GEORGE A. The Public Health Tesseract: Managing the Multiplicative Threat. MINN. J.L. SCI. & TECH. 2006;8(1):237-247.

The Public Health Tesseract: Managing the Multiplicative Threat

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The public health community tends to manage population health issues separately. For example, we separate bioterrorism from antibiotic-resistant tuberculosis from obesity from influenza, and so on. Understandably, this has occurred because the requirements for dealing with each of the many different public health issues can be complicated and unique. To simplify the complexities, we have pulled apart the tangled strands of health-related challenges in an effort to identify and deal with them individually. However, we often neglect the reality that we have to deal not only with the individual strands but with the problems their interactions and the entire tangle present, as well. The threats to public health are multiplicative. We must take both measured and multidimensional approaches to address them.

Public health management left the second and third dimensions behind long ago and should now be modeled upon the four-dimensional tesseract. The tesseract is based on the four-dimensional analog of the cube, with eight cubicle cells, twenty-four faces, thirty-two edges, and sixteen vertices (Figure 1).[1]

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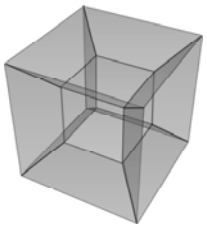
1. H.S.M. COXETER, REGULAR POLYTOPES 122 (Dover Pub. 1973) (1948).

FIGURE 1. TESSERACT



With its eight cubicle cells, the tesseract better shapes our thinking and actions, and more accurately represents the challenges presented by population health issues. Each of the seven individual cells of the tesseract represents an issue that is often otherwise inappropriately addressed in isolation. The eighth cell represents the whole tesseract, symbolizing the entirety of what must be held in the leader's mind when making decisions. This four-dimensional construct embodies the totality of the problem and its individual parts, thus leading to better results. The combined threat of pandemic influenza (naturally-occurring) and bioterrorism (human-generated) can be used to illustrate and support the use of this model.

THE FIRST CELL: ANTICIPATION OF PANDEMIC INFLUENZA

Experts consider an influenza pandemic long overdue.[2] A pandemic could occur via a number of mechanisms, including: sustained and efficient human-to-human transmission of avian influenza,[3] the rise of novel strains of the virus, antigenic shift

2. Maggie Fox, *Flu Pandemic Could Kill Half Million in US*, Reuters, June 24, 2005.

3. *See id.*; *see also* Alison Abbott, *Chicken Flu Races Through Dutch Poultry Farms*, 422 NATURE 247 (2003); Andrej Trampuz et al., *Avian Influenza: A New Pandemic Threat?*, 79 MAYO CLINIC PROC. 523, 523-530

in the virus,[4] genetic reassortment or recombination of human influenza with another strain,[5] the intentional release of a strain known to be extremely virulent in today's populations or genetically engineered to cause a pandemic,[6] or the accidental release of a strain from a laboratory.[7] Given current levels of U.S. preparedness and health, an influenza pandemic could cause 500,000 to die and more than two million to become severely ill. Additionally, more than seven million might die worldwide.[8] Further, it is expected that pandemic influenza will affect the entire age spectrum, including young adults.[9] Thus, the first cell of the tesseract addresses the anticipation of a pandemic caused by influenza as it relates to preparedness, detection, and response requirements.

THE SECOND CELL: PANDEMIC INFLUENZA AS A TERRORISM MULTIPLIER

An enemy could take advantage of the next influenza pandemic by applying force-multiplier theory[10] (where one seeks to multiply the force of an attack by combining effects, building upon pre-existing conditions, etc.) in the terrorism context. For example, naturally-occurring or human-generated biological or non-biological agents could be released while a pandemic is already underway. Even though it may take decades for a pandemic causing influenza virus to occur naturally, some cultures may be willing to wait, in order to

(2004); World Health Organization, *Avian Influenza A(H5N1) – Situation (Poultry) in Asia as of 2 March 2004: Need for a Long-Term Response, Comparison with Previous Outbreaks*, 10 WKLY. EPIDEMIOLOGICAL REP. 96, 96-100 (2004).

4. *See* Nancy J. Cox et al., *Influenza Pandemic Planning*, 21 VACCINE 1801, 1801-03 (2003).

