

Comprehensive Pandemic Risk Management: A Systems Approach

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“The consequences of catastrophic events... are more and more determined by the interconnectivity of our world and thus by the interdependency of its natural, social, and artificial systems.”

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“Gentlemen, it is the microbes who will have the last word”

Louis Pasteur

Abstract

The world is generally not prepared for a severe pandemic, whether of natural or engineered sources, risking potentially catastrophic impacts on global health, and other systemically interdependent sectors critical to human and civilisational security. Current efforts to improve pandemic preparedness are mostly focused on the strengthening the indigenous capacity and financing of national public health systems through compliance with the standards of the International Health Regulations, as part of an international emergency framework oriented to prevent outbreaks with infectious disease from becoming international health crises. While such efforts are absolutely necessary, they are centered primarily on the health sector to mitigate public health emergencies and are not sufficient to systematically manage the multisectoral, multidimensional risks and impacts of inevitable novel severe pandemics. A new cost-effective systems-based paradigm is needed to manage a “spectrum” of pandemic risk to both national and global security.

This paper identifies the key features of a full-risk-spectrum Comprehensive Pandemic Risk Management System (CPRMS), to prevent, prepare for, respond to, and mitigate the multisectoral impacts of severe pandemics. Presented, is an illustrative “roadmap,” with next steps for the early development of the CPRMS. An Annex considers the management of pandemic risks of human origin.

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Foreword

In the wake of the 2014-15 Ebola crisis, international strategic dialogue and related initiatives on preparedness and response to infectious disease with pandemic potential have generally focused on the development and financing of national health system capacities as part of an international emergency framework to prevent outbreaks with infectious disease from becoming international health crises.

The more recent outbreaks of Ebola in the Democratic Republic of the Congo, that started in 2017, extending well into 2019, demonstrate the special challenges of managing epidemics in countries whose health and security systems are weak, struggling in context of a society beset with violent conflict, insurgency, and mistrust of central authority and its institutions.

Severe pandemics with widespread multisectoral impacts represent a critical threat to human security, and to the increasingly interdependent globalized socio-economy on which it depends. Needed, is a cost-effective, integrated global system for prevention, reduction, and management of risks from pandemics as well as from other hazards with catastrophic global impacts.

Overview: Highlights, Conclusion, Next Steps

This concept paper locates global health security within the broader UN-endorsed strategic framework of global “human security.” Accordingly, it argues that an “emergency-centered” strategy on pandemic preparedness and response, primarily focused on the health sector, while necessary, is not sufficient to prevent and manage multiple risks to global health and human security. Instead, this paper proposes a multisectoral, systems approach for a comprehensive, integrated “full-spectrum” risk-management system to prevent and mitigate complex socio-economic risks and impacts of severe pandemics.

Part I describes the profound, growing threat to human security posed by potentially severe pandemics, whether of natural or engineered origins. The threat is embedded in a process of a generalized systemic transformation of risks (some with existential, catastrophic potential), owing to multiple drivers that collectively tend to increase risk vulnerability and reduce societal resilience. The drivers underlying this process include a growing global population, large scale animal husbandry, intensive transportation networks, advances in biotechnology, increasing contact among animal and human habitats, as well as the alarmingly accelerating stressors, notably including climate change, resource depletion, environmental degradation, limits on growth, and financial crises. These factors contribute to the fundamental strategic deficiency of the current international approach to pandemic preparedness, which is still primarily committed to improve the emergency response capacity in the human and animal health sectors. Instead, this section introduces the generic characteristics and principles of the CPRMS as a new pandemic risk management paradigm. The conceptual grounding of the approach includes but transcends the currently dominant framework of global health security, in favor of the more useful and multidimensional concept of human security. In this perspective, the systems management approach encompasses a full-spectrum of risks including those relevant to priority microbes, the animal-human dynamics of transmission and spread, as well as those impacting the flow of essential services and infrastructure in the networked global socio-economy. Critical to the CPRMS would be a strategic coherence; a systematic, preventive risk-management policy agenda; harmonized leadership; governance, and organization; and sustainable financing.

Part II of this paper reflects on the practical constraints and feasibility of the CPRMS, explores its fundamental institutional structural elements, and illustratively elaborates on its global, regional, and

national dimensions. Presented, is a “Roadmap,” a prospective illustration of potential system formation; and specific, “Next Steps” that may inform international strategic and policy deliberation to chart the path to the development and establishment of the CPRMS at global, national, and regional levels.

The *Annex* to this paper discusses the risks and risk management of pandemics as threats to national and global security, caused by human activity – either from state-sponsored, weaponized biological agents or from non-state bioterrorism. A brief review and critique of selective, current global and national initiatives to manage these risks is presented, along with a discussion of key considerations for the way forward, as part of the integrated systems approach to pandemic risk management advocated by this paper.

Highlights:

Part I

- Severe pandemics, either natural or man-made, are predictable, perpetual threats; and are among the most disruptive, catastrophic shocks impacting global human, socioeconomic, and civilisational security. Annual global economic losses anticipated in future decades have been variously estimated, using different assumptions. According to one estimate, they may average at about \$570 billion. Hardest hit, will be developing countries in which years of investments will have been wasted, as was recently illustrated in the West Africa Ebola crisis of 2014-2015, and the ongoing (as of August 2019) 2-year outbreak of Ebola in the Democratic Republic of Congo.
- Evidence suggests that the complex, tightly interconnected world economy can rapidly and widely propagate shocks, contributing to a transformation of globalized risk that increases societal vulnerability and diminishes resilience. This is exacerbated by the persistent growth of multiple demographic, economic, environmental, and political stressors.
- The prevailing international strategy for pandemic preparedness and response emphasising national and international public health capacity to prevent local outbreaks from becoming international emergencies, while necessary, is not sufficient. It is primarily reactive, which means it cannot be either cost-effective, allocatively efficient, or sustainable for purposes of preventing and managing the pervasive multisectoral impacts of severe pandemics caused by novel, highly infectious and virulent microbes.
- A more comprehensive, proactive, and complex-systems-based global strategy for the management of high-consequence risks to human security, including those of severe pandemics, is necessary as an important global public good.
- Such a new, systems-paradigm strategy would help prevent and manage both the direct human security risks to health as well as to the necessary flow of essential services and critical infrastructure in the interconnected global socio-economy, on which health security depends.
- Accordingly, the architecture of a CPRMS would be founded on a risk-management framework that includes a spectrum of targeted risk nodes, starting with the genetic risk of emergence of microbes with pandemic potential, to the risk dynamics of animal-human transmission and spread, as well as to the risks to the functional continuity of essential services and critical infrastructure.
- The approach would emphasise primary prevention and risk reduction in key essential service and infrastructure sectors, including but transcending the One Health model, and its conventional moments for emergency preparedness, response, containment, and recovery. When viewed through a systems lens, the CPRMS would have the generic attributes of a hazard-independent risk management system.
- Key characteristics and principles underpinning the CPRMS include its being Risk-based, and evidence-based through application of the complex-systems disciplines. The approach

would also be committed to a long-term, multisectoral, beyond-One Health, Whole-of Society process, integrating prevention, preparedness and response in health, essential services, and critical infrastructure. It needs to be sustainable to remain effective in meeting 21st century challenges at both national, and international levels.

- Institutionally, a CPRMS would also be structured as a system whose structure and functions embody the six critical elements of all systems: leadership and governance; financing; information systems management; requisite human resources; essential commodities and related logistics; and a capacity for operational interventions and service delivery. Crucially, governance of the CPRMS must now be considered in the broader, increasingly urgent governance and management of a wider set of potentially catastrophic, existential risks.

Part II

- Human societies and civilizations appear to have difficulty in mobilizing a collective will to avoid the catastrophic impacts of perceived, future low-probability, high-impact threats such as pandemics. While predisposing factors necessary for momentous achievements with global-scale impacts are amply demonstrated through human history, the prevention and mitigation of existential threats such as nuclear war, environmental collapse, climate catastrophe, or cataclysmic pandemics is far from guaranteed. Documented history also offers ample examples of civilisational collapse as consequence of failure to prevent and manage particular high-impact risks, and the overshoot of carrying capacity. However, there are also examples positive achievements of effectively organised social agency for the common good on a global scale. The CRPMS is theoretically feasible, but not guaranteed.
- The proposed Roadmap for the CPRMS assumes it to be complex system, both in conceptual scope, as well as in its institutionalised architecture – i.e. in structure, and function at global, regional, and national levels. In each of these geographic dimensions, the integrated CPRMS includes the six system attributes that engage to effect intentional change.
- The Roadmap for the Global CPRMS provides the overall vision, leadership and coordination of global policy and action. The overall global goal of the CPRMS would be to protect human and civilisational security from the direct and indirect risks of pandemics to human welfare. At this level, the principal focus should be the effective management risks to global health and to the flows of essential global services and infrastructure, as a global public good.

Since no one existing institution has the capacity to exercise effective world-wide cooperative leadership, new models of global crisis governance involving key global public international, national, and non-government stakeholders will need to be considered. A proposed illustration of such an approach involves a specifically empowered UN system, with participation of a de-facto group of globally influential public international, national, and private sector stakeholders.

Discussion of innovative global system approaches to sustainable financing, information and human resource, commodity and operational service delivery to support the global CPRMS agenda is provided.

The steps ahead, in pursuit of the Global CPRMS would begin with a series of consensus-oriented multiple stakeholder consultations in order to initiate the exploration and development of a strategic framework, to include the important issue of governance and leadership and other key institutional systemic components (financing, human resources, etc.) of the global CPRMS. The steps ahead also advocate for the continuity of promising existing international pandemic

preparedness efforts and recommend a series of additional interim steps for the attention of international stakeholders.

- The National moment of the CPRMS constitutes the front line of the integrated system; and its effective functionality is fundamental to the integrity and effectiveness of the overall CPRMS. The goal of national systems would be to protect the human, socioeconomic, and governance security of countries from the direct and indirect risks of epidemics and pandemics. The purpose of institutionalised national systems would be to systematically plan, coordinate, and implement country-wide and local actions to prevent, reduce and manage pandemic risks along the pandemic risk spectrum.

Consistent with a multisectoral approach, the focus of a national CPRMS system governance network should be a multisectoral body with select public-private representation of key service sectors and critical infrastructure, led by a “beyond-health” minister as chief executive or special coordinator.

Suggested steps ahead include the formation of national sectoral working groups; the development of comprehensive multisectoral pandemic risk assessments as a basis for national pandemic risk management plans; and related provisions for sustainable financing.

- The goal of the Regional dimension of the CPRMS would be to protect global human and civilisational security from the direct and indirect risks of pandemics to human health and welfare among the countries of the region. The purpose at this level would be to systematically plan, coordinate, and implement regional actions to prevent, reduce and manage pandemic risk and mitigate direct and indirect pandemic impacts along the pandemic risk spectrum among the countries of the region, in concert with global efforts and their lead organizations. Examples of existing regional cooperation organisations such as the North American Plan for Avian and Pandemic Influenza (NAPAPI) are provided to illustrate the model potential of regional CPRMS institutions.

Suggested Regional steps ahead include those oriented to the generation of consensus on the regional CPRMS framework among key regional public and private stakeholders; the organisation and establishment of regional systems within each region, each with its own multisectoral, public-private governance and leadership structure; and steps to generate comprehensive regional pandemic risk assessments, regional strategies, implementation plans, and cooperative alliances and agreements on sustainable financing of regional efforts.

Annex -- The Threat of Human-caused Pandemics

- Pandemics can be potentially caused by both natural causes as well as through accidental or deliberate human activity. This may be the outcome of careless laboratory practices involving stored pathogens, like the smallpox virus; the misuse of “dual-purpose research”; or the deliberate manufacture and spread of natural or genetically modified microbes through state-sponsored biological warfare, or bioterrorism. Regardless of cause, the numerous impacts of severe pandemics on nations and the global human ecology may, potentially, be equally catastrophic.
- Existing attempts to establish effective models of governance for the risk- management of man-made pandemics at global and national level remain inadequate and centered on individual state priorities – a reflection of a seemingly inherent conflict of interest between the global public good and national security. Nationalism and its corresponding political expression obscure the reflexive relationship between national security global security.

Lacking, is a rigorous international strategic consensus on the global public good, backed by a coordinated institutional strategy, and commitment of financial, human, and operational resources at global, regional, and national levels.

- The management of pandemic risks due to human agency is envisioned as being entirely consistent with the defined characteristics of both, the multisectoral CPRMS model as well as with the six institutional system building blocks described in Section I of this paper. Importantly, prevention, risk-reduction, preparedness and response will need to extend to a range of disciplines and sectors, specifically to include national and international intelligence, security, public safety, law enforcement, biomedical and genetic research, defense organisations, as well as non-governmental organisations, and the general public.
- The most fundamental challenges to an effective integrated system for management of state, and non-state-sponsored pandemic threats will certainly include the paramount role of CPRMS systemic *leadership and governance*. Other key challenges certainly include sustainable financing, and *sensitive information sharing* in a world in which states and non-state actors are in a chronic, even growing conflicts of interest among national, ethnic, priorities on the one hand, and the global public good on the other.
- The way ahead for the governance dimension of the CPRMS will not depend on a planetary “world government” but rather on a broad, multisectoral cooperative and collaborative, UN-based global governance network discussed in this paper. Strategic planning developed through a collaborative, global catastrophic risk management framework consensus would be informed by high-level risk assessments, jointly developed strategic process, and adequately resourced contingency plans.

Conclusion and Recommendations; Next Steps

An effective CPRMS is achievable through a paradigmatic shift emphasising systems thinking and the development of inclusive governance and leadership frameworks as part of integrated risk management at global, regional and national levels. The roughly illustrated approach to a new CPRMS model presented in this paper requires an inclusive international and in-depth exploratory process to generate international stakeholder consensus on the broad goals and objectives of an international governance framework, and on its effective, and sustainable practical engagement.

Proposed, is a “Next Steps” agenda, illustrating a multisectoral, multidisciplinary and research-based approach to inform a process of high-level global, regional and country stakeholder consultations. The objective would be an in-depth exploration and development of the CPRMS and its six system components. A priority on this exploratory agenda would be consensus on governance/leadership, and financing of the CPRMS.

Part I: Comprehensive Pandemic Risk Reduction System (CPRMS)

Introduction – Pandemics: Chronic Threats to Human Security

As highlighted below, a number of leading national and international strategic planning, financing, and industry institutions have concluded that severe pandemics, either as natural or man-made biological threats, are among the most disruptive shocks to global health and therefore to the socioeconomic security of globalised society.

The U.S. Strategy on Pandemic Influenza treats pandemic preparedness as a national security issue, suggesting that “Transmissibility, susceptibility and mobility of populations to novel viruses mean that the whole world and all societies will be affected. This has ramifications not only for the health and wellbeing of populations, but for the national and economic security of nations and the functioning of society.”¹ The importance of the global management of risks of serious infectious disease was echoed by the U.S. President’s pronouncement on the Ebola epidemic in West Africa, whereby the crisis was viewed as a “top national security priority for the United States.” According to a White House brief, “The Ebola epidemic reminds us that our global efforts to build the capacity to prevent, detect, and rapidly respond to infectious disease threats like Ebola have never been more vital.”² The current U.S. Government Health Security Strategy (May 2019) reinforces the US commitment to promote global health security to detect and mitigate outbreaks as a key element of the U.S. national security strategy. Three interrelated goals underpin the strategy: “1) strengthened partner country global health capacities; 2) increased international support for global health security; and 3) a homeland prepared and resilient against global health threats.”³

The UK National Security Council and the Cabinet Office considered an influenza pandemic and a bioterrorism attack as a highest, tier one (of three tiers) priority risk for UK national security, considering both likelihood and impact of such an event. The U.S. National Intelligence Council’s “Global Trends 2030: Alternative Worlds” lists pandemic threats at the top of eight “black swan” events that would cause the greatest disruptive impact on society. The report asserts that “An easily transmissible novel respiratory pathogen that kills or incapacitates more than one per cent of its victims is among the most disruptive events possible. Such an outbreak could result in millions of people suffering and dying in every corner of the world in less than six months.”⁴

The private corporate world also recognizes the critical, pervasive threat of severe pandemics. A 2013 Towers Watson international survey of 30 thousand insurance industry experts, lists pandemics at the top of the list of “extreme risks” that were of paramount long-term importance to the insurance industry.⁵

A Possible Existential Threat to Civilisation

The Global Challenges Foundation includes pandemics among key threats to a *collapse* of human civilisation, defined as a “drastic decrease in human population size and political, economic/ social complexity, globally and for an extended time.”⁶

Thus, in today’s globalised, interdependent economy, a severe pandemic on the order of the 1918 influenza pandemic would be a high-consequence, trans-boundary global catastrophic shock and a threat to both public health and socioeconomic, if not civilisational stability. Recurrence of severe pandemics is certain, with a statistically significant probability of occurrence within a 30-year planning horizon. According to a recent estimate by the Bill and Melinda Gates Foundation, if a similar outbreak were to happen today, “the death toll could reach 360 million, despite the availability of vaccines as well as modern antiviral and antibacterial drugs.”⁷

A World Bank analysis suggests that a severe influenza pandemic hypothetically occurring in the world of 2013 but patterned on the infectiousness virulence and GDP impact of the 1918 pandemic, could have an economic cost equivalent to approximately \$4.2 trillion.⁸ Assuming a 1% probability of occurrence of such once-a century pandemics, the annualized costs of such a pandemic amount to \$42 billion per year.⁹ A more recent study by L. Summers, V. Fan, and D. Jamison in a 2016

National Bureau of Economic Research working paper, concludes that a pandemic on the order of the 1918 Spanish Flu may carry an “inclusive” cost (cost of mortality, plus income lost) of US \$570 billion per year.¹⁰

The true costs of a severe pandemic are difficult to estimate, given that methodologies differ, and comprehensive analyses that consider the broad knock-on systemic social, political, agricultural and economic effects are rare and difficult to quantify. A case in point is illustrated by different estimates of the 2014-2015 Ebola outbreak in West Africa. According to a World Bank analysis conducted in 2016, the 2014-15 Ebola crisis in Guinea, Liberia, and Sierra Leone led to a loss in GDP estimated at a minimum of \$2.8 billion in these three countries.¹¹ In great contrast however, a 2018 analysis of the total global economic and (uniquely) social costs of the same outbreak in the same affected West African countries has produced an estimate of \$53.19 billion.¹² This is a dramatically higher estimate of costs, illustrating the highly significant underestimate of the actual comprehensive, *systemic costs* of severe outbreaks of infectious disease. This is a significant finding, for it begs the question regarding the methodological validity of conventional economic cost analyses stemming from disruptions within non-linear, multisectoral complex systems.

The Globalization and Transformation of Risk

“There are signs of strain in many of these systems: our accelerating pace of change is testing the absorptive capacities of institutions, communities and individuals. When risk cascades through a complex system, the danger is not of incremental damage but of ‘runaway collapse’ or an abrupt transition to a new, suboptimal status quo”

-- Global Risk Report, 2018, World Economic Forum¹³

There is increasing evidence that the globalised, tightly-linked economy characteristically manifesting a rapid propagation of shocks is increasing vulnerability, eroding resilience, and increasing risks. According to the World Economic Forum 2016 Global Risks Report, “evidence is mounting that inter-connections between risks are becoming stronger, for example climate change and involuntary migration or international security, often with major and unpredictable impacts.”¹⁴ This transformation -- the “globalization of risk” in an interconnected economy -- highlights a new set of under-examined risks emerging from the interrelationship of threats previously not connected.

Accordingly, to manage the ‘new,’ globalized risks it is crucial to develop a broadly-defined, systems view of *human security* that also provides a broad context, a *global strategic framework*. Only by developing this approach can we adequately risk manage pandemics as well as other multiple-impact catastrophic hazards and threats to civilisation. The idea of “human security” is not new. The concept was first endorsed by the United Nations Development Programme in its 1994 Human Development Report (HDR 1994).¹⁵ It reflects a multidisciplinary, multisectoral understanding of threats to security of individuals and society, along seven key interconnected categories:

- Health security, from disease, lack of safe food and water, or health services
- Food security from hunger and famine
- Environmental security from natural disasters, pollution, environmental degradation, resource depletion
- Economic security from poverty, unemployment
- Personal security from physical violence, crime, terrorism, domestic violence, and child labour
- Political security from repression, abuse of human rights
- Community security from inter-ethnic, religious and other identity tensions

The human security paradigm is therefore not only multisectoral, but comprehensive, context-specific, and prevention-oriented. Recognized for its power as a strategic framework, the “human security” concept was adopted by Canada as a framework for its foreign policy strategy.¹⁶ Importantly, the human security strategic concept usefully appeals to the interrelated and interconnected complexity of all multiple-impact, potentially trans-national and global threats, including *inter alia* pandemics, major natural disasters, economic and financial crises, climate change, war and terrorism. The concept also appeals to a comprehensive and integrated approach, using a wide variety of means to prevent and manage the apparent threats along with its precedents as well as its widespread secondary and tertiary impacts.

Pandemic Risk Management: A Global Human Security Public Good

The transformative “*globalization, of risk*” in an interconnected economy of an increasingly urban, vulnerable population makes the concept of effective pandemic risk management a clear necessity and a *global public good*. To protect global human security, the establishment of a *rigorous proactive system for pandemic prevention and risk management* should be a high priority of globalised industrial civilisation. Sustainable investment in an effective global pandemic risk and impact management system architecture is also a global public good.

In light of the above, *what is the current state of strategic thinking on protection of civilisation against cataclysmic pandemic risks?* The aftermath of the recent Ebola crisis offers a useful insight. Deficiencies and failures in the international response to the Ebola virus outbreaks of 2014-2015 generated a number of analyses and recommendations from a variety of international, academic, government, and scientific panels.¹⁷

The common thrust of these efforts intended to improve global health security through better management of future health crises, including those with pandemic potential. Notably, one of the panels -- the Commission on a Global Health Risk Framework (GHRF) -- in its report on the “Neglected Dimension of Global Security – A Framework to Counter Infectious-Disease Crises, asserts that “*Pandemic prevention and response, ... should be treated as an essential tenet of both national and global security – not just a matter of health.... Compared with other major threats to global security, we have grossly underinvested in efforts to prevent and prepare for infectious disease threats.*”¹⁸

The Preparedness and Response Model.

A review of these panel reports, however, reveals a shared, explicit strategic emphasis focused primarily on *preparedness and response* to outbreaks of infectious disease, specifically aiming to “*prevent, protect against, control, and respond to the international spread of disease.*”¹⁹ The implicit assumption seems to be that outbreaks cannot be prevented, but only contained in order that they do not become “major outbreaks.”

