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Ecological determinants of health: food and environment on human health

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Abstract Human health and diseases are determined by many complex factors. Health threats from the human-animal-ecosystems interface (HAEI) and zoonotic diseases (zoonoses) impose an increasing risk continuously to public health, from those emerging pathogens transmitted through contact with animals, food, water and contaminated environments. Immense challenges forced on the ecological perspectives on food and the eco-environments, including aquaculture, agriculture and the entire food systems. Impacts of food and eco-environments on human health will be examined amongst the importance of human interventions for intended purposes in lowering the adverse effects on the biodiversity. The complexity of relevant conditions defined as factors contributing to the ecological determinants of health will be illuminated from different perspectives based on concepts, citations, examples and models, in conjunction with harmful consequential effects of human-induced disturbances to our environments and food systems, together with the burdens from ecosystem disruption, environmental hazards and loss of ecosystem functions. The eco-health literacy should be further promoting under the "One Health" vision, with "One World" concept under Ecological Public Health Model for sustaining our environments and the planet earth for all beings, which is coincidentally echoing Confucian's theory for the environmental ethics of ecological harmony.

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Introduction

Concepts of diseases are developed at different stages throughout the history of public health developments. The basic premise of ecological thinking is that human health and their determinants are interrelated, and different determinants of health are leading to different patterns in the burdens of diseases. The world is constantly changing and different approaches for public health have also been adjusted to accommodate the transitional needs of the situations from the conversion of an old public health model to a new public health model, and till recently, an ecological public health model is the ultimate focus of this transitional needs for an attempt to make positive movements and actions to counter these multiple influences of our health arising from those of ecological determinants.

WHO (1947) defined that "Health is a state of complete physical, mental, and social well-being, and not merely the absence of disease and infirmity." However, this definition of health has received much criticism over the years and considered to be inadequate to capture variations in health, as health is dynamic and changes from time to time and with multiple dimensions (Sharma and Atri 2010). In fact, many literatures also revealed different dimensions for the health concept in areas such as physical health, mental health, social health, environmental health, spiritual health and emotional health (Ananth 2008). Concepts of health are indeed defined in much broader sense, especially there are different meanings of focuses that set forth the boundaries in its field of concerns in relation to the particular health issues and/or determinants per se. This paper discusses more focuses on expanding the

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boundary in the concepts of health with emergence of complicated factors involved as our understandings developed through the correlations of these complex systems towards the twenty-first century in ecological public health developments, regarding the ecological determinants of health in conjunction with the harmful consequential effects of human-induced disturbances to our environments and food systems, together with the burdens from ecosystem disruption, environmental hazards and loss of ecosystem functions.

In actual fact, different determinants of health such as biological, psychosocial, environmental, socio-economical, health behaviour practices, medical advancement as well as ecological determinants imply for different public health approaches in tackling the subsequent or potential health problems. Public health refers to "all organized measures (whether public or private) to prevent disease, promote health, and prolong life among the population as a whole. Its activities aim to provide conditions in which people can be healthy and focus on entire populations, not on individual patients of diseases. Thus, public health is concerned with the total system and not only the eradication of a particular disease" (WHO 2015a). Transforming from the perspectives of old public health model that focused on hygiene, sanitation, clean water and housing to a new public health model that shifted to person-in-action directly towards health with emphasis on lifestyle approach, which is also in line with the governmental policies of "better health for all" as an initiative, in which the prime focuses are on the lifestyle dimension as an integral part in its concept for health, and till now in the ecological public health concern in the direction of momentous demands and focuses to support the sustainability of our eco-environments and human communities for our ongoing existence on this planet earth, inter alia with issues on global environmental hazards to human health such as climate change, stratospheric ozone depletion, loss of biodiversity, changes in hydrological systems and the supplies of freshwater, land degradation and stresses on food-producing systems, as well as other ecological determinants such as health threats from the human-animal-ecosystems interface (HAEI) and zoonotic diseases (zoonoses). Host-agent-environment model is an early public health framework that has also been viewed as adhering to this ecological standpoint, in which eco-epidemiology is grounded in the principle of ecologism with emphasis on the concept of disease resulting from complex interactions between man, an agent (e.g. domestic food animals, poultry and wildlife) and the environments.

In this context, factors affecting the ecosystem functions to human health are being addressed, which are also tied to the overall development of ecology, and the emergence of these eco-health are in the spot of significant concerns, including the related impacts of food and environment on our health. This is especially so, as our understandings unfolded on the complexes of factors that interacted and interrelated to the effects of our human health under the influences of these ecological determinants, which are beyond our systems thinking yet is also systemic in a web of relationships, and all of which are also undergoing change to different health transitions (Rayner and Lang 2012). This understanding of health-disease process from different perspectives and stages across public health developments in terms of the patterns in health transition, in turn, is an integral part of evidences supporting this paradigm shift.

This paper specifically illustrates the importance of this ecological paradigm, and those actual and potential health threats from the HAEI and zoonoses impose an increasing risk continuously to public health, from those emerging pathogens transmitted through contact with animals, food, water and contaminated environments that arise from such existence of ecological determinants under this shift. This paradigm shift is focused on "One Health" vision and "One World" concept as generated for the Ecological Public Health Model in order to promote ecological harmony and preserve the eco-environments for our co-existence of healthy ecosystems, healthy animals and healthy humans. As Rayner and Lang (2012, p. 12) reckoned that "A new ecological sense of public health is emerging based on the recognition of the limits on nature, that nature no longer offers an endless cornucopia of its resources for human use or that the biological world can be ceaselessly altered to human advantage". Therefore, it is important to understand those ecological factors such as effects of ecosystem services, environmental hazards and its related impacts on the eco-environments and food systems to our human health, plus health threats being strained by HAEI. The ultimate goals of ecological public health approach served as the proactive interventions to counter or minimize those actual and potential problems.

Importance of ecosystem services and its related drivers

As Bousfield and Brown (2011, p. 2) pointed out, "the rise of emerging and resurging infectious diseases threatens not only humans, but also the fauna and flora comprising the critically needed biodiversity that supports the living infrastructure of our world", in which human health and animal health are intimately connected. Food and environment served as a key connecting point to the challenges in this domain, as WHO (2014a) indicated that HAEI and zoonotic diseases (zoonoses) are common to man and animals, which have been recognized for many centuries. The complexity of factors and issues arising from food systems and environments in relation to the ecological determinants of health is indeed focused on more holistic spectrums of all those inducing factors rather than just the causes confined in the disease-centred biomedical model.

Ecosystem refers to the combined physical and biological components of an environment, with a dynamic complex of plant, animal and microorganism communities and their nonliving environment interacting as a functional unit. These organisms form complex sets of interrelationships and functions in our planet earth and any of ecosystem disruption can have adverse impact on our health in various ways through complex pathways. Friis (2012) stated that physical and social environments play major roles in the health of individuals and communities and also further emphasized maintaining environmental quality is a pressing task for the twenty-first century. The concept of environmental hazards can be in the form of biological, chemical, physical, psychological and sociological or site and location hazards, which are harmful to our human health, and those hazards can also be affected by the changes or disturbances of biodiversity and its subsequent ecosystem services (Romanelli et al. 2014). Every disturbance to the eco-environment will prime to the subsequent alteration of disease patterns and our human exposure to the altered and later disease outbreaks that in effect guide to the increasing burdens on global health (Barrett et al. 2015).

WHO (2014b) spelled out that human health is affected by changes or disturbances in biodiversity and ecosystem services, with which the natural ecosystem functioning are indispensable to the well-being of all people in the world. The report by Millennium Ecosystem Assessment (2005) also detailed how ecosystem health contributes to human well-being through sustainable ecosystem services and conditions for human health. The resultant changes or disturbances to biodiversity and to ecosystem services are, in turn, affecting the ecosystem functions in provisioning, regulating, cultural and supporting dimensions to all life on earth; Diagram 1 shows the "Direct drivers of change" consequentially imposed adverse effects on the "Ecosystem Services".

WHO (2005) listed some examples of health impacts such as altered or increased infectious disease risk on our human health, and that is one of the harmful effects of the ecosystem disturbance due to environmental changes, loss of biodiversity and ecosystem impairment; Diagram 2 also shows a brief summary of health synthesis from those interrelationships.

