The Local and Global Outbreak Response to Severe Acute Respiratory Syndrome (SARS) in Toronto

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Introduction

A major effect of a natural or technological disaster is the disruption of routine flows of various types. Indeed, much of the disruptive character of disasters may be traced to the impacts resulting from the interruption of various flows and their respective supporting and interdependent infrastructures, such as for example, electricity, fuel, water, transportation, food systems and so on. Understandably much of the attention and activities of disaster managers and responders is devoted to the restoration of the essential flows and supporting infrastructures required to return life to the previous state of normalcy and order. As a disaster type, however, disease outbreaks and pandemics are qualitatively a bit different. Because the transmission of infectious/communicable disease is dependent on the flows of human contact (or contact between animals and humans), the *contagious* character of this particular type of disaster needs to be taken into account in the disaster management process. As such, the overall disaster management challenge in an outbreak situation is to disrupt the flow of the infectious agent virus, while selectively maintaining the flow of uninfected individuals (Ali and Keil, 2007). In this light, unlike a sudden onset disaster such as a chemical explosion, a hurricane or even a creeping environmental disaster such as global climate change or desertification, disease outbreaks present unique challenges for disaster managers.

Unlike the disaster agents involved in other types of natural or technological disasters, the agent in a disease outbreak is not a material/physical substance or force such as a hurricane wind, energy released during an earthquake, or the crystallization of ice on surfaces during an ice storm. Rather, the disaster agent is biologically defined, that is, it is usually a virus, bacteria, or some other type of infectious pathogen. As biologically defined disaster agents, pathogens "survive", "live" and persist as long as the proper environmental and social conditions continue to be met. Classically these conditions are defined in terms of the epidemiological triad. The epidemiological triad proposes that certain necessary and sufficient conditions are required for the occurrence and continuance of a disease outbreak. Specifically, these conditions are conceptualized in terms of the coincidence and co-presence of a disease-causing agent, the host for that agent, and amenable environmental conditions that enable the disease agent to travel between hosts. As biological agents, viruses and other pathogens require a host in order to survive in the long term.

Specifically, a virus cannot propagate on its own, but requires the machinery of a human or animal host cell to reproduce itself. From the point of view of viral survival, the dilemma is that in using the host cell to reproduce, the host cell itself becomes destroyed in the process. For this reason the virus needs to find another host cell, thus infecting other parts of the body or tissues until the final outcome is the death of the entire host organism itself. To "survive" before the host expires the virus must "jump" to another host, thus contributing to the contagious character of infectious disease transmission. In turn, in order for the virus to jump from one host to another the environment must be facilitating. For example, for some viruses there must be sufficient moisture, or adequate temperature for the virus to make the leap from one host to the next as part of the transmission process. The disaster response to an infectious disease outbreak is therefore ultimately based on the strategy of breaking any of the linkages between the host, environment and disease agent thus enabling the viral flow to be disrupted and ending the chain of transmission. Commonly, such a strategy seeks to disable the ability of the pathogen to jump from one human host to the next by isolating and quarantining the infected human host. In light of the mechanics of transmission of infectious disease, it is clear that public health officials in treating an outbreak situation as a disaster, are involved in breaking the chain of transmission, that is, in interrupting the viral flow through various restrictions of human movements (Ali and Keil, forthcoming). A key part of this strategy is the tracing of contacts by public health officials. Contact tracing involves trying to identify all those that are infected or possibly infected by asking the infected to list all of the people he/she had been in contact with in a previous period of time. Through follow-up it would then be determined if the contacts were infected and those found to be infected would be quarantined or isolated to break the chain of transmission.[2]

Similar to a natural or technological disaster an official end to an outbreak disaster can be declared. In reference to a disease outbreak or pandemic the biological dimension involved allows this endpoint of this type of disaster to be ascertained with some certainty, namely if there are no new cases arising over the length of the incubation period of the pathogen (i.e. the time between exposure and symptom onset, or how long it takes the pathogen to

[2] The detainment of individuals may infringe on individual rights for the benefit of the public right to safety. For a discussion of the legal and ethical implications of quarantine and isolation during the SARS outbreaks in Toronto see Van Wagner (2008).

replicate itself), then the indications are strong that the viral flow has been permanently interrupted for that particular locality or community. The decision to declare the end of an outbreak situation (or for that matter to officially declare the onset of an outbreak during the initial phase) may however be influenced by political interests, as we shall discuss in the case of SARS.

Tracing the Flows of the SARS Coronavirus (S-CoV)

In November 2002, the city of Foshan in the Guangdong province of China experienced an outbreak of an unknown but highly contagious respiratory disease referred to at the time as "atypical pneumonia" with patients suffering from symptoms such as: fever, nonproductive cough, muscle ache, shortness of breath, and headache (Booth and Stewart, 2005).[3] Within the next several weeks the mysterious illness spread to other cities in the province including Heyang and Guangzhou, then subsequently to cities outside the province, most notably Beijing (Kaufman, 2006). Because the Chinese government did not require the adoption of formal surveillance techniques and protocols for mandatory data reporting for diseases classified as pneumonia (atypical or otherwise), epidemiological information about the disease spread was not widely communicated, shared or forthcoming. As such, the extent to which the disease spread during the initial stages was widely unknown. Further, since Chinese law classifies epidemics as state secrets, local health officials combating the mysterious outbreaks were not legally in a position to publicly comment about the outbreaks until official permission was granted by national authorities, but this was not readily forthcoming for various political reasons including efforts not to disrupt a recent leadership transition in the Chinese government (Saich, 2006). These actions were later interpreted as part of a systematic coverup and denial concerning the extent of the outbreaks on the part of the Chinese government; actions which received admonishment from the global public health community and the World Health Organization (Eckholm, 2006).

[3] These symptoms are of course also common to other illnesses, such as influenza, making the determination of SARS cases challenging, and underlining the importance of the need for a uniquely defined SARS case definition during the outbreak.

By late February 2003, the extensive nature of the outbreaks could no longer be hidden from the public view as news about the outbreaks traveled through informal channels involving text messaging and the Internet (Heymann, 2006). At this point, the World Health Organization initiated a formal inquiry based on reports they received on their Global Outbreak Alert and Response Network (GOARN) (Heymann, 2004). To further investigate and to offer assistance, the WHO dispatched a team to the Guangdong province of China but team members were denied entry to the affected areas for two months (Kaufman, 2006).