Current international dialogue and most development efforts are premised on this conceptual model. Infectious disease outbreaks are viewed as *disaster emergencies*, with most attention focused on preparedness and response. This notion is also consistent with the conventional crisis paradigm where actions are undertaken in response to apparent disasters or crises. Collaborative efforts during the past year by numerous global health security development actors, including the WHO and the World Bank, have engaged to develop a conceptual framework for preparedness and response against such potential health crises, and to find means of sustainable financing for such a system. While the current approach adds more emphasis to anticipation, preparedness, and early response to such crises, the overall strategic objective remains primarily focused on limiting and containing the outbreaks, so they do not become cross-border emergencies. The aim of interventions is the prompt return to pre-crisis, baseline conditions. “*Prevention,*” in this context, is primarily aimed at

A Missing Strategy: The Comprehensive Pandemic Risk Management System (CPRMS)

Underrepresented in the expert panel reports, and in the current international developmental dialogue, is the dimension of *primary prevention and comprehensive systemic risk reduction*. The strategic focus on preparedness and response to contain local outbreaks to prevent epidemic and pandemic spread, as the subject of intense international and multilateral efforts, is clearly a necessary aspect of managing infectious disease. It is, however, not sufficient as it represents a neither cost-effective nor sustainable strategy.

Cost-effectiveness

A strategy for global health security based on *emergency* preparedness and response – while certainly appropriate and necessary—is not adequate or sufficient as a strategy against outbreaks of new microbes with uniquely *severe pandemic potential*. Novel, efficiently transmitted viral strains of influenza (e.g. H5N1, H7N9), or other novel variant strains of SARS, MERS-CoV, or of engineered smallpox virus strains are obvious examples. A novel, highly infectious and significantly virulent strain, would inevitably cross boundaries and quickly spread via modern transport routes throughout the globe. The recent, relatively mild H1N1 pandemic of 2009 is a good example of the difficulty of containing a virus with true pandemic potential. The emergency-based preparedness and response model, intended to prevent international spread of infectious disease, would likely not be an effective core strategy to prevent and optimally manage the risks of a microbe with severe catastrophic potential. Logically, in such perspective, the absence of effectiveness also puts the matter of its cost-effectiveness in question. Efficiency without effectiveness has no meaning.

Sustainability

The “emergency preparedness-and-response” model is also non-sustainable. First, the emergency paradigm is completely and inherently unsuitable for rapidly-mutating, viruses, supremely adapted to co-evolve with the changing environment. Complex adaptation and natural selection pressures contributing to this process now certainly include those introduced globally by human ecology and technology. Microbes and infectious diseases are clearly a permanent threat to human health security; and pandemics are not random emergency events but a predictable, perpetual evolutionary threat. This fact alone, makes it imperative that pandemic risk management must be fundamentally grounded as an ongoing effort based on primary prevention and risk reduction within the One Health, animal and human model. True preventive risk management must anticipate, understand, and reduce risks of virus families at the earliest opportunities in the causal framework, based on their genetic potential for interaction with and consequences to animals and humans in the changing human ecology.

Secondly, the ‘preparedness and response model’ is fundamentally reactive, triggered by an actual outbreak of infectious disease in society. If containment is not possible, an efficiently infectious microbe will quickly spread globally, well before the 4-6-month process necessary to develop countermeasures such as vaccines, antivirals, or antitoxins. The model is therefore not suitable to the risk management of emergent novel microbes with high infectivity and devastating consequences to globalised civilisation and economy.

Thirdly, the conventional preparedness and response strategy fails to take into account the vulnerability of the complex and concentrated socioeconomic systems upon which it depends, including power, water, communications, and transport. The model is generally related to the

human/animal health response and does not adequately address the broader complex management of ever more tightly interconnected risks beyond the animal-human health subsystem – i.e. the risks that condition the functionality of essential service systems and critical infrastructure, so important to the functioning of the globalised socio-economy and therefore the general welfare of societies. From experience to-date, planners tend to assume a homeostatic stability of the global system and therefore take for granted that containment strategies can be effectively operationalised. However, as is argued below, such assumptions will be increasingly hard to maintain as those societal systems show signs of multiple and growing stresses.²¹ The characteristically occurring multiple pandemic waves would therefore find societies progressively more vulnerable and less resilient.

Finally, managing the risks of evolutionary microbial emergence, re-emergence, and resistance is an increasingly resource-intensive undertaking. It is all the more daunting in light of the onslaught of growing “*temporal stressors*” such as secular economic stagnation, the demands of a growing global population, depletion of critical natural resources and related conflicts, profound and diverse impacts of climate change, the alarming threat and costs of antimicrobial resistance, and environmental degradation.²² These all amplify risks and costs of preparedness response and mitigation, while further challenging societal resilience at global as well as at national and regional levels. To these stressors, one must add unprecedented, and growing levels of national, corporate and personal *debt*. In such a resource-competitive context, surplus financial resources necessary to effectively prepare for and respond to catastrophic pandemics, within the present strategic paradigm may well be insufficient, ineffective, and unsustainable.

Thus, in the face of the above stressors, the linear, emergency-preparedness-response model is not likely to be either effective or efficient to address catastrophic shocks, amplified by the growing stresses and conditions of the 21st Century human ecology.

The allocation of and use of increasingly scarce disaster management resources is currently severely distorted and irrational. According to European Commission Vice-President and Disaster Risk Reduction Champion, and recent acting CEO of the World Bank, Kristalina Georgieva, “Globally, only 4% of spending on disasters goes towards disaster prevention and preparedness, with 96% spent on response. This has to change”.²³ To conserve and make efficient use of limited resources on an increasingly stressed planet, an investment in radically preventive, proactive risk management is essential to develop the most cost-effective strategies with maximum return on investment. The existing model is allocatively inefficient, as it leads to expenditure of limited if not diminishing surplus resources for emergency response without the potential efficiency benefits from investment in prevention and risk reduction. As such, the continuation of the current response-dominant “emergency model” represents a potentially catastrophic opportunity cost, jeopardizing the collective future ability to manage future disasters. As UN Secretary General, Ban-Ki-Moon stated, “*We are playing with fire. There is a very real possibility that disaster risk, fuelled by climate change, will reach a tipping point beyond which the effort and resources necessary to reduce it will exceed the capacity of future generations.*”²⁴

The above line of argument notwithstanding, the point is not that pandemic emergency preparedness and response measures to prevent international health crises are somehow inappropriate or misguided. Nor should the argument be construed as a criticism of the necessary collaborative initiatives to strengthen global national capacity of public health systems or to effectively implement the provisions of the International Health Regulations or other worthy initiatives, including the Global Health Security Agenda. An emergency response to current outbreaks of infectious disease, enabled by appropriate preparedness measures is and will always be a necessity. However, a global strategy for a high-consequence, civilisational threat like a severe pandemic demands a robust preventive system firmly grounded on rigorous analysis and systematic, anticipatory reduction of risks and preparedness. Accordingly, integrated, highly targeted risk reduction, primary prevention and preparedness must systematically precede outbreaks. Such a

global system is needed, possible, but largely non-existent.

The Characteristics and Principles of the CPRMS

New strategic, cost effective systems-thinking is necessary to prevent and manage the growing risk of potentially cataclysmic, world-changing pandemics. This approach would be fundamentally different than the current model which emphasises *health-centered* preparedness-for-response, designed primarily to contain and prevent local outbreaks from becoming major international health crises. A new approach would manage a “risk continuum” to include not only the risks of microbe emergence, amplification, and spread, but also the diverse and pervasive impacts of pandemics upon the delivery systems of essential services upon which global human security depends.

As a robust, anticipatory and proactive preventive framework, such a risk-continuum model would begin with a targeted understanding of genetic risk factors inherent to the microbe itself and continue to include those risks related to the transmission and amplification dynamics involving wild and domesticated animal hosts, reservoirs and vectors, and their environmental interface. To start, this would mean identifying all the riskiest viruses and other microbes whose genetic characteristics predispose to critically adverse interaction with the human genome so as to threaten human health both directly, and via wild and domesticated animals.²⁵ With this practical understanding, vaccines could be developed well in advance of most of the riskiest microbe outbreaks. The spectrum framework also extends to risks of transmission from animal to human, and efficient spread and amplification among humans, involving not only the natural environment, but also aspects of human ecology, culture, behavior, technology, and economic activity. The systems model would therefore need to consider specific preventive approaches and risk reduction/management of *multiple cascading impacts and severe disruption* of essential services, critical infrastructure, and of possible multiple-system failures, potentially leading to large-scale system collapse. Key risk nodes on the risk spectrum would potentially include the following:

- Risk of microbe emergence due to genetic shift or drift;
- Risk of specific wild and/or domestic animal infection;
- Risk of transmission to and amplification among wild and domestic animal reservoirs and vectors with potential exposure to humans;
- Risk of spill over, or species jump from wild animal or domesticated animals to human hosts;
- Risk of human research/bioengineering leading to deliberate or accidental release of microbes with pandemic potential;
- Risk of amplification and transmission among humans; with risks determining effectiveness of countermeasures and clinical management;
- Risk of failed national containment efforts, and of cross-border, pandemic spread;
- Risk of causing critical patterns of absenteeism and compromise of technical systems, to disrupt minimal necessary flow of essential goods and services and damage to critical infrastructure nationally and internationally;
- Risk of excess mortality and complex humanitarian crises among most vulnerable populations from multiple system disruption and dysfunction (e.g. from health system or security system dysfunction);
- Risk of systemic collapse of multiple key globalised systems, such as financial systems and critical infrastructures that could lead to a major shut-down in the distribution of essential goods and services

Overall, the proposed comprehensive risk-management approach, as a strategic preventive system, would emphasise risk reduction and primary prevention, as part of an integrated system that appropriately includes conventional emergency preparedness, response, containment, and recovery.

An important implicit asset of the proposed full-spectrum systems approach is that it can be a model for managing catastrophic risks of a range of threats and hazards with global and civilisational impact. The model, and its key characteristics, when viewed through a generic conceptual lens, is therefore “hazard-independent,” with a fundamental orientation to addressing the impacts on critical service systems in the human ecology.

Each key risk node-complex along the spectrum must be subject to evidence-based research, *systems analysis* of vulnerabilities, and an in-depth understanding of how these factors interrelate to optimise societal resilience. Using a “one health” and “whole of society”^{26, 27} model, new *complex system* approaches for gathering and assembling data, information and understanding can be employed for the benefit of decision and policy makers, managers and operational experts at international, regional, national and community levels. The above framework and process will be essential to the iterative, ongoing improvement of a comprehensive preventive pandemic risk management system.

In the above perspective, and in anticipation of the development of a comprehensive, systems-based pandemic risk-management model, the following characteristics of such a system would seem to be indicated and useful:

Complex Adaptive System. The mind-set for understanding and managing the threat of pandemics should deliberately and actively incorporate and expand on the known principles and methods of systems thinking and “complexity science.” Pandemics, including their agents, networks, interconnections and feedback mechanism, implicate risks and direct as well as indirect impacts, are manifestations of a complex system. Organised human efforts to manage the risks and impacts of infectious disease and pandemics on society are also self-organised, complex systems and sub-systems, each with their own unique structures, behavioural attributes and inter-related mechanisms. Together, they potentiate, condition, and describe the emergence, spread, and impacts of microbes in all aspects of human ecology. A systems understanding of the dynamic interface among microbe, animals, environment, human ecology, culture, behaviour, and policy will help optimise the risk management of infectious disease and of socioeconomic impacts of pandemics on society. The model therefore suggests an approach that is essentially proactive, progressive, and anticipatory, rather than reactive to the periodic, and expected, yet unpredictable onset of shocks and emergencies. The history of failed development strategies and policies is testimony to the deficient, habitually linear understanding of development or disaster challenges and problems.

Contextualised in Multiple Global Catastrophic Risks. The grounding of the CPRMS within an anticipatory complex-system understanding also serves to underscore the deep awareness of its being inextricably embedded in the 21st Century realities of the transformation and globalisation of multiple, interconnected catastrophic risks. The inescapable implication of this awareness is that the strategic and operational governance and financing of the CPRMS must also be contextualised in the broader global governance and resourcing challenges attendant the management of emerging global catastrophic risks. We will address this issue in Part II of this paper, in a discussion of governance and financing of the CPRMS.

Evidence-Based. To enable intelligent and wise strategy, policy, and intervention management, the systems model must be soundly grounded in and justified on the basis of empirical evidence to demonstrate persuasive allocative efficiency and cost-effectiveness. Such evidence would justify and drive strategy, policy, operational intervention management, as well as the related process of ongoing monitoring and evaluation. Variables targeted for deeper understanding must be critical to the overall behaviour of the complex “pandemic system.”

An excellent, if not iconic, example of this approach, and of the overall risk-management model, is the *Global Virome Project*, (GVP) which proposes to identify and “characterize” the virome of all

high-consequence wild viruses. In a paper published in *Science*, GVP authors report that as many as 1.6 species viruses found in birds and mammals are still unknown, of which an estimated 650,000 to 840,000 have the potential to infect and sicken humans.²⁸ The GVP proposes that 75% of these viruses would be discovered within the first 4 years of the project, with the remaining 25% of virus discovery subject to the increasingly time-and-cost-intensive, asymptotic process. Early discovery of novel viruses with evident strong potential for efficient infection of domestic animals and humans, can give rise to efficiently targeted preventive interventions, including the development of vaccines, other medical, and non-medical countermeasures to appropriately modify risk behaviour.²⁹ Discovery would include each virus' ecologic profile, its geographic habitat, the wild and domesticated animal species it infects, and the specific human populations at potential risk.³⁰

The GVP would complete its virus categorisation within 10 years, at a cost of \$3.44 billion, or \$344 million per year.³¹ It is worth noting that such a cost is far lower than that of the 2014-2016 outbreak of Ebola in West Africa.

Another example of the evidence-based, systems orientation to pandemic risk management is the emergence of the Coalition for Epidemic Preparedness Innovations (CEPI). At its annual meeting in Davos, Switzerland, the World Economic Forum announced the launch of the CEPI, which marked a concrete, funded step in support of a research-based preventive strategy to pandemic risk reduction, consistent with the vision of the Global Virome Project.³² As of December 2018, CEPI, a coalition of governments, foundations, and NGOs, has secured more than USD \$747 million towards its USD \$1 billion funding target to accelerate the development of vaccines for three of top 10 important viral threats identified by WHO: MERS, Nipah virus, and Lassa Fever.³³ The objective is to prepare two new pre-outbreak vaccines for each disease within the next several years.

Risk-Based. Comprehensive Risk Management Continuum. This is the core of the CPRMS paradigm. The organising principle of the risk management approach is evidence-based identification of hazards, risk analysis and impact analysis to inform priority setting and resource allocation. Thus, the pandemic risk management framework should *pursue a continuous systematic process of managing strategically selected, priority risks as precursors to an eventually manifest pandemic. This stands in contrast to a framework whose primary focus is the episodic "emergency" preparedness and response dedicated to the containment of disease outbreaks.* As such, comprehensive pandemic risk management will necessarily focus on prevention and risk-reduction, as well as on preparedness and response -- and these as part of *one continuum of risk management in all relevant sectors and levels, from national to regional and global.* This continuum will need to be examined for a whole range of implicit and explicit constituent risks for subsequent intelligent systems-literate interventions. For example, risks amenable to prevention and reduction would include exposure to particular classes of microbes, particular environments, specific wild animal vectors; risk of wild animal to domestic animal transmission; risk of animal-human transmission, risks of human-human transmission, etc.

Secular scope. This is an approach that is secular, or long-term oriented, in keeping with co-evolutionary, microbe-animal-human-technological-environmental selection process that is also secular and dynamic, rather than episodic and driven by post-outbreak declared emergencies at the societal level. Time, and fundamental continuity of effort is therefore an explicit dimension in the systems approach model.

Multisectoral/Multidisciplinary – One Health; and Beyond Health. Viewed through a "complexity lens," the management of pandemic threats, must span the full spectrum of engagement, from microbe, to animal-human as reflected in the "One Health" concept, to *"beyond health,"* including the management of pandemic impacts in key service systems in the human socio-economy.

Borne from the acknowledged concept that human, animal, and eco-system well-being are

inherently interconnected, the One Health” approach emerged as a multisectoral, collaborative effort to address potential or existing risks that originate at the animal-human-ecosystems interface.

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“Beyond health” complements and extends the active, multisectoral and coordinated One Health approach” to manage risks to essential societal services and related critical infrastructure. These Eight Essential Services and Related Critical Infrastructure include public and curative health services; energy and power; food and water management systems; transportation and resupply networks; telecommunications and communications; national security and public safety; and associated infrastructure such as the postal system, power plants, refineries, water treatment plants, food storage facilities, etc. Global health security in a globalised world is utterly dependent on these systems, and their managed protection from the impacts of pandemics is a global public good, essential to human security.

Integrated, Whole of Society. The One Health/Beyond Health conceptual shift in perspective also serves to support a “whole of society” approach to the management of pandemic risk.³⁴ The approach is contingent on a coordinated collaboration of whole of global society, including government, private and community organisations and individuals at all levels, global to local, to preserve *social cohesion* in the face of existential risk. Conceptually, the whole of society orientation must also be integrated within national and international disaster risk management frameworks including existing national disaster risk management organizations and the UN International Strategy for Disaster Reduction (UNISDR) and the World Health Organization (WHO).

Integrate Prevention, Preparedness, and Response. As implied by the above-mentioned multisectoral approach, the risk-based model will need to span a range from prevention and risk-reduction in the microbe-animal-human realm, to preparedness and response to contain and mitigate the direct impacts of infectious disease on human health, as well as the indirect impacts on national and global essential services and infrastructure.

Financially Sustainable at National and International Levels. To be holistically useful and effective for the long-term, the comprehensive pandemic risk management system must be functionally sustainable in the context of current and future 21st Century governance structures, and an assortment of known and unknown challenges and shocks. Adequate, sustainable resource mobilization at both national and international levels will depend on both public and political will, and be rationalised by persuasive, rigorous macro-policy supported by clear evidence of allocative efficiency and cost-effectiveness.

Strengthen Multisectoral Systems. The risk management framework must set the stage for an organized and coordinated local-global effort to enact practical operational strategies, policies, and interventions. These would be implemented by a multisectoral network of existing service-oriented systems including public health, energy, communication, transport, and other essential service systems and infrastructure. Each service system would, inherently, consist of generic **structural “system building blocks”** operating functionally at all levels -- local, national, regional, and global.³⁵ These generic service system building blocks include:

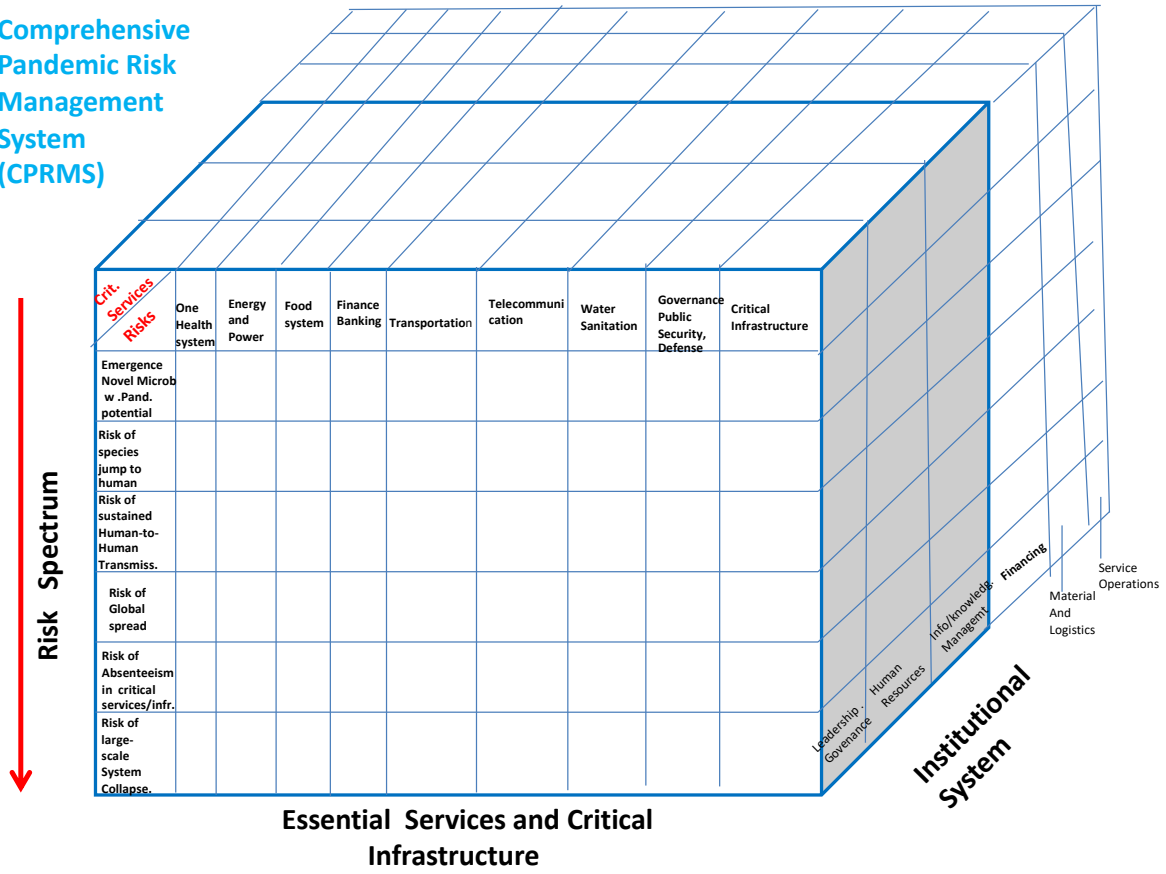
- Leadership and governance/coordination;
- Financing;
- Information systems (coordinated generation, and distribution of data, information, knowledge);
- Human resources;
- Essential commodities and related logistics; and
- Operational interventions/service delivery capacity.

The same six characteristic building blocks, from appropriate leadership and governance, to operational intervention mechanics, would also pattern the macro-framework of a comprehensive pandemic risk management system, *qua system*.

The graphic presented below provides an illustration of the key dimensions of the CPRMS, as discussed above. These “dimensions” include the Risk Spectrum on the vertical axis; the range of Essential Services and Critical Infrastructure on the horizontal axis; and the six System Elements of an institutionalized CPRMS on the third, depth dimension. Accordingly, each category of illustrative risk on the risk spectrum, is related to preventive and response measures to be taken into account for each essential societal service and critical infrastructure. Further, where risk and essential infrastructure intersect, the CPRMS as an institutional system needs to have an essential capacity for effective risk management function. For example, to manage the risk of the emergence of a novel microbe, the One Health (human and veterinary) system requires an appropriate leadership and governance structure and process.

Graphic: The CPRMS – Interrelating the Spectrum of Risk, Essential Services and its Institutional System Elements

**Comprehensive
Pandemic Risk
Management
System
(CPRMS)**



Part II: Towards the CPRMS -- A Roadmap

Is the CPRMS Feasible? Challenges and the Imperative of Necessity

“Leaders at all levels hold the key. It is their responsibility to prioritize preparedness with a whole-of-society approach that ensures all are involved and all are protected.”

