring a healthy future of its citizens [14, 15]. Meeting the urgent growing healthcare needs in Africa requires strategic and technical approaches in the development and integration of sound and harmonized regulatory systems for diagnostic products, new drugs and vaccine R&D. While reinforcing the national and international public health laboratories networks are able to improve collaborative and participative early disease detection, early warning and surveillance research in guiding proactive vigilance and smart response activities.

Effective good governance and leadership coordination of sustainable strategies on emerging outbreak preparedness and response capacity is necessary towards the transformation from traditional to modernized digital laboratory systems in timely and effective quality service delivery. However, the need for laboratories quality improvements and accreditation of methods, tools and programs are critical in upholding the gains preparedness, and emergency response in various infectious diseases programs and strategies should be supported through both national and international initiatives. Bilateral

and multilateral cooperation with the World Bank, UN and WHO, Global Fund to fight AIDS, tuberculosis and malaria, worthy philanthropic individuals and organizations efforts can enable country to be ready and capable of early detection, prognosis, prevention, and smart response or management in any detrimental natural or man-made epidemics eventuality, while facing operational challenges and setting new research priorities [5, 7, 21, 22], for contextual “One Health and biosecurity” programs, are also need to be supported with appropriate regulations and guidelines.

Mobilizing on mitigation of climatic changes and disasters and lifestyle adaptations strategies

There is an urgent need to invest in basic and operational research on climatic, ecological and evolutionary changes for understanding and forecasting persistent and future emerging threats dynamics and epidemics. Timely evidence-based translation into policy programs and interventions is imperative to defeat the budding threat and burden through coordinate robust actions and better stakeholders leadership in response advocacy and mitigation in line with The Paris Climate Change Declaration in December, 2015 [16, 17].

Fostering integrated approaches with cutting-edge inter-sectoral and trans-disciplinary partnership is also needed evidence-based nationwide scaling up contextual surveillance and response capacity. Moreover, with improvement of targeted strategies to deal with emerging outbreaks and infectious diseases of poverty elimination, understanding human-animal interface with increasing urbanization, globalization of trade and travel are necessary. Hence, China-Africa “One Health” strategy sustainable implementation and alignment with local and national priorities hold great promises. Integrating collaborative human-animal-environmental projects and programs have substantial prospects in increasing local and national food production and global food security [28, 29]. This is critical in averting or reducing the persistent malnutrition, under-nutrition and related health complications and diseases (e.g. malnutrition linked Kwashiorkor or rickets, obesity, typhoid, diarrhea, dysentery) resulted in children and youth developmental



retardation, poor educational performance, poor quality of life and living including high DALY and low QALY short life expectancy, worsening the vicious cycle of poverty and premature death documented in Africa countries [4, 9, 11, 13, 14]. Similar high public health challenges and burden in Africa were recorded in China before 1980s, mainly in Chinese rural communities circumventing with the implementation of the Chinese rural cooperative medical insurance schemes. However, more investment is still needed in achieving food auto-sufficient and balanced food and nutrition/diet for all in both continents [15]. Developing and integrating climate changes resilience, mitigation and adaptation measures in allied health programs is vital in protection, conservation and management of the adverse socio-demographic, ecological, health and economic effects of greenhouse gas emissions and changes consequences, and in securing the future benefits of green and eco-friendly environment.

The value of China-Africa “One Health” strategy implementation

Financial support from governments and various levels, advocacy and social mobilization to develop supportive community environment for infectious and emerging zoonoses threats and epidemics in population-based public health control and elimination interventions is imperative through implementation of evidence based and cost-effective “One Health” surveillance and response strategy, in order to integrate human, animal, and environmental landscape, continue health education promotion, improve awareness and quality public health service delivery performance and effectiveness metrics across Africa. Enhanced disease surveillance response, community capacity development and strain capacity can provide significant opportunities in health education and promotion, shared responsibility, positive behavior changes and best practices by different health facilities, training health practitioners of diagnosis, treatment and rehabilitation services. Identification of local and national health needs and evidence-based effectiveness of “One Health” solutions are urgently needed to improve appropriate and sustainable resource development policies and strategic programs across Africa. Such new partnership initiatives linked to China Belt and Silk

Initiative action plan should attract more indigenous and international partners and stakeholders, more qualified multidisciplinary professionals to work, communicate and share experiences and lessons collectively. Building local and national trans-disciplinary and trans-sectoral research teams towards improved understanding the genetic and molecular mechanisms of invasive pest and drug resistance, and control of complex disease systems and in strengthening continuous improvements of human, animal, ecosystem health and well-being [22-25].

