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Pandemics and Urban Travel – Lessons for COVID-19 from the 1918-1920 Spanish Flu

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Abstract

This paper contrasts the Spanish Flu and COVID-19 pandemics and how they impacted travel in Australian/United States cities to identify lessons learned. The paper focusses on public transport ridership impacts and explores infection rates, health and transport policy responses in both countries.

The Spanish Flu (1918-1920) infected more people (broadly a third of the world's population) and was substantially larger than COVID-19 (up to June 2021). In the US, a 2.5 times larger population share was infected by the Spanish Flu compared to COVID-19, while in Australia this ratio is over 300 times. Australian infection and mortality rates for both pandemics were substantially lower than the United States. For the Spanish Flu, this appears to result from a later arrival date of infection, during a less aggressive wave. For COVID-19 to June 2021 (and before the Delta Variant), Australia has been independently assessed to have had a more effective health policy response based on a 'Crush and Contain' strategy, tight lockdowns, stay at home orders and a much higher public trust in, and adherence to, government responses. Australian and US approaches to mitigation of the Spanish Flu were broadly similar though neither were successful at containing the pandemic. Australia may have had a more successful border quarantine system than the US, though it was still not very effective.

Substantial differences in public transport ridership trends have been found between the two pandemics. COVID-19 reduced ridership in both Australia and the US to around 30% of pre-pandemic levels. Impacts of the Spanish Flu involve much smaller declines in ridership in selected years of the pandemic in the United States and some growth in ridership. Virtually no ridership declines were found at all in Australia during the Spanish Flu as ridership on public transport instead increased during the pandemic. Lessons for transport and health policy are also identified, as are areas for future research.

1. Introduction

The COVID-19 pandemic has generated the largest and most widespread shifts in urban travel in recent contemporary history. Enforced population lockdowns and social distancing rules have reduced urban public transport ridership by more than 80% in London (UK) and Sydney (Australia) and over 60% in Phoenix (USA). Driving a car and walking reduced by more than 80% in Pune (India), and by more than 60% in London, Sydney and Phoenix (Praharaj et al., 2020). The scale of the pandemic has created much uncertainty in the planning of transport in cities and a great deal of anxiety about the future of transport and activity in cities.

It is often forgotten that COVID-19 (to June 2021) is not the largest global pandemic ; it is a relatively small event compared to the 1918-1920 Spanish Flu. The World Health Organisation (June 2021) reports 181M cases and 3.9M deaths related to COVID-19 (World Health

Organisation, 2021). This means that about 2.3% of the world population has been affected[1]. In contrast, the Spanish Flu pandemic of 1918-1920 is estimated to have infected over 500M people or one third of the world's population (Centre for Disease Control, 2021) and caused between 50-100M deaths (Efron and Efron, 2020).

This raises the question; **is there anything we can learn from how the Spanish Flu pandemic affected travel in cities to inform our response to the COVID-19 pandemic?** This research paper explores how the Spanish Flu pandemic of 1918-1920 affected urban travel. It has a focus on public transport use in Australian and United States cities[2], although some evidence comes from wider geographic regions. It explores how the response to the two pandemics varied and how this affected public transport travel, with a view to identifying lessons that might be learned for managing urban travel and the COVID-19 pandemic.

The paper is structured as follows; the next section sets explores and contrasting the two pandemics in Australian and the United States. This includes a review of pandemic policy responses in both cases. A review of the impacts of the pandemics on urban travel is then outlined in Section 3. The method exploring travel impacts is then described in Section 4, followed by results in Section 5. The paper ends discussing key findings and their implications for policy and research futures.

2. Pandemics in Context

2.1. The COVID-19 Pandemic

COVID-19 was detected in Wuhan, China in December 2019 (Page et al., 2021). The first Australian case was 25th January 2020 (Australian Government Department of Health, 2020). Over 30,000 confirmed cases were reported nationally by June 2021 with the majority of these being in Victoria (20,718 cases to July 6, 20201). At the time of writing (June 2021), 907 deaths were reported nationally, with a fatality rate of 2.96% (Ting et al., 2020).

Australian policy for the management of the pandemic emphasized suppression rather than elimination, aiming to drive down community transmission but expecting that new outbreaks would occur (Osborne, 2020). There have generally been high levels of public trust in governmental responses, with key features of the Australian policies being early limitation on transmission from other countries through border closures, contact tracing and the use of apps to monitor contact activity, and short but intensive lockdowns including closure of all schools, workplaces and outdoor activities)(Wikipedia, 2021a).

A global COVID-19 policy response index rates Australia at 81.4 out of 100 (for March 15th 2021, FP Analytics, 2021) which is 5th ranked in the world and in the top quartile of the most successful out of 36 major countries. The same index rates the United States at 19.9 out of 100, putting it in the lowest quartile.

COVID-19 was first reported in the US on January 20th 2020 (Holshue et al., 2020). Policy responses to the pandemic were enacted only slowly, were not well coordinated and resulted in very varied responses in different jurisdictions (Wikipedia, 2021b). Mandatory stay at home orders were issued in only 36 states (72%), face coverings became mandatory in public places in only 25 states (50%) and large gatherings were banned in all states, but out of state travel was banned in only 13 states (26%). All states closed schools at some point, while most also closed daycares, bars and restaurants. To June 2021, the US had 34.5M cases or 103,754/M population representing 10.3% of the population. This compares to 30,611 cases or 1,187/M

[1] Using a world population of 7.875B WORLDOMETER. 2021. *World Population projects* [Online]. Available: https://www.worldometers.info/world-population/world-population-projections/ [Accessed 30-06-2021.

