Unanticipated Consequences of Pandemic Flu - transportation related issues
A preliminary literature review

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Broadly speaking, plans for the containment and treatment of pandemic flu lead to a set of circumscribed outcomes, which include process outcomes (e.g., numbers of individuals vaccinated, numbers of health care workers vaccinated, numbers of intensive care beds opened up) as well as health outcomes (e.g., flu-related morbidity and mortality, transmission rates, and attack rates). Less well-known or researched are other health outcomes, such as excess morbidity and mortality from untreated or undertreated illness and injury distinct from influenza, and social outcomes related to such issues as increased crowding, health system congestion, increasing scarcity of resources (including monetary resources), major population shifts, and degradation of various workforces (health care, urban infrastructure such as police and sanitation, critical infrastructure,etc.) with their consequent effects.

The New York City Department of Health and Mental Hygiene Pandemic Influenza Preparedness and Response Plan (July 2006) represents the "first-order" response to human-to-human transmission of avian flu. Community-level activities to be considered, as outlined in the city's plan, include increased surveillance at ports, transportation hubs, and within the health care system; promotion of personal respiratory and hand hygiene; isolation of confirmed cases and possible quarantine of confirmed contacts; the possible closure of schools; the possible cancellation of public gatherings; and efforts to reduce crowding on mass transportation systems. A level of "second-order" consequences would involve individual and organizational responses to first-order directives as well as responses to the ongoing and cumulative effects of the pandemic. For example, although it is unlikely that public authorities will purposefully close mass transit in order to reduce transmission, it is possible that work shortages due to illness and unwillingness to work may lead to transportation closures or curtailment.

As part of the larger NCDP project to consider the unanticipated consequences of pandemic flu in New York City, the investigators are generally considering the following questions:

1. How will populations react to a pandemic flu?
2. How will populations react to non-pharmaceutical interventions (NPI) such as
    a. School closures?
    b. Mass transportation curtailment or closure?

        i. What are demographics of ridership?
        ii. What happened in previous transportation closures?
3. How will health systems be affected by NPIs?
    a. Among their workforce
    b. Institutionally and organizationally
4. What other systems will be affected by flu and by NPIs..., and how have systems responded previously to major disruptions in critical infrastructure sectors?
    a. Urban infrastructure
        i. Sanitation
        ii. Water and utilities
        iii. Banking and finance
        iv. First response (police, fire, EMS)
5. What are estimates of excess mortality and morbidity that are not caused by flu?
6. Is it possible to model "second-order" health and social consequences in an urban environment such as NYC?

This initial literature review sought to identify evidence, theoretical frameworks, and other supporting documentation from the peer-reviewed press, the "grey" literature of study reports and public documents, and press reports that might inform the larger project, above and beyond its direct association with transportation-related issues. We organized the literature review around four major themes:

- Critical infrastructure loss
- Consequences of specific transportation shutdowns
- Social behavior related to elements of a pandemic, including historical evidence, survey research on population attitudes and anticipated behavior, and workforce-related issues
- Health and social consequences of crowding and health system congestion, directly or indirectly associated with pandemic flu and first-order responses.

Health, Social, and Economic Consequences of Critical Infrastructure Loss

The Northeast Blackout of 2003, which left eight US states and a Canadian province powerless for eighteen hours in mid-August, and with reduced power for up to four days afterwards, represents a very different type of disaster than does the accumulating morbidity and mortality of a pandemic infectious disease, but it does afford a look at the impact of a major critical infrastructure loss. Whereas a pandemic will not independently cause such a critical infrastructure loss, it is possible that the secondary effects of absenteeism and specific policy actions (such as limits, curtailment, or closure of transportation systems) could potentially lead to such massive infrastructure loss. Even setting aside the low probability of a pandemic resulting in such an infrastructure loss, it is valuable to consider the organizational and human responses to the disaster environment.