5. *See* Robert B. Belshe, *The Origins of Pandemic Influenza – Lessons from the 1918 Virus*, 353 NEW ENG. J. MED. 2209, 2209-11 (2005); *see also* Graeme Laver & Elspeth Garman, *Pandemic Influenza: Its Origin and Control*, 4 MICROBES & INFECTION 1309, 1309-1316 (2002).

6. *See* Kathleen F. Gensheimer et al., *Influenza Pandemic Preparedness*, 9 EMERGING INFECTIOUS DISEASES 1645, (2003); *see also* Mohammad Madjid et al., *Influenza as a Bioweapon*, 96 J. ROYAL SOC'Y MED. 345, 345-46 (2003).

7. *See* Walter R. Dowdle, *Influenza Pandemic Periodicity, Virus Recycling, and the Art of Risk Assessment*, 12 EMERGING INFECTIOUS DISEASES 34, 38 (2006).

8. Fox, *supra* note 2.

9. *See* Eve E. Slater, *Industry and Government Perspective in Influenza Control*, 31 TEX. HEART INST. J. 42, 42-44 (2004) (noting that the 1918 "Spanish flu" was particularly bad among young adults).

10. EDWARD LUTTWAK, A DICTIONARY OF MODERN WAR 226 (Harper & Row 1991).

capitalize on the panic and confusion created by the virus – if for no other reason than it would take equally long to manufacture an equally dangerous biological threat. While countries throughout the world are focused on the pandemic, their infrastructures (including those related to national security) would be weakened and strained, making them easy targets for successful attacks.

An enemy could catalyze a pandemic by collocating birds, pigs, and humans,[11] and by preventing adequate communication of health information, including that generated by surveillance.[12] An enemy could introduce current versions of the disease in places where public health infrastructures are known to be weak, in order to draw down global medical resources. Furthermore, an enemy could seek to destroy stockpiles, manufacturers, distributors, government agencies, and laboratories once a pandemic does hit. As a result, an enemy can increase world disorder and prevent countries and regions from responding sufficiently to the diseases caused by influenza and other organisms.[13]

The very threat of a pandemic and the resulting research into vaccines and antiviral therapies designed to combat it, could benefit potential enemies.[14] Research designed to develop a vaccine against a pandemic strain could require the generation of a more virulent strain that could itself be used as a weapon of mass effect. This would allow an enemy to acceptably create increasingly virulent and/or bioengineered strains of influenza,[15] and develop vaccines and antiviral therapies against them, under the supportive eye of the worldwide health science establishment. An enemy would not necessarily share this research but if caught could say it was trying to validate its results before publishing and otherwise releasing its findings. The vaccine could then be used to

11. *See* Michael T. Osterholm, *Preparing for the Next Pandemic*, 352 NEW ENG. J. MED. 1839, 1841-42 (2005).

12. *See* Neil M. Ferguson et al., *Public Health Risk from the Avian H5N1 Influenza Epidemic*, 304 SCIENCE 968, 968-69 (2004).

13. Anne Applebaum, Op-Ed., *Only a Game?*, WASH. POST, Jan. 19, 2005, at A19 (discussing the break-down that occurred from a simulated smallpox attack in a simulated war game called Atlantic Storm).

14. *See* Tony DeCrappeo, *Biosecurity and Dual-Use Research*, 36 NAT'L COUNCIL U. RES. ADMIN. NEWSL., July/Aug. 2004, at 2 (noting that new security controls on who can work with "select agents" have decreased the number of people working on treatments for highly virulent diseases).

15. Slater, *supra* note 9, at 44.

protect the enemy population or a subgroup while the disease is released and a pandemic ensues.

Should an enemy decide to incorporate pandemic influenza into its plans to wage war or terrorism against other nations, information regarding the disease and the state of readiness of other countries could easily be gathered. This information is readily available on the Internet. In addition, an enemy could hide behind the nobility of seeking to improve the public health of their own nation, region, or even the world, to obtain additional information that is not available on the Internet. It would not take much time or research to ascertain the pervasive lack of preparedness throughout the world, however. This lack is evidenced by the dearth of national pandemic preparedness planning;[16] mounting difficulties with current-day influenza vaccine development, production, and distribution;[17] and increasingly flimsy public health infrastructures.[18] Even when significant efforts have been taken to plan for pandemic influenza (such as the Implementation Plan for the National Strategy for Pandemic Influenza[19]), activities required to operationalize those plans have not occurred pervasively. This second cell of the tesseract addresses the use of a pandemic to multiply the ill-effects of a terrorist event as it relates to prevention, preparedness, detection, response, and recovery.

