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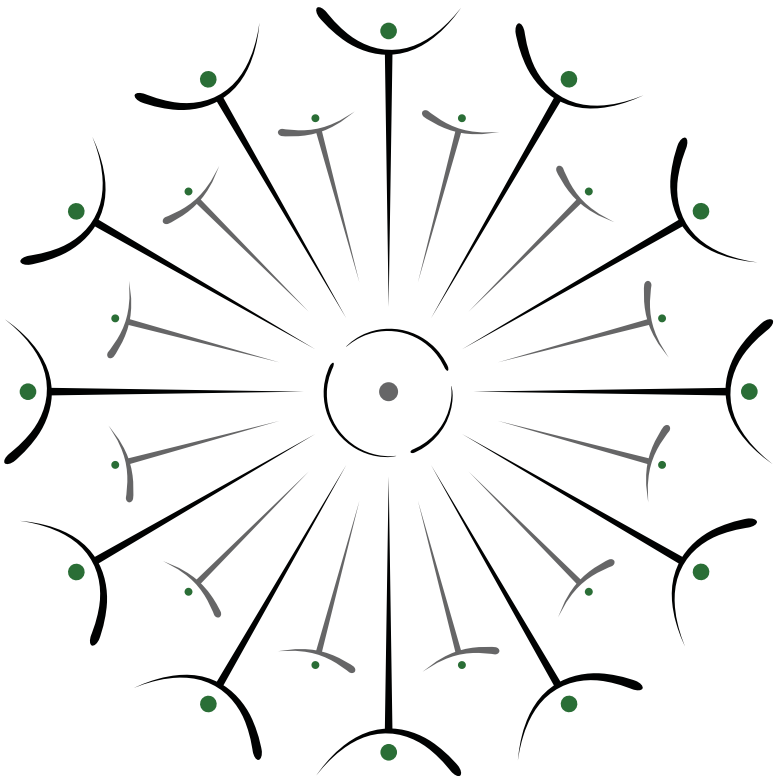

Global Air Traffic Patterns During the H1N1 Influenza Pandemic and their Public Health Implications

A Report Released by St. Michael's Hospital

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The authors of this report maintained full control over all scientific research performed during the course of this project. The views expressed herein do not necessarily represent those of the Public Health Agency of Canada.

DISCLAIMER

The authors of this report received data from a variety of public and private sources without representation or warranty as to their accuracy and/or suitability for any purpose. While authors of this report took exceptional measures to ensure that all data were of the highest quality, we decline responsibility for errors, omissions, or deficiencies in data, as well as any damages that may arise from reliance thereon.

RESEARCH ORGANIZATION

The conduct of this research was based out of the Centre for Research on Inner City Health – part of the Keenan Research Centre in the Li Ka Shing Knowledge Institute of St. Michael's Hospital.

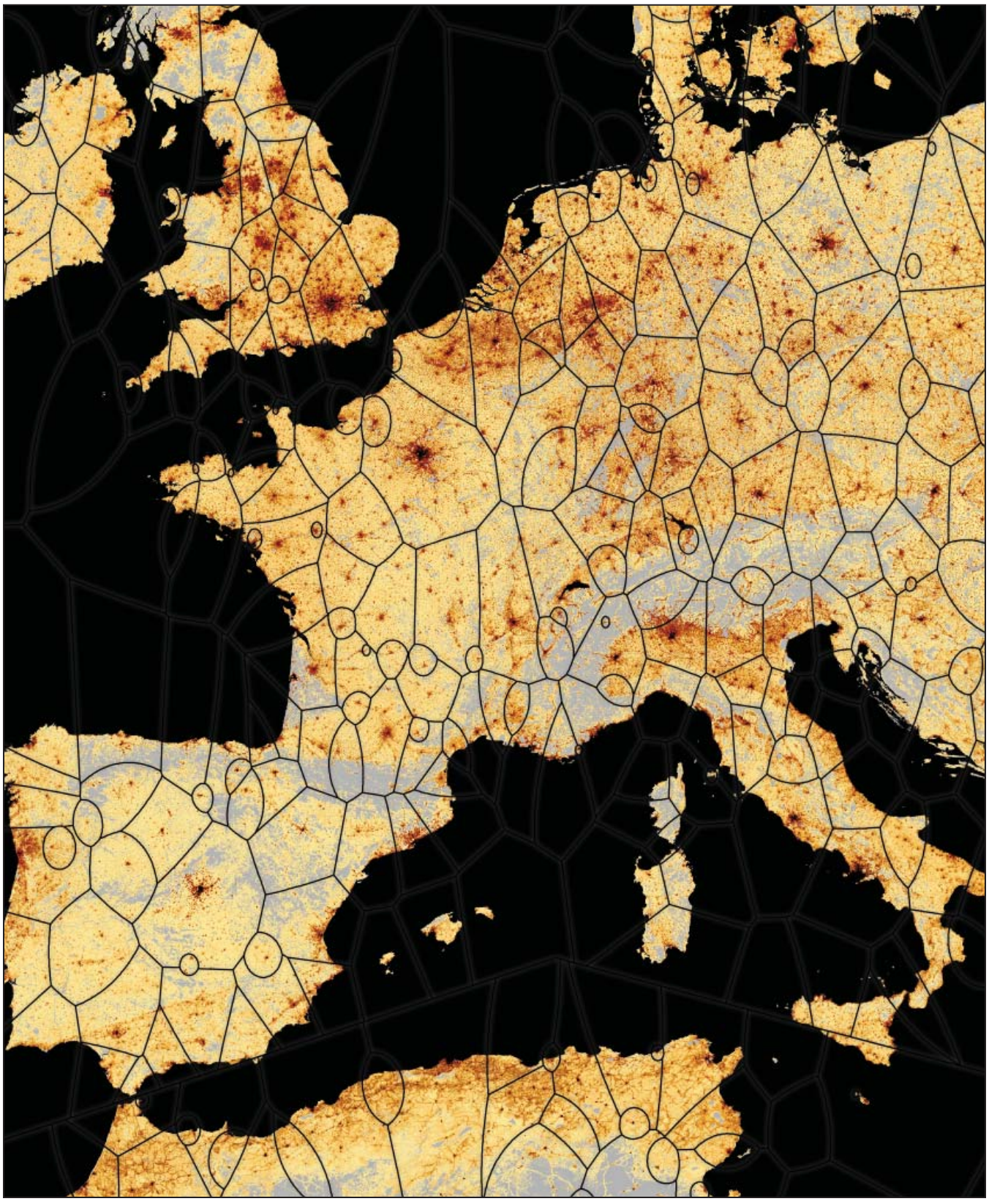
The Centre for Research on Inner City Health (CRICH) at St. Michael's Hospital in Toronto is Canada's only hospital-based research organization focused on the health consequences of urban life and social inequality. Across a range of health care policies, lower income populations are at greatest risk for illness and experience the greatest unmet need for health care services.

CRICH generates scientific evidence and tools to address these health care barriers and to design effective interventions aimed at reducing health disparities. Our research priorities include: health-promoting neighbourhoods, health effects of homelessness and under-housing; and evaluating health services for marginalized groups. Our health database program maintains one of Ontario's most extensive arrays of administrative datasets pertaining to health and social services and also to community infrastructure.

Genuinely transdisciplinary, CRICH scientific strengths include economics, ethics, geography and GIS mapping techniques, health services research, medicine, psychology, psychiatry and social epidemiology. One-third of CRICH faculty members are front-line physicians at St. Michael's Hospital, providing a direct link between population research and patient care. Most issues studied at CRICH span multiple policy sectors, and CRICH researchers are called upon to collaborate with communities and decision-makers in health care, housing, community and social services, urban planning and immigration portfolios.

LIST OF EXHIBITS

CONTEXT



In the final week of April 2009, the world learned of an epidemic in Mexico stemming from a novel H1N1 strain of the influenza A virus.[1] Identification of cases with the same novel virus in the United States[2] offered compelling signs that this epidemic could – and may have already begun to – transform into the first pandemic of the 21st century. While infectious disease epidemics have historically spread along transportation routes, modern commercial air travel enabled this threat to evolve faster than any other in human history.[3,4]

As the world enters the first influenza season since the H1N1 pandemic was declared over,[5] an opportunity presents itself for careful retrospective examination of this global event. Herein, we analyze global air traffic patterns during the H1N1 influenza pandemic with a focus on understanding their implications to public health security in Canada. It is hoped that the knowledge gained will assist in efforts to better prepare for and respond to future global infectious disease threats.

In this report we focus on five key questions:

- Did awareness of the H1N1 threat precipitate a rapid departure of travellers out of Mexico? If so, could this have accelerated importation and evolution of the H1N1 epidemic in Canada?

- What impact did the H1N1 pandemic have on international air travel to and from Mexico? Was international air travel to and from the United States and Canada also disrupted, and if so in what way?

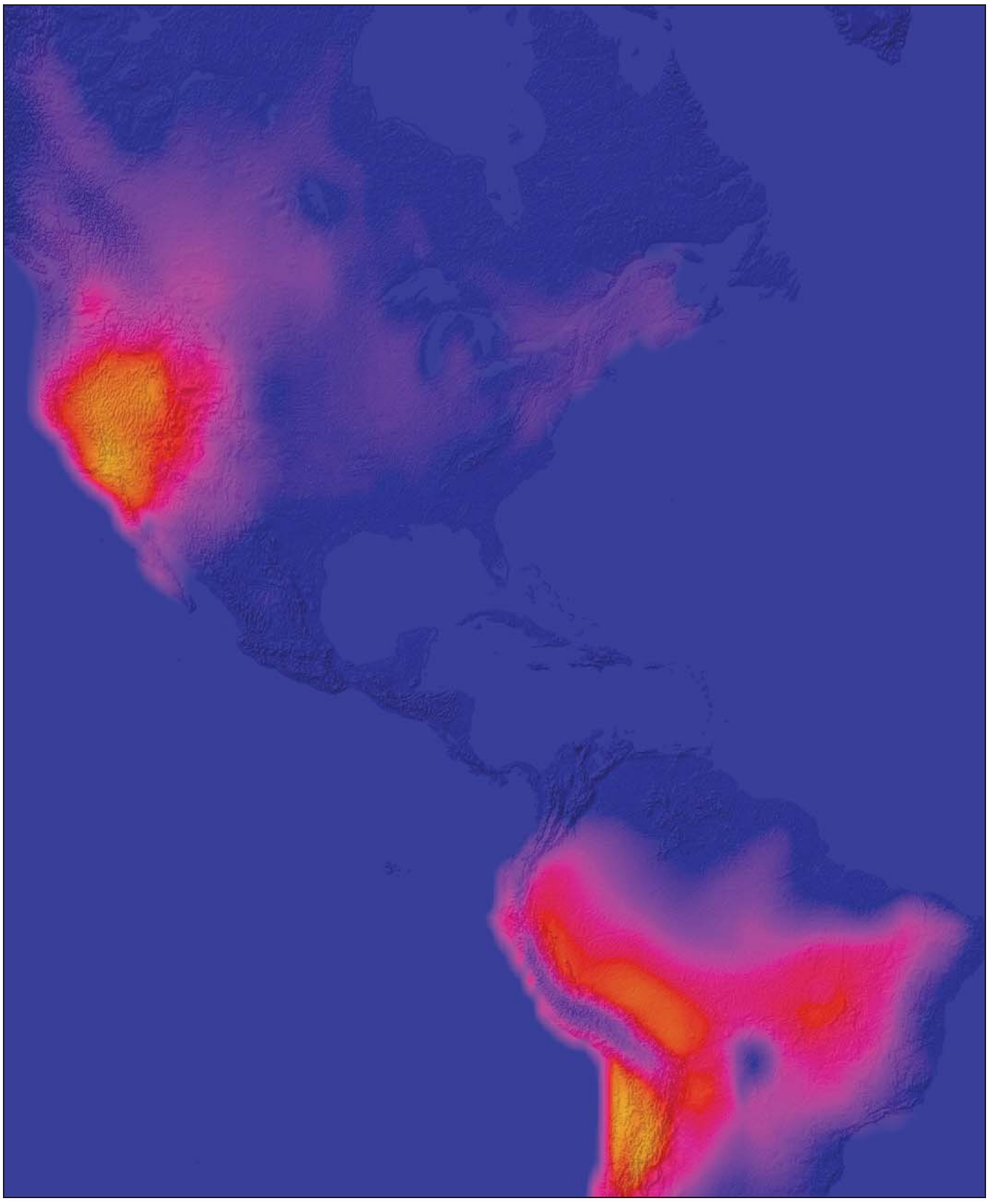
- Some airlines temporarily cancelled international flights between Mexico and Canada during the early stages of the H1N1 pandemic. Did this interruption in air travel hinder population mobility between the two countries and if so, could it have delayed the spread of H1N1? Or did travellers simply bypass these cancelled flight routes to reach their intended destinations?

- During infectious disease emergencies, public health decision-makers often face pressure to implement airport-based screening measures such as infrared thermography scanning to prevent disease importation. How efficient or inefficient would these measures have been if they were implemented in Canada during the early stages of the H1N1 epidemic?

- Well into the course of the H1N1 pandemic, Canada hosted the 2010 Winter Olympic Games in Vancouver. While mass gatherings have been known to attract, amplify, and subsequently disseminate infectious diseases around the world,[6-8] this was not observed with H1N1 during the Olympic Games. However, could knowledge of global air traffic patterns help mitigate infectious disease risks associated with future mass gatherings?

In late April 2009 – just days before the novel H1N1 influenza threat in Mexico was recognized – our scientific team produced a report commissioned by the Centre for Emergency Preparedness and Response at the Public Health Agency of Canada entitled "An Analysis of Canada's Vulnerability to Emerging Infectious Disease Threats via the Global Airline Transportation Network".[9] This report extends the scientific research produced from the first report through careful retrospective analysis of global air traffic patterns during the H1N1 influenza pandemic.

SCIENTIFIC METHODS



The information generated in this report is largely derived from detailed analysis of worldwide commercial air traffic patterns over the past decade. This includes analysis of (i) the roughly 3,500 commercial airports that comprise the architecture of the global airline transportation network, (ii) the flows of international travellers to and from the world's largest commercial airports, and (iii) the travel itineraries of the more than two billion passengers that board commercial flights every year. Special emphasis is placed on studying the movements of travellers departing Mexico via commercial airlines immediately after the H1N1 threat and its global implications were recognized.

Scientific analyses in this report were produced using three sources of commercial air traffic data:

- Official Airline Guide (OAG)[10]
- Airports Council International (ACI)[11]
- International Air Transport Association (IATA)[12]

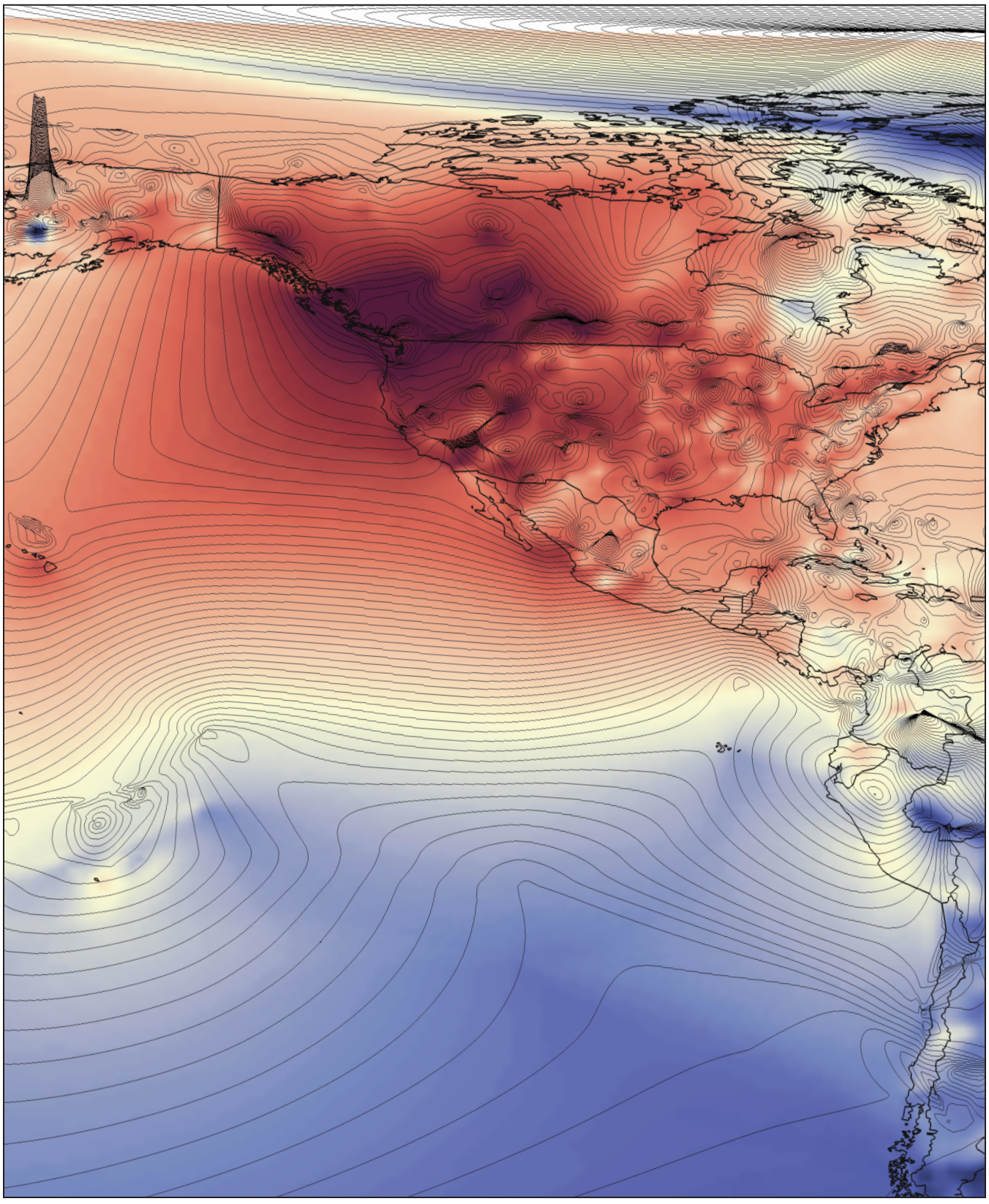
OAG data were analyzed to study the architecture of the global airline transportation network during the early stages of the H1N1 pandemic. Using network analysis, these data – which include information on the flight schedules of approximately 95% of all commercial flights worldwide – were used to analyze how cities with commercial airports worldwide are connected to one another, including the time required to travel between them.

Data from ACI were analyzed to determine if the H1N1 influenza pandemic disrupted international air travel in selected cities in Mexico and Canada and if so, to quantify the extent and duration of this disruption. We performed time series analysis using monthly ACI data from January 2000 to December 2009 with an autoregressive integrated moving average (ARIMA) model. In cities with highly predictable air traffic patterns, deviations between observed and predicted traffic flows (i.e. residual values from the ARIMA model) offered insights into the impact of the H1N1 pandemic on international travel. Historic events (e.g. terrorism, tropical storms etc.) known to disrupt air travel were adjusted for in each ARIMA model where applicable.

Data from IATA were analyzed to describe and visualize the magnitude, travel routes, and final destinations of international passengers departing Mexico during the early and latter stages of the H1N1 pandemic. These data were integrated with information generated from analysis of OAG data to produce estimates of the potential efficiency of airport-based screening to detect travellers infected with H1N1 arriving in Canadian airports.

Complementing these analyses of air traffic data, we included an analysis of weekly online media activity pertaining to the H1N1 pandemic produced by the Global Public Health Intelligence Network (GPHIN) at the Public Health Agency of Canada.[13] Key words used to select online publications included "H1N1" or "influenza" or "swine flu" or "epidemic" or "pandemic". Public health personel with expertise in infectious disease surveillance subsequently reviewed each publication. Briefly, GPHIN is an Internet-based infectious disease surveillance system that continuously monitors news stories of infectious disease threats published on the Internet in nine languages. In this report, online H1N1 activity was displayed in three language categories – English, Spanish, and Other Languages (i.e. which includes French, Arabic, Farsi, Portuguese, Russian, Simplified Chinese and Traditional Chinese). We also displayed data produced by HealthMap[14] – an Internet-based infectious disease surveillance system based out of Children's Hospital Boston at the Harvard Medical School – as part of a conceptual model aimed at mitigating infectious disease risks associated with mass gatherings.

