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Where did all the passengers go? - transit commuter transitions through COVID-19

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Abstract

This paper tracks the travel and activity transition of pre-COVID public transport commuters through the COVID-19 pandemic and on to likely post-COVID patterns of commute with a focus on Melbourne, Australia. It adopts a large online survey of pre-COVID public transport riders to chart their activity and mobility patterns during, through and out of the pandemic.

About half of pre-COVID public transport commuters exclusively worked from home during the first lockdown of the pandemic. 15% lost their jobs while 9% transitioned to car driving and 5% shifted to other modes. Only 22% continued commuting on public transport during COVID lockdown 1. 75% of pre COVID transit commuters expect to return to transit post-COVID levels. About half of returning riders transition from working from home during COVID back to public transport use. Interestingly the share of pre-COVID transit riders who drive increases after COVID, with many expecting to transition from working from home exclusively to driving a car. Transit commuters who exclusively worked from home during Lockdown 1 substantially reduce post-COVID as work-from-home behaviour transitions back to public transport or using other modes of travel.

Each public transport mode has a different pattern of COVID rider transition. During COVID more train commuters worked from home (52%) than tram (45%) while a higher share of Multi-modal PT commuters did not have work during COVID (16%). After COVID more pre-COVID train commuters transition to car driving (15%) compared to tram (12%). Residual long term work from home behaviour is also higher for pre-COVID train commuters (6%) than tram commuters (4%).

Implications for policy and future research opportunities are discussed.

1. Introduction

The COVID-19 pandemic has seen significant shifts in local travel behaviour in cities. Public transport has been particularly impacted; usage declined by more than 90% in the first stages of lockdowns in almost all cities (Van Oort & Cats, 2020). This has had a significant impact on the global public transport with withdrawal of services in many cases and financial collapse of some systems (Habib & Anik, 2021). In Australia, the share of residents using public transport fell from 23% in March 2020 to 14% in 2021 (Australian Bureau of Statistics, 2021).

So where did all the public transport travellers go during the pandemic? And how many will return after COVID?

This paper aims to identify shifts in travel and activity of public transport commuters as a result of the pandemic. It also explores how and if pre-Covid public transport commuters will return to public transport when the COVID-19 pandemic is over. Its focus is Melbourne Australia. It uses a large online survey of pre-COVID public transport commuters to chart their activity and mobility patterns during, through and out of the pandemic.
The paper is structured as follows; a research context follows including a review of relevant research literature and an outline of the research context of COVID-19 in Melbourne. The research approach is then outlined followed by a detailing of the results. The paper closes with a discussion and conclusions.

2. Research Context

2.1. Public Transport Impacts of COVID-19

Pandemic lockdowns have seen considerable reductions in all travel not just public transport use (e.g. Jenelius & Cebecauer, 2020). However reduction in transit ridership have been larger than most modes with reductions of more than 90% reported in many cases (Tirachini & Cats, 2020; Van Oort & Cats, 2020). The central causes of rider reductions is infection fear related to close rider interaction with strangers and crowding within public transport vehicles (Shelat S et al, 2022). In addition to user perceptions of infection fear, some health authorities have actively discouraged public transport use as an infection control measure (Gkiotsalitis & Cats, 2021). While others have imposed social distancing measures on public transport vehicles and enforced mask wearing mandates (Gkiotsalitis & Cats, 2021; Tirachini & Cats, 2020). This has acted to reduce effective capacity and further reduce travel. In some cases, service levels of public transport have been reduced to reduce costs and financial losses in response to reduced farebox revenue (Gkiotsalitis & Cats, 2021). It is reported that in the USA, 90% of transit agencies reduced service levels to some extent in response to COVID-19 (González-Hermoso J & Freemark Y, 2021). This will also act to reduce service attractiveness and hence usage.
It not yet clear if, in the long term and post-COVID, transit ridership will return to pre-COVID levels. However the general pattern of global ridership has been an increase from lockdown lows when activity returns (Van Oort & Cats, 2020). But ridership is still well below pre-COVID levels. A number of research approaches have been adopted to estimate ridership futures. Some studies (including this paper) use respondent self-reported expectations of travel after the virus has gone (Awad-Núñez et al, 2021; Currie G et al, 2021b). Current estimates suggest ridership will return but not to pre-COVID levels; a common forecast is that it will return to levels 20% below pre-COVID levels (Currie G et al, 2021b).
The other main approach adopted is to explore ridership levels in cities with zero COVID infection. For example Easther & Delbosc (2022) tracked ridership in Hobart, Australia when there was no infection. Similarly, Currie G et al (2021a) explored ridership in Auckland, New

