Acta Tropica xxx (2013) xxx–xxx

Contents lists available at ScienceDirect

Acta Tropica

journal homepage: www.elsevier.com/locate/actatropica

Interplay between environment, agriculture and infectious diseases of poverty: Case studies in China

Guo-Jing Yang[a,b,c], Jürg Utzinger[d,e], Xiao-Nong Zhou[f,g,h,*]

[a] Jiangsu Institute of Parasitic Diseases, Wuxi, Jiangsu 214064, People's Republic of China
[b] Key Laboratory on Control Technology for Parasitic Diseases, Ministry of Health, Wuxi, Jiangsu 214064, People's Republic of China
[c] School of Public Health and Primary Care, The Chinese University of Hong Kong, Satin, Hong Kong
[d] Department of Epidemiology and Public Health, Swiss Tropical and Public Health Institute, P.O. Box, CH-4002 Basel, Switzerland
[e] University of Basel, P.O. Box, CH-4003 Basel, Switzerland
[f] National Institute of Parasitic Diseases, Chinese Center for Disease Control and Prevention, Shanghai 200025, People's Republic of China
[g] Key Laboratory on Biology of Parasite and Vector, Ministry of Health, Shanghai 200025, People's Republic of China
[h] WHO Collaborating Center for Malaria, Schistosomiasis and Filariasis, Shanghai 200025, People's Republic of China

ARTICLE INFO

Article history:
Received 1 March 2013
Received in revised form 14 July 2013
Accepted 17 July 2013
Available online xxx

Keywords:
Environment
Agriculture
Emerging diseases
Infectious diseases of poverty
Case study
China

ABSTRACT

Changes in the natural environment and agricultural systems induced by economic and industrial development, including population dynamics (growth, urbanization, migration), are major causes resulting in the persistence, emergence and re-emergence of infectious diseases in developing countries. In the face of rapid demographic, economic and social transformations, China is undergoing unprecedented environmental and agricultural change. We review emerging and re-emerging diseases such as schistosomiasis, dengue, avian influenza, angiostrongyliasis and soil-transmitted helminthiasis that have occurred in China due to environmental and agricultural change. This commentary highlights the research priorities and the response strategies, namely mitigation and adaptation, undertaken to eliminate the resurgence of those infectious diseases.

1. Introduction

Economic growth, population dynamics (growth, urbanization, migration) and industrial development over the past 50 years have resulted in changes in the natural environment and agricultural systems leading to persistence, emergence and re-emergence of infectious diseases in developing countries (Aguirre and Tabor, 2008; Patz et al., 2000, 2008; WHO, 2013). Climate change and climate variability, in part the consequence of atmospheric pollution, add new layers to this conglomerate of basic driving forces, as do the numerous factors which underlie human over- and under-nutrition (Gage et al., 2008; Patz et al., 2008). Infectious diseases are non-linearly correlated with poverty as the burden falls most heavily on poor people in developing countries (Guerrant and Blackwood, 1999), particularly on infants and children, e.g. about three million children die each year from malaria and diarrhoeal diseases alone. The disability-adjusted life year (DALY), a measure of overall disease burden (WHO, 2008), of diarrhoea and malaria of all age groups in 2004 accounted for 4.8% (72.8 million) and 2.2% (34 million) of total DALYs, respectively (WHO, 2004)

All infections involving an agent (or pathogen) and/or host(s) are already present in the environment. Some agents (or pathogens) require vectors or intermediate hosts to complete their life cycles, a situation which can amplify impact (Butler, 2012; McMichael, 2004). Environmental conditions have a broad-based influence by either favouring or hindering pathogens, vectors, host defences directly or by changing the habitats exploited by the participating species (host or infectious agent). On rare occasions, changing environmental conditions can provide the opportunity for new pathogen variants to emerge, for instance, new influenza viruses (Aguirre and Tabor, 2008; Epstein, 2001; Zell, 2004). Landscapes altered by agricultural development can also become more sensitive to changes in other environmental variables, setting up a feedback loop that further degrades the ecosystem affecting human society adversely. Poor agricultural practises, for example, have the power to directly degrade living conditions via malnutrition due to food shortage (Sheeran, 2008), while water-borne diseases emerge following water resource development (Hunter et al., 1993; Keiser et al., 2005; Steinmann et al., 2006; Yang et al., 2005). Indeed,

* Corresponding author at: National Institute of Parasitic Diseases, Chinese Center for Disease Control and Prevention, Shanghai 200025, People's Republic of China. Tel.: +86 2164738058.
E-mail addresses: xiaonongzhou1962@gmail.com, ipdzhouxn@sh163.net (X.-N. Zhou).

0001-706X/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.actatropica.2013.07.009

most influenza pandemics appear to have an agricultural origin (Ho and Su, 2004; Zhong, 2008). There are many examples of interaction between environmental or agricultural changes and infectious diseases, e.g. the emergence of the severe acute respiratory syndrome (SARS) in China in 2003 (Zhong, 2008) and Lyme disease in Europe in 2000 (Aguirre and Tabor, 2008; Ogden et al., 2008; Randolph, 2008). Changed interaction between humans and wild or domestic animal populations comes to mind as the most probable facilitator of the emergence of bovine spongiform encephalopathy (BSE), avian influenza, Nipah virus, and the human immunodeficiency virus (HIV) (Chastel, 2004; Genne, 2007; Kong et al., 2008; Snowden, 2008).