Ecological triad: disease triangle with multiple factors and environmental hazards

The fundamental concepts and principles of ecological systems that impacted on our eco-environments and consequential effects on human health from the interrelationships between the epidemiological transition and ecological transition in its changing patterns to the burdens of disease by those actual and potential health threats of zoonoses imposed by HAEI are being reviewed from the perspectives of the environment and their implications interconnected with human health. In fact, environmental impacts are an important factor in the interaction of agent and host under this epidemiological or ecological triad. Traditionally, the concerns of environmental epidemiology included the contamination of air, water and food. Nowadays, the focus is expanding to include predisposing factors such as climate change and other large-scale environmental impacts related to globalization and urbanization, with which also imposed a significant number of adverse health outcomes from those anthropogenic activities, for instance, as Barrett et al. (2015) stated that widespread burning of fossil fuels, combined with the destruction of forests, has already influenced earth's temperature, sea level and climate, which is threatening to wreak havoc on an unprecedented scale as the major determinant as of Omran's "Age of Degenerative and Man-Made Diseases".

It is also recognized that determinants within and between different domains and levels interact along complex and dynamic pathways to "produce" health at the population level, and health itself can also be influenced by its multilevel and multinature determinants (Huynen et al. 2005). The pathways between these determinants and population health are not unidirectional as other developments that possibly affect our future health such as environmental factors could be an outcome of these multiple drivers and pressures (Huynen and Martens 2006). According to Friis (2012), the ecological determinants emphasize the interdependent relations amongst system of environments that can affect human health by those

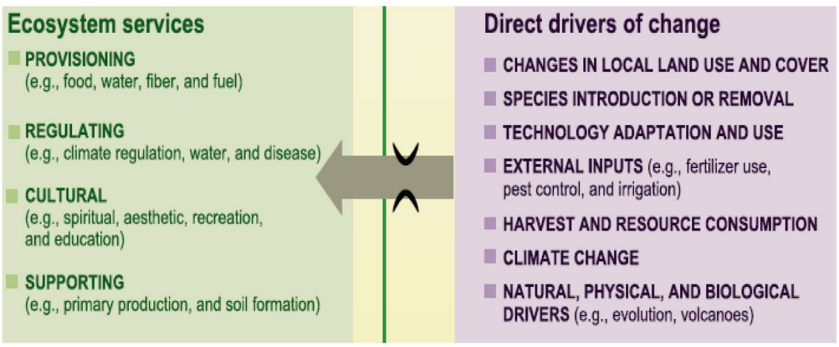

Diagram 1 Ecosystem services are being affected by direct drivers of change (Millennium Ecosystem Assessment 2005 p. iii)

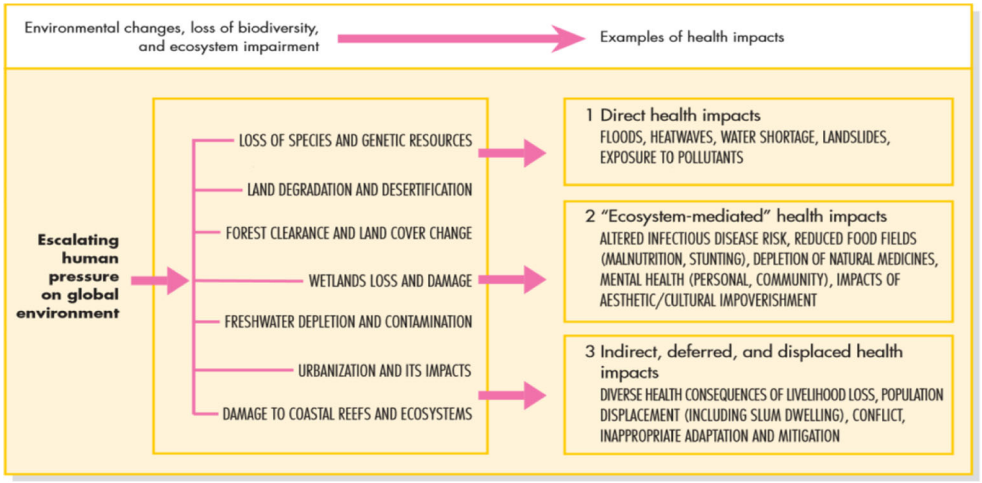

Diagram 2 Ecosystems and human well-being: health synthesis (WHO 2005)

components of physical, biological and psychosocial environments, which contained:

- Physical: air, water, soil, housing, climate, geography, heat, light, noise, debris, radiation, etc.
- Biological: man, viruses, microbial agents, insects, rodents, animals and plants, etc.
- Psychosocial: cultural values, customs, beliefs, habits, attitudes, morals, religion, education, lifestyles, community life, health services, social and political organizations

Besides, the significant part of ecological factors certainly includes climate change, stratospheric ozone depletion, loss of biodiversity, changes in hydrological systems and the supplies of freshwater, land degradation and stresses on food-producing systems. These large-scale and global environmental hazards are, in fact, the major ecological determinants with consequential effects on our human health. The following effects of changes are some examples interconnected with those causes by adverse geo-climatic changes and environmental hazards, with further subsequent adverse outcomes such as:

1. Higher mean of global temperatures that can lead to increase water-borne, food-borne and vector-borne diseases, e.g. wider distribution of insects, with resultant effects of increase in malaria, dengue, lyme diseases, etc. (Barrett et al. 2015; Mills et al. 2010; Patz et al. 2003; Brown and DeGaetano 2011)
2. Sea level rise as a special type of climatic disaster that can cause inundation (Hunt 2002; Reguero et al. 2015)
3. Climate change, drought, desertification and/or flooding can have subsequent effects on crop failure and other food productions, as well as food-, vector- and water-borne diseases and human health (Yeh et al. 2015; Yusa et al. 2015; Brown and DeGaetano 2011)
4. Climate and atmospheric change that leads to stratospheric ozone layer depletion with increasing UV radiation, which can impose high risks to human health such as skin cancer and cataracts (Lucas et al. 2015)
5. Acid emissions affect ocean and freshwater acidification, which can cause the loss of key aquatic life and damages to coral reefs that is also one of the inducing factors causing ecological disturbances (Driscoll et al. 2001)
6. Soil acidification can adversely affect the agricultural and forest productivity (Driscoll et al. 2001)
7. Air, water and soil pollutions and eco-toxicity by persistent organic pollutants (POPs), etc. (El-Shahawi et al. 2010)
8. Resource depletion both from renewable and nonrenewable resources such as the nitrogen and phosphorus cycles, as they are essential nutrients for the survival of all living organisms, plants and animals, as well as control the ecosystem mass balance (Vitousek et al. 2010), with examples taken as follows:

(a) The ecological implications of human alterations to the nitrogen cycle from many human activities have a significant impact on the nitrogen cycle, such as burning fossil fuels, application of nitrogen-based fertilizers and other activities which can dramatically increase the amount of biologically available nitrogen in an ecosystem, and any large changes in the availability of nitrogen can lead to severe alterations of the nitrogen cycle in both aquatic and terrestrial ecosystems (Driscoll et al. 2001; Vitousek et al. 1997)

(b) The phosphorus cycle is the slowest of the biogeochemical cycles, and phosphorus enters the environment from rocks and from deposits such as fossilized bone or bird droppings, of which is an essential mineral nutrient for all plants and animals. Food production depends on mineral phosphorus supplies that are nonrenewable and are being depleted (Childers et al. 2011)

(c) Global freshwater depletion and contamination are also one of the greatest environmental threats to our human health as the World Health Organization has indicated (WHO 2015b)

9. The value of the biophysical environment is being affected due to land degradation by the combinations of multiple forces, including extreme weather conditions and human-induced processes or anthropogenic activities (Gibbons et al. 2014; Powers et al. 2011)
10. Stresses on food-producing systems from other risks associated with environmental contaminants and pollutants, as well as the man-made contaminations; misuses of antibiotics; food fraud and violations in domestic food animal and poultry welfares in productions; etc.

Global environmental hazards as above-mentioned climate change, stratospheric ozone depletion, loss of biodiversity, changes in hydrological systems and the supplies or depletion of freshwater, land degradation and stresses on food-producing systems, which are continuously imposing a lot of ecological risks and diseases on our human health (McMichael 2012). Specifically, when our populations grow and global consumption increases, and the nature's capacity in the ecological footprint might not able to meet these demands, and in fact, starvation, hunger, malnutrition or under-nutrition are still at the world's top list of health threats, with which the dual burden of the cost of chronic diseases often coexist (Davison 2011). Additionally, climate change is one of the major sources affecting the crop yields and water supplies under this multitude of reasons with multifactorial causes for this tragic situation of world-scale hunger and malnutrition.