Zealand, with zero infections. In both cases transit ridership was 20% below pre-COVID levels, a level exactly the same as is forecast by the self-reported expectation studies.
No research to date has clearly established where public transport riders have gone during COVID-19. Increasing rates of working from home have been demonstrated (Bick et al, 2020; Jain T et al, 2022; Rubin et al, 2020) and its clear that transit riders will represent a share of this group (though the extent to which this is happening is unclear). Low income riders may also have lost jobs, notably causal work, suggesting reduction in ridership due to unemployment (Australian Bureau of Statistics, 2020), though again it is unclear how much ridership has been impacted by this and by how much a return to work will act to increase ridership. Shifts from transit to other modes have also been reported, with much variety of impacts relating to the specific circumstances of each city (Combs & Pardo, 2021; Habib & Anik, 2021).
This research paper aims to clarify how transit commuters in Melbourne have shifted their activity during the pandemic, including an analysis of expectations of behaviors when the pandemic has gone. To explore these issues it is helpful for the reader to understand the research program which this paper is a part of and also to have some context of the pandemic in Melbourne, the focus of the study.

2.2 The Authors Research Program on COVID-19 in Melbourne

The authors have been engaged on a research program exploring the impacts of COVID-19 on travel in Melbourne (reported in detail in Currie G et al, 2021b). This paper is exploring specific aspects of the research program related to transit riders. However, aggregate city-wide patterns of behavior are also of interest and can assist in better understanding these patterns. Large reductions in Melbourne travel are reported including a 90% reduction in public transport use and 30% reduction in car use (Currie G et al, 2021b). Fear of infection and perceived crowding are new and significant concerns amongst public transport users. CBD-related travel shows significantly larger reductions in travel. Results for respondent self-reported expectations of travel when the virus has gone suggest that:

- There will be a post-pandemic reduction of 20% in public transport commuting; this is particularly large for CBD/downtown areas
- Work from Home (WFH) increased substantially during the pandemic; this will reduce after the pandemic as enforced WFH is replaced by voluntary WFH. Nevertheless, a sustained future ongoing increase in WFH above pre-pandemic levels is suggested, acting to reduce peak commuting (all modes) by 6%
- Increased WFH is much larger for CBD jobs and results in a long-term reduction in commuting to Melbourne CBD of 20% (all modes).

Infection fear is a new top concern of public transport users since the pandemic. This fear has transitioned from ‘fresh infection fear’; the initial concerns when the pandemic started to ‘residual infection fear’ (Wang, 2014); a long-term effect when the virus has gone.

2.3 The Melbourne Context

Melbourne has population of 4.97 million people (2020) over nearly 2,000 km^2; much of which is low density development. The CBD plays a dominant role for retailing, employment and recreation. Melbourne’s transit system (Figure 1) consists of train, tram, and bus services with rail and tram focusing on CBD-radial travel, while bus services provide suburban access. Melbourne is dependent on the private car for most travel, but particularly in the suburbs.

COVID-19 was detected in Melbourne in early 2020. Government response was strict; one global policy rating of policy in 2020-21 suggests Australia is ranked 4th in the world out of 36

major countries for effective responses (FP Analytics, 2021). Two large lockdowns occurred in 2020 in Melbourne; March 23rd to May 13th and 9th July to 2nd August. 2020 saw a total of 20,345 cases of COVID-19 and 820 deaths (Department of Health and Human Services, 2020). Victoria experienced some 306 COVID-19 cases per 100,000 population (Statista, 2020b) which compares to 2,626 in the UK, 4,500 in the USA and 5,189 in Belgium (Statista, 2020a).