[2] This paper is developed from an undergraduate student research project ; XU, Y. & CURRIE, G. 2021. Urban Transport Impacts of the 1918-1920 Spanish Flu Academic - Lessons for COVID-19 Department of Civil Engineering, Monash University.

residents in Australia, representing just 0.1 % of the population (1 July 2021, Worldometer, 2021). Australia has had 910 confirmed COVID-19 related deaths representing 35/M residents, while the United States has had 620,22 deaths or 1,863 deaths/M population (Worldometer, 2021).

In a review of global approaches to ending the COVID-19 pandemic Boston Consulting Group (2021) in mid 2021 (pre Delta strain) identified the following progressions:

- 'Continuation' – where the "curve was never quite flattened";
- 'Crush and contain' – where new infections have continued to stay low because community transmissions were largely contained after the initial first wave; and
- 'Resurgence' – where the curve was initially flattened as in the 'crush and contain' progression, but one or more resurgences have led to continued community infections.

Boston Consulting Group (2021) identifies the epidemic progression of COVID-19 in the United States as being of the 'Continuation' pattern, representing on ongoing battle where the curve is never quite flattened. As a result, longer-term mitigation of the pandemic is heavily reliant on vaccination, and the USA has been called a vaccine 'Rollout Leader', alongside the UK, Israel and Chile. In contrast, Australia is considered to be amongst the 'Crush and Contain' countries, meaning that the virus has been contained and a more conservative approach to vaccine rollout is being adopted.

2.2. The Spanish Flu Pandemic

Sometimes termed the '1918 influenza pandemic' or the 'Spanish Flu', this pandemic was caused by the H1N1 influenza A virus and lasted from February 1918 to April 1920 (Crosby, 2003). Despite its name, the flu did not start in Spain but in Kansas in the US at an army training camp where troops were preparing to join the First World War (Taubenberger and Morens, 2006). It quickly transitioned to Europe and then on to the rest of the world. Four waves of the 1918 pandemic are commonly identified in the literature:

1. Early 1918 – a relatively mild wave starting in Kansas, spreading to other US training camps and then on to the European ports of arrival for the troops;
2. Late 1918 – a deadlier wave that spread from Boston to overseas ports, with New York seeing its first fatality in September 15th. The United States as a whole reported 292,000 deaths from all causes between Sept-December 1918, compared to just 26,000 during the same period in 1915 (United States Census Bureau, 1920).
3. January 1919 – during which time the pandemic spread to Australia, where it killed 12,000 people. This wave also affected Spain, Serbia, Mexico and Great Britain. In the United States this wave was considered less severe, but isolated outbreaks were seen in Los Angeles, New York City, Memphis, Nashville, San Francisco and St Louis (Vaughan, 2018). US mortality rates were in the 10s of thousands in the first months of 1919 compared to the 292,000 in the last 4 months of wave 2.
4. In the northern hemisphere Spring of 1920 a fourth wave occurred in isolated areas of New York City, Switzerland, Scandinavia and South America. New York reported 6,374 deaths between Dec 1919 and April 1920.

Overall the Spanish Flu is estimated to have killed 675,00 Americans (Centers for Disease Control and Prevention, 2021) with 25% of the US population being infected. Impacts were less severe in Australia, because it did not arrive until the beginning of 1919 and was finished by the end of 1919 (Curson and McCracken, 2006). The first cases were found in Melbourne on the 9th and 10th of January 1919, but were so mild that a delayed policy response led to the infection spreading to New South Wales and South Australia by the end of January 1919. Total

Australian deaths are reported as 15,000[3], representing 2.7 deaths per 1,000 residents (or 2,700/M) and being one of the lowest in the world (National Museum of Australia, 2021), despite a third of Australians being infected (Hobbins, 2019).

Our understanding of policy responses to the Spanish Flu is limited by a lack of historical detail and the need to rely on only a few available sources. However, it seems clear from these reports that authorities in US were not prepared for the Spanish Flu pandemic (Human Virology at Stanford, 2021). A common view at that time was that the pathogens were transmitted through air and that it could be stopped by limiting the number of people in any particular space. It was also believed that good ventilation and providing 'fresh air' would be "the best of all general measures for prevention, and this implies the avoidance of crowded meetings" (British Medical Journal, 1918). Restrictions on large public gatherings were enacted, including the closure of public institutions, but it appears the closure of schools was not widely adopted in the United States (Human Virology at Stanford, 2021). Medical research on these historical responses has suggested that measures that limited activity were effective in reducing inflection in the U.S. (Hatchett et al., 2007), but strict interventions were rare. Some research suggests measures were either implemented too early or for too short a period of time (Bootsma and Ferguson, 2007). There was a lack of border quarantine measures and, because of the First World War, a prerogative to maintain international travel for troops.

The first major policy responses to the Spanish Flu in Australia were in late January 1919, when mandatory wearing of masks was introduced in Sydney. Public buildings, including schools, were closed. There were also restrictions on interstate travel to and from NSW (Kildea, 2020). These proved successful and restrictions were withdrawn within a month as infection rates declined. Unfortunately, mid-March the number of new cases began to rise again, leading to restrictions being re-imposed in April. It appears that after this the NSW Government abandoned its attempts to manage the pandemic, and instead let it run its course (Kildea, 2020). Approaches in other Australian states were varied and uncoordinated, but generally followed similar patterns to NSW. There was also a lack of Federal involvement in managing the pandemic; states seem to have been left to sort out their policy on their own. Many incoming ships were quarantined, but the regulations were not seriously adopted by all in the maritime community and there were several instances of troops breaking quarantine. The poor policy response at the national level may have been partly due to the relatively recent formation of Australia as a Federation in 1901, but it appears to have helped inspire better national coordination into the 1920s (McQueen, 1976).

Overall Australian and US policy responses were similar. The biggest difference appears to be that the Spanish Flu arrived later in Australia than elsewhere, by which time it was not as virulent or lethal.