THE THIRD CELL: PREPAREDNESS PLANNING

Lack of pandemic influenza preparedness plans is a clear indicator of national vulnerability, if only because draft plans are not funded or otherwise provided the resources required to execute the activities they incorporate. Parts of a draft plan could certainly be adopted for use if a pandemic were to occur before the plan was finalized. However, this necessarily renders disease prevention and preparedness secondary. An enemy can accurately assume that if a plan is still in draft, then the authoring country faced with a pandemic will only respond to a pandemic if it occurs, and will not be truly prepared for it ahead of time. Therefore, that country is vulnerable to the disease as well as the approaching

16. *See generally* Osterholm, *supra* note 11, at 1839-42.

17. Applebaum, *supra* note 13.

18. Trampuz, *supra* note 3, at 523-27.

19. HOMELAND SECURITY COUNCIL, NATIONAL STRATEGY FOR PANDEMIC INFLUENZA IMPLEMENTATION PLAN (2006).

pandemic.[20] Compounding the problem, many nations are waiting for industrialized countries to complete their planning so they can see what works before developing and implementing their own plans. This third cell of the tesseract addresses planning as an indicator of national vulnerability as it relates to preparedness, response, and recovery.

THE FOURTH CELL: VACCINE DEVELOPMENT

Vaccine manufacturers have faced increasing difficulties with current influenza vaccine development.[21] Such difficulties are not surprising. The same basic egg-based procedures have been used to develop these vaccines for decades. While these methods have been improved upon, it still takes months to develop a new vaccine, regardless of how well it actually prevents disease once produced and delivered.[22]

Further, we still guess about which components for new strains of the influenza virus will combine in the future. Although this speculation is certainly informed, there is no reason to expect that it will always be correct or that the predictions will hit the mark completely.[23] Should they turn out to be incorrect, vaccines for the correct strain would need to be developed after the expression of the virus, further delaying delivery to populations throughout the world.[24] Lastly, as with vaccines for organisms that could be used for bioterrorism, vaccine manufacturing companies find influenza vaccine development to be a difficult business enterprise. Without an outbreak of the disease to increase the demand for vaccine, it is hard to make an effective business case for engaging in development of a new vaccine. This becomes harder as time goes by and vaccines fail to be produced.[25] Possible solutions include government-run programs that encourage companies to develop vaccines by providing grants.[26] However, participation

20. World Health Organization, *supra* note 3, at 98-99.

21. Applebaum, *supra* note 13.

22. Erica Seiguer, *Protecting the Nation's Health: Ensuring a Stable Supply of Influenza Vaccine*, COMMONWEALTH FUND, July 2005, at 1.

23. *See id*.

24. *See* Slater, *supra* note 9, at 43 (noting that under optimal conditions, it will take nine to twelve months to prepare adequate vaccine to fight a pandemic); *see also* Trampuz, *supra* note 3, at 528-29.

25. *See* David Brown, *How US Got Down to Two Makers of Flu Vaccine*, WASH. POST, Oct. 17, 2004, at A01 (stating that even under the best circumstances, vaccines have never been very attractive investments).

26. *See id.*

in such grant programs is not lucrative. Some money being better than none is not particularly motivational in the business context. Thus, this fourth cell of the tesseract addresses vaccine development issues as they relate to disease prevention.

THE FIFTH CELL: PUBLIC HEALTH INFRASTRUCTURE

Public health infrastructures throughout the world have experienced erosion and decline for decades. Prevention and preparedness are often sacrificed in efforts to contain health care costs or to pay for other health programs that address more urgent real-time needs.[27] Countries make public health reinvestments sporadically, often after a disease thought to be close to eradication reappears and/or has mutated into something worse (for example, those diseases caused by antibiotic resistant organisms, such as tuberculosis).[28] Although many consider the public health infrastructures of third world countries to be inadequate, such countries may very well find themselves in better stead when it comes to dealing with pandemic influenza because they focus many of their public health efforts on combating epidemics from other diseases on an ongoing basis.[29] However, localized disease outbreaks could overwhelm any country's public health infrastructure,[30] and pandemic influenza could overwhelm the public health infrastructure in every country around the world. This fifth cell of the tesseract addresses public health infrastructure as it relates to disease prevention, deterrence, preparedness, detection, response, recovery, and mitigation.