In view of new evidence on the interplay between environmental changes and the emergence or re-emergence of infectious diseases (WHO, 2012, 2013), the following issues require attention. First, environmental changes cause significant hazards to human health, which might exacerbate due to increased air pollution, declining water quality, inadequate sanitation, and toxic industrial discharges (Harpham and Tanner, 1995). Second, agricultural practices, including intensive use of fertilizers, pesticides, and other industrial input, degrade natural resources and the environment leading to a slowdown or even decline in agricultural growth in addition to negative impact on human health, biodiversity and ecosystems (Trias, 1987). Third, a specific disease can have either positive or negative effects on an individual or entire communities (McMichael, 2004; WHO, 2003). For example, an infectious disease outbreak can alert more people to take attention to the health development of a community, while poverty cannot be eliminated. Environmental degradation exacerbates malnutrition, disease, and injury, whereas infectious diseases of poverty cannot be alleviated in circumstances of hazardous lifestyle, and poverty (Zhou, 2012). Hence, all components of the eight Millennium Development Goals (MDG) are closely interlinked (Wagstaff et al., 2006) and concerted efforts are reputed to break the poverty cycle related to human health (Tyer-Viola and Cesario, 2010).

In the face of rapid demographic, economic and social transformations, P.R. China is undergoing unprecedented environmental and agricultural change. Consequences of this change are manifested in environmentally induced challenges such as reduced water run-off in some rivers and flooding in others, extreme weather events (floods, blizzards and dust storms) (Yang et al., 2005). Most recently, the 2008 earthquake in Sichuan province took the life of 70,000 people, about 1300 schools had to be reconstructed and 25 townships relocated (Hu et al., 2012). There is also growing concern about the potential future effects of climate change on agricultural productivity. While China has made progress in controlling and eliminating infectious diseases, important public health challenges such as tuberculosis, HIV/AIDS, schistosomiasis and hepatitis B persist (Yang et al., 2008). In recent years, the country has witnessed outbreaks of newly emerging infectious diseases (Aguirre and Tabor, 2008; Yan et al., 2012), including the occurrence of SARS in 2003, avian influenza in 2004, *Streptococcus suis* infection in 2005, angiostrongyliasis in 2006, enterovirus 71 (EV71) in 2008, and chikungunya fever in 2010.

In response to these challenges, it is important to investigate the links discussed above to facilitate interdisciplinary research from a variety of natural, social, and health sciences, and train professionals to learn from case studies. We present in this article a framework which integrates three characteristics of the interrelationship between the environment and infectious diseases and poverty: (i) environmental hazards; (ii) agricultural development; and (iii) social factors. Applying this framework to a number of case studies, we put forward recommendations for research priorities.

Table 1
Infectious diseases with an important environmental contribution in developing countries.

Infectious diseases of poverty	Burden of disease attributable to environmental causes	Environmental risks
Diarrhoeal diseases	94% of the 1.8 million annual deaths	Unsafe drinking water and inadequate sanitation
Lower respiratory infections (LRI)	1.5 million deaths annually (41% of the LRI disease burden)	Exposure to indoor smoke from solid fuels and outdoor (ambient) air pollution
Vector-borne disease	Over 500,000 deaths annually	Modifiable environmental factors (such as poorly designed irrigation and water systems; poor housing and settlement; deforestation and ecosystem change/degradation)

2. Environmental hazards and infectious diseases of poverty

There is a growing consensus among ecologists that ecological dysfunction, habitat fragmentation, climate change, and the accumulation of toxins are largely attributed to human activities (Table 1) (Watson, 2000). All of these have worked synergistically to diminish biodiversity and ecosystem function (Brook et al., 2008), which has promulgated the spread of infectious disease in wildlife and humans (McMichael et al., 2004). People in developing countries are more vulnerable to environmental degradation than those in the developed countries (McMichael et al., 2004).

China is experiencing extraordinary environmental changes, thus eliciting many human health challenges. Environmental change, such as climate changes and agricultural changes, will clearly alter the areas of transmission and the intensity of important vector-borne diseases still not eliminated in the country, such as dengue and schistosomiasis.

2.1. Schistosomiasis

Schistosomiasis is caused by infection by with the blood fluke *Schistosoma japonicum* through water contact, as the intermediate host is a snail. Historical records show a high correlation between schistosomiasis transmission intensity and environmental or ecological factors, such as temperature, vegetation and rainfall (Yang et al., 2005; Zhou et al., 2008). More recently, research focused on the impact of climate change on schistosomiasis transmission based on the fact that January mean temperature of $\leq 0\,^{\circ}$C restricts the distribution of *Oncomelania hupensis*, the intermediate host of *S. japonicum* (Mao, 1990). The impact of global warming on the transmission of schistosoma japonica can be grouped into (i) direct and (ii) indirect effects (Fig. 1). It has been reported that the 0–1 °C isotherm in January, a crucial feature determining *O. hupensis* survival, has shifted latitude from 33°15′N to 33°41′N between the 1960s and the 1990s (Yang et al., 2005). This shift translates to a potential surface area expansion of 41,335 km^2 (Yang et al., 2005). An estimated additional 20.7 million people are thus potentially at risk of *S. japonicum* infection in central China (Yang et al., 2005). In view of the current estimate that 779 million people are at risk of schistosomiasis worldwide (Steinmann et al., 2006), the 20.7 million additional at-risk Chinese translates to 2.7% on the global scale. Although moderate, this increase will have profound public health and economic implications. However, these figures are dwarfed by might be in store in the longer perspective. Using combined indexes, namely temperature thresholds of both the parasite and

Please cite this article in press as: Yang, G.-J., et al., Interplay between environment, agriculture and infectious diseases of poverty: Case studies in China. Acta Trop. (2013), http://dx.doi.org/10.1016/j.actatropica.2013.07.009