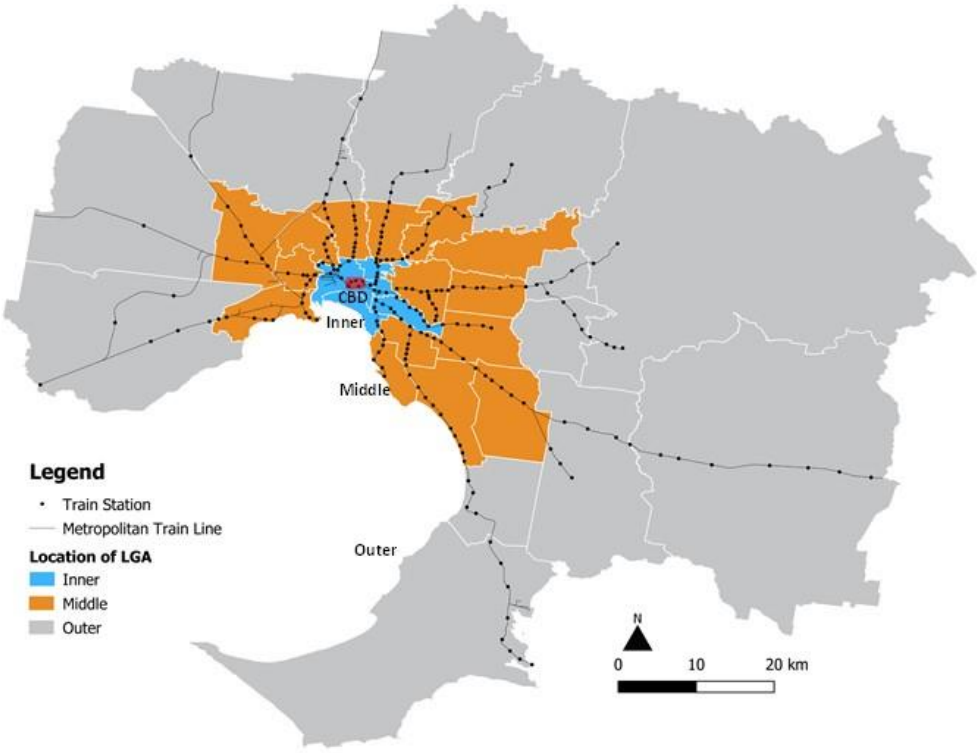


Figure 1: Public transport network in Melbourne. (LGA=Local Government Area)

COVID-19 shutdowns decreased travel in Melbourne (Figure 2). Compared to baseline 2019 data, all travel declined with public transport modes and (CBD) walking declining by around 90%. Car travel declined by 29% while cycling declined the least; by 8%.

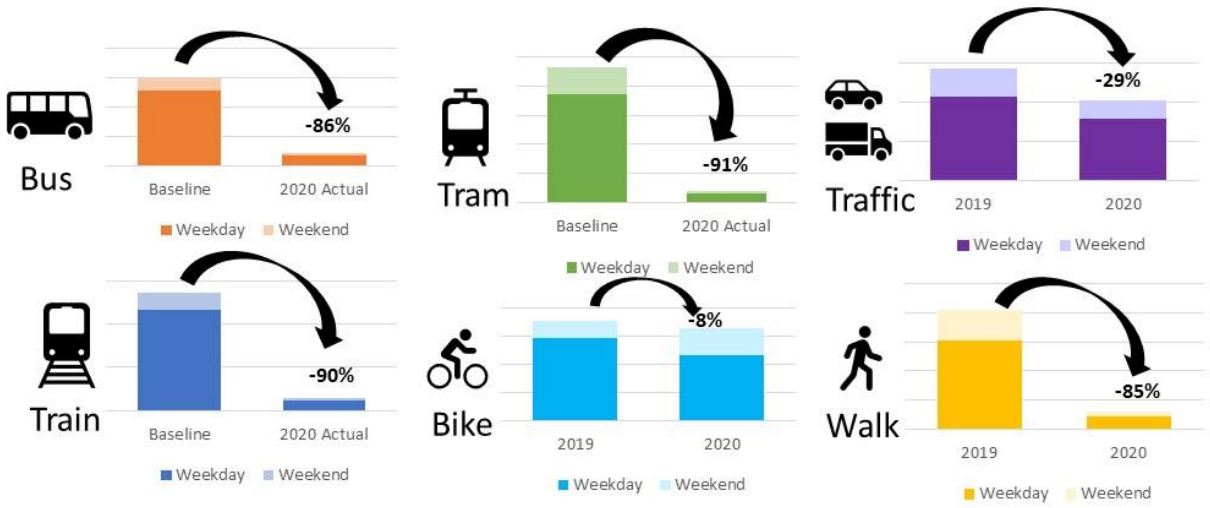


Figure 2: COVID-19 shutdown impacts on travel count data in 2020 (av. Trips/week)
Source: Currie G et al (2021b)