Robust evidence in comprehensive control for multiple risk factors including health guidance on diet, fitness activity and promoting individual and community self-management model is important to services by general practitioners and mainly in translational research directed toward sustainable development activities and global environmental health. To support integrated veterinary, medical and ecosystem education, and to provide more professional career development opportunities, the governments need to continuously increase its investment in public health intervention programs and financial support to health insurance schemes. Increased funding from both central and local governments needs to be directed to the underdeveloped regions and poorer rural areas to support global and national programmes on infectious diseases of poverty and sustain control and elimination agenda for emerging epidemics tackle maternal and child health challenges, improve NCDs mitigation interventions, and set up better health insurance schemes. In addition, it is equally important to strengthen monitoring of the use for public health interventions. “One Health and biosafety” systems research projects development and implementation are also urgently needed in improving training programs and educational empowerment in guiding human-animal health and environment programming and technical assistance. Addressing the existing and unprecedented public health emergencies or disaster risks requires optimizing the “One Health and biosecurity” targets and interventions which will benefit indicators metrics monitoring in routine public health programs and humanitarian emergencies crises response [27, 28].

There is need to promoting “One Health and biosecurity” youths voices in healthy and ecofriendly



“One Health” community advocacy, engagement and participation. Strengthening and sustaining “One Health and biosecurity” strategy will improve the cost-effectiveness surveillance and communication interventions through continuous awareness, and knowledge improvements for the overall China-Africa and global health security benefits [15, 26, 29, 30].

Conclusion

Robust and sustainable leadership commitment and investment is needed in integration of “One Health” and global health security. Advocacy and mitigation programs is needed in China-Africa health development initiatives. To establish public emergencies indicators and metrics for early and timely community engagement and effective risk communication, following actions need to be handled to achieve SDGs and global health agenda: (1) community-based partnerships and programs ownership, (2) assessment for evidence based “One Health”, (3) identification of the various stressors or risk factors, (4) programmatic and proactive development and implementation of appropriate and sustainable “One Health”, (5) resource mobilization mechanisms and solutions based on animal-human-environment interface challenges and impacts surveillance, preparedness, and timely collective response to public health threats and humanitarian emergency crises.

Additional files

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Availability of data and materials

Data are freely available and accessible.

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Consent for publication

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Ethics approval and consent to participate

Not applicable.

References

1. Tambo E, Ugwu CE, Guan Y, Wei D, Xiao-Ning, Xiao-Nong Z. China-Africa Health Development Initiatives: Benefits and Implications for Shaping Innovative and Evidence-informed National Health Policies and Programs in Sub-Saharan African Countries. *Int J MCH AIDS*. 2016;5(2):119-33.
2. Xu J, Yu Q, Tchuente LT, Bergquist R, Sacko M, Utzinger J, et al. Enhancing collaboration between China and African countries for schistosomiasis control. *Lancet Infect Dis*. 2016;16(3):376-83.
3. Xia ZG, Wang RB, Wang DQ, Feng J, Zheng Q, Deng CS, et al. China-Africa cooperation initiatives in malaria control and elimination. *Adv Parasitol*. 2014;86:319-37.
4. Nkengasong JN, Maiyegun O, Moeti M. Establishing the Africa Centres for Disease Control and Prevention: responding to Africa's health threats. *Lancet Glob Health*. 2017;5(3):e246-7.
5. Tang S, Meng Q, Chen L, Bekedam H, Evans T, Whitehead M. Tackling the challenges to health equity in China. *Lancet*. 2008;372(9648):1493-501.
6. Liu P, Guo Y, Qian X, Tang S, Li Z, Chen L. China's distinctive engagement in global health. *Lancet*. 2014;384(9945):793-804.
7. Degeling C, Johnson J, Kerridge I, Wilson A, Ward M, Stewart C, et al. Implementing a One Health approach to emerging infectious disease: reflections on the socio-political, ethical and legal dimensions. *BMC Public Health*. 2015;15(1):1307.
8. Courtenay M, Sweeney J, Zielinska P, Brown Blake S, La Ragione R. One Health: An opportunity for an inter-professional approach to healthcare. *J Interprof Care*. 2015;29(6):641-2.
9. Alcorn T. New orientation for China's health assistance to Africa. *Lancet*. 2015;386(10011):2379-80.
10. Zhou XN, Bergquist R, Tanner M. Elimination of tropical disease through surveillance and response. *Infect Dis*



