

Original Contribution

Finding a Place for Systems-Based, Collaborative Research in Emerging Disease Research in Asia

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Abstract: The need to adequately predict, prevent and respond to infectious diseases emerging unexpectedly from human–animal–environmental systems has driven interest in multisectoral, socio-economic, systems-based, collaborative (MSC) research approaches such as EcoHealth and One Health. Our goals were to document how MSC research has been used to address EIDs in Asia, and to explore how MSC approaches align with current priorities for EID research in Asia. We gathered priorities for EID research from the peer-reviewed and grey literature, documented organizational descriptions of MCS research approaches, and analysed a series of EID MSC projects. We found that priority areas for EID research in Asia included (1) understanding host-pathogen-environment interactions; (2) improving tools and technologies; (3) changing people’s behaviour; and (4) evaluating the effectiveness of interventions. We found that the unifying characteristics of MSC research were that it was action-oriented and sought to inspire change under real-world conditions at the complex interface of human and natural systems. We suggest that MSC research can be considered a type of ‘pragmatic research’ and might be most useful in describing change in complex human–animal–environmental systems, accelerating research-to-action, and evaluating effectiveness of interventions in ‘real world’ settings.

Keywords: emerging infectious disease, Asia, EcoHealth, One Health, research priorities, systems, collaborative

INTRODUCTION

In recent years, there has been a number of emerging infectious diseases (EIDs) originating in Asia, such as severe acute respiratory syndrome (SARS) (Koh and Sng 2010) and H5N1 influenza (Sims et al. 2005). After each EID event, significant effort has gone into researching the causes of the event and into thinking about how to predict, prevent or mitigate future similar events. Many Asian coun-

tries, particularly those with limited resources, have been assisted with this process financially and technically by international governmental and non-governmental organizations including the World Health Organization (WHO), Food and Agriculture Organization of the United Nations (FAO), Association of Southeast Asian Nations (ASEAN), United States Center for Disease Control (CDC), Australian Agency for International Development and the Canadian International Development Research Centre (IDRC).

Because EIDs emerge from complex systems, it is challenging to predict, prevent or respond to the threat they

pose (Stephen et al. 2014). Researchers, donors and policy makers have expressed growing interest in applying systems-based and collaborative approaches, such as EcoHealth, One Health, health promotion, global health and conservation medicine to the challenges of EIDs in Asia. In general, these approaches share a broad goal of integrating knowledge from multiple sectors, species and/or disciplines in a collaborative fashion to improve health, identify health risks and develop options for risk reduction. We use the phrase *multisectoral, socio-economic, systems-based, collaborative (MSC)* research to describe this group of related research approaches. The hypothesized value of a MSC approach is twofold; (1) its simultaneous inquiry about different aspects of a problem may better reflect how that problem is manifested in a ‘real-world’ setting, and thus recommendations arising from the research might be better able to identify the implications of actions in response to the problem; and (2) it engages people whose actions influence or can be influenced by the problem and thus may shorten the time between discovery and knowledge mobilization. International agencies such as the WHO and FAO actively promote MSC approaches, in particular One Health, as a preferred strategy against EIDs. However, to date, there has been limited peer-reviewed documentation of how MSC methods had been used for EID research in Asia to date (Nguyen-Viet et al. 2015), and of how these methods align with EID research priorities. Our purposes for this paper were (1) to summarize current research priorities for EIDs in Asia; (2) to explore how organizations describe MSC research and to understand how MSC methods had been used for EID research in Asia to date; and (3) to synthesize results of these tasks to understand how priorities and methodology intersect and diverge in theory and in practice. Our objective was to provide a basis for a donor agency to begin the development of strategy for MSC methods in current or future EID research needs in Asia.

METHODS

Characterizing MSC Research

The authors’ professional knowledge and a general Google search were used to find major organizations involved in MSC research that aimed to address emerging, zoonotic or neglected infectious disease challenges. Descriptions of the organizations research approaches were reviewed. Keywords and phrases that described the organizations re-

search approach were identified, and the frequency of their use was counted (maximum one time per organization). Relative frequency of word use across organizations was calculated and the website wordle.net¹ was used to create a word cloud in which words or phrases were displayed in a random position in a block of text, with the word’s size being proportional to its frequency of use, so more frequently used terms appear larger. Word clouds are a useful way to see the terms associated with a concept and their relative importance. For each organization, website content was reviewed to determine if the organization self-identified as being affiliated with One Health or EcoHealth or another MSC approach.