Several articles and reports identified the impact on the health care system. Although hospitals

in NYC had emergency plans to switch their operations to emergency electrical generation, a number of problems emerged, such as generator failures, insufficient fuel supply, hospital elements (such as specific wards, air conditioning systems, or information and communication systems) that were not hooked up to emergency electrical feeds, and loss of steam supply (particularly critical for sterilizing equipment) (GNYHA testimony, 2003; C Torres, 2003). A number of hospitals reported difficulties communicating with their critical staff, who were dependent upon cordless and cellular telephones rather than hard-wired phones (J Geodert, 2003).

Several after-action reports, press reports, and testimony noted that the 911 emergency dispatch system experienced a brief disruption in the immediate aftermath of the electrical outage. Furthermore, there was an overall increase in ambulance runs throughout the EMS system; an increase in emergency department (ED) visits for such complaints as respiratory difficulty (anecdotally related to loss of air conditioning), cardiovascular events (anecdotally related to people taking stairs rather than elevators), and renal issues experienced by dialysis patients who could not receive treatment at their free-standing centers; an increase in hospital-based laboratory and pharmacy services because patients could not access these services outside the hospitals; and general seeking of shelter by elderly patients who needed relief from the heat or access to stable food and water supplies (GNYHA, 2003; C Torres, 2003; M Sisson, 2003). A reported increase in diarrheal symptoms in ED visits was hypothesized to be related to contaminated fish and meat that had been left unrefrigerated (MMWR). The literature also reported that a number of interfacility transfers were conducted, prompted by electrical failures and concerns for the most critical patients (M Haberman and O Moritz, 2003; B Hamilton, 2003). One press report featured a woman whose liver transplant was deferred (despite being scheduled) because the surgical staff did not want to risk such a procedure, and the patient lost her priority status on the transplantation list (D Grady, 2003). One report of a busy urban ambulance service in Yonkers NY indicated that EMS calls increased an average of 250% during the first ten hours of the electrical outage, with an increase in presenting conditions related to the heat, and to respiratory conditions secondary to loss of home-respiratory equipment. Although on-scene time increased by 63%, overall response and transport times were unaffected (DA Rand et al, 2005).

The electrical outage also led to failures of city water treatment plants and pumping stations, which led to a release of 490 million gallons of untreated water and sewage in to New York area waters (Gennaro, 2003). Area beaches were closed pending fecal coliform testing, and area residents were warned not to fish the waters until they had been declared safe.

The economic impact of the electrical outage was estimated as approximately $6.4 billion in the US and over $1 billion in NYC alone, which included a $250 million loss of perishable food, $800 million lost in “gross city product” (wages, revenue, plus other factors), $40 million in tax revenue, $10 million in overtime pay for city workers, and $7 million in lost mass transit fares (Recchia, 2003). Losses estimated for the city’s 22,000 restaurants were between $75 million and $100 million in lost business and wasted food.

The New York City Emergency Response Task Force issued a report with recommendations in October 2003 that summarized many of the issues noted above within six broad themes – emergency response, business continuity, the city as employer, communications, transportation, and public health, safety and preparedness (A Alper and SL Kupferman, 2003) . A number of the problems and issues that the authors highlighted in reference to the particular critical infrastructure loss of a major electrical outage are equally germane to disaster preparedness planning for a pandemic flu: problems running and staffing command centers, inconsistent and uncoordinated agency response plans, diffculties mobiling and deploying city employees and other critical workforces and vendors, insufficient resources to handle long periods without resupply, and inadequate communication across multiple networks (first response, city agencies to one another, city to the business community, etc.). Among the vulnerable populations singled out for particular attention was homebound citizens; the city's disabled population is estimated at 1 million, including 15,000 homebound seniors and an estimated 68,000 who received city-administered homecare services.

