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Acceptability and perceived feasibility of strategies to increase public transport use for physical activity gain – a mixed methods study

Running title

Public transport use and physical activity

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Acceptability and perceived feasibility of strategies to increase public transport use for physical activity gain – a mixed methods study

Abstract

Issue addressed: Public transport (PT) users typically accumulate more physical activity (PA) than motor vehicle users. This mixed-methods study aimed to determine acceptability and perceived effectiveness of strategies to increase bus use for PA gain in a regional Australian setting. Methods: In a 2017 online survey, Tasmanian adults (n=1,091) rated the likelihood of increasing their bus use according to 10 hypothetical strategies (fare-, incentives-, information- or infrastructure-based). Three focus groups and five interviews (n=31) included infrequent bus users from the survey to determine reasons for strategy preferences and potential impact on PA. Results: The top three strategies in the survey, with supporting rationale from qualitative data, were: provision of real-time bus information (“...because I can better plan...”); bus-only lanes (“...it just speeds the whole thing up...”) and employee incentives/rewards e.g. bus fare credits (“...it really comes down to money...”). Full-time students favoured cost-saving strategies most and residents in outer suburbs favoured infrastructure-based strategies most. Qualitative data indicated that potential for enhanced certainty, efficiency or cost savings drove strategy preferences and some strategies may lead to PA gain (e.g. through the location of Park and Ride facilities). Conclusions: Real-time

information, bus-only lanes and employee incentives/rewards appear most promising for increasing bus use in this population, but tailoring strategies may be required. Discrete PT enhancement strategies may result in PA gain. So what? Increasing PA through transport behaviour has been underexplored. The potential for PA gain through greater PT use and discrete PT use enhancement strategies is an important public health consideration.

Summary

Public transport use can lead to physical activity (PA) gain. 1,091 adult Tasmanian survey respondents favoured three/ten strategies to increase bus use: real-time bus information, bus-only lanes, employee incentives/rewards. Follow-up focus groups/interviews (n=31) indicated: potential for better certainty, efficiency or cost-savings drove strategy preferences; some strategies may facilitate PA gain.

Keywords

environment and public health; health; walking; public policy; exercise; transportation facilities

1. Introduction

Physical inactivity is one of the most significant global health concerns, causing 6-10% of coronary heart disease, type 2 diabetes and breast and colon cancers (1). It poses similar risk for premature mortality as smoking and obesity with productivity losses and healthcare costs to the international community conservatively estimated at INT\$67.5 billion in 2013 (1,2). Globally, physical activity (PA) participation is low and appears to be declining, while in Australia the proportion of persons (≥ 15 years) not meeting PA targets has remained stagnant since the 1980s, at around 35-40% (3,4). Much effort has focused on redressing physical inactivity through leisure-time activity, with little obvious impact, suggesting that targeting other domains of PA is required (5).

Many international, national and state-based frameworks for PA promotion highlight that environments that support healthy transport (e.g. walking, cycling, public transport (PT)) can lead to daily PA gain (6,7,8,9,10). Up to 33 minutes/day of PA is accumulated through PT use and PT users are 3.5 times more likely to be classified as sufficiently active than motor vehicle drivers (11,12). Compared with motor vehicle users, healthy transport users have

lower body mass index (BMI) and those who walk or cycle to work have lower cardiovascular risk than non-active commuters (13,14).

Healthy transport use also has significant social, environmental and economic benefits. For example, increasing PT patronage through less motor vehicle use may help to mitigate air pollution's contribution to the global burden of disease (15). In an ageing population greater PT use over motor vehicle use may reduce the decline in PA and isolation commonly associated with ageing (16,17). Despite many potential benefits, overall PT use in Australia is low. In the 2016 Australian census, of those employed ≥ 15 years, only 9.2% used PT as a single method of transport for the journey to work (18). In regional areas and smaller cities PT patronage is commonly lower compared with more densely populated areas. For example, 2016 Australian census data indicated that in Tasmania (an island state of Australia), within the Greater Capital City, Hobart, only 5.3% of employed residents were estimated to use PT to get to work compared with 20.9% in the more densely populated Greater Capital City, Sydney (18). Lower PT use in regional areas is concerning, because PA rates are frequently lower in regional areas when compared with major cities and geographical health inequities exist favouring those living in major cities (19). There may be opportunity to increase population levels of PA through increased PT use and concomitant reductions in motor vehicle use. However, there are knowledge gaps regarding strategies that may reduce motor vehicle use and enhance PT use and the relationship between PT enhancement strategies and PA behaviour, especially in regional settings. A 2014 systematic review and meta-analysis of behavioural interventions to reduce car use, concluded that across the 15 included studies in the review there was significant heterogeneity and a high risk of bias because of questionable methodological quality. Further, only two urban-based intervention studies (both European based) designed to reduce motor vehicle use through increased PT or active transport (e.g. walking or cycling) provided adequate information to be included in the meta-analysis (20,21,22).