Country Level Research Priorities for Asian Countries

For the literature review, research priorities were defined as key statements in reviewed documents that indicated a need for urgent research to address a particular topic or question. We gathered data about research priorities for EIDs for Asian countries WHO Country Cooperation Strategies (CCS)- and International Health Regulation (IHR)-related documents publically available online as of 31 Dec. 2014. A CCS details a country’s health profile, the work done in the previous multi-year term of assistance, and the strategic agenda for the next term. We included the Strategic Agenda and future planning sections in the review. Countries for which CCS or IHR documents were not available, and those with a CCS that had not been updated after 2008 were excluded from analysis. Priorities for EIDs were recorded on a spreadsheet. Descriptive analysis of relative frequencies of priorities was performed by country.

We performed scoping reviews of peer-reviewed and grey literature published between 2008 and 2014 to amass a detailed list of research priorities for EIDs in Asia. We searched 13 databases (Table 1) using terms intended to capture research priorities for EIDs in Asia (Table 2). Documents were selected for full review if the title, executive summary or abstract indicated that an objective or outcome of the document was to prioritize research needs, either generally or with a specific focus (e.g. a specific class of diseases or specific country or region), to reduce emergence or impacts of infectious diseases. Documents were not restricted based on geography as long as they were broadly (i.e. globally focused) or expressly applicable to one or more Asian regions or

¹<http://www.wordle.net/>.

Table 1. Databases and Websites Searched to Identify Literature on Research and Development Priorities for Emerging Infectious Diseases in Asia.

FAO Corporate Document Repository	Food and Agriculture Organization of the United Nations (FAO) collection of publications and meeting documents
IDL-BNC	International Development Research Centre (IDRC) digital library. It includes research results and documents generated by IDRC-funded projects, IDRC funding recipients, and IDRC staff
IDRIS+	IDRC Development Research Information System is a comprehensive database of IDRC project information
WHOLIS	The World Health Organization (WHO) online digital library. It includes WHO documents as well as to other sources of scientific literature produced around the world
IRIS	WHO Institutional Repository for Information Sharing. The digital library of WHO published material and technical information in full text
Google and Google Scholar	
PubMed	
Other organizations websites	<ul style="list-style-type: none"> South East Asia Regional Organization (SEARO) of WHO US Centers for Disease Control World Bank Association of Southeast Asian Nations (ASEAN) United States Agency for International Development (USAID) Australian Agency for International Development (AusAid)

Table 2. Keywords Used in the Literature Review to Identify Research and Development Priorities for Emerging Infectious Diseases in Asia.

Search of Google and Google Scholar

('Emerging infectious disease' AND 'research priorities') AND ('global' OR 'Asia' OR 'Southeast Asia' OR 'Afghanistan' OR 'Armenia' OR 'Azerbaijan' OR 'Bahrain' OR 'Bangladesh' OR 'Bhutan' OR 'Brunei' OR 'Myanmar' OR 'Cambodia' OR 'China' OR 'Cyprus' OR 'East Timor' OR 'Georgia' OR 'India' OR 'Indonesia' OR 'Iran' OR 'Iraq' OR 'Israel' OR 'Japan' or 'Jordan' OR 'Kazakhstan' OR 'Kuwait' OR 'Kyrgyzstan' OR 'Laos' OR 'Lebanon' OR 'Malaysia' OR 'Maldives' OR 'Mongolia' OR 'Nepal' OR 'North Korea' OR 'Oman' OR 'Pakistan' OR 'Palestine' OR 'Philippines' OR 'Qatar' OR 'Russia' OR 'Saudi Arabia' OR 'Singapore' OR 'Sri Lanka' OR 'South Korea' OR 'Syria' OR 'Taiwan' OR 'Tajikistan' OR 'Thailand' OR 'Turkey' OR 'Turkmenistan' OR 'United Arab Emirates' OR 'Uzbekistan' OR 'Vietnam' OR 'Yemen') OR ('WHO' OR 'FAO' OR 'EU' OR 'CDC' OR 'IDRC') OR ('ecosystem health' OR 'One Health')