Those ecological health determinants exist simultaneously in these causal relationships that impact on human health; biodiversity is the crucial issue of environmental linkage between species diversity and ecosystem functions that embed the ecosystem processes, and consequentially any biodiversity change affects the flow of ecosystem services through many ways that the "econature" supports our human endeavour. As such, those ecological factors are the most significant components in our environments as the driver of services which provide us with basic human needs like food, clean air, clean water and clean soils, and such ecosystem functions could also prevent the spread of disease through biological control, which are essential concerns under the ecological determinants of our health. Huynen et al. (2005) and Brown and DeGaetano (2011) also reckon those multiple factors induced global environmental changes that could continually impose profound effects on the provision of ecosystem goods and services. Luque et al. (2013) reinforced those ecological effects of environmental change drivers and their interactions, including habitat loss and fragmentation, pollution, invasive species and climate change, which further imposed stress on the ecosystem through the complex environmental responses to global change across an ecological continuum of the populations, communities and eco-environments.

Moreover, ecological disturbances will continually alter the pattern of various pests and pathogens in plants, livestock and humans, and these large-scale environmental changes are likely to impose food insecurity and water stress along with increasing range and seasonality of various infectious diseases, especially vector-borne diseases (McMichael et al. 1998), due to those aggregate environmental impacts of humankind having changed the world's great biophysical systems through the loss of biodiversity, land degradation, depletion of fisheries, declines in major freshwater aquifers and the global dispersion of non-biodegradable chemical pollutants (McMichael et al. 1998 and Huynen et al. 2005), e.g. persistent organic pollutants (POPs) are one of the organic compounds with resistance to chemical, biological and photolytic processes as going through environmental degradation, and become substances of the environmental contaminants. Ritter et al. (2002) illustrated there are two primary routes of contaminants to surface waters, groundwater, sediments and drinking water as follows:

1. Point-source pollution originates from discrete sources whose inputs into aquatic systems can often be defined in a spatially explicit manner. Examples include industrial effluents (pulp and paper mills, steel plants, food-processing plants), municipal sewage treatment plants and combined sewage-storm-water overflows, resource extraction (mining) and land disposal sites (landfill sites, industrial impoundments).
2. Non-point-source pollution, which originates from poorly defined diffuse sources that typically occur over broad geographical scales. Examples include agricultural runoff (pesticides, pathogens and fertilizers), storm-water and urban runoff, and atmospheric deposition (wet and dry deposition of persistent organic pollutants such as polychlorinated biphenyls [PCBs] and mercury).

In fact, environmental contaminants can be man-made or natural substances that are present in such amounts to be potentially and adversely affecting human or ecosystem health. The routes of environmental contamination may be chemical, physical and biological as pointed out by the Canadian Nurses Association (2005), and Timmis (2010) also stated the levels of ecosystems' risk depend on the characteristics of the pollutant in the environment, and human activities consuming resources and producing waste can also put the ecosystems at risk, for instance, the ratios of metal concentration to the hazard criteria, in which the metal concentrations exceed the tolerable or permissible levels in soils, with which crops being produced are considered unsafe for human health (Ezeh et al. 2008). It is matter of significant fact that most contaminants have either been demonstrated to pose significant risks to human health and/or aquatic ecosystem integrity, or which are suspected of posing such risks, including nutrients, metals, pesticides, POPs, chlorination by-products and pharmaceuticals (Ritter et al. 2002).

Other ecological factor of determinants is unethical and/or unregulated use of antimicrobial agents that have lead to the development and spread of antimicrobial resistance (AMR), which has indeed become a global public health problem by

the misuse of antimicrobial agents in both humans and animals. Kim (2014) revealed that food is a vehicle of antimicrobial-resistant bacteria and/or genes to human in many ways due to its ability to acquire and harbour resistance gene, which potentially increase overall risk to human health from food-borne antimicrobial-resistant microorganisms that associated with food-borne illnesses.

Heuer et al. (2009) signified that the misuse of antimicrobial agents in aquaculture presents a risk to public health because of the development of acquired antimicrobial resistance in fish pathogens and other aquatic bacteria and such drug-resistant bacteria can act as reservoirs of resistance genes, from which genes can disseminate to human pathogens such as the spread of resistance genes from *Aeromonas* species to *Escherichia coli*. Kim (2014) reinforced, yet again, that antimicrobial resistance is a major global public health concern, as when pathogens become resistant to antimicrobial agents, they can pose a greater health risk resulting in potential treatment failure, loss of treatment options and increased likelihood and severity of disease.

The magnitudes and blueprint of ecological transition, epidemiological transition and health transition have indicated the changes in patterns of illness within a human population with those supporting evidences elucidating how human health is affected or impeded within ecology of food and related environments on human health. Some of such correlated effects have significant impacts on our quality of life, our health and the sustainability of our planet, especially with increasing population, urbanization and industrialization around the world place that exerted enormous stress on our ecosystems, in addition to the harmful effects further imposed by human activities on the biophysical environment through more new chemicals and industrial processes being rapidly developed that can potentially impose further unforeseen risks to both human health and the ecosystems, which even worsening the current situations (Canadian Nurses Association 2005). Those multiple factors are interconnected and interlinked amongst the drivers and can create an impact through the disease triangle to affect our health. In fact, these cumulative impacts may lead to dramatic ecological changes that also affect the vitality of these ecosystems and its related drivers for the natural functioning of ecosystem services and such subsequent disturbances to the direct drivers of the eco-environments, including the life cycles of pathogens, and which can also induce much more health threats of zoonoses through interactions of HAEI.

Health threats imposed by human-animal-ecosystems interface: zoonoses

Pathogens have their abilities to evolve and have perfected their life cycles in an environment that is more and more favourable to them by replicating and moving from a diseased host to a susceptible new host (FAO/OIE/WHO 2012). Younes (2012) estimated 60 % of known infectious human diseases have their source in animals and are caused by all types of pathogenic agents—including bacteria, parasites, fungi and viruses; zoonotic pathogens of those organisms from a nonhuman animal source in fact represent three quarters of emerging infectious diseases in humans as indicated by the World Health Organization, and those zoonoses still represent significant public health risks posed by endemic, epidemic and potential pandemic events, as over two hundred HAEI and zoonotic diseases have been described (WHO 2014a). Scientists widely recognize the inherent link between human and animal health in this respect of HAEI. Because of the inherent unpredictability of influenza viruses, the associated risks to both animal and human health are still unknowable at certain extent, and therefore a public health risk is assumed to exist whenever influenza viruses are circulating in certain animal populations, especially those in direct contact with humans, as well as those antimicrobial resistance pathogens and antibiotic-resistant bacteria. There are numerous examples of emerging health threats of zoonoses through:

- Water-borne diseases that are transmitted through drinking water, e.g. hepatitis A virus, *Salmonella*, cholera, amoebic dysentery, *Shigella*, polio virus, *Cryptosporidium* and *Giardia*.
- Food-borne diseases are those transmitted through food, e.g. bacteria *Salmonella*, serotype enteritidis, *E. coli*, bovine spongiform encephalopathy and variant Creutzfeldt-Jacab disease/mad cow disease. In fact, food- and feed-borne diseases are one of major factors for our public health concern (Kneifel 2014).
- Vector-borne diseases are those transmitted by insects or other arthropods, e.g. West Nile fever, tick-borne encephalitis, malaria, dengue fever and plague.
- Air-borne diseases such as Middle East respiratory syndrome corona-virus (MERS-CoV) and avian influenza H5N1 and H7N9, and pandemic A(H1N1) 2009 influenza.
- Antimicrobial resistance in pathogens

Huynen and Martens (2006) reminded that outbreaks of severe acute respiratory syndrome (SARS) and other re-emerging diseases are a reminder of the sudden disease emergence and the possible threats to our future mankind should be anticipated and recognized, and they also addressed the next stage in the health transition could possibly be characterized by those emerging disease and re-emerging disease outbreak, for instance like the Ebola outbreak. Muyembe-Tamfum et al. (2012) indicated that Ebola virus had been absent from 1980 to 1993 and then re-occurred again, for example there were Ebola outbreak in Kaluamba, with 32 cases and 14 deaths in 2008. But in 2015, the re-emerging Ebola outbreak continues with numbers keep climbing since from last year and as of in

March 2015, there are 24,701 cases being affected and 10,194 deaths had been recorded (The Economist 2015).