An important precursor to intervention development is formative research that tests the acceptability and feasibility of possible strategies with the target group of interest. PT use enhancement strategies, particularly in regional areas, may have unique place-based considerations and a failure to understand these may plausibly result in mis-targeted, inappropriate and costly interventions that are unlikely to succeed. Research that gauges

community perceptions of the likely success of interventions to augment PT use are therefore required.

The aim of this mixed methods study was to fill a knowledge gap identified by key stakeholders (a public transport provider and local and state government) by determining the acceptability and perceived impact of several hypothetical strategies aimed at increasing PT use for PA gain, among adults in a regional Australian setting.

2. Material and methods

2.1 Study design

This cross-sectional mixed-methods study incorporated a quantitative online survey and nested qualitative focus groups and individual telephone interviews. The aim of the qualitative study was to gain a deeper understanding of preferred intervention strategies identified in the survey. The study was designed in consultation with a PT provider, a local council and a state government department. Both the quantitative and qualitative studies were underpinned by a geo-social-psychological conceptual model of travel behaviour to comprehensively capture travel behaviour, preferences, perceptions and attitudes. (23). The Consolidated Criteria for Reporting Qualitative Research (COREQ) guided the design of the qualitative study (24).

2.2 Study population and recruitment methods

Tasmania is a regional island state of Australia with approximately 510,000 people (25). A little more than half of the population live outside the capital city (Hobart), commonly in significantly-sized regional centres (25). The only mode of PT is bus, with metropolitan services predominantly afforded by one provider, Metro Tasmania. Less than 3% of Tasmanian commuters were estimated to use only PT to get to work in 2016 and only 5.3% within the Greater Capital City area of Hobart (18). Tasmania has some of the highest rates of chronic disease in Australia and is characterised by high levels of socioeconomic disadvantage (26).

Survey participants were adults (18+ years) residing in Tasmania March-April 2017. Recruitment approaches included: disseminating electronic or paper-based advertising material through professional networks and community groups or providers of community services (e.g. Metro Tasmania, member-based organisations, local and state government,

non-government organisations, libraries and aged care facilities); at formal and informal Park and Ride facilities; and through traditional (newspaper, radio) and social (Facebook, Twitter) media. Further, a link to the survey was included in a parallel biennial University of Tasmania Staff and Student Travel Behaviour Survey (27). To encourage participation, survey respondents were able to enter a draw to win one of five AUD\$100 vouchers.

At the end of the survey, participants were asked to provide contact details if they were interested in being involved in the follow-up qualitative study (n=509). Prospective participants for the focus groups and interviews were purposively selected using survey data to ensure that a range of subgroups would be represented (e.g. non and sometimes users of PT, men and women, younger and older persons, those with university and non-university qualifications, residents within and outside of the capital city, Hobart). Focus groups and interviews were conducted between June and August 2017. Engagement in the qualitative study entitled participants to a \$20 Metro Tasmania voucher.

2.3 Procedure

Ethics approval was granted by the Tasmania Social Science Human Research Ethics Committee (H0016327).

The survey was prefaced with an information sheet and informed consent was required to commence the survey. Purposively selected focus group and interview participants (n=83) were emailed an information sheet and consent form. Of the 52 participants who did not participate in the qualitative study, this was most commonly due to unavailability or lack of response to email or telephone messages. Written informed consent was obtained prior to participating in the focus groups (n=26) and verbal consent was obtained before the telephone interview commenced which was audio-recorded (n=5). Participants engaged in one focus group up to 1.5 hours' duration, involving up to 10 participants at a university campus, Hobart, and telephone interviews with survey participations residing in the North West of Tasmania were up to one hour in duration. Telephone interviews instead of focus groups were conducted with survey participants in the North West of Tasmania because participants were geographically dispersed. No repeat interviews were conducted. One author (AL) led all focus groups and another assisted with the focus groups (e.g. note taking) and led all individual interviews (MS).

2.4 Measures

The online quantitative survey consisted of 55 questions about: travel behaviours (including travel diaries recording mode, purpose and duration of travel in the past seven days); PA (using items from the short version of the International Physical Activity Questionnaire (IPAQ-S) related to walking and moderate- and vigorous-intensity PA in the past seven days (28,29)); strategies to increase PT use; and demographic information (age, gender, highest level of education, employment status, language usually spoken at home, household composition, health status, motor vehicle/cycle access).

