SARS, Pandemics and Public Health

Julia Skelding
University of Toronto*

Ross Upshur
University of Toronto†

1 Introduction

Emerging and re-emerging infectious diseases are newly or previously identified diseases that are increasing in incidence or changing in geographic range (Lederberg et al., 1992). Severe acute respiratory syndrome (SARS) and avian influenza are two of the most prominent recent examples of such diseases. It has been apparent for the better part of two decades that a host of interacting factors are causally linked to this emergence, including ecological changes, changes in human demographics and behaviour (particularly the explosion of air travel in the past twenty years), technology and industry, and microbial adaptation and change. More importantly, deficiencies in public health infrastructure coupled with globalization have diminished the capacity of public health systems to respond adequately to the threat of infectious diseases. Authoritative scholars have issued warnings about viral emergence and detailed the steps necessary for civilization to respond. These seemingly dire and apocalyptic warnings have, in fact, come partly true. The emergence of infectious disease is an enduring aspect of human existence, one neglected at our peril.

Infectious disease outbreaks like SARS have historically been drivers for public health initiatives and reform. Given the learning opportunities provided to us during and after SARS, preparing for a pandemic is regarded as necessary for public safety and allaying public fear. Since SARS, there have been a number of commissions and enquiries, each issuing wide ranging recommendations for reforming and reconstructing public health governance in Canada. The recommendations from the National Advisory Committee on SARS and Public Health (Public Health Agency of Canada (PHAC), 2006a), the SARS Commission (2006), and the Expert panel on SARS (2003) envision a transformed and revived public health system. Achieving this comes with significant investment costs both financially and with respect to human resources. The key issue to resolve is how investments in high technology are balanced against the need for

*E-mail: j.skelding@utoronto.ca
†Corresponding Author. E-mail: ross.upshur@sunnybrook.ca
investment in human resources. Innovative new genetic technologies, although important, entail investments and incur costs. How to set priorities for what needs to be funded is a perennial ethical quandary in health care. We will argue that the pressing need in public health is for human resource investment in the short and intermediate term at the expense of high technology development.

This is not to diminish the importance of such technology, merely to contextualize it within the current crisis in Canadian public health. Calls to improve laboratory capacity with the ability for higher technology capabilities like genome sequencing, may no doubt play a vital role for epidemiologists and public health authorities for contact tracing, comparative studies, or if a patient is failing therapy. Yet, during a real-time epidemic/outbreak like severe acute respiratory syndrome (SARS), the needs of public health go beyond these options.

This paper examines the relevance/effectiveness of SARS genome sequencing and its impact on public health interventions (real-time, intermediate and long-term). The role of science and technology coupled with human resource investments in pandemic planning and preparedness will be explored to answer the question of whether pandemics as drivers of public health initiatives are opportunities for waste or reform.

2 Was SARS genome sequencing relevant to the public health response?

The answer to this question depends on how one conceptualizes an adequate public health response. Public health has been defined as what we, as a society, do collectively to assure the conditions for people to be healthy. The overarching mission of public health is to protect populations from health threats (infectious and otherwise) while promoting health through a variety of means, including the use of legal and policy levers. Unlike clinical medicine, the focus is on communities and populations with responsibilities that are usually exercised by governments. Thus, public health intervention relies on legally sanctioned action to protect, restore, or enhance health.

What role does genetic technology play in an infectious disease emergency? The isolation of an unknown agent during an epidemic is typically completed during an emergency, under pressure and often without suitable information systems and data-sharing protocols (Public Health Agency of Canada (PHAC), 2006b).

To what extent do such technologies add value to public health interventions to stem the tide of infectious disease during an epidemic? Pathogen identification and gene sequencing are only the first steps providing a description of the genetic structure of the virus, and serve as a departure point to further research informing us on how the pathogen functions. The identification of the coronavirus occurred near the end of the first wave of SARS, leading scientists into further investigations for the development of diagnostic tests and rational therapeutic agents. On April 14, 2003 both Canadian and CDC officials announced
their laboratories had sequenced a nearly identical strain of the SARS-related coronavirus (Slezak et al., 2003).