('Research priorities') AND ('infectious diseases of poverty' OR 'neglected diseases of poverty' 'zoonoses' OR 'marginalized diseases' OR 'influenza' OR 'vector-borne' OR 'human pandemic influenza' OR 'avian influenza' OR 'malaria' or 'lymphatic filariasis' OR 'dengue' OR 'chikungunya' OR 'Angiostrongyliasis' OR Arbovirus' OR 'plague' OR 'leptospirosis' OR 'Japanese encephalitis' OR 'cestode' OR 'gender')

Search of PubMed, FAO Corporate Document Repository, IDL-BNC, IDRIS + , WHOLIS, IRIS, South East Asia Regional Organization (SEARO) office for WHO, Center for Disease Control (CDC), World Bank (WB), Association of Southeast Asian Nations (ASEAN), United States Agency for International Development (USAID), Australian Agency for International Development (AusAid)
'poverty' or 'zoon*' or 'emerg*' and 'infect*' and 'Asia'

countries. Inclusion was not restricted on the basis of the methods documents used to establish priorities. Inclusion was restricted to documents published in English. During full review of each included document, we cut and pasted all stated research priorities from the publication into a word processing document. Literature cited in each included document was also included in the review process. We performed a qualitative content analysis using the priorities to generate list of themes. Priorities were then coded under each relevant theme; therefore, a priority might be coded under two or more themes. We performed a simple quantitative content analysis (Bernard and Ryan 2010) to tally the number of priorities included in each theme.

Case Series

We reviewed a case series of research projects that explicitly intended to apply a MSC approach to an EID problem in Asia. The purpose was to determine how MSC was used in practice and to determine if these cases shared the priorities identified in the literature review. We asked four expert collaborators based in Asia to propose candidate projects, which could be located in any region of Asia, and could be of any scale (local, regional, national). All collaborators held academic, donor or government posts, were familiar with MSC methods and were part of EID MSC research networks in their region. Project documentation was obtained from any available source including local contacts,

funding agencies, online grey-literature materials, and peer-reviewed publications in any language. Local research associates used an online survey tool (Fluid Surveys²) to record anonymized information about each project using a structured questionnaire. A combination of descriptive and thematic analysis was used to analyse the case series and explore similarities and differences between projects.

RESULTS

Characterizing MSC Research

Figure 1 highlights the terms most consistently used by organizations engaged in MSC research to address emerging, zoonotic or neglected infectious diseases; namely human animal environment interface, research, collaboration, and scale (i.e. local, national, international). Table 3 provides a typology of different approaches used for MSC research and EIDs based on how organizations self-described their work. When One Health and EcoHealth were examined separately, One Health focused mostly on public health outcomes of integrated disease prevention and surveillance, food safety, and food security. Collaborations and communications sought by most One Health involved health disciplines almost exclusively, with a major emphasis

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Figure 1. Keywords and phrases associated with multisectoral, socio-economic, systems-based, collaborative research to address emerging, zoonotic or neglected infectious disease challenges.

on veterinarians and biomedical researchers. Concepts of threat detection, response and prevention using public health tools were common. EcoHealth focused on cooperation amongst a broader group of collaborators, including non-health professionals, communities and policy-makers. EcoHealth also placed greater emphasis on social dimensions of problems. Participatory and transdisciplinary approaches, equity, social justice, gender, systems approaches, resilience, and sustainability were highlighted.

Research Priorities

WHO Country Cooperation Strategy (CCS)

WHO Country Cooperation Strategies (CCS) were available for 31/48 Asian countries, including the 12 with the lowest human-development index. CCS priorities were largely operational and emphasized political, funding, and capacity-strengthening priorities needed to meet IHR regulations. Research was a stated priority in only one CCS. Evaluation, forecasting, and community participation were other priorities that could include a research component (Fig. 2). Twenty-seven CCS documents included statements about EIDs.

Peer-Reviewed Literature

The majority of the 6000 titles returned by our search of the peer-reviewed literature described results of epidemiological studies or laboratory research on individual emerging pathogens. Only 11 included priorities, or discussion around priorities, for reduction in EID events and impacts. The 5 publications that included research priorities are summarized in Table 4, while the remaining 6 publications focused primarily on operational priorities, rather than research. All 5 publications that included research priorities focused on Southeast and South Asia. Research into EID pathogen-host-environment systems was the only priority

common to the 5 publications while 4 called for research to improve tools for diagnosis of various emerging pathogens in people and animals.

