Transport and wellbeing in a newly constructed greenfield estate: A quantitative exploration of the commuting experience

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A B S T R A C T

Introduction: Private car dependency is widely recognised as problematic. While ongoing advances in technologies of connectivity mean our capacity to envision a less car dependent city is stronger than ever, many cities and routines remain defined by the private car. Greenfield development on the outskirts of cities provides a case in point of how this comes to be. Car dependence is perpetuated in newly established outer urban areas because residential growth often precedes the arrival of the infrastructure, jobs and services required to live a less car dependent life. These asynchronies in greenfield development processes are known to have negative health implications. Less explored are the health impacts of the specific transport practices associated with relocating to a greenfield estate. This paper seeks to fill this gap by providing new insights into the health impacts of the transport practices associated with relocation to the suburbs.
Procedures: The study draws from a sample of 317 recently relocated residents to a greenfield estate in Sydney, Australia and uses multiple regression techniques to provide a quantitative exploration of the commuting experience.
Findings: Substantial increases in commute times for relocating residents are revealed and these commutes are car-dependent. This impacts wellbeing in different ways. Increases in commute time and changed commute time of departure are found to be significantly associated with lower mental health scores and decreased indices of subjective wellbeing. Conversely, an appreciation of private car use and disregard for public transport access is associated with increased happiness.
Conclusions: The pathways between commute time, mental health and subjective wellbeing are complex and embedded in subjective experiences of the commute both past and present. These findings need further research in the future.

1. Introduction

Recognising the negatives associated with private car use, many scholars and practitioners are excited by the emergence of new technologies and cultural trends that suggest a less car dependent future is on the horizon. Yet countless cities, and the routines of their residents, remain defined by private car use. Greenfield development (Maher, 1994; Yigitcanlar et al., 2007; McGuirk and Dowling, 2011) provides a case in point of how this comes to be. Regardless of cultural intention or technological potential, car dependence is perpetuated in newly established outer urban areas because residential growth often precedes the arrival of the infrastructure, jobs and services required to live a less car dependent life (BITRE, 2012; Sultana and Weber, 2014). This outcome has attracted various labels such as 'asynchronous growth' and 'infrastructure lag' in infrastructure planning practice.

These asynchronies in greenfield development processes are known to have negative implications for affected communities (Walters and Rosenblatt, 2008; Williams and Pocock, 2010; Thompson, 2013; Nicholls et al., 2015). Although studies have explored the health impacts of this urban form typology, there is little understanding of the health impacts of the specific transport practices associated with a relocation to a greenfield estate (Nicholls et al., 2017). While greenfield development, with resultant signature car-dependence, continues to characterise the accommodation of new populations in many cities around the world, such understanding is

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urgently required. This paper contributes to this understanding. Drawing from a sample of 317 recently relocated residents to a greenfield estate in Sydney, Australia, the paper provides new insights into the health impacts of the transport practices associated with relocation through a quantitative exploration of commuting experience.

2. Literature context

The study reported here investigates the health impacts of transport practices, specifically commuting, for new residents of greenfield sites. There are two streams of literature that underpin the assumptions and directions for this investigation. The first examines the links between transport, access and health (reviewed by Cohen and Watkins, 2011 and Cohen et al., 2014). The second is concerned with the impact of residential relocation choices on travel behaviour (explored, for example, by Beenackers et al., 2012; de Vos, 2018; Hirsch et al., 2014; Oakil et al., 2011, 2014; Prillwitz et al., 2007).

The health impacts of transport are complex and multifarious (Cohen et al., 2014), ranging from the respiratory impacts of transport related emissions to the harsh human cost of traffic collisions (Ewing and Dumbaugh, 2009; Najaf et al., 2018) to the links between transport, physical inactivity and the dehumanisation of public spaces (Frank et al., 2004; Bassett et al., 2008). Much of the research in this space positions the private car firmly at the heart of the negative health impacts of transport (Frank et al., 2010; Douglas et al., 2011). In many developed nations, including Australia, the private car claims responsibility for the majority of trips that make up modern life, with the result being increased risk of exposure to respiratory illness, transport accidents, the health impacts of greenhouse gas emissions and a higher likelihood of living a sedentary lifestyle. Several studies have examined specifically the negative health impacts of long, car-based, commuting. Almost 80% of Australians travel to work by private car (ABS, 2016) and a recent analysis of longitudinal data on the impact of time spent commuting on mental health for 16,805 Australians found declines in mental health for those experiencing longer commutes (Milner et al., 2017). This confirms previous research undertaken in the USA, Sweden and the UK which have also linked longer commute times with physical health outcomes such as increased weight and blood pressure, heart disease, reduced time sleeping and exercising and fatigue (Hansson et al., 2011; Christian, 2012; Hoehner et al., 2012; Sandow et al., 2014; Kunn-Nelen, 2016; Sugiyama et al., 2013; Gimenez-Nadal and Molina, 2019). Studies in this space often focus purely on the concept of time as an objective measure, ignoring the complexity of links between time use and availability and human health. Of course, there is the impact of time paucity inevitably experienced by those with long commutes, whereby time to, for example, exercise, source healthy food and connect with those around us is diminished (Strazdins et al., 2011; Christian, 2012). Also of relevance, however, is the notion of commute related stress, which includes the health impacts of experiences of impedance, crowding, unpredictability and perceptions of wasted time. Research demonstrates that commuting stress is linked to a swathe of adverse mental and physical health impacts (Gottholmseder et al., 2009). Of particular note is that studies in this space consistently demonstrate that experiences of commute stress are subjective, influenced by an individual's lifestyle, attitudes, external environment, physical and mental resilience, as much as more objective measures such as traffic intensity, reliability or actual minutes spent commuting (Novaco et al., 1990; Simonsohn, 2006). This is nicely articulated by Koslowsky et al. who write: "A commute is "long" only if the driver perceives it as such" (Koslowsky et al., 2013, Page 9). Inherent to this subjectivity is that commute related stress is also influenced by past experiences which create expectations and resilience for the individual around the commute (Chen et al., 2009). The individual is likely to compare the stress they feel with their current arrangement against past positive or negative experiences, as well as against the experiences of those around them (Koslowsky et al., 2013). The very nature of subjectivity renders it difficult to attribute greater perceived stress to any particular mode or duration, the important point for the current study is that the health impacts of commuting are individual and, potentially, shaped by previous experiences.