Transportation shutdowns

Similar to the electrical outage noted above, the 60-hour NYC transit strike that occurred in December 2005 represents a significant critical infrastructure loss to the city. As one of the largest mass transit systems in the world, the NYC subway system handles an average of 4 million riders during weekdays and the bus ridership averages 2.5 million per day (NYC Transit Committee, 2003). The economic impact of the strike, mostly from lost revenue, was estimated as ranging from $250 to $400 million per day. The literature review did not uncover any reports published to date that estimated the health or social costs or consequences of the 2005 transit strike, although one news report did indicate that the levels of air particulate matter increased slightly during the course of the three-day strike, which might have been related to increased automobile and truck traffic during the midday hours (DeStefano, 2006).

One research study did examine the effects of a three-week mass transit bus strike in Minneapolis, Minnesota in 1996 on "no-show" rates at a large university-affiliated teaching hospital. The author analyzed no-show rates prior to and after the strike as well as during the strike, and reported them by clinical setting (internal medicine, specialty care, nursing care, ED). The patient population was largely urban and impoverished, with over 70% of the patients having household incomes below $20,000. The author hypothesized that the transit strike would significantly increase the no-show rate and decrease the number of appointments because of transportation access barriers, however he found no significant differences of "strike" versus "non-strike" except for patients scheduled to see a nurse for a non-urgent issue. He concluded that the strike had a negligible impact on health service utilization, in that patients either used more costly taxis or private transportation or delayed appointments until the strike was over (Pheley, 1999).

Social behavior during a pandemic

In contrast to the negative, dysfunctional images of disaster behavior – panic, disorder, and

helplessness – empirical research suggests that behavior in disaster situations is adaptive and problem focused (K Tierney et al, 2001). Pro-social, rather than anti-social, behavior seems to be the norm. Behavior in emergency situations is strongly influenced by pre-emergency behavior patterns. One major exception to this pattern involves anti social behavior, which tends to **decline** during the post disaster emergency response phase. Crime rates tend to decline following large scale disasters (M Lindell and R Perry, 1992), and contrary to common wisdom it has never been necessary to declare martial law after a US disaster.

The city's pandemic flu plan relies, in part, upon voluntary social isolation and prevention efforts to limit influenza transmission. Although it is unknown how the city's population will respond to a pandemic, recent survey research offers some guidance on potential behavior. A recent national random-digit-dial telephone survey (n=1,697, oversampling households with children under 18), asked respondents about their willingness and ability to comply with public health directives (RJ Blendon et al, 2006). Virtually all respondents (94%) indicated they would stay at home for 7-10 days if they had the flu and 85% said that all members of the household would stay at home if any household member had the flu. One quarter of the respondents, though, said they had no one to care for them if they were home with the flu, and this varied considerably by income, with 36% of individuals living in a household earning under $25,000 in annual income having no one to care for them, compared to 15% of individuals in households with greater than $75,000 annual household income. Furthermore, although a majority of respondents would stay at home for 7-10 days if public health officials thought they were exposed to others with the disease (86%), a large number (27%) thought they might lose their job or business if they stayed at home for that length of time. This concern for job loss was greatest among Hispanic respondents (53%), black respondents (41%), and all respondents earning less than $25,000 in annual household income (41%). Overall, 25% of employed respondents said they would suffer serious financial problems if they had to miss work for 7-10 days, 57% would suffer a problem if they had to miss one month, and 76% would suffer a serious financial problem if they had to miss work for 3 months.

In a survey of 6,248 New York City health care workers, respondents were asked if they were able and willing to work given one of several circumstances, ranging from a weather emergency, to bioterrorism, to an environmental disaster, to an untreatable infectious disease outbreak such as SARS (K Qureshi et al, 2005). Responses varied widely depending on the particular event. Whereas 80 to 82% of respondents indicated their ability to work in the event of an explosion or environmental disaster, only 64 to 68% were able to work in the face of a smallpox, radiation, or infectious disease event. In terms of willingness to work, respondents were overwhelmingly willing to work in a snow blizzard, an explosion, or an environmental disaster (80 to 86%) and least willing to work in response to a SARS-like event (48%). In a multivariate regression analysis, the factors most associated with an unwillingness to report to work included being female, being under 45 years, and having either childcare or eldercare obligations.