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27. *See* COMM. FOR THE STUDY OF THE FUTURE OF PUB. HEALTH DIV. OF HEALTH CARE SERVS INST. OF MED., THE FUTURE OF PUBLIC HEALTH 70, (National Academy Press 1997) (1988) (noting that new health concerns such as AIDS, Alzheimer's disease, alcoholism, and others).

28. *See* Andrew C. Hayward & Richard J. Coker, *Could a Tuberculosis Epidemic Occur in London as it did in New York?*, 6 EMERGING INFECTIOUS DISEASES 12, 15 (2000) (stating that London needs to learn from the New York tuberculosis epidemic and take prompt action to improve control by developing solutions based on the local epidemiology of the disease).

29. *See* WORLD MED. ASS'N, WMA DECLARATION OF WASHINGTON ON BIOLOGICAL WEAPONS 1 (2003), *available at* http://www.wma.net/e/policy/b1.htm (discussing how health systems worldwide are currently struggling to meet the demands created by resistant organisms, civil strife, unclean urban environments, and aging populations).

30. *See id.*

THE SIXTH CELL: INFORMATION COLLECTION PRIORITIES

Countries can identify potential enemies (who may use easily available information regarding pandemic influenza to attack others) by tracking what sort of information is being generated and collected, and by whom. For example, influenza vaccine and antiviral research and development, such as that regarding cell-culture-based vaccines[31] can be monitored.[32] Having identified these research and development programs, contributions to the scientific body of knowledge regarding influenza can also be monitored at conferences and in journals. The difference between what is discussed regarding influenza and what is produced regarding other diseases could be obvious.

Information gathered through surveillance mechanisms regarding the rates of influenza already occurring in various parts of the world can also be evaluated for anomalies relative to the rates within individual countries and regions.[33] If rates suddenly decline and stay low as compared to other areas, yet no explanations have been published or otherwise articulated, these rates could be indicators of the development of a successful vaccine that protects the enemy's population better than that of other countries.[34]

Furthermore, we must be prepared to deal with the impact and aftermath of a pandemic for up to two years.[35] A pandemic would interrupt normal social processes, including: communication, transportation, and diplomacy, diminishing and/or possibly destroying cultures.[36] Social disorder, chaos,

31. *See* Osterholm, *supra* note 11, at 1840; Slater, *supra* note 9, at 43.

32. *Cf.* Ferguson, *supra* note 12, at 968 (stating that the World Health Organization Global Influenza Network's major focus is to compile information for influenza vaccine formulation, based on the analysis of viral isolates).

33. *Id.* at 968 (presenting a method to detect increases in viral transmissibility based on examination of clusters of human cases). *Cf.* Johan Walden & Edward H. Kaplan, *Estimating Time and Size of Bioterror Attack*, 10 EMERGING INFECTIOUS DISEASES 1202, 1202–04 (2004) (discussing a method for determining the number of people who will be symptomatic and require medical attention after the attack).

34. *Cf.* Walden & Kaplan, *supra* note 33, at 1202 (discussing how an outbreak forecast could assist in determining the response effort required).

35. *See* Osterholm, *supra* note 11, at 1840.

36. *See* Danuta Skowronski, *The High Impact of an Influenza Pandemic*, 170 CAN. MED. ASS'N J. 768, 768 (2004) (describing the estimated number of Canadians who would be affected by a pandemic of influenza).

and anarchy could ensue, resulting in reduced security throughout the United States and the world. The need for information will increase, but the ability of organizations to collect and analyze that information will be curtailed.[37] How will the United States distribute medications and deliver medical aid to stranded personnel worldwide? How will information continue to be collected and sent back to the United States in this context? What is the plan for dealing with the perception that Americans have access to medication (just because they are American) that they are not sharing? How will our embassies, consulates, and other offices be protected if our security forces are depleted? All of these questions relate directly to the health of the groups of people involved. Therefore, it is the shared responsibility of the public health and intelligence communities (as well as the broader government, military, and public) to answer these questions.