In light of such momentous fact that the movement of influenza viruses across animal and human populations is increasingly being recognized, those influenza viruses circulating in animals have also caused significant social and economic impacts and posed both pandemic and direct threats to our human health. Epidemiological transition and health transition of those emergences of new infectious diseases or the re-emergence of "old" ones and its costs of human lives are shown in Fig. 1—the emergence of zoonoses, which evidentially projected major concerns in public health.

Ecological changes are the major predisposing factors of those arising health threats of zoonoses under the ecological transition, there are numerous examples of emerging and the resurgence of various infectious diseases that are linked, in part, to the ecology of vector habitats, climatic changes, and disruptive patterns of land use, changes to the hydrological environment, as well as these resultant effects of disturbances of rodent ecology, in addition to the human-induced disturbances to our environments and food systems, such as air pollutions, water pollutions, misuse of antibiotics and growth hormones, overfishing, abuse of chemical usages, food fraud and overlook of food animals and poultry welfares, in fact, all of which have raised the considerable worries and concerns in public health.

Food and environment on human health

Hippocrates (c. 460–377 BCE), the medical genius of the "Golden Age" of Greece, with his essay on "Airs, Waters, and Places", describes the effects of climate and environment on medical conditions and especially on the spread of epidemics, and that is a prime example defining this field of public health (Schneider and Lilienfeld 2008). As in the great Corpus Hippocraticum, the historical development of public health with the idea of the environment playing a crucial role in causing disease was known as "*De aere*, *aquis et locis*" by Hippocrates, in which he had noted the effect of food, of occupation and especially of climate in causing diseases, and that is also classed as the earliest concept or treatise on human ecology in public health (Schneider and Lilienfeld 2008; Yadavendu 2013). The theory of miasma in the nineteenth century of the developmental stage in public health has also accepted that polluted water and lack of proper waste disposal in the environment can spread communicable diseases (Tulchinsky and Varavikova 2014).

Besides, many important zoonoses also relate in some way to animals in the food production chain, and therefore the food becomes an important vehicle of these zoonotic pathogens with a variety of examples ranging from mad cow disease (bovine spongiform encephalopathy) and *E. coli* outbreaks to intentional melamine contamination, etc. which are evidentially noted and specified by Mackenzie et al. (2013). Lake et al. (2012) also further illustrated any such altered conditions for food production may result in emerging pathogens into new crop and livestock species, as well as the altered use of pesticides and veterinary medicines that also affect the main transfer mechanisms through which contaminants can move from the environment into food.

Therefore, any extensive use of antimicrobials in all sectors, for human, agriculture, aquaculture and horticulture, means these drugs are often also found in the environment, especially in waterways and soils (Mackenzie et al. 2013). In reality, such uses of antibiotics in animals have been over the years and also resulted in a selective pressure for AMR microorganisms, which are contributing significantly to our human health problems as people, animals and the environment are directly and indirectly interconnected (Mackenzie et al. 2013). In this

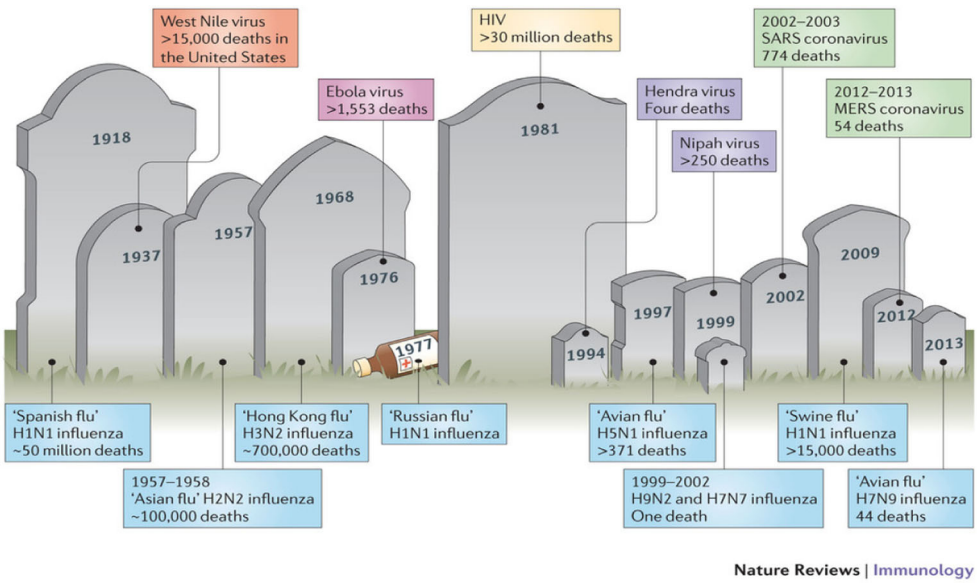

Fig. 1 Emergence of zoonoses (Bean et al. 2013)

context, it means that none of the things that the people put into the ecosystem simply disappears, but in actual fact, what we do to this eco-environment, we do to ourselves, because pollutants reach humans through the food we eat and the water we drink as well as the air we breathe. Food and environment on our human health is always a complex issue with many factors interacting and relating to each other as indicated all the way through air pollutions, water pollutions, misuse of antibiotics and growth hormones, over-fishing, abuse of chemical usages, food fraud and overlook of food animals and poultry welfares, as well as other determinants of environmental contaminants, climate changes and food-producing systems, etc.

Many infectious diseases have emerged due to the ecological threats of HAEI, and others have unexpectedly re-appeared due to anthropogenic activities such as urban crowding, environmental changes, intensified food production and increased mobility and trade in the food systems (McMichael and Butler 2006), in addition to the increasing production of animals for human consumption that is also producing large amounts of animal waste or biosolids, which contain a range of pathogens, including influenza viruses, to the environment (Graham et al. 2008). For instance, scientists suggest that a virus passed from hogs to humans may have caused the 1918 "Spanish Influenza" pandemic, which caused acute illness in 25–30 % of the world's population and eventually killed 40 million people worldwide (Taubenberger 2006). Vandegrift et al. (2010) affirmed that influenza virus transmission in wild and domestic animals and humans is intimately connected, and anthropogenic change such as human population growth, land use, climate change, globalization of trade and agricultural intensification is continuously affecting the ecological and evolutionary determinants of transmissibility of such virulence in birds and humans, which can in turn impose potential for subsequent spread of pandemic, as evidence suggested viral transmission in domestic poultry, spillover to other domestic animals, wild birds and humans. Furthermore, the high rates of growth, substantial genetic selection for improved growth and feed conversion on poultry breeds that resulted in reduced genetic diversity of domestic poultry would also enhance the potential epidemic transmission and evolution of influenza viruses (Vandegrift et al. 2010).

Meanwhile, the food-producing systems around the world are changing rapidly, with profound implications for diets and food consumption outcomes. For instances, the risk of type 2 diabetes is closely linked with the growing problem of obesity, as the WHO highlighted the worldwide prevalence of obesity more than doubled between 1980 and 2014, with global estimations of approximately 1.9 billion adults being overweight in 2014, and 42 million children under the age of five being overweight or obese in 2013 (WHO 2015c). Johnston et al. (2014) also pointed out the existing global imbalance with a "triple burden" of the trends revealed an alarming increase of such health issues of more than one billion people worldwide being overweight and obese, whereas 868 million people are suffering from hunger, and another two billion are suffering from micronutrient deficiencies globally.

Furthermore, there is increasing evidence of climate change posing unprecedented threats to affect human health in several ways by impacts on food and water security, heat waves and droughts, violent storms, infectious disease and the altered distribution of allergens, plus dramatic increase of greenhouse gas emissions from anthropogenic activities and the rising sea levels (Barrett et al. 2015; Franchini and Mannucci 2015; Yeh et al. 2015; Yusa, et al. 2015). Those climate changes subsequently imposed adverse effects significantly affecting ecosystem health, water supplies and food production (Yeh, et al. 2015; Brown and DeGaetano 2011). For instance, as according to Weller et al. (2015), the global rice agriculture will also be increasingly challenged by water scarcity. Other food production problems are the increasing concentrations of atmospheric carbon dioxide (CO_2) and/or hazards of heavy metals in agricultural systems that could lower the content of zinc and other nutrients in important food crops, and in effect, zinc deficiency is currently responsible for large burdens of disease globally, and the populations who are at the highest risk of zinc deficiency (Myers et al. 2015; Savic et al. 2015). The dietary deficiencies of zinc and iron are a substantial global public health problem, with an estimated two billion people suffering from these deficiencies, causing a loss of 63 million life-years annually, due to crops grown under field conditions at the elevated atmospheric CO_2 concentration (Myers et al. 2014). Moreover, environmental contaminants such as heavy metals can also endanger and decrease the ecological value of surrounding water and agricultural land resources by exposing food production to potential contaminants with complex pollution sources (Savic et al. 2015).

