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Public Health and Epidemiology: An Overview

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While doctors and nurses focus on caring for individual patients, public health and epidemiology are concerned with the health of entire communities and populations. Armed with epidemiological health-related data, public health practitioners focus on reducing preventable injuries, illnesses, and chronic diseases. At the same time, public health organizations must respond quickly to outbreaks of contagious diseases, or epidemic and even pandemic outbreaks of new diseases. This research paper explains the basics of public health and epidemiology, and explores how the lessons of pandemic history inform public health practice today.

Cover photo: Erica Simmons

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Jason Apostolopoulos

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Laura Anthony and Sude Behar Beltan

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Initiatives to Improve Access to Legal Services and Dispute Resolution

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Lauren Warner

Hospital Overcrowding

RESEARCH PAPER 11-19

Jason Apostolopoulos

Flood Management

RESEARCH PAPER 21-12

Sude Bahar Beltan

Introduction

The outbreak of the COVID-19 coronavirus pandemic in early 2020 thrust public health and epidemiology into the mainstream. Public health officials previously little known to the public suddenly appeared on camera for news briefings alongside political leaders. Terms like "self-isolation," "social distancing," and "flattening the curve" became part of everyday discourse. But while the pandemic brought public health ideas to the fore, behind the scenes, the daily work of public health and epidemiology is ongoing.

Figure 1:
"Talk with your teen about vaping: A tip sheet for parents"

Source: Santé Canada, Considère les conséquences du vapotage

Health Canada's "Consider the Consequences of Vaping" is a public health campaign aimed at young people.

In contrast to doctors and nurses who focus on caring for individual patients, public health is concerned with the health of entire populations. This may mean a local community such as a municipality or rural region, or an entire province, territory, or country. International bodies such as the World Health Organization deal with public health on a global scale. Regardless of the jurisdiction they serve, public health practitioners know that in a globalized context, "a disease anywhere is a disease everywhere."[1] Even when public health practitioners are focused on local populations, they must always keep an eye on what is happening elsewhere, and be ready to respond quickly to outbreaks of contagious disease such as measles and influenza, or epidemic and even pandemic outbreaks of new diseases.

Public health practice emphasizes reducing preventable injuries, illnesses, and chronic diseases such as diabetes and heart disease. This means addressing social, economic, environmental, demographic and lifestyle factors that contribute to higher disease burdens in specific populations and communities. Typical public health initiatives include anti-smoking campaigns, vaccine drives, and campaigns promoting healthy eating and regular exercise. Public health organizations also conduct food safety inspections, monitor drinking water, track air pollution levels and much more.

The role of epidemiology

To understand and address the health needs of a population, public health practitioners rely on epidemiology, known as the basic science of public health. Epidemiology involves the collection, analysis, and interpretation of health data in populations, and the application of this data to the control of health problems.[2]

Epidemiologists are concerned with the frequency and pattern of health events in a given population. For example, a measles outbreak affecting more than the expected number of people in a specific year might signify the beginning of an epidemic. Using sophisticated public health data, epidemiologists look for the causes and other factors influencing health events such as chronic diseases or infectious disease outbreaks.

Among other things, epidemiological data shows which communities or populations have a comparatively higher burden of chronic diseases such as asthma, heart disease, and diabetes. This helps public health practitioners develop programs targeting the populations most affected by those specific diseases. At the same time, epidemiologists also track emerging infectious disease outbreaks anywhere in the world, as discussed in greater detail below.

Public health surveillance

Public health practitioners and epidemiologists alike depend on comprehensive data from public health surveillance, defined by the World Health Organization as the "ongoing, systematic collection, analysis and interpretation of health-related data essential to the planning, implementation, and evaluation of public health practice."[3] This surveillance informs and guides public health policies and interventions while also providing the data needed to evaluate the effectiveness of those interventions.