Gene sequencing did very little for the real-time public health management of the outbreak. Furthermore, the laboratory infrastructure within several Canadian cities experienced a breakdown of communication and reporting structures, which compromised investigation efforts (Public Health Agency of Canada (PHAC), 2006b).

But what was needed to mount an effective public health response to SARS? Knowing the causative organism was certainly a benefit; providing the identity of an organism from a known family of pathogens ended speculation and uncertainty as to the cause of the illness. Ironically, the successful identification of the SARS organism occurred while public health epidemiologists managing the outbreak were hamstrung by antiquated information systems and hampered by archaic legislation which impeded timely sharing of crucial information. For example, the yellow stick-on-note was often used in the management of the outbreak, which provides insight into the realities of the gap between the high technology world of genomics and the real world of public health practice in industrialized countries.

The sequencing of the SARS genome was admirably rapid and serves as an exemplary moment in collaborative global health research. There were, however, elements of the SARS epidemic that provided significant incentives to draw the full attention of molecular biologists globally. It was an unknown pathogen with significant morbidity and mortality, and much was at stake in the rapid identification of the organism (both in terms of enhanced public good and professional reputation). This makes SARS more the exception than the rule, and expectations raised by the rapid success with SARS may not necessarily be the case for more routine needs for molecular analysis in public health. Researchers such as Slezak et al. (2003) and Chain et al. (2003) suggest that there have been wait times in excess of a year to analyze and publish a genome sequence, attributing this to the current tools being used to perform these analyses. Further, these tools are incapable of dealing with “large-scale genomic rearrangements that occur among distantly related genomes.” Thus, there is an inability to identify “common mechanisms that may have mutated...yet should be recognized as having a common origin” (Chain et al., 2003) The implementation of tools that have this capability are imperative to the future success of real-time responses to public health crises such as SARS.

Additionally, the development of more commercially valuable commodities has been typified by the sort of competition more characteristic of industry than the necessary collaboration ideal for coordinated public health control of pathogens. As reported in Science, at least ten different groups, representing academia and industry, were competing to develop candidate SARS vaccines (Marshall and Enserink, 2004). As is often the case, the path to effective vaccine development has met predictable obstacles in terms of finding both an appropriate agent to induce immunity and an appropriate animal model to test antigenicity. Trials were underway three years after the SARS epidemic (Jiang et al., 2005).
It has been years since the SARS epidemic. The length of time required to
develop and test a new vaccine for a novel disease is instructive in light of con-
cerns about avian influenza. Despite the promises of biotechnology, there are, as
yet, no examples of the rapid discovery and dissemination of vaccine technolo-
gies timely enough to control a novel human infectious disease epidemic. The
long history of hopes raised and dashed in the pursuit of an effective HIV vac-
cine serves to underscore the complexity of viral pathogens, whose ecology and
evolutionary biology are poorly understood (Lederberg et al., 1992). It is likely
that traditional public health interventions such as case identification, contact
tracing, and use of social distancing measures such as isolation and quarantine
will continue to be the initial defense of populations against novel infectious dis-
eases. These measures are imperfect, though effective, working primarily on the
understanding that breaking transmission chains can effectively stop epidemics.
However simple this may be in principle, in practice, the implementation of such
measures poses significant ethical challenges, can require immense political will,
personal sacrifice, and as shown by SARS, a well staffed, well trained public
health work force (Singer et al., 2003).

In the intermediate and long-term time frames, genome sequencing is essen-
tial for providing information for disease occurrence in terms of transmission,
history and to aid in understanding treatment options such as vaccine devel-
opment. Further, it is a tool for tracking disease transmission, identifying and
confirming unknown environmental risk factors, and interventions for popula-
tion health (Khoury et al., 2005).

During SARS, Canada did not have the resources like a CDC for rapid re-
sponse or the capacity for rapid turnaround to act on the real-time information.
During SARS, many hospitals were by-passing the provincial lab and sending
samples directly to Winnipeg or conducting testing themselves (Public Health
Agency of Canada (PHAC), 2006b). Furthermore, initially investigators did not
know what they were looking for, did not know the virulence and transmissi-
bility of the organism, and many were taking significant risks to identify the
pathogen.