- Poverty. 2013;2(1):1.
11. Yan F, Tang S, Zhang J. Global implications of China's healthcare reform. *Int J Health Plann Manage.* 2016;31(1):25-35.
 12. Ernest Tambo, Oluwasogo A Olalubi, Moussa Sacko. Rift valley fever epidemic in Niger near border with Mali. *The Lancet Inf Diseases.* Dec. 2016, 16(12), 1319–1320. DOI: [http://dx.doi.org/10.1016/S1473-3099\(16\)30477-7](http://dx.doi.org/10.1016/S1473-3099(16)30477-7).
 13. Tambo E, Chuisseu PD, Ngogang JY, Khater EI. Deciphering emerging Zika and dengue viral epidemics: Implications for global maternal-child health burden. *J Infect Public Health.* 2016 May-Jun;9(3):240-50.
 14. Mazet JA, Wei Q, Zhao G, Cummings DA, Desmond JS, Rosenthal J, et al. Joint China-US call for employing a transdisciplinary approach to emerging infectious diseases. *Ecohealth.* 2015;12(4):555-9.
 15. Peilong L, Berhane Y, Fawzi W. China Harvard Africa Network (CHAN) team. China, Africa, and US academia join hands to advance global health. *Lancet.* 2017 Aug 19;390(10096):733-4.
 16. Xia ZG, Wang RB, Wang DQ, Feng J, Zheng Q, Deng CS, et al. China-Africa cooperation initiatives in malaria control and elimination. *Adv Parasitol.* 2014;86:319-37.
 17. Heymann DL, Chen L, Takemi K, Fidler DP, Tappero JW, Thomas MJ, et al. Global health security: the wider lessons from the west African Ebola virus disease epidemic. *Lancet.* 2015;385(9980):1884-901.
 18. Sims LD, Peiris M. One health: the Hong Kong experience with avian influenza. *Curr Top Microbiol Immunol.* 2013;365:281-98.
 19. Tong YG, Shi WF, Liu D, Qian J, Liang L, Bo XC, et al; China Mobile Laboratory Testing Team in Sierra Leone. Genetic diversity and evolutionary dynamics of Ebola virus in Sierra Leone. *Nature.* 2015;524(7563):93-6.
 20. Cui HH, Erkkila T, Chain PS, Vuyisich M. Building international genomics collaboration for global health security. *Front Public Health.* 2015;3:264.
 21. Grépin KA, Fan VY, Shen GC, Chen L. China's role as a global health donor in Africa: what can we learn from studying under reported resource flows? *Global Health.* 2014;10:84.
 22. Fan HJ, Gao HW, Ding H, Zhang BK, Hou SK. The Ebola threat: China's response to the West African epidemic and national development of prevention and control policies and infrastructure. *Disaster Med Public Health Prep.* 2015;9(1):64-5.
 23. Liu P, Guo Y, Qian X, Tang S, Li Z, Chen L. China's distinctive engagement in global health. *Lancet.* 2014;384(9945):793-804.
 24. Lu H. China takes an active role in combating an Ebola outbreak: On-site observations and reflections from a Chinese healthcare provider. *Intractable Rare Dis Res.* 2015;4(4):217-9.
 25. Wang LD, Utzinger J, Zhou XN. Schistosomiasis control: experiences and lessons from China. *Lancet.* 2008;372(9652):1793-5.
 26. Wang LD, Chen HG, Guo JG, Zeng XJ, Hong XL, Xiong JJ, et al. A strategy to control transmission of *Schistosoma japonicum* in China. *N Engl J Med.* 2009;360(2):121-8.
 27. Steinmann P, Keiser J, Bos R, Tanner M, Utzinger J. Schistosomiasis and water resources development: systematic review, meta-analysis, and estimates of people at risk. *Lancet Infect Dis.* 2006;6(7):411-25.
 28. Tambo E, Ai L, Zhou X, Chen JH, Hu W, Bergquist R, et al. Surveillance-response systems: the key to elimination of tropical diseases. *Infect Dis Poverty.* 2014;3:17.
 29. Tambo E, Chengho CF, Ugwu CE, Wurie I, Jonhson JK, Ngogang JY. Rebuilding transformation strategies in post-Ebola epidemics in Africa. *Infect Dis Poverty.* 2017;6(1):71.
 30. Blanchet K, Ramesh A, Frison S, Warren E, Hossain M, Smith J, et al. Evidence on public health interventions in humanitarian crises. *Lancet.* 2017;6. [Epub ahead of print]