Data from public health surveillance also serves as an early warning system to identify infectious disease outbreaks and other public health emergencies. The Public Health Agency of Canada works with provincial and territorial public health surveillance systems to collect a wide range of data such as the incidence of chronic diseases, congenital anomalies, measles/rubella, influenza, HIV/AIDS, immunizations, Lyme disease, opioid-related harms, and much more.[4] Similarly, local public health practice in Ontario is informed by public health surveillance at the provincial level.[5]

Determinants of health

In collecting and interpreting health-related data, public health practitioners and epidemiologists cast a wide net. Their aim is to capture the many overlapping social, environmental, and economic factors that affect the health outcomes of individuals in the context of communities and populations. These factors, known as the "determinants of health," are loosely described as the "conditions in which people are born, grow, live, work and age."[6] They include a constellation of factors such as "income and social status, employment and working

conditions, education and literacy, childhood experiences, physical environments, social supports and coping skills, healthy behaviours, access to health services, biology and genetic endowment, gender, culture, race/racism."[7]

The understanding of what constitutes a determinant of health—and therefore a public health concern—is always evolving. Public health authorities may speak out about all sorts of social issues that they believe have an impact on public health such as speed limits on city streets, or communities that are 'food deserts' (without local access to affordable fresh food) or experience food and/or housing insecurity.

There is also growing recognition that, as Health Canada notes, "experiences of discrimination, racism and historical trauma are important social determinants of health."[8] Indeed, evidence shows higher rates of stress-related chronic diseases in individuals and communities experiencing racism.[9] In response, a host of public health and related organizations as well as municipalities in Canada, the United States, and elsewhere have declared systemic racism—and anti-Black racism in particular—to be a public health concern, and even a crisis.[10]

Across Canada and the United States, the inequitable impact of the COVID-19 pandemic on low-income, racialized, and marginalized communities, seen in higher rates of infections and fatalities, has highlighted these concerns.[11] As Ontario's Alliance for Healthier Communities explains: "COVID-19 does not flatten these disparities; it amplifies them."[12]

Pandemic preparedness and response

Another important part of the public health mandate is to prepare to respond to outbreaks of epidemic and pandemic diseases. ("Epidemic" is the term used for a regional outbreak of infectious disease exceeding expected numbers; a "pandemic" is an epidemic that spreads globally.)

In the twenty years preceding the COVID-19 pandemic there were epidemic outbreaks of Ebola, SARS, Zika, swine flu, and avian flu as well as the 2009-10 H1N1 flu pandemic. Public health experts have long warned of the need to prepare for an inevitable flu pandemic of devastating scope and impact.[13] The World Health Organization cautioned in 2011 that "the world is ill-prepared to respond to a severe influenza pandemic or to any similarly global, sustained and threatening public-health emergency."[14]