2.3. Pandemics in Synthesis

Table 1 presents a synthesis of how the Spanish Flu and COVID-19 impacted Australia and the United States, including a summary of policy responses and outcomes, and categorization of the policies against the 'Continuation' and 'Crush and contain' approaches identified by Boston Consulting Group (2021). Australian/US Spanish Flu policies are seen as 'Continuation' strategies as the virus is not contained with high infection rates (25%/33%). For COVID-19, lower infection/mortality rates in Australia, are associated with the 'Crush and Contain' strategy, with strong lockdowns, face covering mandates and stay at home orders. This was all up to June 2021 before the Delta strain of the virus emerged.

[3] Note there is confusion over how many deaths resulted from the Spanish Flu in Australia; one source suggests 12,000, another 15,000.

Table 1: Synthesis of COVID-19 and Spanish Flu – Infection and Mortality Rates; Policy Responses

Data	COVID-19		Spanish Flu	
	USA	Australia	USA	Australia
INFECTION AND MORTALITY RATES				
Dates	Jan 2020-June 2021	Jan 2020- June 2021	Feb 1918-Apr 1920	Jan 1919-Dec 1919
Cases	34,540,845	30,611	26,125,000[2]	1,750,000[1]
Deaths	620,249	910	675,000	12-15,000
Cases/Million	103,747	1,187	250,000[2]	330,000[1]
Deaths/Million	1,863	35	6,459[2]	~2,700
% Population Infected	10.3%	0.1%	25%	33%
HEALTH POLICY MITIGATION RESPONSES				
'Crush and Contain'	-	***	-	-
'Continuation' (Not Contained)	***	-	**	**
Vaccination Based	***	*	*	*
Lockdowns	*	***	*	*
Stay at Home Orders	**	***	-	-
Mandatory Face Coverings	*	***	*	*
Border Controls	*	***	*	**
Public Trust in Government	Low	High	Unclear	Unclear
Global policy response index mid 2021[3]	19.9 (lowest quartile)	81.4 (highest quartile)	-	-

Key: *** Strong/Consistent Policy ** Medium/Semi-Consistent Policy * Weak/Inconsistent Policy

Note: [1]Based on a national Australian population of 5.304M in 1919 and adopting the reported 33% infection rate from Hobbins (2019). [2]Based on a national US population of 104.5M in 1919 and adopting the reported 25% infection rate from Centre for Disease Control (2021). [3]Based on FP Analytics (2021).

Health policy varies between the pandemics; an important difference is stay at home orders: there is no evidence of stay at home orders being used in the Spanish Flu; yet this happened consistently and firmly during COVID-19 in Australia and in many places in the United States. A major reason is the ability of 21st Century populations to leverage electronic communications to maintain social contacts and also to work from home. The implication is that there has been a significant reduction in out of home activities and travel during COVID-19 compared to the Spanish Flu. This is the focus of the rest of this paper.

3. Pandemics and Urban Travel

This section explores how urban travel, particular transit, has been impacted by the pandemics.

3.1. The COVID-19 Pandemic

COVID-19 has acted to reduce significantly urban travel on all modes, but especially on public transport (Beck and Hensher, 2020, Praharaj et al., 2020, Tirachini and Cats, 2020, Currie G et al., 2021). These effects are larger during enforced lockdowns with stay at home orders, and there has been a significant increase in the share of working from home during these events (Dingel and Neiman, 2020, Rubin et al., 2020, Currie G et al., 2021). Tirachini and Cats (2020) detail policy measures to manage COVID-19 on public transport, which include:

- physical distancing to limit virus transmission limiting passengers on board vehicles and, in some cases, increased public transport capacity to reduce crowding;
- requirements to use face masks on public transport; and
- enhanced hygiene, sanitization and ventilation on board public transport vehicles.

What is also clear from the COVID-19 pandemic is that activity and travel have returned once lockdowns and stay at home measures have eased. Figure 1 illustrates this effect on public transport in many cities, including cities in Australia and the USA, by showing public transport ridership for each week after the first lockdown ended as a share of ridership level before COVID-19 (Currie G et al., 2021). As can be seen ridership 'floors' of between 5% and 35% are apparent, but activity returns to higher levels each week after lockdowns end. However, in some cases second lockdowns act to reverse these trends (e.g. Melbourne in week 4, and Auckland in week 15 are clear examples).