The index case for the international spread of SARS was an elderly physician who had been treating patients with the still unidentified virus in Guangzhou. In late February 2003 this physician traveled to Hong Kong to attend a relative's wedding and stayed at the Metropole Hotel. Here the virus spread to 11 hotel guests who continued their respective travels to various cities around the world, including Toronto, Singapore, Taipei, Hanoi and to other parts of Hong Kong (Abraham, 2004). The exact mode of transmission in the hotel has not been conclusively determined as some of the guests who became infected may not have had direct contact with the index case. The prevailing theories propose that the virus contaminated an elevator or traveled through the ventilation system (NACSPH, 2003). Such suspicions would be in line with another phenomenon observed during the SARS outbreaks, namely the phenomenon of "superspread", where an individual exhibits an unusually high tendency to infect others, possibly because of the production of higher viral loads or a greater amount of respiratory secretions that may linger in the surroundings (Centers for Disease Control and Prevention, 2003).

By the end of the following month there were 1,320 confirmed cases and 50 deaths from the disease worldwide (Murray, 2006:20) and by July this increased to 8,437 probable cases and 813 deaths worldwide (NACSPH, 2003). Although the absolute number of deaths from the disease remained relatively low[4], SARS nevertheless represented the first severe and readily transmissible new disease to emerge in the twenty-first century (WHO, 2003).

[4] Levy and Fischetti (2003:31) note that more people die of influenza in one week in the U.S. than had died of SARS worldwide during the first two months of the outbreak. Nevertheless, the casualty rate from SARS was quite high in Canada (17%) compared to the worldwide rate of 10% (http://www.who.int/csr/sars/country/table2004_04_21/en/index.html).

The SARS Outbreaks in Toronto

One of the travelers infected at the Metropole Hotel was a 78-year old woman who returned to her family home in Toronto where she passed away on February 23, 2003. Two days later her infected 44 year old son was admitted to Scarborough Grace Hospital where he died shortly thereafter. From this one primary case, a chain of secondary and tertiary cases developed, as two patients in the room shared with him became infected (Low, 2003). The specifics of the chain of transmission have been identified through detailed contact tracing and I will review these briefly here to give some idea of the extremely contagious nature of the disease. One of the two neighbouring patients was implicated in the spread of the disease to a total of 20 others: his wife, 2 paramedics who transferred the patient to another hospital, a firefighter, 5 emergency department staff, 1 other hospital staff, 2 patients in the emergency department, 1 housekeeper and 7 visitors. In turn, these hospital staff, visitors and patients transmitted the infection to 8 household members and 8 other family contacts. Similarly, the second patient sharing the room with the primary case initiated a transmission chain involving 19 others in the hospital setting including: his wife, 1 patient in the Emergency Department, 3 emergency staff, 1 housekeeper, 1 physician, 2 hospital technologists, 2 Coronary Care Unit patients, 1 paramedic, and 7 Coronary Care Staff members. The infected staff, in turn, transmitted the virus to 6 family members, 1 patient, 1 medical clinic staff, and 1 other nurse in the Emergency Department. Further, a physician who performed an intubation on one of the patients sharing the room with the primary case became infected and transmitted the virus to a family member, while 3 nurses aiding in the procedure also acquired the virus with one of them transmitting the infection to a household member. From these earlier experiences with the outbreak it soon became evident that in Toronto, transmission was largely occurring within the hospital system and studies later confirmed that of the 128 cases occurring in the first of two outbreaks in the city, 47 (37%) of these involved hospital staff while 36 (28%) were patients and visitors (Varia, et al., 2003). This nosocomial (i.e. hospital-acquired) nature of SARS transmission, as will be discussed, presented particular challenges for public health and hospital officials in their SARS response efforts.

During the last week of March, the province declared SARS an official emergency and issued an unprecedented "Code Orange" directive that directed hospitals to suspend nonessential services, limit visits, create isolation units for potential SARS patients, and to use protective clothing (NACSPH, 2003). Despite the prevalence of nosocomial transmission, it was realized that concerns about community transmission were still warranted because the initial transmission from the Metropole Hotel revealed that community transmission was a real possibility. Such concerns were further reinforced by the occurrence of community outbreaks in other cities, such as among 300 residents of the Amoy Gardens apartment complex in Hong Kong and a cluster of 14 cases in the Pasir Panjang wholesale market in Singapore in late March (Teo, Yeoh, Ong, 2008). In mid-April, the possibility of a wider spread community outbreak was revealed in Toronto when a cluster of 31 cases was identified in closely-knit religious community (NACSPH, 2003). This cluster was traced to members of a large extended family within that community that had visited the initial epicenter hospital (Naylor, Chatler and Griffiths, 2004; Basrur, Yaffe, Henry, 2004). As a result, about 500 members of the religious group were placed under quarantine (ibid).

By May, the number of new SARS cases seemed to have leveled off, and by the middle of this month, an official pronouncement was made that the outbreak was over and the Code Orange emergency directive was lifted. One week later, however, a new cluster of SARS cases was being investigated in a Toronto-area hospital (referred to as SARS II). The transmission chain involved in this second outbreak occurring from May 23 to June 30, 2003, and was limited to that one hospital. The cause of SARS II has remained undetermined despite extensive investigations by Toronto Public Health, Health Canada and the Centres for Disease Control (NACSPH, 2003). Over the duration of the two Toronto outbreaks, there were 44 SARS related deaths with 438 probable, and suspected cases (NACSPH, 2003) and 13,374 people placed in quarantine with court orders issued for 27 individuals for not voluntarily complying with quarantine orders (Basrur,Yaffe and Henry, 2004).[5]

The repercussions of the SARS outbreaks for the economic and cultural domains of Toronto were devastating. It has been noted that the tourism, hospitality and film industries of Toronto were particularly hard hit, with an

[5] The figures vary somewhat according to source, for example, Basrur, Yaffe and Henry (2004) record that there were 224 confirmed cases.

estimated decline of 18 percent in tourism leading to a loss of about C$993 million in 2003 (Canadian Press, 2003), as hotel vacancy rates plummeted with drastic reductions in tourists and the cancellation of international conventions. Similarly, the city's film sector witnessed a similar decline of 18 percent or a loss of $163 million (Porter, 2004). Much of the blame for these declines was focused on the what was alleged to be sensationalist media coverage of the outbreak which gave the impression that SARS was "out of control" (Drache and Clifton, 2008; Hooker, 2008), thereby leading to what has been termed a SARS-induced panic (McKercher and Chon, 2004). The decline was also attributed to the issuance of a travel advisory by the WHO on April 20 warning potential travelers to postpone travel to Toronto.