The second general body of research of relevance to this study is the well-developed collection of scholarship unpicking the impact of moving house on transport behaviour, and the role of transport environments on residential choice. Often these studies use the concept of mobility biographies to examine the way key events in life can be moments where behaviour change is possible (Klinger and Lanzendorf,2016; Rau and Manton, 2016). This possibility has its roots in Bas Verplanken's habit discontinuity hypothesis which highlights how disruptive events can bring a subconscious habit to the surface and thus provoke reflection on its utility (Verplanken et al., 2008). Using this theory are several studies examining the ability of a relocation to provoke a shift in transport mode choice, particularly a shift away from private car use (for example, de Vos et al., 2018). Of key importance, yet often overlooked in research, is that the mobility biography paradigm conceptualises residential relocations as a "biographical transition" within an individual's mobility biography – this means relocations are an adaptation often related to several colliding circumstances rather than an event in and of itself. This implies that the impact of residential relocation on transport behaviour is a complex and well thought out interplay between individual preferences and attributes in the environment (as captured by research on residential self-selection (see for example Bagley and Mokhtarian, 2002; Bohte et al., 2009; Cao et al., 2009; Schwanen and Mokhtarian, 2005)) which are further complicated by changed routines of working, parenting, socialising and caring. Within this complexity are several studies suggesting that transport practices are not quite as open to change through the process of residential relocation as some scholars have hoped. Weinberger and Goetzke (2010) for example demonstrate the extent to which people maintain familiar yet irrational transport behaviours through changing residential circumstances. This finding has been verified more recently by Smart and Klein (2018). Both studies conclude that people carry transport practices with them when they move, regardless of whether these practices are the most efficient way to travel. This finding is reflected in research attempting to understand the role of transport and access factors on residential location decision making. This research has generally found that decisions on where to live and work can be influenced by factors beyond transport and access issues, including the journey to work (Chatman, 2009 and as captured by the notion of the commuting paradox popularised by Stutzer and Frey, 2008). For example, affordability, the quality of housing, the quality of the neighbourhood and the absence of crime are factors that often eclipse concerns about the transport environment when

families are deciding where to live (Wolday et al., 2018).

This brief review of two very broad bodies of research establishes the empirical and theoretical basis for four assumptions on which the present study is based. First, people do not necessarily choose where they live based on where they work. For many families, a short commute is likely less of a priority than access to good schools and better housing. Second, people are likely to carry their learned, habitual, comfortable and predictable transport behaviours with them post relocation, particularly if alternative transport infrastructure is poor. In the case of greenfield development, characterised by its very isolation from existing jobs, services and alternative transport infrastructure, these two notions indicate that longer, car-based commutes for the residents of these estates are inevitable. It is the health implications of this inevitability that are of interest in this paper. The third assumption therefore, is that long, car-based, commutes are associated with poor health outcomes, with the fourth notion of relevance being that these commutes are experienced as relative according to our mobility biography of previous experiences. It is not only the commute time itself that impacts our health, it is also the way we experience that commute relative to previous experiences spent travelling to work.

This loose collection of four empirically founded assumptions remain under-explored in the literature, yet as questions they are warning signs of augmented transport related health issues for those relocating to greenfield estates. The aim of this study is first to test elements of these four assumptions and, in doing so, determine the impact of associated outcomes, particularly increased commute times, on health and wellbeing.

3.0. Case study: Oran Park, camden, sydney

A combination of economic agglomeration, an ambitious immigration program, natural increase and bio-physical fragility ensure Australia's cities face constant pressure to accommodate population growth (Greater Sydney Commission, 2017). While densification within existing urban footprints is a key land use planning strategy (Hamnett and Freestone, 2017), around 50% of housing construction still occurs as low density detached dwellings in new, "greenfield" suburbs at the rural-urban interface of major Australian cities (Newton et al., 2012). The local government area (LGA) of Camden, 60 km south-west of the Sydney CBD, contains several swathes of greenfield sites central to the accommodation of Sydney's anticipated population growth (Greater Sydney Commission, 2017) and Oran Park is one such site.

3.1. Oran Park: land-use and demographic context

Prior to 2010, the 300 ha site of Oran Park was used as a dairy farm, and was also well known as a car racing circuit. Rezoning of the site occurred in 2006, construction of residential dwellings commenced in 2007, and the first residents arrived in 2010. When complete, Oran Park will house over 21,000 people in mostly free-standing houses. Future plans provide for substantial retail and commercial floor space, three schools, the new administration headquarters for Camden Council, a retirement village, library, aquatic centre and an integrated health care facility. The vision for Oran Park as articulated by its developers was for the precinct to be 'self-contained', both in terms of access to services and, to a degree, employment. This implies a vision where the residents of Oran Park have no need nor want to leave the precinct, with the desired outcome being reliance on walking and cycling for transport.

In 2018, Oran Park is home to over 6000 people (see Table 1) and the first stage of the main shopping centre has opened. Camden Council opened its new Civic Centre at Oran Park in September 2016 and a new library and community centre are under construction,

Table 1
Oran park and greater sydney metropolitan region statistical profile.