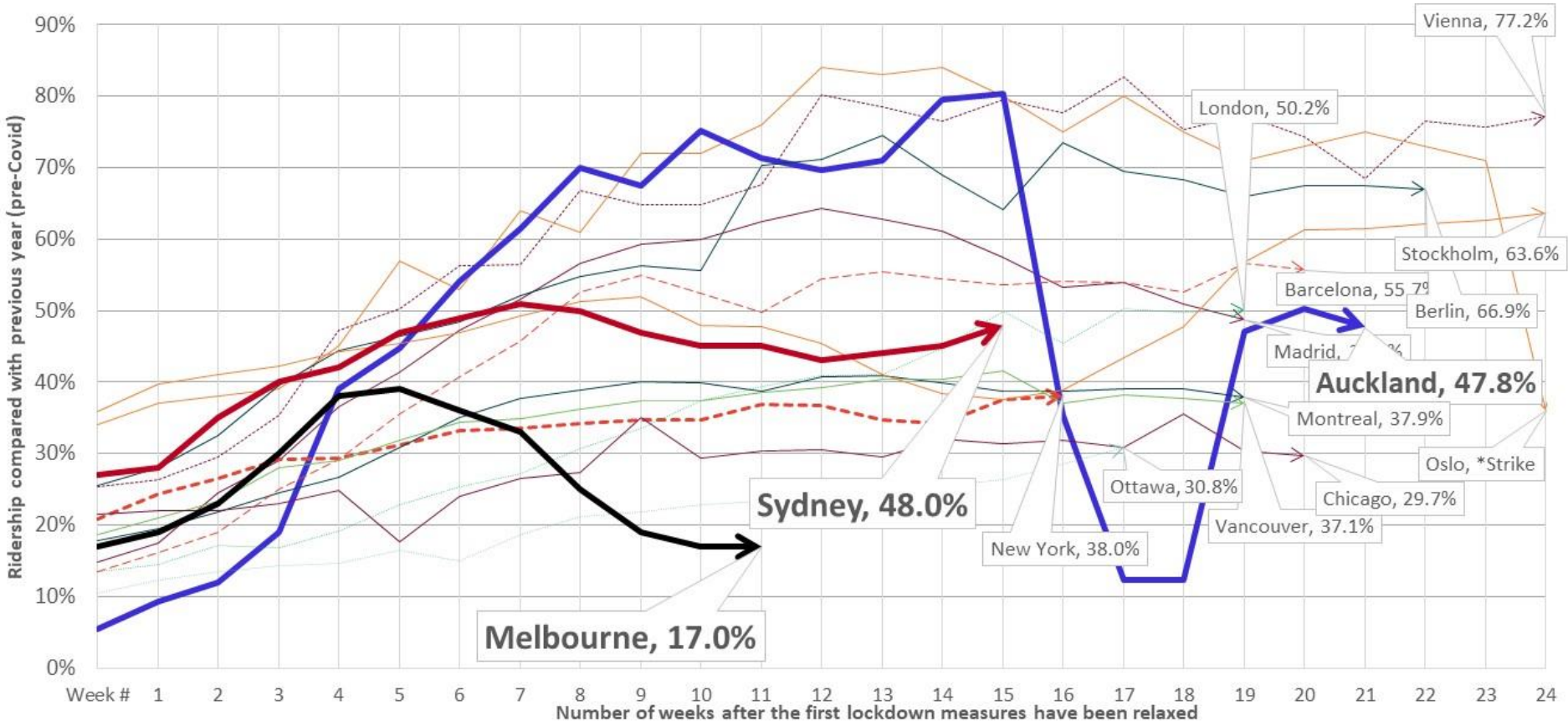
3.2. The Spanish Flu Pandemic

It is a significantly more difficult task to explore urban travel impacts of the Spanish flu on cities. Available ridership data is extremely rare and very limited, while historical accounts do not comprehensively explore travel impacts in any detail. However, Table 2 provides a synthesis of the measures adopted to mitigate Spanish Flu transmission on transport. Anti-crowding and hygiene were the focus of most of the virus transmission measures noted in Table 2. The anti-crowding measures ranged from: simple encouragement that people avoid crowding on transit, travel at peak times, or the use of transit entirely; through to restrictions on passenger numbers, the provision of extra services, officials monitoring crowding levels in the field, shifted opening hours for businesses and places of employment, and even complete closure of streetcar systems. Hygiene-related measures included banning spitting in some systems, requirements to wear masks on services (although not always successfully implemented), cleaning and fumigation of vehicles, banning children from transit as part of efforts to keep them home during school closures, and removal of infected passengers.

4. Travel Analysis Methodology

Research aims to compare on public transport ridership impacts of the Spanish Flu and COVID-19. However, the collection of ridership data from the early 20th century is problematic. Little data is now available and what was found was not ideal for our purposes. Weekly or monthly data was sought, since this can illustrate micro trend effects in and out of any lockdowns. Since travel tends display seasonality it was also considered important to obtain data from pre-pandemic periods to establish relative ridership changes during the pandemic[4]. However, only annual data was located, though there was enough to establish baseline, pre-pandemic ridership levels. Analysis sought to present changes in ridership relative to pre-pandemic ridership levels, using an index of ridership to display proportional changes.

[4] The major sources found for US historical travel data were annual reports of railway companies including the Detroit and Mackinac Railway Company TRANSPORTATION HISTORY COLLECTION - RAILROADS. 2007. *Railroads.* [Online]. Available: Available at: https://quod.lib.umich.edu/r/railroad/. [Accessed [Accessed 27 April 2021]., Great Northern Railway Company**,** Pennsylvania Railroad Company, Mesaba Railway Company and the Boston Elevated Railway Company HATHITRUST DIGITAL LIBRARY. 2021. *HathiTrust Digital Library | Millions of books online.* [Online]. Available: Available at: https://www.hathitrust.org/. [Accessed [Accessed 15 April 2021].. Australian data for Spanish Flu-related ridership was sourced from State Annual Year Books and Year Book Australia editions from the Australian Bureau of Statistics. Since Spanish Flu-related travel data was annual, we collated similar records on Australian and US cities using authority annual reports. COVID-19 data was obtained from the Department of Transport Annual Reports for Melbourne and from the American Public Transit Association DICKENS, M. 2021. American Public Transportation Association Quarterly Ridership Report. American Public Transportation Association. for the US.



Note:

(1) Monash University analysis of raw data collated from Victorian Department of Transport, Transport for NSW, NZ Transport Agency, UITP.