Critics contend that political concern over the economic impacts of SARS led to unacceptable and suboptimal decision-making in the SARS response. For example, Dr. Richard Schabas, a former provincial Chief Medical Officer of Health for Ontario and the Chief of Staff at a Toronto-area hospital during SARS has commented that political pressure to downplay SARS after the issuance of the WHO travel advisory "contributed to some of the key mistakes that were made in the middle of April and that led directly to SARS II…We went from SARS panic to SARS denial. And I think the move to SARS denial was at least in some measure a political response. And it was unfortunate because by going into SARS denial, we didn't do the kind of surveillance we should have been doing that would have found SARS II " (quoted by Branswell, 2004).[6] Similarly, it was noted by the provincial Commissioner of Public Security that problematic risk communication resulted in public confusion during the SARS outbreaks because of conflicting messages, such as "stay at home if you are sick" with the message that "Toronto is safe to visit" (Young, 2003). As such, Heymann concludes that "The perceived risk of SARS was many times greater than the actual risk, a factor that compounded its negative social and economic impact" (2004:1129).

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[6] Toronto-area hospital nurses raised specific concerns prior to the emergence of the second SARS outbreak. These were directed at hospital administrators and the newly relaxed infection control measures surrounding febrile respiratory disease patients rather than "surveillance" (NACSPH, 2003).

The Response to SARS in the Toronto Hospital Setting

Under the emergency protocol of the provincial government, all Toronto-area hospitals were compelled to restrict visitors; screen people entering the hospitals for signs of SARS; ensure that health workers wore masks, gowns, and gloves; suspend non-urgent transfers between health care facilities; develop a patient transfer protocol; and have available security personnel and police to enforce these precautions (Hall et al., 2003). Furthermore, the hospitals had to shut down all elective activity, thus, resulting in a massive backlog of deferred services, although during the second wave, the circumstances were different as a network of 4 Toronto hospitals were dedicated to SARS care, thereby enabling full activity to be maintained at the other 24 area hospitals (Naylor, Chatler and Griffiths, 2004). All suspected or probable SARS patients within the dedicated hospitals were placed in negative-pressure isolation rooms.

Booth and Steward (2005) note that of the four Toronto-area hospitals that had major nosocomial outbreaks of SARS, three experienced these in their Intensive Care Units (ICUs) with entire ICUs quarantined due to staff infection (Hawryluck et al., 2005). To deal with this situation, quarantined physicians and other hospital staff communicated through regular, thrice-weekly teleconferences with representatives from public health, infection control, infectious diseases, government, and hospital administration in order to coordinate the hospital response and to discuss the most current clinical information and therapeutic challenges (Booth and Steward, 2005).

As mentioned previously, the outbreaks in Toronto were largely limited to the hospital setting and it was estimated that about 43% of the total number of suspected cases were health care workers, whereas in other places which had experienced community outbreaks the proportion was much lower -- for example, in Hong Kong the proportion was 22% (Naylor, Chatler and Griffiths, 2004). That most cases of SARS were found in Toronto hospital setting can partially be explained by considering the epidemiological curves of this disease. Such frequency distributions reflect the finding that those having SARS were most contagious at that point in which they were the most ill, and it was precisely at this point that infected individuals were most likely to admit themselves into hospital for care, thereby limiting the possibility of community outbreak -- but at the same time enhancing the spread of the disease within the hospital setting (Varia et al., 2003). A second partial explanation may be that

Toronto designated SARS-dedicated hospitals too late in the outbreak, unlike other cities, which experienced little or no transmission to staff because of much earlier action in this regard (Hawryluck et al., 2005)

Several factors complicated the initial attempts by hospital staff to grapple with the outbreak response, including: the absence of a universally accepted case definition and diagnostic test to confirm suspected cases, as well as the lack of an effective treatment or vaccine for the novel disease (Gostin, Bayer, Fairchild, 2003). Consequently, key officials often had to make decisions in the absence of the full picture (Basrur, et al., 2004:24) and this had significant ramifications. For example, Booth and Steward (2005) observe that the spread of SARS from the epicenter hospital occurred during the early stage of the outbreak when two patients not recognized as having SARS were transferred to other hospitals due to the shortage in resource capacity faced in the epicenter hospital. Furthermore, the partial knowledge situation may have also contributed to the lack of trust observed between front-line workers and leadership because as Hawryluck et al. (2005) note, the changing of previous directives, for example, confusion over whether the responsible virus could be airborne and variable use of airborne versus droplet projection, led to a lack of confidence in leadership with the concomitant spreading of rumours and speculation amongst health care workers and a general loss of workplace morale.

A particularly critical factor in limiting the effectiveness of the response, however, was a lack of hospital surge capacity in its various dimensions, including the necessary expertise and adequate personnel and beds to accommodate the increased patient loads arising during the outbreaks. The SARS outbreaks revealed that knowledge of infectious disease as well as the application of appropriate infection control practices in Toronto hospitals was lacking and this may have accounted for the high rate of transmission amongst health care workers as there was “limited awareness of the correction precautions and/or how to apply them” while “little, if any, monitoring of infection control practices and few consequences for non-compliance” (Canadian Hospital Epidemiology Committee cited by NACSPH, 2003). Further, the standard recommendation of the Canadian Infection Control Alliance of one infection control practitioner per 175 beds was not met by 80% of Canadian hospitals, a situation worsened by the fact that over 60% of hospitals were completely lacking any infection control director with advanced qualification in infectious disease, medical microbiology or infection control (NACSPH, 2003). Toronto, for example had only a handful of hospital epidemiologists. One notable consequence of the lack of expertise in this area was the absence of institutionalized disease control strategies based on the creation of a hospital infrastructure whose overall objective would be to contain biological threats through the tracking and managing of hospital-acquired infections, education of hospital staff, and reinforcing the necessary precautions (NACSPH, 2003).