RESEARCH FINDINGS



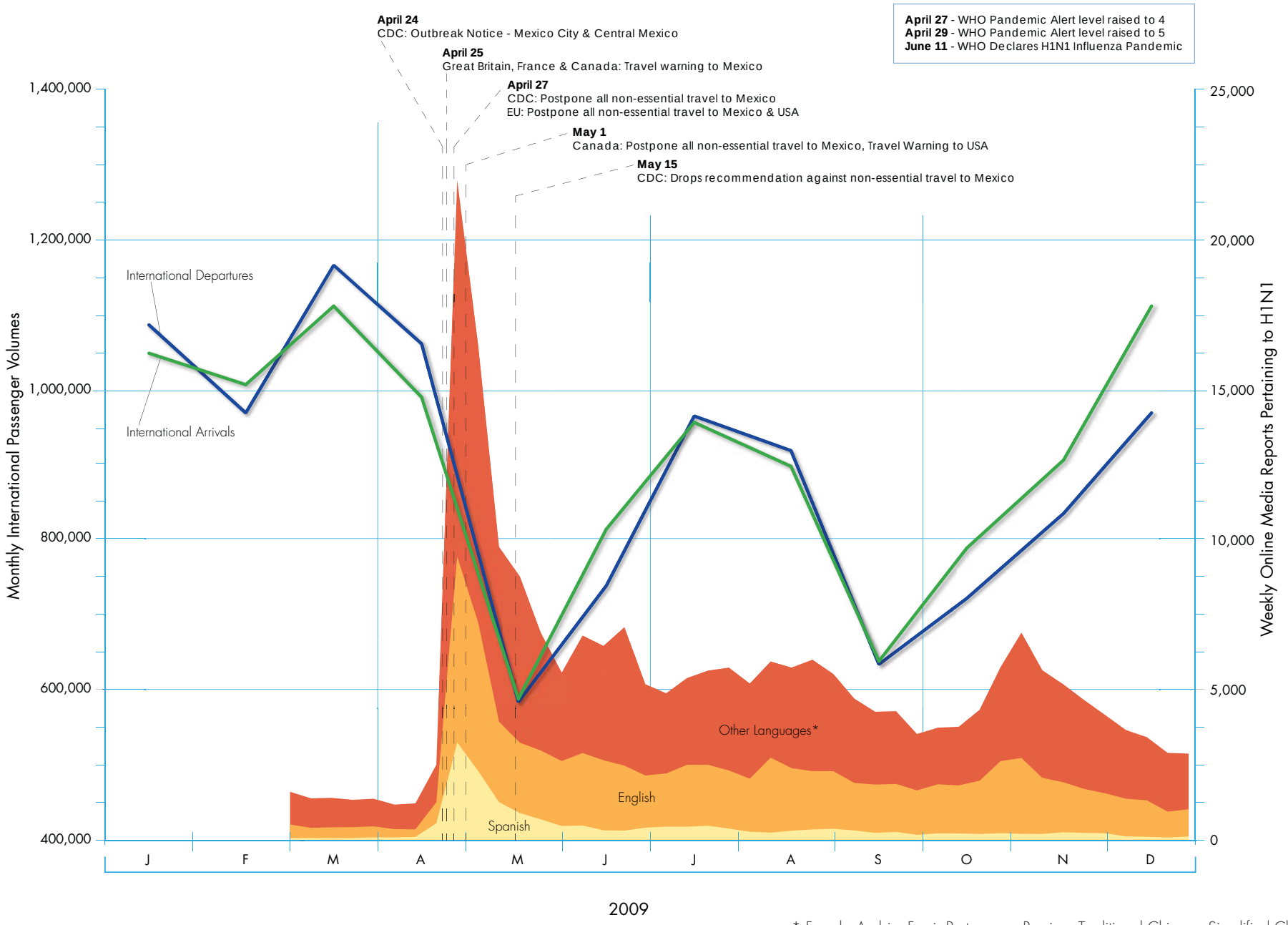
We return to the five key questions raised in this report:

1. Did awareness of the H1N1 threat precipitate a rapid departure of travellers out of Mexico? If so, could this have accelerated importation and evolution of the H1N1 epidemic in Canada?

During the early stages of the H1N1 threat, anecdotal reports of mass departures of travellers from Mexican airports raised the possibility that H1N1 exportation, and hence the global evolution of the H1N1 pandemic, could have been amplified and accelerated. With many Canadians vacationing in Mexico in the spring, this phenomenon – if real – would have had significant public health implications to Canada. To determine if this occurred, we retrospectively analyzed international passenger arrivals into and departures from Mexican airports before and after the H1N1 threat and its global implications were recognized. Exhibit 1 depicts the 2009 monthly volumes of international arrivals into and departures from Mexico alongside government issued travel alerts or warnings and the intensity of online media reporting pertaining to H1N1. If travellers did indeed depart Mexico at an accelerated rate, at a minimum, we would expect to see the volume of international departures exceed the volume of international arrivals. However, our analysis demonstrates a precipitous but parallel decline in both international arrivals and departures in the month of May as H1N1 related media reporting peaked.

To evaluate the possibility that travellers accelerated their return specifically to Canada, we produced a series of scatterplots comparing volumes of international passengers departing major Mexican cities for destinations inside Canada (and the United States) in May 2009 and compared these with volumes observed in May 2008. In Exhibit 2 we observed that passenger traffic from Mexico to Canada in May 2008 generally exceeded the corresponding volume of passenger traffic in May 2009. Given that international air travel declined throughout much of the world in 2009 in response to changes in the global economy, this finding was largely anticipated. However, we noted that patterns of passenger traffic into Canada differed between Mexican resort cities (i.e. Cancun, Puerto Vallarta, and Cabo San Lucas) and non-resort cities (i.e. Mexico City, Guadalajara, and Monterrey). From resort cities, travellers appeared to enter Canada in greater numbers in May 2009 and this effect was most evident in Cancun and Puerto Vallarta. While this observation raised the possibility that travellers from resort cities may have returned to Canada in greater numbers than anticipated in response to news of the H1N1 threat, further analysis of air travel between Mexico and Canada in March and April 2009 also demonstrated an increased volume of travellers compared with the corresponding month in 2008. Collectively, these findings suggest that Canadians travelled to Mexican resort cities in greater numbers in the spring of 2009 than they did in the spring of 2008 (in contrast with the observation for non-resort cities) and does not appear to suggest that travellers accelerated their departure from Mexican resort cities in response to the H1N1 pandemic.

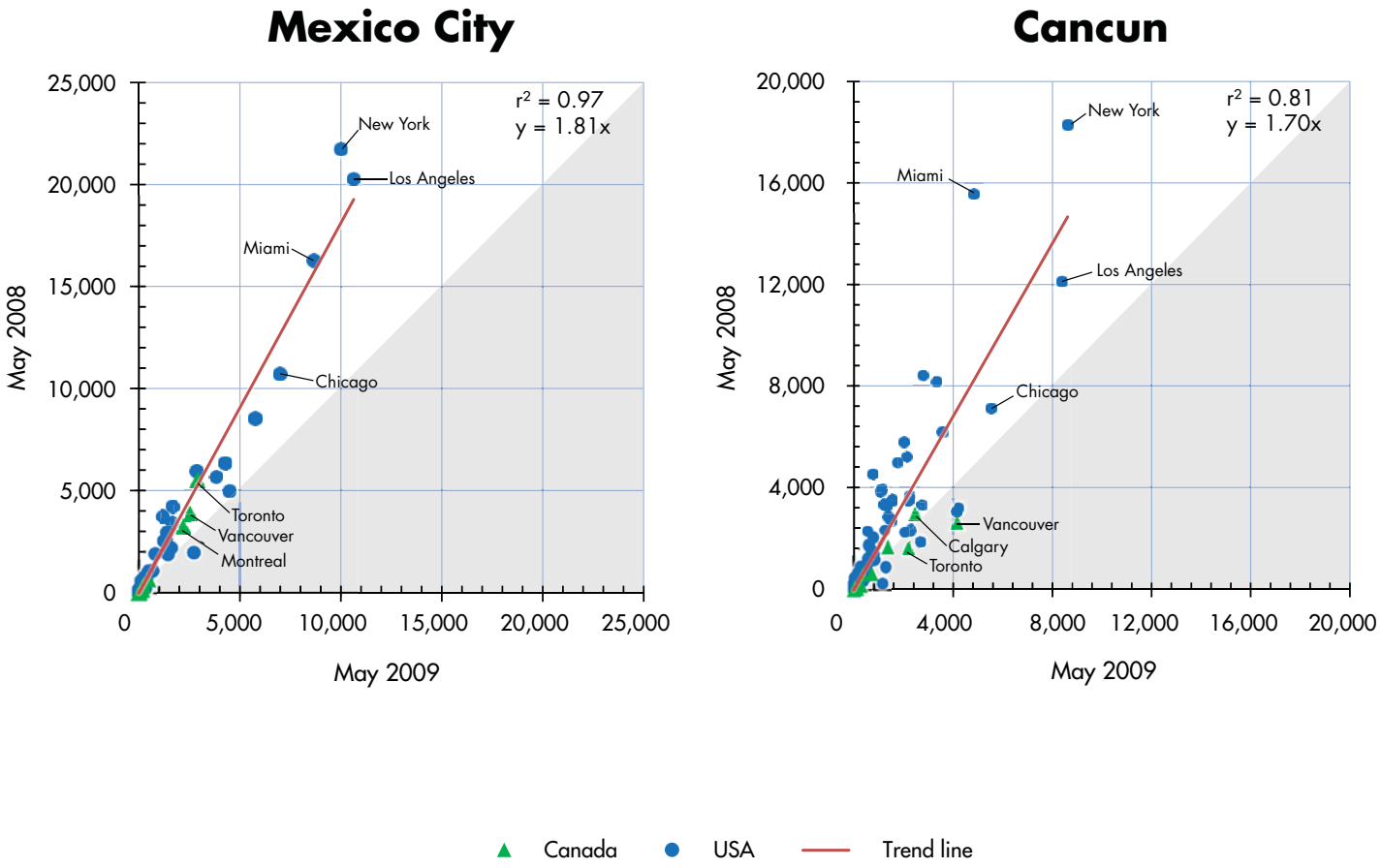
Exhibit 1: Online Media Activity Pertaining to the H1N1 Influenza Threat and International Passenger Traffic Arriving into and Departing from Mexico, 2009



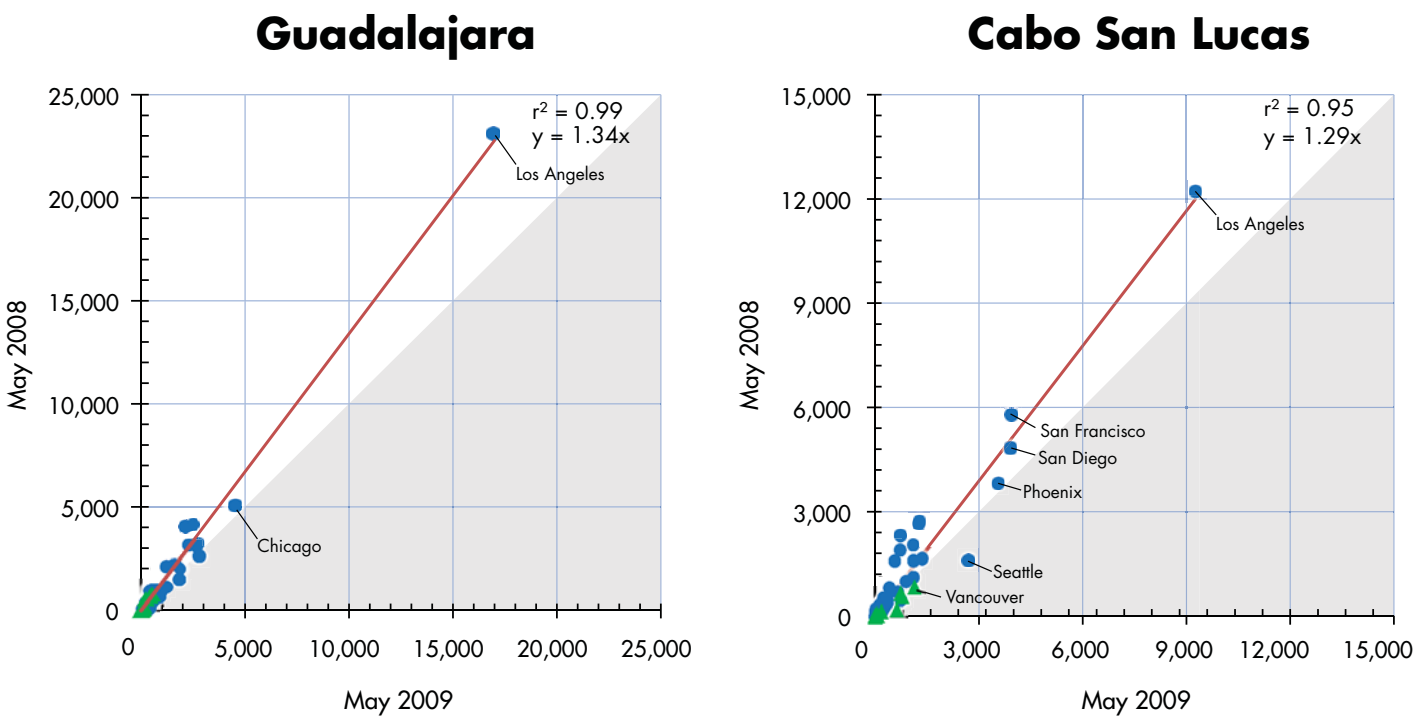
* French, Arabic, Farsi, Portuguese, Russian, Traditional Chinese, Simplified Chinese

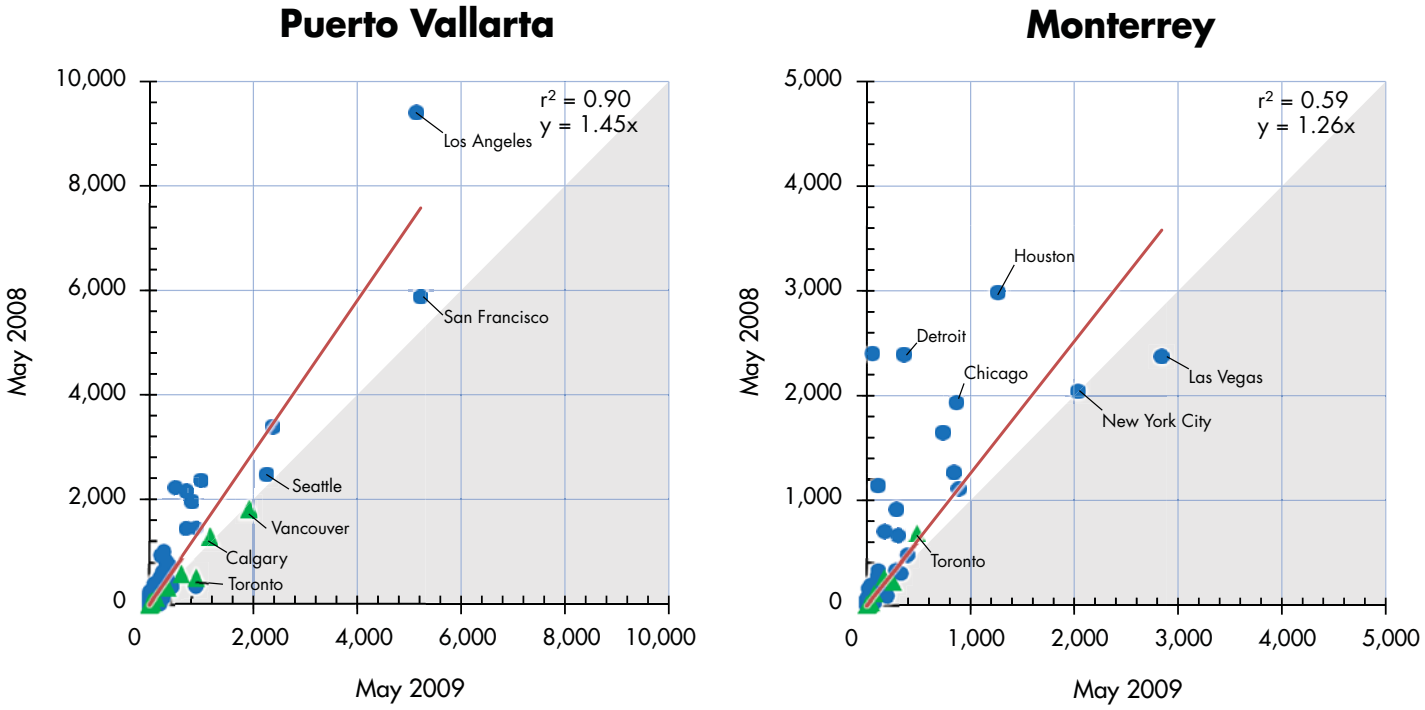
Data Sources: Global Public Health Intelligence Network (GPHIN), Public Health Agency of Canada, International Air Transport Association (IATA)

Exhibit 2: International Passenger Departures from Six Leading Mexican Cities into Cities in Canada and the United States, May 2008 & May 2009



Data Source: International Air Transport Association (IATA)





Data Source: International Air Transport Association (IATA)

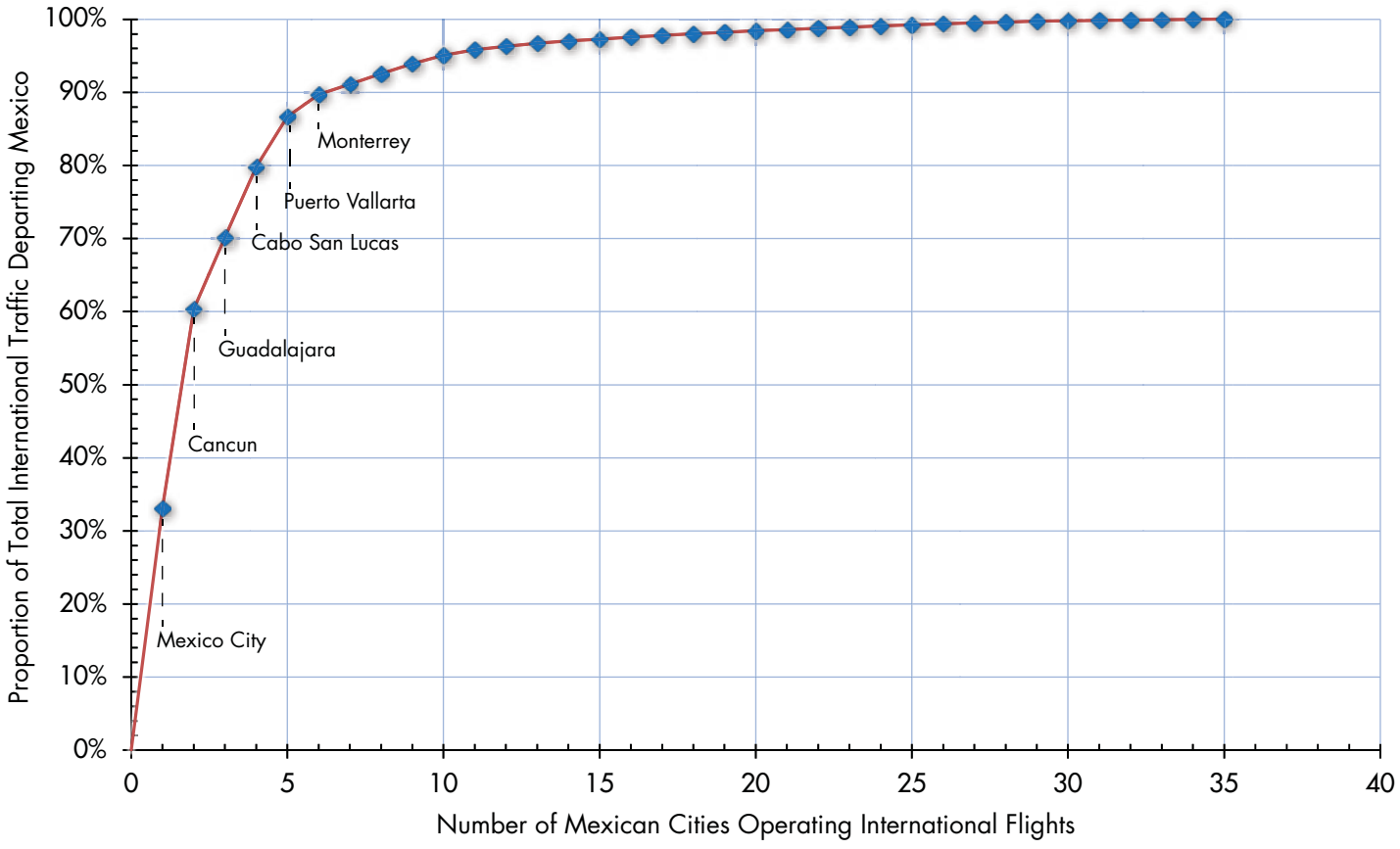
2. What impact did the H1N1 pandemic have on international air travel to and from Mexico? Was international air travel to and from the United States and Canada also disrupted, and if so in what way?

We assessed commercial air traffic activity in Mexico by analyzing the flows of international passengers at selected Mexican airports before and after emergence of the H1N1 pandemic. First, we identified that 35 commercial airports in Mexico were operating international flights in the month of May 2009. However, in Exhibit 3 we see that just six of these airports accounted for 90% of all international passenger departures out of Mexico. We subsequently focused our analyses of international air traffic on these six airports, which included Mexico City (Juarez International Airport), Cancun, Guadalajara, Cabo San Lucas, Puerto Vallarta, and Monterrey (General Mariano Escobedo International Airport). Using time series analysis, we observed significant disruption to international passenger traffic in each of these six airports in association with the H1N1 threat, although the impact was most prominent in Cancun and Mexico City, where declines of close to 500,000 and 300,000 passengers respectively were observed in the month May 2009 (see Exhibits 4-9). Cumulatively across the six aforementioned Mexican airports, there was an estimated decline of nearly 1,000,000 international passengers in the month May 2009 alone. While the usual pattern of international traffic in each of these cities was restored after a short period of just one to two months, a longer period of observation is needed to determine when pre-H1N1 baseline levels of international air traffic will be achieved.

We also assessed if and how the H1N1 pandemic affected international air travel in Canada. First, we identified that 17 commercial airports in Canada were receiving international passengers from Mexico in the month of May 2009. However, in Exhibit 10 we see that just five of these airports accounted for 95% of all passengers travelling into Canada from Mexico. We subsequently focused our analyses of commercial air traffic on these five airports, which included Vancouver, Toronto (Pearson International Airport), Montreal (Pierre Elliot Trudeau International Airport), Calgary, and Edmonton. Using time series analysis, we did not observe a disruption in international passenger traffic in four of the five airports (see Exhibits 11-15).

The notable exception was Edmonton, which experienced a modest decline in international traffic in May 2009 relative to what would have been expected based on time series analysis. Looking at international traffic entering Canada from all airports worldwide across each month in 2009, we observed only modest declines during the months of May and June 2009, shortly after the H1N1 epidemic threat was recognized (see Exhibit 16). Thus, while patterns of international air traffic in Mexico were heavily impacted for a short duration, international air travel in Canada was minimally affected through the end of 2009.