Figure 1: Public Transport Ridership as a Share of Pre-COVID-19 Levels – Ridership Return by week after first COVID-19 shutdowns – Selected Cities

Table 2: Synthesis of Sources Identifying Spanish Flu Transmission Mitigation Measures

Measures	Sources	Details
Anti-Crowding Measures	The History Press (2021)	Local authorities in Britain suggested people avoid crowding on trains by travelling later.
	Stetler (2017)	Philadelphia limited public gatherings, including crowds at football games to prevent spread on the trolley cars.
	University of Michigan Center for the History of Medicine (2021), Ott et al. (2007), Sykes Berry (2010)	In Louisville and Washington DC people were advised to avoid streetcars. Richmond in Virginia similarly encouraged avoidance of crowded streetcars, while Minneapolis and San Francisco encouraged shifting travel to non-peak times.
		In Minneapolis and San Francisco people were encouraged to travel at non-peak times,
		Boston's Health Commissioner encouraged people to reduce unnecessary travel on transit. Extra trains where run. Shops and office hours staggered, but this was abandoned when transit crowding only shifted instead of reducing.
		Denver, Detroit, Indianapolis, Los Angles, Milwaukee, New York, Rochester, Salt Lake City, Seattle Toledo and Washington DC staggered or restricted opening hours or shifts to reduce transit crowding.
		Extra streetcar trips ran in New Orleans to reduce crowding. Similarly, Columbus' transit operator was ordered to run more streetcars, and police were added to stop crowding. Texas asked the operator to run extra streetcars and limit passenger numbers.
		Denver, Des Moines, Kansas City, Milwaukee, Minneapolis, New Orleans, Omaha, Portland, Salt Lake City and Spokane similarly restricted passenger numbers on streetcars, often through disallowing standing passengers.
		Detroit's streetcars where shut because of a state-wide order to close places of assembly. Trains were forbidden from travelling to Lancaster because the city refused to follow state health department orders.
		Portland drafted school teachers to encourage compliance with health orders, and police streetcars to prevent crowing.
	Kalnins (2006)	St Louis restricted passenger numbers on streetcars
Hygiene Measures	Keefe (2020)	In Philadelphia, spitting on the train was forbidden.
	Kildea (2020)	NSW made masks mandatory on public transport.
	University of Michigan Center for the History of Medicine (2021), Phun (2016), Sykes Berry (2010)	Seattle made masks mandatory on streetcars.
		Denver had multiple attempts at regulations requiring masks on streetcars, but the final order "order was so watered down by this point as to make it practically meaningless."
		Portland similarly attempted to pass an ordinance requiring masks on public transport, but it failed to pass the city council.
		Baltimore, Charleston, Chicago, Denver, Kansas City, New Haven, Omaha, San Francisco and Spokane ordered or asked that streetcars be well ventilated. In New York, subway ventilation was a similar focus for the health commissioner.
		In Chicago smoking was banned on transit.
		Cincinnati closed schools, but also banned children under 16 from many places, including from streetcars, to prevent congregation. Milwaukee banned children from streetcars after 7pm and Pittsburgh asked that children be kept at home and off the streetcars.
		Indianapolis' streetcars were fumigated, their windows had to be left open and health inspectors rode services to discourage spitting, monitor cleanliness and exclude those with symptoms. Kansas City similarly fumigated streetcars.
		In Portland windows were removed from the streetcars entirely!
		Los Angles, Texas and Syracuse disinfected streetcars daily.
		Pennsylvania and Grand Central stations in New York had examination rooms at the stations. Physicians and nurses would see arriving passengers who felt ill and prevent those who had influenza from continuing their journeys on transit.

5. Travel Analysis Results

Figure 2 illustrates the results for the US rail companies during the Spanish Flu pandemic compared to US national public transit system data for the COVID-19 pandemic. In general, Figure 2 indicates that for the US there are significant contrasts in ridership trends between the two pandemics:

- For COVID-19 substantial declines in ridership are illustrated:
  - train ridership declines most (to 26% in 2021),
  - bus ridership declines the least (to 43% in 2021), and
  - all riderships decline slightly less in 2020 than in 2021 - this is because the pandemic impacts did not commence until sometime into 2020; while
- For the Spanish Flu; ridership declines are far smaller:
  - the largest declines in ridership are in Boston (to 85% in 1919) and for the Detroit and Mackinac Railway Company (to 86% in 1918),
  - most railway companies demonstrate some degree of decline in 1918 but, with the exception of Boston, all these companies have growing ridership during the pandemic years of 1919 and 1920, and
  - one rail company, the Pennsylvania Railroad Company, actually has continuous ridership growth during all years of the Spanish Flu pandemic.

Overall these findings suggest that the impacts on ridership in the US were far smaller for the Spanish Flu than for COVID-19. Of course, it should be noted that the pandemics may not be the only influences on ridership trends. Population and employment growth (and decline) often impacts ridership and it is entirely possible these were influencing ridership at the time. In the United States a significant number of armed services personnel would have been returning from Europe during the Spanish Flu and this may well have been influencing ridership trends. Nevertheless, it is clear from Figure 2 that in the United States the Spanish Flu's impact on ridership was minor compared to the impact of COVID-19.

Figure 3 illustrates the results for Australian rail companies during the Spanish Flu pandemic and compared it to trends in Melbourne during COVID-19. This illustrates that:

- Much like the US data (Figure 2) there are substantive differences between ridership trends between the Spanish Flu pandemic and the COVID-19 pandemic in Australia.
- For COVID-19 in Melbourne:
  - ridership declines are substantial, reaching lows in 2021 where ridership for tram (to 22%) and train (to 27%) are the lowest. Bus ridership is more resilient (reaching 40% in 2021), which is also reflected in the US data.
- What is also interesting about the COVID-19 Melbourne data is that ridership declines are slightly larger compared to the United States (Figure 2), possibly reflective of the wider ranging lockdown and stay at home measures adopted in Australia.
- For the Spanish Flu in Australia:
  - almost all ridership trends are increases, with only the minor exception of the 1% decline in the Western Australia Tramway company in 1919

Figure 3 also shows some post pandemic ridership trend data for the Spanish Flu period; all display substantive increases in ridership.