3. Research Approach

This research aims to track public transport commuters who used public transport Pre-COVID, to trace their activities during the pandemic. Then self-reported expectations of commuting after the virus had gone (stated intention method) are explored. An online survey was developed to cover a representative sample of Melbourne residents. To achieve this a sampling frame based on age and income cohorts and geographic area (inner, middle and outer) was developed with random sampling adopted within these cohorts. The survey covered all travel and activity, not just public transport commuting which is a subset of the survey sample. A total sample of 2,100 was targeted and delivered by a market research company (Ipsos) using an online panel. The survey ran between 26 June 2020 and 8 August 2020 and is described in detail in Currie G et al (2021b). Quota-based exclusion criteria were used to ensure that the respondent characteristics were in line with the sampling frame. The final sample had 2,163 valid responses with all sampling for each of the regions above the minimum required and almost all age/income quota achieved.

The questionnaire sought to understand both reported travel behaviour before and during COVID-19 and self-reported expectations of travel post-COVID. The sample responses were adjusted using weightings to be representative of all travel in Melbourne[1].

4. Results

The results track respondent mode/activity of commuting from pre-COVID (public transport use) to travel during COVID (the first major lockdown period was chosen) and then to the post-COVID period (self-reported expectations of commuting after the virus has gone). Results are reported in two parts:

- Commute travel in total for all public transport use
- Commute travel by public transport mode.

4.1. Work Related Travel – Total Public Transport Use

Out of the total sample of 2,163, a weighted sample of 421 pre COVID public transport commuters was separated for analysis for this research. Table 1 shows the weighted sample outcomes for public transport commuters in the pre-COVID period by mode and compares the weighted sample share with known commuters from the 2016 census journey to work survey for Melbourne (Australian Bureau of Statistics, 2016).

Table 1: Sample Public Transport Commuters by Mode – Pre-COVID

	Main Public Transport Mode			
	Bus	Train	Tram	Multiple- PT Modes
Unweighted Sample	26	254	135	94
Weighted Sample	24	256	67	78
Share (%)	6	60	16	18
2016 Census Share (%)	7	45	15	33

This suggests the weighted sample is broadly representative of mode share in Melbourne, however train-only travel is overestimated and multiple-mode PT trips (which mostly involve trains e.g. bus-train and park-and-ride trips to stations) are underestimated. Together the estimated share of train plus multiple PT trips is 78%, while in the census this was exactly the same; 78%. So overall while the sample has some definitional problems for rail users it is

[1] A target sample of 700 each for inner, middle and outer Melbourne was adopted. The outcome sample was adjusted using weightings to account for the actual populations in each of these zones.

broadly representative of rail and multi-modal travel in aggregate. While the bus sample share is very accurate the actual number of respondents for bus is low (26). This is too small for a reasonable tracking of movements between each mode/activity combinations in the COVID and Post-COVID periods[2]. This meant we had to remove bus from the disaggregate analysis of results by mode.

Table 2 shows the total weighted public transport commute sample by COVID phase and mode/activity during each period. Figure 3 illustrates the pattern of these mode/activity transitions between the Pre-COVID, COVID and Post-COVID periods. These indicate that:

- During COVID:
  - about half of public transport commuters transition to exclusively working from home, which is the most common transition during COVID
  - some 22% continued to use public transport
  - 15% no longer have work, so no longer commute by public transport (or at all)
  - The most common transition to travelling by another mode is car driving (9%)
  - 5% use other modes
- After COVID, self-reported expectations of travel are:
  - Most (75%) pre-COVID public transport commuters expect to return to transit.
  - Those pre-COVID public transport commuters not returning transit post-COVID are:
    - those who expect to commute driving a car (15%),
    - those who expect to commute using other modes (walk, bike etc.)(6%), and
    - those who will continue to exclusively work from home after COVID (5%).
- The path of public transport users who expect to return to public transport use is complex. As a share of future post-COVID ridership
  - only 26% stayed with public transport use throughout COVID. 74% stopped using public transport then returned
  - almost half (48%, and the largest share of the future public transport market) return to using public transport from working from home
  - some 15% return to using public transport from having been unemployed
  - some 7% return to using public transport from haven driven a car during COVID
  - some 4% return to using PT having travelled by other modes during COVID.
- There are some interesting trends in mode use after the pandemic:
  - car driving by public transport users during the pandemic substantially increases (by 72%) post COVID. Most of this increase comes from those transitioning from work from home to car driving
  - other mode use also increases after the pandemic; again driven by those transitioning from working from home during COVID.
  - The biggest single behavioural shift between COVID and post-COVID is the substantial reduction in working from home which declines by 91%.