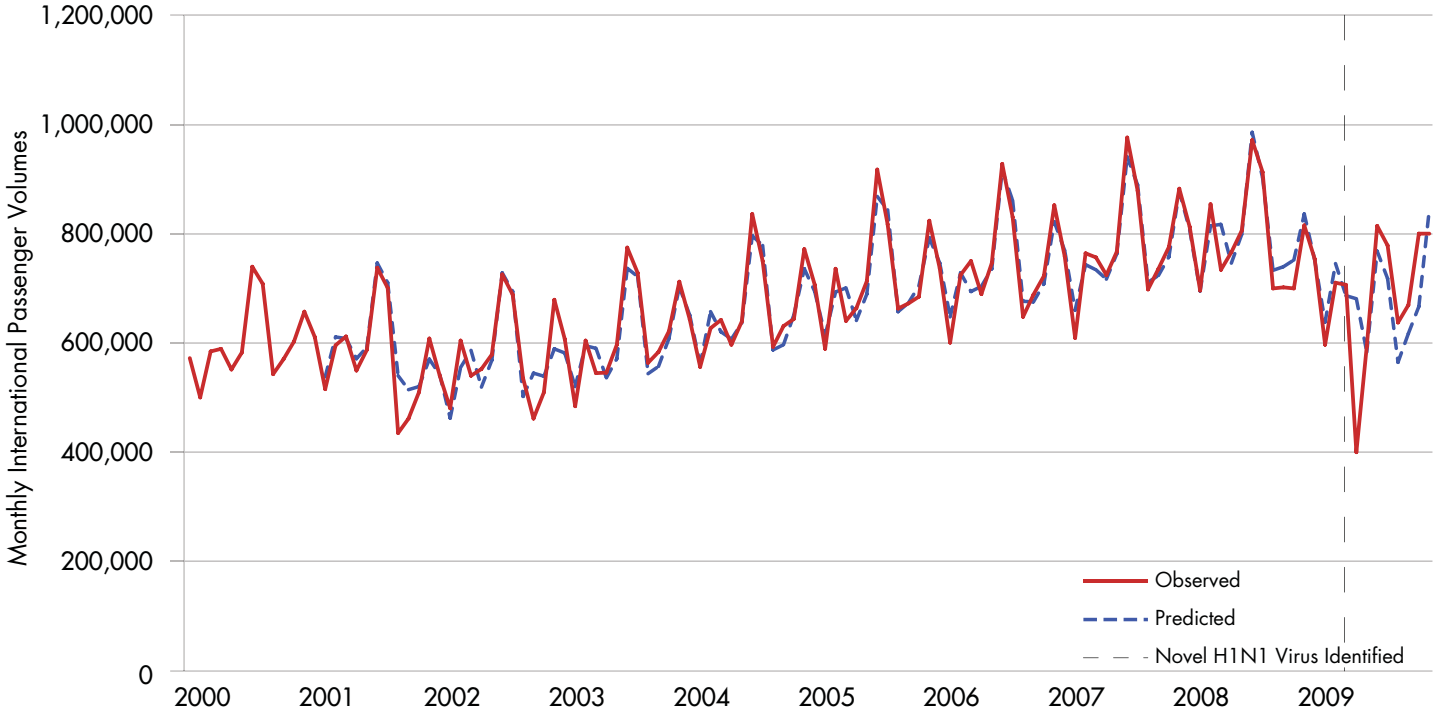
Exhibit 3: International Passenger Traffic Departing Mexico by City, May 2009



Data Source: International Air Transport Association (IATA)

Exhibit 4: International Passenger Arrivals plus Departures in Mexico City, 2000-2009 (Juárez International Airport)

A Comparison of Observed versus Predicted Traffic Flows



Data Source: Airports Council International

Deviation between Observed and Predicted Flows of International Passenger Traffic in Mexico City, 2001-2009

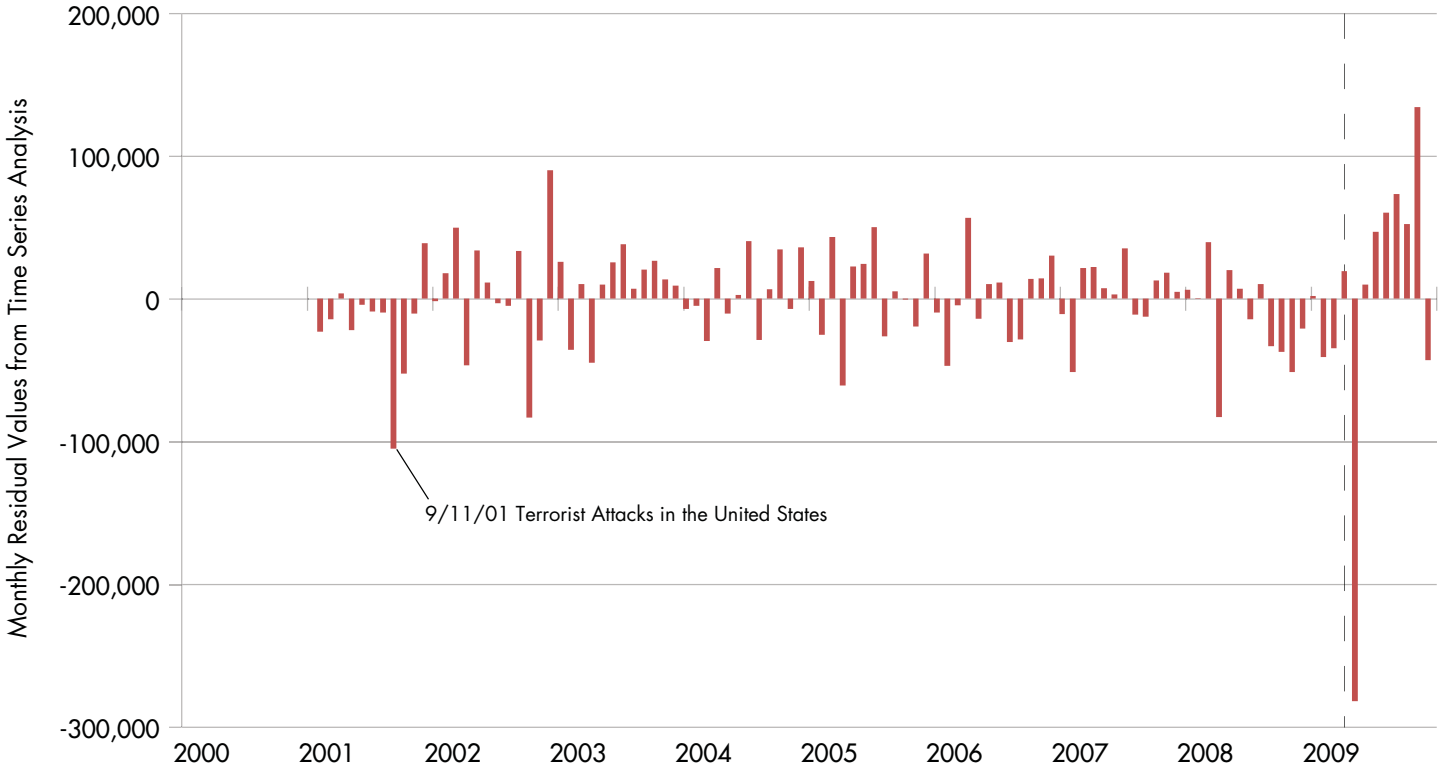
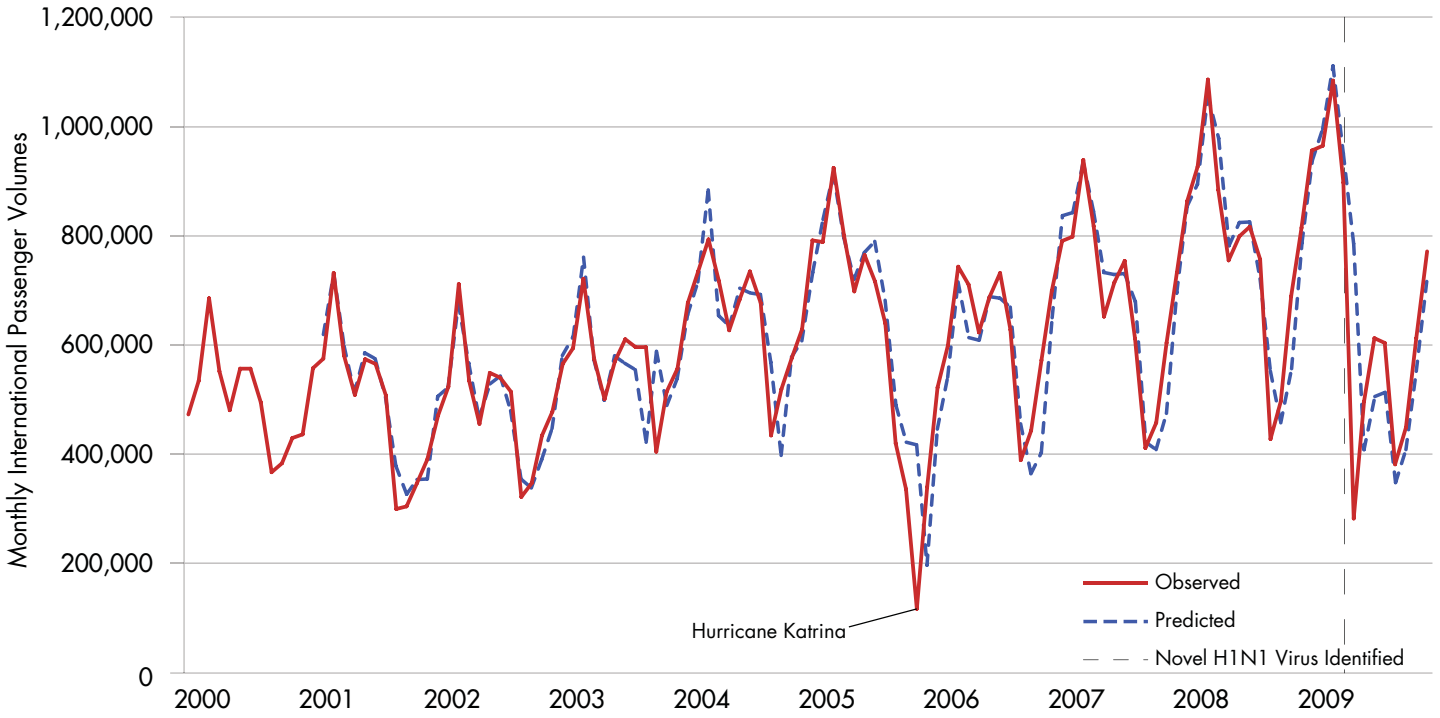


Exhibit 5: International Passenger Arrivals plus Departures in Cancun, 2000-2009

A Comparison of Observed versus Predicted Traffic Flows



Data Source: Airports Council International

Deviation between Observed and Predicted Flows of International Passenger Traffic in Cancun, 2001-2009

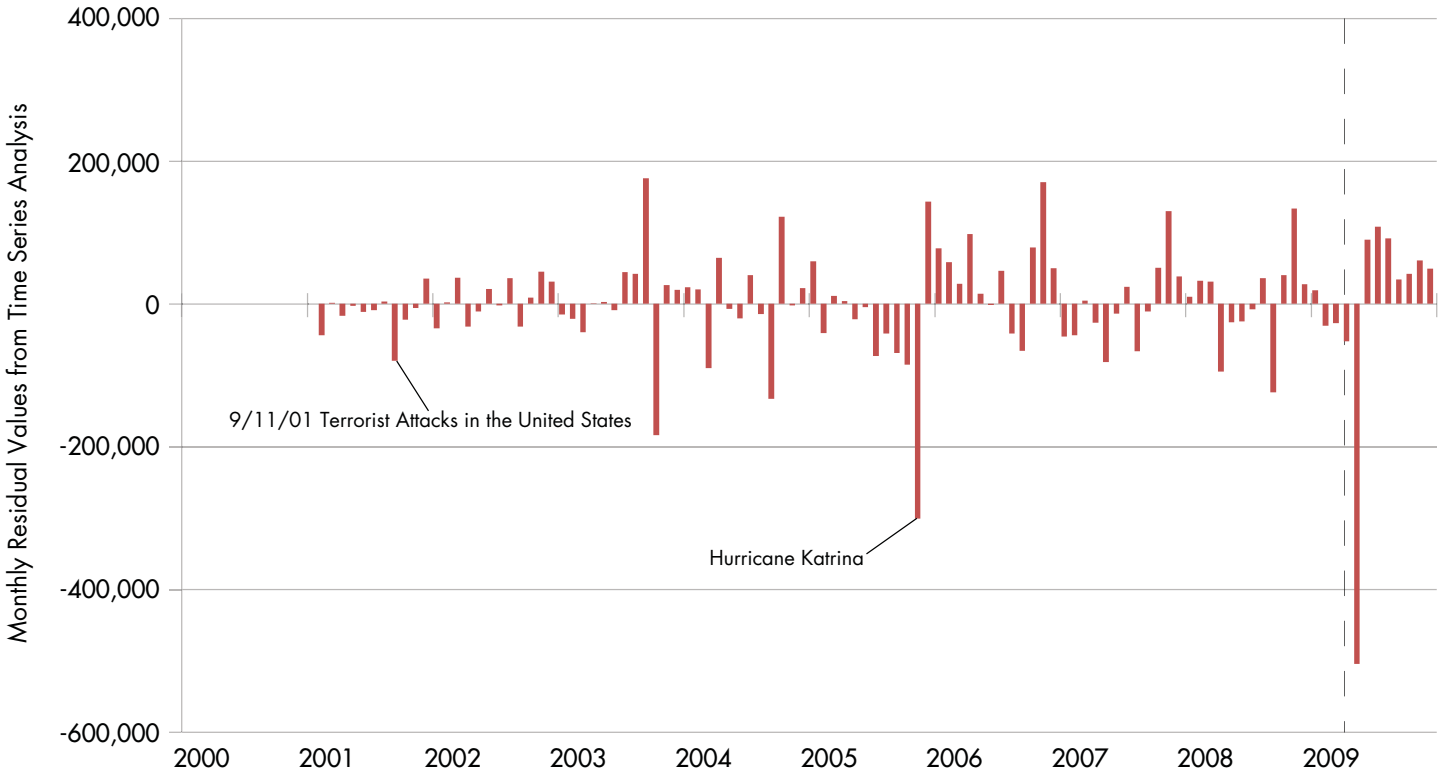
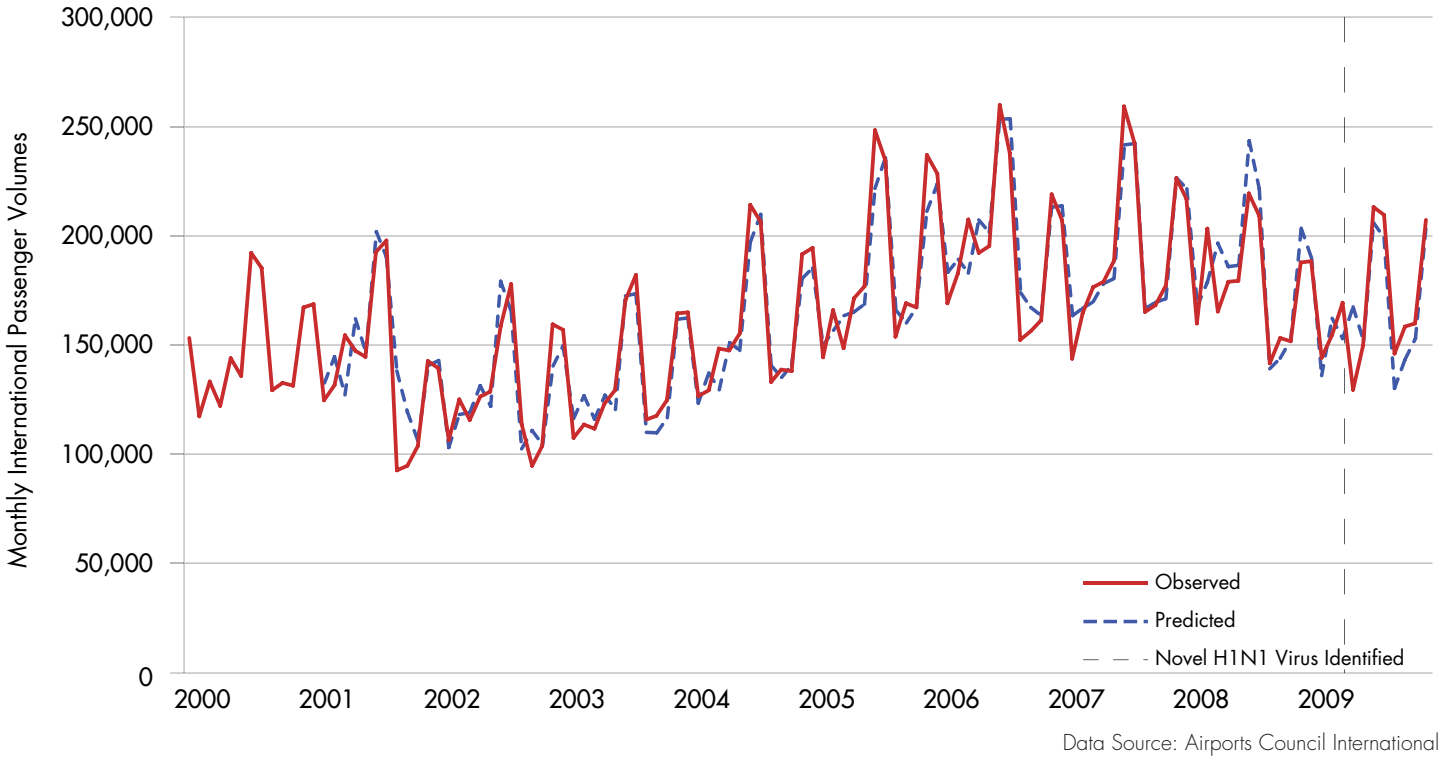


Exhibit 6: International Passenger Arrivals plus Departures in Guadalajara, 2000-2009

A Comparison of Observed versus Predicted Traffic Flows



Data Source: Airports Council International

Deviation between Observed and Predicted Flows of International Passenger Traffic in Guadalajara, 2001-2009

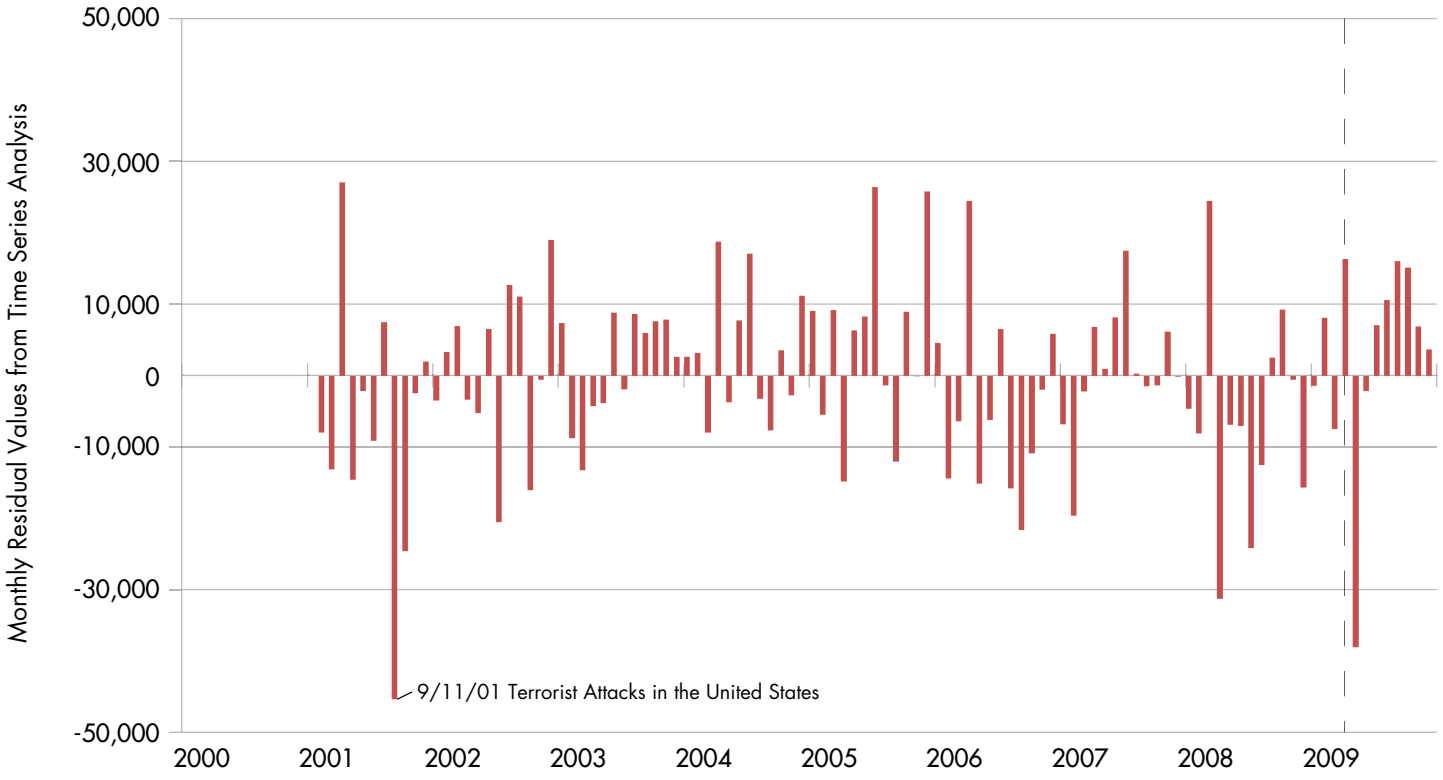
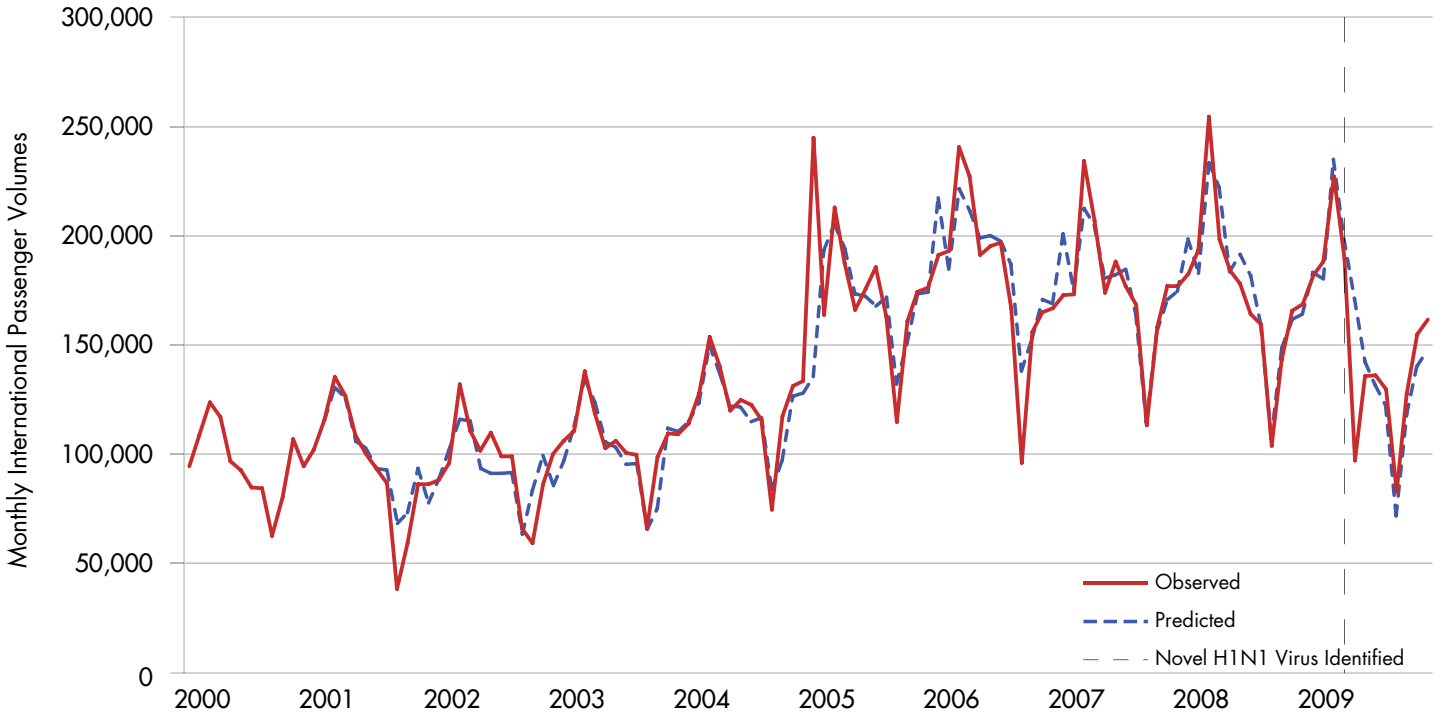