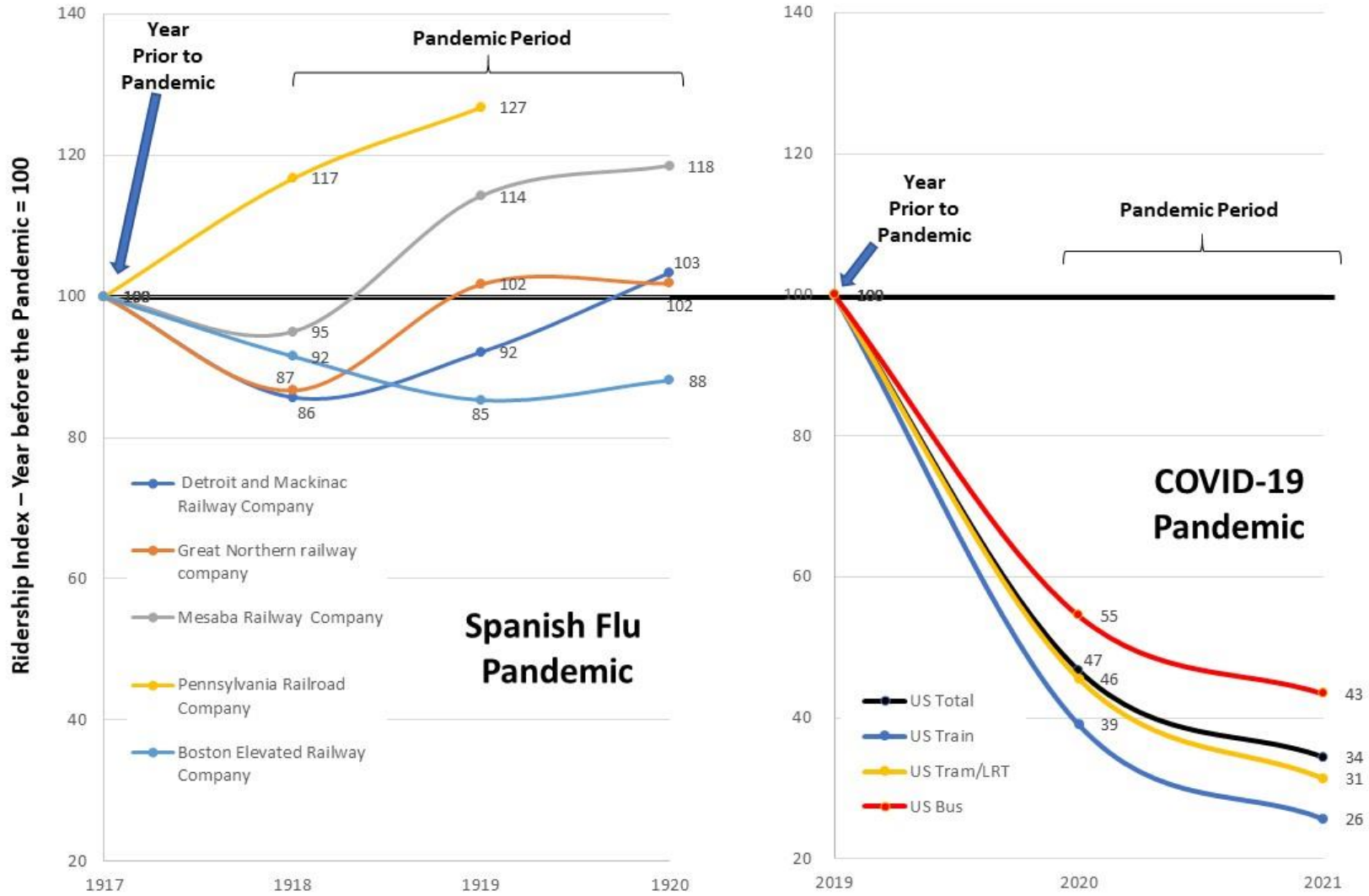


Figure 2: United States of America - Change in Public Transport Ridership During the Spanish Flu and COVID-19 Pandemics

Note: 2021 data is annual data to June 2021 (the time of writing)**.** We have smoothed trend lines between data points.