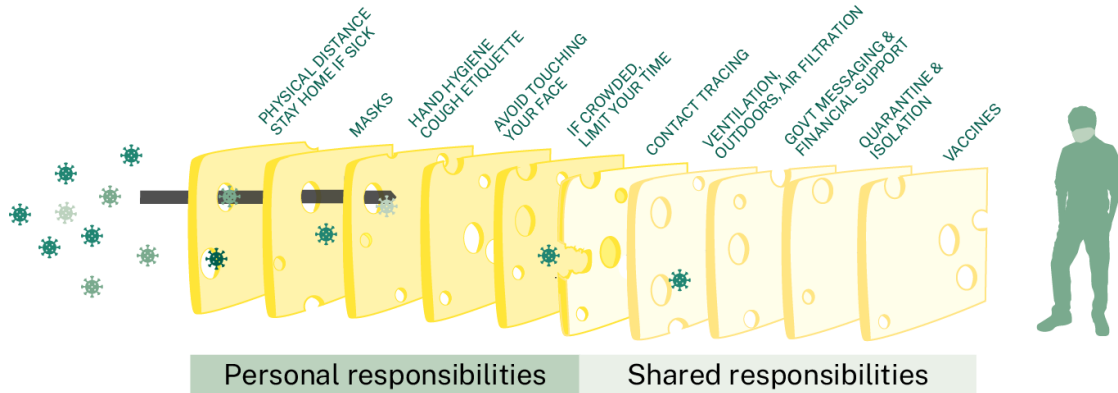## Community mitigation strategies

During epidemics and pandemics, when no vaccine or treatment is yet available, public health strategies of necessity focus on using multiple layers of what are termed "nonpharmaceutical interventions" (NPIs) or "community mitigation strategies" to reduce the spread of the disease. These tools include increased handwashing and other hygiene measures, wearing face masks, quarantines, self-isolation, social distancing, contact tracing, closures of schools, businesses, entertainment, and other venues where groups of people might gather, as well as bans on mass gatherings, and more.[15]

This layered approach has been described as the "Swiss cheese model" of pandemic defence. Virologist Ian Mackay explains that "multiple layers of protection, imagined as cheese slices" slow or block the spread of contagious disease:

> *No one layer is perfect; each has holes, and when the holes align, the risk of infection increases. But several layers combined – social distancing, plus masks, plus handwashing, plus testing and tracing, plus ventilation, plus government messaging – significantly reduce the overall risk. Vaccination will add one more protective layer.*[16]

Figure 2:
**Swiss Cheese Model of Respiratory Pandemic Defense**

Source: Adapted from The Swiss Cheese Respiratory Virus Defense, 2020. Ian M. Mackay.

As medical historian Howard Markel explains, the goal of community mitigation measures is to flatten the curve of the epidemic:

> *The idea is by shifting the epidemic curve to the right with a series of non-pharmaceutical interventions ..., one would hopefully see a delay in the outbreak's peak; a decompression of the burden on hospitals and infrastructure; a diminution of overall cases and health impacts; and more time to develop new medical therapies.*[17]

Figure 3
Flattening the Curve
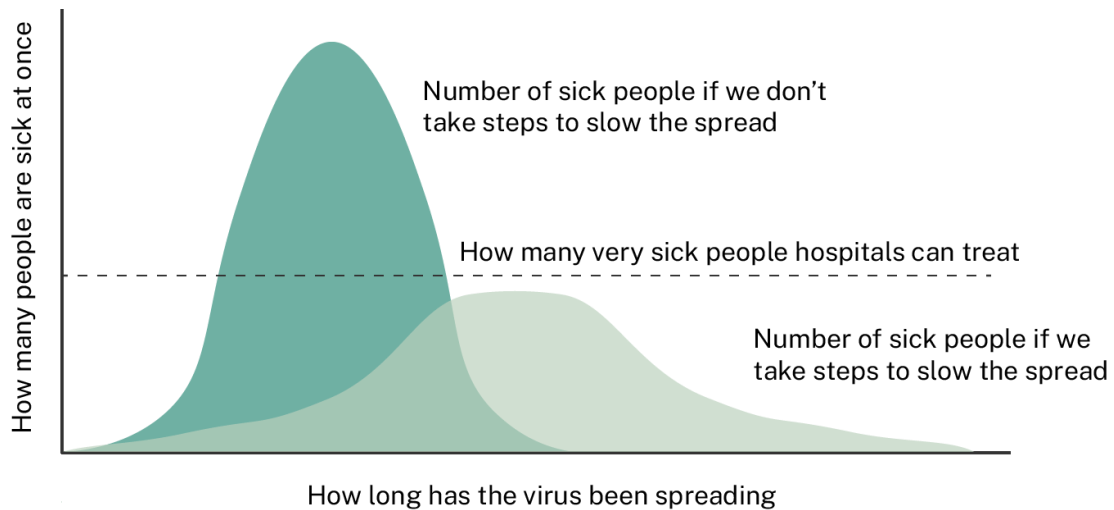
Source: Adapted from University of Michigan, Institute for Healthcare Policy & Innovation, and the US Centers for Disease Control and Prevention.