Exhibit 7: International Passenger Arrivals plus Departures in Cabo San Lucas, 2000-2009

A Comparison of Observed versus Predicted Traffic Flows



Data Source: Airports Council International

Deviation between Observed and Predicted Flows of International Passenger Traffic in Cabo San Lucas, 2001-2009

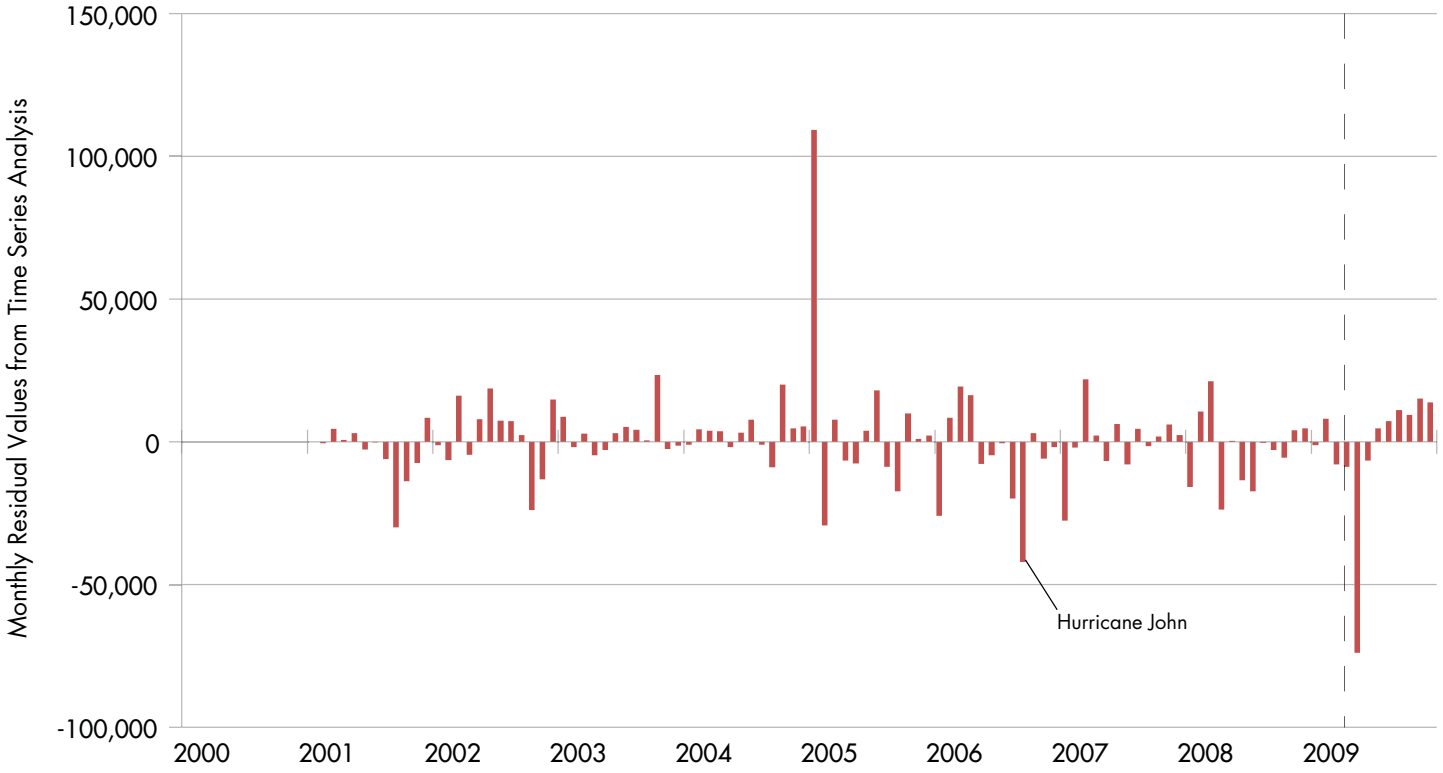
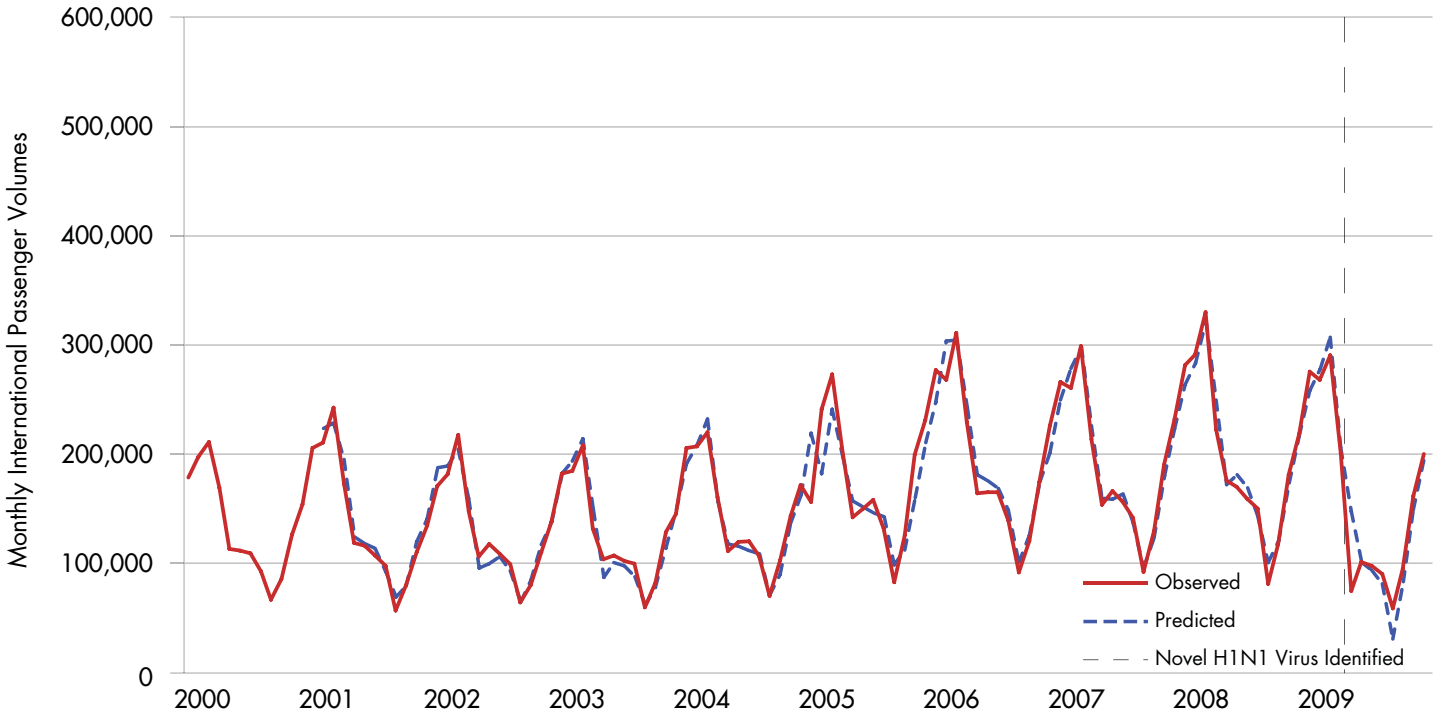


Exhibit 8: International Passenger Arrivals plus Departures in Puerto Vallarta, 2000-2009

A Comparison of Observed versus Predicted Traffic Flows



Data Source: Airports Council International

Deviation between Observed and Predicted Flows of International Passenger Traffic in Puerto Vallarta, 2001-2009

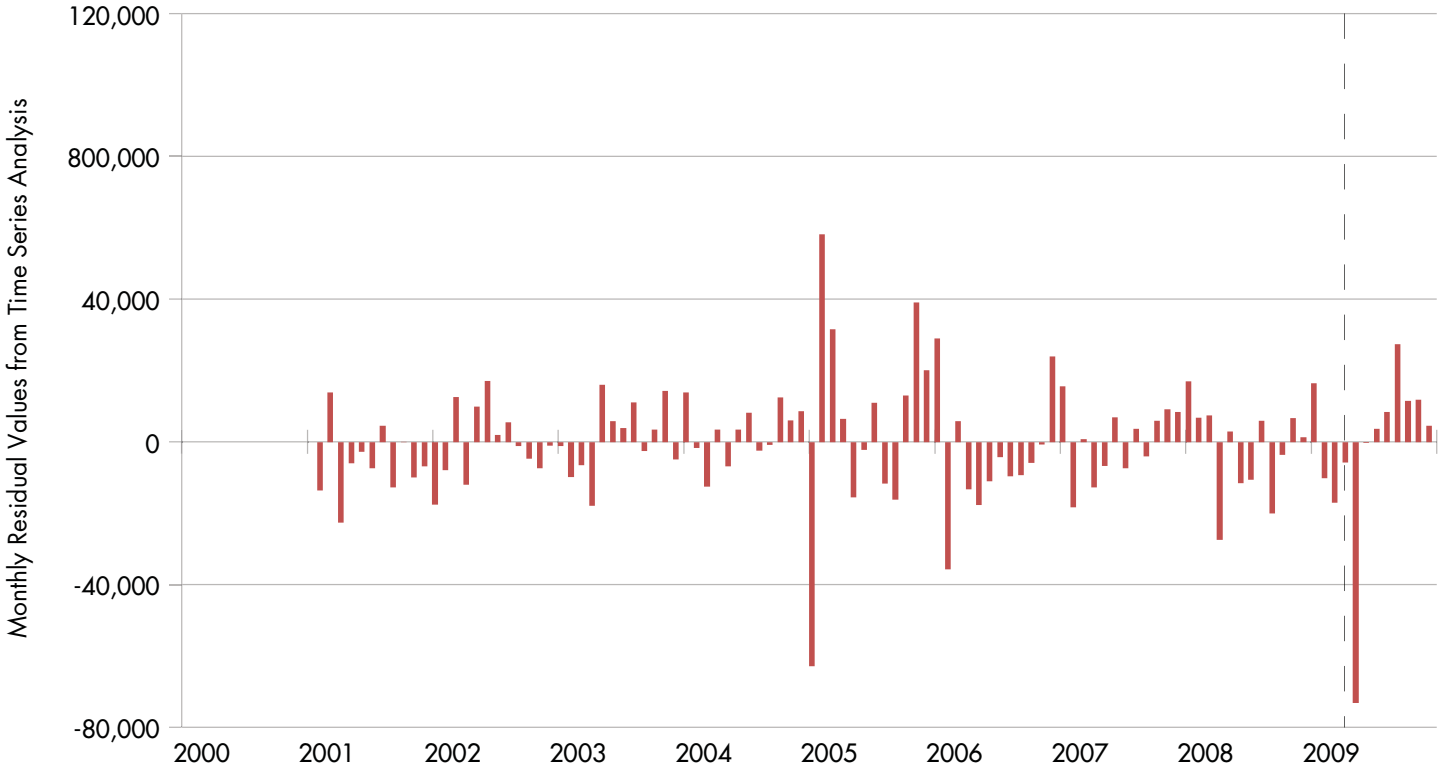
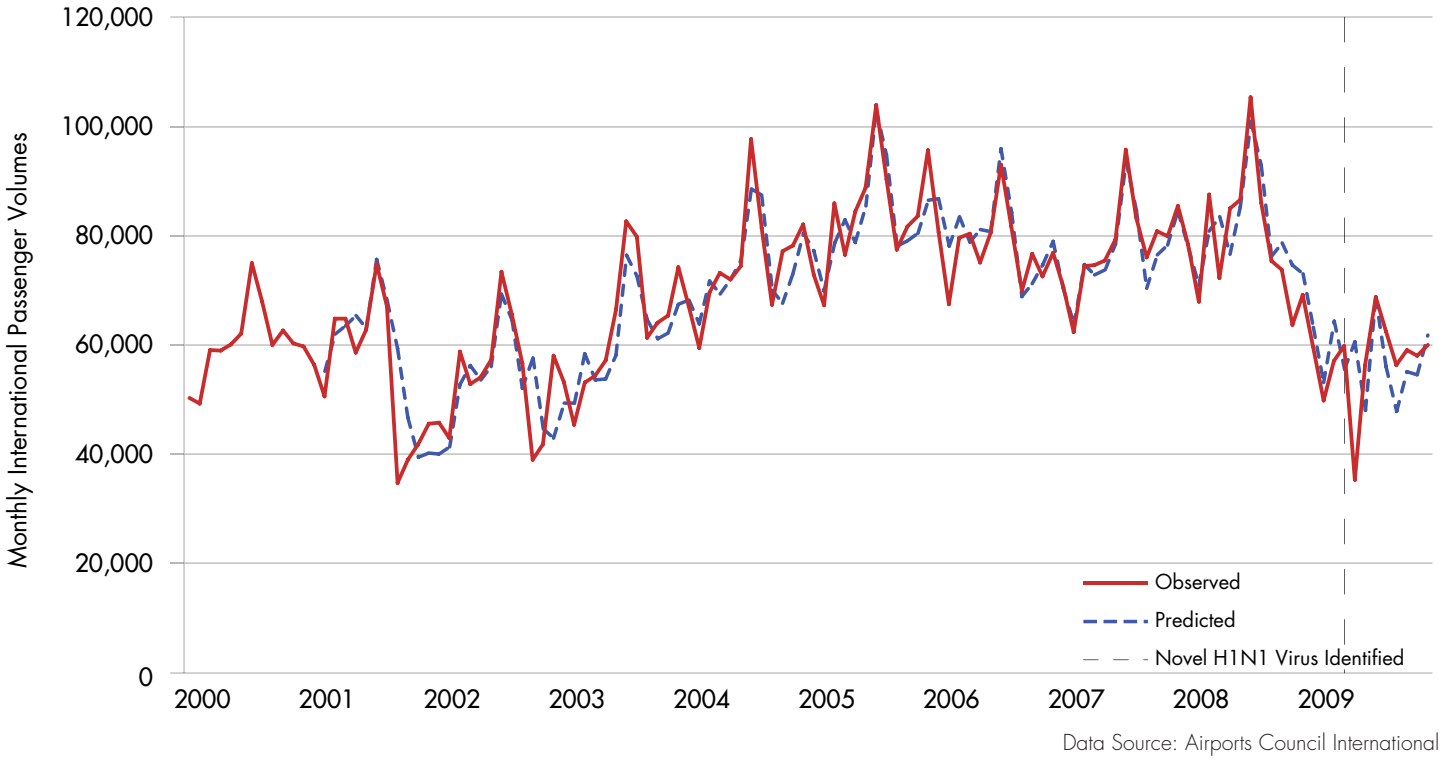


Exhibit 9: International Passenger Arrivals plus Departures in Monterrey, 2000-2009 (General Mariano Escobedo International Airport)

A Comparison of Observed versus Predicted Traffic Flows



Data Source: Airports Council International

Deviation between Observed and Predicted Flows of International Passenger Traffic in Monterrey, 2001-2009

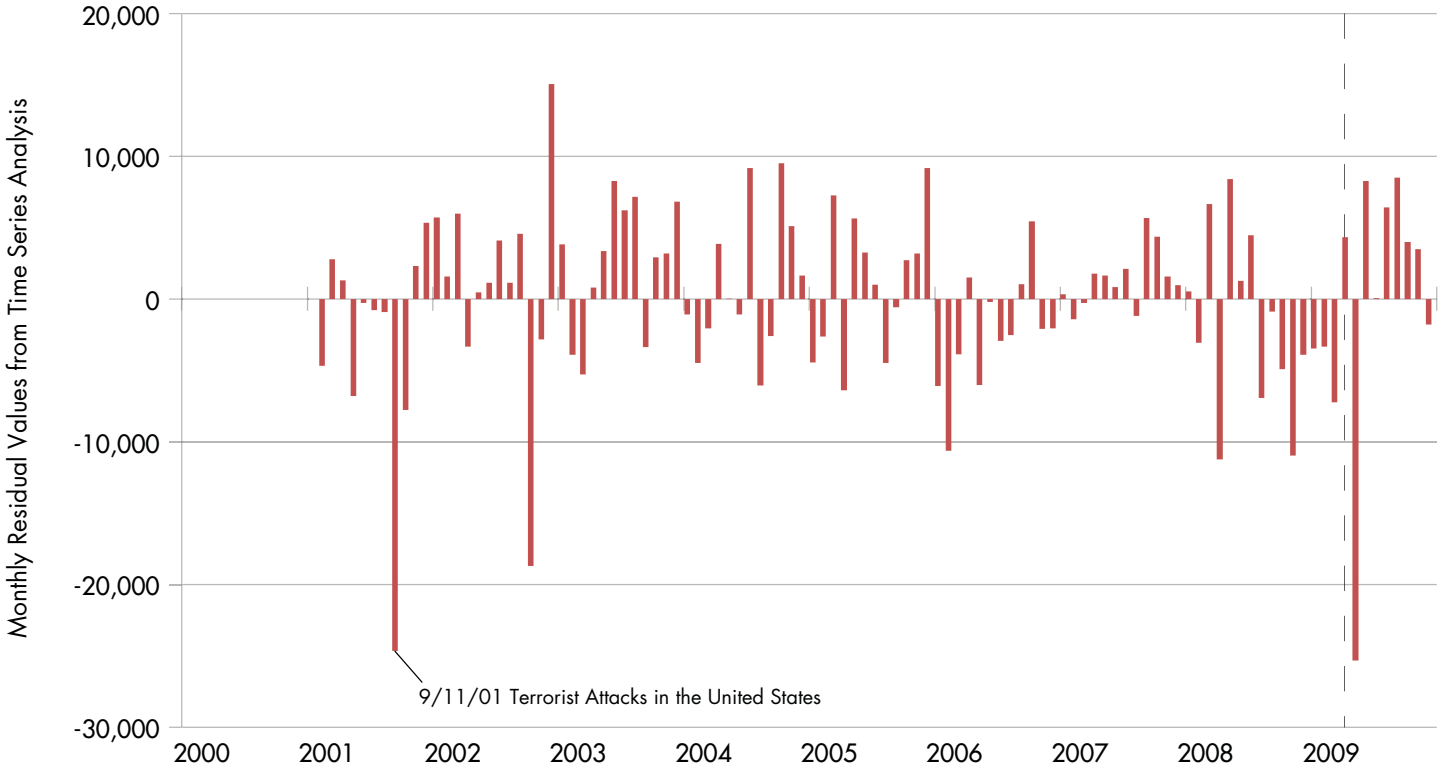
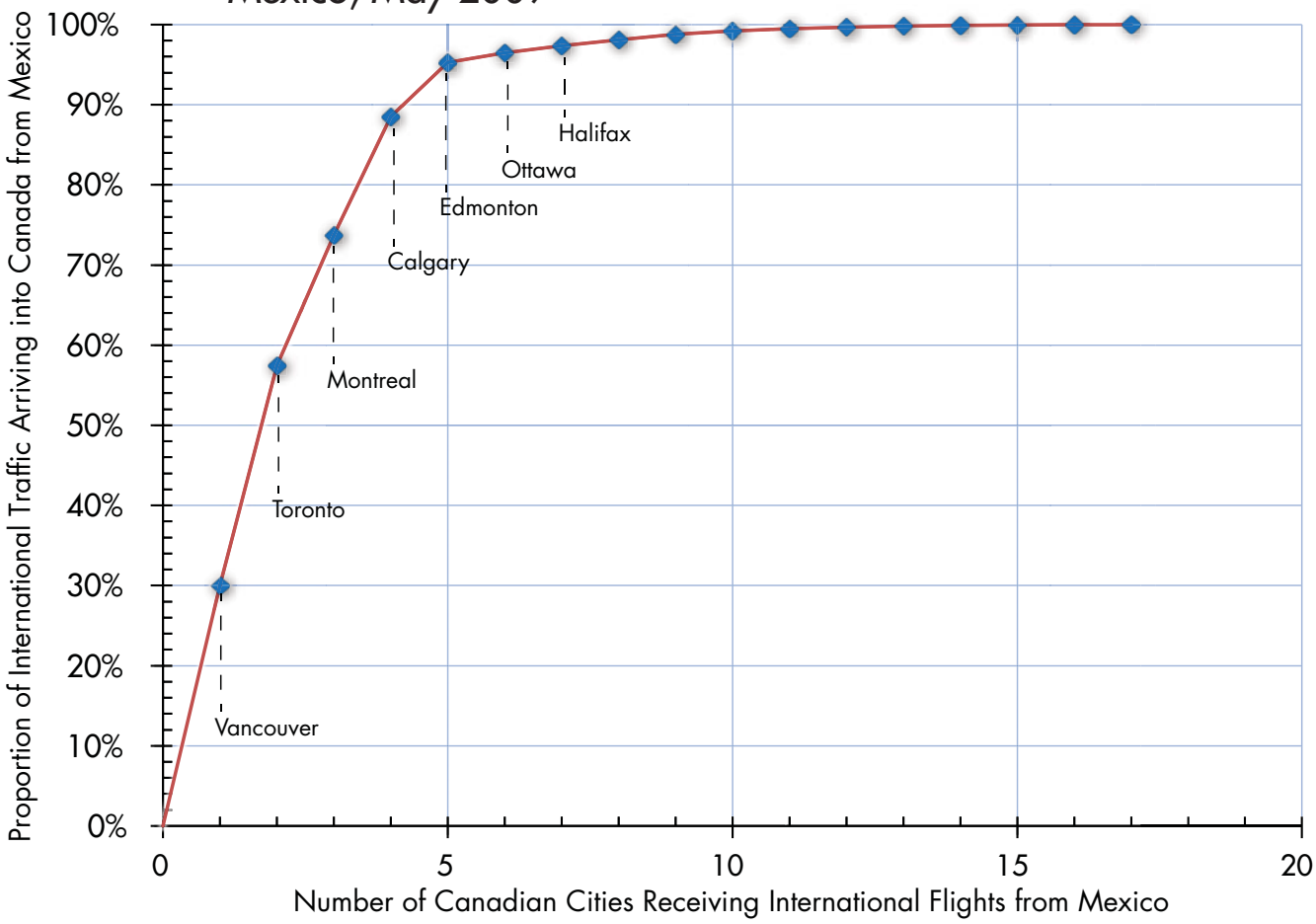