There is also a growing need to fill the information and intelligence void when it comes to disease. There is much more to health-related intelligence than the science of identification, determining the impact of disease on foreign dignitaries, and tracking disease patterns.[38] It is important to understand how a country or region handles disease, as well as how the sick are viewed (and in a pandemic, how they are treated – ostracized and possibly mishandled). The comprehensiveness of extant infrastructures needs to be quantified and judged by evaluating the level of medical science and technology, how well indications are identified, how early warning is provided, and whether medical facilities are present, functioning, and well-equipped, to name a few examples.[39] Additionally, there are real differences between countries, particularly in how they handle or wish to handle issues such as quarantine.[40]

37. *Cf.* DENIS C. KAUFMAN, DEFENSE INTELLIGENCE AGENCY, MEDICAL INTELLIGENCE: A THEATER ENGAGEMENT TOOL, 22–24 (2001) (stating that there are not enough medical intelligence analysts).

38. *See id.* at 1–3 ("Medical intelligence, which informs the preventative medicine process, identifies medical threats to U.S. forces, but also assesses medical trends, organizations, and related events that affect foreign populations, and that may impact—directly or indirectly—U.S. policies and interests.").

39. *See id.* at 9–11.

40. Mary Ann Benitez, *Hong Kong's Health Policies Focus on Containing Avian Influenza*, 361 LANCET 318, 318 (2003) (stating that Hong Kong's strategy includes active surveillance and improved hygiene in markets and on farms); Caroline Brown, et. al., *Avian Influenza: Current Situation in Southeast Asia and Impact on Europe*, 10 EUROSURVEILLANCE WEEKLY, Jan. 20, 2005, at 1, 1-10, http://www.eurosurveillance.org/ew/2005/050120.asp

Prioritization and diversion of limited resources will come into play in ways unique to each country. This broad spectrum of issues cannot be fully addressed by the intelligence or diplomatic communities alone.[41] Most members of these communities do not possess the understanding of public health necessary to comprehend and apply the information gathered. This sixth cell of the tesseract addresses health-related intelligence collection requirements as they relate to prevention, preparedness, and attribution.

THE SEVENTH CELL: INFORMATION ANALYSIS

Considering the lack of attention and priority the U.S. public health community garners, it would be absurd to delegate the entirety of this information analysis requirement to public health professionals while the intelligence and other communities focus their efforts elsewhere, and vice versa. However, the public health community is the only community in a position to combine information from various sources in order to correctly and comprehensively identify the varied implications of disease. Years have gone by while various organizations, agencies, and countries have discussed the implications of naturally-occurring and human-generated disease. We need to realize now that there is no other professional community capable of filling this gap. This seventh cell of the tesseract addresses information analysis requirements as they relate to prevention, preparedness, detection, response, attribution, and mitigation.

THE EIGHTH CELL: MANAGEMENT IMPLICATIONS

The eighth cell of the tesseract is the composite – the entire grouping of the seven cells. It best represents the mind of the decision maker as it should be, thinking about different but significant aspects of individually important and related public health issues and problems.

(noting that the Vietnamese government attempts to control outbreaks by culling infected birds, preventing transport of poultry to and from infected areas, controlling the slaughter and transport of poultry, and temporarily stopping imports of fowl and fowl products from neighboring countries); Trampuz, *supra* note 3, at 528-29 (stating that isolation precautions identical to those recommended for Severe Acute Respiratory Syndrome should be implemented and continued for fourteen days).

41. *See* Applebaum, *supra* note 13 (stating that security efforts should also focus on fixing the health care system and sharing vaccines).

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CONCLUSION

As public health professionals, we must entertain the notion of a tesseract to broaden our thinking and manage the complex interactions between and among the eight cubicle cells, sixteen vertices, twenty-four faces, and thirty-two edges. This is not a case of making way for the public health community to take a leadership role in dealing with various threats. The community is already there, and by mission and for professional and organizational survival, it must use the assets, resources, organizational acumen, analyses, and operational expertise that it possesses beyond all others to deal with the threat. Using the tesseract will enable us to respond to the threat successfully, by applying our skills broadly, and addressing the issues and their interactions comprehensively. Managing the multiplicative threat is our mission and our calling.