3 Communication, Coordination and Cooperation

The lack of a central coordinating body, like the Centre for Disease Control in
Atlanta, rendered centrally coordinated efforts a moot point in SARS. The new
Public Health Agency of Canada, headed by the Chief Public Health Officer
(appointed in September 2004) is a step toward filling this gap. Their mission
is: ‘To promote and protect the health of Canadians through leadership, part-
nership, innovation and action in public health’. Reportedly, the creation of
this Public Health Agency of Canada is to improve collaboration with provinces
and territories... focused on more effective efforts to... respond to public health
emergencies and infectious disease outbreaks’ (Public Health Agency of Canada
Also, their intentions are to ensure adequate health human resources and strengthen capacity to respond to regional and national public health emergencies while enhancing national surveillance and information infrastructure. They are working to create a Pan-Canadian Public Health Network, initially, to “complement and—if it proves effective—eventually subsume, some of the existing mechanisms and arrangements for intergovernmental collaboration on public health matters. The network would serve as a forum for “the promotion of dialogue...coordination of response to public health threats development of strategies nationally...and to encourage the advancement of public health expertise across the country” (Public Health Agency of Canada (PHAC), 2006). Of course, the question remains, will this include the financial support vital to the success of the implementations of their recommendations?

The lack of collaboration and information sharing across Canada has become a ‘hot button’ issue driving the development of the new Public Health Agency. Although an integrated agency is vital for the safety of Canadians, simply having improved communication and timely laboratory testing to develop treatments is not enough. Preparation, communication and improved technologies are a vital marriage for Canada to avoid another SARS experience. We turn now to discuss in closer detail the elements of a successful integration of knowledge, people, and technology to face emerging challenges to public health.

4 High-tech versus low-tech science and technology investments and human resource investments

There is a prevailing view that infectious disease threats ought to be met with the best of science and technology, as represented not only in terms of knowledge, but also in terms of the physical capacity of science and technology: “...[L]abs are at the heart of our protection against infectious disease” (SARS Commission, 2006).

The SARS experience demonstrated our lack of laboratory capacity (Public Health Agency of Canada (PHAC), 2006; SARS Commission, 2006), lack of cohesive reporting structure and dissemination of this information locally, provincially, federally and globally. Further, the experience with SARS revealed the lack of capacity caused by a retraction in public investment to coordinate communication systems, databases and improve the “professionally impoverished” three public health human resources. It appears as though Canada was a walking target. Both the Campbell and Naylor reports expose the decline in our public health capacity care for “decades.”

A basic distinction between ‘high’ and ‘low’ science and technology is fairly intuitive, but can be elaborated. Low technology science includes such things as shared databases, renovations and expansions to created more laboratory capacity, and access to improved testing technologies coupled with human resource investments.
5 Changes in Laboratory Capacity, Communication and Mandate

The SARS Commission urged Ontario’s government to modernize Ontario’s central health lab and public health laboratory system, that is, to bolster low-technology capacity in Ontario. Laboratories are an important part of the public health strategy to detect and then mitigate the effects of disease. Laboratories are typically where the first indication of a reportable disease emerges; and later they are the point of verification in the diagnosis of many diseases and can provide important technical services such as surveillance. Increasing capacity to meet demand for laboratory services during a health emergency is vital to public health outcomes—but what about the costs of implementing these strategies so far in advance or ‘just in case’?

Although the review of public health laboratories was recommended in the Naylor report (Public Health Agency of Canada (PHAC), 2006a) to ensure they have the “appropriate capacity and protocols to respond effectively and collaboratively,” these reviews do not guarantee a rapid turn around of easily utilized information for either genome sequencing or vaccine development. Further, while Campbell in the SARS Commission report commends major strides in public health initiatives, such as appointing a new Chief Medical Officer of Health in Ontario, the report notes that there is still a fundamental lack of harmonization among laboratories throughout the country, a sharp lack of laboratory capacity and a lack of epidemiologists, microbiologists, and point-of-care public health staff.