Grey Literature Review

The grey literature searches returned 33 relevant documents. Thirty of the included documents were policy documents, with 10 of these emerging from regional meetings or standing committees, while three included documents were technical guidelines. Fifteen of the 33 documents discussed EIDs generally and were not focused on specific diseases or disease classes. Of these 15, 10 examined EIDs in a global or whole world setting, and contained 55 research priorities in total. The remaining 5 examined EIDs in Asia specifically, and contained an additional 33 priorities—all 5 focused on Southeast, South or East Asia. Eighteen of the 33 documents listed priorities for specific EIDs or EID classes including influenza, helminthes, vector-borne disease (e.g. Japanese encephalitis, Chikungunya, malaria). Nine of these focused specifically on Southeast, South, Eastern Asia, while the rest included all of Asia. None focused specifically on Central or Western Asia. Additionally, Nepal, China, Cambodia, India, and Pakistan had on-line country-specific documents (additional to the IHR and CCS) listing EID research priorities.

Four themes emerged from the grey literature review; (1) understanding host-pathogen-environment interactions; (2) improving tools and technologies; (3) changing people’s behaviour; and (4) evaluation. Understanding host-pathogen-environment interactions was the most often encountered research theme. Priorities ($n = 38$) categorized under this theme included research to understand systems, transmission dynamics, and disease emergence. The majority called for examining influences on and interactions of host-pathogen-environment systems in ‘real-world’ settings (Lambrechts et al. 2009; WHO 2013). Additional areas of research included examination of how and why host-switching occurs (FAO 2008), and systems of microbiological persistence in host-environment systems (FAO 2008). Research questions focused on the environment dealt largely with environmental drivers of changes to host-pathogen interactions and host resilience, particularly how changing environments might alter these factors (Keusch et al. 2009).

For people as hosts, research priorities focused on understanding human vulnerability, for example, understanding how climate change might impact at-risk popu-

Table 3. Candidate Differentiating Features in a Typology of Multisectoral, Socio-economic, Systems-Based, Collaborative (MSC) Research.

Dimension	Types	Comments
Problem	Focus on 1 problem	Other factors seen as causal variables influencing the outcome/problem of interest
	Focus on multiple problems	Explicit attempt to simultaneously explore interactions or interdependence of different problems on the health status of the same population
Disciplines	Single or same lineage	Teams of either the same discipline or sub-disciplines under the same epistemological origins work on the problem
	Multiple but isolated	A team of disciplines are working on the same problem, may share infrastructure, capacity and educational resources but tend work in isolation on separate parts of the problem. Integrations, if it occurs, occurs after the investigations are complete
Goal	Multiple and integrated	As above but 2 or more disciplines work on the same part of a problem from conception through investigation to conclusions and/or there is an explicit attempt to integrate perspectives, methods and results of inquiry from multiple diseases during the research process. In this context, the term 'discipline' should be interpreted broadly and might include policy makers, managers, community members or other stakeholders
	Description	Focused on documenting the relationships between components of the system or bearing witness to impacts of events on specific populations
Goal	Discovery	Seeking to uncover new understanding of causal mechanisms or relationships between variables
	Solution	Dedicated to finding either immediate ways to improve a health status or sustaining improvements in health