Communications and public trust

Because community mitigation measures are difficult to enforce, effective public health communications are crucial in persuading large numbers of people to change their behavior in order to protect their own and others' health. Public trust is essential to win society-wide compliance. In order for the public to perceive public health leaders as "trusted and credible," say the US Centers for Disease Control and Prevention, the leaders must show "empathy and caring, honesty and openness, dedication and commitment, and competence and expertise."[18]

Over the first six months of the COVID-19 pandemic, medical experts everywhere struggled to make sense of the characteristics, transmission patterns, and health impacts of the virus. As the scientific understanding evolved, so did public health advice and directives. For example, early in the pandemic, public health authorities in Canada and the United States alike advised against the wearing of face masks.[19] A few months later, people were urged to wear face masks, and not long after that, masks became compulsory in some indoor settings. As a Canadian researcher put it, public health guidance was changing "at a dizzying pace."[20]

For medical experts, this scientific (or "epistemic") uncertainty in the face of new diseases is to be expected. But as the US National Academies of Sciences, Engineering, and Medicine acknowledge, there is a risk that the public "may attribute uncertainty to poor science" and as a result, "in some cases, communicating uncertainty can diminish perceived scientific authority."[21] In the early months of the pandemic, public health authorities around the world grappled with how to communicate scientific uncertainty about COVID-19 without undermining their own credibility.

Early in the COVID-19 outbreak, some countries, notably South Korea, Taiwan, and Singapore, saw broad public compliance with directives to use NPIs. By contrast, the United States experienced a public backlash against NPIs, and especially against directives to wear facemasks.[22] Researchers posited that a crucial factor underlying compliance with NPIs was the degree of "social trust" in a population, defined as a combination of trust in political authorities, and a sense of social responsibility towards others.[23]

The lessons of pandemic history

Research into historical pandemic responses has been important in informing current public health responses to emerging pandemic diseases, including COVID-19. Each pandemic outbreak infuses investigations into previous pandemics with new urgency, as researchers consider the lessons that can be learned and how these lessons can be applied in the present.

Quarantine: The oldest public health tool

Figure 4:

Quarantine placards, 1920s to 1940s
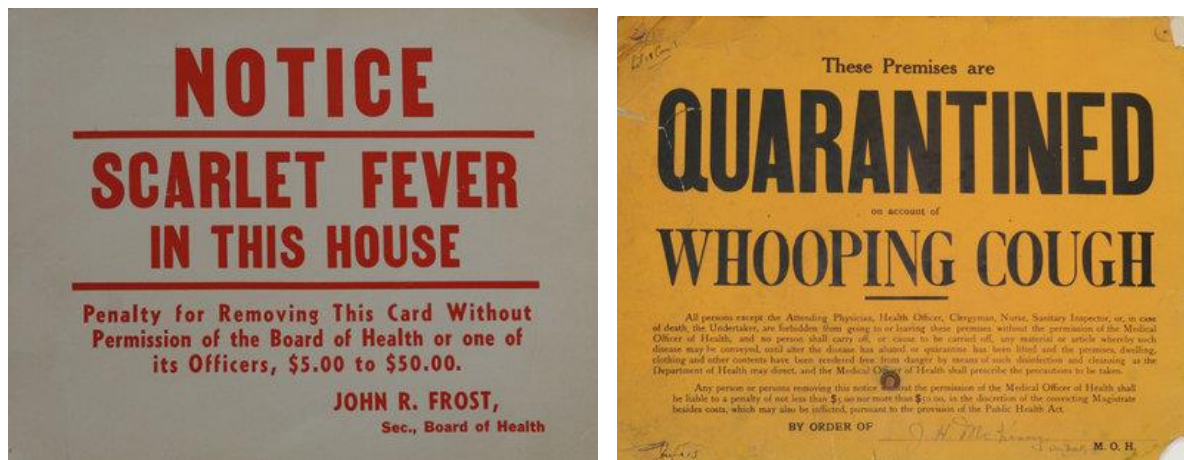
Source: Whitby Public Library Archives

Quarantine placards were placed on the doors of homes, businesses, schools and other places to keep ill people inside and warn others to stay away.