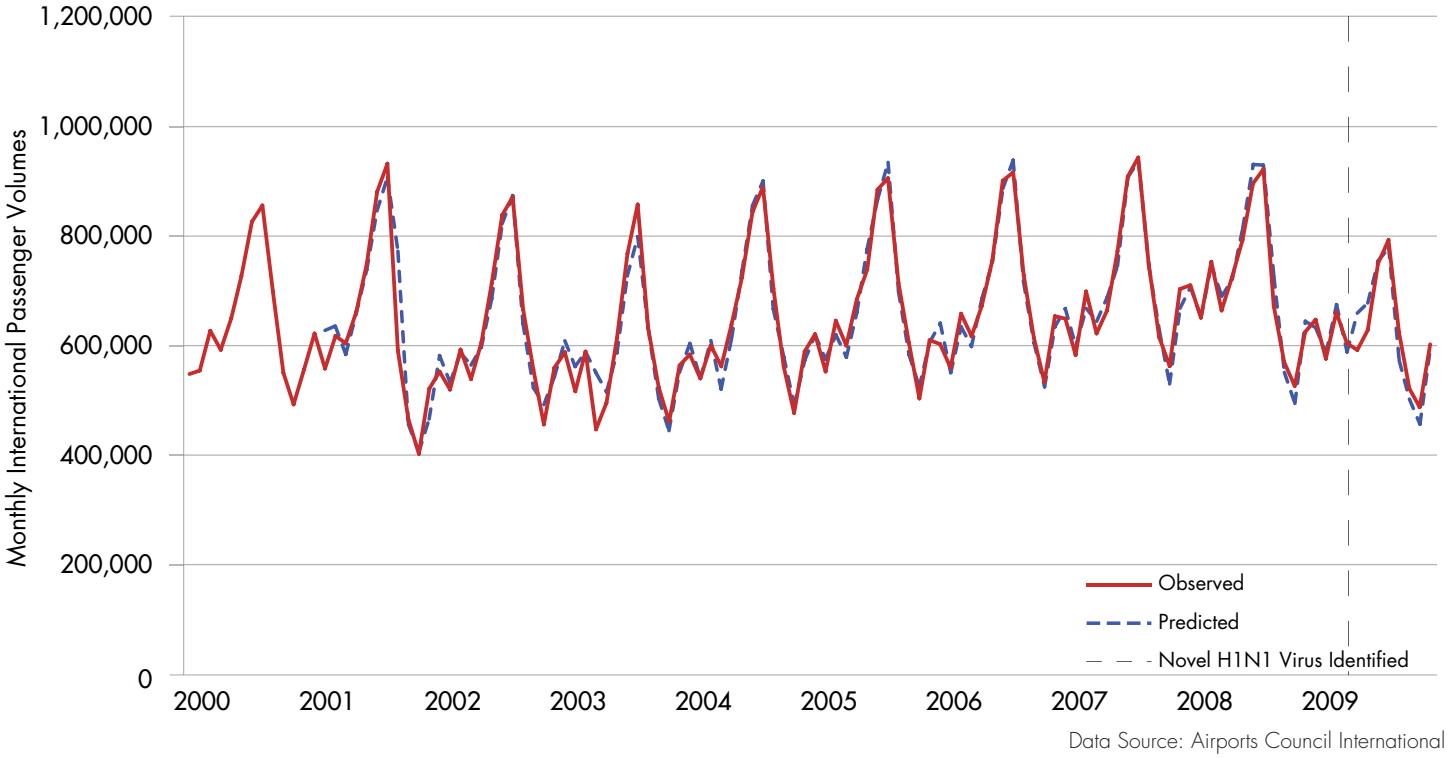
Exhibit 10: International Passenger Traffic Arriving into Canadian Cities from Mexico, May 2009



Data Source: International Air Transport Association (IATA)

Exhibit 11: International Passenger Arrivals plus Departures in Vancouver, 2000-2009

A Comparison of Observed versus Predicted Traffic Flows



Data Source: Airports Council International

Deviation between Observed and Predicted Flows of International Passenger Traffic in Vancouver, 2001-2009

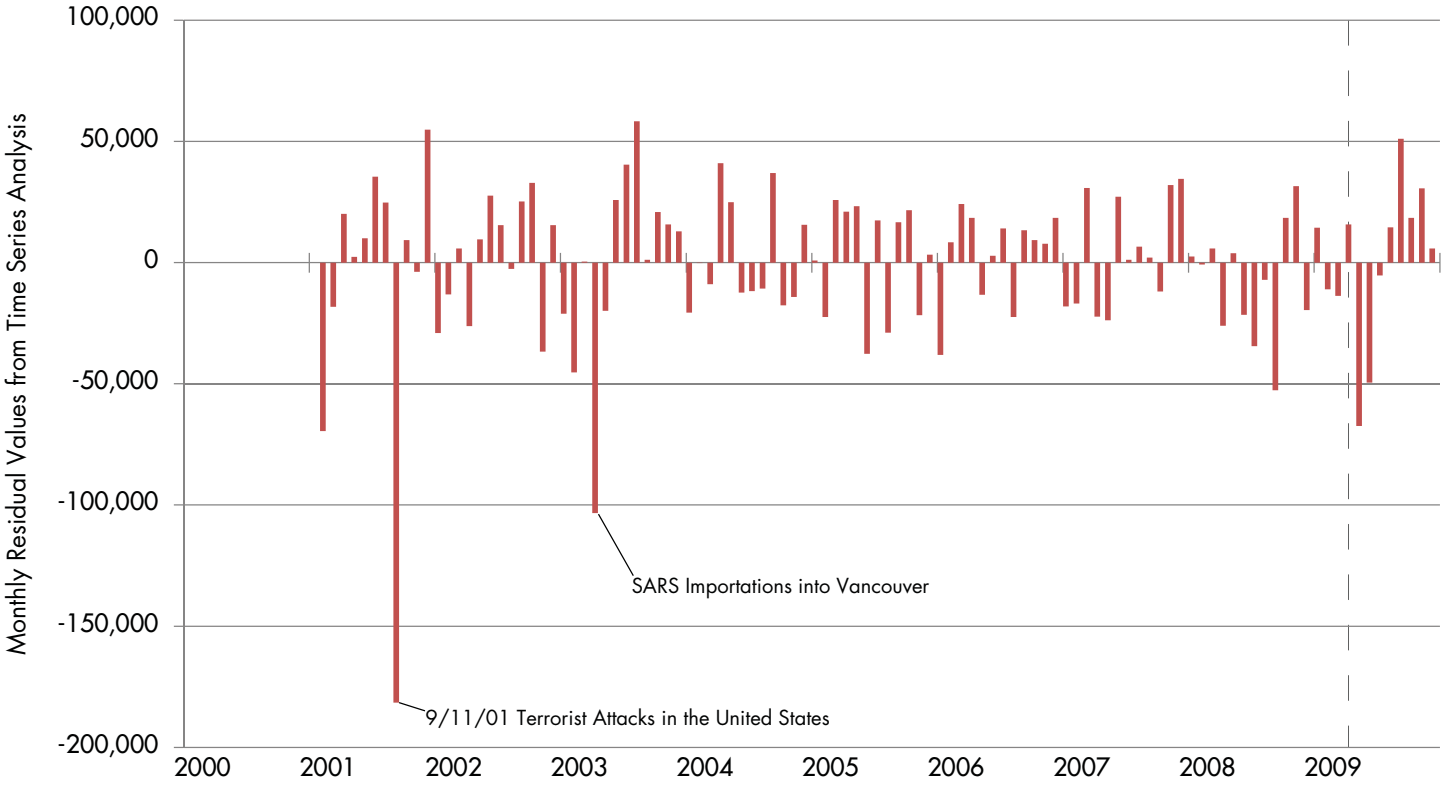
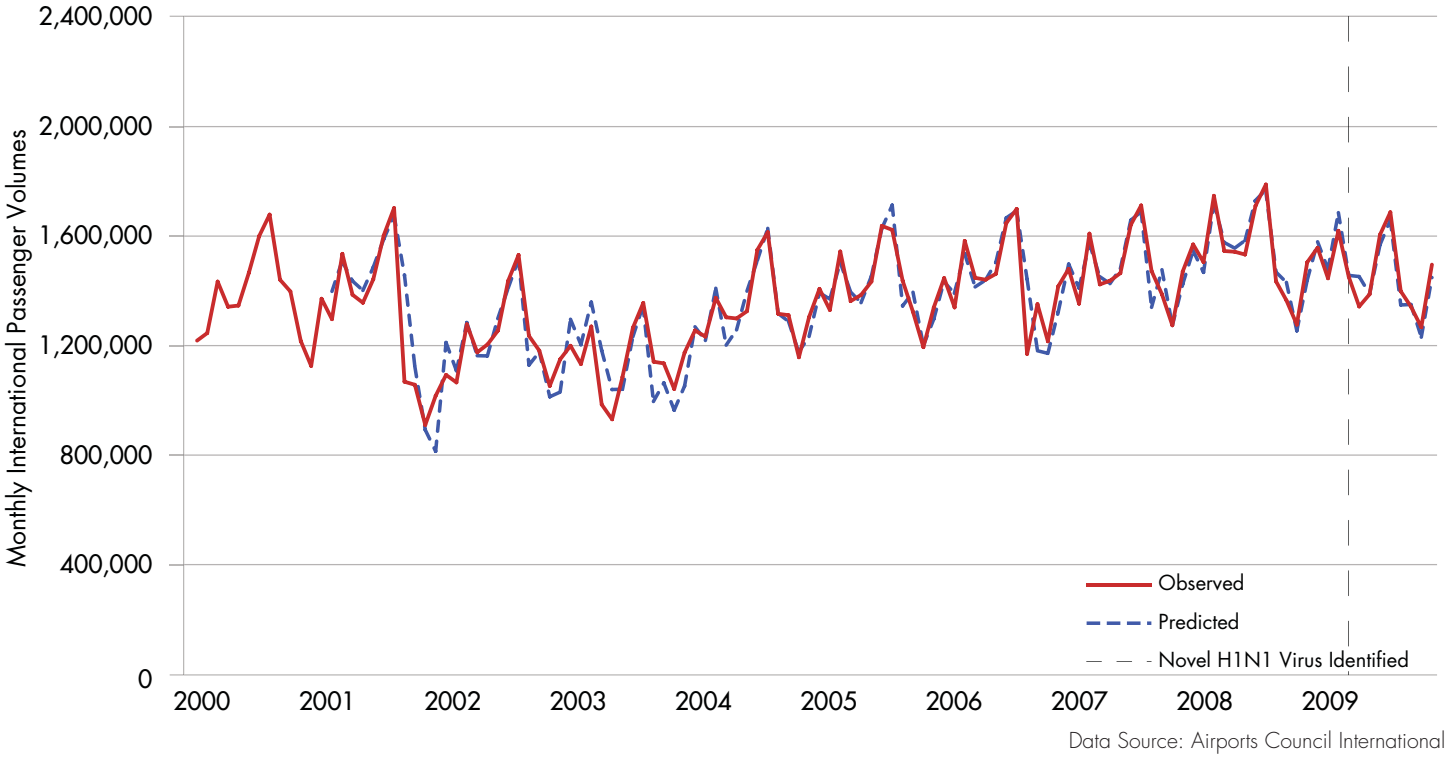


Exhibit 12: International Passenger Arrivals plus Departures in Toronto, 2000-2009 (Pearson International Airport)

A Comparison of Observed versus Predicted Traffic Flows



Data Source: Airports Council International

Deviation between Observed and Predicted Flows of International Passenger Traffic in Toronto, 2001-2009

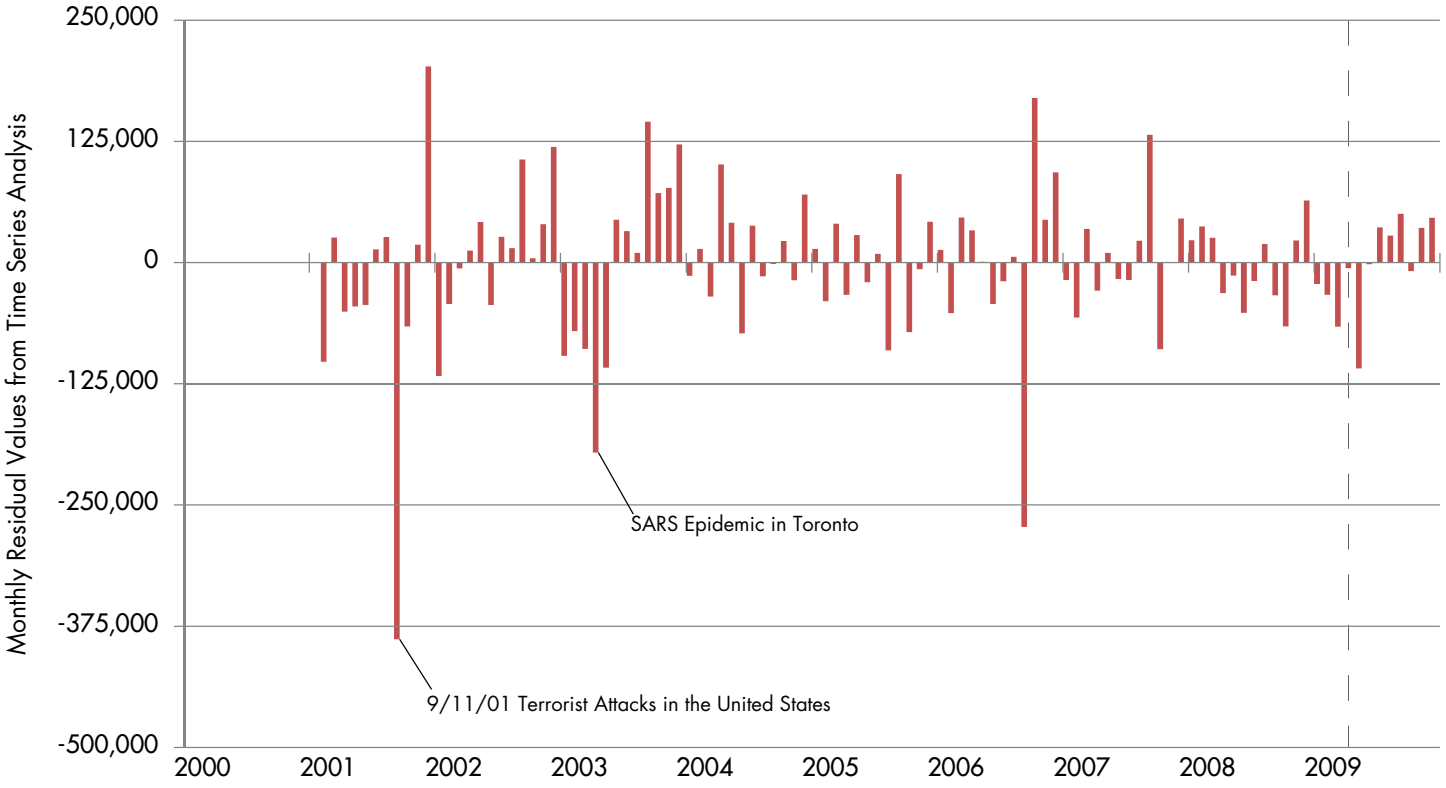
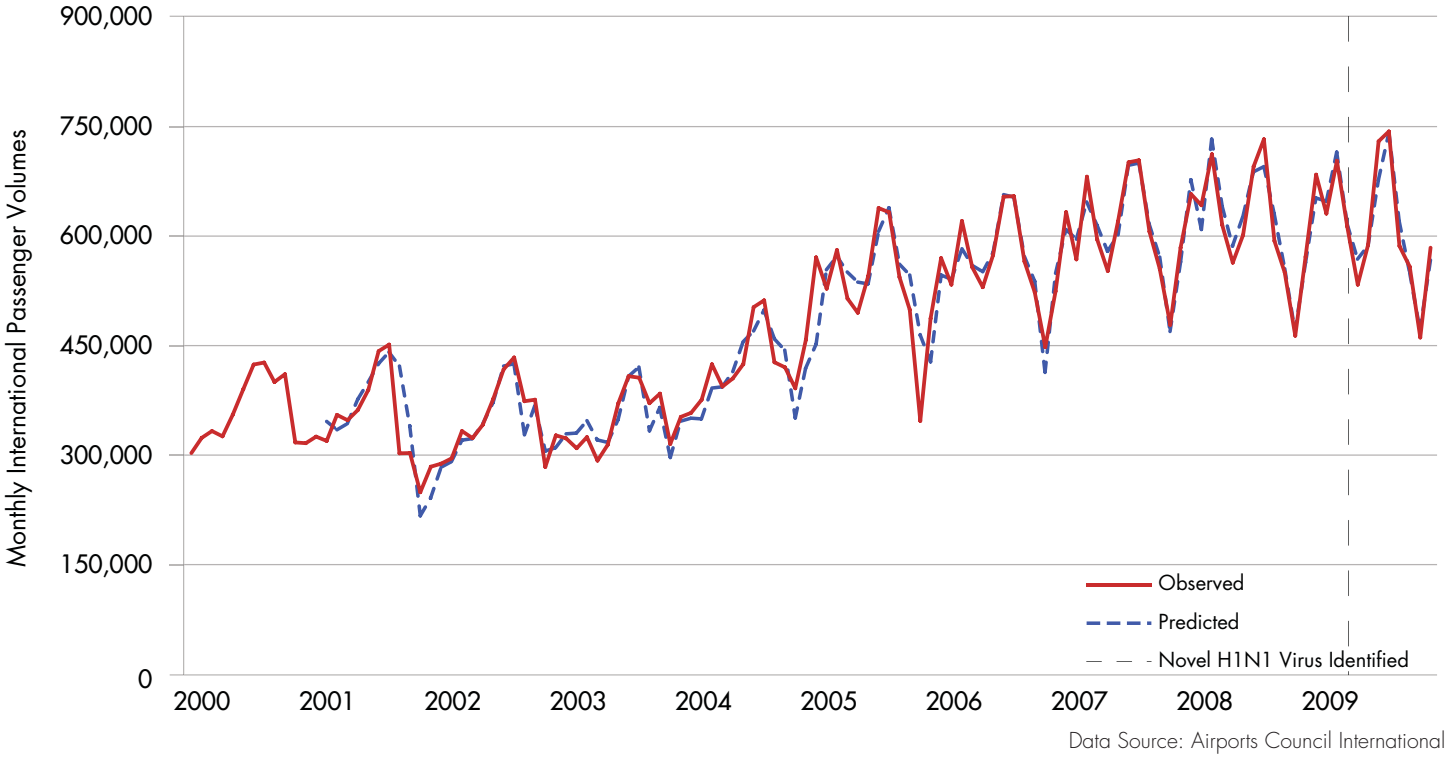


Exhibit 13: International Passenger Arrivals plus Departures in Montreal, 2000-2009 (Pierre Elliott Trudeau International Airport)

A Comparison of Observed versus Predicted Traffic Flows



Data Source: Airports Council International

Deviation between Observed and Predicted Flows of International Passenger Traffic in Montreal, 2001-2009