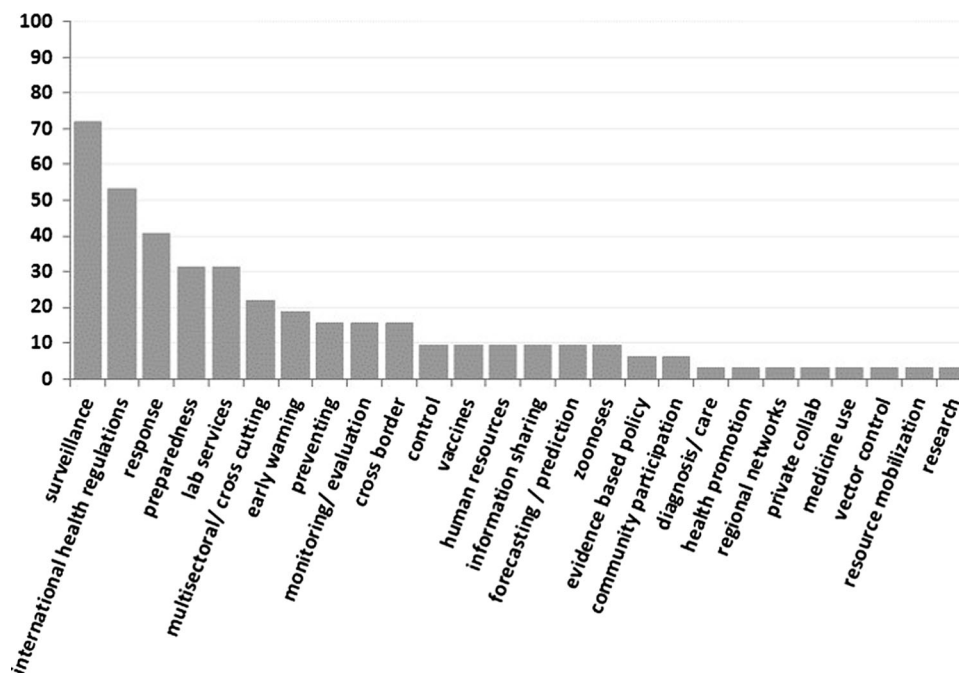


Figure 2. Frequency with which emerging infectious disease-related priorities were listed in World Health Organization Country Cooperation Strategies for Asian nations.

lations or how social and demographic trends might impact contact between people, animals, and vectors (CDC 2011). For animals as hosts, research priorities focused on the animal as a disease carrier (i.e. as a risk to people) and called for the isolation and molecular characterization of pathogens carried by animals and research into understanding factors that provoke shedding of pathogens from carrier animals (FAO 2008). This included documenting the microbiome of wildlife species and monitoring wildlife trade in order to prepare for or prevent disease events in people (WHO 2009). Pathogen-focused priorities recommended laboratory-based research to document pathogen characteristics, particularly genotypes.

Improving tools and technologies was the theme with the second largest number of priorities ($n = 15$). Priorities focused on improving tools for EID detection, and to a lesser extent on prevention and treatment technologies. Disease detection priorities focused mainly on improving the ability to detect disease events early and inexpensively, particularly in remote areas. The need to develop rapid, pen-side or point-of-care diagnostic tests was commonly mentioned in this category of research needs (FAO 2008; Jeggo 2011).

Improving vaccines was a major focus of priorities related to EID prevention (Jeggo 2011). For vector-borne diseases, improving technology to monitor and reduce in-

sect numbers and prevent insect bites was prioritized. For helminth diseases, prevention of health impacts through developing improved anthelmintics and improved use of existing medications was prioritized. There was very limited discussion in global and regional documents about treating EIDS, but treatment research, including developing and comparing treatment regimens, was prioritized frequently in documents that focused on specific diseases such as malaria, influenza, and helminthiasis. Communication technology for event detection and developing new animal identification tools were additional technological priorities (Laegrid 2008).

The third theme of research priorities was changing people's behaviour ($n = 15$). Most commonly, priorities grouped under this theme ($n = 9$) focused on changing researcher behaviour to increase collaboration and integration of human and veterinary-public health systems and to increase knowledge-to-action activities (WHO 2013). Another group of behaviour change ($n = 6$) focused on populations at risk, such as learning 'how communities understand zoonoses epidemiology, prevention, and treatment in order to foster local participation in disease reporting and surveillance activities' (Keusch et al. 2009) and understanding 'the social, cultural and community behavioral practices leading to disease transmission including studies on knowledge, attitude and practices

Table 4. Summary of 5 Peer-Reviewed Papers Listing Emerging Infectious Disease Research Priorities for Asia.