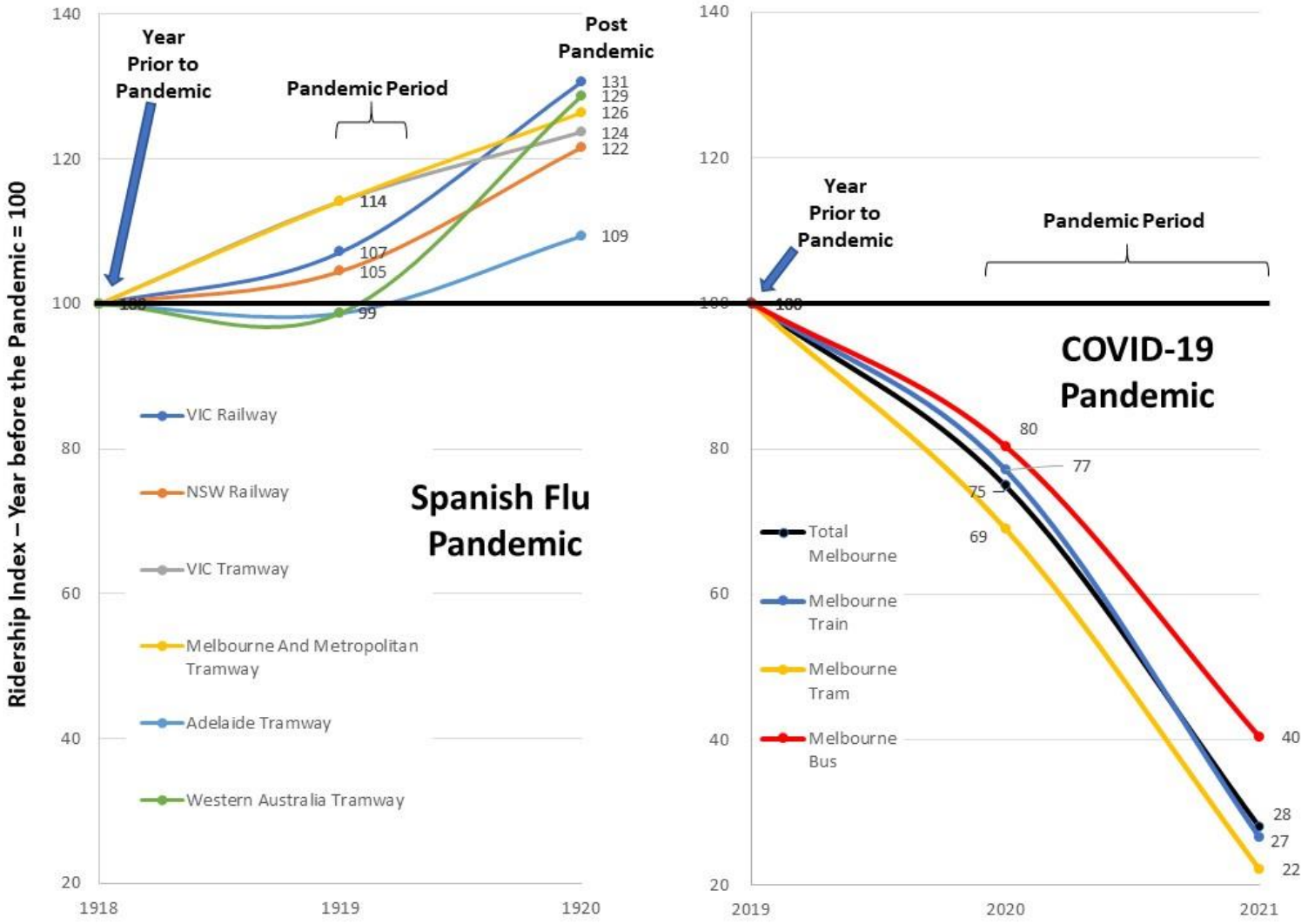


Figure 3: Australia - Change in Public Transport Ridership During the Spanish Flu and COVID-19 Pandemics

Note: 2021 data is annual data to June 2021 (the time of writing)**.** We have smoothed trend lines between data points.

Overall it is difficult to find any negative ridership effects at all surrounding the Spanish Flu in Australia in this data. In comparison, the US experience of the Spanish Flu was that ridership on many systems decline, but all these declines were generally small. These contrasting experiences appear likely to link to the relatively less aggressive experiences of the Spanish Flu in Australia compared to in the US. In contrast, the ridership patterns for COVID-19 pandemic are consistently negative in both Australia and the US. There was a greater reduction in ridership in 2020 in the US than in Australia, which may link to the greater levels of COVID-19 transmission in the community. Ridership has continued to decrease into 2021 in both countries, but to a greater extent in Australia than in the US.

6. Discussion/Conclusions

This paper explores how the Spanish Flu pandemic affected urban travel in Australian and United States cities and contrasts this to the COVID-19 pandemic. The Spanish Flu infected more people (broadly a third of the world's population) and was substantially larger than the COVID-19 pandemic to June 2021. Australian and US approaches to mitigation of the Spanish Flu were broadly similar, though neither were successful at containing the pandemic. Australia may have had a more successful border quarantine system than the US, though it was still not very effective. Australian infection and mortality rates for both pandemics were substantially lower than the United States:

- for the Spanish Flu because of a later arrival date of the pandemic in Australia, when the infection was less aggressive and had lower mortality impacts; and
- for COVID-19 (to June 2021) because of Australia's health policy response based on:
    - a 'Crush and Contain' strategy, with tight lockdowns and stay home orders, and
    - a much higher public trust in, and adherence to, government responses.

These differences in both policy approaches and public health outcomes between Australia and the US during COVID-19 mean that in the US a 2.5 times larger share of the population was infected by the Spanish Flu compared to COVID-19, while in Australia this ratio is over 300.
Substantial differences in public transport ridership trends have been found between the two pandemics. COVID-19 reduced ridership in both Australia and the US to around 30% of pre-pandemic levels. During the Spanish Flu there were much smaller declines in ridership in selected years of the pandemic, and some growth in ridership in other years, in the United States. Virtually no ridership declines were found at all in Australia during the Spanish Flu, and ridership on public transport actually increased during and after the pandemic. It seems likely that the Spanish Flu had only relatively minor impacts on urban travel. Compared to COVID-19, this can best be linked to weaker and less consistent lockdown health policies and the absence of stay at home orders during the Spanish Flu. Health and transport policies during COVID-19 have also been able to leverage a more electronically connected population and workforce, including working from home. This has maintained social and economic activity during COVID-19 while reducing levels of infection transmission, but also reduced travel. This seems to explain the contrasting patterns in ridership trends between the two pandemics.
So what lessons can be learnt for the COVID-19 pandemic from these findings? The evidence suggests that at least up to June 2021, strict and early 'Crush and Contain' strategies seem to create better health outcomes of the COVID-19 pandemic in Australia versus the US and both the Australian and US responses to the Spanish Flu. However for COVID-19 this lesson only applies to June 2021 when this paper was written; since then the Delta strain has shown lockdowns have limited effectiveness in reducing infection rates. Nevertheless even with the Delta strain, mortality rates have been far lower in the Australia due to the 'Crush and Contain' strategy.

Another lesson is that stay at home orders and the electronic communications capability of the 21st century, which make these possible, act to better manage pandemics whilst also maintaining social and economic activity. The casualty of this strategy is travel, which reduces substantially as a result. Based on these observations Figure 4 illustrates the strategic trajectories that the two pandemics have followed.