Apparently, today's food system is on an unsustainable course with problem beginning with and is driven by industrialized production of both crops and animals, due to reliance on the intensive use of nonrenewable and hard-to-renew resources—soil, antibiotics, fresh water and fossil fuels on one end and produced excess wastes and pollutions on the other (Wallinga 2009), plus further constraints with the confluence of population, economic development and environmental pressures resulting from increased globalization and industrialization that also pose an increasingly resource-constrained world (Johnston et al. 2014). For those reasons, eco-friendly food products and sustainable diets should be an integral part of the concept under the ecological public health model. Tulchinsky and Varavikova (2014) also recognized that health and disease are on a dynamic continuum that affects everyone, hence suggested for expanding the concept of public health to meet the needs of the twenty-first century.

In 2010, the International Scientific Symposium "Biodiversity and Sustainable Diets: United Against Hunger" held at FAO, addressed the linkages among agriculture, biodiversity, nutrition, food production, food consumption and the environment, in which the panel reached consensus for the

definition of sustainable diets as "those diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources" (Burlingame et al. 2010 p. 7). IOM (2014) also projected a series of major workshops with themes on "Sustainable Diets: Food for Healthy People and a Healthy Planet", which also described how different diets have different environmental impacts with respect to greenhouse gas emissions and the use and contamination of air, water and other natural resources. The concept of sustainable diets offers an opportunity for the commitments to sustainable development to the need for improving the quality and environmental sustainability of our food system, especially given the alarming pace of biodiversity loss and ecosystem degradation (Johnston et al. 2014). For instance, the Mediterranean diet has become the object of increasing studies on its environmental sustainability, because of its mainly plant-based dietary pattern and its lower greenhouse gas emissions and lower water footprints, energy resources and the overall impact on the ecosystem (Dernini and Berry 2015). In fact, this is also in line with our One World concept under Ecological Public Health Model as illustrated in this paper, for sustaining our environment and the planet earth for all beings, as also echoing to Confucian's theory for the environmental ethics of ecological harmony. In fact, lack of ecological health literacy and eco-environmental ethics in practices is one of the most important factors leading to the present devastations and worries.

Confucian's environmental ethics

Humankind is to co-exist with the planet earth, and therefore more holistic relationship with the earth is utmost essential, as Kibert et al. (2012) reinforced the necessity to realize the fundamental ethical value is to take into account natural capital and manage natural resources in a sustainable way. As the industrial civilization develops quickly in the modern times, more and more ecological and social problems are emerging. While lots of the scholars pay more and more attention to Confucianism again, Zhou (2008) claimed that human can find much resourceful and valuable wisdom in Confucianism thoughts in the hope that Confucianism can benefit to the ecological civilization, with the theory of "the unity of nature and man" stressing on harmonious development of man and nature, which is not merely a humanist thinking principle but also the actualization of such principle in the activities of treating nature kindly and preserving natural environment.

In fact, this ecological approach has rooted with historical heterogeneity and the pertaining key is the natural ecosystem with concepts of taking care of the natural world; otherwise, it can cause a breakdown of these systems and come back to haunt us in ways we know little about. A critical example is a developing model of infectious disease that shows most epidemics, as mentioned in previous sections regarding health threats under the impacts of the ecological triad. Susser and Susser (1996) stated that eco-epidemiology is a perspective that balances traditional biomedical concepts of risk with the broader social and environmental context and community ownership principles; in this way, eco-epidemiology rests on an understanding of a universe in which "nothing exists as a thing by itself, but only has existence in relation to everything else". Such as forest filter the water we drink, and birds and bees pollinate crops, both of which have substantial economic as well as biological value.

Accepting the values of harmony with nature is the only way to deepen our "ecological wisdom" of how nature works, and attaining our "self-realization" of every species is fundamentally biocentric or ecocentric and they have equal rights to live and flourish (Adler 2014). The promotion of ecological health literacy is utmost important for embracing the morality as an integral part of our inherent human nature for the realization of ethical value in the environmental ethics. And therefore, understanding human systems and environments from this natural system in the contexts of environmental ethics at its core are, in fact, based on the premise that human beings and the natural world share a common nature that makes possible the meaningful correspondence of human interests and natural patterns, human creativity and the natural creative process of change, functioned as the divination system (Adler 2014).

Ecological public health: paradigm of One Health and One World concept

Human health needs to go beyond just concern for biomedical-focused disease model; the impacts of our well-beings are vitally dependent upon improving the management of the healthy earth's ecosystems, humans and animals' health, and they are undeniably intimately connected and evidentially supported reciprocally from those ecological perspectives. As the proverb by Rudolph Virchow (1821–1902) says that "Between animal and human medicine there is no dividing line – nor should there be". In 2008, FAO, World Organisation for Animal Health (OIE), WHO, United Nations Children's Fund (UNICEF), the World Bank, and UN System Influenza Coordination (FAO et al. 2008) have developed a strategy to address emerging infectious diseases that specifically focused on the interdependence of human, animal and ecosystem health, with strategic framework of breaking down the barriers among agencies, individuals, specialties and sectors in order to unleash the innovation and expertise needed to meet the many serious challenges to the health of people, domestic animals and wildlife as well as to the integrity of ecosystems. Rayner and Lang (2012) postulated

a broader conception in the "thinking" focus of the environment with recognition that human activity was altering nature and that humans depend on that environment, not least through food, but also the realization of the impact of climate change, biodiversity loss and global interconnectedness as the challenge under an era of ecological threat.

Integrating human, animal and ecosystem health disciplines will better address today's dynamic health threats that are being imposed by the ecological determinants resulting from the interaction of agent and host in the epidemiological or ecological transitional triad through the disease triangle in a web of interrelationships. In this regard, a broader understanding of health and disease requires interdisciplinary and cross-sectoral efforts working collaboratively to attain optimal health for people, animals and our environments for ensuring the biological and biophysical integrity of our planet earth. Consequently, the recognitions of these relationships amongst humans, domestic animals, wildlife, ecosystem services and climate, as in the "One health concept" under "ecosphere and zoosphere" of this one world system, are therefore being formulated. A better understanding of the links between biodiversity, health and disease has direct and indirect implications for public health, as loss of biodiversity, habitat fragmentation and the loss of natural environments threaten the full range of life-supporting services provided by ecosystems at all levels of biodiversity, including species, genetic and ecosystem diversity (Romanelli et al. 2014). The diversity of relevant criteria defined around the public health interventions will be placed on in using One Health approach with this One World concept; FAO/OIE/WHO (2012) built the One Health vision in support of the collaborative multidisciplinary work for the health of humans, animals and ecosystems, in order to reduce the risk of diseases at the interfaces between them. Its critical vision facilitate the diffusion and understandings towards collaborative intervention keys with broad vision to encompass other disciplines that also impact human health from different sectors such as economics, food security and food safety. Enormous challenges are imposed on the ecological perspectives on food, including aquaculture, agriculture and the entire food systems, and hence scientific and public health interventions are required as examples taken in the following:

1. Eco-aquaculture is an alternative model linked between aquaculture, the environment and society that acted as complementary roles of aquaculture in allowing the time for our eco-environment recovery (Costa-Pierce 2010).
2. Efforts from the regulatory use of antimicrobial agents are needed in order to prevent development and spread of antimicrobial resistance in aquaculture and to reduce the risk to our human health. There has been much debate about the origins of AMR. Nevertheless, linkages between misuse and increasing AMR are of our concerns. FAO/OIE/WHO (2012) indicated that the accelerated emergence of resistance and the discovery and development of new antimicrobial drugs have slowed to the extent that the development of AMR is now exceeding the availability of new antimicrobial agents, making AMR a global threat to our health.
3. Reduction on food waste to minimize the adverse cycle on the environmental problems by landfills, which cause pollution and produce methane that is a harsh greenhouse gas emission with adverse effects to our eco-environments (Kosseva and Webb 2013). For example, food wastes in Hong Kong were from less than 400 tonnes per day in 2002 to over 800 tonnes per day in 2012, and the landfill problems with excess food wastes are the major constituent of the municipal solid waste; despite the food waste is highly degradable, it can easily cause odour and hygiene problems that pose risk to our health as well as an adverse cycle by depleting the limited landfill space in HK (HKEPD 2015).
4. Promotion of ecological health literacy and environmental ethics to the public via public health interventions and education in order to provide the public with knowledge to understand this emerging concerns is utmost vital in terms of the consequences of human actions and interactions amongst humans, animals and wildlife within the natural context of the eco-environments and its functions to our planet earth's ecosystems. A matter of education to promote the environmental ethics and way of living with concept of sustainable diets, as well as providing education and training programmes to create more ecologists as a potential workforce, should also be the prime focus, as Kosseva and Webb (2013) supported that these are critical for eco-innovation for our human capital needs in the delivery of the eco-innovative solutions to our concern.