Emerging infectious diseases in Southeast Asia: regional challenges to control (Coker et al. 2011)
Emerging infectious diseases in ASEAN countries
Reviewed peer-reviewed English language literature through PubMed and grey literature published between 2000 and 2011 focused on factors leading to the emergence of infectious diseases in ASEAN countries, surveillance capacity, and governance of control systems
Priorities
Understand factors associated with risk of emerging infectious diseases
Strengthen predictive analyses, including develop robust datasets on factors associated with infectious diseases emergence
Analyse operational prevention, containment, and mitigation capacity to inform investment linked to global, regional, and domestic public health and economic priorities
Emerging and re-emerging arboviral diseases in Southeast Asia (Dash et al. 2013)
Arboviruses in Southeast Asia
Informal literature review
Priorities
Understand environmental factors that facilitate disease emergence
Study the evolution of pathogenic infectious agents resulting in changes in infectivity, virulence, transmissibility
Develop tools for diagnosis, management, control, and prophylaxis
Develop of research-based evidence to influence public policy
Escalating the global fight against neglected tropical diseases through interventions in the Asia Pacific region (Hotez and Ehrenberg 2010)
Neglected tropical disease in the Asia Pacific Region
Methods not described
Priorities
Operational research to circumvent the biological and social barriers to disease control in areas of low coverage
Monitoring efforts to examine the sustainability of disease control
New control tools including improved diagnostics and vaccines to prevent infection
Estimate disease prevalence and burden to support advocacy and informed policy decisions
Coordinating research on neglected parasitic diseases in Southeast Asia through networking (Olveda et al. 2010)
Neglected parasitic diseases in Southeast Asia
Expert-opinion
Priorities
Research the impact of social determinants and economic issues on the epidemiology of helminth zoonotic infections
Document, develop, and apply health metrics in practice
Promote GIS/RS techniques for the study of the impact of climate change on the target diseases and other applications
Improve and standardize diagnostic capabilities, including development of new products and techniques
Encourage the study of genetics and the immune responses against parasites to better understand the pathology caused and ultimately to apply the new knowledge to the development of new drugs and vaccines
Research options for controlling zoonotic disease in India, 2010-2015 (Sekar et al. 2011)
Zoonoses in India
Adapted and applied priority setting methods developed by the Child Health and Nutrition Research Initiative. A multidisciplinary group of 17 experts identified priority diseases, knowledge gaps for the next 5 years
Priorities
Measure morbidity, mortality, and economic burden of disease in humans and animals
Determine the spatial, temporal, and directional interactions of transmission between wildlife, humans, and domestic animals
Develop field diagnostics for zoonotic diseases
Perform cost-benefit, cost-effectiveness, and affordability analyses of zoonoses interventions

(KAP) in relation to different stakeholders such as the general population, decision-makers, health-care providers' (Majra and Acharya 2011).

Evaluation was the fourth theme encountered in the literature. Priorities ($n = 9$) grouped under this theme included evaluation of various components of EID preven-

tion and control programs. In some cases, documents prioritized evaluation of complete systems (Keusch et al. 2009), however, most focused exclusively on evaluation of surveillance components (Jeggo 2011; Keusch et al. 2009). Less commonly, documents prioritized evaluating some other components, such as evaluating tools to assess their ability to rapidly monitor knowledge, attitudes, beliefs and practices in different population groups to guide communication efforts (FAO 2008).

Our expert collaborators from Asia validated literature review results regarding priorities for EIDs in Asia; however, they cautioned that there is often a disconnect between stated priorities in policy documents produced for an international audience and the true needs and priorities of people on the ground in Asia.

Case Series

Eight research projects that used MSC methods for meeting challenges posed by EIDs in Asia were identified. Five were completed and three were in the late stages of operation. Four took place entirely in one specific country and/or state, while four were multi-country projects. Case studies included projects in a total of 10 countries in South, East and Southeast Asia. No case studies were available that included projects in Western or Central Asia. Studies addressed between one and eight specific research questions. Five of the research projects involved multiple sub-projects. One involved a first and second sub-project in a single location while the others involved multiple simultaneous sub-projects in different places.

All projects were attempting to address an EID problem in one or more specific locations rather than answer research questions that would remain the same regardless of where the research was performed. Research questions ($n = 24$) could be grouped into 5 themes. All cases wanted to understand how 'best' to implement control measures for a specific disease in a specific place-based system or to compare 'best' approaches in multiple locations. In this context, 'best' included themes such as most likely to be implemented by stakeholders, most likely to halt disease transmission and having least negative impacts on people and/or environments. Six research questions focused on understanding the ecology of a specific disease/pathogen in one or more research locations, including the social and environmental characteristics of a specific location that influenced the pathogen transmission risks and cycles. Five questions focused on understanding the prevalence of a disease in the research

location in either vectors, or human or animal hosts. The fourth type of research question ($n = 3$) examined how to use research outputs to motivate stakeholders, ranging from household members, through to bureaucrats and politicians, to make decisions that could reduce disease risk. The final type of research question ($n = 2$) examined how to improve capacity for collaboration to implement disease control activities. Knowledge sharing was a stated goal of all eight projects and the available documentation generally provided detailed plans for knowledge sharing amongst stakeholders.