		Oran Park	Sydney Metropolitan Region
Population		4770	4,823,991
Dwellings		1559	1,855,734
Average household size		3.17	2.60
Median Age, years		29	36
Households with children		58%	46%
Median weekly mortgage repayment		$612	$495
Median weekly rent		$547	$447
Households with a mortgage		51%	32%
Households renting		29%	33%
Overseas born		22%	37%
Language at home other than English		25%	36%
University qualification		19%	28%
Trade qualification (certificate)		25%	15%
Unemployment rate		3%	6%
Participation rate (population in labour force)		72%	62%
Public transport to work		9%	23%
Private car to work		73%	57%
Households with no cars		< 1%	11%
Households with 1 car	20%	35%	
Households with 2 cars	46%	31%	
Households with 3 or more cars	23%	15%	

Fig. 1. Marketing material from Oran Park Town website, a site maintained by the developer, Greenfields Development Company.

due to open in 2019. Table 1 uses data sourced from the 2016 Australian census to demonstrate some key idiosyncrasies for the population of Oran Park relative to the Sydney Metropolitan Region (Sydney MR).

3.2. Oran Park: the transport context

Cars have had pride of place in Oran Park since 1962 when the site was home to the Oran Park Motor Racing Circuit. The development of Oran Park Town celebrates its heritage as the former raceway through public art, including an artistic rendition of a chequered flag where the old finish line used to be, and commemorative street naming after famous racing car drivers.

Perhaps ironically, while celebrating its car racing history, the Oran Park Town precinct has been developed explicitly to encourage reduced car dependence (Fig. 1). In addition to the developer's intention for the precinct to be as self-contained as possible, Oran Park was designed in collaboration with the state government Ministry of Health and used the Heart Foundation's *Healthy by Design* guidelines to incorporate a best practice approach to the provision of walking and cycling networks (National Heart Foundation, 2004).

This vision of a contained, actively accessible precinct with residents living lives independent of private cars begins to disintegrate at the notion that the residents of Oran Park will have no need or desire to leave their estate. Although all the basics of life may be within the shops, services, schools and facilities of Oran Park, residents will no doubt leave to visit a favourite café, see family and friends, and access the things they may not need, but certainly want, from outside of their local neighbourhood. Furthermore, it is likely that employment options in the area will only support a small percentage of the growing community. Over 65% of Camden residents do not work within the Camden LGA, let alone within their own walkable neighbourhood (ABS, 2016). Even for those who do work locally, travelling to work by car is very much the norm – over 95% of Camden's workers either drive or are driven to work (ABS, 2016). Analysis of the alternative transport options available in Oran Park demonstrates just how difficult it currently is for residents to leave the precinct using any other mode than a private car. The closest train station to Oran Park is 13 km away at Leppington. The only other alternative to the private car is three bus routes. None of them are direct to commonly accessed destinations such as the Leppington station and at peak times buses come approximately every 30 min. This is reduced to hourly outside of peak times, with services ceasing to operate between 9pm and 5.30am (Transport for NSW, 2018). In short, the frequency of services and connectivity to the wider network is inadequate to stimulate regular public transport use, and as a result the precinct is currently car dependent.

4.0. Method

4.1. Survey instrument and analysis

A survey instrument was designed to explore the interplay of the transport context with the behaviours, attitudes and wellbeing of the newly established community of Oran Park. Administration of the survey was approved by the Human Research Ethics Committee at the University of Sydney (project number: 2016/639). It was available online to residents of Oran Park between April and July 2017. Only people over the age of 18 who had moved to Oran Park within the past two years were eligible to participate, enhancing the likely accuracy of questions based on participant recall of practices prior to relocation (Purvis and Ruiz, 2003). Participants were recruited through a combination of hard copy posters and postcards delivered to residents and local businesses and postings on social media. The survey was self-administered, and took, on average, 18 min to complete.

The survey consisted of eight sections including questions on the commute past and present (time, mode, time of day, access to parking), transport attitudes and reasons for relocating to Oran Park. The survey concluded with several questions on physical and mental health and demographics. As much as was practicable, established and tested measures were used to enhance the validity of findings.

The survey was completed by 317 people. Assuming only one person per household completed the questionnaire, this results in a response rate of 20.3%. Although this is a reasonable response rate, the useable sample for more complex analysis was lower, depending on which variables were used. The actual sample for analysis is provided in Table 6. The limitations of the sample size are addressed in detail in the presentation of results and in the conclusion.

As established in the review of the literature context (Section 2), this study examines elements of transport practices and attitudes

Table 2
Summary characteristics of study participants.

Time lived at current address (n = 189)	%
0–3 months	18.5
3–6 months	17.5
6–9 months	14.8
9–12 months	13.8
1–2 years	35.4
Employment status (n = 239)	**%**
Not working	18.4
Employed FT	53.6
Employed PT	4.2
Self employed	18.8
Other	5.0
Gender (n = 183)	**%**
Male	30.1
Female	69.9
Age group (n = 148)	**%**
18–34	51.4
35–44	26.4
45–64	16.9
65 and above	5.4
Median age (years)	34
Household composition (n = 179)	**%**
Households with children	60.9
Household tenure (n = 183)	**%**
Owned with a mortgage	68
Rented	16
Other	16

of recently relocated residents to Oran Park to measure the interplay between these elements and health and wellbeing. Descriptive statistics and dimension reduction informed further analysis using multiple regression techniques. Regressions focussed on five key health-related measures as dependent variables. These were explored using a series of independent variables covering transport practices, attitudes to transport and relocation, and socio-demographic factors. The next section of this paper outlines the independent variables, including dimension reduction techniques. This is followed by the approach and results of the regression analyses, including a review of the independent health measures used.