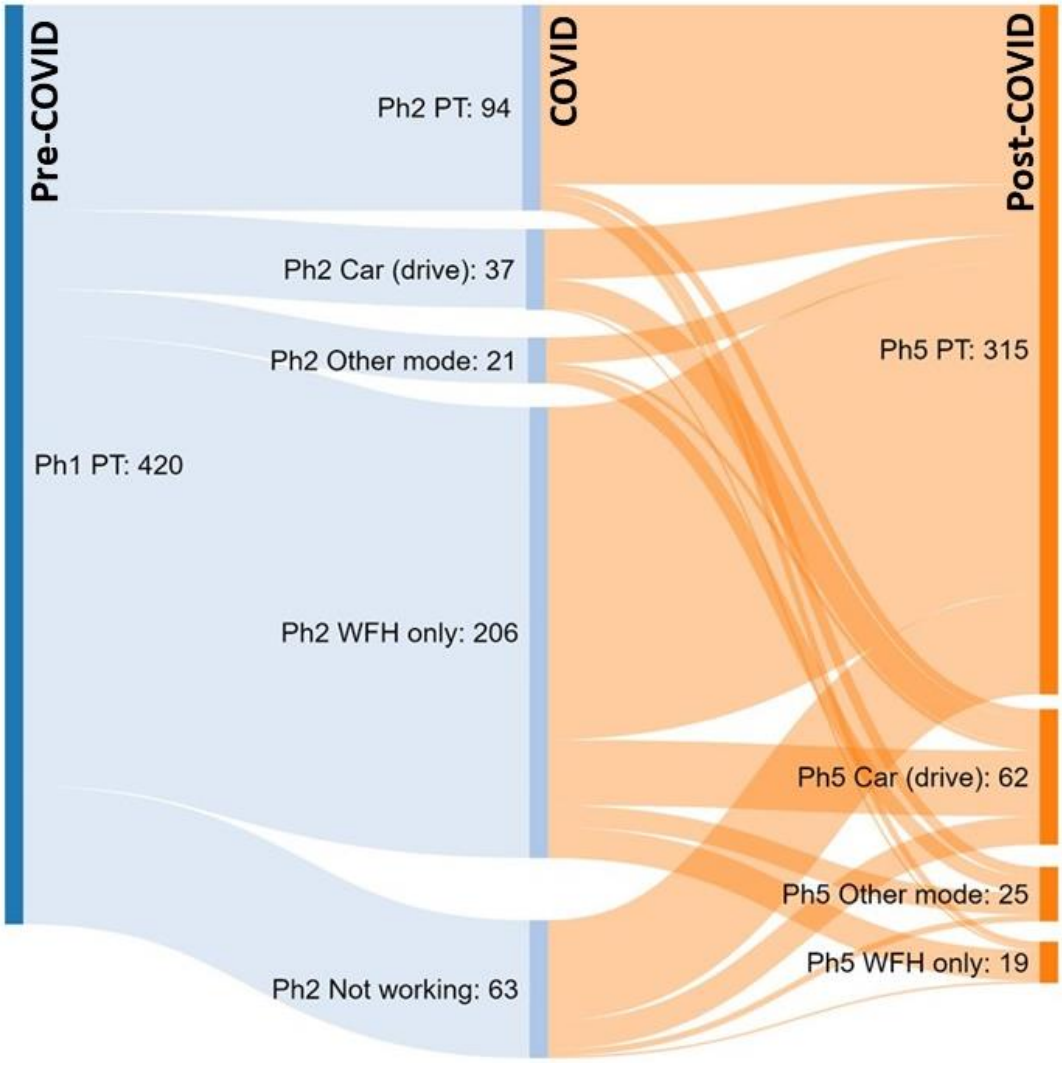
Overall these transitions suggest that working from home dominates pre COVID ridership transitions during the pandemic. Post COVID mode shift of transit users to car driving is the largest single cause of loss of ridership. This feature may represent a concern for Melbourne as additional road traffic implies greater traffic congestion. Work from home is still an important factor in lost ridership after COVID-19, however it only represents 1 in 20 of pre COVID users. Loss to other modes of travel post COVID is around the same share.

[2] There are twenty combinations of modes/activities which respondents can take. Therefore, tracking 26 respondents through this is not a large enough group to provide meaningful results.