With respect to the lack of surge capacity in term of personnel, the mass voluntary quarantine of those with hospital exposures included up to 5,000 individuals, most notably hospital staff (NACSPH, 2003). The quarantine of health care workers significantly reduced the pool of people able to combat the disease, especially in relation to nursing staff and physicians. For example, the federal commission noted that Sunnybrook and Women's College Hospital carried the largest volume of SARS patients in the Toronto area, but many of the of the physicians with the greatest relevant experience were quarantined, forcing hospital administrators to desperately request support through numerous channels (NACSPH, 2003). No where was this lack of surge capacity more felt than in the case of the nursing staff and the SARS outbreak experience has revealed some significant structural shortcomings in the way the nursing sector operates in Toronto and Ontario and it is worth considering these at this point.

For some time now, Ontario has experienced a shortage of nurses, but the effects of this were most dramatically revealed by the SARS outbreak response in Toronto hospitals. As a consequence of quarantine measures, those remaining nurses who were able to work were forced to work longer shifts -- for example, nurses typically worked 12-hour shifts -- which in turn increased the risk of exposure because overworked staff were more likely to make mistakes and many did not strictly follow preventive procedures or take adequate precautions because of fatigue (Varia et al., 2003). Perhaps as a consequence of this, and coupled with the fact that nurses represented the majority health care worker group who had direct contact with the respiratory secretions of SARS patients (Hall et al., 2003), the SARS attack rate amongst nurses assigned to SARS patients was found to be quite high, with an estimated range of 25 to 40 per cent (Varia et al., 2003). It was not surprising to learn therefore that 5 Toronto-area nurses quit their jobs because of SARS burnout due to stress and working conditions, mental and physical hardships over long hours (Talaga, 2003). The plight of the nurses involved in the SARS response was worsened by the unfortunate community "shunning" of nurses as well as the families of health care workers that undoubtedly contributed to the low morale found amongst the staff (Hall, et al., 2003). To understand these developments it is necessary to consider the context of the larger political economic context in which the nursing sector in Ontario operates, most notably in terms of the neoliberal political economic climate of the province (see also Salehi and Ali, 2006 as well as Sanford and Ali, 2005).

To deal with the reduced amount of funds available to remunerate nurses, hospitals were forced to adopt certain strategies such as the casualization of health care work where Ontario employers are not obliged to pay-out benefits to part-time (i.e. "casual") workers. In this context, the nursing labour force in Ontario is highly "casual" (Perkel, 2003; Nuttall-Smith, 2003). Such circumstances increased the potential for inter-hospital spread of the S-CoV as many nurses were forced to work at multiple jobs at multiple locations to earn a full-time wage equivalent. Fortunately, perhaps due to the directive that nurses only work at one site during SARS (Burcher, 2003), only one case of inter-institutional transmission was documented (NACSPH, 2003). However, such restrictions further constricted the available pool of nurses (Hall et al., 2003). The casualization of nursing labour has several other implications for the ability to respond effectively to outbreak. First, since casual workers are paid on an hourly basis, a latent incentive may be created for casual work nurses workers to continue to work while ill, thus increasing the potential for disease spread (NACSPH, 2003). Second, casualization may lead to an attenuation of a sense of workplace community and a reduced awareness of infection control protocols, both essential for front-line workers faced with an outbreak situation (NACSPH, 2003). Third, the nursing shortage meant that 4 to 5 patients were assigned to one nurse but it was soon recognized that this was a potentially dangerous ratio that could lead to enhanced disease transmission (Loutfy et al., 2004).

The Response of Toronto Public Health to SARS

In contrast to the management and treatment of SARS cases within the institutionalized setting of the hospital, the local public health agency (i.e. Toronto Public Health) was responsible for the SARS response in the community setting. Specifically, Toronto Public Health focused on infectious disease surveillance, case investigation and management, identification and quarantine of contacts, and the reporting of health risk assessment and infectious control advice to health institutions (Basrur, Yaffe and Henry, 2004). In some ways, the efforts of public health officials to track the disease in the community are parallel to efforts undertaken by hospital officials to track the disease within the institutional setting and indeed even reflects the tasks involved in the global public health response (see section below). During the initial stages of the outbreak, tensions arose between public health and hospital officials because the latter was asking the former for assistance in tracking the spread of disease with hospitals. Public health officials argued, however, that syndromic surveillance within hospitals was a matter for institutional infection control, and therefore outside the mandate of public health. Moreover, Toronto Public Health contended that they lacked the resources to implement surveillance programs in hospitals in any case (Basrur, Yaffe and Henry, 2004).

The first case of SARS was brought to the attention of Toronto Public Health (as a possible case of tuberculosis) on March 9, 2003, and five days later the agency activated its emergency response plan to respond to an outbreak situation (Basrur, Yaffe and Henry, 2004). This response included the establishment of a public information hotline, and the assignment of full-time staff dedicated exclusively to outbreak investigation involving such activities as manning the case reporting telephone line, tracing the chain of contacts by investigating all reports through follow up calls, obtaining detailed histories of symptoms, and compiling laboratory results and epidemiological linkages with other SARS cases (Basrur, Yaffe and Henry, 2004).

Similar to the situation in Toronto hospitals, Toronto Public Health lacked surge capacity in specialists trained in infectious disease, as well as in general staff, and had to redeploy and train officials from other departments (including Public Health Nursing, Family Health, Health Lifestyle, Health Environments, and Communicable Disease Control) on how to conduct epidemiological field work related to outbreak investigation. Consequently, about 700 Toronto Public Health staff were involved in the SARS response from mid-March to end of June, with 400 working on any given day (Basrur, Yaffe and Henry, 2004). During the course of the outbreaks 224 SARS cases were identified on the basis of 2,000 case investigations, each taking close to 9 nine hours to complete (ibid). Over 23,300 people were identified as contacts of whom 13,374 were placed in quarantine where the movement of suspected or probable cases was restricted to their homes (ibid). A high degree of compliance was found with only 27 isolation orders being issued to deal with those who did not comply to quarantine. One notable example of this was an employee who defied a quarantine order by returning to his place of work at an information technologies firm – infecting a co-worker and leading to the quarantine of close to 200 employees (Naylor 2003).