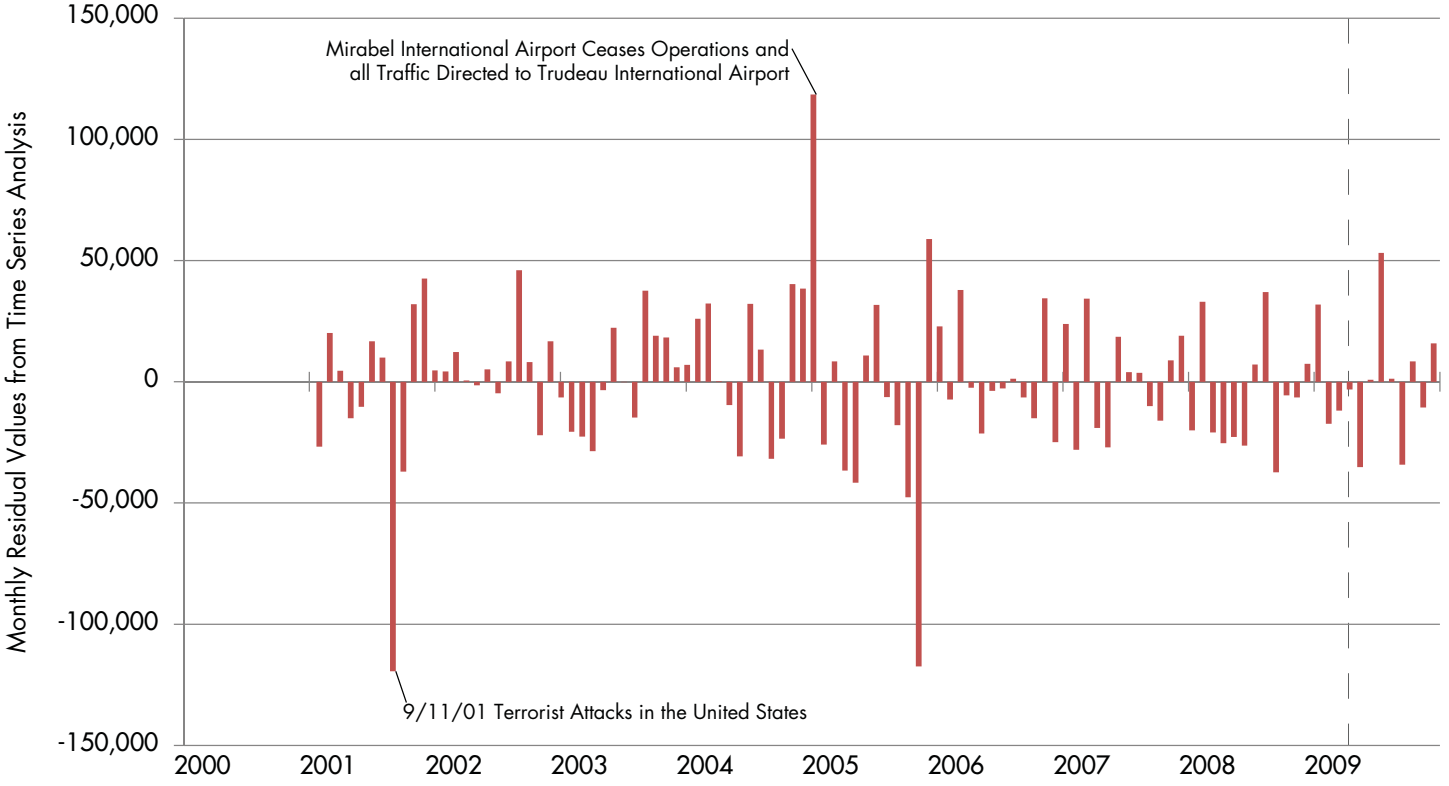
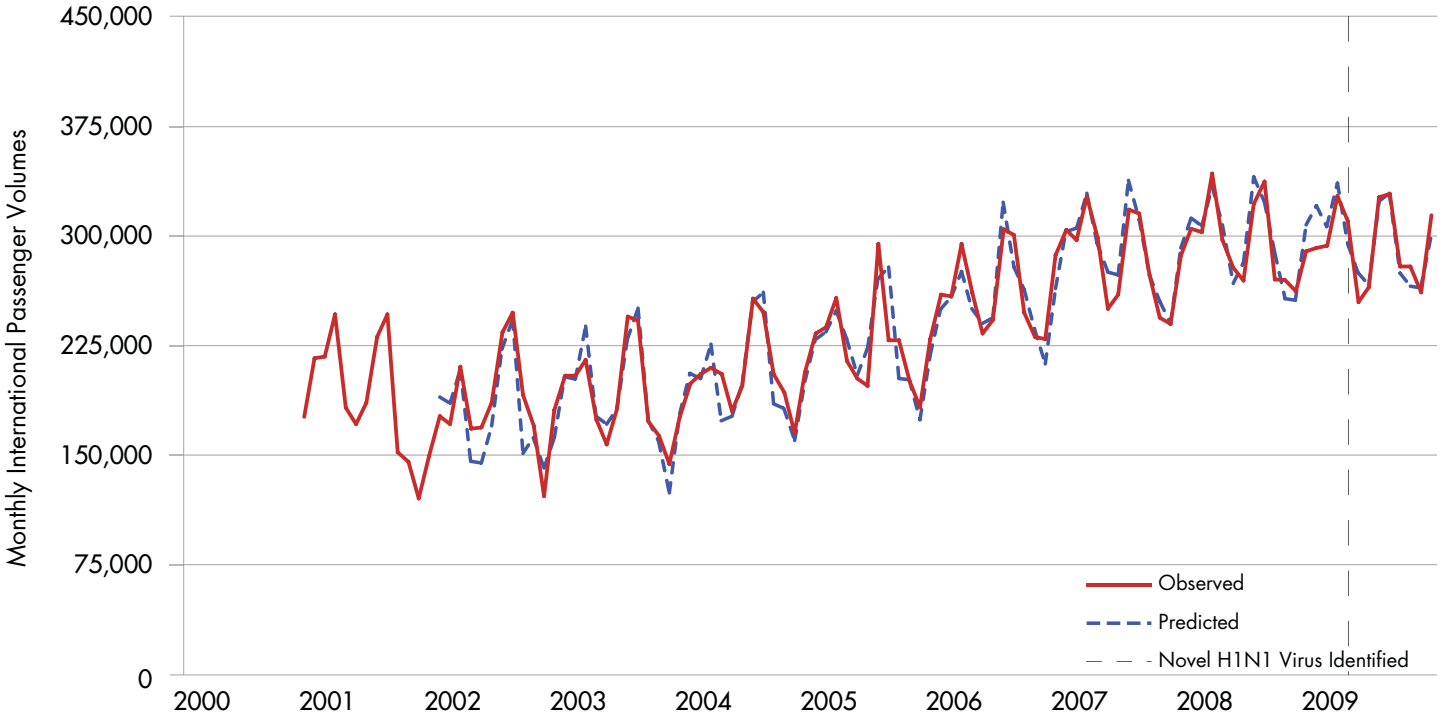


Exhibit 14: International Passenger Arrivals plus Departures in Calgary, 2000-2009

A Comparison of Observed versus Predicted Traffic Flows



Data Source: Airports Council International

Deviation between Observed and Predicted Flows of International Passenger Traffic in Calgary, 2001-2009

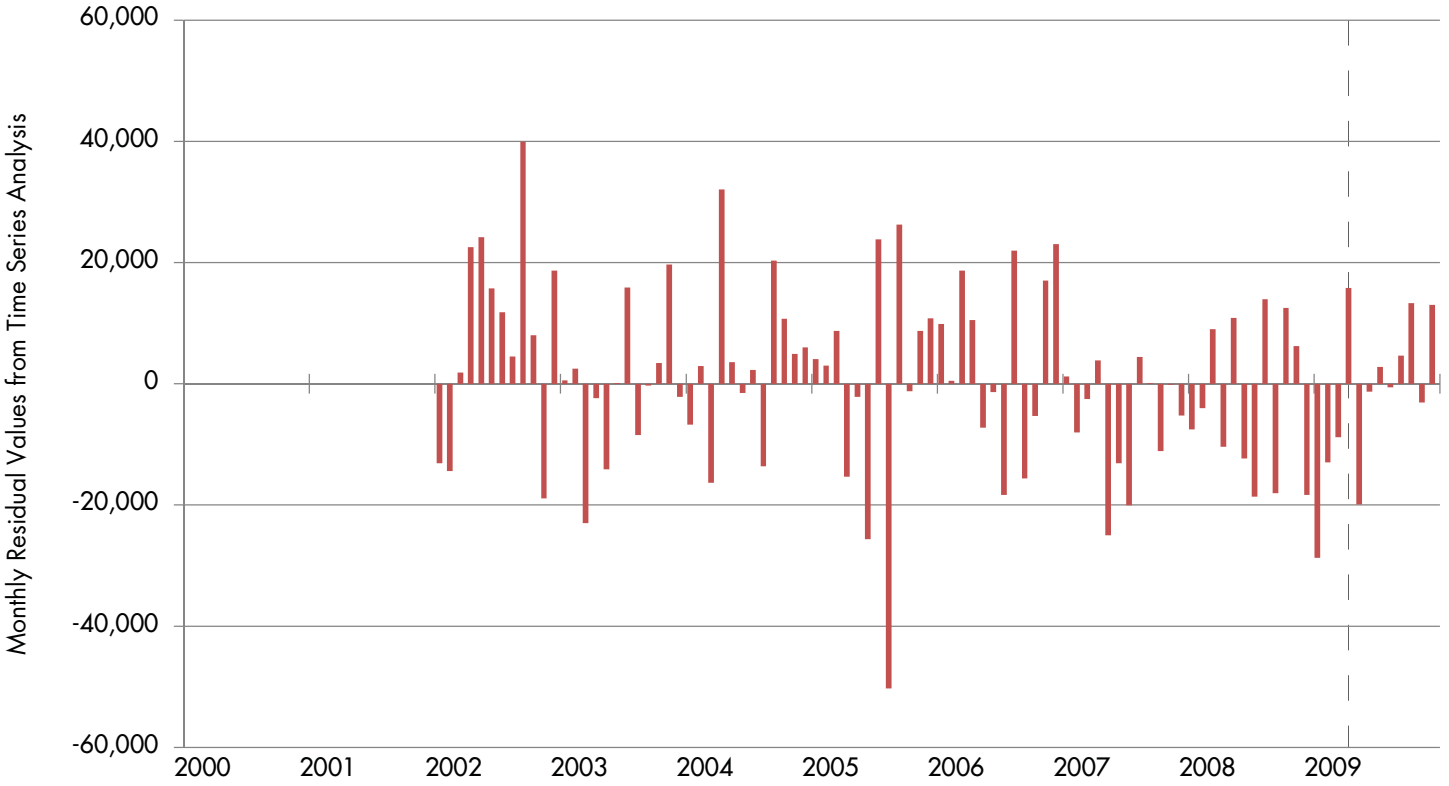
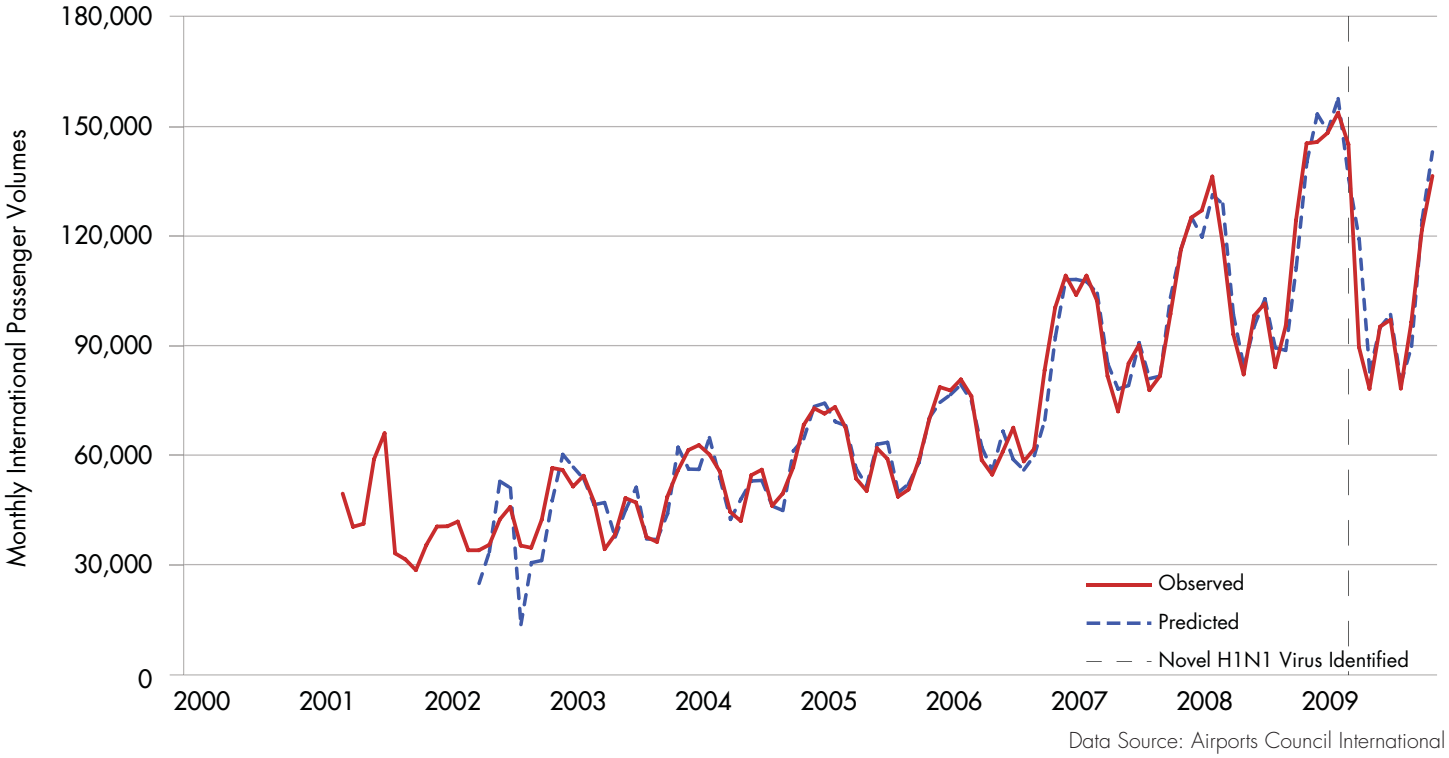


Exhibit 15: International Passenger Arrivals plus Departures in Edmonton, 2001-2009

A Comparison of Observed versus Predicted Traffic Flows



Data Source: Airports Council International

Deviation between Observed and Predicted Flows of International Passenger Traffic in Edmonton, 2002-2009

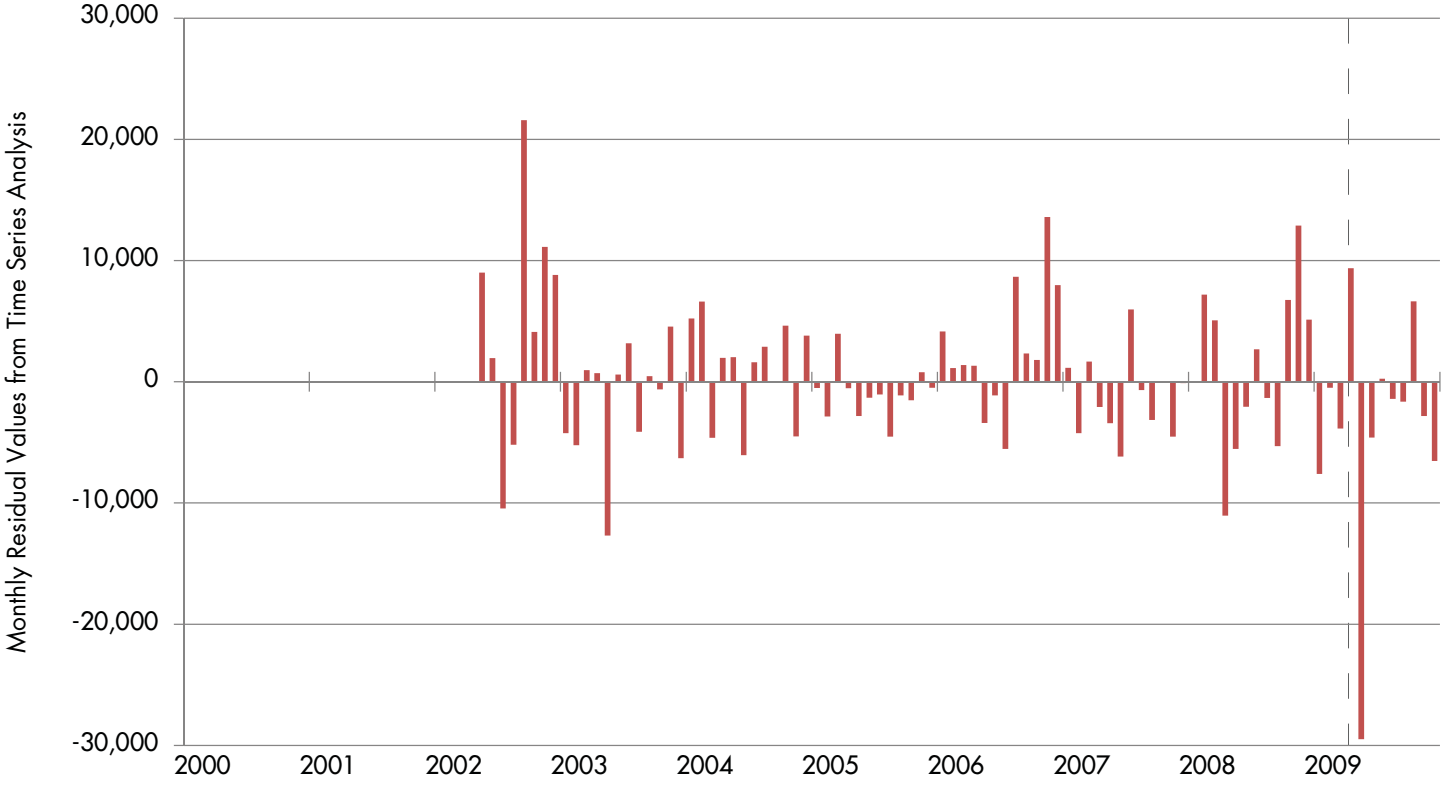
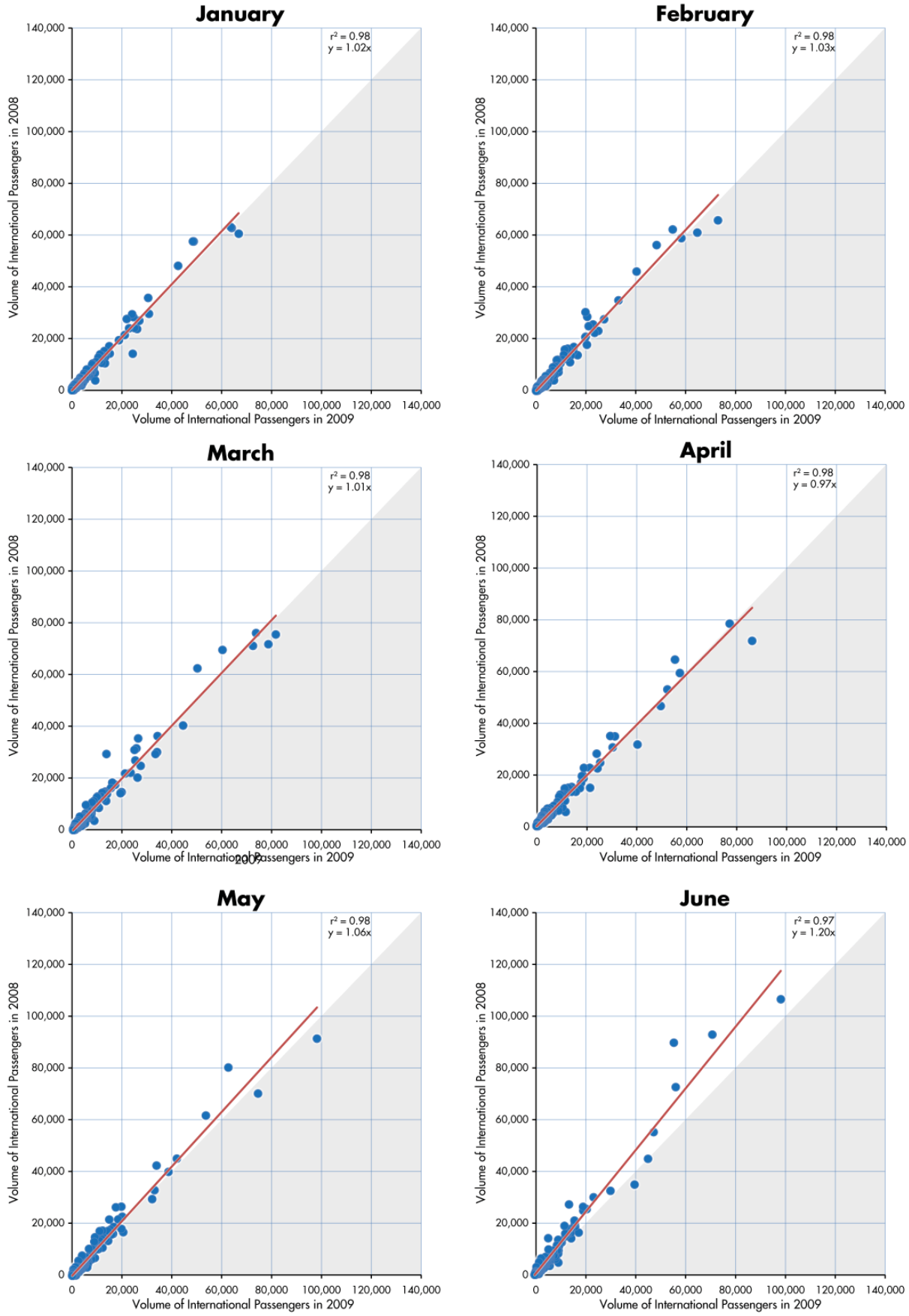
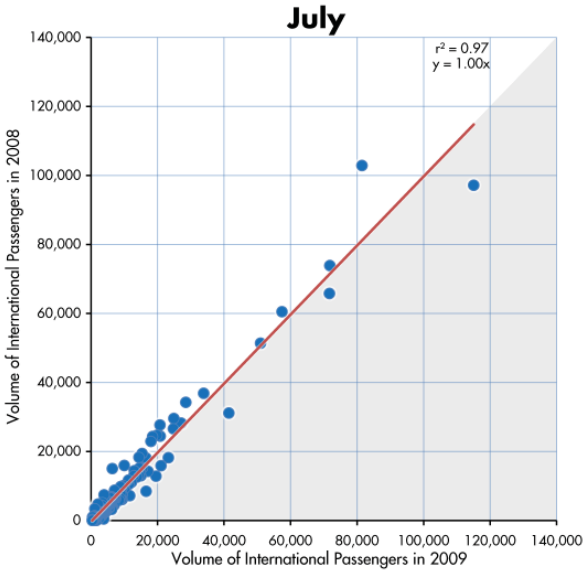
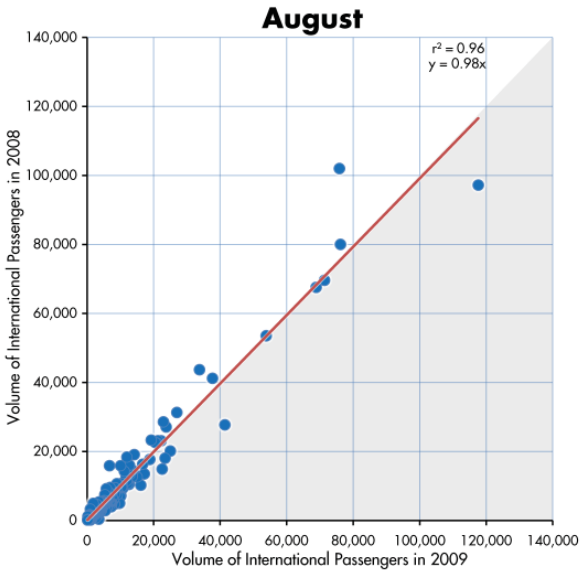