The understanding of health-disease process from different perspectives offers a broad outlook and shows the necessity of more integrated and collaborated demands from every individuals' effort and responsibility for creating an ecological harmony practices and ethical culture of this "one health and one world" concepts, principles and its applications to the conservation of biodiversity and sustainability of our eco-environments, which cannot be separated from the concerns of our human health at all. These prior and vital definitions of ecological health literacy further strengthen up our belief and practice to our everyday life choices that could well be derived from our understandings of such ecological webs and then form our "sense of place" in relation to, yet again, our everyday life choices. Reynolds et al. (2009) suggested that every people should be equipped with this ecological health literacy, with connections that ripple out over the globe and to the future generations being actually the foundations of a sustainable society.

Bousfield and Brown (2011) emphasized on the One Health idea as a paradigm shift in the way we think about human and animal health in the world, and they further describe this paradigm shift is a revolution and a transformation or a metamorphosis with a complex set of multifactorial circumstances such as population growth,

changes in nutritional, agricultural and trade practices, globalization, the shifts in land use, accelerated urbanization, deforestation, encroachment on wildlife and climate change. Their insights and visionaries are not about one disease or a few main listed diseases, but rather concern all human and animal diseases under all related ecologies, as The American Veterinary Medical Association (2008) also supported the concept of One Health should be the collaborative effort of multiple disciplines in order to attain optimal health for people, animals and the environment.

Romanelli et al. (2014) also reinforced the links amongst ecosystem services, biodiversity and global health are multifaceted and complex and are manifested at various spatial and temporal scales; hence, ecosystem approaches are absolutely relevant to One Health concept, which embrace the interconnectedness of people (and human development), wildlife and ecosystems to improve global health outcomes. In America, Centers for Disease Control and Prevention (2004) have offered guidelines as referred to in the "Manhattan Principles" to build the bridges to our health in this "Globalized World", which summarized the importance of focuses from the perspectives of holistic approach for the prevention of an epidemic/epizootic disease and the maintenance of ecosystem integrity. Global health is the contemporary public health movement for the twenty-first century public health and that should be shifted into an ecological paradigm with ecological and ethical thinking for the concerns of eco-health in support of the sustainability of our environments and our planet earth for all plant, animal and human health.

Conclusion

The impact of these ecosystem changes affect the interdependent relations in climate and atmospheric change with resultant effects such as ozone depletion; acid emissions; pollution and ecotoxicity; air, water and soil pollutions; resource depletion; and loss of biodiversity and its ecosystem functions. In 2010, Harvey stated that "Ecology and ecosystem health must be brought front and centre. Whereas policy-makers easily see connections between animal and human health, the connections between ecosystem health and human and animal health are more subtle but no less important. Articulating these connections and their relationship to environmental conservation, biodiversity, and economic health, is also a major challenge" (Harvey 2010 p. 73).

Ecosystem services are the outputs of ecological processes that contribute to human welfare and those outputs include food and drinking water, clean air and water, and pollinated crops; therefore, there is the need to protect the services provided by natural systems (Munns et al. 2015). Ecosystems affect human and animal health. Human and animal activity affects ecosystem health. Few would debate the interdependence but the links often are not considered by policy-makers, members of the public, and medical and veterinary professionals. As humans encroach more on natural terrestrial and marine ecosystems, as the population increases and as the effects of anthropogenic climate change are realized in the next few decades, the health of the earth's ecosystem will impact everyone, in developed and developing countries alike.

Health threats being imposed by the ecological determinants resulting from the interaction of an agent and host in the epidemiological or ecological triad of the disease triangle with the dilemma drivers of environmental hazards have to be tackled collaboratively. The impacts of eco-environmental drivers on the population health are elucidated together with recommendations from the implication of using ecological thinking and approaches for public health interventions and education to counter these arising problems under those ecological threats.

Seeing that globalization on human health is interlinked with all those determinants, and this ecological paradigm has also been expanded for the role of public health through ecological approaches in forming a supportive framework with the joint efforts in using effective strategies and interventions to ensure coherence of action with the networks of expertise on public health authorities, to further enhance the public's understandings of health-disease process from different perspectives. As Munns et al. (2015) also indicated and suggested the adoption of ecosystem services as a type of assessment endpoint is intended to improve the value of risk assessment to environmental decision-making, linking ecological risk to human well-being as well as providing an improved means of communicating those risks in the field of public health.

Factors indicating the necessary actions as proposed in my Ecological Public Health Model with One World concept (Li 2014) are as addressed from the historical developmental perspectives in this paper, and the transitions lead to the current public health approaches of eco-health literacy and interventions for enhancing ecological harmony that resonances to Confucian's view in "maintaining the oneness of humankind and nature, the harmony and unity between two" (Li 2003 p. 3) as our "Ethical Concerns to All" under this One Health vision and One World concept for the sustainability of eco-environments, animals and human health as a new paradigm for the challenges under this recommended ecological public health model.

References

Adler JA (2014) Chapter 3: the great virtue of health and earth: deep ecology in the Yijing. In: Miller J, Yu DS, Veer PVD (eds) Religion and ecological sustainability in China. Routledge, NY

Ananth M (2008) Chapter 1: introduction to the concept of health. In: Ananth M (ed) In defense of an evolutionary concept of health:

nature, norms, and human biology. Ashgate Publishing Limited, England **(2012)**

Barrett B, Charles JW, Temte JL (2015) Climate change, human health and epidemiological transition. Prev Med 70:69–75. doi:10.1016/j.ypmed.2014.11.013

Bean AGD, Baker ML, Stewart CR, Cowled C, Deffrasnes C, Wang LF, Lowenthal JW (2013) From studying immunity to zoonotic diseases in the natural host—keeping it real. Nat Rev Immunol 13:851–861. doi:10.1038/nri3551, http://www.nature.com/nri/journal/v13/n12/abs/nri3551.html

Bousfield B, Brown R (2011) One World One Health. Vet Bull Agric Fish Conserv Dep Newsletter 1(7):1–12, Available at: https://www.afcd.gov.hk/english/quarantine/qua_vb/files/OWOH2.pdf

Brown, P. and DeGaetano, A. (2011). Chapter 4: consequences of climate change on human health. In Finkel, M.L. (Ed.) (2011) Public health in the 21st century: global issues in public health. USA: ABC-CLIO, LLC

Burlingame, B., Dernini, S., Nutrition and Consumer Protection Division. and FAO. (Editors). (2010). Sustainable diets and biodiversity: directions and solutions for policy, research and action. The Proceedings of the International Scientific symposium on Biodiversity and Sustainable Diets United Against Hunger. November 2010, Rome: FAO Headquarters. Available at: www.fao.org/docrep/016/i3004e/i3004e.pdf

Canadian Nurses Association (2005). The ecosystem, the natural environment, and health and nursing: a summary of the issues. pp1-8. Also available at: http://www.cna-aiic.ca/~/media/cna/page-content/pdf-en/bg4_the_ecosystem_e.pdf?la=en

Centers for Disease Control and Prevention. (2004) One World, One Health: building interdisciplinary bridges to health in a 'Globalized World': the Manhattan principles, Manhattan, New York, USA, 29 September 2004. Available at: http://www.cdc.gov/onehealth

Childers DL, Corman J, Edwards M, Elser JJ (2011) Sustainability challenges of phosphorus and food: solutions from closing the human phosphorus cycle. Bioscience 61(2):117–124, Available at: http://bioscience.oxfordjournals.org/content/61/2/117.full