The outbreak response by Toronto Public Health, although ultimately successful, was plagued by certain challenges and problems. As can be inferred from the above description of activities related to outbreak investigations, these activities are not only very labour intensive but also very much information-intensive. It is perhaps self-evident how limits in surge capacity or the number of personnel will have a direct impact on ability to carry out the outbreak investigation. What was also revealed by the SARS outbreak, however, were the numerous inadequacies faced in the collection, processing and communication of epidemiological information and data. The federal investigative inquiry found that initially Toronto Public Health's capacity to collect and process data was overwhelmed, resulting in the inability to generate timely data during the first two to three weeks of the outbreak (NACSPH, 2003). The collection and processing of data was limited by certain interrelated constraints, the first involving an inefficient information and communications infrastructure in place during the time, and secondly a lack of coordination in communications between hospitals and public health agencies at different levels of government.

The provincially mandated information system for the surveillance of reportable disease was found to be very outdated and the 14-year-old system was not able to support the quarantine management functions required for the management of SARS cases during the outbreak situation. Although a plan was proposed by the provincial Public Health Branch to update the system in the years previous, the proposal was not approved for funding by the government, forcing Toronto Public Health to develop their own software tools to track SARS cases and contacts (NACSPH, 2003). The development of this electronic surveillance tracking system was started at the beginning of April through the efforts of a professor of epidemiology from the University of Toronto who was seconded by the province to work on this task (ibid). Due to the urgency of keeping track of cases and contacts, prior to the development of this on-the-spot software tools, Toronto Public Health maintained their records on paper charts and maps, using colour-coded Post-It notes (Basrur, Yaffe and Henry, 2004). The city's chief medical officer of health remarked that this was like using nineteenth century tools to fight a twenty-first century disease (NASCPH, 2003).

With the realization by the province that the expertise to deal with the outbreak was not in place, a provincial emergency team was organized and co-chaired by the provincial medical officer of health and the commission of public health and security (NACSPH, 2003). As part of this initiative, a Scientific Advisory Committee was formed consisting of a group of volunteer physicians, infection control practitioners, and administrators from across the country who essentially comprised a "human-cellphone conglomerate" (ibid). The Scientific Advisory Committee devoted themselves to the task of developing quarantine guidelines and hospital directives covering topics such as those relating to the restriction of access, isolation precautions, employee screening and patient transfers. Once developed, these directives were forwarded to the Hospitals Branch of the Ontario Ministry of Health and Long-Term care to be reworded as operational protocols, or as the team referred to it, "translation into 'Hospitalese'" (NACSPH, 2003). The work involved by these groups, however, were also hampered by difficulties related to the inadequacies and insufficiencies of the data in fulfilling the data requirements needed for the tasks at hand.

Related to the inadequacies of the computerized platform were problems involving loosely linked data collection systems within Toronto Public Health itself and the lack of compatibility among data management systems across local health units and hospitals in the province. It was in this organizational context that Affonso et al. (2004) observe that hospitals in Toronto tend to operate autonomously with their respective information and communications systems functioning independently of each other. This lack of interoperability increased the potential for disease spread because flow patterns of the disease would more likely remain unchecked, particularly in circumstances of nosocomial transmission such as those found during the SARS outbreaks. Furthermore, it was clear that such communications difficulties made it difficult to coordinate the SARS response among local, provincial and federal health authorities, the health care sector, the community and other agencies (Basrur, Yaffe, Henry, 2004). For example, later in the outbreak, once a universally accepted case definition was being used in diagnosis, and hospital laboratories took over testing for the SARS Coronavirus, the ability of the provincial laboratory to monitor data at the national and provincial level, as well as the ability to link already-limited epidemiological data to laboratory results were directly affected by the lack of a coordinated communications and information infrastructure (NASCPH, 2003).

As noted by the provincial Chief Medical Officer of Health at the time, problems in communicating SARS data also arose because of requirements to protect patient confidentiality before releasing sensitive data to Health Canada and the Ontario Public Health Branch (D'Cunha, 2004), although Health Canada countered that this should not have been a problem since they never requested personal identifiers, but simply requested more detail as required by their obligations to keep the World Health Organization informed about the extent of the outbreak. Problems in data reporting were in fact found to form the backdrop to the emergence of terse relationships between officials from the three levels of government (NACSPH, 2003) that ultimately contributed to dysfunctional qualities of the outbreak response.

The Global Public Health Response to SARS

The rapid international spread of the SARS dramatically illustrates how connections between different places in the world, particularly between global cities, have significant implications for the spread of infectious disease in contemporary times (Ali and Keil, 2006). Such globalized connections, in turn, have brought to the fore the crucial need to develop globally coordinated strategic responses to potential pandemics, and has thus turned the spotlight onto the role of the WHO as the central agent to take on this function. Traditionally, the WHO's ability to coordinate the response to disease outbreaks followed internationally agreed upon communication and information sharing protocols whereby the international agency could only communicate with the representatives from national government agencies of the affected region. Thus, in the case of SARS in Toronto, it was Health Canada who communicated with the WHO in terms of agreeing upon local outbreak response strategies, the implementation of such strategies and the sharing of epidemiological, clinical and laboratory data. Such communication protocols, as was alluded to previously, in the case of the relationship between China and the WHO were problematic, as revealed for example, by the fact that requests by the WHO for data on the outbreaks in China were initially denied by the Chinese government, while early requests by WHO officials to visit the affected areas were delayed by the national government.

As the central coordinating agency involved in an international outbreak response, the WHO relies on obtaining information from affected areas. The SARS outbreak revealed that unlike an earlier era where the WHO had to exclusively rely on the information officially provided to them by the governments of UN member states, in the age of the Internet, information can now be obtained through other, sometimes unofficial channels. It was in this context that in the year 2000 the WHO formalized the establishment of GOARN – a network of 120 partners (including national government agencies and scientific institutions having expertise in infectious disease) located across the world (Levy and Fischetti, 2003:7). The mandate of GOARN included the provision of technical assistance in identifying the causes of unusual infectious diseases, their sources, and their routes of transmission (Levy and Fischetti, 2003:24). Since its inception GOARN has led to responses in more than 50 localized outbreak situations in developing countries, but SARS was the first GOARN identified outbreak involving international spread (Heymann, 2006). One of GOARN's members was the Health Canada based Global Public Health Information Network (GPHIN), a computer application that continuously and systematically trawls web sites, news wires, local online newspapers, public health e-mail services, and electronic discussion groups in 6 languages (English, French, Spanish, Russian, Arabic and Chinese) for reports of infectious disease outbreaks using key words or phrases (Heymann, 2006:350), and it was GPHIN that first alerted the WHO about suspected outbreaks of "atypical pneumonia" in Southern China in late November, which in turn served as the impetus for the subsequent request by the WHO for information about the suspected outbreak from China on December 5 and 11 (Heymann, 2006) .