Global Preparedness Monitoring Board, September 2019.

While there is ample historic evidence of societal capacity for momentous achievements in culture, technology, and socio-political organisation with global-scale impacts, it is also true that such leaps of civilisational agency are dependent on a certain threshold of collective vision, supported by persuasive data, information, and systems-literacy; prioritisation among numerous competing societal goals and objectives; and political will to mobilise and allocate adequate resources. These predisposing factors are theoretically within the evident reach of human capacity, but an optimally desired alignment of political will, resource allocation, and action to achieve consensus goals is never guaranteed.

Reason and evidence linking relative costs to benefits alone are not sufficiently persuasive for consensus and effective mobilisation. This common finding introduces the possibility of an inherent structural cognitive deficiency of the species, which is exemplified in the historic record of failed civilisations that were unable to effectively manage the risks of low-probability, high-consequence threats. While the common adage that an ounce of prevention is worth a pound of cure finds widespread agreement, the application of that principle to prevention and reduction of predictable, high-consequence risks, is notoriously unreliable. Thus, the common pattern associated with disease outbreaks of international concern begins with initial surprise and panic; then transitioning to a delayed, inefficient response, followed by the predictable, post-recovery complacency and eventual neglect.

The fact remains that most humans, and perhaps especially politicians tend to underestimate and therefore ignore the rare, high-impact risks, such as catastrophic pandemics, nuclear war, or human extinction. But when examined carefully --even within the span of a human lifetime -- the risks of dying from pandemics are hardly trivial. According World Bank health economist, Olga Jonas, children with a life expectancy of 70 years have a 70 per cent chance of experiencing a pandemic, with a 1:140 risk of dying when in a developed country and 1:40 in a developing country.³⁶

There is a persistent, if not growing acknowledgment of the serious inadequacy of pandemic preparedness in most countries. According to a 2018 article in the *British Medical Journal*, the world is ill-prepared for a severe pandemic, with many “gaps in funding, monitoring global capacity, and global leadership.”³⁷ Evidence for this is more than hinted through the experience of the 2014-15 Ebola Crisis in West Africa, and the August 2018 outbreak of Ebola in the Democratic Republic of the Congo (DRC), which on July 2019 was declared by WHO a Public Health Emergency of International Concern.³⁸ This latter complex crisis is exacerbated by ongoing conflict and extensive distrust of government outbreak response and mitigation efforts by a public health and security system ill-prepared to effectively manage risk reduction, preparedness and response to contain the epidemic. At the time of writing this paper, the uncontrolled outbreak threatens to become an urban and regional emergency. Constraints in managing the epidemic certainly included deficiencies in domestic and international emergency governance, resource mobilisation, and operational response capacity. Similar systemic weaknesses affect many lower- and middle-income countries. Out of 167 reporting countries, most are not in full compliance with the International Health Regulations, with its legally-binding reporting and preparedness requirements.³⁹ Even the U.S. -- a wealthy, advanced industrialised country -- is ill-prepared for a novel pandemic. According to the results of a pandemic simulation exercise named “Clade X,” conducted by the Johns Hopkins Centre for Health Security in May 2018, within 20 months the bioengineered microbe killed 150 million people, including devastating impacts on the U.S., where many vulnerabilities, including leadership challenges, were

”hardwired into the American system.”⁴⁰

As of September 17, 2019, the first annual report of the independent Global Preparedness Monitoring Board (GPMB), a monitoring body on global health emergency preparedness, jointly convened by the WHO and the World Bank Group, also prominently concluded that the world is not prepared to respond to a pandemic.⁴¹ The report’s key finding was that the world needs to proactively invest in the systems needed to detect and control potential disease outbreaks at community and global levels, as a global public good. The report appealed to coordinated leadership, governance, and financing to take urgent action on the following seven priorities supporting the above goal:

1. Heads of government must commit and invest.
2. Countries and regional organisations must lead by example.
3. All countries must build strong systems.
4. Countries, donors, and multilateral institutions must be prepared for the worst.
5. Financing institutions must link preparedness with financial risk planning.
6. Development assistance funders must create incentives and increase funding for preparedness.
7. The United Nations must strengthen coordination mechanisms.

Accepting the premise of the CPRMS as a theoretically feasible proposition also comes with the sober awareness of the many real-world difficulties with the development and adoption of a multisectorally and geographically integrated, sustainable risk management system. While bold initiatives on pandemic preparedness such as the “Global Health Security Agenda (GHSA) and the Global Virome Project attest to the potential of human vision and ingenuity, the persistent lack of effective global governance and commitment of necessary resources to effectively manage the spectrum of pandemic risk underscores the magnitude of constraints. These challenges can be broadly summarised into two broad categories:

Paradigmatic -- Conceptual and Strategic. First, as was already mentioned, humans seem to be constitutionally and conceptually slow to be energized to prepare for rare, high-consequence threats. To some extent, this inertia is facilitated by a paucity of persuasive, rigorous information on the nature/extent of risk, and on the real socioeconomic costs and multi-systemic impacts of severe pandemics, potentially undoing years of development investments. There are persistent deficiencies and gaps in relevant systems-knowledge related to the full spectrum of risks, starting with the microbes of greatest threat to society, to the complexities of the animal-human-environment interface, to the prevention, management, and mitigation of pandemic risks in the socio-economy. For example, the lacking systems-understanding of the zoonotic interface among the estimated one billion livestock keepers, chronically at risk for diseases contracted from their kept animals is of major consequence for preventive policy formation and rational resource allocation with substantial promise for a potentially large benefit pay-off. To illustrate, a World Bank analysis suggests that in 2013, preventive investment of \$3.4 billion on veterinary and related public health systems in 2013 would produce annual benefits of \$37 billion.⁴²

Second, political frameworks tend to prioritize the use of limited resources for the immediate, ever-present risks associated with endemic causes of excessive population (e.g. high infant and maternal mortality, malaria, malnutrition). This tendency may be expected to become more acute as the growing stresses of climate change, natural disasters, depletion of resources and environmental degradation, food insecurity, and migration, depress prospects for economic growth and place even more severe strain on limited financial resources and leads to competition and conflict.

Third, resistance to commitment of political will for investment in a domestic CPRMS also stems

from the inevitable competition among ideologies and political priorities that underpin the resource allocation process. This is further enabled by the “free-rider” tactic, whereby politicians rely on grants of external assistance in the event of extraordinary health emergencies, as is the case with the recent Ebola outbreaks in Africa.

Practical and Systemic. This category of functional constraints reflects the logical consequences of the above challenges. These constraints become manifest in the quality and effectiveness of institutional systems intended to manage pandemic risk – i.e. the quality of governance and leadership; country budgets; information systems; human resource capacity; material and logistical capacity; and operational service capacity.

Notwithstanding the numerous systemic and practical constraints outlined above, there is also evidence of successful societal mobilisation in response to major threats and challenges. The history of human civilisation, while replete with examples of societal failure and collapse, also provides encouraging examples well-organized and ultimately effective collective social agency. Milestone achievements such as the eradication of smallpox, the successful Apollo 11 mission to the moon, and the containment of the SARS crisis in 1993, suggest that success in overcoming the obstacles and challenges of global human and civilisational security are not only possible, but necessary. Necessary, because the global population is increasing, as is the demand for continued economic growth, while climate, the biosphere, and limits on resources, including energy, water, and soil fertility create increased risks, disasters, and vulnerabilities. Necessary, also, because the many costs associated with the above constellation of global-scale predicaments are growing rapidly and may be eventually unaffordable.

While the inertia of existing patterns of governance and social organisation is very real, always reflecting older patterns of technological adaptation to a changing human ecology, the fact of the matter is that humanity is now facing unprecedented, existential challenges that must be faced with new, more appropriate forms of rapid, scaled-up adaptation -- for better or worse. Necessity, as ever, will be the mother of invention. While there are no guarantees -- for human history is also a history of collapsed civilisations -- robust, research-driven, and adequately resourced efforts in comprehensive risk management like the CPRMS are justified and must be attempted simply because they have become necessary.

Accordingly, many things can and should be pursued in the face of the inertia and constraints discussed above. As emphasised by the Global Preparedness Monitoring Board (above), an effective global effort will certainly require strong leadership including that of a much stronger institutional role and mandate for the WHO and other effective, and adequately financed governance and coordination structures at global, regional, and national levels involving all sectors of society. Each country will need to assume primary responsibility for local, national risk management in accordance with international agreements such as the IHR, and an enhanced UN International Strategy for Disaster Risk Reduction, under effective global governance and coordinating mechanisms. Information management must support a rigorous economic case that persuasively reflects on the macro-critical risks and benefits of risk management in a manner that is relevant to individual country and private business priorities. Robust evidence-based research and development as basis for policy making, program design and evaluation, including the methods of complexity will need coordinated public and private financial support. Innovations will need to emphasise cost-effective prevention and risk reduction as well as effective service delivery systems for all essential goods and services, including the emergency access to power, finance, and production and delivery of critical pharmaceuticals.

Systems Thinking, Complexity and the CPRMS

The System. The “Key Principles for a Risk Management System” presented in Part I, Section 5, above, helped define the desirable general characteristics of the CPRMS. As we set the stage for presenting the “Way Ahead,” some brief remarks on what makes the CPRMS a “system” in Donella Meadow’s very accessible primer on systems thinking may be useful.⁴³

All systems, including the thermostat, the human immune system, a national economy, and the behaviour of a microbe in animal and human hosts, consist of a coherently organized framework of elements oriented to effect a meaningful change within this context. As integrated entities, systems are composed of constituent elements, bound by certain interconnections among them; and a particular function or purpose, as the unifying, integrating principle. Elements, or “building blocks” can be visible and physical, or invisible and intangible. The interconnections can also be physical flows, laws and natural processes, or communicated feedback impulses, laws, rules, and policies. Purposes can also be either explicit or implicit, made apparent through the actual, rather than stated or intended behaviour of the system. Further, sub-systems can be contained within broader systems, each with its own functions and purposes. Systems are more than the sum of their parts; are often self-organising, and co-evolve with changing environmental conditions and contexts, often in non-predictable ways. They are self-repairing and oriented to maintain overall stability, resilience, and functional integrity, but apparently within certain limits.

A major, desideratum to inform the “Way Ahead” in pandemic risk management is to prioritise and implement an expansive agenda of complex systems research as a fundamental global public good. The aim of research would be to better understand the structure, functions, and characteristics of pandemics in the context of “one health,” and within the networks of multisectoral global socio-economy and its institutions.

The Six Institutional Building Blocks of the CPRMS. In its institutional guise, the CPRMS structure consists of the six multisectoral system building blocks (from WHO’s building blocks of a “health system”), as discussed at the end of Part I, namely:

1. Governance, Leadership and Coordination
2. Financing
3. Information and information systems (research, generation and distribution of data/information, knowledge)
4. Human resource/capital
5. Essential material commodities and related logistics; and
6. Operational interventions/service delivery

This multisectoral institutional CPRMS framework transcends health, to include the full pandemic risk spectrum, including other sectors of the socio-economy, essential services and infrastructure critical to human security. Thus, the health system and others like the telecommunications, energy, and power systems can each be appreciated as “complex systems,” each consisting of its respective six component system building blocks.

A CPRMS Roadmap

Geographic Scope. This general and abbreviated description of the roadmap toward a comprehensive CPRMS is presented in its interrelated and interconnected global, national, and regional dimensions. We consider each of these three geographic realms in terms of the six component structural systems building blocks. The roadmap approach is premised on each geographic framework having its own internal coherence, but also with interrelated links to the other two complementary realms. To anchor the roadmap in its global context, we first address the global dimension of the process, and then the national and the regional dimensions of the CPRMS.

We then suggest some illustrative “steps forward” within each geographic milieu.

A. Global Implementation

While strong national multisectoral systems must constitute the front lines of an effective global system, the overall strategic plan must begin with the establishment and consolidation of a sustained global strategic vision, leadership, governance, and a resourced operational framework as part of an integrated strategic consensus.

The overall goal of the CPRMS would be to protect global human, and civilisational security from the direct and indirect threats of pandemics to global human welfare. At the global level, the principal focus of the CPRMS should be the effective management of critical “global functions” -- i.e. those that include the supply of global public goods, such as research and active development and introduction of new technologies, international agreements, policies and regulations; leadership and stewardship; and the management of cross-border externalities.⁴⁴

The purpose of an institutionalised global CPRMS would be to systematically plan, and collaboratively coordinate and implement a worldwide global public good agenda to prevent, reduce and manage pandemic risks and mitigate pandemic impacts along the pandemic risk spectrum with direct impacts on regional, and national/local pandemic risk management. This would, accordingly, include a focus on those public global good elements directly related to the prevention, reduction of risks to, and mitigation of disruptions in the large-scale international flow of essential goods and services to needy countries and vulnerable populations as a result of severe outbreaks and pandemics. This global undertaking would define the CPRMS as both a global public good and as a *commons*. Its common concern would be with the formally cooperative management of shared global risks, including pandemics. As such, the effort would be subject to agreed-upon principles and collective, collaborative action, with corresponding appropriately structured and organised economic, political, and institutional conventions.

Let’s first examine the six institutional building blocks of the *global* domain of the CPRMS.

1. ***Governance and Leadership.*** Since threats, risks, and costs of pandemics, as well as the benefits of comprehensive risk management are widely borne by both public and private sectors, it makes sense that the governing architecture of the CPRMS inherently includes both global public, and private stakeholders. International experience with recent outbreaks, including the recent Ebola crisis shows the persistent weakness of global capacity for coordinated governance, exposing misaligned and conflicting national, international, and private interests.

No single existing institution has the capacity to exercise such cooperative governance function necessary to the CPRMS. A number of approaches proposed by policy research and academic institutions hint at novel and potentially useful models of governance. Based on a study conducted by the independent policy institute, the Royal Institute for International Affairs (Chatham House), a network 203 public, private, government, financial, academic, and philanthropic transnational actors primarily concerned with the improvement of international health and its governance, finance, and delivery, constitutes a kind of *de facto*, informal “global health system.”⁴⁵ To strengthen leadership in the health sector, Chatham House suggested the establishment of an integrated, “UN-HEALTH” organization involving all UN agencies with health-related mandates.⁴⁶ Another approach to a common global governance and leadership framework on health security was proposed by the Harvard-London School of Hygiene and Tropical Medicine Panel on Global Response to Ebola, which suggested the establishment of a “Global Health Committee as part of the

UN Security Council to expedite high-level leadership and systematically elevate political attention to health issues, recognising health as essential to human security.”⁴⁷ In this time of growing and accelerating existential threats, a more comprehensive, proactive, and complex-systems-based global strategy for the management of high-consequence risks to human security, including severe pandemics, has become necessary, as an important global public good. Such a model would reflect an inclusive, all-hazards *global governance approach* involving agreements on shared goals, guiding principles, laws, and procedures emphasising networking, coordination and collaboration. One source defines this type of global governance paradigm as “*the complex of formal and informal institutions, mechanisms, relationships, and processes between and among states, markets, citizens and organisations, both inter- and non-governmental, through which collective interests on the global plane are articulated, duties, obligations and privileges are established, and differences are mediated through educated professionals.*”⁴⁸

An Approach to Governance of Global Catastrophic Risk Management.⁴⁹

In spite of the current organisational and funding difficulties experienced by the UN system, an international, multi-stakeholder governance model that can coordinate the multisectoral risk and impacts management of global catastrophic threats, including severe pandemics is a compelling notion. If anywhere, such a “Global Catastrophic Risk” governance model should emerge from and be located in the most appropriate, *existing* public international institutional framework dedicated to the global public good – i.e. an enhanced, and appropriately empowered UN system, with added provisions for the inclusive roles of state and non-state, public, and private institutions.

Illustratively, the origin and development of a Global Catastrophic Risk governance model might unfold as follows:

A coalition of national government and non-government, public and private international stakeholders would undertake efforts leading to a UN General Assembly resolution on a coordinated approach to governance and leadership in order to manage global catastrophic risks as non-traditional security threats to international human security and global civilisation, including pandemics.

A limited (illustrative only) national example of such a coalition of opinion leaders which can have its analogue in a global, international context, is the Commission on Strengthening of America’s Health Security of the *Center for Strategic and International Studies (CSIS)*. The Commission functions as a periodic convocation of prominent security and health opinion leaders (including members of Congress and former high-level officials) from both the public and private sectors. The Commission’s aim is to help articulate a practical vision for the U.S. role in global health security, and communicate this vision to the U.S. Congress. In its most recent deliberations (June 2019) the consensus articulated a health security agenda implicating the U.S. role in a forward-looking agenda of ongoing “prevention, protection, and resilience.” The following “doctrine” proposed by the Commission illustrates the far-reaching potential for advocacy by a high-level body of opinion leaders:

--Press for the restoration of health security leadership at the White House National Security Council.

--Ensure full and sustained, multi-year funding for the Global Health Security Agenda.

--Establish a global health crises response corps.

--Use multilateral tools through the World Bank to incentivise countries to invest in their own preparedness.

--Secure new tools for the future. (e.g. universal flu vaccine; new antibiotics; and expanded research of emerging infectious diseases and biosafety).⁵⁰

- The General Assembly can refer the issue for a formal endorsement, or (if possible) a legally-binding decision of the UN Security Council, which can establish a “UN Office on Global Catastrophic Risks” (OGCR).
- The OGCR would be led by a *Special Representative of the Secretary General on Global Catastrophic Risk Management*, an institutionalised role, within the Executive Office of the Secretary General (EOSG).
- The OGCR would embody a number of Catastrophic Risk Centres, each concerned with a particular existential threat, including a “**Centre on Comprehensive Pandemic Risk Management**” (CCPRM), under the lead of a “*UN System Pandemic Risk Management Coordinator*.” Such an initiative could form the core of an institutionalized, multiple-sector (beyond health – i.e., beyond WHO), public-private focus of global governance and leadership. The CCPRM would have a wide stakeholder representation and key roles for WHO, UN, ISDR, FAO, OIE and UNOCHA, as well as key members of what the Chatham House study identified as the “global health system,” with the appropriate representation of important development, NGO, and financial institutions like the World Bank, the International Monetary Fund (IMF), and the World Economic Forum (WEF).
- The CCPRM would rely on an existing and augmented network of collaborating experts to collect and analyse information useful to inform policy and program formation and development. Special measures would be taken to ensure the political neutrality and independence of such a body.
- The CCPRM would coordinate the setting of global and national objectives, relevant international agreements and laws, targets, and indicators, and oversee the continued implementation of important international initiatives and conventions analogous to the International Health Regulations (IHR).
- The role of the private and corporate sector in the global cooperative risk management of pandemics would be negotiated in light of shared risks, shared risk management, and shared benefits. An important platform like the WEF can help organise the multinational private sector as a key partner in the public-private, UN-led international global crisis governance architecture.
- Key international political and economic fora can also be engaged to help achieve high-level consensus on the CCPRM and strongly support its global agenda. In particular the annual meetings of the members of the G 20 dominant economies, generally including the participation of central banks like the World Bank and the International Monetary Fund, present excellent opportunities to build global momentum.

As the above illustration suggests, a variety of approaches to governance and management of global challenges are theoretically possible. However, to be credible, and have legitimacy, the approach to governance must be centered within an appropriately empowered UN system. The conception and testing of these frameworks must be commensurate with the complexity and diversity of the 21st Century global socio-economy; the context of growing ecological, demographic, and socio-political stresses; and changing nature of globalised risk. A future system of governance capable of managing global risk will require inclusive,

international, multisectoral consensus, regrettably in the face of currently accelerating negative trends of anti-globalisation, nationalism, populism and authoritarianism. These challenges will likely also be exacerbated by the ongoing climate crisis, a degrading biosphere, scarcity of resources, and widespread societal disruptions.

Other, more institutional, customary headwinds in the process will likely include institutional resistance from various UN system organisations that will perceive the organisational developments as threats to substantive territorial and budgetary entitlements. Another organisational objection may come from those who may object to the establishment of an entity whose task is to await the emergence of a catastrophic crisis. The reply to such concerns is to emphasize that humanity is already immersed in an inter-related, crisis-prone environment, one in which immediate, ongoing challenges of preparedness and contingency planning for response and recovery require prompt and continuous attention.

Finally,

2. *Sustainable Financing*

As asserted previously, the current system for shared international, public and private funding of pandemic risk management is inadequate, inefficient, and lacking in strategic coherence. WHO, still undergoing reforms in the wake of painful lessons-learned during the West Africa Ebola crisis, suffers from insufficient and uncertain funding, with over 71% of its programme budget dependent on voluntary contributions.⁵¹

A strategic resource financing plan for global functions, under an overall global strategy agreed within the UN-based global CCPRM, would support a viable way forward. The financing of the global public-good aspects of the CCPRM should be the leading dimension of an integrated financing system that includes the separate sustainable financing of national and regional dimensions of the CCPRM, as further addressed further below in our discussion of its national and regional domains.

Importantly, “financing” should be viewed as a systematic endeavour that transcends the mere mobilisation of funds and includes strategic budgeting; the efficient allocation of funds; cost-containment; cost-recovery; as well as any innovative, favourably tested shared-risk arrangements.

The strategic conceptual planning on financing would need to take into account of the customary questions:

- What financial resources are currently spent/available?
- What is needed for a strategic global plan; and
- Where and how to secure a sustainable and reliable flow of resources for the necessary global functions?

What’s available/spent? The previously referenced study report by Schaefferhoff *et al* asserts that “the actions of the global health systems are not commensurate with the size and nature of pandemic threats.”⁵² The study found that in 2013, out of the US \$22 billion in external funding for international health support, only \$4.7 billion was allocated for global functions (vaccine and drug research, harmonisation of international health regulations, market shaping activities, knowledge generation and sharing, intellectual property sharing) and cross-border externalities, which include “outbreak preparedness and response, response to antimicrobial resistance, response to marketing of unhealthful products, and control of cross border disease movement.” Funding for this category amounted to only US\$ 188 million, with only approximately US\$ 158 million spent for outbreak preparedness and response in all recipient countries. A resource base for global functions and for pandemic preparedness and response respectively, represents a glaringly inadequate investment for

global health security as a public good. New innovative ways to secure a steady flow of financing from both national and international public and private sources are necessary.

What's needed? According to the World Bank, the 2013 annual cost of providing critical basic animal-human preventive, risk reduction measures in developing countries has been estimated at about \$3.4 billion. This relatively small cost is associated with an estimated \$37 billion-dollar annual benefit from these One Health preventive measures alone.⁵³ A more recent report by the *Commission on A Global Health Risk Framework* of the National Academy of Medicine in the U.S., which estimates a \$60 billion annualised cost in pandemic losses, recommends that an annual risk-management investment should amount to an estimated “financing gap” for improvements in preparedness of U.S. \$ 4.5 billion. This would include US\$ 3.4 billion for improvements in national health systems; \$1 billion for R&D; and up to US \$ 155 million for global preparedness initiatives by the WHO and the World Bank.⁵⁴ As the above estimates suggest, the true economic burdens of infectious disease, including pandemics, are neither well known nor well-understood.