Many basic public health tools, such as quarantine, face masks, social distancing, contact tracing, and hand hygiene, have been in use for over a century. In particular, quarantine—the practice of separating the ill (or potentially ill) from the healthy—is one of the oldest known public health tools. The term itself may be traced back to mid-fourteenth-century Venice which required ships to stay at anchor for 40 days (*quaranta giorni*) at a quarantine island in order to protect the city's residents during a bubonic plague pandemic.[24]

The practice of quarantining incoming vessels—even without any reported diseases on board—survived into the twentieth century. Vessels might be held offshore, or passengers obliged to stay on a quarantine island or other quarters set aside for this purpose, before being allowed to mingle with the general population. Whether carrying immigrants, visitors, or just crew members and cargo, all ships were potentially dangerous sources of infection.[25]

Quarantine and other community mitigation measures were crucial in combatting successive epidemic waves not only of cholera but also of smallpox, diphtheria, tuberculosis, and many other diseases that swept through communities across Canada and the United States in the eighteenth and nineteenth centuries.

During a smallpox epidemic in 1884, for example, Ontario's recently-established provincial board of health used these tools to successfully contain an outbreak. Public gatherings were banned, schools and churches were ordered closed, stagecoach service into the area was suspended, and quarantine was enforced by sanitary constables stationed on roads and at railway stations. Homes were disinfected and fumigated, and medical students were recruited to go door-to-door providing vaccinations.[26]

But such public health measures were not always well-received. In the neighboring province of Quebec, the poverty-stricken neighbourhoods of Montreal most affected by the smallpox epidemic "would not cooperate with the health authorities," says historian Michael Bliss. People refused to go into isolation at smallpox hospitals and refused to be vaccinated. "When the sanitary police placarded their homes, they tore down the placards. Quarantine was ignored."[27] The death rate rose exponentially, with people collapsing and dying in the streets.[28]

Figure 5:
Montreal anti-vaccination cartoon, 1885

Source: The Thomas Fisher Rare Book Library, University of Toronto

A mother flees with her children, pursued by a vaccinator, and death.

When Montreal resorted to making vaccinations compulsory, angry crowds gathered and vandalized Board of Health offices. "The mob ultimately laid siege to city hall," Bliss tell us, "their protests and battles with police mounting to the level of a full-scale riot."[29] The mayor had to call for militia backup. Shocked by Montreal's weekly death toll, and fearful of the disease's spread, Ontario and neighboring US states barred entry to any Montrealers who could not prove they had been vaccinated by showing vaccination scars or a special vaccination card.[30]

Spanish Influenza (1918-19): "Dangerous slackers"

Arriving on the heels of the First World War, the 1918-19 Spanish Influenza pandemic swept across Canada in a month, eventually killing an estimated 50 million or more people worldwide.[31] Long before the development of flu vaccines, the only option for slowing the disease's spread was the use of NPIs such as mask-wearing, physical distancing, limits on mass gatherings, and the closure of schools, churches, businesses, and "places of amusement" like theatres and bowling alleys.[32]

In Ontario, as elsewhere, public health decision-making was fraught with uncertainty about the best course of action. Reluctant to cause panic, the provincial public health department at first advised against measures "likely to dislocate business or the ordinary affairs of life." If local communities deemed it necessary to close schools or implement similar measures, however, the provincial authorities said they would not interfere. Newspapers covered the flu's spread across Canada, the United States, and Europe, noting death tolls, the strain on hospitals and medical staff, and the range of community decisions on closures and other NPIs.[33]

At first, it was not clear that the Spanish flu spread like wildfire. On October 2, 1918, the *Globe and Mail* reported that the disease was "apparently not making serious inroads in Toronto" as there were no cases in local hospitals. Sudbury's Medical Officer of Health said there was no cause for alarm. Local doctors had reported forty cases of 'ordinary, everyday' flu but said it was "not the famous 'Spanish flu.'" Less than a week later, however, the alarm was raised: the flu had "invaded" Toronto and Sudbury, quickly spreading to Ottawa and other communities.