As David Heymann, the WHO Executive Director of Communicable Diseases during SARS notes, the role of GPHIN and other electronic websites such as ProMed, have led to a new situation in which countries can no longer hide information about disease outbreaks that occur within their sovereign borders, as shown in the case of SARS information and China as: "New norms and standards for reporting and responding to public health events of international importance have been established and clearly demonstrated in the world's response to SARS" (Heymann, 2006:353).

On March 15, 2003, the WHO officially pronounced SARS a worldwide health threat and on the basis of this understanding issued travel advisories to the various SARS affected locations (Heymann, 2004). The assessment of SARS as a global public health threat was based on the ever-accumulating epidemiological evidence concerning identified outbreaks in Hong Kong, Hanoi, Singapore and Toronto, as well as increasing concern over the potential for the global spread of the disease by air travel (see section below). Further, based on analysis of the cumulative real time clinical information regarding symptomology, a case definition of SARS was developed by the WHO and agreed upon by an international scientific consensus (Heymann and Rodier, 2003). The case definition was than posted on the WHO website and brought to the attention of officials in affected areas to help identify them cases in the various outbreak localities (although some jurisdictions retained the use of their own case definition). Notably, the available Internet technologies allowed the WHO to "quickly to chart the disease's spread, eliminating guesswork that in years past might have prompted the agency to take a wait-and-see approach. It was now possible to identify and respond to threats so much more quickly, and an early alert was justified" (Levy and Fischetti, 2003:9).

Not only did the global public health response to SARS involve new ways of communicating and analyzing epidemiological (i.e. regarding the frequency and distribution of cases) and clinical information (i.e. regarding symptoms and a case definition), it also involved news ways of laboratory research collaboration in relation to the identifying the causal agent of a new and emerging disease. In this connection, the GOARN enabled the linking of laboratory scientists from around the world in virtual networks in which satellite broadcasts, teleconferencing and Webcasts were used to share laboratory results (Levy and Fischetti, 2003:14). Thus, on February 20, the WHO was able to mobilize its Global Influenza Surveillance Network to start analyzing samples from a patient with atypical pneumonia who had traveled to Hanoi from Hong Kong. And by mid-March, the WHO coordinated the distribution of patient samples from other outbreak locations to twelve laboratories that dedicated their resources to identifying the causative agent of SARS, with a teleconference being held on March 26 to allow experts from around the world to share their findings (Levy and Fischetti, 2003:24). It was on the basis of this rapid real-time information sharing and analyses that the viral agent and its genetic code were identified in the unprecedented span of several weeks (as opposed to the past experiences of at least several months)(ibid) and highlights one of the greatest successes of the global outbreak response (Ali, 2008).

SARS and Air Travel

With nearly simultaneous outbreaks emerging in Hanoi, Hong Kong, Singapore and Toronto from March 11-14, the WHO quickly recognized the importance of air travel in the international spread of SARS. Two incidents in particular further reinforced the WHO's concern over the potential threat of SARS transmission through air travel. The first occurred on March 15, involving the case of an infected individual who had boarded Air China flight 112 from Hong Kong to Beijing after visiting a sick niece at a Hong Kong hospital (Abraham, 2003:91). As a "super-spreader" this individual infected 21 others on board the flight, including crew members and passengers sitting as far as seven seats away. In fact, two of the infected stewardesses on this flight initiated a transmission chain of nearly 300 infections in their home province of Mongolia (Abraham, 2003:91). The spread of infectious disease during a flight is unusual, as modern aircrafts are equipped with high-efficiency particulate air filters, similar to those used in hospital operating and emergency rooms (Abraham, 2003:92). It was later found, that transmission aboard Air China 112 was the exception and not the rule, however, this was of course not known at the time of the flight itself and the WHO opted to err on the side of caution in future situations.[7] Thus, when if was learnt that an infectious disease specialist who had treated patients during the Singapore outbreaks and subsequently traveled to New York City with family members to attend a medical conference, the WHO took action. On his return flight back home to Singapore via Frankfurt on March 14, the airline was alerted and the specialist and his family members disembarked and were hospitalized in Frankfurt (Heymann, 2004).

[7] Apart from this one flight, only five other people in the world are believed to have caught the disease from a fellow airline passenger (Bowen and Laroe, 2006).

Because of the potential spread of SARS through air travel, the WHO asserted that it "regard[ed] every country with an international airport, or bordering an area having recent local transmission, as a potential risk for an outbreak" (cited by Gostin, Bayer and Fairchild, 2003:3231). As such, travel advisories were issued by the WHO in order to warn passengers not to travel to such areas. Furthermore, the WHO insisted that airports in affected cities take certain measures to screen passengers for SARS. In particular, airports were asked to screen passengers for history of contact with SARS.[8] Thus, in Toronto and Vancouver, these measures took the form of the distribution of information cards with screening questions handed to passengers, accompanied by secondary assessments by officials as required and the implementation of thermal screening at airports (to identify those who have elevated body temperatures as a first indication of a potentially infected individual). By the end of August roughly 9,100 passengers were referred for further assessment by screening nurses or quarantine officers but none were identified as having SARS (NACSPH, 2003). Other countries yielded similarly low results and critics have subsequently raised the issue of dubious efficacy of using thermal monitors as a screening measure for infectious disease (St. John, 2003). One public health specialists involved in the SARS response in Singapore noted however, that despite the low efficacy of thermal screening at airports, such measures nevertheless fulfilled certain useful functions (Interview with Singapore Travel Medicine specialist, January 5, 2006). It was argued that from a public health perspective, the conspicuous presence of thermal scanners could serve to raise the public awareness of SARS, and secondly, in a related manner, their presence could serve a social and political function with respect to public relations within the particular context of Singapore, namely thermal scanners represented a visibly symbolic gesture or "indication of how good your government is"; a particularly influential and relevant ideological factor within the paternally based political culture of this particular global city-state (Teo et al., 2005).