Table 2: Public Transport Commuters Mode/Activity Transitions by COVID phase

Mode/ Activity	Pre-COVID		During COVID		Post-COVID			
	No.	Share	No.	Share	Mode/ Activity	No.	Total	Share
Public Transport	421	100%	94	22%	Transit	82	315	75%
					Car Driver	4		
					Other Mode	5		
					WFH	3		
Car Driver			36	9%	Transit	23	62	15%
					Car Driver	13		
					Other Mode	0		
					WFH	1		
Other Mode			21	5%	Transit	12	25	6%
					Car Driver	2		
					Other Mode	7		
					WFH	0		
Work frm Home			206	49%	Transit	152	19	5%
					Car Driver	30		
					Other Mode	10		
					WFH	14		
Not Working			63	15%	Transit	46	N/A[3]	N/A[3]
					Car Driver	13		
					Other Mode	3		
					WFH	1		
Total	421	100%	421	100%			421	100%

Figure 3 : Public Transport Commuters Mode/Activity Transitions by COVID phase



[3] Pre-COVID transit commuters expecting to not be working post-COVID were excluded from the analysis.

4.2. Work Related Travel – Separate Public Transport Modes

Table 3 and Figure 4 shows the results for each separate pre-COVID transit commuting mode. These results indicate that:

For the During COVID lockdown:

- Multi-modal travel (26%) and tram (22%) had slightly higher retention of riders compared to train (20%).
- Work from home was slightly larger for pre-COVID train commuters (52%) compared to pre-COVID multi-modal (48%) commuters. The lowest by some margin was for pre-COVID tram commuters (45%).
- Multi-modal pre-COVID commuters had the highest share of commuters not working (16%) followed by Train (15%). Tram was lowest (13%).
- Interestingly Tram had the highest share of commuters turning to Car driving during COVID (15%) compared to Train (8%) and Multi-modal PT (5%).

For the Post-COVID period:

- Multi-modal PT has the highest transit commuter recovery (77%) followed by Train and Tram at 75%.
- The highest share of commuters shifting to car driving post-cOVID is for Multi-Modal PT travel (17%) followed by Train (15%) and Tram (12%).
- Use of Other modes post-COVID is much higher for pre-COVID Tram (9%) compared to Train (5%) and Multi-Modal (6%). We speculate that tram trips are shorter, and so walk/bike/micro-mobility modes are more competitive for these commuters.
- The long term post-COVID retention of exclusively work from home affects Train (6%) more than Tram (4%), but doesn't influence Multi-modal trips at all.

The patterns of travel/activity changes during COVID are not the same for Train and Tram:

- A larger share of Train commuters exclusively worked from home (52%) than for Tram (45%).
- A higher share of Tram commuters transitioned to Car driving during COVID (15%) compared to Train (8%).