This makes accurate estimates of annual investment for a minimally effective global CPRMS hard to assess at present. Beyond general prevention and preparedness costs associated with the existing health and animal health systems, the annual costs of full-spectrum risk management, including measures to reduce the risks to the continued flow of essential services and integrity of critical infrastructure would be certainly higher. No global estimates for the distribution of priority essential goods and services and infrastructure, as global public goods have been found in extant literature. A more complete cost estimate should be developed, to include the costs associated with the six system building blocks of the global CPRMS involving all sectors, animal-human health, as well as the critical global services and infrastructure. In light of the fact that full-spectrum annualised pandemic losses are likely much higher than the above estimates, a significantly higher annual sum will need to be justified through an improved estimation methodology, still-to-be developed.⁵⁵ Improved methodologies would also need to estimate the globally critical essential services and infrastructure, and the jointly-shared, national-international-regional financing arrangements for these services and infrastructure.

Sources of Sustainable Financing.

Financing at the Country Level. Since the Ebola crisis of 2014-15, the strategic thinking of international multilateral and bilateral stakeholders, has been focused on strengthening vulnerable country public health systems and capacity for preparedness and response to outbreaks of infectious disease. This strategy has, accordingly, translated into encouraging the strengthening of country-based capacities in defined technical competencies of public and veterinary health systems, as required under the International Health Regulations and other international veterinary conventions. Closely supporting this strategy is the growing international stakeholder resolve to encourage middle-income countries to commit to the increased indigenous financing of national health systems for improved indigenous preparedness, and response to outbreaks of infectious disease. According to some recent data, most countries would need to commit to an annual expense of \$0.50 to \$1.50 per capita in order to have an “acceptable level of epidemic preparedness.”⁵⁶ This would amount to less than 2 per cent of annual health expenditures.⁵⁷ Currently, none of the targeted low and middle-income countries have adequately-financed preparedness and response plans.

To help meet this need, recognising that many countries under-invest in health due to a lack of funding and other competing political and social priorities, there is an international resolve to create new financial mechanisms that would incentivise countries to increase their budgets for preparedness. For example, according to the suggestion of the *CSIS Commission on Strengthening America's Health Security*, the World Bank should commit to an additional annual investment of at least \$1 billion for *preparedness* in low-and-middle-income countries over the next three years through its 2019 IDA Crisis Response Window in order to close the \$4.5 billion annual financing

gap mentioned previously.⁵⁸

Financing of the Global CPRMS. The same, of course, can be said for the inadequate financing of mechanisms for global pandemic risk management. Financing the global CPRMS will support the global public good agenda for risk reduction, prevention, preparedness response, and mitigation, and will require a universal, reliable political commitment and extensive public-private collaboration under the coordination of the proposed UN CCPRM and its partner organisations, including the World Bank. A systematic exploration of sustainable financing strategies and mechanisms should involve the participation of all key stakeholders represented in the CCPRM and should include contributions from member states; regional and NGO organizations; international finance, banking and insurance; philanthropy; and international corporate business, including the extraction industries, transport, pharmaceuticals, energy, power, and telecommunications – all with clear interests in minimizing the globally shared risks to production, demand and distribution of goods and services during pandemic disasters. To avoid the pattern of widespread flagging commitment following emergency pledging campaigns, a collaborative, strategic UN CCPRM governance approach will require both conventional and innovative models, including agreements and treaties, to secure stable, uninterrupted, and sustainable financing that is proactive, allocatively efficient, and accountable.

A number of potentially workable, innovative approaches to sustained global resource mobilisation have been suggested.

With reference to its stated goal of securing at least \$1 billion annually to strengthen health system preparedness in low-income-and-middle-income countries, the CSIS Commission on Strengthening America's Security recently proposed the establishment of a new global financing platform to support country preparedness capacity and related plans through new international donor contributions.⁵⁹

Separately, Nobel-prize winning economist, Joseph Stiglitz proposed the following approach to resource generation:

- *Revenues from the management of global natural resources.* Global natural resources like the sea bed, Antarctica, space satellite slots, and the global atmosphere can be efficiently managed to generate substantial revenues. For example, fishing rights can be auctioned; and charges applied for greenhouse gas emissions.
- *Revenues from the issuance of Special Drawing Rights (SDRs) – global greenbacks.* Stiglitz points out that the inefficiencies, in the global reserve system, which effectively “buries” US \$200 - \$700 billion in reserves, can be managed to generate revenues from the issuance of SDRs in order to finance global public goods.
- *Revenues from taxation of negative global externalities* like pollution, arms sales to developing countries, and destabilising cross-border financial flows.⁶⁰

Other potential approaches for generation of funds for the CCPRM include,

- Bill Gates' suggestion that global health-related financial resources could be generated from taxes applied to carbon emissions (as previously suggested by J.E. Stiglitz); air fuel and transportation; financial transactions; and tobacco.⁶¹
- Taxation of cannabis, in countries with a policy of legalisation.⁶²

In-kind contributions from industry partnerships should also be considered part of the financing system, and include commodities, technical, training, and administrative human resource support. Additionally, as suggested by at least one source, partnerships with the World Bank and/or the IMF can be set up to ensure that the capital of funds such as the WHO Contingency Fund for

Emergencies (CFE) is maintained at or above a desirable operational level.⁶³

Once the resources are mobilised, other dimensions of the financing plan related to the most efficient allocation of resources for global functions should be harmonised with the overall strategic CCPRM plan. This should take place in close coordination with national and regional financial plans, which would pursue the same issues at their respective levels. Specific implementation plans at all levels would also require close coordination to ensure coherence among objectives and targets, standardized indicators, monitoring, tracking, and evaluation systems.

Incentivising sustained national and global financing of the CCPRM

As discussed earlier in this document, the behaviour of humans apparently evolved to favour relatively short-term survival concerns, rather than to slow-onset existential threats to the entire species and the ecosystem that sustains it.

This, coupled with the still-dominant evolutionary human tendency to identify with and favour the familiar social in-group, as opposed to the broader external (out-group --“them, strangers”), makes incentives for effective organisation and mobilisation of resources for a global human security a chronic challenge. This problem is compounded by nationalism to the detriment of the common global good, and of course, by the more mundane realities of conflicting national and local priorities that are viewed as more urgent than the establishment and financing of long-term, systems to manage global existential threats.

Unfortunately changes in behaviour of nations, both individually and collectively can be only stimulated by painful catastrophic events. But even those are subject to reversals, as lessons-learned yield to social amnesia. In the current international milieu, visionary leaders, researchers and policymakers appeal to behaviour change on the basis of ethical norms, or research-based information providing evidence regarding costs and benefits of policy options. This is the approach evident in the studies and economic analyses we highlighted. These all intend to persuade national and global policymakers that relatively small investments in prevention and preparedness will prevent vastly larger expenditures to contain outbreaks and to recover from their negative impacts. According to one source, the former President of the World Bank, Jim Kim was quoted as stating (approximate quote) that “for every \$1 million spent on preparedness, one can save \$10 million for response, and \$100 million for recovery.”⁶⁴

It is this reasoning that underpins the current strategic thinking now supported by the WHO, FAO, OIE, the World Bank, and a host of bilateral donors. These prominent stakeholders encourage developing country policymakers to begin making indigenous investment in prevention and preparedness, in order to develop and sustain an effective local capacity for meeting the requirements of the IHR.

Making the above case to ministers of finance and key national policymakers is clearly not an easy challenge. Politically-motivated priorities of leading influentials, as well as those that reflect private conviction, ideology, and those driven by public pressure contribute to the uncertain process. Adding to the mix, is the quality, credibility and persuasiveness of information and communication on a range of related issues, such as the perceived costs of prevention, and preparedness; the sustained long-term benefits of public investment; and perceived opportunity costs. It is for this reason that availability of quality *information* and analyses regarding the costs and benefits of preparedness, in contrast to the assessed-but-unmanaged risks, is so important.

3. *Information and Knowledge Systems.*

As asserted by Joseph Stiglitz, knowledge and its production and protection, is an important public

good whose collaboratively governed generation, distribution, and use is equitable to both producers and consumers.⁶⁵ A systems approach to integrated information, knowledge, education, and communication to inform the global dimension of CPRM should include all types of data and information needed for multisectoral risk assessment and analysis; strategy, policy and legal framework formation; program design; implementation; and monitoring and evaluation.

This broad agenda would include a coordinated international public and private, collaborative global public good research and development program along the full risk spectrum. The research would adopt, apply, and further develop the methods of complexity science, making progressive use of emerging cognitive computing and artificial intelligence technologies. Consistent entrainment of new technologies would be directed to everything from understanding the drivers and progression of outbreaks with pandemic potential, to the impacts on human ecology at various nodes along the pandemic risk spectrum. This would include a range of topics, starting with the identification of microbes with rationalised pandemic potential as proposed by the Global Virome Project.⁶⁶ This risk continuum would unfold to include the management of risks among the previously mentioned eight categories of essential global services and critical infrastructure.⁶⁷ Information gained from evidence-based research would also appropriately lead to the identification of key risk indicators and other information useful for the coordination of prevention, preparedness, response, and mitigation at the global level, and to informing strategic and public risk communications, training, international agreements, and treaties. It would strengthen the capacity for coordinated sharing and direct application of evidence-based information for strategy and policy development; program design/planning; and evaluation influencing all geographic levels, and all six global systems building blocks (from governance, financing, and human resource systems, to essential commodities, logistics, and service delivery).

Four important categories of research-based *information* necessary for strategy, policy, resource allocation and management are worth highlighting:

- Multiple-Sector and intersectoral global public good research important to comprehensive pandemic risk reduction and preventive systems. One example is a multi-institutional network coalition on large-scale systems research on the cascading impacts of pandemics in key sectors, services and infrastructure, and on related risk management methods. Other important areas of needed research would include the expansion and completion of ongoing initiatives like the Global Virome Project which aims to identify all the microbes representing differential pandemic risk to humanity, as well as other areas others to be added to the complex-system research agenda.⁶⁸
- Multisectoral Global Risk Assessments along the full risk spectrum, including on the risks related to disruption of the flow of essential goods and services to majority of the world's population under pre-pandemic and pandemic conditions.
- A new generation of more accurate analyses of comprehensive, complex costs of pandemics. These would include not only the traditional calculation of *economic losses* including changes productivity, but also the more-recently introduced analyses of broader complex *social costs* (e.g. health, inequity, crime, political failure and disruption) *and macro-systemic costs of complex, interrelated multiple-systemic failure* of supply chains of essential goods and services and of critical infrastructure at national and global level as well as the *added* costs of potential recovery of function in these systems. Good cost analyses of this latter, more comprehensive type do not currently exist. Related to such more sophisticated systems-based cost estimates is the challenge of generating *discount rates* that would help policymakers determine how much to invest in the present in order to realize a future benefit in pandemic risk reduction. Calculation of these rates is notoriously subject to differences in methodology, assumptions, and ethical

considerations.

- **Financial and Resource Tracking, Monitoring and Evaluation.** Aside from the now-familiar, inconsistent reporting by donors, a major challenge plaguing the current state of pandemic risk financing is the widely acknowledged inadequacy of current systems for financial tracking and accountability of resources. Without an accurate and transparent means of tracking and accounting for the application (and outcomes) of available resources, pandemic risk management in all its forms will continue to manifest delayed timeliness and coordination of response, and inefficient use of resources—all translating into unnecessary loss of life, damage to livelihoods and wasted investments. According to one independent review, current tools for tracking donor financial resources are not adequate, to “reliably understand, measure, and compare the amounts and types of resources that have been pledged, what resources have been disbursed, and what gaps remain unfilled.”⁶⁹ As summarised by Global Health ONE, problem details are many, and include lack of standardised reporting; inconsistent reporting (definitional problems with pledges, commitments, disbursements); tracking only humanitarian relief; confusion about in-kind contributions; concurrent parallel channel reporting on prevention, risk reduction; and research; and lack of implementation tracking to determine optimal allocative and operational efficiencies.

4. Human Capital Resources

At a global level, CPRMS planning would need to define the categories, standards, and norms necessary to develop and establish a sustainable human resource infrastructure of the global CPRMS. This would include the development of international educational training and practice standards for the development and deployment of various categories of technical expertise for the CPRMS. Principal categories would include not only “one-health” human and veterinary professionals, but also planners and managers of long-term and emergency managers in the eight essential service and critical infrastructure sectors at global, regional and national levels. Provisions for the deployment of trained teams for rapid-response outbreak investigation, surveillance, outbreak containment, clinical management, communications, community outreach and psychosocial interventions, and logistical support will also be high priority.

To make this possible, international coalitions and cooperative networks involving major public and private academic and training institutions would be mobilised and appropriately supported by the global CPRMS, and related regional and national organisations. Internationally supported education and training of researchers and senior leaders and managers should include knowledge and skills related to assessing direct and indirect risks and impacts of infectious diseases on society; predictive analytics and modelling using evolving cognitive computing technologies; and to the institutional, collaborative management of comprehensive pandemic risks in large scale, complex -system environments.

5. Essential Commodities and Logistics

Commodities related to the delivery of the above essential services would include selected strategic stockpiles of medical and non-medical commodities, including other resources, such as food, water, fuel, and accessible cash and credit, to permit access to essential goods and services in the absence of access to banking and finance systems during emergencies.

6. Operational Service Delivery

At the global level, the overriding purpose of this systems element is to secure the functional,

operational integrity and continuity of the previously defined, eight essential services and critical infrastructure sub-systems that enable the necessary flow of critical goods and services to sustain the globalised socio-economy. This would, illustratively, include the adequate capacity to deliver goods and services related to:

- a. Emergency Health and Humanitarian Response, including
 - Emergency response to contain and mitigate the health impacts of outbreaks, epidemics and potential pandemics, by the concerned public international, civil, and public-private international organizations like the WHO, OCHA, UNICEF, the World Bank, MSF, Save the Children, and others.
 - Related humanitarian response to provide assistance to preserve life, health, and human security—for example, through the WFP, OCHA, and the IFRC.
- b. International and inter-regional supply-chain-continuity of essential goods, services, and infrastructure, including
 - Insurance guarantees for key international and inter-regional sea, air, and land shipping operators, with priority for energy, food, water, vaccines, essential drugs, supplies and other defined critical commodities
 - Key international banking and financing entities to ensure critical access to credit and cash
 - Key global producers and international distributors of energy and power
 - Key telecommunication networks and support systems
 - Key food producers, international distributors, and related means of transport
 - Dominant international security frameworks (UN, Security Council, G 20).

Global Steps Ahead

Initiating International Consensus-Building and Advocacy

A consensus-oriented process of international, regional, and national multisectoral and multidisciplinary stakeholder consultations is needed to initiate the exploration and development of a conceptual strategic framework for the global CPRMS.

The initiative would begin with the organisation and conduct of a series of international stakeholder meetings to generate awareness building, and commitment to a global vision and agenda for a global CPRMS and its coordinated and integrated development at global, regional, and national levels. Initial organisers and sponsors might include a coalition among the primary international public organizations (e.g. WHO, UNISDR, OIE, UNDP, FAO, and WFP); national representation from the G 20 and largest bilateral development donors; international financing organisations, especially the World Bank and the IMF; and major philanthropic organisations (e.g. Bill and Melinda Gates Foundation, Rockefeller Foundation, the Wellcome Trust). The eventual list of participant stakeholders would represent not only the *de facto* public-private global health system, as identified by Chatham House (see Part II, Section 3. A. 1 on Governance and Leadership), but also key multisectoral, public and private stakeholders in the global socio-economy. This would include representatives of government strategic and security planning entities; international corporate membership of the World Economic Forum; major industries connected with international trade and delivery of essential services and critical infrastructure (transport, energy, power, telecommunications, finance and banking, pharmaceuticals and biologics, food security, etc.); key humanitarian service organisations; academic and policy research institutions; and consumer and human rights organisations. To develop such a definitive participant list, Chatham House or a group of research institutions should collaborate in a similar analysis related to identify the principal *de*

facto global multisectoral systems network related to CPRMS.

The structure and agenda of such stakeholder consultations should be collaboratively formulated and staged to permit the initial deliberations on the fundamental conceptual framework (i.e. the “what”) to be followed by additional meetings designed to explore and articulate an agenda for the “how” – i.e. the strategic planning as well as the sustainable financing of a workable conceptual CPRMS model. Topics on the discussion agenda would include the development of a global strategic, policy and legislative framework as well as that related to the structure and function of the integrated global, regional and national CPRMS systems in terms of the standard six institutional system building blocks (end of Part I). Related important issues would include the operational definition of the “risk spectrum,” the “essential global services and critical global infrastructure” related to regional and health and human security; and the identification of countries and populations particularly vulnerable to severe disruptions of international supply chains of essential goods and services.

Outcomes of the discussions should be widely distributed to the concerned stakeholders as well as the public, to inform debate on national and international public policy, strategy, regulatory and legislative frameworks. A summative meeting/event should be held to announce and propose a prospective action agenda to guide the subsequent collaborative development and implementation of a global CPRMS.

Governance and Leadership Framework

The above consensus-building and advocacy process might initiate steps leading to the institutionalisation of an UN-based, collaborative governance and leadership framework for the CPRMS. Based on a proposal supported by a coalition of member states, the UN General Assembly might approve a non-binding resolution and refer the issue for the binding resolution of the Security Council in order to establish a “UN Organization on Global Catastrophic Risks” (OGCR). The OGCR would be led by a *Special Representative of the Secretary General on Global Catastrophic Risk Management*, an institutionalised role, within the Executive Office of the Secretary General (EOSG). As a continuation of the institutional development process, a multisectoral, public-private “Centre on Comprehensive Pandemic Risk Management” (CCPRM), would be instituted under the lead of a “Special UN Pandemic Risk Management Coordinator.” Other Centres would each focus on separate, defined global catastrophic risks using, in-part, an “all-hazards” approach to mitigate the large-scale systemic impacts of catastrophic and existential threats.

Continuity of Ongoing Initiatives

Anticipating the above potential developments, it is critical that many existing international initiatives on emergency preparedness and response supported by international stakeholders be continued within a balanced perspective that must include regional and national policies, programs and actions. While these are not oriented to a comprehensive risk management approach, they constitute an important dimension of the CPRMS as advocated in this paper. A number of the most important actions should include the following:

- A number of ongoing “universal health security” initiatives, including the *Global Health Security Agenda*, collaboratively pursued by the WHO, the Organization for Animal Health (OIE), the World Bank, and other stakeholders. A special focus of these initiatives would continue to strengthen national capacities to fulfill the requirements of the International Health Regulations (IHR).
- The Coalition for Epidemic Preparedness Innovations (CEPI), whose purpose is the preemptive, rapid development and approval of vaccines against the most likely microbes, for prompt distribution following outbreaks. CEPI also aims to help select countries

strengthen their capacity for preparedness and response.

- A series of additional actions by the international stakeholder community to strengthen global preparedness and response capacity, include the WHO's Health Emergency Program (HEP), the World Bank's Contingent Emergency Response Component (CERC), and the Africa Risk Capacity (ARC) program.

Other Recommended Interim Steps

The concerned stakeholder community should encourage and begin funding evidence-based analyses of the risks attendant the most critical parts of the pandemic risk spectrum. The purpose would be to determine the costs and benefits of the CPRMS against the comprehensive costs of a severe pandemic – i.e., not only the direct economic costs; indirect costs of human mortality and morbidity; but also, the additional, cascading indirect costs that ripple throughout the socio-economy. These costs should include both, the delayed costs of recovery, as well as the possible irreversibility of certain systemic failures.

The report of the International Working Group on Financing Preparedness, entitled *From Panic and Neglect to Investing in Health Security* (2017) provides a number of recommendations compatible with and useful to the broader agenda of the CPRMS described in this paper:

Bilateral, multilateral, and private international development partners should:

- Commit support to finance national pandemic preparedness activities in priority countries and help mobilise domestic, national resource mobilisation.
- The World Bank should integrate the economic risks of infectious diseases into its macroeconomic and market assessments.
- The World Bank should continue the development and promotion of experimental insurance products like its Pandemic Emergency Facility (PEF) to stimulate private sector investment to support rapid response and recovery from infectious disease outbreaks among under-resourced countries; and to advocate for the sustained budgeting of domestic resources for pandemic preparedness and response.
- The World Bank should develop and include preparedness indicators for a comprehensive pandemic risk management approach in the country-specific systemic country diagnostics; in the Country Policy Institutional Assessment (CPI) tool; and its International Development Association (IDA) loan allocations for the poorest developing countries.
- The WHO should develop benchmarks for core capabilities and performance of national health systems; create a mechanism to assess their performance; and provide technical assistance to fill any gaps;
- The WHO should continue improvements in its *Center for Health Emergency Preparedness and Response* and a sustainable contingency fund of \$100 million to support rapid deployment of emergency response assistance; generate a daily high-priority "watch list" of outbreaks and encourage preparedness activities;
- International R&D stakeholders should commit \$1 billion a year for the development of new drugs, vaccines, diagnostics, personal protective equipment, and medical devices; and
- The UN, World Bank, IMF and various bilateral and multilateral funders should secure financial support for lower-middle- and low-income countries; establish clear mechanisms for coordinating responses; and establish an enhanced Pandemic Emergency Financing Facility as a rapidly deployable source of funds.⁷⁰

National CPRMS Implementation

While a coherent, coordinated global strategic vision and master plan for the CPRMS requires a functioning institutionalised global system, national CPRMS systems are of central importance. Just

as all politics have been said to be “local,” so too prevention, risk management, and mitigation of pandemics achieves full meaning at the local and national level -- the front-line functional framework for risk management and response efforts.

The overall goal of a national CPRMS would be to protect national human, socioeconomic, and governance security from the direct and indirect risks of epidemics and pandemics.

The purpose of an institutionalised national CPRMS would be to systematically plan, coordinate, and implement country wide and local actions to prevent, reduce and manage pandemic risks and mitigate socioeconomic pandemic impacts along the pandemic risk spectrum at national and local levels. This would include the prevention, reduction of risks to, and mitigation of disruptions in the livelihoods and supply of essential goods and services, country-wide, and among particularly vulnerable populations.

In keeping with the previously-described illustrative framework of the *global* CPRMS, the complementary national CPRMS would also be reflected in its system-building blocks, including the interrelated aspects of governance, financing, information and knowledge systems, human resources, commodities/logistics, and essential operational services. It is beyond the purpose of this paper to present a full exposition of national and regional systems elements. Accordingly, we will selectively comment on the governance systems element, and then proceed to highlight the national “way ahead.”