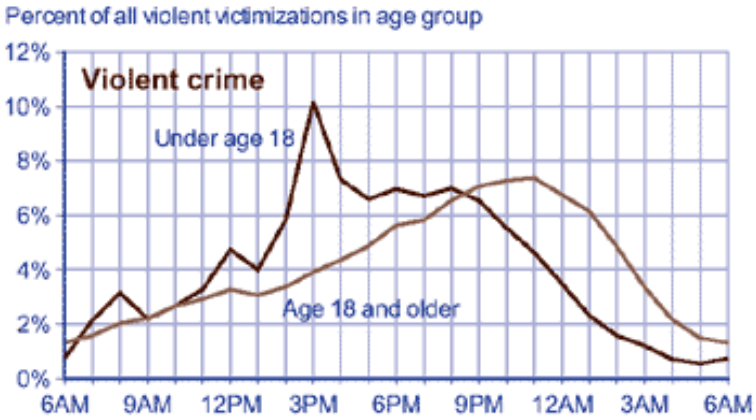
<u>Health and social consequences of crowding and health system congestion</u>

Two social consequences of a pandemic flu outbreak that may be anticipated are increased

crowding within households and neighborhoods, and increased congestion at health-care facilities. Crowding will likely occur as a consequence of several factors, including school and tranportation closures or restrictions, sick household members, workplace closures (or an unwillingness of household members to go to work), closings of congregate venues such as movie theaters, travel restrictions, and a general unwillingness to venture far from home in an uncertain environment. Health-care congestion will likely occur at larger facilities (principally hospitals and clinics) as private facilities close or curtail hours (including medical offices, labs, and pharmacies), as individuals seek care for flu and non-flu-related illnesses and injuries, and as medical facilities redeploy personnel to handle a shifting patient volume and type.

Risk behavior and violence

Research has shown that children tend to engage in risky behavior during unstructured and unsupervised time. The after-school hours are the peak time for juvenile crime and risky behaviors such as alcohol and drug use (Juvenile Justice Bulletin, 1999). For example, the peak hour for juvenile crime is from 3 p.m. to 4 p.m., the first hour that most students are dismissed from school (see chart, ibid). Consequently, one of the unintended consequences of the community safety protocol of school closure could be increase in risky behavior by youth.



In addition to the potential for increases in juvenile crime, one research study suggests that children may be at greater risk for child abuse and traumatic brain injury after a natural disaster, which the authors hypothesize to be associated with mental health distress and “disruption of the social fabric” (HT Keenan et al, 2004).

For others, isolation and/or quarantine would result in increased sedentary activity/TV watching. Increased television watching has been shown to be associated with childhood obesity (In multiple logistic regression, the odds ratio of children having a BMI >85th percentile was 1.06 (95% confidence interval [CI]: 1.004–1.11) for each additional hour per day of TV/video viewed, independent of child age, child sex, parental educational attainment, and race/ethnicity) (B Dennison et al, 2002).

In a study of over 500 youth in NYC (age 13-20), 80% reported signficant exposure to at least 1

form of media coverage of September 11th. These rates were comparable with the citywide survey of public school students in New York City conducted by the New York City Department of Education. Results of a structural equation model that included controls for previous levels of mental health and social attitudes, as well as a range of demographic factors, indicated that media exposure predicted posttraumatic stress disorder symptoms in the youth. (Gershoff and Aber, 2004).

Loss of Individual Privacy/Crowding within the home

One particular human reaction to crowding is the tendency of individuals to withdraw from others in order to reduce stimuli; many times this is a protective mechanism. Social withdrawal in response to acute crowding can be an effective coping strategy for reducing short term stress (G Evans et al, 2000). Some research indicates there may be a threshold effect and only after that point does the density effect come into play (a little bit of crowding could be incorporated into the family structure and routine, but at some tipping point, whether that be in time or space—the crowding could become more than "inconvenient") One study looking at the relationship between crowding and withdrawal found that the lowest levels of density lead to a reduction in withdrawal up to a point, after which the effect becomes increasing positive (W Regoeczi, 2002).