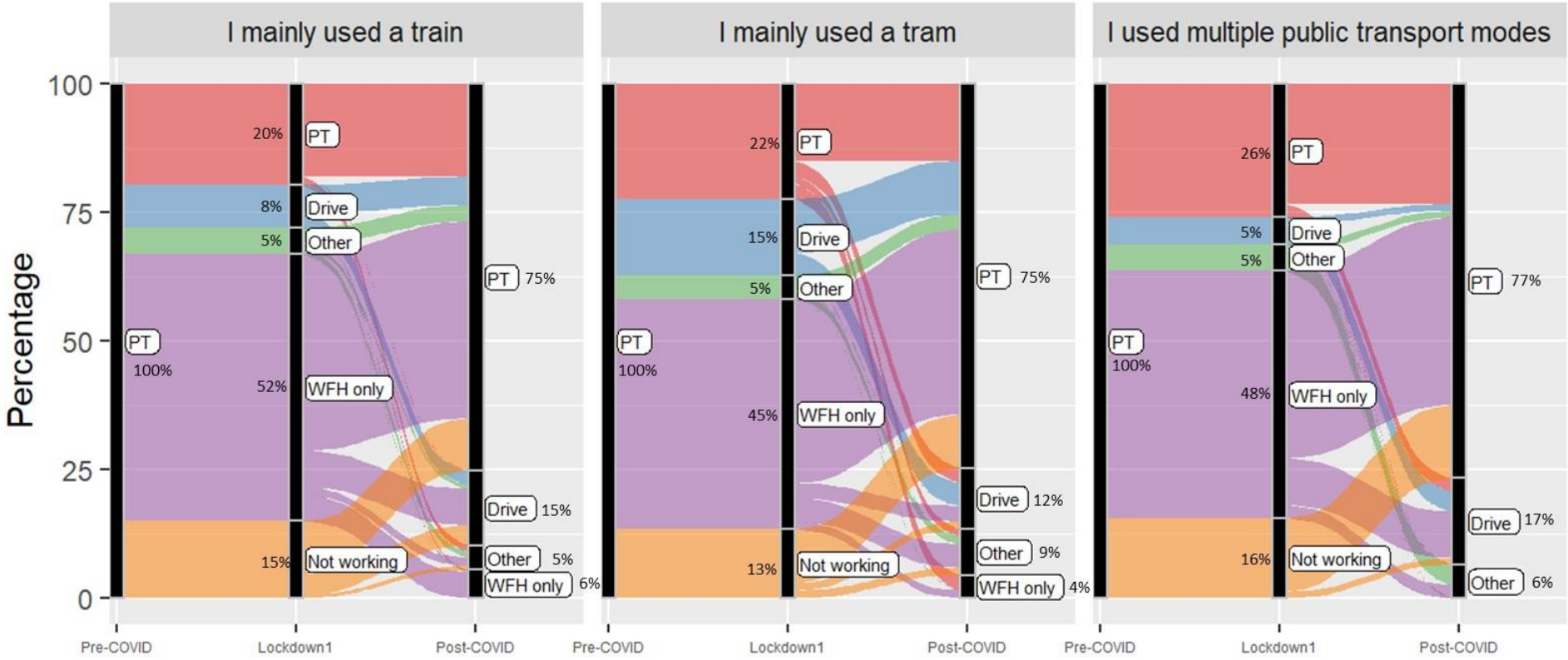
Post-COVID Train and Tram transitions are also different. Train has a much higher share of Car drivers post-COVID (15%) compared to Tram (12%). This is mainly driven by Train Work from Home respondents during COVID transitioning to Car driving post-COVID. 14% of Train commuters who exclusively worked from home during COVID expect to move to Car driving post-COVID compared to only 7% for Tram. This has a larger impact as Train also had a larger share of commuters exclusively Working from home during COVID (52% compared to 45% and 48% for Tram and Multi-modal respectively).

Although, as noted earlier, Multi-modal PT trips are very associated with Multi-modal train travel, they demonstrate some interesting and distinct patterns in the results. There are no post-COVID Work from home behaviours at all from the Multi-modal PT group. All of the Work from home respondents in this group during COVID either transition back to PT or other modes. One possible reason for this is that passengers who make Multi-modal trips may be less associated with white collar office employment where working from home exclusively (i.e. no commuting at all) is more feasible. Multi-modal PT travelers are more likely to live in suburbs more remote from the rail network. In Melbourne this tends to imply a lower socio-economic status which might well be associated with higher shares of manual and causal labor that has to be done at a workplace. Multi-modal PT group also had the highest share of unemployment during COVID, which might be consistent with overall trends that those employed casually and in face-to-face roles where more likely to not have work during lockdowns. Multi-modal PT also had the highest share of Car driver commuters Post-COVID, which may reflect a desire to avoid transfers.

Table 3: Public Transport by Mode Commuters by Mode/Activity Transitions by COVID phase