Consistent with the multisectoral approach advocated in this paper, the focus of a national system governance network should be a multisectoral body with select public-private representation of key service sectors and critical infrastructure. In many countries, approximations of this model of governance and executive action is vested in national disaster management organizations (DMOs), with leadership sometimes held at ministerial level. An example of this approach, though weak on involvement of key private sector organisations, is found in the Republic of Philippines working group, the National Disaster Risk Reduction and Management Council (NDRRMC), which includes government, non-government, private, and civil sector entities, all chaired by the Secretary of the Department of National Defense.^{71,72}

A model of the national CPRMS worthy of examination for the “way ahead” would be one institutionalised within a multisectoral, public-private national disaster management organisation, led by a “beyond health” minister as chief executive or special coordinator.

National Steps Ahead:

- All countries would strengthen and/or establish financially and organisationally sustainable multisectoral, comprehensive pandemic risk management working groups within their national disaster management organisational frameworks. Leadership needs to be at an appropriately high level, and membership include empowered government, civil society, and private sector organisations, each with key roles in the provision of essential health and socioeconomic services and critical infrastructure.
- National governments would secure a formal political, social and financial commitment to national human security through a comprehensive national CPRMS.
- Countries should conduct, with development donors and private sector support, a comprehensive assessment of risks and related financial needs along the entire multisectoral pandemic risk spectrum. This would include a gap assessment in compliance with the International Health Regulations (IHR) via the Joint External Evaluation (JEE) process, and the animal-health oriented, international Performance of Veterinary Services (PVS) protocol.⁷³
- Importantly, the full-spectrum, national pandemic risk assessment would include the

risks to the functional flow of essential services and integrity of critical infrastructure during a severe pandemic.

- Develop a prioritized, costed “National Pandemic Risk Management Plan” with participation of all multisectoral domestic and international public-private stakeholders.
- Develop a related budget and financial plan to secure a sustainable resource base for its execution, considering as possible resources various innovative forms of taxation; international development assistance; and appropriately regulated private sector investments in the national multisectoral pandemic risk management agenda.⁷⁴

Regional Implementation

The overall regional goal of the CPRMS would be to protect global human, and civilisational security from the direct and indirect risks of pandemics to regional human welfare.

The purpose of an institutionalised CPRMS would be to systematically plan, coordinate, and implement regional actions to prevent, reduce and manage pandemic risks and mitigate pandemic impacts along the pandemic risk spectrum among the countries of the region. This would include the prevention, reduction of risks to, and mitigation of disruptions in the supply of essential goods and services, to particularly vulnerable countries of the region and their populations.

The purpose of regional CPRMS governance and leadership functions would be to bridge between relevant global policy, strategic and operational functions and analogous functions at the national level. This coordination and mediation would be conducted in close collaboration with the key UN organizations (e.g. WHO, FAO, and UN ISDR), their regional representatives, and other concerned public international organisations. Similar to the integrated global governance and leadership architecture, the regional governing framework would need to engage a variety of regional organisations whose missions and role are best suited to participate in a regional CPRMS, with inclusion of representatives from concerned governments and key regional civil society and private, corporate entities.

Examples of regional cooperation organisations that would likely play a role in the development of the CPRMS governing architecture within their regions would include organisations like the Association of Southeast Asian Nations (ASEAN), the Asia-Pacific Economic Cooperation (APEC), the African Union (AU), the Caribbean Community (CARICOM), the European Union (EU), the Arab League (AL), and the Union of South American Nations (USAN), as well as other respective regional organisations specifically involved with disaster management and humanitarian assistance, like the ASEAN Coordinating Centre for Humanitarian Assistance (AHA).

The best example of an existing regional, international agreement, specifically committed to multisectoral regional cooperation related to the management of risks from infectious disease is the North American Plan for Avian and Pandemic Influenza (NAPAPI), which provides a comprehensive, regional and cross-sectoral, health security framework among Canada, the U.S., and Mexico. The Plan aims to strengthen emergency response capacities, as well as the development of trilateral collaboration to enable a coordinated response to outbreaks of animal or human influenza.⁷⁵ Specifically, the Plan provides for,

- Mutual assistance during a response, particularly with regard to sharing medical countermeasures and personnel;
- Interconnected systems for surveillance and early warning;
- Protocols for emergency communications, laboratory sample transportation, and joint epidemiological investigations;
- Integration on human and animal health; and
- Development of border policies and protection of critical infrastructure.

The NAPAPI model for regional cooperation but modified to explicitly focus on the goal and purpose of CPRMS should be considered for each geographic region, as an important contribution to the global framework for governance and leadership. It would help strengthen regional coordination of policy, strategy, program design and implementation, and in the conduct of preparedness and response operations. Each regional organisation so oriented would potentially organise their activities around a “Regional Comprehensive Pandemic Risk Management Plan,” in accordance with the respective regional strategy.

Regional Steps Ahead

- Key representatives of public and private regional organisation stakeholders would participate in the development of the global CPRMS structural and functional framework. The generated consensus, principles, and guidelines would in turn inform the development of distinct but globally harmonised regional CPRMS systems within each respective region.
- To that end, all regional organisations would establish and convene multisectoral working groups on comprehensive pandemic risk management within their national disaster management frameworks. These working groups would establish the regional CPRMS within their regions, each under appropriately high-level leadership, and political involvement of member states, regional civil society, and private sector networks. The latter would include organisations with key roles in the provision of essential services and critical infrastructure.
- The regional CPRMS organisations would conduct comprehensive regional risk assessments along the entire relevant multisectoral pandemic risk spectrum, including both health and other essential sectors.
- Subsequently, assessments of currently available financial resources would be supplemented with estimates of unmet resource needs necessary for prospective budget and financial planning.
- Based on the risk assessments, each regional CPRMS would develop a “Regional Pandemic Risk Management Strategy.”
- Each regional CPRMS would establish alliances among regional neighbour countries intended to strengthen their collective and country-specific emergency preparedness and response capacities, as well as the development of multilateral collaboration and capacities, to enable a coordinated preparedness and response capacity to outbreaks within the region. Agreements among regional partner states would provide for the sharing of medical countermeasures and personnel; cooperative surveillance, early warning, outbreak investigation and response for containment; protocols for strategic communication; provisions for laboratory sample transportation and testing; and integrated “one health” system development. Importantly, the collaborative regional agreements would provide for the development of harmonised border controls for trade and population movement, and the functional continuity of the flow of essential services and the protection of critical infrastructure important to the entire region.
- Finally, regional CPRMS governance would oversee the development of a prioritized, costed, Implementation Plan along with a budget and financial plan to secure a sustainable resource base for plan execution. A variety of standard and innovative funding sources would be considered, involving all regional stakeholders, member states, public, private and corporate organisations, as well as external development donors.

Conclusion; and Next Steps Towards Comprehensive Pandemic Risk Management

“We acknowledge that governments should continue to focus most attention on more likely small-scale outbreak threats, but some modicum of attention should be paid to the extreme end of the risk spectrum – pandemic events that could profoundly affect the arc of history. To date, that extreme end has gone largely ignored in even the wealthiest nations. The consequences could be, will be, catastrophic.”⁷⁶

-- Clade X, Pandemic scenario exercise,
Johns Hopkins University Bloomberg School of Public Health Center for Health Security

The perspective offered in this paper argues for a paradigm shift to what we called the “full-risk spectrum” approach to managing the multisectoral, beyond-health risks of catastrophic pandemics. In light of an emerging understanding that a severe pandemic can be an existential threat to civilisation, the approach is presented as global public good.

The world is not prepared for a severe pandemic, whether of natural or engineered sources. This looming threat implies serious risk of potentially catastrophic impacts not only on global health, but also on other systemically interdependent sectors critical to human and civilisational security in today’s complex, tightly interconnected and highly interdependent globalised socio-economy. The primary health impacts of a severe pandemic shock can propagate rapidly to disrupt the flow of interdependent goods and services that make our global economy and industrialised civilisation. Importantly, the threat of severe pandemics is nested in an evolving process of fundamental transformation of civilisational risk and vulnerability from multiple concurrent and growing systemic stressors that include ecological, resource, demographic, climatic, financial, and political predicaments.

In the absence of effective global governance and leadership, the prevailing international strategic orientation for pandemic risk management is focused on health-sector-centered preparedness and response, emphasising the strengthening of national and international public health systems to prevent local outbreaks from becoming international emergencies. While necessary, this approach is neither sufficient, efficient, or sustainable. In spite of a fledgling One Health (integrated, animal-human) orientation and references to multisectorality, the *de facto* approach is for the most part reactive, overly focused on direct impacts on human health from local outbreaks rather than on a balanced, comprehensive and integrated, (beyond-health) approach to human and civilisational security.

A more comprehensive, proactive and complex-systems-based global strategy for the management of high-consequence pandemics is necessary as an important global public good. The architecture of a full-spectrum CPRMS would be founded on a risk-management framework that includes a continuum of risk nodes. The risk continuum would begin with the genetic risk of emergence of microbes with pandemic potential, and progress to the risk dynamics of intra-animal species amplification; then, animal-human transmission and spread; human-human transmission; and finally, to risks to the functional continuity of societal essential services and critical infrastructure. The approach would emphasise primary prevention and risk reduction in key essential service and infrastructure sectors, including but transcending the One Health model, and its conventional moments for emergency preparedness, response, containment, and recovery. When viewed through a systems lens, the CPRMS would have the generic attributes of a hazard-independent risk management system which can be applied to managing the (similar) risks of impacts from other large-scale systemic shocks, such as global financial failure or large, multi-systemic cyber-attacks.

The CPRMS presented in this paper is conceived as both a necessary and a feasible approach to enhance global health, human, and civilisational security as a global public good. Key characteristics and principles underpinning the CPRMS include its being risk-based, and evidence-based through application of the complex-systems disciplines. The approach would also be committed to a long-term, multisectoral, beyond-One Health, Whole-of Society process, integrating prevention, preparedness and response in health, essential services, and critical infrastructure. It needs to be sustainable to remain effective in meeting 21st century challenges at both national, and international levels. Institutionally, a CPRMS would also be structured as a system that provides for the critical six functions: leadership and governance; financing; information systems management; requisite human resources; essential commodities and related logistics; and a capacity for operational interventions and service delivery. Critical to the CPRMS system would be a strategic coherence; a systematic, preventive risk-management policy agenda; harmonised leadership; effective governance and organisation; and sustainable funding.

A Paradigm Shift

The systems-centered approach central to this concept on the CPRMS is also part of a broader paradigm shift that is gradually gaining recognition, in part due to gains in the data-based understanding of impacts of civilisation on the planetary systems, including the stability of climate, and biodiversity. A systems approach based on the principles and illustrative examples presented in this paper holds the promise of radically changing our capacity to manage the risks of pandemics and help safeguard global human security in a hyper-connected world. In addition to the widely accepted, if not adequately operationalised One Health and Whole of Society memes, and to the breakthrough concept reflected in the Global Virome Project (another recent example of a complex systems mindset), is the establishment of the Planetary Health Alliance.⁷⁷ Fundamental to its founders' vision is the definition of "planetary health" as "the health of human civilisations and the ecosystems upon which they depend." Of central importance in this effort is the capacity of human institutions to address global challenges impacting the stability and sustainability of global civilization within the context of the momentous geospheric and biospheric changes now underway. The concern with "global health security" that is at the core of this paper is one of those critical challenges.

In light of the increasingly complex nature of globalised industrial civilisation and the related ongoing radical transformation of risks from pandemics as potentially globally catastrophic threats, there are several summative points of consequence to global, regional and policy formation that are worth mentioning. These are certainly not exhaustive but help to set the stage for the way ahead.

The first, is that current international efforts now underway under the banner of global health security be urgently expanded to generate a system of multi-stakeholder governance, sustainable financing, strategic planning and operational capacity building to effectively manage systemic risk from pandemics. The CPRMS should therefore be seen as an initial stepping stone to the improved management of risk from a variety of emerging existential threats to civilisation. Existing health-centred approaches to pandemic preparedness are not sufficient, for they neglect the management of risk to the continuity of globally interconnected infrastructure, goods, and services. During this century of increasingly costly and unprecedented planetary stressors ranging from the climate change to the depletion of natural resources, environmental degradation, and uncontrollable conflicts threatening the welfare of billions, a comprehensive, prevention-oriented system to reduce and manage the multisectoral risks of catastrophic pandemics may vastly reduce the long-term costs of global health and human security.

The second, is that the new approaches and institutions concerned with governance, leadership, policy formation, and financing of a CPRMS should be structured and empowered to function consistently in the interest of the global public good, transcending the constraints of interests of

individual nation states to protect the global commons.

The third, is that just as our understanding of the global socioeconomy and natural ecology has been much enhanced by advances in systems science, solutions to the CPRMS and to other global systemic risks, should actively and rigorously harness the tools and methods of complexity science, modern information and bio-technology. Ongoing progress in these technologies will be driven by the growing power of modern computing, including socially-responsible artificial intelligence. Just as pandemics and their determinants and drivers are part of a complex system, so must be the evolving, complexity-savvy approach to pandemic risk management. Together, these emerging technologies can contribute to a base of actionable, and rigorous evidence-based information that can translate to options in strategy, policy, program planning, operations, monitoring and evaluation. Key problems will need to be articulated as researchable questions, subject to the currently known methods of complexity thinking and practice, and efforts made to apply the knowledge and understanding within organizations socio-technical environments.

A fourth observation refers to the critical, elusive challenge of an effective means of *governance and leadership* to serve in the global public interest, not only on health security, but on the other existential threats to civilisation and planetary health. New ways of generating consensus, organization-to-scale, necessary resources, and operational capacity to achieve effective comprehensive pandemic risk management. Socially-sanctioned global systems of governance have never been more important, given the scale and power of human impact on one interconnected planetary system on which the future of civilisation and human security is utterly dependent.

The Roadmap

An illustrative “Roadmap” to a CPRMS was presented, providing a glimpse of a potential system architecture, and actions that may help chart the path to a coherent CPRMS framework, functioning at global, national, and regional levels. At each geographic level the critical six systemic functions (governance/leadership, financing, information systems, etc.) contribute to the operational achievement of CPRMS goals and objectives.

In its global dimension, the goal of the CPRMS is to protect human and civilisational security from the direct and indirect risks of pandemics to human welfare. At this level, the principal focus should be the effective management of risks to global health and to the flows of essential global services and infrastructure, as a global public good.

Since no one existing institution has the capacity to exercise effective world-wide cooperative leadership, new models of global crisis *governance* involving key global public international, national, and non-government stakeholders need to be considered. An illustrative institutional example was described: One endorsed by the UN General Assembly and the Security Council and located within a “Center on Comprehensive Pandemic Risk Management.” under the lead of a “Special UN Pandemic Risk Management Coordinator.” Innovative approaches to sustainable financing, information and human resources, commodity and operational service delivery to support the global CPRMS agenda will also be needed, including the consideration of innovative revenue generation, generated from a range of previously unexplored sources. Illustratively, these might include those from the management of global natural resources; from the issuance of Special Drawing Rights; or from taxation of negative global externalities such as carbon emissions.

The national aspect of the CPRMS Roadmap constitutes the front line of the integrated system, and its effective functionality is fundamental to the integrity and effectiveness of the overall CPRMS. The goal of national systems would be to protect the human, socioeconomic, and governance security of countries from the direct and indirect risks of epidemics and pandemics. The purpose of institutionalised national systems would be to systematically plan, coordinate, and implement

country-wide and local actions to prevent, reduce and manage pandemic risks along the pandemic risk spectrum. Consistent with a multisectoral approach, the focus of a national CPRMS system governance network should be a multisectoral body with select public-private representation of key service sectors and critical infrastructure, led by a “beyond-health” minister as chief executive or special coordinator.

Progress in the national sphere, would include the formation of national sectoral working groups; the development of comprehensive multisectoral pandemic risk assessments as a basis for national pandemic risk management plans; and related provisions for sustainable financing.

The goal of the regional dimension of the CPRMS would be to protect global human and civilisational security from the direct and indirect risks of pandemics to human health and welfare among the countries of the region. The purpose at this level would be to systematically plan, coordinate, and implement regional actions to prevent, reduce and manage pandemic risk and mitigate direct and indirect pandemic impacts along the pandemic risk spectrum among the countries of the region, in concert with global efforts and their lead organizations. Examples of existing regional cooperation organisations such as the North American Plan for Avian and Pandemic Influenza were provided, to illustrate the model potential of regional CPRMS institutions.

Regional progress would depend on consensus among key regional public and private stakeholders; the organisation and establishment of regional systems within each region, each with its own multisectoral, public-private governance and leadership structure; and steps to generate comprehensive regional pandemic risk assessments, regional strategies, implementation plans, and cooperative alliances and agreements on sustainable financing of regional efforts.

Next Steps: Towards the Launch of a Globally Integrated CPRMS

These Next Steps provide one illustrative vision of an agenda and practical initiatives for the consideration of an apparent, but not yet adequately activated *globalised stakeholder community*.

Target Audience: This paper aims at the emergent, *de-facto*, informal public-private stakeholders with an interest in the broad, multisectoral systemic determinants of global environmental and human security. One limited example of a relevant stakeholder community was illustrated in this paper through reference to the Chatham House study that identified a set of organisations as the *de facto* public-private global “health system” with capacity for strategic influence, resource mobilisation, and operational intervention.⁷⁸ In this context, however, we envision a *de facto*, informal system of a broader set of global, multiple-sector actors whose interest can extend to the broader, beyond-health system management of severe-catastrophic pandemics and other potential existential threats. The identification of the dominant public and private constituents of such an emerging “de-facto” system functioning in the interest of human security by a credible research institution or think tank would be a worthwhile endeavor.

This broader stakeholder community can initiate a process of strategic dialogue on governance, policy, and financing, under the convening capacity and role of the UN (General Assembly, World Health Assembly, Security Council), in partnership with major multilateral, bilateral, regional, private, academic, and NGO organisations.

Goal: To facilitate a global consensus on a “strategic convergence” between current international initiatives in global health security, on the one hand, and the “missing strategy “ of the CPRMS, which explicitly includes the global multisectoral risk management of catastrophic pandemics.⁷⁹

This strategic shift would guide innovative efforts leading to the comprehensive risk

management of pandemics as complex disasters of scale, whose impacts threaten global and national systems of essential services and critical infrastructure. In addition, the strategic shift would help in the development of innovative, complexity-based systems to manage the numerous risks and vulnerabilities associated with pandemics (including those caused by novel, natural or engineered microbes).

The emergent paradigm would also serve as a, system-based model for the further development of risk management of other large-scale catastrophic shocks (e.g. major financial collapse, or large-scale power grid failure) with ultimate impacts on continuity and function of essential services and critical infrastructure in the modern, globalised socio-economy.

Purpose: In light of the above goal, organise a series of high-level consultative events involving select representatives of prominent multiple-sector, public and private organisations with significant roles and influence relevant to the systemic management of risks of severe pandemics.

Assumptions: A continued commitment to the following internationally-endorsed initiatives:

1. The current international consensus on global health security, including the universal compliance with the objectives of the IHR; the objectives of the multi-national Global Health Security Agenda (GHSA); and other related international conventions and initiatives endorsed by the WHO, FAO and OIE.
2. Existing international efforts to encourage low-to-mid-income countries to self-finance most or all costs of national compliance with IHR and OIE animal health requirements.
3. Addressing the current, serious financial resource gap for *prevention, risk-reduction, and preparedness* against outbreaks of infectious disease with pandemic potential at global, regional, and national levels.

Objectives: The series of consultative events will advance the development of the CPRMS through the following topical objectives:

1. *Risks, Costs and Benefits.* Generate an updated, evidence-based analysis of multisectoral, systemic risks of catastrophic pandemics, and of their related economic, social, and systemic (continuity of flow of essential goods and services) costs; Current level of investments in managing the risks; Necessary levels of additional investment needed to acceptably manage these risks.
2. *The CPRMS Model.* Present and deliberate on a CPRMS-like model to systematically manage these risks across the entire risk spectrum, to include the impact risks in global and national supply chains of essential goods and services and critical infrastructure.
3. *The CPRMS Systems Framework.* The outlines of an institutionalised system (its six system components, as discussed) for the CPRMS.
4. *Governance and Financing the CPRMS.* A stakeholder resolution, with recommended next steps to formalise governance and sustainable financing functions, centering them within the UN system, under a broad, novel public-private participatory governance framework; outlining a prospective approach to further develop and implement the CPRMS.
5. *Informing the global stakeholders and concerned public.* Take appropriate steps to widely disperse information about the CPRMS consultation process and its outputs, outcomes, and next steps, via written and electronic media.

Time-frame; and Phases: The proposed Next Steps activities would span a time horizon of *three years* and be implemented in *three phases of work*.

Informing the Process: Activities, events and deliberations describing each of the three phases would each be informed by prior preparatory studies, analyses, and related reports. The

study/analysis agenda would be formulated by members of an expert technical advisory group and financed by a Trust Fund specifically established for this initiative (see section on financing, below). The events can include carefully selected *table top simulation exercises* to showcase particular challenges and to consider impacts of alternate strategies and policies, with respect to current and future risks to human security. Methods and tools of applied complexity science would be introduced and integrated into the agenda, with participation of select partners and subject matter experts from the complexity disciplines.

Phase I: Organising, Launching the CPRMS Consultative Process

- *Organisation, Financing, Implementation Planning.* The World Bank Group (WBG) convenes a Stakeholder Advisory Steering Group to agree on the concept, organisation financing, general agenda for global, regional and country-specific consultations, and the related research/study/analysis plan to inform the 3-year stakeholder consultative process. Participants: Select advisory Steering group members identified by the WBG and a small number of representatives from leading public international organisations, countries, foundations, international private sector and NGO organizations.
- Conduct First Global Kick-off High-level Stakeholder Consultation
 - Present, analyse, and discuss the multisectoral risk spectrum associated with severe, catastrophic pandemics; possible simulation(s).
 - Summarize current expenditures, costs, benefits and gap analysis for the current approach to infectious disease preparedness and response.
 - Introduce the CPRMS concept as a generic, systems-based, multisectoral approach to pandemic risk management. Articulate its principal structural and functional features and attributes; and its primary global, regional and national roles, and functions.
 - Agree on goals, objectives, deliverables, process of the consultative series.
- *Continue with similar regional consultative events* – one in each geographic region. The CPRMS at regional level – structure, function?
- *Continue with select sub-regional or country events* in 3 middle-income and 3 low income countries. The CPRMS at country level – structure, function?
- Analyze and Summarise outputs/outcomes of the initial global, regional, country consultative process.
- Conduct a *Second global high-level consultative event* to present and discuss progress, outcomes from Phase I, and to advance recommendations in order to inform Phase II of the CPRMS consultative process. Include recommendations and plans for the preparatory conduct of studies and analyses to be completed prior to implementation of Phase II.