Headlines warned "death toll mounting" and "hospitals taxed to capacity." Sudbury's mayor received an urgent telegram from the mayor of Sherbrooke, Quebec, asking if Sudbury could send any nurses. (Sudbury could spare only one nurse.) The *Toronto Daily Star* reported that 10,000 pupils (one sixth of all schoolchildren) in the city were absent from school for "fear of contracting the disease." In Sudbury and Toronto, local public health officials initially decided against closing schools, saying that children were safer in classrooms than out roaming the streets or crowding into movie theatres.

Figure 6:
"Wear a Mask and Save Your Life!"

Source: International Committee of the Red Cross (ICRC)

In 1918, the Red Cross stigmatized those who refused to wear masks as "dangerous slackers." (In 2020, the International Committee of the Red Cross put the historical ad online with the caption: "We said it in 1918. We're saying it today.")

As communities across North America scrambled to respond, there was no consensus on what should be done. The *Globe* dismissed the idea of lockdowns, calling them "extreme measures" that had had "no appreciable effect" in Boston, Massachusetts. There was no need for "drastic action," Sudbury's Medical Officer of Health reassured the public. Lockdowns and closures were "very detrimental" and only served to paralyze businesses.

Toronto's Medical Officer of Health Charles Hastings advised shopping by phone to reduce congestion in stores. Crowded places—and kissing—should be avoided. London, Ontario, implemented "strict rules" that no one with a cough or cold was allowed to leave their home or "sneeze openly." The town of Lindsay closed schools and cinemas while Kingston and St. Thomas both rejected such measures. The public was warned against quack cures, and urged to avoid traveling on crowded streetcars.

Despite the relentless spread of the flu on both sides of the Atlantic, Hastings said that too many Torontonians persisted in ignoring public health guidance. "No department of health could take people by the ears and tell them what to do," he complained in frustration. "We cannot force them to take the necessary precautions."[34] The *Globe* accused Hastings of blaming the victim, reporting his comments under the sarcastic headline: "If You Have 'the Flu' It's Your Own Fault."

By mid-month it was clear that drastic measures were necessary. On October 15th, Toronto schools were closed down. On October 16th, Kingston's medical officer of health announced a city-wide lockdown while Sudbury banned public gatherings, and closed schools, churches, and places of amusement. No more than 25 diners at a time were allowed in Sudbury restaurants, which were required to remove excess chairs. Toronto closed down theatres and other places of amusement on October 19th. At the end of the month, a Sudbury man was arrested for breaking quarantine: police caught him driving on a highway that had been ordered closed by local public health officials.

As flu cases came in waves, communities across the province implemented, lifted, and then reinstated lockdowns and quarantine orders.