6 Public Health Human Resources

Canada continues to experience a shortage of human resources that is particularly worrisome in public health (Advisory Committee on Health Delivery and Human Resources (ACHDHR), 2000). This has been noted for some time and the situation continues to worsen without evident respite. In 2006, one-third of health units in the province of Ontario lacked legally required medical officers of health, and the future for recruitment looks dim to the extent that fewer than 1% of medical graduates pursue careers in public health. Public health requires highly trained nurses, health inspectors, epidemiologists, laboratory personnel, infection control practitioners/specialists, health promoters and communicators, and lawyers. These are deficient in Canada. It is expected that within eight years, 31% of medical officers of health will retire. Further, the average age of registered nurses is forty-four, and with most nurses retiring in their mid-fifties, many are also expected to retire within the same time frame (The nursing sector study corporation, n.d.; O’Brien-Pallas and Baumann, 2000). A cumulative loss of total working nurses is expected to reach between 17,000 and 18,000 in Ontario alone. This, coupled with the rise in patient acuity from unknown infectious disease, will place the safety of our public at further risk (Advisory Committee on Health Delivery and Human Resources (ACHDHR), 2000; Aiken
et al., 2002). The loss of experienced healthcare professionals leads to deficiencies in the mentoring of new graduates (Aiken et al., 2002). Coupled with declining interest in the field, this illustrates further vulnerability. Additionally, many public health practitioners, like their clinical colleagues who experienced SARS, are contemplating career changes in light of the personal sacrifices and risks incurred in fighting the disease.

Data also reveals a lack of MD-prepared and PhD-prepared microbiologists (Public Health Agency of Canada (PHAC), 2006b). The requirement of MD-trained laboratory heads in hospitals, like the requirement by law that all medical officers be MDs, perhaps contributes to the lack of capacity. Perhaps it is time to rethink these restrictions if they are too restrictive, do not serve the public interest and fail to capture the core competencies required of these positions. Walker and Naylor also emphasized Canada’s lack of epidemiologists and microbiologists with the ability to conduct outbreak investigations and infectious disease research. More important, is Campbell’s disclosure that in the “fall of 2001, the Ministry of Health and Long Term Care had laid off its PhD level scientists from [its] provincial laboratory:... do we want five people sitting around waiting for work to arrive?” (SARS Commission, 2006, p. 9).

Canada’s experience reflects a global trend. A recent editorial in the Lancet noted:

Years of underinvestment in health, coupled with enforced economic reforms that restricted investment in public health services and education, have left many countries with critical shortages of health workers. The attractions of international migration, and concentration of the remaining professionals in urban areas, means, according to the WHR, that many national health systems are weak, inequitable, unresponsive, and unsafe (The Lancet, 2006).

7 Pandemics as drivers of public health initiatives—opportunities for waste or reform?

Preparation for pandemic influenza has occurred in light of the above considerations, and this preparation is certainly being hailed by public officials as the reason why the 2009 swine flu did not spread significantly. Critics of both the public health response to SARS and the swine flu note that there is a mixture of strong optimism about the promise and unprecedented power of new technologies, including vaccine technology, and yet at the same time this scientific and technological capacity is not reconciled with the global crises in health human resources.

It is instructive to recall that SARS brought a sophisticated, modern, developed, urban health care system to a standstill. Perhaps even more remarkable in its effects was that SARS was largely a nosocomial disease with very little community spread. While very different from SARS, pandemic influenza could pose serious challenges to health care systems globally as community spread...
will no doubt be extensive, with a large pool of people vulnerable to severe complications from influenza. It is telling in this case to reflect on the public relations chaos and confusion that erupted in 2009 with swine flu—federal and provincial public health officials had difficulty in providing consistent messages to the public, and there is lingering doubt regarding the efficacy of public health interventions, such as the large scale vaccination programs.