4.2. Independent variables

4.2.1. Demographics

Table 2 shows the frequencies for demographic variables. These build on the picture presented in Table 1. Whilst the sampling frame meant that it was not feasible to apply quotas to achieve representativeness, the sample provides insights to some of the idiosyncrasies displayed for Oran Park relative to the Sydney GMR discussed earlier. Respondents came mostly from households with children (60.9%). This is similar to the general population of Oran Park (58%). The sample had a median age of 34, compared to 29 for Oran Park – both are younger than the population of Sydney. The workforce participation of the sample was slightly higher than that of Oran Park more generally (82% *cf* 72%) and higher than the rate for greater Sydney (62%). Most respondents were paying a mortgage and noticeably fewer respondents were renting their property as compared to Oran Park and the Sydney region (16% *cf* 29% and 33%). It is not surprising that every respondent lived in a household that owned at least one car. This is reflective of Oran Park, where only 0.6% of households are car-less. As is often the case with situated, survey-based research, the sample was dominated by female respondents (70%). This is not reflective of the gender split in Oran Park or Sydney region. It is more likely a product of the fact women are more likely than men to participate in research about domestic matters (Sax et al., 2003).

4.2.2. Reasons for choosing Oran Park

Section 2 presents research indicating that transport context, particularly relevant to place of employment, does not necessarily influence residential location choices. To measure reasons for relocation to Oran Park, the survey asked respondents whether they

agreed or disagreed with a series of 12 statements on a 5-point scale from 1 ('not important at all') to 5 ('extremely important'). Confirming existing research, several variables related to quality of life and housing affordability feature, taking priority over access concerns such as proximity to work and access to public transport.

Factor analysis was used to extract the fundamental dimensions spanned by these 12 statements with results used as independent variables. Table 3 shows the three underlying dimensions identified using principle components extraction and varimax (i.e. orthogonal) rotation. The choice of the number of factors is based on eigenvalues being greater than one together with visual inspection of the scree plots. Cronbach's alpha measures the internal consistency of the dimension with values above 0.7 showing good consistency. Here the dimensions of family and friends and quality of life show good internal consistency with work, college and school being less so.

4.2.3. Transport – commute characteristics and transport attitudes

Travel behaviour was variously measured through a series of questions on commute trips and non-work trips, both before and after relocating to Oran Park, as well as questions on attitudes to transport.

Regarding characteristics of the commute, respondents were asked to estimate the amount of time, past and present, it takes them to get to work 'on most days'. They were asked to rate their satisfaction with their commute time, both past and present, as well as the time of day they usually travel, both past and present. In addition, respondents were asked to list vehicles currently available to the household, and access to parking both onsite and at their place of work or study.

Table 4 shows that most participants travelled to work or study by car. Comparing mode prior to relocation with mode from Oran Park, the incidence of car travel increased by 6.5%pts and participants were less likely to commute using public transport (23.5% present compared to 26.5% prior to moving). Those who did commute by public transport from Oran Park were more likely to drive to the train station or bus rather than walk. Table 4 also shows that commute times, on average, increased substantially on moving to Oran Park. Commute time increased by an average of 16.3 min one way with a large increase in the percentage of very long commutes (> 80 min) and a decrease in short commutes (< 20 min). Commuters were also leaving home earlier to get to work, and were less likely to be satisfied with their commute than they were before they moved.

Several independent variables were constructed from this data, including 'Travel time earlier since moving to Oran Park', 'Increase in travel time since moving to Oran Park', 'Free parking at work/study' and 'Changed travel mode when moving to Oran Park'.

To measure attitudes to transport, the survey asked respondents whether they agreed or disagreed with a series of 27 statements on a 5-point scale from 1 ('strongly disagree') to 5 ('strongly agree') (based on Handy et al., 2005). Factor analysis was used to extract the fundamental dimensions spanned by these 27 statements. Table 5 shows the three underlying dimensions that were identified using principle components and varimax (i.e. orthogonal) rotation. As above, eigenvalues and scree plots were used to determine the number of factors. Cronbach's alpha shows good internal consistency for all dimensions except pro-car.

4.3. Regression approaches

Different functional forms were explored using regression analysis and more detail is provided below alongside the results. The number of valid cases available for regression analysis was between 105 and 130 depending on which independent variables were used. There were 39 potential independent variables but the high ratio of independent variables to valid cases justified implementation of a filtering process which used two considerations. First, whether there was a significant (or near-significant) correlation between the independent and dependent variables. In cases where the correlation was small and statistically insignificant the potential independent variable was excluded from the regression. Second, the extent to which potential independent and dependent variables are identified in the literature as significant. This criterion was intended to capture cases where an independent variable,

Table 3
Factors characterising location decision in Oran Park (n = 248).

Factor	Statements contributing highly to factor	% [a]	Loadings[b]			Cronbach's alpha
Family and friends	Being close to family	50			.854	0.743
	Being close to friends	37		.263	.818	
Work, College and School	Being close to paid work	61		.721		0.614
	Being close to where you study	32		.729	.317	
	Being close to schools	71	.367	.666		
	Returning to the neighbourhood of my childhood	13		.418	.385	
Quality of life	Good public transport access	59	.400	.397		0.802
	Being able to drive everywhere	84	.522		.289	
	Better quality housing/new build	90	.822			
	Being able to afford a bigger home	78	.723	.265		
	Attractive urban environment	87	.841			
	Family friendly area	90	.799			

Notes.
[a] % of respondents indicating that the sentiment of the statement is 'important' or 'extremely important'.
[b] Loadings less than 0.25 suppressed for ease of presentation.