In addition to social withdrawal, close proximity of others may cause difficulties in routine behaviors (W Regoeczi, 2002) which would be an inconvenience. However, would the effects of crowding within a household be more severe? The view that living in a crowded environment is unhealthy is well supported by research on animal populations; there is clear evidence of a "density effect". (The "density effect" includes increased aggression, heightened mortality and reduced fertility) Empirically demonstrating harmful effects of crowding among humans is more difficult (W Regoeczi, 2002); however, one study did demonstrate that chronic exposure to residential crowding is associated with increased levels of psychological distress (S Lepore, G Evans, and M Palsane, 1991). An additional cost of high density living appears to be heightened vulnerability to the demands of relatively minor social hassles. People exposed to social hassles may experience ill effects only if their adaptive capacities have been compromised by chronic strain.

Psychological stressors within families could become intensified due to being contained in close quarters. Boredom, depression and stress could occur. People could become unable to cope with minor daily hassles—which in turn, could affect drug and alcohol (as they are coping mechanisms which people use to self medicate against these factors) Alcohol and drug abuse can result in violent behavior within families and communities and therefore, as stress levels in homes increase, domestic violence rates could also increase. From analysis of data in US and Canada, violence against women does seem to increase after natural disasters (E Enarson, 1999).

This could be particularly acute in families or communities in which the baseline level for domestic violence is already high. For example, in a study of risk factors for domestic violence in South Africa, crowding alone was not associated with violence. Domestic violence is most strongly associated to the status of women in a society **and to the normative use of violence in**

conflict situations. Consequently, if a neighborhood with high rates of domestic violence is subjected to quarantine, it is likely that domestic violence rates would increase (R Jewkes, J Levin, and P Loveday, 2002).

Stigmatization of individuals in quarantined area
Because of their evolving nature and inherent scientific uncertainties, outbreaks of emerging infectious diseases can be associated with considerable fear in the general public or in specific communities, especially when illness and deaths are substantial (B Person et al, 2004).

In 1993 an outbreak of hantavirus infection in the Four Corners area (where the borders of four states—Arizona, New Mexico, Utah, and Colorado—meet) of the United States was initially referred to by reporters as a Navajo disease, which led to severe fear, stigmatization, and discrimination of Native Americans in the region (CDC, MMWR 1993). Previous scientific studies have shown that fear associated with stigmatization and discrimination has negatively affected public health efforts with chronic conditions and diseases such as mental illness, HIV/AIDS, tuberculosis, leprosy, and epilepsy (B Schulze and MC Angermeyer, 2003; GM Herek, 2002; JW Carey et al, 1997; JS MacLeod and JK Austin, 2003).

Mental health issues during a pandemic
Research following a natural disaster indicated that persons with Severe Mental Illness (SMI) were resilient *if* they were able to continue to receive treatment after the disaster (KR Lachance et al, 1994). The comprehensiveness of the services received and the ability to maintain those services through the disaster (in which staff members took extraordinary measures to ensure continued care) were the key reasons why these participants functioned well after the disasters. If people with SMI are unable to continue treatment due to quarantine, psychiatric decompensation could occur.

Research on middle-aged women during the SARS epidemic in Hong Kong suggests that there are increases in depression, associated in part with feeling scared, sleeping poorly, and having suffered financial losses (HYR Yu et al, 2005). A large household study conducted in Taiwan immediately after SARS had been controlled compared impacted populations, measured as having friends or family who had been infected or quarantined, with a non-impacted population. The researchers reported that the impacted group had higher levels of depression, poorer neighborhood relationships, poorer self-perceived health, and personal economic losses than did the non-impacted individuals (CH Ho et al, 2006).

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