Costa-Pierce B.A, (2010). Sustainable ecological aquaculture systems: the need for a new social contract for aquaculture development. Marine Technology Society Journal 2010, .44, 3 p.88-112 http://www.ecologicalaquaculture.org/Costa-PierceMTSJ.pdf

Davison, A.J. (2011). Chapter 5: global nutrition in the 21st century: opportunities and challenges for the developed and developing worlds. In Finkel, M.L. (Ed.) (2011) Public health in the 21st century: global issues in public health. USA: ABC-CLIO, LLC

Dernini, S and Berry E.M. (2015). Mediterranean diet: from a healthy diet to a sustainable dietary pattern, frontiers in nutrition. Vol.2, Published online 2015 May 7. Available at: doi: 10.3389/fnut.2015.00015

Driscoll CT, Lawrence GB, Bulger AJ, Butler TJ, Cronan CS, Eagar C, Lambert KF, Likens GE, Stoddard JL, Weathers KC (2001) Acidic deposition in the northeastern United States: sources and inputs, ecosystem effects, and management strategies. Bioscience 51(3):180–198, Available at: http://ny.water.usgs.gov/pubs/jrn/ny0177/i0006-3568-051-03-0180.pdf

El-Shahawi, M.S., Hamza, A., Bashammakh, A.S. and Al-Saggaf, W.T. (2010). An overview on the accumulation, distribution, transformations, toxicity and analytical methods for the monitoring of persistent organic pollutants, Talanta 80 (2010) 1587 – 1597. Published by Elsevier. Available at: http://www.jelena-suran.com/joomla/images/stories/An_overview_-_POPs.pdf

Environmental Protection Department (2015). Food waste challenge: problems and solutions, Environmental Protection Department in Hong Kong. Available at: http://www.epd.gov.hk/epd/english/environmentinhk/waste/prob_solutions/food_waste_challenge.html

Ezeh HN, Anike OL, Egboka BCE (2008) Evaluation of heavy metals pollution of soils around the derelict Enyigba mines and their sources. Int J Appl Environ Sci 3(1):1–10, Also available at: www.icoia.org/ijaes.pdf

FAO, OIE, WHO, UN System Influenza Coordination, UNICEF, The World Bank (2008), Contributing to One World, One Health: a strategic framework for reducing risks of infectious diseases at the animal-human-ecosystems interface, consultation document. Available at: http://un-influenza.org/files/OWOH_14Oct08.pdf

FAO/OIE/WHO (2012) Food and Agriculture Organisation, the World Organisation for Animal Health and World Health Organisation Report on high-level technical meeting to address health risks at the human-animal-ecosystems interfaces Mexico City, Mexico: FAO/OIE/WHO http://www.who.int/zoonoses/hltm_2011/en/

Franchini M, Mannucci PM (2015) Impact on human health of climate changes. Eur J Int Med 26(1):1–5. doi:10.1016/j.ejim.2014.12.008

Friis, R.H. (2012) (2nd Edition). Essentials of environmental health USA: Jones & Bartlett Learning

Gibbons SM, Jones E, Bearquiver A, Blackwolf F, Roundstone W, Scott N, Hooker J, Madsen R, Coleman ML, Gibert JA (2014) Human and environmental impacts on river sediment microbial communities. PLoS ONE 9(5), e97435. doi:10.1371/journal.pone.0097435

Graham JP, Leibler JH, Price LB, Otte JM, Pfeiffer DU, Tiensin T, Silbergeld EK (2008) The animal-human interface and infectious disease in industrial food animal production: rethinking biosecurity and biocontainment. Public Health Rep 123(3):282–299, Also available at: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2289982/

Harvey HA (2010) Building bridges to protect health: enhanced partnerships among animal, human, and ecosystem health sectors in New Zealand. Fulbright, New Zealand

Heuer OE, Kruse H, Grave K, Collignon P, Karunasagar I, Angulo F (2009) Human health consequences of use of antimicrobial agents in aquaculture. Clin Infect Dis 49(8):1248–1253. doi:10.1086/605667

Hunt JC (2002) Floods in a changing climate: a review. Philos Trans A Math Phys Eng Sci 360(1796):1531–43

Huynen, M. and Martens, P. (2006) Globalization and human health: toward scenarios for the 21st century. Interactions between global change and human health. Pontifical Academy of Sciences, *Scripta Vario* 106, Vatican City 2006. Also available at: www.pas.va/content/dam/accademia/pdf/sv106/sv106-huynen.pdf

Huynen MMTE, Martens P, Hilderink HBM (2005) The health impacts of globalization: a conceptual framework. Glob Health 1:14. doi:10.1186/1744-8603-1-14

IOM (Institute of Medicine) (2014) Sustainable diets: food for healthy people and a healthy planet: workshop summary. The National Academies Press, Washington, DC

Johnston JL, Fanzo JC, Cogill B (2014) Understanding sustainable diets: a descriptive analysis of the determinants and processes that influence diets and their impact on health, food security, and environmental sustainability. Adv Nutr 5(4):418–429. doi:10.3945/an.113.005553

Kibert CJ, Monroe M, Peterson A, Plate RR, Thiele L (2012) The ethics of sustainability. John Wiley & Sons, New Jersey

Kim, H.J. (2014) Antimicrobial-resistant bacteria: a challenge for the food system. In Programme and Abstracts Proceedings of the 1st International Conference on Food Safety: from Experience to Perspectives 16–18 June, 2014, p.51. HK: The University of Hong Kong

Kneifel, W. (2014) Global food safety: recent crises and lessons to be learned. In Programme and Abstracts Proceedings of the 1st International Conference on Food Safety: from Experience to Perspectives 16–18 June, 2014, p.49. HK: The University of Hong Kong.

Kosseva M, Webb C (2013) Food industry wastes: assessment and recuperation of commodities. Elsevier Inc., USA

Lake, I.R., Hooper, L., Abdelhamid, A., Bentham, G., Boxall, A.B.A., Draper, A., Fairweather-Tait, S., Hulme, M., Hunter, P.R., Nichols, G. and Waldron, K.W. (2012). Climate change and food security: health impacts in developed countries. Environmental Health Perspectives. Nov. 2012, Vol.20, Issue 11. Available at: doi:10.1289/ehp.1104424

Li T.C. (2003). Confucian ethics and the environment, Culture Mandala: The Bulletin of the Centre for East–west Cultural and Economic Studies: Vol.6, Issue 1, Article 4. Available at: http://epublications.bond.edu.au/cm/vol6/iss1/4

Li A.M.L. (2014). A public health approach to emergency medicine: preparing for the 21st century, Poster presentation in the 15th International Conference of Emergency Medicine 2014, HK

Lucas RM, Norval M, Neale RE, Young AR, de Gruijl FR, Takizawa Y, van der Leun JC (2015) The consequences for human health of stratospheric ozone depletion in association with other environmental factors. Photochem Photobiol Sci 14(1):53–87. doi:10.1039/c4pp90033b

Luque, G.M., Hochberg, M.E., Holyoak, M. Hossaert, M. Gaill, F. and Courchamp, F. (2013) Ecological effects of environmental change, Ecological Letters. May 2013, Vol. 16, Issue Supplement s1, pp.1-3. John Wiley & Sons Ltd. DOI: 10.1111/ele.12050

Mackenzie JS, Jeggo M, Daszak P, Richt JA (eds) (2013) One Health: the human-animal-environment interfaces in emerging infectious diseases. Springer-Verlag Berlin Heidelberg, NY

McMichael AJ (2012) Insights from past millennia into climatic impacts on human health and survival. Proc Natl Acad Sci U S A 109(13): 4730–4737. doi:10.1073/pnas.1120177109

McMichael, A.J. and Butler, C.D. (2006). Emerging health issues: the widening challenge for population health promotion. Health Promotion Int., Dec. 2006, Suppl.21, Vol.1, pp.15-24. Available at: PMID: 17307953

McMichael AJ, Patz J, Kovats RS (1998) Impacts of global environmental change on future health and health care in tropical countries. Br Med Bull 54(No.2):475–488, Also available at: http://bmb.oxfordjournals.org/content/54/2/475.full.pdf

Millennium Ecosystem Assessment (2005) Ecosystems and human well-being: biodiversity synthesis. World Resources Institute, Washington, DC, Available at: http://www.millenniumassessment.org/documents/document.356.aspx.pdf

Mills JN, Gage KL, Khan AS (2010) Potential influence of climate change on vector-borne and zoonotic diseases: a review and proposed research plan. Environ Health Perspect 118(11):1507–1514. doi:10.1289/ehp.0901389, Published online 2010 Jun 24