Table 4

Characteristics of the commute.

Mode of travel to work/study	% Before moved (n = 170)	% Present (n = 170)
Car by self or others	67.6	74.1
(of which car with others)	(4.7)	(5.3)
Car to public transport	10.6	19.4
M/C or scooter	0.6	0.6
Walk	4.7	1.2
Walk to PT	15.9	4.1
Work at home	0.6	0.6
Estimated commute travel time one way	**% Before moved (n = 170)**	**% Present (n = 170)**
0–20 min	38.8	21.2
> 20–40 min	31.8	25.3
> 40–60 min	20.0	27.0
> 60–80 min	5.9	6.5
> 80–100 min	1.7	13.5
> 100 min	1.8	6.5
Estimated commute travel time minutes one way	**Before moved (n = 170)**	**Present (n = 170)**
Average	33.8	50.1
Satisfaction with commute travel time	**% Before moved (n = 170)**	**% Present (n = 170)**
Very dissatisfied	6.5	20.0
Dissatisfied	11.8	25.3
Neither satisfied nor dissatisfied	21.8	19.4
Satisfied	38.8	22.9
Very satisfied	21.2	12.4
Commute time of day	**% Before moved (n = 170)**	**% Present (n = 170)**
Between 5am and 7am	21.8	28.8
Between 7am and 10 a.m.	68.8	64.1
Between 10am and 3pm	4.7	4.1
Between 3pm and 7pm	1.8	0.6
After 7pm and before 5am	2.9	2.4

whilst not directly correlated with the dependent variable, would come into play as an explanatory factor when considered as part of a multiple regression model (i.e. it may be a factor that explains other less directly causal but correlated potential independent variables). This filtering process stabilised the modelling process and helped to avoid spurious relationships that can appear when relatively small samples are used to model large numbers of potential explanatory variables. Regression diagnostics were used to examine the models to ensure they met the assumptions of the linear regression model. Multicollinearity was checked using variance inflation factor scores. All other assumptions (homoscedasticity, normality of the error terms, linearity, and zero autocorrelation) were checked by visual examination of the error plots.

4.4. Regression results

The key result is that travel behaviour attributes, including experiences of change to these attributes, as well as travel attitudes, are influential on mental health and subjective wellbeing.

Table 6 presents the results of the five regressions used to explore the research question. It shows where common variables are included in more than one model, with the following sections interpreting each model in turn. In all cases, statistically non-significant independent variables are included in the models where suggested by prior expectation and where their exclusion may cause bias when the model is used to produce estimates from the significant variables.

4.4.1. Models 1 and 2: mental and physical health (MCS12 and PCS12)

General physical and mental wellbeing was assessed using the Short Form-12, version 2 (SF-12-v2) (Ware et al., 1995). This scale consisted of 12 items scored so that high scores reflect better health (Cronbach's alpha = 0.87). Following recommended scoring algorithms, the items were converted into standardized T-scores and summed to form two scales. The first, Mental Component Summary (MCS12) measures mental health. The second, Physical Component Summary (PCS12) measures physical health. As continuous variables, these were used as dependent variables in multiple regressions.

The results of the linear regression model for mental health are shown in Table 6 as **Model 1**. In terms of goodness of fit, the R-square suggests that nearly 23% of the variation in the data is explained by the model and this is statistically significantly different

Table 5
Factors characterising travel attitudes (N = 218).

Factor	Statements contributing highly to factor	%[a]	Loadings[b]							Cronbach's alpha
Resents travel time	Travel time is generally wasted time	55.7	.752							0.761
	My commute is a real hassle	45.2	.677	.255						
	My commute trip is a useful transition between home and work	28.6	-.642							
	The travelling that I need to do interferes with doing other things I like	47.9	.744							
	I use my commute time productively	24.7	-.573	.347						
	Getting stuck in traffic doesn't bother me too much	8.2	-.617							
Pro public transport	Travelling by car is safer overall than taking public transport	26.2		-.607						0.769
	I prefer to take public transport rather than drive whenever possible	21.5		.736			.283			
	Public transport can sometimes be easier for me than driving	40.6		.716						
	I like taking public transport	22.3		.725						
Pro car	I like driving	63.3		-.262	.609					0.551
	Getting there is half the fun	27.7			.705					
	I like to drive just for fun	19.6			.729					
	I feel free and independent if I drive	77.3			.670					
Pro bike	Travelling by car is safer overall than riding a bicycle	77.4		-.290		-.400				0.678
	I like riding a bicycle	23.3				.801				
	I prefer to ride a bicycle rather than drive whenever possible	4.1				.798				
	Riding a bicycle can sometimes be easier for me than driving	5.5				.751				
Pro walk	I prefer to walk rather than drive whenever possible	34.8					.796			0.738
	Walking can sometimes be easier for me than driving	26.2					.763			
	I like walking	69.4					.732			
Pragmatic car user	To me, the car is a status symbol	11.4						-.733		0.655
	It does not matter to me which type of car I drive	54.3						.785		
	To me the car is nothing more than a convenient way to get around	58.0						.628	0.366	

Notes.
[a] % of respondents indicating that they either 'agree' or 'strongly agree' with the statement.
[b] Loadings less than 0.25 suppressed for ease of presentation.

from zero (F = 7.386, p = 0.000). This model indicates two variables that are significantly associated with a lower mental health score. The first is having to leave for work earlier since moving to Oran Park. These are participants who, for example, may have left for work between 7am and 10am before moving to Oran Park, and now find they need to leave for work between 5am and 7am. This is the most important variable in the model in terms of explaining the mental health score. Those experiencing a change in their travel time of day had an MCS score of 9.4 less (against an average score of −13.2) than those whose travel time of day stayed the same. The second is the attitude to transport that resents time spent travelling. These people were more likely to say that their commute was wasted time, that transport generally interferes with more enjoyable activities, and that travel time cannot be used productively. An increase of 1 in the 'resenting travel time' factor is associated with a reduction of 2 in mental health score in Oran Park.