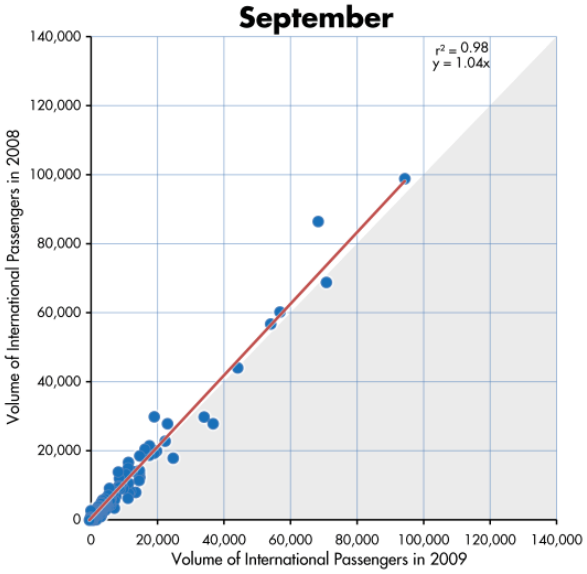
Exhibit 16: Worldwide International Passenger Departures into Canada by Month in 2008 & 2009

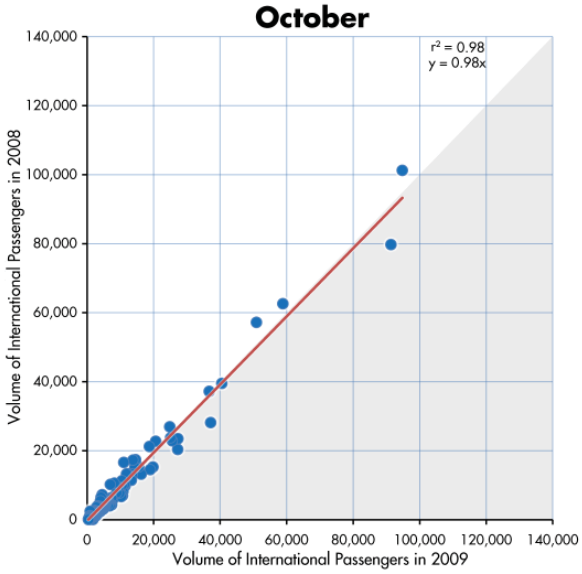


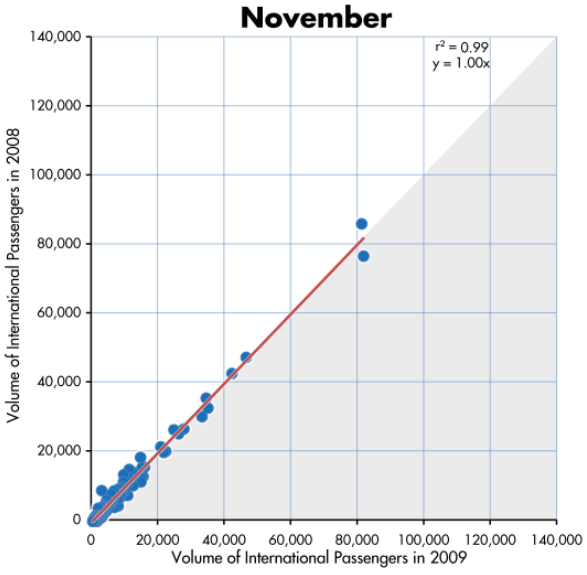
Data Source: International Air Transport Association (IATA)

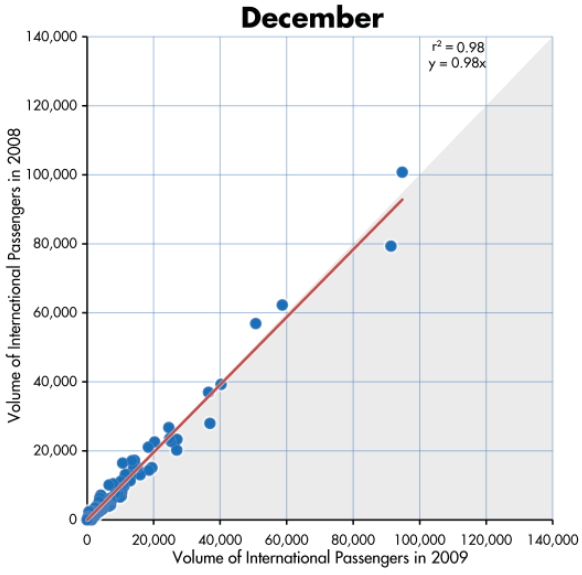










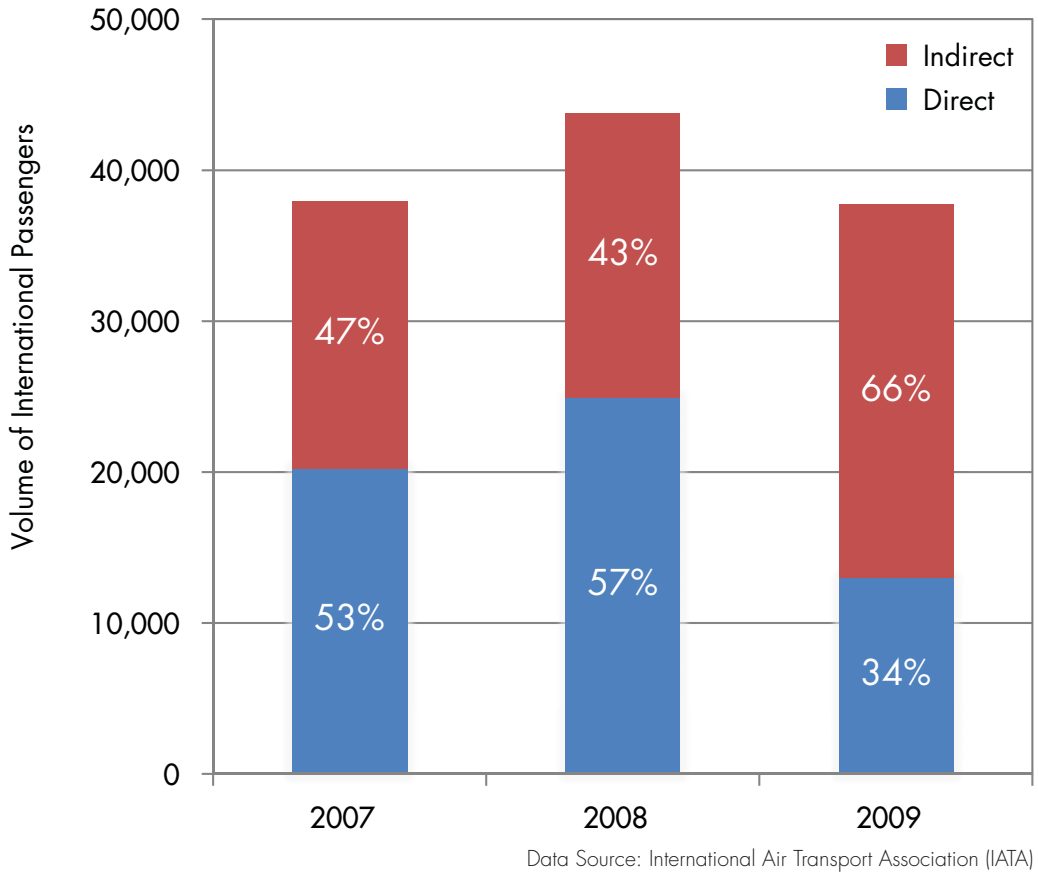


Data Source: International Air Transport Association (IATA)

3. Some airlines temporarily cancelled international flights between Mexico and Canada during the early stages of the H1N1 pandemic. Did this interruption in air travel hinder population mobility between the two countries and if so, could it have delayed the spread of H1N1? Or did travellers simply bypass these cancelled flight routes to reach their intended destinations?

Although flight restrictions are rarely contemplated by public health agencies today, discussions about their potential to disrupt or delay the spread of infectious diseases have arisen in the past. We took the opportunity to evaluate whether temporary flight cancellations between Mexico and Canada by some commercial airlines during the early stages of the H1N1 pandemic might have diminished international passenger traffic between the two countries. We assessed this by comparing the volumes and travel routes of passengers departing Mexico for Canada in May 2007, May 2008, and May 2009. In doing so, we observed a modest decrease in the number of passengers travelling from Mexico to Canada in May 2009 relative to May 2008, however the magnitude of this decrease was consistent with declines observed from the 2009 global economic downturn. We did however see a significant rise in the proportion of passengers that used connecting flights to enter Canada in May 2009 (66%) compared with May 2008 (43%) and May 2007 (47%) (see Exhibit 17). These findings suggest, but do not prove, that travellers in Mexico may have bypassed these cancelled flight

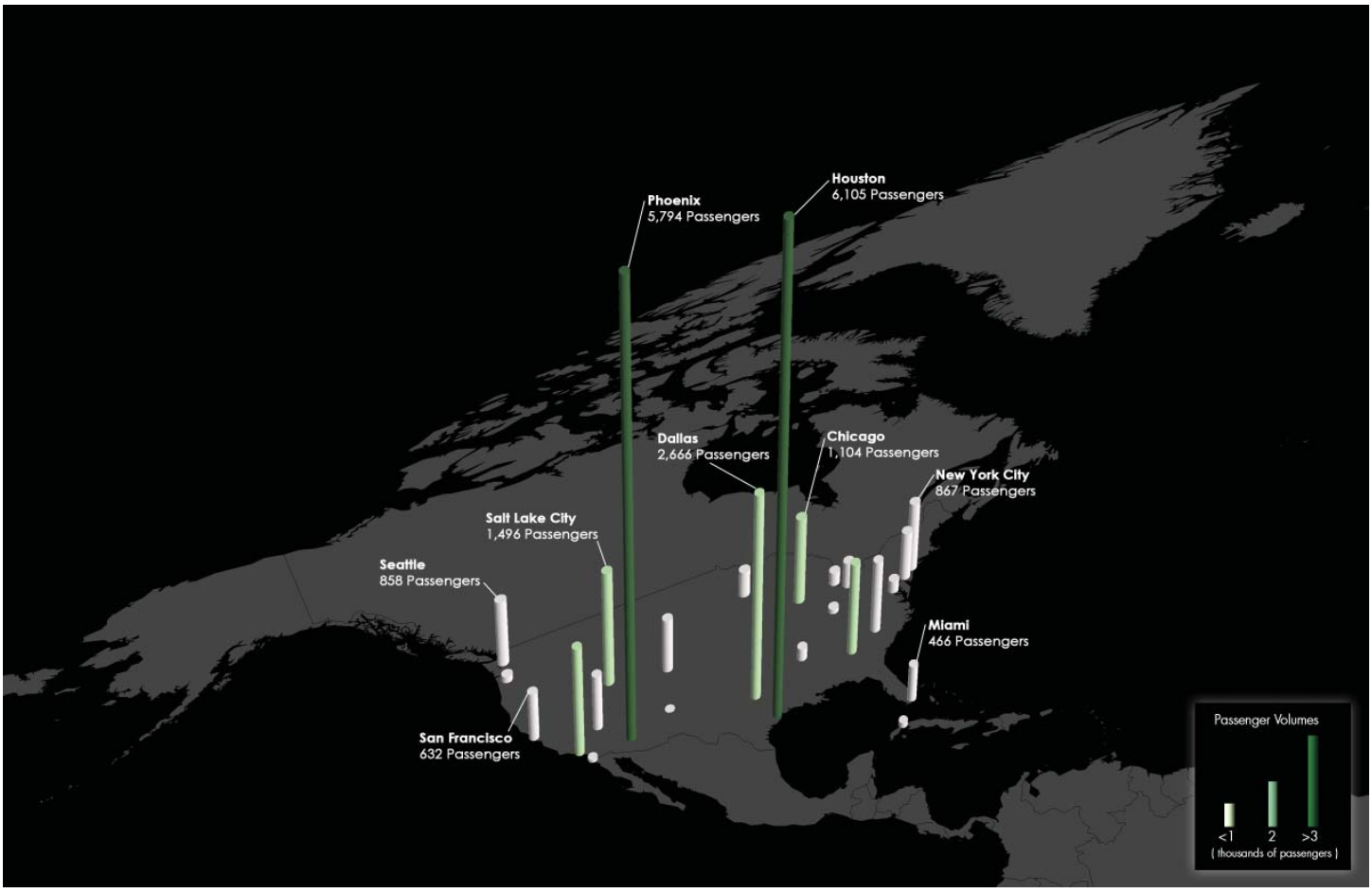
Exhibit 17: Travel Routes used by International Passengers Departing Mexico for Final Destinations in Canada, May 2007, 2008 & 2009



Data Source: International Air Transport Association (IATA)

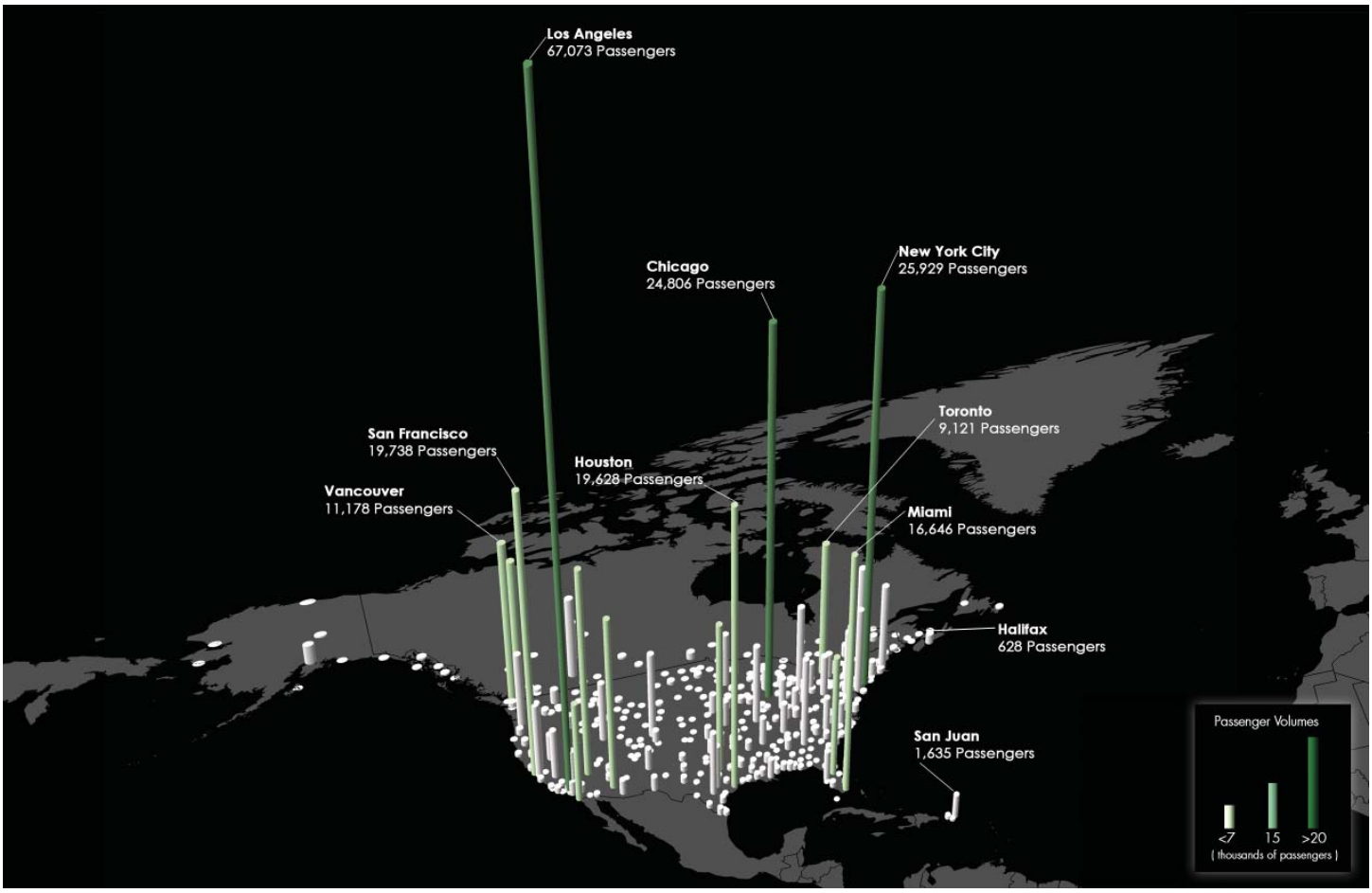
routes and used connecting flights to reach their intended destinations in Canada. The international locations where travellers departing Mexico most frequently made flight connections en route to Canada (see Exhibit 18) and the final destinations of those travellers in Canada (and the United States) are shown (see Exhibit 19).

Exhibit 18: Leading Cities for Connecting Flights by International Passengers Travelling from Mexico to Canada, May 2009



Data Source: International Air Transport Association (IATA)

Exhibit 19: Final Destinations of International Passengers Travelling from Mexico to Canada and the United States, May 2009



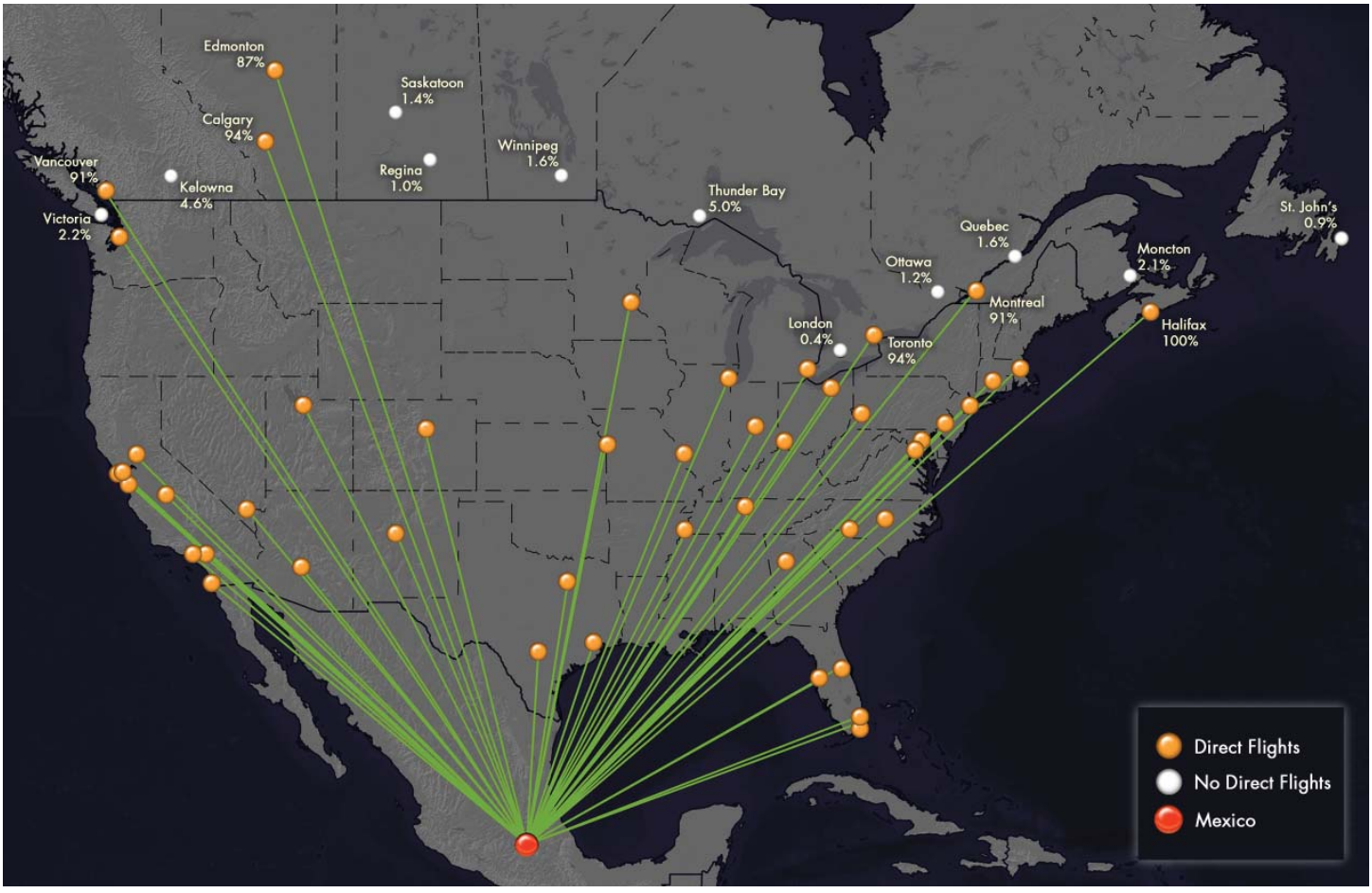
Data Source: International Air Transport Association (IATA)

4. During infectious disease emergencies, public health decision-makers often face pressure to implement airport-based screening measures such as infrared thermography scanning to prevent disease importation. How efficient or inefficient would these measures have been if they were implemented in Canada during the early stages of the H1N1 epidemic?

The use of airport-based screening measures such as infrared thermography scanning of passengers has been used in past epidemics,[15-18] was employed by several countries during the H1N1 pandemic,[19-21] and continues to be used routinely in selected airports today. When the efficiency of airport-based screening has been evaluated in the past, it has generally been deemed inefficient, particularly if all international passengers arriving into an airport were screened regardless of their geographic point of origin.[22,23] In this report, we assessed the maximum potential efficiency of airport-based, entry screening of travellers arriving in Canadian cities in response to the H1N1 pandemic. We defined maximum potential efficiency as the proportion of travellers arriving into Canadian airports who originated their trip from an H1N1 affected area (i.e. defined as the country of Mexico in this analysis). Where direct flights connect cities between Mexico and Canada the efficiency of entry screening may be increased through targeted screening of specific flights.

We find the maximum potential efficiency of entry screening travellers arriving in Canadian cities without direct flight connections with the country of Mexico to be extremely limited (i.e. maximal efficiency of less than 5%). This is because all international arriving travellers must be screened regardless of their geographic point of origin. By contrast, the maximum potential efficiency of entry screening travellers would significantly increase if specific flights originating from within Mexico are targeted (i.e. maximal efficiency exceeds 85%; see Exhibit 20). It is important to recognize however that these values do not take into consideration the prevalence of H1N1 infection in the travelling population. If the prevalence of H1N1 infection in travellers is sufficiently low (or if the prevalence of other febrile illnesses in travellers is high), even targeted entry screening of travellers from affected areas could become inefficient.