Munns, W.R., Rea, A.W., Suter, G.W., Martin, L., Blake-Hedges, L., Crk, T., Davis, C., Ferreira, G., Jordan, S., Mahoney, M. and Barron, M.G. (2015). Ecosystem services as assessment endpoints for ecological risk assessment, Integrated Environmental Assessment and Management. Sept. 2015, Vol.1. Available at: Doi: 10.1002/ieam.1707

Muyembe-Tamfum, J.J., Mulangu, S., Masumu, J., Kayembe, J.M., Kemp, A. and Paweska, J.T. (2012) Ebola virus outbreaks in Africa: past and present. AOSIS OpenJournals. Available at: doi: 10.4102/ojvr.v79i2.451 and in http://www.ojvr.org/index.php/ojvr/article/view/451

Myers SS, Zanobetti A, Kloog I, Huybers P, Leakey AD, Bloom AJ, Carlisle E, Dietterich LH, Fitzgerald G, Hasegawa T, Holbrook NM, Nelson RL, Ottman MJ, Raboy V, Sakai H, Sartor KA, Schwartz J, Seneweera S, Tausz M, Usui Y (2014) Increasing CO2 threatens human nutrition. Nature 510(7503):139–142. doi: 10.1038/nature13179, Epub 2014 May 7; and http://www.ncbi.nlm.nih.gov/pubmed/24805231

Myers, S.S., Wessells, K.R., Kloog, I., Zanobetti, A. and Schwartz, J. (2015). Effect of increased concentrations of atmospheric carbon dioxide on the global threat of zinc deficiency: a modelling study, The Lancet. Global Health. Jul 2015. Available at: doi: 10.1016/S2214-109X(15)00093-5

Patz, J.A., Githeko, A.K., McCarty, J.P., Hussein, S., Confalonieri, U. and deWet, N. (2003). Chapter 6: climate change and infectious diseases. In McMichael, A.J., Campbell-Lendrum, D.H., Corvalan, C.F., Ebi, K.L., Githeko, A.K., Scheraga, J.D. and Woodward, A. (2003). Geneva: WHO. Available at: http://www.who.int/globalchange/publications/climatechangechap6.pdf and http://www.who.int/globalchange/publications/climchange.pdf

Powers JS, Corre MD, Twine TE, Veldkamp E (2011) Geographic bias of field observations of soil carbon stocks with tropical land-use changes precludes spatial extrapolation. Proc Natl Acad Sci U S A 108(15):6318–22. doi:10.1073/pnas.1016774108

Rayner G, Lang T (2012) Ecological public health: reshaping the conditions for good health. Routledge, NY

Reguero BG, Losada IJ, Diaz-Simal P, Mendez FJ, Beck MW (2015) Effects of climate change on exposure to coastal flooding in Latin America and the Caribbean. PLoS ONE 10(7), e0133409. doi:10.1371/journal.pone.0133409

Reynolds, H.L., Brondizio, E.S. Robinson, J.M. Karpa, D., and Gross, B.I. (2009) (Ed.) Teaching environmental literacy. USA: Indiana University Press

Ritter L, Solomon K, Sibley P, Hall K, Keen P, Mattu G, Linton B (2002) Sources, pathways, and relative risks of contaminants in surface water and groundwater: a perspective prepared for the Walkerton inquiry. J Toxic Environ Health A 65(1):1–142

Romanelli C, Cooper HD, de Souza Dias BF (2014) The integration of biodiversity into One Health. Rev Sci Tech 33(2):487–96

Savic R, Ondrasek G, Josimov-Dundjerski J (2015) Heavy metals in agricultural landscapes as hazards to human and ecosystem health: a case study on zinc and cadmium in drainage channel sediments. J Sci Food Agric 95(3):466–70. doi:10.1002/jsfa.6515

Schneider D, Lilienfeld DE (eds) (2008) Public health: the development of a discipline. Rutgers University Press, USA

Sharma M, Atri A (2010) Essentials of international health. Jones and Bartlett Publishers, LLC., USA

Susser M, Susser E (1996) Choosing a future for epidemiology: II. From black box to Chinese boxes and eco-epidemiology. Am J Public Health 86:674–7

Taubenberger JK (2006) The origin and virulence of the 1918 "Spanish" influenza virus. Proc Am Philos Soc 150(1):86–112

The American Veterinary Medical Association. (2008). One Health: a new professional imperative. One Health Initiative Task Force: Final Report. July 15, 2008. Available at: https://www.avma.org/KB/Resources/Reports/Documents/onehealth_final.pdf

The Economist. (19th March 2015). Ebola in graphics: the toll of a tragedy Available at: http://www.economist.com/blogs/graphicdetail/2015/03/ebola-graphics

Timmis, K.N. (ed). (2010). Handbook of hydrocarbon and lipid microbiology. DOI: 10.1007/978-3-540-77587-4_349, Springer-Verlag Berlin Heidelberg

Tulchinsky TH, Varavikova EA (2014) The new public health: an introduction for the 21st century. Elsevier Inc., USA

Vandegrift KJ, Sokolow SH, Daszak P, Kilpatrick AM (2010) Ecology of avian influenza viruses in a changing world. Annual N Y Acad Sci 1195:113–128. doi:10.1111/j.1749-6632.2010.05451.x

Vitousek, P.M. Aber, C.J., Howarth, R.W., Likens, G.E., Matson, P.A., Schindler, D.W., Schlesinger, W.H. and Tilman, G.D. (1997). Human alteration of the global nitrogen cycle: causes and consequences. Issue in Ecology. No.1 Spring 1997. Published by the Ecological Society of America. Available at: http://www.esa.org/esa/documents/2013/03/issues-in-ecology-issue-1.pdf

Vitousek PM, Porder S, Houlton BZ, Chadwick OA (2010) Terrestrial phosphorus limitation: mechanism, implications, and nitrogen-phosphorus interactions. Ecol Appl: Publ Ecol Soc Am 20(1):5–15

Wallinga D (2009) Today's food system: how healthy is it? J Hunger Environ Nutr 4(3–4):251–281. doi:10.1080/19320240903336977

Weller, S., Janz, B., Jorg, L., Kraus, D., Racela, H.S., Wassmann, R., Butterbach-Bahl, K. And Kiese, R. (2015). Greenhouse gas emissions and global warming potential of traditional and diversified tropical rice rotation systems. Global Change Biology. Sept. 2015. Available at: doi: 10.1111/gcb.13099

WHO (2005) Ecosystems and human well-being: health synthesis. Millennium ecosystem assessment. World Resources Institute, Washington, DC

WHO (2014) Zoonoses and the human-animal-ecosystems-interface http://www.who.int/zoonoses/

WHO (2014) Climate change and human health: biodiversity. http://www.who.int/globalchange/ecosystems/biodiversity/en/

WHO (2015a). Public health. Trade, foreign policy, diplomacy and health. Retrieved in September, 2015 at: http://www.who.int/trade/glossary/story076/en/

WHO (2015b) Water, health and ecosystems. Available at: http://www.who.int/heli/risks/water/water/en/

WHO (2015c). Obesity and overweight. Fact sheet No.311, Media centre of World Health Organization. Available at: http://www.who.int/mediacentre/factsheets/fs311/en/

World Health Organization. (1947). "Constitution of the World Health Organization," Chronicle of the World Health Organization, 1/1–2 (1947): 3

Yadavendu VK (2013) Shifting paradigms in public health: from holism to individualism. Springer, India

Yeh SW, Park RJ, Kim MJ, Jeong JI, Song CK (2015) Effect of anthropogenic sulphate aerosol in China on the drought in the western-to-central US. Scientific Rep 5:14305. doi:10.1038/srep14305

Younes M. (2012) One Health: the importance for health security, working at human-animal-ecosystem interfaces within the framework of One Health organized by WHO Available at: http://onehealth.grforum.org/archive/one-health-2012/outcomes/keynote-iii-maged-younes/

Yusa A, Berry P, Cheng JJ, Ogden N, Bonsal B, Stewart R, Waldick R (2015) Climate change, drought and human health in Canada. Int J Environ Res Public Health 12(7):8359–8412. doi:10.3390/ijerph120708359

Zhou, Yuanxia (2008). The modern significance of Confucianism, Asian social science, Vol.4, No.11, Nov. 2008 pp.13-16. Also available at: http://ccsenet.org/journal/index.php/ass/article/view/782/756