Phase II: The CPRMS as an Institutional System; Its Governance and Financing at all Levels

- Conduct the *Third, high-level global stakeholder consultation*; two related regional consultations; and three select country consultations in order to:
 - Identify and discuss the previously presented six “building blocks” of the CPRMS as a “system” at global, regional and country levels; ⁸⁰
 - Agree on the process and steps leading to the eventual establishment of an inclusive, UN-based, public-private participatory *governance framework* for the CPRMS;
 - Identify and discuss the options for the *adequate and sustainable financing* of the CPRMS at global, regional and country levels. An important option for sustainable CPRMS financing should include innovative approaches to organised private investment in comprehensive risk management technologies and their application.
- Analyse and summarise outputs and outcomes of the global, regional, country

consultative process.

- Conduct a *Fourth, high-level global consultation event* to present and discuss progress, outcomes from Phase II with an emphasis on governance and financing, and to advance recommendations, in order to inform Phase III of the CPRMS consultative process. Include recommendations and plans for the preparatory conduct of studies and analyses to be completed prior to implementation of Phase III.

Phase III: Towards the Implementation of the CPRMS

- Conduct the *Fifth, high-level global consultation* in order to review and discuss the outcomes of Phase II, as informed by the subsequent studies and analyses conducted in the wake of Phase II.
- Reach consensus on approaches to CPRMS leadership and governance and to the sustainable financing of the CPRMS at all levels;
- Formulate a *Resolution* and a recommended approach for the *governance* of the CPRMS, with endorsement of the participating stakeholder community for delivery to the UN Secretary General for consideration of the General Assembly and the UN Security Council. The resolution would include a recommendation to establish a possible (as one option) executive coordinating body on large-scale global systemic risk, like a “*UN Organization on Global Catastrophic Risks*”, with a number of risk-specific Global Systemic Risk Centres, including a Centre on Comprehensive Pandemic Risk Management (CCPRM), under the lead of a Special UN Pandemic Risk Management Coordinator.
- Formulate a *Resolution* concerning the recommended approach to the *financing* system, to support all building block system components of the CPRMS.
- Formulate a *Proposed Plan* for advancing the consensus towards ongoing, prospective development and implementation of the CPRMS, with a particular focus on its governance and financing. This would include its advancement for support in such international fora as those of the G 7, the G20, and of the World Economic Forum.
- Implement a widespread *public information campaign* about the consultative process and its outputs, outcomes, and next steps via written and electronic media.

Deliverables:

- A series of global, regional and national consultative events to inform and advance the attainment of above-stated objectives.
- Reports on the above consultative process, its outcomes and results.
- A resolution concerning the recommended approach to the *governance* of the CPRMS, endorsed by the participating stakeholder community and delivered to the UN Secretary General for subsequent consideration of the General Assembly and the UN Security Council.
- A resolution concerning the recommended approach to the *financing* system and the other system components of the CPRMS. This would include the system dimensions on information and knowledge generation (i.e. a research agenda) and management, human resources, material resources and logistics, and operational/service capacity of the CPRMS.
- A proposed plan for advancing the consensus towards ongoing, prospective development and implementation of the CPRMS, with a particular focus on its governance and financing.
- Widespread dissemination of public information about the consultative process and its outputs, outcomes and next steps via written and electronic media.

Organisation, Sponsorship and Coordination of the Consultative Process

Organiser/Coordinator: The World Bank Group (WBG). Notably, the WBG has already conducted a series of international stakeholder consultations between 2016-2019 on the subject of financing of response and preparedness to outbreaks of infectious disease.

Financing Sponsors: A specific Trust Fund set up with donation commitments from national government(s), private foundation(s), corporate donors. The World Bank would manage and track the overall fund. There is precedent for these kind of trust funds by the WBG, such as that established for the international response to the Avian Influenza crisis (2015-2010) and with the response to the Ebola crisis of 2014-2015).

Illustrative Participants: Public and private stakeholders from,

- Governments (national and human security, disaster management organizations. E.g. US Department of Health and Human Services, Centers for Disease Control, National Security Council; similar UK organizations)
- Bilateral development assistance organisations (e.g. DFID, U.S. Agency for International Development, JAICA)
- Multilateral and regional organisations (e.g. UN, WHO, FAO, OIE, UN International Strategy on Risk Reduction (UN ISDR), UN OCHA, World Food Programme, World Bank Group, other Regional Banks, IMF, EU, European Commission, ASEAN, African Union)
- Private Philanthropic Foundations (e.g. Bill and Melinda Gates Foundation, Rockefeller Foundation, Global Challenges Foundation)
- Policy Research organisations and think tanks (e.g. Royal United Services Institute [RUSI], Chatham House)
- Academic institutions, such as the Policy Institute, King's College, London; Cambridge University Center for the Study of Existential Risk; Center for Non-Traditional Security, Nanyang School for International Studies, Singapore.
- International NGOS and humanitarian PVOS (e.g. International Committee of Red Cross, Medecins Sans Frontieres)
- International associations (e.g. World Economic Forum)
- Corporate Industry (energy and power, health, pharmaceuticals, transport, telecommunications, tourism, etc.)
- Defence-related centres for security studies (e.g. related to US, like the Asia Pacific Center for Security Studies, and those in the UK military, like RUSI)
- Institutions involved in the advancement of complexity science (e.g. Santa Fe Institute; The New England Complex Systems Institute; Sandia National Laboratories; The Division of Mathematical Modelling, British Columbia Centre for Disease Control, and its related "Complexity Science for Health Systems Group (CS4HS)"; Northeastern University Department of Physics, Center for Complex Network Research, and Center for Interdisciplinary Research on Complex Systems.)
- Leading organisations in applications of information technology, cognitive computing and artificial intelligence to problems of

human security threats (e.g. Google, and IBM, with its “Watson project” on multidisciplinary applications of cognitive computing and artificial intelligence to problems, including those in medicine, finance, and development.)

Budget for the Consultations: The estimated cost of the consultative series cycle is estimated at US \$4.5 million.

The vision of a comprehensive, pro-active, systems approach to pandemic risk management presented in this paper is dedicated as a global public good in the interest of human security against the threat of catastrophic pandemics.

Annex: Human-caused Pandemics as Threats to National and Global Security

“The threat of state and non-state use of weapons of mass destruction will continue to grow....some applications of technologies may lead to unintentional negative health effects, biological accidents, or deliberate misuse.”⁸¹

-- Daniel R.Coates, US Director of National Intelligence, 2018

Introduction

According to the 2019 Doomsday Clock statement published by the Bulletin of the Atomic Scientists, which includes 15 Nobel laureates, humanity is only two minutes before the symbolic midnight of civilisational catastrophe – as close as it has ever been to this threat. The Bulletin, usually focused on nuclear annihilation, identified two simultaneous threats – nuclear holocaust and climate change -- both exacerbated by weaponised use of information and amplified by other risks in the complex global techno-economy.⁸² The Doomsday Clock algorithm does not presently include the equally real but under-estimated civilisational threat of severe pandemics, natural or engineered.

Bioterrorism and biological warfare, both based on deliberate introduction of microbes with possible pandemic potential, blur the distinction between traditional and non-traditional threats to national and global security. This is particularly true of the feared advent of deliberate, custom-engineered introduction and global spread of microbes as weapons of large-scale mass destruction (WMDs) – something that as yet has no precedent. In such circumstances, it may be that bio-terror-engineered microbes including strains of plant pathogens such as smut of wheat, could cause widespread destruction of grains and therefore impact food insecurity. The impact would be significant, with large-scale human mortality caused through famines and other diseases. There is also a possibility that the growing threat of widely-documented natural antimicrobial resistance, could be hijacked and with AMR genetically and deliberately manipulated.

All this adds an additional threat of to the world of the 21st Century. One in which all manner of

microbes -- viruses, bacteria, and fungi -- may be deliberately rendered resistant against existing or future antimicrobial countermeasures. Weaponised use of microbes by both sovereign military establishments as well as by small “non-state” terrorist groups or individuals, albeit on a relatively small scale, is a matter of historical record. Professor Yonah Alexander included the following examples of deliberate human spread of naturally-occurring microbes.⁸³

- In the year 1346, during a siege of the city of Kaffa (in current Crimea), the invading forces catapulted corpses of victims of smallpox to introduce that disease into the besieged city.
- In 1767, during the French Indian Wars in North America, English soldiers distributed smallpox-virus-infested blankets to infect the resisting native American population.
- In 1972 the neo-Nazi group “Order of the Rising Sun” planned to infect the water supplies of some Midwest cities in the US with an agent intended to spread typhus.
- In 1980 the German Red Army Faction in Paris, France, was caught producing *Clostridium botulinum* bacteria for bioterror operations.
- In 1994 and 1995 the Japanese doomsday cult Aum Shinrikyo carried out neuro-active pathogen attacks, including the infamous sarin attack on the Tokyo subway (1995).
- In the wake of the terror 9/11 attacks, a rogue U.S. government research scientist sent letters containing anthrax spores to various individuals, including members of the U.S. Senate, resulting in the infection of 18 persons, of whom five died.
- In January of 2016, ISIS was discovered to be planning the contamination of Turkish water utilities with the *Francisella Tularensis* microbe.

Fortunately, the intentional deployment of biological agents is – for the time being – sub-national and certainly sub-global. Since 1900 there have been approximately 100 instances of recorded bioterrorism, most poorly organised, and with small impacts.⁸⁴

That said, it *is* probably reasonable to expect that in the 21st Century, widely accessible advances in biotechnology and genetic engineering, enhanced by developments in cognitive computing and artificial intelligence, will likely make these tools available to a growing universe of both state and particularly non-state actors. It is certainly reasonable to plan for such an eventuality.

Whether of natural, zoonotic origins, or intentionally engineered, or stemming from misuse in “dual-purpose research,” or due to accidental release from research settings, the resulting impacts of pandemics can be equally devastating to health and all other dimensions of human security, including socioeconomic and political collapse at national, regional, and global levels. The cliché that a local outbreak of a microbe with pandemic capacity is also global threat everywhere will equally apply. Engineered microbes, however, may have malicious designer-enhanced attributes and characteristics that, for example, significantly shorten the incubation period, or enhance the efficiency of human-human transmission, severity, or resistance to known vaccines, antimicrobials and/or other medical countermeasures. This premise accepted, it is not unreasonable to imagine the theoretical release of multiple engineered microbes, each designed to target different targets of opportunity -- including genetic, immunologic, pharmacologic, or logistical, as a broad-spectrum-attack strategy.

Managing Risk in Complex Outbreak and Failed State Environments

Settings of conflict and complex emergencies create specific constraints and complications for the comprehensive management of pandemic risks from both man-made as well as natural outbreaks of disease with pandemic potential. A conflict context, often accompanied by an environment of chaos and lawlessness, is conducive to both. Pandemic prevention, risk reduction and risk management under such circumstance is immeasurably more challenging due to impaired capacity of relevant sectoral institutions. At the same time, conflict settings can make for severe constraints on

surveillance, outbreak response, mitigation and recovery efforts, thus creating risk of uncontrolled, potentially international or global spread of disease and systemic dysfunction. The 10th, poorly-controlled outbreak of Ebola in the conflict zone of Democratic Republic of Congo in late 2018 and early 2019 is a dramatic illustration of this latter point.

Consistent with a comprehensive risk-management approach advocated in this paper, while diverse impacts on societies and the globalised world will be structurally similar, the specific range of risks attendant bioterrorism, biological warfare, accidental pathogen release will need to be identified, and prioritised in order to effectively prevent, prepare, detect, respond to contain, and recover from a pandemic of human origins. Where naturally occurring threats of infectious disease and pandemics are primarily treated as public and even as integrated veterinary-human health, risks underlying outbreaks of intentional human origin will need to be assessed and addressed as part of a systematic approach to prevention and risk-reduction on its own, specific risk-spectrum. Prevention, risk-reduction, preparedness and response will need to engage not merely public health, but additional sectors and expertise, including national and international intelligence, security, public safety, law enforcement, biomedical and genetic research, defence organisations, as well as the general public. The strategic operational framework for comprehensive pandemic risk management must therefore also include the national security, defence, and disarmament sectors. This is another example to underscore that comprehensive pandemic risk management must be inherently a multisectoral strategic, “beyond health” enterprise.

One implication of such specialised risk-management is that information sharing will continue to be a difficult challenge. It will be recalled that information sharing about outbreaks or sharing of microbe samples among public health practitioners to facilitate rapid development of vaccines was a problem to be overcome during the height of the avian influenza crisis 2005-2010. The sharing of information considered sensitive to national security interests or deliberately controlled for tactical reasons as part of preventing, detecting and countering domestic or international bioterrorist operations, will be significantly more difficult. Attention will nevertheless need to be given to the development of effective multisectoral coordination mechanisms among the security, public health, and other essential sectors within national and international frameworks.

Global and National Initiatives

“The paradox is that...when each country pursues its own security without regard for others, we create global insecurity that threatens us all.”

-- UN Secretary-General, Antonio Guterres, 2018

In light of the anticipated threat of the increasingly globalised pandemic risks of bioterrorism and biological warfare in the 21st Century, what is the status of current steps taken to manage these threats on the global and national level? Are these appropriate, and sufficient? To what extent do these constitute an adequate “systems” approach to governance, to optimize effectiveness and efficiency of risk management?

As presented in this section, a selective review of attempts to establish models of governance at global and national level suggests that these are still in early development and characterized by insufficient international consensus and multilateral commitment; strategic, and policy coherence; lacking systemic articulation and operational depth at required scale; deficient institutional capacity; inadequate resources; and weak executive enforcement. At this time, neither the global community nor any individual nation can be considered adequately prepared to a severe natural or engineered pandemic. While there are some signs of international collaboration, the world is still far from being prepared for adequate prevention and response against a major biological attack.⁸⁵ International attempts to establish a global security regime, such as the Biological Weapons Convention, or the

UN Agenda for Disarmament, as well as the informal effort of the Australia Group to coordinate policy on export controls to constrain the development of chemical and biological weapons all suffer from only partial participation, agreements, and commitment among nations; and from inadequate mechanisms for investigation and enforcement of accepted conventions in the interest of deterrence. The glaring inadequacy of the current international biosecurity regime is the same one prevailing in the political and economic spheres: national security comes first; global, leaving multilateral security systematically weakened. This is the core confounding paradox of the currently bankrupt paradigm of security in a globalised socio-techno-economy: there is no national security without global security; and there is no global security without national security. A brief, selective review of several prominent global initiatives on biological security illustrates the tension between national and global security interests.

Global Institutions

The most prominent international institutions relevant to global biological security include the Biological Weapons Convention; the UN strategic “Agenda for Disarmament”; and the Australia Group on Export Controls. Each institution, while intended to reduce threats arising from production and/or deployment of biological or other weapons of mass destruction, is compromised by its inherently weak institutional capacity for the development and enforcement of international agreements on biosecurity, and the propensity of many nation states to seek technological advantage through the developments of new weapons for national security, including bioweapons.

The Biological Weapons Convention (UNSCR 1540). As documented by the United Nations Office for Disarmament Affairs (UNODA), the Biological Weapons Convention (BWC) is also described as the “*Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction.*”⁸⁶ The BWC is a treaty among 182 participating nation states (with inclusion of ten states that neither signed nor ratified the convention). Since 1975, when the treaty entered into force, a number of fundamental institutional weaknesses became consistently apparent. While banning the production, stockpiling, transfer, acquisition, assistance with acquisition, retention of biological agents and related weapons, equipment and delivery vehicles, the convention *does not ban or prohibit the use* of biological weapons or biodefense programs.⁸⁷ Second, complaints related to treaty implementation or enforcement which are referred to the UN Security Council, can be vetoed by China, France, Russia, the UK and the US. Third, as pointed out by the Arms Control Association, violations by individual member states are not uncommon, with some nations, such as the former Soviet Union and Iraq continuing to develop and maintain biological arms programs, and others like North Korea and Iran generating international concern with potential non-compliance. Most state do not declare relevant facilities, programs, and activities.⁸⁸

UN Strategy: “Securing our Common Future: Agenda for Disarmament”⁸⁹

On May 24, 2018 UN Secretary General Antonio Guterres launched the new strategic “Agenda for Disarmament” with a renewed focus on three priorities in disarmament to meet the challenges of the 21st Century: weapons of mass destruction, conventional weapons, and new battlefield technologies, including bioengineered threats.⁹⁰ The approach argues for a stronger, more effective Biological Weapons Convention. Some improvements would be pursued through development of stronger national health systems, more effective countermeasures, and improved linkages among international commitments such as the Global Health Security Agenda (GHSA); Sustainable Development Goal 3 on health and well-being; and oversight of dual-use biomedical research. Proposing a stronger institutional capacity of the UN and the BWC, Guterres proposed the establishment of an UN-based framework to conduct independent international investigations and coordinated response to the use of biological weapons.⁹¹

The presumed hypothesis is that a timely investigation would contribute to timely detection of actual or potential use of biological weapons and would therefore provide the basis for deterrence. Support from the General Assembly would be solicited in order to find longer-term solutions for both effective prevention and response. Unfortunately, the Agenda for Disarmament is burdened by the same fundamental, nationalistic and institutional weaknesses outlined above. These are all driven by an ethic of prioritised national self-interest, and the perceived need to maintain comparative advantage in weapons technology, which stands in contrast to a voluntarily weakened security posture -- a veritable security opportunity cost -- in the service of what is touted by multilateralists as a global public good. The more robust, enforceable form of global multilateralism envisioned by the Agenda for Disarmament appears to be facing significant headwinds in today's zeitgeist of re-ignited national identity, suspicion of aggregate regional and global governance frameworks, growing conflict, and an emerging technologically-driven arms race.

Australia Group on Export Controls

According to its official statement, "The Australia Group" (AG) is an informal forum of countries which, through the harmonisation of export controls, seeks to ensure that exports do not contribute to the development of chemical or biological weapons. Coordination of national export control measures assists Australia Group participants to fulfil their obligations under the Chemical Weapons Convention and the Biological and Toxin Weapons Convention to the fullest extent possible."⁹²

Objectives. Since chemical and biotechnology industries can serve terrorists and proliferators as sources of materials for chemical and biological attacks, the main objective of Australia Group participants' is to harmonise their countries' national export licensing measures to ensure that exports of certain chemicals, biological agents, and dual-use chemical and biological manufacturing facilities and equipment, do not deliberately or inadvertently contribute to the spread of chemical and biological weapons. While export licensing is not a substitute for the strict multilateral compliance with the 1925 Geneva Protocol, the 1972 Biological and Toxin Weapons Convention (BWC) and the Chemical Weapons Convention (CWC), participants in the Australia Group are States Parties to both the BWC and the CWC, and export licensing measures contribute to support of key provisions of these conventions. Global chemical and biological industries apparently support this resolve.

Australia Group Common Control Lists include detailed, specific lists of

- Chemical weapons precursors
- Dual-use chemical manufacturing facilities and equipment and related technology and software
- Dual-use biological equipment and related technology and software
- Human and Animal Pathogens and Toxins
- Plant pathogens

These guidelines and lists support global best practices for chemical and biological export controls to "regulate the export, re-export, transfer and re-transfer of defence or dual-use items which can be used by proliferators and terrorists in the development of chemical and biological weapons."⁹³

One obvious problem with the effectiveness of the Australia Group is its limited membership. Only 43 countries from Europe, Asia, North America, South America, and Australia comprise the Australia Group. No African countries are listed as participants. One country, Kazakhstan, is currently listed as a unilateral "adherent" country which is not subject to AG membership acceptance decisions, but which provided the AG chair with written notice of political intent to adhere to the AG guidelines and *Common Control Lists*. A key, fundamental problem is of course the fact that the materials, equipment, and software that can be used in the production and distribution of biological weapons can

be transferred or smuggled, in violation of official guidelines and export controls.

Effective global, institutionalised governance of pandemic risk management through improved biosecurity against either state-sponsored biological warfare or non-state bioterrorism is contingent on national commitment to this goal. Global security from pandemics is not possible without universal state commitment and accountability for preventive management of risks emanating from state and non-state actors. At this time, the world is at risk from microbes with potential for weaponised use, with pandemic outcomes. We simply do not know the true level of the risk and have no pandemic “Doomsday Clock” to monitor its urgency or magnitude.

National Bio-Security Strategies

The widely perceived need to prevent, prepare for, and respond to natural and intentional threats to national biosecurity has stimulated significant national security interest, as evidenced in the development of a number of national bio-security strategies. Countries and organisations taking steps to establish strategic frameworks include Germany, which conducted at least one international symposium on the subject; France, which organised a national simulation drill; and NATO, which is also active in developing biodefense efforts.⁹⁴ In spite of this growing interest, no country is at present prepared for pandemics – natural or man-made.

Two prominent examples of relatively more ambitious national biodefense strategies include those developed by the United States and by the United Kingdom, respectively. Not surprisingly, these are primarily motivated by national self-interest, and are more confidently grounded in a sovereign governance framework. On the positive side, these strategies appropriately reflect the awareness that effective biosecurity in a globalised civilisation is a global challenge that requires international cooperation, coordination and collaboration. In contrast to global initiatives discussed above, these strategies attempt to establish more systematic, all-government and beyond-government (including the private sector) approaches to biothreat risk management, impacting human, animal, and plant health. The approaches address biothreats that are natural, accidental, or deliberate, and include wide-spectrum measures to prevent, detect, prepare for, respond to and recover from biological threats. They aim for a comprehensive, multisectoral and multidisciplinary framework, and each attempt to link domestic the respective domestic dimensions of the strategy with international and bilateral intervention to secure systems that serve both global health and national health security objectives. In the UK, part of the national strategy on biological threats is included within a separate, broader initiative, the UK Strategy for Countering Terrorism (CONTEST), which is specifically intended to prevent people from becoming terrorists and to stop terrorist attacks. The biodefense-related strategies of the US and of the UK rely on each nation’s national security governance infrastructure involving all major branches of government.

United States: National Biodefense Strategy of 2018

The *National Biodefense Strategy* is the latest approach, succeeding a series of efforts originally inspired by the *1925 Geneva Protocol*, which banned the wartime use of biological weapons, but effectively allowed the proliferation of state-sponsored bioweapons programs.⁹⁵ Prior presidential directives, strategies, and policy decisions sought to refine the strategic focus to include natural, accidental, or deliberate public health threats; include human, animal and plant health; emphasise a multisectoral, an integrated all-of-government and private sector approach; and strengthen a comprehensive, coordinated model that prevention, response, and recovery.⁹⁶

The current National Biodefense Strategy -- an “all-of-government” strategy -- is intended to “... assess, prevent, detect, prepare for, respond to, and recover from biological threats, (whether natural, deliberate or accidental), coordinating its biodefense efforts with those of international

partners, industry, academia, non-governmental entities, and the private sector.”⁹⁷ The basis and implementation of this self-avowed “risk management” strategy is consistent with the National Security Strategy, and with certain international obligations such as those described in the World Health Organizations’ International Health Regulations of 2005. Given the persistent and multiple-source nature of the bio-threat, assumptions underpinning the strategy include the need for a comprehensive, multisectoral, multidisciplinary approach, supported by advances in life sciences and biotechnology, which would also contribute to reducing the risks of intentional or accidental misuse.