Mode/ Activity	Pre-COVID		During COVID		Post-COVID			
	No.	Share	No.	Share	Mode/ Activity	No.	Total	Share
Train								
Train	256	100%	50	20%	Transit	46	191	75%
					Car Driver	14		
					Other Mode	3		
					WFH	1		
Car Driver			21	8%	Transit	14	37	15%
					Car Driver	7		
					Other Mode	0		
					WFH	0		
Other Mode			13	5%	Transit	8	12	5%
					Car Driver	2		
					Other Mode	3		
					WFH	0		
Work frm Home			132	52%	Transit	97	14	6%
					Car Driver	18		
					Other Mode	4		
					WFH	13		
Not Working			38	15%	Transit	26	N/A	N/A
					Car Driver	10		
					Other Mode	2		
					WFH	0		
Total	256	100%	254	100%			254	100%
Multi-Modal Public Transport Trips								
Multi-Modal PT	77	100%	20	26%	Transit	18	59	77%
					Car Driver	2		
					Other Mode	0		
					WFH	0		
Car Driver			4	5%	Transit	1	13	17%
					Car Driver	3		
					Other Mode	0		
					WFH	0		
Other Mode			4	5%	Transit	1	5	6%
					Car Driver	0		
					Other Mode	3		
					WFH	0		
Work frm Home			37	48%	Transit	28	0	0%
					Car Driver	7		
					Other Mode	2		
					WFH	0		
Not Working			12	16%	Transit	11	N/A	N/A
					Car Driver	1		
					Other Mode	0		
					WFH	0		
Total	78	100%	77	100%			77	100%
Tram								
Tram	67	100%	15	22%	Transit	10	50	75%
					Car Driver	2		
					Other Mode	1		
					WFH	2		
Car Driver			10	15%	Transit	7	8	12%
					Car Driver	3		
					Other Mode	0		
					WFH	0		
Other Mode			3	4%	Transit	2	6	9%
					Car Driver	0		
					Other Mode	1		
					WFH	0		
Work frm Home			30	45%	Transit	24	3	4%
					Car Driver	2		
					Other Mode	3		
					WFH	1		
Not Working			9	13%	Transit	7	N/A	N/A
					Car Driver	1		
					Other Mode	1		
					WFH	0		
Total	67	100%	67	100%			67	100%

Figure 4 : Public Transport by Mode Commuters - Mode/Activity Transitions by COVID phase



5. Discussion and Conclusions

This paper tracks the travel and activity transition of pre-COVID public transport commuters through the COVID-19 pandemic through to likely self-reported post COVID patterns of travel. It adopts a large online survey of pre-COVID public transport commuters to chart their activity and mobility patterns during, through and out of the pandemic.

About half of pre-COVID public transport commuters work from home during the pandemic. 15% lose their jobs while 9% transition to car driving and 5% to other modes. Only 22% continued to commute using public transport during COVID. Post-COVID, most public transport commuters expect to public transport (75%). About half of returning public transport commuters will be transitioning from exclusively working from home during COVID back to public transport use. Interestingly the share of pre-COVID riders who drive increases after COVID and many transition from working from home to driving a car rather than returning to public transport. Transit commuters who exclusively worked from home during COVID substantially reduce as work from home behaviour transitions back to public transport or using other modes of travel.

Commuters in each public transport mode have different patterns of transition through COVID. During COVID more train commuters worked from home (52%) than tram (45%). A higher share of Multi-modal PT commuters did not have work during COVID (16%). Also more tram users drove a car (15%) than train (8%). After COVID more pre-COVID train commuters transition to car driving (15%) compared to tram (12%). This is because a very high share of train commuters working from home during COVID transition to car driving. Residual long term Work from home behaviour is also higher for pre-COVID train commuters (6%) than tram commuters (4%). Interesting none of the pre-COVID multi-modal PT commuters continued to work from home after COVID but a high share decided to transition to car driving (17%).

Work from home was the dominant behaviour of public transport commuters, particularly train commuters, during COVID. Most pre-COVID transit commuters expect to return to public transport. However, 25% do not, suggesting a lingering post-COVID impact on ridership in the long term. Another concern is that most of those lost from PT in the long term will drive cars, not a very progressive activity in a city which was already congested with traffic before COVID. However these findings do not necessarily represent the actual outcomes of future travel. They are self-reported expectations of commuters and expectations can be changed. Public transport planners should be targeting those working from home during the pandemic and encouraging them to return to public transport. The difficulties they will create if they return to commuting, but switch to car driving should be made clear, including the traffic congestion, delay and the relative cost/price advantages of public transport. The COVID safe features of public transport should also be emphasised.

There are many areas where the approach to this research could be improved and extended. Although the sample was large (and expensive to collect) we did not collect enough bus passengers to carry out this research for the bus market; an important and interesting addition to this research. This would be a worthy topic of a separate study focussing only on the bus market. A larger sample might enable separate modes to be explored in the 'other mode' group, with the influence of cycling a particular area of interest. A range of interesting questions could also be added to explore new issues in the survey undertaken. Although the authors have already explored factors driving work from home behaviour (Jain T et al, 2022)

and general travel influences (Currie G et al, 2021b), it would be useful to understand factors driving COVID and Post COVID expectations such that they may be targeted to achieve better travel behaviour change outcomes.

Overall the research has demonstrated public transport commuter transition into COVID and potential expectations of Post COVID Futures. We need to better understand and thus manage future transitions to achieve a better outcome for Post COVID cities.

6. Acknowledgements

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