The dependent variable, PCS12 assesses participants' level of activity, incidences of impedance due to physical incapacity and experiences of physical pain. The results of the best linear regression model for physical health are shown in Table 6 as **Model 2**. This model shows a bivariate relationship with only one variable significantly associated with physical health – age. Younger people were more likely to report a higher physical health score in Oran Park. This is as expected. Despite R-squared being significantly different from zero (F = 16.013, p = 0.000), the model explains just over ten per cent of the variation in the data. The constant term being insignificant suggests that there are no seriously missing variables. It is possible that changes in physical health scores take longer to materialise and that changes in travel behaviour might be reflected in changed scores in the future. This is further discussed below.

4.4. 2: models 3, 4 and 5 - subjective wellbeing

While subjective wellbeing (SWB) is a broad concept, its defining feature is that it is a self-evaluation of health and happiness life (Diener, 2000). SWB is measured as cognitive (thought) and affective (felt) states (Diener et al., 1998).

To ensure the survey remained as brief as possible, cognitive SWB was measured using the Satisfaction with Life Scale (SWLS) developed by Diener et al. (1998). This scale has been applied widely as a comprehensive assessment of satisfaction with one's life rather than satisfaction with specific domains of life (such as work or family). It has shown strong internal reliability, and moderate temporal stability (Pavot and Diener, 1993). It consists of five items ("In most ways my life is close to my ideal"; "the conditions of my life are excellent"; "I am satisfied with my life"; "so far I have gotten the important things I want in life" and "if I could live my life over, I would change almost nothing"). The participant is asked to provide an evaluation of their life for each and the mean score is used as the dependent variable.

Table 6

Best model results for mental and physical health and subjective wellbeing (SWB). p-values are given in parenthesis.

	Model 1	Model 2	Model 3	Model 4	Model 5
Method	Multiple Regression	Multiple Regression	Censored Tobit Regression	Binary Logistics Regression	Binary logistic regression
Dependent variable	*Mental Health Scale (MCS12)*	*Physical Health Scale (PCS12)*	*SWB Life Satisfaction*	*SWB Negative Effect*	*SWB Positive Effect*
Constant	−15.740 (.000)	2.999 (.177)	4.837 (.000)	−1.382 (.000)	0.777 (.007)
Travel time earlier since moving to OP	−9.460 (.001)			Exp(B) = 4.317 Wald = 7.805 (.005)	Exp(B) = 0.327 Wald = 4.200 (.040)
Transport factor score: Resent travel time	−2.067 (.033)			Exp(B) = 1.209 Wald = 0.778 (.378)	
Transport factor score: Pro car			0.267 (.006)		Exp(B) = 1.903 Wald = 8.576 (.003)
Age	.118 (.213)	-.221 (.000)			
Increase in travel time mins when moved to Oran Park	−1.664 (.421)				
Travel time of day changed when moved to Oran Park			−0.666 (.017)		
Changed travel mode when moved to Oran Park			−0.198 (.431)		
Free parking at work/study			0.251 (.285)		
Increased satisfaction with interaction with neighbours since moving to Oran Park					Exp(B) = 5.168 Wald = 5.539 (.021)
Work status self employed					Exp(B) = 4.119 Wald = 4.347 (.037)
N	126	140	123	129	127
R-square	0.228	0.104			
Pseudo R-square			0.050		
Goodness of fit	F = 7.386 (0.000)	F = 16.013 (0.000)			
Loglikelihood			−202.130		
−2 Loglikelihood				136.383	126.501
Chi-Square			21.21 (.000)	10.324 (.006)	27.259 (.000)
Cox and Snell R-square				0.077	0.193
Nagelkerke R-square				0.113	0.279
Number of cases	105	139	129	129	127

Note: Exp(B) shows the factorial effect on the odds ratio if a unit change in the independent variable.

The results of the Tobit (censored) regression model for life satisfaction are shown in Table 6 as **Model 3** where a censored analysis recognises the dependent variable has a minimum value of 1 and a maximum value of 7. The model is significant with $p < 0.0005$, but it explains just 5% of variance in the subjective wellbeing score. Nevertheless, it indicates two independent variables that are significantly associated with the SWLS. The first is an attitude to transport that favours driving and car use. These people were more likely to say they like driving, that they drive just for fun, and that they feel free and independent when they drive. Having an appreciation of private driving and private car use is associated with higher life satisfaction in Oran Park: a unit increase in the factor score is associated with an increase in the social wellbeing score of 0.27, or approximately a quarter of a point increase on the 1–7 scale. The second is a change in the commute time of day since moving to Oran Park. This variable is similar to that featuring in Model 1 for mental health and below in Model 5 for happiness. These are participants who have had to change the time of day they commute since moving to Oran Park. Both earlier and later commute times were significant – it is simply the change that is important. Having to leave for work at a different time since moving to Oran Park is associated with a decrease of 0.67 in the score for satisfaction with life.

Affective SWB was measured using two questions asking about specific emotions experienced by the respondent 'yesterday'. This is also a widely applied measure (see Ettema and Schekkerman, 2016). The number of emotions in this inquiry was limited to two (as used in Ma et al., 2018) to reduce the survey burden for participants. The two questions are "I felt happy yesterday" (positive affect) and "I felt anxious yesterday" (negative affect). Each item was scored using a seven point Likert scale, ranging from strongly disagree to strongly agree and the mean of the scores are used as dependent variables analysed separately from life satisfaction. In creating scores for the positive and negative affect SWB, the seven point score described above was reduced to a binary variable by recoding all the agree responses as 'yes' and all others (including neutral) to 'no' so that a binary logistic regression was possible. This rescaling of the dependent variable was motivated by the sample size which did not permit a multinomial logit regression including all seven data points.