The governance mechanism for overseeing the implementation of the strategy is established under the executive lead of the President, with coordination by staff of the National Security Council, and the day-to-day execution by the Secretary of the Department of Health and Human Services. Inputs on strategic and policy coordination will be provided by the Assistant to the President for National Security Affairs through a process involving the National Security Council, the Homeland Security Council, and related Subcommittees. An inter-departmental, inter-agency Biodefense Steering Committee chaired by the Secretary of Health and Human Services will coordinate strategy implementation and coordination with other domestic and international stakeholders.

Under a layered risk-management approach, the Biodefense Strategy established five principal goals, each with its own related series of multiple objectives.

Goal 1: Enable *risk awareness* to inform decision-making across the biodefense enterprise.

Goal 2: Ensure biodefense enterprise capabilities to *prevent* bio-incidents.

Goal 3: Ensure biodefense enterprise preparedness to reduce the impacts of bio-incidents.

Goal 4: Rapidly *respond to limit* the impacts of bio-incidents.

Goal 5: Facilitate *recovery* to restore the community, the economy, and the environment after a bio-incident.

The Biodefense Strategy, however, is still burdened with the undue inherited structural complexity that includes 414 discrete responsibilities assigned to 22 agencies. According to the Bulletin of Atomic Scientists “...responsibilities are frequently assigned to multiple designees; it is not uncommon to find one responsibility assigned to five or more agencies, with no delineation of specific roles. It is also common for seemingly overlapping responsibilities to be assigned to disparate agencies”.⁹⁸

According to another outside observer, Dr. Daniel Gerstein of the Rand Corporation, the strategy is also hampered by recent reductions in funding budgets for surveillance, international risk reduction through support of international capacity for both preparedness and response. The strategy has many ends, but no clear approach to implementation, and an under-resourced budget, with a research component recently reduced by 20 per cent. While there are improvements in conceptual and policy development, the strategy is short on a clear implementation plan, and the country is far from being prepared against a severe biological event.

Still other critics point to systemic weaknesses in the U.S. health insurance system and in immigration policy that is likely to compromise rapid access of populations at-risk to preventive, epidemiologic, and clinical medical services to limit spread of disease. Individuals without insurance and immigrants concerned about deportation will not seek urgently needed services and thus contribute to spread of disease. ⁹⁹

To its credit, the fifth goal of the Biodefense Strategy addresses a coordinated social and economic recovery from a bio-attack. In this, recovery to a prior “normal” is presumed, without a consideration of the potential scale or severity of impacts, which could be inherently catastrophic, an existential threat to civilisation. In such a plausible scenario, prevention, preparedness, response and

recovery would require a distinct strategic approach to contingency and implementation planning.

United Kingdom:

Biological Security Strategy.¹⁰⁰ *The UK Biological Security Strategy* (2018) bears some conceptual similarity to the U.S. National Biodefense Strategy, particularly in its explicitly comprehensive, all-government, multisectoral and multidisciplinary approach to managing risks in coordination with multiple domestic and international partners. The strategy acknowledges the roles of technology and globalisation in modulating risks, seeing these as both challenges and opportunities. The approach also places a premium on early intervention to prevent and limit the spread of natural and human-initiated bio-threats, both domestically as well as in the international arena through development assistance on global health security. International engagement would strengthen developing country capacity to comply with the requirements of the International Health Regulations; strengthen public health system capacity, including better surveillance, lab capacity, and preparedness and response against emerging threats of infectious disease. Domestic efforts would support all relevant scientific research, including that related to diagnostics and medical countermeasures such as vaccines and pharmaceuticals.

There are four stated “pillars” supporting the *Biological Security Strategy* – all thematically driven by appropriate current and future scientific and biological research capacity, and close collaboration with industry and academia:

1. **Understand** the current and future biological risk. (collection, analysis, sharing of actionable information)
2. **Prevent** risk emergence at its source and prevent spread and threat to the UK and its interests (collaborate with key international fora, diplomatic frameworks and organisations like the UN, WHO, FAO, OIE and GHSA to strengthen international and domestic and border health and biosecurity).
3. **Detect early**, characterise and report emerged biological risks (through domestic and international public, animal, and plant health surveillance and laboratory systems); and
4. **Respond** to contain and mitigate threats that have reached the UK or UK interests (based on numerous, exercised human, animal, and plant response contingency plans; support of international preparedness mechanisms like the WHO emergency response networks, and relevant international assistance programs. Plans also include the strengthening of various domestic emergency and health systems, stockpiling of vaccines, drugs, and treatments, and implementation of relevant strategies like the five-year UK Antimicrobial Resistance Strategy, and the program on decontamination.

The *governance* framework charged with the implementation of the UK Biological Security Strategy will continue to rely on existing portfolios and departmental mechanisms. However, a new “*Cross-Departmental Governance Board*” will oversee strategic implementation, and report to the Threats, Hazards, Resilience and Contingencies Subcommittee of the National Security Council (NSC) through the Security Minister; and oversight over the outcomes of the Biosecurity Strategy will be managed by the Government Chief Scientific Adviser.¹⁰¹

It is noteworthy that the biological security strategy includes considerable interest in plant biosecurity, to protect agricultural and environmental plant resources. Specific focus on bio-terrorism and biological warfare is not emphasised under this strategy, although it does provide a broad national biosecurity context, which includes the more specialized *UK Strategy for Countering Terrorism* framework that includes including reducing risks of bioterrorism, as further described, below.

UK Strategy for Countering Terrorism (CONTEST, June 2018).¹⁰² The UK CONTEST strategy

on counter-terrorism, now in its fourth published version since 2006, is managed by the Home Office, within its Office for Security and Counter Terrorism, which in turn works across the government and with international partners to reduce the risk of terrorism, including bio-terrorism against the UK or its interests. The purpose of the strategy is "to reduce the risk to the UK and its interests overseas from terrorism, so that people can go about their lives freely and with confidence."¹⁰³ The strategy builds on the 2015 National Security Strategy (NSS) and the Strategic Defence and Security Review (SDSR), "which identified terrorism as one of the highest priority risks to the UK, and set out our vision for an integrated, whole of government approach to countering terrorism, using capabilities across security, defence, diplomacy, and development."

The "risk-reduction" strategic framework of CONTEST is structured along four lines of intent, each including a number of objectives, all intended to reduce risk:

- *Prevent*: stop people becoming terrorists or supporting terrorism (reduce intent)
- *Pursue*: stop terrorist attacks (reduce capability)
- *Protect*: strengthen protection against a terrorist attack (reduce vulnerability)
- *Prepare*: mitigate the impact of a terrorist attack (reduce impact).¹⁰⁴

In its current, 2018 iteration CONTEST places a relatively greater emphasis on emphasis on the "Prevent" dimension, to prevent radicalisation and make possible the early identification of potential terrorists. Given that the UK National Risk Assessment has determined the risk of chemical, biological, and radiation/nuclear (CBRN) terrorism as one of the highest impact-risks, CONTEST appropriately includes specific requirements for specialist capabilities and special contingency plans. Coordination of multi-agency emergency services is conducted under the flexible Joint Emergency Service Interoperability (JESIP). A response to a CBRN attack would include life-saving interventions, multi-agency technical and scientific support; and coordinated, inter-agency recovery in the sites of attack.¹⁰⁵

The strategic risk management of bioterrorism would rely on collaborative domestic and international networks; a wide sharing of data and information; early intervention to discourage and disrupt potential radicalisation and terrorist plans; collaboration with private sector and communication providers; improving community resilience; and support of citizens affected by terrorism. In the international arena priority actions would engage UK overseas diplomatic, development, economic, defence, counter-terrorism police, and intelligence assets. The purpose would be to disrupt attacks on overseas UK interests and citizens; reduce drivers and capacities of terrorism and mitigate impacts of attacks.¹⁰⁶

Governance and oversight.

As described in the current CONTEST strategy, oversight responsibility is placed in the National Security Council, chaired by the Prime Minister, based on changing risks, effectiveness of efforts, and available resources.¹⁰⁷ As detailed further in the strategy document, the Home Secretary coordinates the overall counter-terrorism response, with oversight of MI5 and the National Crime Agency and the police, including Counter-Terrorism units. Parliament (Intelligence, Security Committees) scrutinises the work of the Government, based on accountability of the Home Secretary. Approximately 30 government entities and ministerial bodies are also assigned CONTEST responsibilities under a whole-government approach. Illustratively, the Foreign Secretary is responsible for international elements of the strategy, as well as for the Secret Intelligence Service and the Government Communications Headquarters. The Chancellor implements the freezing of terrorist assets. Implementation of the strategy also includes extensive engagement with the public, civil society, academia, and industry.

Criticism of the CONTEST in the public sphere is generally focused on its potential violation of the human rights, of (mostly) Moslem minorities.¹⁰⁸ Specific objections made part of the public record between 2009-2017 include the charges of stigmatisation, Islamophobia, and racial discrimination.¹⁰⁹ Other objections charged restrictions on freedom of expression, suspicion, and confusion in academia and civil society in general.¹¹⁰ Commentary from the Royal United Services Institute (RUSI), the prominent UK security think tank, cautions about the resonance that unsavoury ideas will have with people, and lead to engaging the “Prevent” strand of CONTEST in ways that violate civil rights, in spite of the unproven connection between extremism and terrorism.¹¹¹

In spite of the above criticism, CONTEST is apparently acknowledged as a promising, model of a national counterterrorism strategy. Rigorous, research-based evidence for its effectiveness is lacking, due to a variety of methodological and theoretical challenges. This perspective is usefully outlined in a 2016 article by Erika Brady, a researcher on counter-terrorist strategies, at Handa Centre for the Study of Terrorism and Political Violence, University of St Andrews. The author argues that the mere paucity of successful attacks is not sufficient basis for evaluating success of CONTEST. Proving which attacks were prevented depends on a clear definition of a prevented plot, and the inevitably subjective source. Current investigations operate in secrecy and reporting is inconsistent or incomplete.¹¹²

From the point of view of this paper, the “gap” in CONTEST strategy becomes apparent in perspective of the impacts of a severe bioterrorist pandemic originating in the UK – impacts that in the modern economy will likely interrupt the flow of essential goods and services, both nationally and globally. Such impacts would manifest a more fundamental, perhaps intractable non-traditional security risk to the UK. CONTEST does not satisfactorily address how the strategy would address this broader risk management challenge to the nation and to the world.

PART II

The Way Forward -- Managing the Risks of Traditional and Non-Traditional Biothreats to Global and National Security

Since even a limited local release of a novel, easily transmissible microbe with requisite characteristics of infectivity and virulence can kill many millions in today’s largely urban, tightly liked, mobile world, an integrated global-national risk management system is of paramount importance. A comprehensive, systems-based approach to managing pandemic risks, including those originating with state and non-state actors must therefore be part of an integrated global strategy with corresponding regional and national components and elements. Accordingly, the principles and system attributes introduced and discussed in Part I of this paper would equally apply to managing the risks of state and non-state biothreats as part of one integrated strategy that addresses both natural as well as human-engineered biothreats. Hence, all of the previously defined characteristics of the generic risk-management-system-strategy would be necessary. As part of a full-spectrum risk management, the approach to manage and address pandemic threats originating with human invention, error, and/or use as a weapon of mass destruction would share certain previously described attributes. The conceptual scope for a globally integrated, multilateral and domestic strategy for global as well as national health security from pandemic risks of human origins would thus need to be,

- Long-term multisectoral and multidisciplinary.
- Inclusive of and transcending One Health -- certainly to include bio-genetic threats to human, animal health; and mass food security, but also related to national security and the

security of the globalised socioeconomy.¹¹³

- Managing “beyond health” risks and impacts in various sectors of global and national systems, including the military; the national intelligence; diplomatic and security apparatus; essential services; and critical infrastructure.
- Whole of global and national society – integrating multilateral organizations, governments, private industrial sector, and civil society.
- Integrating prevention, risk-reduction, preparedness, response, mitigation of socio-economic impacts, and recovery.

If viewed as an integrated institutionalised and organised system, previously identified *structural system building blocks* would also apply in their global, regional, and national dimensions to address the following generic functions:

- leadership and governance;
- financing;
- information systems management;
- appropriately qualified human resources;
- essential commodities/logistics; and
- operational capacity for intervention and essential service delivery.

A detailed treatment of how each of these system building blocks supports the way forward for the risk management of human-induced pandemics at the global, regional, and national level is beyond the scope of this paper. However, reflecting on their critical importance, the critical *governance* function as well as the *research* and *communication* functions are worthy of brief discussion.

The Paramount Role of Governance. While all system building blocks are necessary, the most fundamental challenge to an effective organisational path forward on the man-made biothreat risk management agenda, will continue to be the critical function of coordinated *leadership and governance* – both at the global as well as national level. As illustrated in the brief foregoing review of the *Biological Weapons Convention*, the *UN Agenda for Disarmament* and the *Australia Group on Export Controls*, these organised international agenda-setting organisations are all hampered by inherent structural conflicts of interest between a global, multilateral security agenda on the one hand, and multiple individual national security agendas on the other. Existing international efforts are therefore weak, lacking in conceptual consensus, universality of membership, and enforceable compliance. Consensus is difficult, since any newly proposed initiative is subject to nationally self-serving state vetoes. Prospects for a workable system of global leadership and governance oriented to the global public good are also constrained by the currently growing, nationalistic trend whereby individual nations tend to accord primacy to narrowly conceived national interests, making multilateral consensus and organised efforts in pursuit of the global public good, a continuing challenge.

The way forward on a systems approach to managing the spectrum of human-engineered pandemic risks in both their traditional (state-weaponised) and non-traditional (accidental or bioterrorist) manifestations will nevertheless require an integrated functional network of national and regional institutions coordinated by a multilateral, global strategic governance framework operating with sufficiently strong legal, policy and regulatory consensus and adequate financial, human and material resources.

The global crisis governance model discussed in Part II, Section 1 of this paper offers one possible approach to this specific problem, as part of a wider institutional agenda to manage growing global catastrophic threats (e.g. climate change, eco-system collapse, species extinction). Consistent with the crisis governance model, the system coalition of national, non-government, multilateral, private, academic and civil society stakeholders could generate a UN General Assembly resolution and a

legally-binding decision by the UN Security Council to establish the UN Organisation on “Global Catastrophic Risks” (OGCR). The OGCR would address any of a range of existing or newly-emerging global catastrophic risks, with one of its multiple Centers, being the previously proposed Center on Comprehensive Pandemic Risk Management (CCPRM). A specific unit of the CCPRM would be concerned with strategic development, policies, information exchange, and coordination among global/multilateral, regional, and national activities to prevent, detect, respond to contain, mitigate the impacts, and recover from biothreats of human origin.

The broad scope of this agenda will need to include the critical involvement of traditional health and “one health” organisations such as the WHO, OIE, FAO and their relevant national, domestic partners. Importantly, however, the effort will need to extend to multiple, “beyond-health” domains, and require the additional cooperation, coordination, and collaboration among such existing organisations as a reconstituted and strengthened Biological Weapons Convention, the UN Agenda for Disarmament, the Australia Group on Export Controls, and the World Trade Organisation. Given the nature of the subject matter, necessary involvement will need to include national and multilateral security, law enforcement, and military frameworks, as well as key political and economic fora such as the G-20 economies, the G-7, international financial and trade organisations, and other platforms such as the World Economic Forum.

An analogous multisectoral cooperative network, active at the regional and national level, involving appropriate regional and domestic sectors and institutions will also be necessary. The multisectoral collaborative process will require the development of a common conceptual platform that bridges the mind-set between those concerned with natural microbial threats and those focused on engineered biothreats.

Research, Technology, and Communication

The research and development agenda of a systems approach to the CPRM, including the management of pandemic risks of human origin will need to both be driven by as well as advance the potential inherent in both biotechnology and information technology made possible by the promise of developments in complex systems science, information technology and regulated artificial intelligence, harnessed in the interest of the global public good. Initiatives enabled by these technologies will need to detect and prevent/reduce risk of severe pandemics from both natural and human origins. Easily transmissible, natural and engineered microbes to which the human genome is most susceptible need to be pre-emptively identified and vaccines and medical countermeasures produced and strategically stockpiled, in advance of outbreaks. Advances in communications technologies will also need to be enlisted in the global public interest. This may include sharing and coordination of critical information on risks, whether natural, stemming from bio-warfare, or from bioterrorism. Other advances in the tools and applications of communication technology should consider the development and preparedness of non-pharmaceutical countermeasures, including those to optimise social distancing and related means to secure supply global chains of essential goods and services using technologies that minimise human-to-human transmission of disease.

Non-state Threats. As of this time, there is no publicly-acknowledged capacity among lone-wolf or small group bioterror organisations to engineer and deploy genetically engineered microbes, something difficult even in highly sophisticated laboratory settings. That said, that capacity may be currently present in secret, or may emerge in the future. Where the threats might potentially originate with non-state, terrorist sources, international cooperation, coordination and collaboration will be likely more easily achieved than where the threats and risks emerge from state-sponsored defence and state-security establishments. Even there, genetically altered microbes would be equally a threat to the bioterrorist’s society, hence the motivation for the development of such an uncontrollable agent would be potentially weakened. A severe biothreat targeting one nation would be synonymous with a global threat of mass destruction. As exemplified by suicide bombers who kill

others through an act of suicide, for some, planetary genocide may be acceptably compatible with suicide.

Nevertheless, the perception that bioterrorism remains a threat to humanity persists, and various approaches for risk management, whether technical or social are being considered. Developments in genetic sequencing and bioinformatics to rapidly identify microbes, and bio forensics to identify engineered strains and their origins are thought to add valuable tools to the international risk-management agenda. Emerging developments in metagenomics to analyse whole microbial communities would add to the growing bio-forensic investigatory armamentarium.¹¹⁴

Still, according to some, these kinds of technical developments, while potentially helpful in preparedness for response, are less likely to prevent the production and initial dispersal of microbes by bioterrorists. As quoted by Dr. Norman Kahn, the Nobel Laureate Josh Lederberg opined that “There is no technical solution to the problem of biological warfare. It needs an ethical, human and moral solution if it is going to happen at all.”¹¹⁵ In this light, Kahn suggests that to counter lone-actor or small group bioterrorism, what is needed is a world-wide, culturally-adapted program to encourage informed by-standers to report individuals whose suspicious behaviour may be connected with bioterrorism. This strategy, as we have seen in the case of the CONTEST program, will likely lead to inevitable controversies and charges of abuse of human rights.

Given the uncertainties and incomplete strategies described above, one initial step on the way forward was suggested by Dr. Anthony Fainberg, Scientific Advisor to the Inter-University Center for Terrorism Studies. This expert recommends an “open risk assessment” of biothreats, from both state and non-state actors.¹¹⁶ The assessment would engage leading biological and genetic researchers to generate conclusions on what is possible and what is likely and prioritise risks from existing microbes as well as those that are most likely susceptible to genetic modification to be used as bioweapons. Such an assessment would help in an efficient planning and allocation of resources for the management of bioterror risk management.

State-sponsored Threats. In contrast to non-state actors, the secrecy characterising state-sponsored military strategies, policies and initiatives involving the production, storage, and potential deployment of biological weapons of mass destruction will likely remain narrowly nationalistic, non-transparent to “average by-standers,” and not subordinated to international, consensus and conventions on global human security.

Progress on approaches like the Biological Weapons Convention and the UN Agenda for Disarmament will likely continue to be slow and uneven. Given the clear currently dysfunctional state of the Biological Weapons Convention, an initiative needs to be mounted to reframe its mission and functional agenda to bring it in line with the realities and needs of the current and future era. Also, possibly helpful to the way forward on managing risks from state-sponsored bio-weapons programs, may be the gradual development and widespread adoption of a global system on pandemic risk management, including a broadly-supported program focusing on the risks posed by non-state agents of bio-terror. An effective, widely supported and functional system for the prevention, risk-reduction, preparedness, detection, containment-response, impact-mitigation and recovery from natural and man-made pandemics may potentially strengthen an international political and popular demand-pull to better address the risks of state-sponsored pandemics, and play down the orientation to a dominant, nationalistic agenda. This would follow the logic of reducing risks of a “mutually-assured destruction” (MAD) as has so far been used to mitigate the risks of mutual/global destruction from a massive bilateral use of nuclear weapons.

Given the uncertainties and difficulties in the preventive risk management of state-sponsored threats, concurrent practical efforts to establish effective national and global capacity for pandemic preparedness, response for containment, and multiple-sector impact mitigation will need to be

aggressively pursued as part of an all-hazards approach. International development assistance must increase support to strengthen the network of national and global public health security systems with special emphasis on prevention and risk-reduction as well on preparedness.

The vantage point afforded by this brief overview of pandemic risks of human origin reinforces the premises, strategic principles and way forward explored in the main body of this paper, with its focus on pandemic risk management. We have identified some of the main challenges facing the task of making the world safer from pandemics, and proposed systems-based approaches to address them. Feasibility of options identified, while subject to necessary debate, will be proven only through serious, adequately resourced global and national initiatives at requisite scale, and driven by coordinated political will at all levels.

At this time, the constraints mitigating such an undertaking are formidable: lack of political will; conflicting interests and priorities between the global public good and individual national interests; limits to growth on a planet of growing populations, high expectations, diminishing natural resources; degrading ecosystems; species extinction; and climate change. In the interim, what we know is clear: neither the world, nor any nation is prepared for a severe pandemic – natural or engineered.

¹ The U.S. Pandemic Influenza Strategy <https://www.cdc.gov/flu/pandemic-resources/national-strategy/index.html>

² <https://www.whitehouse.gov/the-press-office/2014/09/16/fact-sheet-us-response-ebola-epidemic-west-africa>, Sept. 16, 2014. This strategic resolve led to the joint commitments among more than 30 countries to accelerate global efforts against infectious disease under the Global Health Security Agenda (GHSA)

³ The U.S. Government Health Security Strategy, 2019, p. 7. <https://www.whitehouse.gov/wp-content/uploads/2019/05/GHSS.pdf>

⁴ U.S. National Intelligence Council, 2013

⁵ <https://www.towerswatson.com/en/Insights/IC-Types/Survey-Research-Results/2013/12/Extreme-risks-insurance-sector-survey-2013>

⁶ <https://api.globalchallenges.org/static/wp-content/uploads/12-Risks-with-infinite-impact-full-report-1.pdf>

⁷ <http://paidpost.nytimes.com/gates-foundation/preparing-for-pandemics.html>

⁸ Andrew Burns, Dominique van Mensbrugge, and Hans Timmer, “*Evaluating the Economic Consequences of Avian Influenza*” (Washington, DC: World Bank, 2008).