On March 26, the premier of Ontario declared SARS a provincial emergency under the Emergency Management Act, thus giving the province the

8 The ability to track the spread of SARS during the early stages was complicated by the inability to accurately and rapidly track travelers from affected areas because airlines do not routinely maintain flight manifests for more than 48 hours after completion of a flight (Central Intelligence Agency, 2003:5).

power to direct and control local governments so as to ensure that the required resources needed to address the emergency could be mobilized. As part of this mobilization strategy, the multi-ministry Provincial Operations Centre for emergency response, situated on the 19th floor at 25 Grosvenor Street in Toronto, was also activated to help coordinate the response. Further, the Ontario government, under the Health Protection and Promotion Act, designated SARS as a reportable, communicable, and virulent disease thereby giving public health officials the authority to track infected people, and issue orders preventing them from engaging in activities that might transmit the new disease. As such, the Medical Officer of Health may designate to public health officials powers similar to those of police officials with respect to civil detention in relation to quarantine (which limits the movement of healthy individuals, that is, those in contact with infected individuals) and isolation (those who are infected and separated out from the community)(Walker-Renshaw, 2003). The granting of widespread powers to quarantine and isolate individuals was also deemed as necessary at the federal level because Toronto Pearson International airport falls under federal jurisdiction (for the implications of jurisdictional issues in dealing with outbreaks at airports see Ali and Keil, forthcoming). Thus, at the federal level, Health Canada transferred its quarantine responsibilities to the Canada Customs and Revenue Agency staff employed at the airport. Airport authorities, however, expressed concerns about this, citing limitations in their ability to provide logistical support and to manage the relevant communications, while noting that Customs staff were simply not trained to be involved in quarantine and isolation duties (NACSPH, 2003), again, reflecting the insufficient surge capacity experiences of hospitals and local public health agencies in Toronto.

Concluding Remarks: Challenges of the Global-Local Dialectic for Infectious Disease Response

The contagious character of the SARS Coronavirus as a disaster agent has meant that response initiatives have had to focus on the mobility of the virus. The ultimate goal of such a focus is to break the chain of human-to-human transmission by intervening in the flow of human contacts by quarantining and isolating those infected or potentially infected. Accordingly, much of the SARS outbreak response efforts were directed towards the gathering of appropriate information and data in order to track the viral/human flows so as to be able to strategically intervene in such a manner.

Because viral flow does not respect borders, while at the same time reflecting the patterned intricacies of human interactions in all its' diversity, the pathways of disease transmission become quite complex, notably, implicating different scales of interaction, from the global down to the local (Ali and Keil, 2009). Thus, for example, at the global scale, the virus spread internationally *amongst* some of the major global cities of the world such as, for example, Beijing, Hong Kong, Singapore, and Toronto. Meanwhile, at the local scale, it spread in the hospitals and communities *within* these cities. Such complex pathways in transmissions among and within different locales around the globe have created challenges for the not only the collection of viral transmission data, but for the sharing of such data across different scales – from the global to the local. Fortuitously, as the SARS experience attests, modern information and communication technologies such as the Internet and teleconferencing helped to deal with such challenges, in particular by providing a platform for real-time exchange of epidemiological, laboratory and clinical information. Nevertheless, the political economic context in which information was gathered and shared played an important role in the response as well. From the review above we have seen that this can happen in several ways. First, at the level of relations between nations, national policies on disease reporting may differ from country to country based on their respective conceptions of protected national sovereignty. Thus, during the early stages of SARS, the global public health effort to track the disease was thwarted by China's reluctance to publicly acknowledge the outbreak and share the relevant information with the global public health community (particularly the WHO). Further, the WHO can not become involved in local global public health responses unless officially given permission to enter the country (which again China was reluctant to give). At the same time, the WHO's response to SARS, in the form of the issuance of a travel advisory to affected locales had broke with the long-held Westphalian tradition that the international public health agency would not interfere with any nation's sovereignty, particularly its' ability to conduct trade and commerce (Fidler, 2004).[9]

Concerns about the influence of infectious disease on trade have a long history, dating back at least to the time of the Black Death in the 1300s when the city-states of Venice and Florence quarantined incoming ships (and their cargo) to port for forty days to ensure that they did not carry infectious diseases (Price-Smith, 2009). In today's era of increased air travel however, the airport (rather than the shipping port) takes on greater significance, and in the context of the SARS outbreak response, we have discussed how specific initiatives, such as airport screening were adopted by the airport to interrupt the flow of the virus.

Our discussion of the SARS outbreaks also illustrated how viral transmission presented certain challenges in the local context as well, particularly in the hospital setting. As alluded to previously, one of the biological characteristics of the SARS Coronavirus was that it made people most infectious at the time they were the most ill (NACSPH, 2003), and it was during this period that people would admit themselves to the hospital. This to some extent was a fortunate turn of events because it meant that those who were the most contagious would withdraw from the larger community to enter the hospital. At the same time, however, this also meant that the hospital became a central location for viral diffusion. It was at this point the political economic once again factors in, this time by affecting the hospital's ability to respond to the outbreak. In this connection, the influences of the political economic context are seen in Toronto's response in several ways, most notably in terms of reduced funding for public health and hospitals that impacted on many aspects of the response, including: the lack of surge capacity and inadequate capacity for epidemiological investigation (leading to difficulties in contract tracing and syndromic surveillance within hospitals as well as in case management) inefficiencies in communications and data sharing), a lack of expertise in infectious disease control, and a lack of coordination between public health and hospital systems. Indeed, it may be concluded that one of the most significant outcomes of SARS was that it dramatically revealed many of the hitherto latent dysfunctions of the existent hospital and public health systems.

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[9] The Westphalian tradition refers to the international political order premised on the notion of the sovereign nation-state having exclusive and sole governance over its defined territory (the term refers to the Peace of Westphalia treaty signed in 1648 between warring European powers; a treaty based on the principles of sovereignty and territoriality).