Since the fall of 2005, media and public attention has focused on the H5N1 avian influenza strain which has spread through domestic and wild bird populations and moved from south-east Asia though Europe and into Africa. The virus is pathogenic in other species, notably cats and humans, but there is no evidence of human to human transmission. The WHO has encouraged all member states to engage in pandemic planning, and has provided guidelines to assist member states in preparing plans. There is, however, much at stake in such initiatives. Although most experts agree a pandemic is inevitable, no one can predict where or when such a pandemic will occur. Although the H5N1 influenza strain is concerning, it is not inevitable that it will be the next human pandemic strain. There is also no guarantee that pandemic strains will emerge from Southeast Asia. As with most public health decision making, it is difficult to get it precisely correct, and success is ultimately measured in terms of what did not happen. Again, it is interesting to reflect on the fact that as grave as avian flu could be, the flu scare of 2009 was swine flu, from Mexico, not South-east Asia, and the pattern of the disease was unlike that of avian flu, making initiatives to anticipate seem in retrospect to be somewhat pointless.

Such planning activities invite intense media attention, and with it the risk of unduly alarming populations. They risk diverting scarce human resources from more pressing health needs (a particular issue in developing world contexts). They also may necessitate investment in stockpiling antiviral medications such as oseltamivir, which has limited shelf life and questionable efficacy for novel influenza strains. The stockpiling of various equipment such as surgical masks, hand sanitizers, and protective equipment has also begun. This seems like a welcome and overdue planning exercise, an opportunity to be proactive instead of reactive. The average cost of oseltamivir for a major teaching hospital to provide prophylaxis for staff daily for a few weeks is over 1 million dollars. Add on the costs to stockpile necessary protective equipment, and the cost soars. As one generalizes these figures to a global scale, credibility as to the feasibility of this approach is strained.

The best possible response to a pandemic would be an effective vaccine. The proof of principle of new genetic based technologies and its relevance to global public health may be tested in its ability to play a role in the rapid development, production, and distribution of a candidate vaccine for a pandemic influenza strain. This sets the bar high for new technologies, as such a vaccine would need to be developed, tested, distributed, and evaluated under the most exigent of circumstances, but such challenges must be met for the technologies to be relevant to the control of communicable diseases.
8 Conclusion

Science and technology investments, including genome sequencing, are important components in healthcare today. There are limits to what molecular science can do, however, and innovative biotechnology investment should take the back seat in the short term to investment in human resources in public health. This will have immediate and important public policy consequences both nationally and internationally.

It is important that we not frame this issue as an either/or proposition. An adequate investment in health human resources should include training in preparation for the molecular age. This entails breaking down silos in training programs and fostering broad interdisciplinarity in training programs. It is also important to recognize that a strong local public health system in isolation from its neighbours is likely of little value. The global health human resources crises must be addressed and the developed world should be supported in capacity development in public health. All the biotechnology in the world is of limited value without trained humans to use it appropriately.

Clearly, the identification of SARS was important, but genome sequencing did not tangibly make a difference to its control. Since SARS, the necessary reforms still have not taken place. The creation of the Public Health Agency of Canada is a welcome development. Recommendations by Campbell, Walker, and Naylor echo those of Krever and Walkerton. All of these cases in which there were risks to public health suggest we need vigilance to protect the health of the public and sustained investment in public health infrastructure. When the next novel virus or pandemic occurs and public health units are still understaffed, with public health practitioners still using sticky notes, then we will be getting our just deserts. Infectious diseases are ineradicable and will ever pose threats to human health. If, as a society, we continue to leave ourselves unprotected and unprepared, then we will ensure that the litany of Royal Commissions and enquiries investigating the same failures will be an equally enduring legacy.

9 Acknowledgements

The authors would like to thank Shari Gruman for her expert assistance in formatting the manuscript. Dr Upshur is supported by the Canada Research Chair in Primary Care Research and a Research Scholar Award from the Department of Family and Community Medicine, University of Toronto.

10 Bibliography


Slezak, T., Kuczmarski, L., Torres, C. and et al. (2003), ‘Comparative genomics tools applied to bioterrorism defense’, Brief Bioinform 4, 133–149.


IAJ, Vol. 10, Iss. 1 (2010), Pg. 50