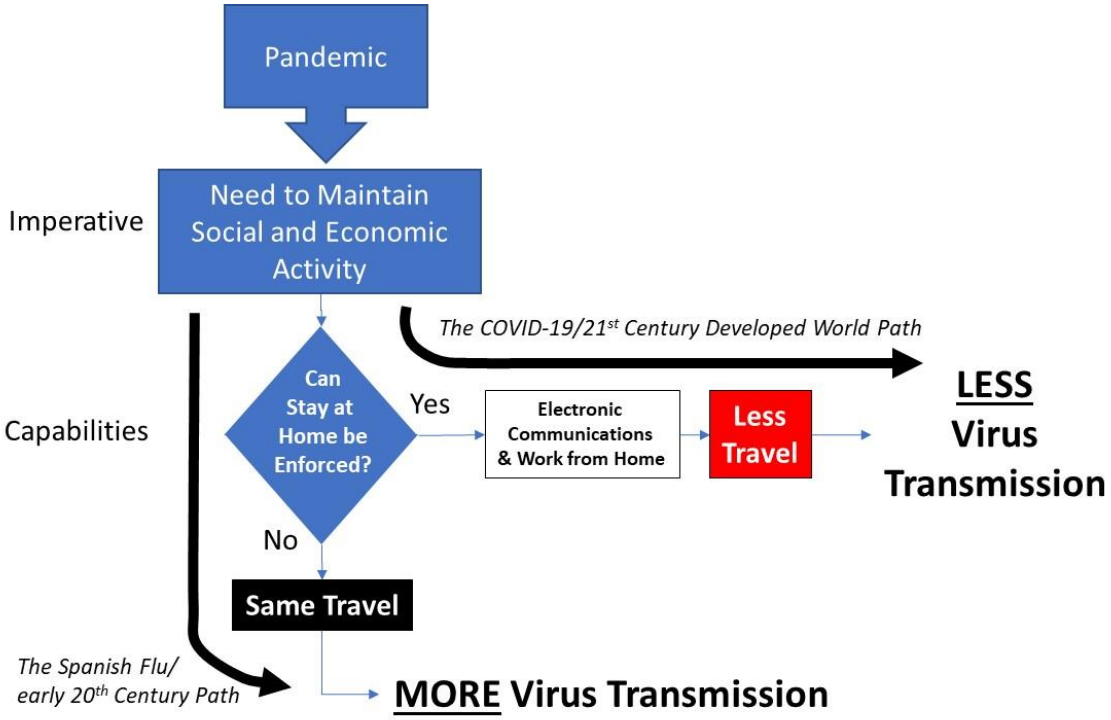


Figure 4: Two Pandemic Trajectories in the Context of Imperatives, Capabilities, Travel and Virus Transmission Outcomes

Both trajectories have an imperative to maintain social and economic activity, but 21st century communications technology and work from home capabilities have enabled the developed world to enforce stay at home orders during the COVID-19 pandemic. This results in less travel and less virus transmission. For the Spanish Flu stay at home orders were not feasible, travel was not impacted and virus transmission increased as a result. In both contexts travel impacts are a symptom of the capabilities and strategies employed.

A further observation from Figure 4 is that the COVID-19 trajectory indicated was only possible in the developed world. The developing world has had less capabilities to manage the pandemic and have followed the Spanish Flu pandemic path. In this context, the electronic communications capabilities of the 21st century and our ability to enforce work from home and stay at home orders seem to be important resilience capabilities for cities in managing pandemics into the future.

There are a range of limitations with this research which warrant exploration in future research. Time and resource availability have limited the time available to collate historical evidence of the impacts of the Spanish Flu on urban travel in Australia and the United States. Further exploration of sources might be more fruitful, as would an expansion of the exploration into a wider range of geographic areas. We were disappointed to not find monthly or weekly ridership trend data from the 1918-1920 pandemic and feel sure that a more intensive and widespread exploration of historic sources might unearth data of this kind.

The research has adopted a comparative pandemic methodology to explore outcomes. However the Spanish flu occurred 100 years before COVID-19 where the context of life,

transport and activity was very different. Transport availability was very different in the late 1910's with limited car ownership. In 2020/21 a substantially wider availability of transport alternatives will impact the patterns of travel demonstrated in this paper. The Spanish flu also affected younger and healthier cohorts while COVID-19 affected older age groups; these impacts need to be considered in any future comparative research of this type. In addition COVID-19 occurs in a period of personalized 24 hour news media proliferation so penetration of the pandemic message to a global population is likely to be substantially better than in the 1910's with the Spanish Flu.

Another major limitation of this research has been the assumption that the trends identified are exclusively the result of pandemic impacts. This is very unlikely, though the pandemic is likely to be a major influence in each case. A deeper exploration of a wider set of influences may be able to model the relative influences of infection rates and health and transport policies on ridership. It would also be fruitful to explore impacts of the Spanish Flu on ridership after the pandemic was over, as this is a major unanswered question we face with COVID-19 at present (to June 2021).

Another useful avenue for future research of this kind would be to explore the relative economic and demographic impacts of the pandemics. Economic lockdown strategies and stay at home orders have reduced infection but caused economic hardship. How does this contrast with the economic performance of Spanish Flu affected economies where stay at home orders and lockdowns had no (or less) economic impact but infection rates were high?

Overall this research has demonstrated that the Spanish Flu had minor ridership outcomes compared to COVID-19, despite its significantly larger scale. Ridership impacts are a symptom of our ability to enforce stay at home orders, which is made feasible by electronic communications capabilities. To better manage pandemics in the future we need to enhance these capabilities and widen their geographic and social availability. Travel impacts are unfortunate, but also a necessary casualty of these factors which enable better pandemic mitigation into the future.

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