All projects combined qualitative methods such as focus groups and participatory appraisals with quantitative methods such as surveys and laboratory-based analysis. In general, researchers used social science methods to understand which interventions were most likely to be acceptable to stakeholders, to examine how to use research outputs to motivate stakeholders to make decisions that could reduce disease risk intervention planning and to determine how to improve capacity for collaboration to implement disease control activities. They used surveys to document social and environmental conditions both before and after project interventions and measure changes in disease prevalence or in impacts of disease on participants. Laboratory-based and quantitative epidemiological analyses were used to measure disease prevalence and document effectiveness of disease control interventions in controlled environment and real-world environments, respectively.

In seven of the eight cases, researchers described one or more systems and used these descriptions to structure research, knowledge sharing or other project activities. To describe systems, researchers most often gathered pre-existing knowledge of stakeholders at the start of the project (e.g. through workshops or meetings, pathway analysis, influence diagram, informal discussions) ($n = 7$) as well as pre-existing researcher knowledge ($n = 3$). They also used stakeholder knowledge and new data gathered as part of the project ($n = 6$) to describe systems part way through or at the end of project to document changes to systems.

DISCUSSION

Our review of the literature generated 4 broad priorities for EID research in Asia. The first was understanding host-pathogen-environment interactions and drivers that change these interactions or cause pathogen emergence. Our case series suggested that disciplinary-focused research, such as determining genetic characteristics of pathogens, docu-

menting animal microbiomes and developing new diagnostic tests, were necessary parts of understanding host–pathogen–environment interactions, but were of themselves insufficient to understand what drives EID’s emergence in a socio-ecological system or how to alter a system to reduce the impacts of EIDs. There are previous examples of socio-ecological approaches to understanding disease ecology (Wilcox and Gubler 2005) but there remains significant challenges of bridging different disciplines and perspectives in applying a social–ecological framework to analyse EIDs (Lewis 2005). Some of these challenges are linked to collaboration, while others are concerned with how to integrate, weigh and assess interactions of different types of data to develop a holistic view of a socio-ecological system. MSC methods have been proposed and used to examine EID systems, and specific descriptions of how MSC approaches can be applied to understanding host–pathogen–environment systems are available (Charron 2012).

The second priority was improving tools and technologies, particularly at the country level in low and middle income countries. Calls for improved disease detection and reporting technologies have been present since strategies against EIDs first entered the health discussion, including in landmark Institute of Medicine report entitled *Emerging Infections: Microbial Threats to Health in the United State* (Lederberg et al. 1992). The 2012 IHRs strengthened expectations that countries be able to inform the global community in a timely fashion when new diseases emerge (Bond and Nolan 2011). To date, most priorities for disease detection have focused on new diagnostic methods (including recent investment in genomic techniques) (FAO 2008; Jeggo 2011). Innovation in information management and use of internet tools have been prioritized to a lesser degree (WHO 2012). Few publications have focused on the human dimensions of surveillance including motivators for participation and reporting and how outputs affect decision making (Sawford et al. 2012); however, our case series review demonstrated that MSC methods are being selected as a methodology to research and influence the human dimensions required for disease surveillance. Since the success of disease detection and reporting systems is equally dependant on technology and human actions MSC methods should be further evaluated as an approach to researching how these factors interact in places challenged by EID problems.

The third priority was effectively influencing behaviour change. Within behaviour change, there were two areas of discussion. The first was to better understand how research

evidence can motivate at-risk people to change their behaviour so as to reduce vulnerability and susceptibility to EIDs and enhance resilience. Very little research has been published in the peer-reviewed literature about what affects behavioural responses to infectious disease outbreaks (Brug et al. 2009). For EIDs in Asia specifically, peer-reviewed evidence into how to translate research into strategies and actions to reduce negative impacts are lacking. Such evidence is vital because, for EIDs, we either expect people to act in a precautionary way to reduce their vulnerability in advance of large scale effects or we wish people to act in a health promoting way to bolster resilience to a future, yet unknown emergence. There is evidence from health promotion that suggests that approaches similar to those employed by MSC researchers are appropriate to support changes in health behaviours (McLeroy et al. 1988). Our case series demonstrates that MSC research is being used in the field to influence behaviour change in at risk populations. Because MSC research engages stakeholder and is place-specific, it could provide a good approach to influence and document behaviour change in the field; however, more peer-reviewed evidence is required.