⁹ Milan Brahmbhatt and Olga Jonas, International Cooperative Responses to Pandemic Threats: A Critical Analysis, *Brown Journal of World Affairs*, Spring/summer 2015, vol. 21, issue 2, p. 169.

¹⁰ <http://www.nber.org/papers/w22137>

¹¹ World Bank Group, “2014-2015 West Africa Ebola Crisis: Impact Update,” 2016, <http://pubdocs.worldbank.org/en297531463677588074/Ebola-Economic-Impact-and-Lessons-Paper-short-version.pdf>.

¹² Caroline Huber, Lyn Finelli, and Warren Stevens, “The Economic and Social Burden of the 2014 Ebola outbreak in West Africa,” *The Journal of Infectious Diseases* 218, (October 2018): pS698-S704, https://academic.oup.com/jid/article/218/suppl_5/S698/5129071

¹³ <https://www.weforum.org/reports/the-global-risks-report-2018>

¹⁴ <http://reports.weforum.org/global-risks-2016/press-releases/>

¹⁵ http://hdr.undp.org/sites/default/files/reports/255/hdr_1994_en_complete_nostats.pdf

¹⁶ “Human Security: Safety for People in A Changing World” a concept paper by Lloyd Axworthy, Minister of Foreign Affairs, Ottawa, Canada April 29, 1999. Sourced from presentation by William H. Lyerly, Jr. FACCP, FAAMA, Retired Director, Global Partnering, Knowledge and Futures Group, Office of the Assistant Secretary for Health Affairs; and Special Assistant for Global Human Security to the Assistant Secretary, Department of Homeland Security. Mr. Lyerly argued that human security can serve as a strategic framework for the public health interface of the broader global health security agenda.

¹⁷ In chronological order, the reports published by these bodies included: WHO Report of the Ebola Interim Assessment Panel (Jul.2015). Harvard University-London School of Hygiene and Tropical Medicine Independent Panel Report on the Global Response to Ebola (Nov.2015). National Academy of Medicine,

International Commission on a Global Health Risk Framework for the Future (Jan. 2016). UN High-Level Panel on the Global Response to Health Crises (Feb.2016).

¹⁸ GHRF Commission (Commission on a Global Health Risk Framework for the Future), 2016. *The neglected dimension of global security: A framework to counter infectious disease crises*. <http://nam.edu/GHRFreport>. doi: 10.17226/21891.

¹⁹ Op. Cit. WHO Report of the Ebola Interim Assessment Panel, Executive Summary, p.1.

²⁰ Parenthetically, it is worth mentioning that current approaches to vaccine development and deployment, while ostensibly “preventive” in nature, do not meaningfully prevent risks of initial outbreaks with pandemic potential. In the current strategic model, vaccines against a novel microbe would become available only 4-6 months after clear identification. This provides more than enough time for a pandemic agent to circumnavigate the globe. Current reliance on vaccine development is also, in this sense, part of a reactive strategy.

²¹ A point made by author David Korowicz, in personal correspondence. Also, see <http://www.davidkorowicz.com/about>.

²² The potential future costs of microbial resistance are a case in point. According to the RAND Corporation study, a scenario of “no effective treatments available,” would mean 444 million adult deaths by 2050, and a corresponding annual loss of \$3 trillion to the global economy. Marco Hafner and Jirka Taylor, Rand Corporation, “The Cost of Resistance and the Attack of the Microbes.” August 2015.

<http://www.rand.org/blog/2015/08/the-cost-of-resistance-and-the-attack-of-the-microbes.html>

²³ UN International Strategy on Disaster Risk Reduction (UNISDR) *UNISDR Annual Report 2015*, p. 60. From Feb.-April 2019 K. Georgieva served as interim President of the World Bank Group.

²⁴ UN Secretary-General Ban Ki-moon speaking at the launch of the 2015 Global Assessment Report on Disaster Risk Reduction.

²⁵ Such an approach has already been proposed in the guise of the “Global Virome Project,” based on initial achievements of a USAID-funded “Predict” initiative involving the Eco Health Alliance, UC Davis School of Veterinary Medicine, and Metabiota. See footnotes 28-30, below.

²⁶ The “One Health” approach views the health of people, and that of animals as being interconnected both with each other and with the environment within which they coexist and co-evolve. Most infectious diseases of humans are “zoonotic,” or of animal origin. According to the U.S. Centers for Disease Control, the goal of One Health is to “encourage the collaborative efforts of multiple disciplines-working locally, nationally, and globally-to achieve the best health for people, animals, and our environment.”

<https://www.cdc.gov/onehealth/index.htm>

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<https://www.cdc.gov/onehealth/index.htm>

²⁸ Carroll, Denis et al, The Global Virome Project, *Science*, 23 February 2018. Vol. 359, Issue 6378, pp. 872-874

²⁹ Kerlin, Kat, Feb. 22, 2018. *Ambitious Global Virome Project Could Mark End of the Pandemic Era*. <https://www.ucdavis.edu/news/ambitious-global-virome-project-could-mark-end-pandemic-era>.

³⁰ Ibid. *Ambitious Global Virome Project Could Mark End of the Pandemic Era*.

³¹ “*The Global Virome Project – How Can We End the Pandemic Era?*” Presentation at the New York Academy of Sciences, June 20, 2016, featuring Dr. Dennis Carroll, PhD, Director of Global Health Security and Development, USAID; and Peter Daszak, President of Ecohealth Alliance. The initiative includes as key collaborators Drs. Jonna Mazet of UC, Davis, School of Veterinary Medicine, and Nathan Wolfe, President of Metabiota. Accessed on <https://www.youtube.com/watch?v=Xn69DMYf27Q>.

³² <https://www.weforum.org/press/2017/01/cepi-initiative-aims-to-prepare-vaccines-to-speed-up-global-response-to-epidemics>. Initial funding for CEPI was provided by the Bill & Melinda Gates Foundation; the Wellcome Trust; the governments of Germany, Japan, and Norway; and global vaccine manufacturers including Glaxo Smith Kline.

³³ https://cepi.net/wp-content/uploads/2019/03/050319-Funding-and-Expenditure-Final_V3.pdf

³⁴ <http://www.onehealthglobal.net/what-is-one-health/>

³⁵ These were adapted from the WHO Health Systems Framework, which proposed these as the six building blocks of health systems. http://www.wpro.who.int/health_services/health_systems_framework/en/ Here we adopt these elements as the generic building blocks of organized systems in all essential service sectors, from health to financing, power, transportation, etc.

³⁶ World Bank, *The Danger of Pandemics*, 5/9/2013, Olga Jonas,

<http://blogs.worldbank.org/developmenttalk/danger-pandemic>.

³⁷ BMJ 2018;362: k3296, Aug. 9, 2018 Is the World Ready for the Next Pandemic Threat?

<https://www.bmj.com/content/362/bmj.k3296.full>

³⁸ WHO, Ebola in the Democratic Republic of the Congo <https://www.who.int/emergencies/diseases/ebola/drc-2019> --Health Emergency Update, as of August 18, 2019.

³⁹ WHO IHR core capacities implementation status, 2017. <https://www.who.int/ihr/procedures/annual-reporting/en/>

⁴⁰ The New Yorker, June 1, 2018. Nicola Twilley <https://www.newyorker.com/science/elements/the-terrifying-lessons-of-a-pandemic-simulation>.

⁴¹ http://apps.who.int/gpmb/assets/annual_report/GPMB_Annual_Report_Exec_Summary_Foreword_and_About_English.pdf. As stated in its website (<http://apps.who.int/gpmb/>), the Global Preparedness Monitoring Board (GPMB) is an ‘independent monitoring and accountability body created to advance the common objective of ensuring preparedness for global health emergencies.’

⁴² Ibid. Olga Jonas.

⁴³ Donella Meadows, *Thinking in Systems*, 2008, Sustainability Institute, p. 11 A “system” has been usefully and simply defined as “an interconnected set of elements that is coherently organized in a way that it achieves something (function or a purpose).”

⁴⁴ Schaeferhoff, M. et al (2015). How much donor financing for health is channelled to global versus country-specific functions? The Lancet, published online July 13, 2015 <http://dx.doi.org/10.1016/S014-6736915061161-8> According to this paper, “cross-border externalities” include “outbreak preparedness and response, response to antimicrobial resistance, response to marketing of unhealthful products, and control of cross border disease movement.”

⁴⁵ Steven J. Hoffman, Clarke B. Cole, Mark Pearcey, Mapping Global Health Architecture to Inform the Future, 20 January 2015, <https://www.chathamhouse.org/publications/mapping-global-health-architecture-inform-future>.

⁴⁶ <https://www.chathamhouse.org/publication/rethinking-global-health-system>

⁴⁷ Ibid <https://www.chathamhouse.org/publication/rethinking-global-health-system>

⁴⁸ https://ebrary.net/188/accounting/concept_global_governance

⁴⁹ The Open Philanthropy Project (OPP) defines catastrophic risks as those... “risks that could...change the very long-term trajectory of humanity in a less favourable direction” (e.g. ranging from a dramatic slowdown in the improvement of global standards of living to the end of industrial civilization or human extinction).

<http://www.openphilanthropy.org/blog/potential-global-catastrophic-risk-focus-areas>.

⁵⁰ The CSIS Commission on Strengthening America’s Health Security. Statement on the 3-d meeting of Commission Members, August 8, 2019.

https://res.cloudinary.com/csiasideaslab/image/upload/c_limit,h_512,w_512/v1565271984/health-commission/GlobalHealth_Commission_CoChair_Statement_muukst.pdf?utm_source=CSIS+All&utm_campaign=27c9509152-EMAIL_CAMPAIGN_2019_08_08_03_28&utm_medium=email&utm_term=0_f326fc46b6-27c9509152-221739845

⁵¹ WHO, Overview of the Financial Situation: Programme Budget 2018-2019.

https://apps.who.int/gb/ebwha/pdf_files/WHA72/A72_34-en.pdf. The total revenue recorded for the Programme budget 2018–2019 was US\$ 3400.3 million, with US 956.9 million from voluntary contributions.

⁵² Schaeferhoff, M. et al Op Cit.

⁵³ Jonas, O. Pandemic Risk, World Bank, 2013, Background paper to the World Bank’s *World Development Report on Risks to Development* (2014).

⁵⁴ <http://nam.edu/wp-content/uploads/2016/01/Neglected-Dimension-of-Global-Security.pdf>, pp 83-84; pp 111-114.

⁵⁵ This author was not able to identify an analysis grounded on such modified methodology.

⁵⁶ International Working Group on Financing Preparedness (IWG), From Panic and Neglect to Investing in Health Security: Financing Pandemic Preparedness at a National Level (Washington, DC: World Bank, December 2017), <http://documents.worldbank.org/curated/en/979591495652724770/pdf/115271-REVISED-FINAL-IWG-Report-3-5-18.pdf>.

⁵⁷ Center for Strategic and International Studies, CSIS Briefs, *Harnessing Multilateral Financing for Health Security Preparedness*, April 2019. Washington, DC

⁵⁸ Ibid. Center for Strategic and International Studies, CSIS Briefs. Another suggestion voiced in the same document by the CSIS Commission encourages the World Bank to convert IDA loans to grants for countries that demonstrably improve their core infectious disease risk prevention, detection and response systems.

⁵⁹ Ibid. Center for Strategic and International Studies, CSIS Briefs.

⁶⁰ Stiglitz, J.E. (2004), “The Future of Global Governance”, in *Initiative for Policy Dialogue (IPD)*, IPD Working Paper, p. 320-321. https://www8.gsb.columbia.edu/faculty/jstiglitz/sites/jstiglitz/files/2008_Future_of_Global_Governance.pdf

⁶¹ Gates B. A Report by Bill Gates to the G-20 leaders – Cannes Summit, November 2011.

<http://www.gatesfoundation.org/What-We-Do/Global-Policy/G20-Report> (accessed May 9, 2016), per The Lancet, Comment, Y-Ling Chi, et al, “Who Should Finance WHO’s Work on Emergencies?” Vol 387, June 25, 2016.

⁶² The Lancet, Comment. June 2016.

⁶³ Ibid. *The Lancet*. Comment

⁶⁴ Presentation by Dr. Larry Kerr, Director, Pandemics and Emerging Threats at U.S. Department of Health and Human Services (HHS), on March 28, 2019 on the “Changing Nature of the Biological Threat” at the Special Seminar on “Biological Terrorism: International Dimensions,” co-sponsored by the Inter-University Center for Terrorism Studies, the International Law Institute, and the Center for National Security Law at the University of Virginia School of Law.

⁶⁵ Op.Cit. J.E. Stiglitz, p. 321.

⁶⁶ <http://www.globalviromeproject.org/> As described in its website, the Human Virome Project will:

- Identify 99% of unknown viruses that could jump from wildlife and livestock hosts to people
- Determine the geographic and host range of detected viruses
- Classify the risk of spill over and epidemic potential using virologic, behavioural, epidemiologic and ecologic data on detected viruses and their hosts
- Create a global surveillance network through local and global capacity enhancements
- Develop an open-access database and biobank
- Identify intervention targets, mitigation options and markers for transmission
- Provide insights into virus biology and ecology, as well as conservation benefits

⁶⁷ These include public and curative health services; energy and power; food and water management systems; transportation and resupply networks; telecommunications and communications; national security and public safety; and associated infrastructure such as the postal system, power plants, refineries, water treatment plants, food storage facilities.

⁶⁸ Illustratively, the research agenda would include One Health livestock-human research and disease risk reduction/prevention; the development, production, distribution of pre-pandemic and pandemic animal and human vaccines; methods of risk communication; improved clinical management; development of novel medical and public health countermeasures, including antivirals and new generation of antibiotics; and antimicrobial resistance important to infectious diseases with pandemic potential; and cascading impacts on human security from the disruption of essential services and critical infrastructure.

⁶⁹ A. Grabowski, and E. Hohlfelder, “When Losing Track Means Losing Lives: Accountability Lessons from the Ebola Crisis” (2015) Global Health ONE.

⁷⁰ <http://documents.worldbank.org/curated/en/979591495652724770/pdf/115271-REVISED-PUBLIC-IWG-Report-Conference-Edition-8-10-2017-low-res.pdf>

⁷¹ Membership includes the Secretaries of all Departments, including those of Health, Agriculture, Energy, Finance, Transportation and Communication, Budget Management, Foreign Affairs, Labour, and Tourism. Presidents of the national insurance system, social security system, leagues of provinces, municipalities and cities are also included, as are representatives of civil sector organizations, and one representative of the private sector. The DRRMC has local sub-national offices and represents the Philippines among various regional and international disaster management fora, including that of the ASEAN Agreement on Disaster Management and Emergency Response (AADMER). Technical support for the NDRRMC’s inclusion and development of the multisectoral pandemic preparedness and response model has been provided through assistance of the U.S. Agency for International Development during 2011-2013.

⁷² This author served as USAID’s Project Manager for the PREPARE project on the multisectoral systems model for pandemic preparedness and response, which provided technical assistance to the Republic of the Philippines, Republic of Indonesia, ASEAN, and a number of other countries in Asia and Africa during 2011-2013.

⁷³ *Op Cit. Panic and Neglect to Investing in Health Security: Financing Pandemic Preparedness at a National Level*, International Working Group on Financing Preparedness, under support from the World Bank and Wellcome Trust, May 2017, Conference Edition, Recommendation 3.

⁷⁴ Ibid., International Working Group on Financing Preparedness.

⁷⁵ <https://www.phe.gov/Preparedness/international/Pages/napapi.aspx>

⁷⁶ <https://www.weforum.org/agenda/2018/07/infectious-disease-pandemic-clade-x-johns-hopkins/>

⁷⁷ The Planetary Health Alliance among universities and non-governmental organizations is led by Sam Myers at the Harvard TH Chan School of Public Health. <http://planetaryhealthalliance.org/> Lancet will publish a new journal, *The Lancet Planetary Health* in 2017.

⁷⁸ Op Cit. Steven J. Hoffman, Clarke B. Cole, Mark Pearcey, Mapping Global Health Architecture to Inform

the Future, 20 January 2015, <https://www.chathamhouse.org/publications/mapping-global-health-architecture-inform-future>.

⁷⁹ The current strategic focus is on strengthening developing country compliance with the IHR requirements and – most recently – on the country financing of these upgrades.

⁸⁰ Governance and leadership, financing, information and its management; human resources, material resources/logistics; operational, service capacity.

⁸¹ Coats, Daniel R. “Worldwide Threat Assessment of the U.S. Intelligence Community.” U. S. Senate Select Committee on Intelligence, 13 February 2018.

⁸² <https://thebulletin.org/doomsday-clock/>

⁸³ Alexander, Yonah. Introduction to “Combating Biological Terrorism: Roadmaps for Global Strategies” The Inter-University Center for Terrorism Studies, January 2018.

⁸⁴ Gerstein, Daniel, Senior Researcher at the Rand Corporation, and Former Acting Undersecretary and Deputy Undersecretary in the Science and Technology Directorate, Department of Homeland Security (2011-2014). This reference is from Gerstein’s oral presentation on March 28, 2019 on the “Changing Nature of the Biological Threat” at the Special Seminar on “Biological Terrorism: International Dimensions,” co-sponsored by the Inter-University Center for Terrorism Studies, the International Law Institute, and the Center for National Security Law at the University of Virginia School of Law.

⁸⁵ Gerstein, Daniel. Ibid.

⁸⁶ <http://disarmament.un.org/treaties/t/bwc/text>

⁸⁷ Arms Control Association, <https://www.armscontrol.org/factsheets/bwc>. The Arms Control Association is a nonpartisan organization established in the U.S. in 1971, committed to “public understanding of and support for effective arms control policies”

⁸⁸ Ibid. Arms Control Association

⁸⁹ United Nations, Office of Disarmament Affairs, *Securing our Common Future: Agenda for Disarmament, 2018*, New York, pp. 26-27.

⁹⁰ Ibid. United Nations Office of Disarmament affairs.

⁹¹ Ibid. United Nations Office of Disarmament Affairs

⁹² <https://australiagroup.net/en/>

⁹³ Ibid., Australia Group Adherents

⁹⁴ Op Cit. Alexander, Y., p. 4.

⁹⁵ <https://www.un.org/disarmament/wmd/bio/1925-geneva-protocol/>

⁹⁶ Bartholomew Rachel, and Omberg, Kristin, January 18, 2019, *Bulletin of the Atomic Scientists*, “Making Sense

of the 2018 National Biodefense Strategy.” <https://thebulletin.org/2019/01/making-sense-of-the-2018-national-biodefense-strategy/>

⁹⁷ <https://www.whitehouse.gov/wp-content/uploads/2018/09/National-Biodefense-Strategy.pdf>

(Above summary quote from Op Cit. Bartholomew and Omberg, p.1)

⁹⁸ Ibid. Bartholomew and Omberg.

⁹⁹ Beier, D. and Srikrishna, D. STAT online media, Oct. 11, 2018, “The U.S. biodefense strategy is undermined by policies on health insurance and immigration” <https://www.statnews.com/2018/10/11/Biodefense-strategy-undermined-policies-immigration-insurance/>

¹⁰⁰ *The UK Biological Security Strategy*, Home Office, London, July 2018.

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/730213/2018_UK_Biological_Security_Strategy.pdf

¹⁰¹ The Governance Board consists of representative of the following departments: Home Office (HO); the Department of Health and Social Care (DHSC, including Public Health England [PHE]); the Department of Food, Environment, Food and Rural Affairs (DEFRA, including the Animal and Plant Health Agency (APHA) representation; Agri-Food and Biosciences Institute (AFBI); Ministry of Defence (MOD, including DSTL representation); the Foreign and Commonwealth Office (FCO, including the Science and Innovation Network); the Department of Business, Energy and Industrial Strategy (BEIS); FID; the Government Office for Science (GO Science); Cabinet Office; the Health and Safety Executive (HSE); the Office for Life Sciences (OLS); Department for International Trade; and the Devolved Administration.

¹⁰² The UK Strategy for Countering Terrorism (CONTEST), the UK Home Department, June 2018.

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/714404/060618_CCS207_CCS0218929798-1_CONTEST_3.0_PRINT.PDF.

¹⁰³ Ibid., p. 25

¹⁰⁴ Ibid., pp. 31, 43, 53, 63

¹⁰⁵ Ibid. pp, 65-67

¹⁰⁶ Ibid. pp 65-71.

¹⁰⁷ Ibid. pp 83-84

¹⁰⁸ Dominic Casciani (30 March 2010). "Prevent extremism strategy 'stigmatising', warn MPs". *BBC*. Retrieved 9 June 2014.

¹⁰⁹ Adams, Richard (28 March 2016). "Teachers back motion calling for Prevent strategy to be scrapped". *The Guardian*. Brighton, United Kingdom. Retrieved 28 March 2016.

¹¹⁰ Gayle, Damien (8 March 2019). "UK's Prevent guidance to universities unlawful, court rules". *The Guardian*. Retrieved 9 March 2019.

¹¹¹ Elshimi, M., 29 June 2018, "The New UK Counterterrorism Strategy: Critical Questions for the 'Prevent' Strand," Royal United Services Institute, <https://rusi.org/commentary/The-New-UK-Counterterrorism-Strategy>.

¹¹² Brady, E. „An Analysis of the UK's Counter-terrorism Strategy CONTEST, and the challenges in its Evaluation". <https://www.sicherheitspolitik-blog.de/2016/10/10/an-analysis-of-the-uks-counter-terrorism-strategy-contest-and-the-challenges-in-its-evaluation/>

¹¹³ Managing the risks to essential global infrastructure and essential global services – a global common good enabling the delivery of critical goods and services in a complex, interrelated and globalized industrial civilization is also replete with challenges. Once again, this problematic is largely contingent on the perceived conflicts between national political and economic interests on the one hand, and global public good interest to secure the functional integrity of the complex world socioeconomic system upon which universal human security depends.

¹¹⁴ Presentation by Professor Rita Colwell, University of Maryland, College Park and the Johns Hopkins University Bloomberg School of Public Health, and Senior Fellow at the Potomac Institute for Policy Studies, on March 28, 2019 on the "Changing Nature of the Biological Threat" at the Special Seminar on "Biological Terrorism: International Dimensions," co-sponsored by the Inter-University Center for Terrorism Studies, the International Law Institute,, and the Center for National Security Law at the University of Virginia School of Law.

¹¹⁵ Quoted by Dr. Norman Kahn, former Director, Intelligence Community Counter-Biological Weapons Program, in a presentation at an event on "Combating Biological Terrorism: Roadmaps for Global Strategies" held on August 24, 2017 at the Potomac Institute for Policy Studies.

¹¹⁶ Presentation by Dr. Anthony Fainberg, at the Special Seminar on "Combating Biological Terrorism: Roadmaps for Global Strategies" held on August 24, 2017 at the Potomac Institute for Policy Studies.