Exhibit 20: Flight Pathways from Mexico into Canadian and U.S. Cities and the Potential Efficiency of Entry Screening, May 2009



Data Source: International Air Transport Association (IATA), and the Official Airline Guide

5. Well into the course of the H1N1 pandemic, Canada hosted the 2010 Winter Olympic Games in Vancouver. While mass gatherings have been known to attract, amplify, and subsequently disseminate infectious diseases around the world, this was not observed with H1N1 during the 2010 Olympic Games. However, could knowledge of global air traffic patterns help mitigate infectious disease risks associated with future mass gatherings?

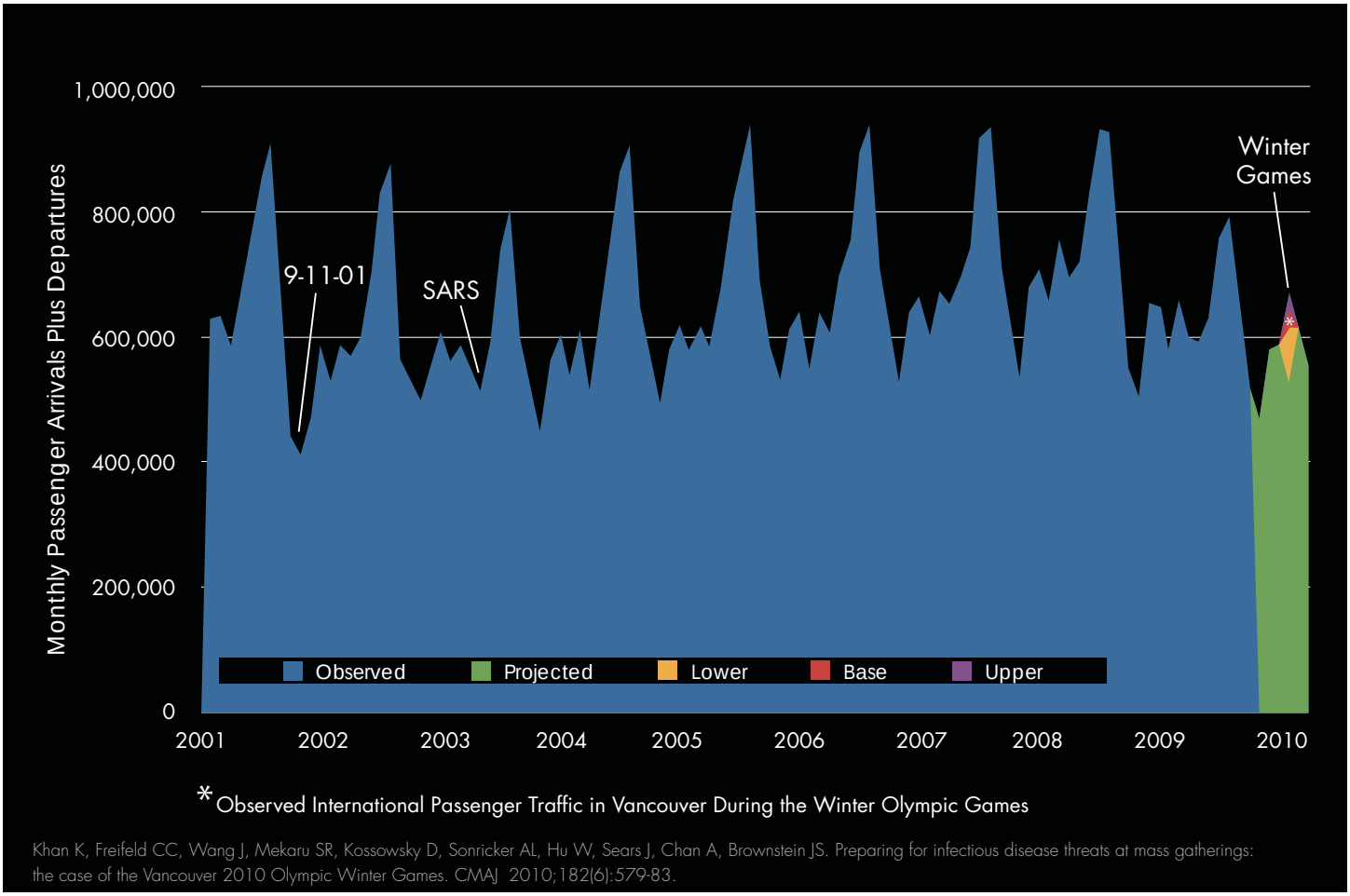
In February 2010, Canada hosted the international community in Vancouver for the Winter Olympic Games. Although the H1N1 epidemic had peaked in the northern hemisphere and pandemic H1N1 vaccine was widely available in industrialized countries, questions were still raised about the potential public health risks associated with this mass gathering during the midst of an influenza pandemic. A few months earlier in November 2009, when pandemic H1N1 vaccine was just becoming available to select populations in the world's most prosperous countries, an estimated 2.5 million pilgrims – most originating from low and middle income countries – congregated in Saudi Arabia for the annual Hajj pilgrimage.[24] Despite the significant potential for this mass gathering to amplify and accelerate the global evolution of the H1N1 pandemic, careful planning and preparations minimized the public health impact of this congregation.[24] Similarly, the Winter Olympic Games in Vancouver proceeded uneventfully from the perspective of the H1N1 pandemic.

Looking to the future, new infectious diseases are emerging faster today than at any other time in human history, while mass gatherings – facilitated by expanding international access to commercial air travel – are increasing in global scale and frequency over time. Hence, the potential for these two events to intersect may be increasing with time. As a frequent host of mass gatherings such as the Olympic Games, the Group of 20 (G20) Summits, the Pan American Games, and World Pride to name a few, we present a model that complements existing efforts to mitigate infectious disease risks associated with mass gatherings. By integrating knowledge of how global populations are expected to travel into the site(s) of a mass gathering with global epidemic intelligence from Internet-based (and/or traditional) infectious disease surveillance systems, this model aims to heighten global situational awareness of infectious disease threats and consequently expand opportunities to confront threats globally before they present at mass gatherings.

Herein, we present the 2010 Winter Olympic Games as a case study.[25] First, we analyzed global air traffic patterns during the Winter Olympic Games in Salt Lake City, USA (2002) and Torino, Italy (2006) and compared these findings with global air traffic patterns in the same cities in adjacent years. These retrospective analyses offered insights into the potential surge in travellers expected during the 2010 Winter Olympic Games (see Exhibit 21). We subsequently analyzed the global origins of all travellers arriving into the city of Vancouver in the month of February 2008 (we did not have access to data from February 2009 at the time this analysis was performed). These analyses helped create a picture of where international travellers arriving into Vancouver would be originating from in February 2010. This knowledge was then used to intensify Internet-based infectious disease surveillance in specific areas of the world where travellers would be expected to travel to Vancouver in their greatest numbers (see Exhibit 22). Integrating knowledge of global population mobility via commercial air travel with global infectious disease surveillance could offer public health decision-makers and planners of mass

gatherings with better situational awareness of global infectious disease activity temporally coinciding with mass gatherings. While this case study pertains to a mass gathering hosted within Canada, the principles described here could easily be transferred to mass gatherings hosted anywhere in the world.

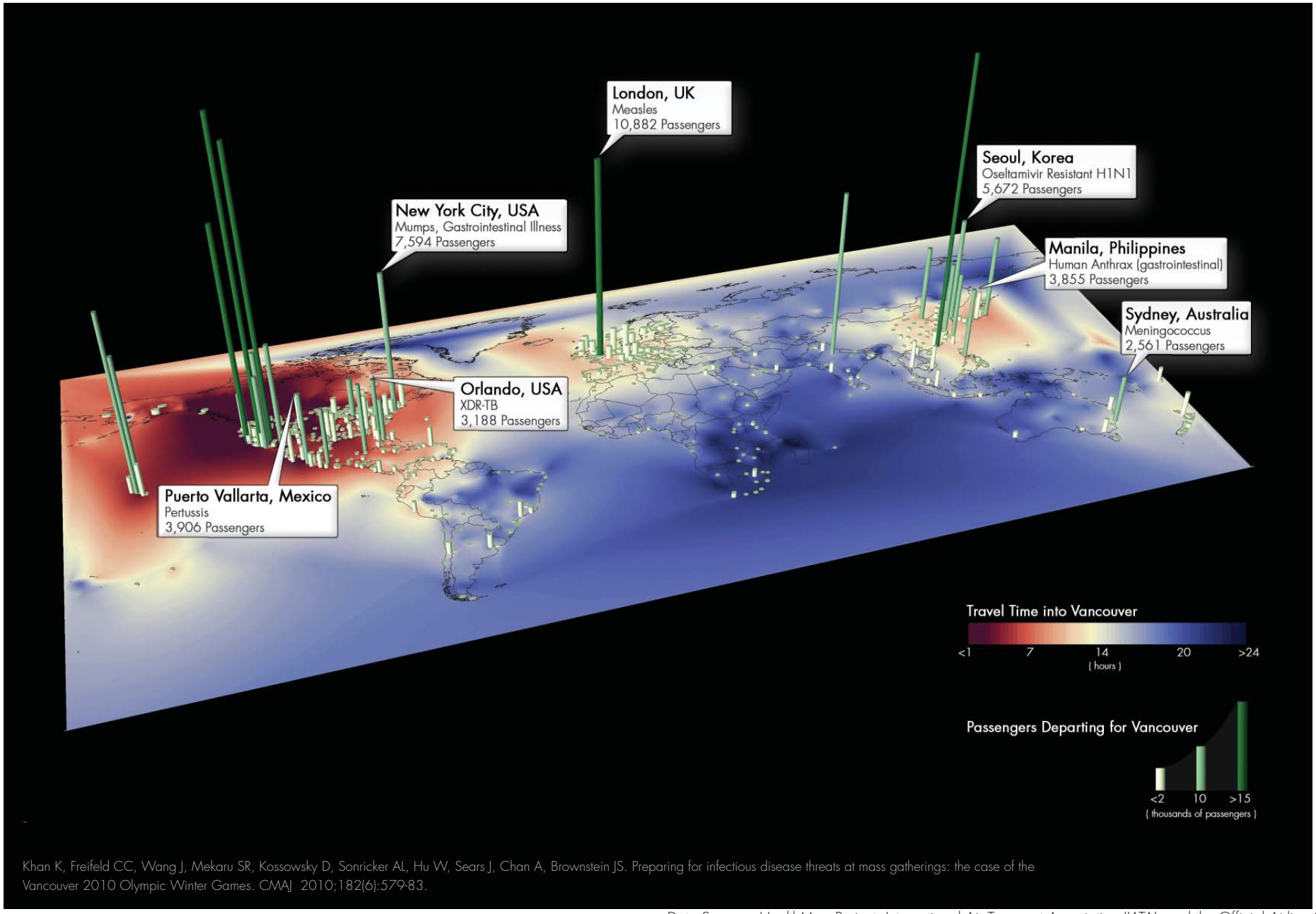
Exhibit 21: Predicting International Passenger Traffic Coinciding with the 2010 Winter Olympic Games in Vancouver



Khan K, Freifeld CC, Wang J, Mekaru SR, Kossowsky D, Sonricker AL, Hu W, Sears J, Chan A, Brownstein JS. Preparing for infectious disease threats at mass gatherings: the case of the Vancouver 2010 Olympic Winter Games. CMAJ 2010;182(6):579-83.

Data Source: Airports Council International

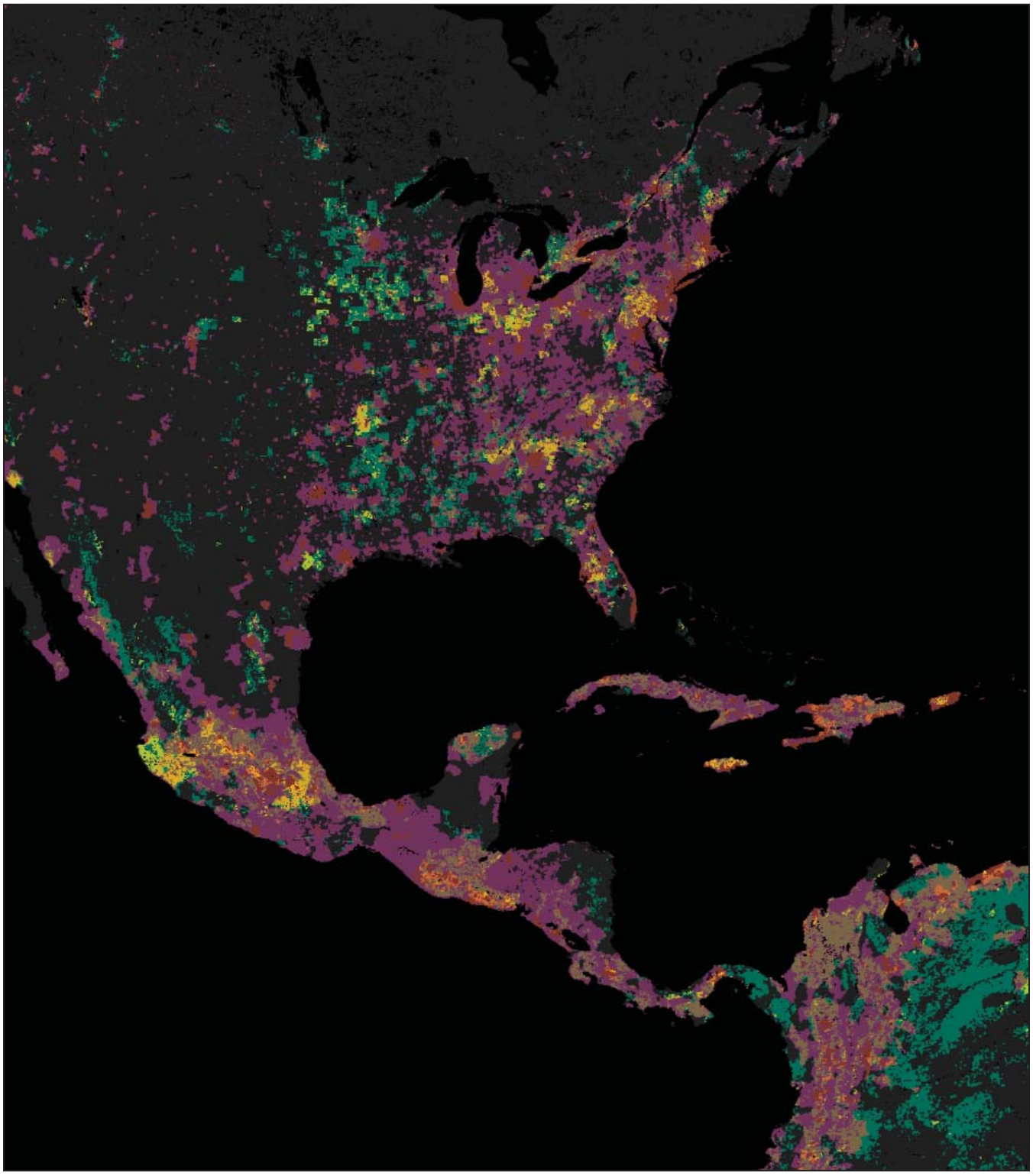
Exhibit 22: Potential Infectious Disease Threats to Vancouver during the 2010 Winter Olympic Games in Vancouver



Khan K, Freifeld CC, Wang J, Mekaru SR, Kossowsky D, Sonricker AL, Hu W, Sears J, Chan A, Brownstein JS. Preparing for infectious disease threats at mass gatherings: the case of the Vancouver 2010 Olympic Winter Games. CMAJ 2010;182(6):579-83.

Data Sources: HealthMap Project, International Air Transport Association (IATA), and the Official Airline Guide

SYNTHESIS & INTERPRETATION



During the initial stages of a suspected or confirmed infectious disease epidemic, the travel behaviours of populations within affected areas may be influenced by news of the threat. If populations perceive a serious and imminent risk, they may leave affected areas in an accelerated fashion. Information about the nature of the epidemic threat could come from official government statements including recommendations about travel, reporting by mass media, and/or communication through social networks. In the case of the H1N1 epidemic threat in late April, there were anecdotal reports of international travellers departing Mexico en masse. Our analysis however does not offer evidence to support this supposition. We find that international passenger arrivals and departures both dropped in parallel in the month of May, shortly after governments issued travel alerts for Mexico and as online media reporting about the H1N1 threat was peaking. Furthermore, given the large number of Canadian travellers who vacation in Mexico in the spring, we conducted an analysis but did not find evidence of a significant surge in travel from Mexican resort cities to destinations in Canada. While this experience may not be transferable to all infectious disease threats of international concern, there does not appear to be evidence of a "mass scattering" of travellers out of Mexico in response to news of the H1N1 epidemic threat.

Although international air travel in Mexico was strongly impacted by the H1N1 epidemic, there was little evidence of disruption in air travel across Canada's major cities. Flows of commercial air traffic in Canada's major cities continued largely as anticipated throughout the course of the 2009 calendar year. One notable exception was Edmonton, which experienced a modest short-term decline in international air traffic immediately after the H1N1 threat was recognized. Furthermore, given that the United States and Canada were among the most heavily affected countries during the early stages of the H1N1 pandemic, we sought to determine if international air traffic arriving into Canada was affected. Our analysis identified only modest declines in the months of May and June, with a subsequent return to baseline levels throughout the 2009 calendar year. These findings suggest that outside of the immediate infectious disease epicentre, international travel, trade, and commerce may be able to continue relatively unaffected over the course of an international infectious disease epidemic or pandemic of mild-moderate severity.

While outright travel restrictions are generally not considered a viable public health strategy in response to infectious disease epidemics, airport-based screening of travellers were used by a number of countries during the course of the H1N1 pandemic. We found evidence to support the notion that travel restrictions are likely to be of limited value within a complex transportation network where travellers have a plethora of travel routes and options to choose from. Specifically, we found that travellers were likely "going around" cancelled flight paths between Canada and Mexico during the early stages of the H1N1 pandemic. With respect to airport-based screening of travellers, we found evidence to suggest that this strategy would be highly inefficient if the screening airport does not receive direct flights from affected areas. This is because, in the absence of a direct flight connection, all international passenger arrivals would have to be screened to detect infected travellers originating from affected areas. Given the amount of population mixing that occurs at connecting airports, populations at risk of infection become highly diluted, resulting in a substantial loss in screening efficiency. While airport-based screening of travellers would be more efficient

if screening could be directed at flights arriving directly from affected areas, a number of other factors should be considered when assessing the potential public health value of screening. These include but are not limited to (i) the estimated prevalence of infection and disease in the travelling population, (ii) whether effective exit screening of travellers with disease is occurring at the point of departure, (iii) the incubation period of the infectious agent under consideration, (iv) the flight time between the points of departure and destination, and (v) the potential opportunity costs of screening. The findings in this report do not outright support or reject airport-based screening of travellers as a public health control strategy, but rather rely on the observed H1N1 pandemic experience to shed light on conditions and circumstances where the value of screening in future infectious disease epidemics would likely be limited.

Expanding global access to commercial air travel is enabling the world's population to participate in mass gatherings like never before. These congregations, which frequently involve millions and sometimes tens of millions of participants from all across the globe, offer tremendous benefits to humankind. However, they have the potential attract, local amplify, and subsequently disseminate infectious diseases in the host nation and around the world via travelling populations. Canada frequently hosts mass gatherings of sporting competitions, economic summits, socially or politically motivated congregations, among others. In this report we present a model aimed at refining existing efforts to prepare for infectious disease threats at future mass gatherings hosted in Canada or elsewhere in the world. By intensifying infectious disease surveillance in targeted areas of the world where populations are expected to travel to the host city (or cities) in large numbers at the time of the gathering, this model may help create new opportunities to detect and respond to high-risk global infectious disease threats at their international origins, before they present themselves at mass gatherings. In this regard, the research produced by our scientific team could potentially enhance the surveillance activities of the Global Public Health Intelligence Network (GPHIN) at the Public Health Agency of Canada.

The science behind global population mobility and its relationship with emerging infectious diseases continues to evolve. This report capitalizes on the unique opportunity to carefully study global patterns of commercial air traffic during the midst of the H1N1 influenza pandemic and contemplate their public health implications to Canada and the global community. We hope that the knowledge gained will assist Canadian efforts to more effectively and efficiently prepare for and respond to inevitable global infectious threats of the future.

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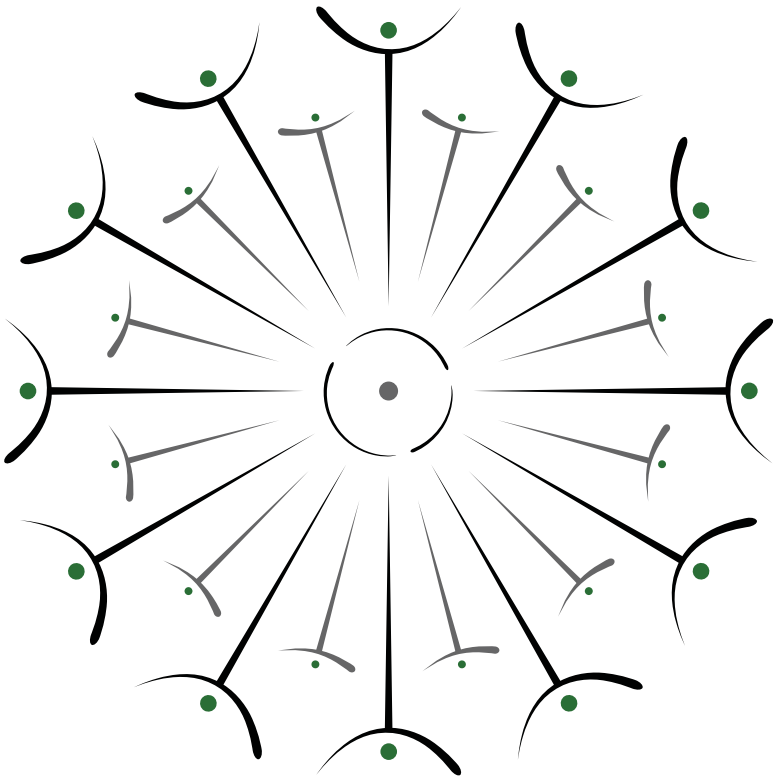

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