The second component within influencing behaviour change was understanding how to increase collaboration across research disciplines, and between researchers, governments, and communities. Little peer-reviewed research has been published on how to build and sustain effective interdisciplinary research teams for EIDs and zoonoses (Anholt and Stephen 2012), and there remains gaps in knowledge of how to evaluate the success of collaboration in reducing EIDs (Munoz-Erickson et al. 2007). Some work on MSC research provides frameworks for interdisciplinary collaboration amongst researchers as well as collaboration with stakeholders and decision-makers (Charron 2012). MSC research also stresses ongoing evaluation and analysis of success and failure in collaborations, which force researchers to consider the creation and sustaining collaborations as an actual research outcome.

The final priority from the literature review was evaluation. There is an existing body of research that describes evaluation methodology for surveillance systems (Buehler et al. 2004; WHO 2006), although there are few publications documenting EID surveillance system evaluations (Vrbova et al. 2010). Currently, there is a large gap in knowledge on how to best evaluate EID systems behaviour or management. Attempting to evaluate research quality by focusing on its real-world impacts and outcomes remains highly challenging. The aim of health research is to improve

health, yet research impacts have traditionally been measured through evaluating scientific quality and researcher outputs, rather than its effects in at-risk or affected systems (Lavis et al. 2003; Smith 2001). The prevailing emphasis on research quality rather than social impact has been called a serious imbalance (Smith 2001). We suggest that MSC methods might have a roll in evaluating complex projects where there is a challenge of assigning proportional causal attribution to the research when there are multiple determinants affecting the outcome (Charron 2012; Hall et al. 2006).

For our case review, no country from Central and Western Asia was represented in cases that were available for analysis. Similarly, none of the 5 peer-reviewed or 33 grey-literature documents returned by our literature search focused on Central or Western Asia. This bias likely reflects a funding and capacity-building focus on China and South and South East Asia, in part due to disease emergence from these regions. In addition, since our cases were selected by local experts, it may reflect structures of researcher networks, so that expert collaborators tasked with selecting cases for our review were more likely to have awareness of projects in China, South and Southeast Asia than in Central and Western Asia. Further work may be necessary to explicitly evaluate and access expert networks in Eastern and Central Asia, and to evaluate how MSC methods are being used in those regions.

From our case series review, we found that the major unifying characteristics of MSC research ‘in the field’ were that it was action-oriented and sought to inspire change under real-world conditions at the complex interface of human and natural systems. The action-oriented and real-world emphasis lead us to suggest that MSC research could be considered a specific example of the broader field of pragmatic health research (Glasgow and Riley 2013). The circumstances and conditions suited to pragmatic research might, therefore, be a guide to help identify appropriate circumstances for MSC research. The circumstances for pragmatic research are as follows; (1) the goal of the research is to accelerate the integration of research, with policy, and practice; (2) the questions, perspectives taken, and outcomes studied are those that are important to stakeholders; (3) the research is conducted in multiple, heterogeneous settings i.e. in ‘the real-world’; (4) characteristics of participants and settings for research resemble those seen in the context where results are to be applied; (5) comparison conditions are real-world alternatives and; (6) there is a focus on using interventions in the midst of the

usual conditions rather than in an ideal setting or population to document or nominate effective interventions in ‘real world’ settings rather discover mechanisms of causation (Glasgow and Riley 2013). We suggest using the criteria listed above to make preliminary assessment of whether what MSC research might have utility in addressing any given EID priority.

EID priorities that we documented tended to focus on a single part of a system and did not explicitly emphasize the ‘science of the whole’. However, EIDs have been described as ‘evolution in the context of accelerating environmental and human behavioural alterations that provide new ecological niches into which evolving microbes can readily fit’ (Morens et al. 2004). Therefore, we suggest that system-based research that embraces the complexity of the origins and control of EIDs, such as MSC research, will be necessary to avoid being surprised by future emergence events (Stephen et al. 2014). The growing interest and investment in MSC research reflects that the priority donors are placing of socio-ecological thinking and argues for continued exploration of the best ways to use MSC research to address the threat of EIDs.

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