For negative effect SWB, the results are presented in Table 6 as **Model 4**. The model overall has a significance level of 0.006 and the reported pseudo R^2 estimates indicate that it explains about 10% of the variation in negative effect SWB. Model 4 shows one variable is significantly associated with feeling anxious – having to leave for work earlier since moving to Oran Park. The reported odds ratio (Exp(B)) of 4.317 indicates that the odds of a person whose travel time of day has become earlier (since moving to Oran

Park) exhibiting negative effect SWB is 4.317 times higher than that of a person whose travel time of day has remained the same or become later. This variable also featured in Model 1 above for mental health, and Model 5 below for happiness. Having to leave for work earlier is associated with feeling anxious in Oran Park.

For positive affect SWB, the results are presented in Table 6 as **Model 5**. The model overall has a significance level of < 0.0005 and the reported pseudo R^2 estimates indicate that it explains about 20% of the variation in positive effect SWB. The model includes four variables that are significantly associated with feeling happy in Oran Park, two of which are transport-related. The first is an attitude to transport that favours driving and car use – also significant in the model for life satisfaction (each unit increase in the factor score increases the odds of positive effect SWB by a factor of 1.9). The second transport related variable of significance for happiness is having to leave for work earlier since moving to Oran Park. This variable also featured in models 1 and 4 for mental health and anxiety. Having to leave for work earlier decreases the odds of positive effect SWB by a factor of 0.327.

4.4.3. Results summary

In summary, results of modelling suggest several significant relationships between transport variables and different indices of wellbeing. First, resenting travel time by, for example, feeling that travel time is wasted, and that the need to travel impedes participation in other activities, is associated with lower wellbeing scores. Second, and obviously related, is that changes to commute times – whether a change to the time of day at which the commute occurs, or a change in duration since moving to Oran Park - is also associated with lower wellbeing scores. Third, having an appreciation for car travel, for example, acknowledging a sense of freedom from driving a car, is associated with higher wellbeing scores in Oran Park. Finally, while several variables were found to be significant for measures of mental health and subjective wellbeing, the results for physical health were less conclusive. In summarising these results it is also instructive to assess those variables included in modelling that were not found to be significant. Satisfaction with neighbourhood facilities and sense of community cohesion, reasons for choosing Oran Park, and the amount of time passed since relocating (0–24 months) did not have significant impacts on health or subjective wellbeing.

5.0. Discussion

It was initially posited that Oran Park residents would experience changes to their commute, including longer commute times compared to their experiences prior to moving, that these commutes would be car dependent, and that this combination would impact wellbeing in different ways. These outcomes are the result of first a lack of public transport options and second a de-prioritisation of transport in the residential decision-making process. The aim of this study was to document these presumptions and then demonstrate the impact of these outcomes on health and wellbeing.

Our findings confirm our presumptions on several fronts. First, our results demonstrate the de-prioritisation of transport and access issues in the residential decision-making process. Over 80% of respondents identified 'better quality housing/new build', 'a family friendly area' and 'an attractive urban environment' as 'important' or 'very important'. This dropped to 60% when participants were asked whether 'good public transport access' and 'being close to work' were important. This de-prioritisation is reflected in the transport practices of our respondents. For example, our results show that the residents of Oran Park face lengthier commute times since relocation. For study participants, the average commute time had increased by nearly half an hour each day and this commute was more likely to be by private car. Nearly 20% of respondents now lived the harsh reality of the 'extreme commute' (defined as more than 90 min one way (Marion and Horner, 2007, page 39; see also Rapino and Fields, 2013; Bissell, 2014b)). This increased from 6.3% prior to relocation. Our results also confirmed our assumption that these commutes would be car dependent. Over 94% of participants used a private car to travel all or part of the journey to work – an increase of 14% since relocating.

In relation to the second component of our aim, the findings confirm that these changed transport practices are related significantly to lower mental health scores, self-reported feelings of anxiety and a negative response for self-reported feelings of happiness. Conversely, enjoying and appreciating the private car was associated with self-reported feelings of happiness in Oran Park.

These findings have implications for the way transport provision and resultant behaviour is impacting the wellbeing of Oran Park's residents, now and into the future. Wellbeing implications of transport-related time poverty for residents of greenfield estates in Australian cities are confirmed (Cf. Dodson and Sipe, 2008; Currie and Delbosc, 2010; Pocock et al., 2012). The findings also add weight to existing evidence that long commute times to work may be a risk factor for poor health (Cf. Costal et al., 1988; Cassidy, 1992; Lyons and Chatterjee, 2008; Gottholmseder et al., 2009; Novaco and Gonzalez, 2009; Hansson et al., 2011; Roberts et al., 2011; Ettema et al., 2013; Olsson et al., 2013; Feng and Boyle, 2014; Legrain et al., 2015; Milakis et al., 2015; Sha and Li, 2018). In addition to verifying these existing studies, the results reported here contribute new knowledge because of their emphasis on not only the actual commute time, but the experiences of changes to commute times. This reveals several key plausible pathways through which day-to-day transport behaviour may affect indices of human health. These are now discussed.