Figure 7:
Lockdown in Kingston, Ontario, 1918
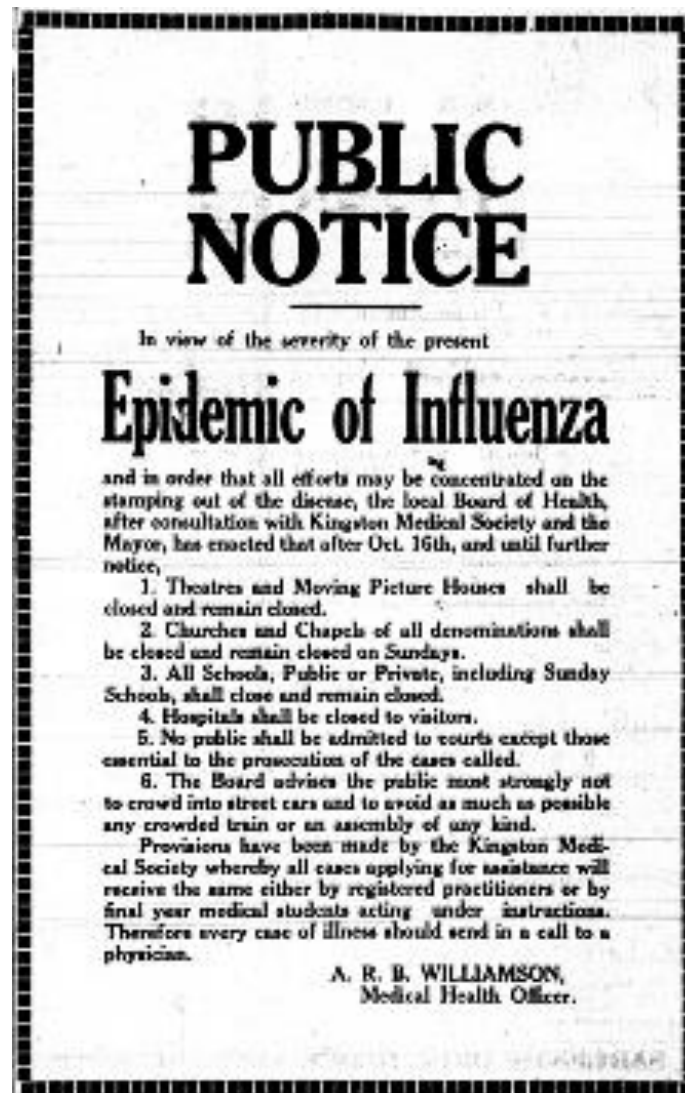
Source: *Daily British Whig*, October 16, 1918.

Figure 8:
Lockdown in Toronto, 1918

OWING to prevalence of influenza the Board of Education has decided to close all the Collegiate Institutes and Public Schools until further notice, this to take effect to-day, Tuesday, October 15th, 1918.

W. O. McTAGGART,

Chairman Management Committee

Source: Historical *Globe and Mail*, October 15, 1918.

CLOSING OF PLACES OF AMUSEMENT

Notice is hereby given that after SATURDAY, OCTOBER 19th, 1918, all Theatres, Moving Picture Shows and other places of amusement, including Pool Rooms, Billiard Rooms and Bowling Alleys, throughout the city shall be closed during the period of the Influenza Epidemic, and shall not be reopened until further notice.

By order of the Local Board of Health.

CHAS. J. HASTINGS,
Medical Officer of Health and
Executive Officer of the Board.

Source: Historical Globe *and Mail*, *October* 18, 1918.

Figure 9:
Theatre closed during Spanish Flu pandemic, 1918

Source: MOHAI, Seattle Historical Society Collection, SHS6338B

> *Across North America, theatres and other gathering places were closed down during the Spanish Flu pandemic.*

In 2006, medical historian Howard Markel was part of a research team that evaluated the effectiveness of NPIs used in large US cities during the Spanish flu pandemic. The team also looked at how government and health authorities responded to public opposition to facemasks and other public health measures.[35]

Markel's research team found that cities that acted early to confront the pandemic, before the virus had a chance to spread widely in a community, using more than one NPI at a time, and using these interventions for long durations "enjoyed far lower morbidity and mortality numbers than those cities that did not act in such a manner."[36] In other words, these cities were able to flatten the curve.

These research findings, says Markel, helped shape the Centers for Disease Control and Prevention (CDC) 2007 pre-pandemic planning guidance and the 2017 update to the guidance, influential documents that have informed subsequent pandemic responses internationally.[37] In keeping with the findings of Markel's team, the CDC's guidance emphasizes the effectiveness of a community mitigation strategy of early, targeted, and layered use of nonpharmaceutical interventions.