Finally, the SARS outbreak experience highlights the important need to cross-train public officials on outbreak investigation and emergency preparedness (Basrur, Yaffe and Henry, 2004). This is perhaps of even greater importance in today's globalized world where the local and distant are even more tightly integrated than in the past because as Kickbusch observes, "In an interconnected world, we must acknowledge the truly global nature of public health, and nation-states must commit to full cooperation if a disease like SARS is to be contained"(2003). In this light, local health care and public health agencies must reorganize themselves towards a more explicitly international orientation (Lee and Abdullah, 2003), as international agencies such as the WHO, which track infectious diseases globally, rely on input from the local level. Thus, as Heymann and Rodier (2003) of the WHO note, inadequate surveillance and response capacity in one city or location can endanger the public health of the whole world. The differential surveillance capacities of locales around the world also points to the increased importance of modeling and simulation exercises in the disaster management response to disease outbreaks. The rationale for this is given by Weiss and McLean:

> [S]uppose the virus had flow from Hong Kong to Durban instead of Toronto. It is a city of similar size but without a similar health infrastructure, and with a significant proportion of inhabitants immunocompromised owing to HIV-1 infection. Then Africa could have been endemic to SARS by now. Epidemiologists and public health experts sometimes frown upon us for indulging in such 'what if?' scenarios. However, modeling what has not yet happened, but might unfold next time, is surely part of contingency planning and preparedness. (2004:1139)

Although the biological particularities of the influenza virus are different from the SARS Coronavirus in some important respects (e.g. infectivity rate, incubation period), the SARS experience did represent a "trial run" of sorts for disaster managers preparing for pandemic flu (Keil and Ali, 2006; Ali et al., 2006). Hopefully therefore, the insights gained in identifying and analyzing the general types of problems and issues arising during the SARS outbreak response will be helpful for the management of future disease outbreaks and pandemics in our increasingly globalized and interconnected world.

Epilogue: The Influenza A/H1N1 (Swine) Flu Pandemic

During the time of this writing in the summer of 2009, as experts around the world were closely monitoring the animal-to-human transmission of avian flu, cases of swine flu originating from Mexico were becoming evident in Canada. Swine flu outbreaks were occurring in First Nations reserves in Manitoba (White, 2009) and overnight summer camps Ontario (Alphonso, 2009a), and in a Nova Scotia high school (Ha and Laghi, 2009). In light of these developments it may be useful to consider briefly how the SARS experience has influenced the response to the unfolding swine flu pandemic.

The diffusion of the two diseases (and therefore the respective responses) will vary according to the biological characteristics of the virus in question and it is thus helpful to compare the respective viruses in this regard. First, the incubation period of 2 to 7 days for SARS was much longer than that of 1 to 2 days for Influenza A/H1N1 (Picard, 2009a). The basic reproductive rate, or the average number of people a disease carrier infects, also varied at 2 to 5 persons for SARS and 1.5-2 persons for Influenza A/H1N1 (Picard, 2009b). These differences coupled with the previously mentioned fact that with SARS, the individual is most contagious when he/she was most ill, have contributed to different viral diffusion patterns. Specifically, unlike the mostly nosocomial transmission of SARS, Influenza A/H1N1 appears to have a stronger tendency for community spread, particularly amongst young adults – a situation different from seasonal influenza where young children and the elderly are most impacted (Picard, 2009c).

It is quite apparent that the nature of the response to Influenza A/H1N1 has been influenced by the SARS experience. This is evident in several ways. First of all, in response to the report of the SARS public inquiry commission, the federal government established the Public Health Agency of Canada in 2004 to help coordinate provincial agencies and testing laboratories across the country and to fill the need for a single point authority for more effective communication during an outbreak (Vanderklippe, 2009). Furthermore, many hospitals have since developed and implemented pandemic plans that included the hiring of more staff and the preparation of more isolation rooms to deal with infected patients (ibid).

A second indication of learning from the SARS experience is revealed by considering the response of individual countries to the outbreaks of Influenza

A/H1N1. China, for example, in contrast to its previous much-criticized secretive response to SARS, has been much more open and vigilant in its response (McKinnon, 2009). Furthermore, the country's government has taken pains to show that it has learned from the past. This is seen for example by much more extensive coverage in the Chinese press, as well by frequent public announcements by government officials concerning the efforts being taken to deal with the potential entry and spread of swine flu within its borders, as well as by the increased public reporting of even suspected cases of swine flu (McKinnon, 2009). This openness in reporting on the status of the infectious disease threat was also noted with respect to Mexico. Thus, Dr. Allison McGeer, an infectious disease expert from Mount Sinai Hospital in Toronto (who was also involved in the SARS response) remarks that before SARS, Mexico would followed the prevailing protocol of that time, namely to investigate a local outbreak but not alert other nations, but that today the situation has changed (Alphonso, 2009b)

A third change in the pandemic response is seen in the actions of the WHO. After SARS and the avian flu, the international agency developed a pandemic alert system that is based on scale comprised of a series six different alerts to inform the international community of the seriousness of the threat (Picard, 2009d). According to the WHO (2009) scheme, the Inter-Pandemic Phase is the first phase and consists of stages 1 and 2. Stage 1 represents a situation where there is low risk of human cases, whereas Stage 2 involves a higher risk that human cases may arise. The alert is moved to the Pandemic Alert Phase once it is known that the new virus causes human cases. The three stages in this phase vary according to whether there is: (i) no very limited human-to-human transmission (Stage 3); (ii) evidence of increases in human-to-human transmission (Stage 4) and (iii) evidence of significant human-to-human transmission (Stage 5). With the development of efficient and sustained human-to-human transmission the final stage of Pandemic is reached (Stage 6).

Notably, this alarm level scale serves as a barometer of the risk of a pandemic and does not indicate the severity of the disease itself (Picard, 2009e). Rather, the pandemic alert system refers strictly to the extent of geographic spread of the disease and does not give information about the severity of the symptoms (Picard, 2009f). As the pandemic unfolded from the spring to the summer of 2009, the alert level was raised as the Influenza A/H1N1 continued its international spread, and on June 11, 2009 it was raised to its highest level (Alphonso, 2009c).

Finally, it should be noted that the response to SARS differed from Influenza A/H1N1 because there was no known vaccine for SARS during the outbreaks but with respect to Influenza A/H1N1, tests indicated that vaccines Tamiflu and Relenza could be effective (Alphonso, 2009b). Consequently, unlike the situation with SARS, the media covered issues pertaining to the availability and distribution of the vaccine supply in Canada (Alphonso and Galloway, 2009; Perreaux, 2009; Alphonso, 2009c).

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