Travel time as wasted time

Primarily, it may be that additional time getting to and from work reduces the amount of time that the newly arrived residents of Oran Park have for other activities (for example, personal care, sleep, exercise, family time), thus cutting into the time available to recover from the demands of a job. A similar explanation has been given for the relationship between long working hours and mental health (Dugan and Barnes-Farrell, 2017; Roxburgh, 2004). As outlined in Section 2 (Literature Context), another related pathway between poorer health outcomes and the commute is that the experience of commuting is stressful in and of itself. There are two components to this. First, unlike other time-related stressors (such as long work hours) time spent commuting may be considered to

be 'wasted,' because individuals are not able to use the time commuting for other activities such as actual paid work, or time with family. Almost half of this study's participants agreed to feeling that travel time was wasted time, and that time travelling prevents participation in more useful activities.. The findings of this study are particularly insightful because they demonstrate the way the perception that a person's commute time is excessive is formed (in part) by the individual's previous experiences of getting to and from work. Hence the anxiety felt by those whose commute time has increased since moving to Oran Park will be greater than those who may have had a similarly long commute time all along. This is demonstrated by the way changes to travel durations and time of day feature in three of our five models, negatively impacting mental health, life satisfaction and experiences of anxiety.

Travel time as stressful

In Section 2, the literature identifies that not all commutes are created equal. For some, an hour speeding up a deserted highway is likely to be less frustrating than 60 min in a slow-moving line of fellow urban aspirants (Gottholmseder et al., 2009). A vast body of psycho-social research has concentrated on the way travel impedance (also known as being stuck in traffic) shapes the stress associated with the commute (Novaco et al., 1990, 1991; Novaco and Gonzalez, 2009). More recently, research in this space has factored in reliability to measures of the health impact of commuting time. This research shows that the most stressful trips result from travelling long distances through multiple intersections at a slow speed, where the average duration of the trip is highly variable. Validation for these concepts has been confirmed in several investigations involving criterion measures of physiology, task performance, mood states, subjective distress, and physical health problems (for example Hilbrecht et al., 2014; Higgins et al., 2018). What seems to be missing from this comprehensive research body are ways to account for individual preferences and past experiences in measures of commute related impedance and predictability. This study has demonstrated that for the commuters of Oran Park, commute stress is likely to be influenced by past experiences of the amount of time spent commuting. While not measured in this survey, it is plausible that this would extend to past experiences of impedance and predictability – an avenue for future research.

Travel time as both duration and point in time

Time in the context of the commute, can be conceptualised as *duration* or a *point in time*. To date, studies of the commute generally concentrate on the impact of the commute duration. The analysis in this paper shows that the point in time when the commute occurs, and more precisely relative changes to this time since relocating, is also important. Again, there are several plausible pathways for this. Respondent X, for example, moved to Oran Park from a suburb approximately 15 km directly to the west of the Sydney CBD. His commute increased by 45 min each way. For reasons not captured by this survey, he started to leave for work between 5am and 7am instead of leaving between 7am and 9am, as he had previously. This might be either to avoid the traffic associated with peak hour in Sydney, or because he simply needs to leave earlier to start work on time. This study's survey shows that he lives in a detached dwelling with a spouse and one child under the age of 6. What is unknown, but can be easily imagined, is that when Respondent X leaves for work, his spouse and child are, quite possibly, asleep. It is dark. His routine prior to relocation of having breakfast with his family is eroded. It is, potentially, *when* the commute occurs, rather than the duration as such, that impacts mental health and subjective wellbeing.

In summary these findings add to an emerging body of research calling for greater emphasis on the subjectivities imbued in any analysis of links between travel behaviour and human health. The way this study has been able to capture the impact of changed travel behaviour rather than simply travel behaviour as a static practice, is novel. This demonstrates the subjectivity of past experience, and the importance of conceptualising travel and its impacts on health as part of the rich continuum that is an individual's life. This influence has been theorised and explored in detail using qualitative methods (for example, Bissell, 2014a and b), however until now it has not been examined using quantitative data on both changed travel times and indices of health and wellbeing. While at an individual level one might say that the impact will decrease over time as people adjust (as suggested by de Vos et al., 2018 and an avenue for future research), of particular concern is that the social and cultural impacts of a community experiencing increased commute related stress *en masse* are, potentially, substantial. This needs to be seen in the context of approximately 134,880 people moving to estates just like Oran Park in the Camden locality over the next five years. This forecast is repeated across several local government areas in Sydney, as the city struggles to accommodate a rapidly increasing population.

6.0. Conclusion

This study is limited by its relatively low response rate. This is often the case with spatially and temporally specific surveys conducted independent of the luxury of an existing panel (Nulty, 2008). This is not a reason, however, to avoid exploration of the many and varied issues associated with transporting the populations of our growing urban areas. In this case, extreme care has been taken in the analysis, and the results are situated within broader findings.

The survey upon which this paper is based is also limited by its cross-sectional nature, which prohibits the assertion of causal relationships. Moreover, the generalisability of the findings are limited because results may be specific to the south-western Sydney transport context. There are other areas of analysis that would have strengthened the findings but were excluded from the survey instrument in an effort to limit participant fatigue. For example, the study did not seek to interrogate transport practices outside of the journey to work. A direct focus on non-commute-based transport would have given a more rounded insight into the extent of car dependence in Oran Park. Finally, the results presented here would be enriched substantially by a mixed methods approach that incorporated qualitative methods to explore, in depth, some of the emergent themes.

Although there are limitations, this paper provides a relatively detailed snapshot in time of life lived in a new greenfield suburb on the outskirts of a large Australian city, and sets the stage for future research. The study has unpicked some of the pathways between commute times, mental health and subjective wellbeing, and identified the prime position of the private car in these indicators. It has also contextualised these findings against a backdrop of a recently re-located population, and revealed links between reasons for relocating and transport practices. These findings need further research in the future.

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