SARS (2002-03): The precautionary principle

The SARS (Severe Acute Respiratory Syndrome) outbreak is sometimes described as the first pandemic of the twenty-first century. Toronto experienced the largest SARS outbreak in North America and is the only jurisdiction in the world to have experienced two waves, with 44 people dying of the disease.[38]   A 2006 commission of inquiry concluded that the most important lesson of SARS was the "precautionary principle" that "action to reduce risk should not await scientific certainty."[39]

During COVID-19, the idea of the precautionary principle was often raised in discussions of whether public health guidance should have directed the public to wear facemasks at the beginning of the pandemic.[40] At the time, as noted above, public health authorities at first cautioned against mask-wearing, saying that there was no evidence showing that facemasks were effective outside of clinical settings.

However, an article in the *Canadian Journal of Anesthesiology* explains that while clinicians normally rely on the principles of evidence-based medicine, during a pandemic, "the evidence required … is limited, subject to uncertainty, and is constantly evolving." The article's authors suggest that "during a healthcare crisis, policy makers cannot wait for scientific certainty to make decisions. Rather, they require alternative approaches to dealing with uncertainty and mitigating risk in decision-making."[41]

COVID-19: An end in sight?

Figure 10:
"Mask or face covering required" sign

Source: Santé publique/Public Health Thunder Bay

Pandemic fatigue

The COVID-19 pandemic's many parallels with the past are striking. Like their counterparts during the Spanish Flu a century earlier, governments and health leaders around the world grappled with how best to respond to the outbreak. Should facemasks be mandatory? Should schools, restaurants, and other businesses be shut down? For how long? It was vital to find a balance between communicating the urgency of the situation, and not leaving the public paralyzed with fear or despair.

In a break with the past, however, there was more awareness of how lockdowns, social distancing and other measures might adversely affect mental health. The World Health Organization (WHO), for example, released guidelines to help public health leaders and governments address "pandemic fatigue," defined as "demotivation to follow recommended protective behaviors." "Understand people," WHO advised. "Acknowledge and address the hardship people experience."[42]

Vaccine mandates, certificates and passports

Figure 11
Let's Get Back to Hugs

Source: Toronto Public Health, 2021

A Toronto Public Health poster explains how getting vaccinated will help people return to normal pre-pandemic life, without the need to social distance from others.

In early 2021, with the growing availability of a number of effective vaccines against COVID-19, public health strategies shifted focus to encouraging vaccination among all those eligible with the aim of reducing or even eliminating the disease's spread. Many jurisdictions began to require proof of vaccination (vaccine certificates), or recent negative COVID-19 test results, in order to enter restaurants, gyms, theatres, and other indoor spaces, while vaccine "passports" were required in order to cross international borders. Some organizations implemented vaccine mandates— policies requiring employees, students, and others to show proof of vaccination or recent COVID-19 tests.[43]

Like many other public health measures used during the COVID-19 pandemic, these tools—vaccine mandates, certificates, and passports—have been used in Canada and internationally for a century or more in order to prevent the spread of smallpox, yellow fever, typhoid, cholera, and other contagious diseases that are now mostly forgotten.

Eighteen months into the pandemic, with rising vaccination rates in many jurisdictions accompanied by diminishing rates of hospitalization for severe COVID-19, some wondered whether an end to the pandemic was within reach. The consensus among public health and epidemiological experts was that COVID-19 was unlikely to disappear altogether. Instead, they anticipated that COVID-19 would become endemic, meaning that it would occur at more predictable, manageable levels, much like seasonal influenza.[44]

In what many hoped were its last stages, as it had from the beginning, the COVID-19 pandemic presented an unprecedented opportunity for cross-jurisdictional public health and epidemiological research, innovation and initiatives on a global scale. While the lessons learned will emerge only in retrospect, the pandemic will undoubtedly shape a new understanding of public health and epidemiology in the future.

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