The travel behaviour questions were informed by best practice guidelines for design of both household and workplace travel behaviour surveys and through consultation with project partners (30,31,32). The IPAQ-S was included because it is a reliable and widely used measure of PA behaviour (33). Ten hypothetical strategies to increase PT use were fare-, incentive-, information- or infrastructure-based (Table 1). Strategies were selected subsequent to discussions with key stakeholders (e.g. fare reductions), following review of strategies that incorporated established behaviour change techniques (e.g. provision of written or verbal information, behavioural economics) and whether they were realistically implementable (34,35,36) (Table 1). Respondents were asked to select one of five options regarding the likelihood that each strategy would encourage them to use PT more often (extremely likely, likely, not sure/maybe, not likely, not at all likely). The top ranked strategies were determined by counting the responses “extremely likely” and “likely”.

The discussion schedule for the qualitative study focused on: use of and perspectives on the benefits and barriers of public and other types of transport; reasons for using or not using PT; the relationship between transport behaviour and PA/health; views on strategies to increase PT use with a focus on those that were most popular in the survey (provision of real-time bus timetable information; bus lanes; Park and Ride facilities; loyalty schemes for using bus services; employee incentives; and reduced fares outside of peak periods). In this manuscript, we present only the findings from the survey and qualitative study relevant to the 10 hypothetical strategies proposed to increase PT use.

2.5 Analysis

Summary survey data are presented as medians for continuous variables and percentages (and numbers) for categorical variables. To determine factors associated with strategy appeal, Chi-square and Kruskal-Wallis tests were used for categorical and continuous variables respectively. If a cell size was ≤ 4 , Fishers exact test was used instead of Chi-square tests. Where small cell numbers rendered tests unreliable, categories were removed or collapsed. Quantitative data were analysed using Stata software (Version 15, Statacorp, College Station, Texas). We conducted a priori sensitivity analyses that stratified the sample by student status (because of the relatively high proportion of student responders likely attributable to co-promotion through the University of Tasmania survey) and by geographical area (because where people live influences travel behaviour (37,38,39)). Subsequently, survey respondents were stratified into one of three geographical areas situated about Tasmania's capital and largest city, Hobart, which has more bus services than the remainder of the state (Figure 1). The three geographical areas were defined as: "Inner Hobart" which included survey respondents residing in the Local Government Area, City of Hobart; "Outer Hobart" which included all other survey respondents residing in southern Tasmanian with residential postcodes commencing with numerals 70 or 71; "Other Tasmania" included all remaining survey respondents who lived in northern Tasmanian with residential postcodes commencing with numerals 72 or 73.

The focus groups and interviews were thematically analysed, facilitated by use of qualitative data management software NVivo 11 (QSR International, Doncaster, Victoria, Australia). Regular discussion and reflexive consideration of the data occurred with investigators familiar with the transcripts (VC, AL, MS) until there was agreement that the data had been comprehensively analysed and no new themes were emerging. Following review of the sample variation and fit of the data with the aim of the study, it was agreed that saturation had been achieved after three focus groups and five interviews. Question prompts, transcripts, notes on research team meetings, project logbook, memos and reflective notes comprised the audit trail. Participants were not requested to check transcripts nor provide feedback on the findings.

3. Results

3.1 Quantitative survey

From a total of 1,355 survey hits, 1,091 respondents completed the survey. Survey completion was defined as having provided all mandatory information. Participants' characteristics are described in Table 2. Survey completers were most commonly women (67%), adults less than 44 years old (65%), working at least part-time (76%), English speaking at home (98%) and had access to a motor vehicle/cycle (82%; access was least common among full-time students), 35% were enrolled as students (24% full-time), half (53%) were university educated, half (53%) were coupled with or without children living at home, 58% rated their health as excellent or very good and 13% reported an injury, illness or disability restricting PA. The survey sample differed from the broader Tasmanian population across several demographic characteristics. Among over-represented groups were women (67% in this study vs. 52% of the broader population), adults aged 18-44 years (65% vs. 40%), full- and part-time students (35% vs. 8%), those employed at least part-time (76% vs. 50%), unemployed looking for work (7% vs. 4%), university educated (53% vs. 15%) and those who usually spoke English at home (98% vs. 88%) (18).

Overall, provision of real-time bus information, bus-only lanes along high frequency corridors and employee incentives to use the bus were the top three ranked strategies (Table 3). Free travel outside of peak times and a loyalty scheme for bus travel were also popular (ranked fourth and fifth, respectively). Least popular were speaking to someone via telephone to assist with journey planning and free travel before 7am. In sensitivity analyses, excluding commuters who only used active modes of transport made no difference to the overall ranking of strategies. However, stratifying the sample by student status and area of residence revealed differences in strategy preferences. Strategies that were cost-saving were overall more popular and infrastructure-based schemes less popular among full-time students when compared with the remaining sample. Infrastructure-based strategies were more popular among those living in "Outer Hobart" compared with those living in "Inner Hobart" and participants from the remaining areas of the state favoured cost-saving strategies.

For non-full-time students (Table 4a), the five top ranked strategies were consistently most popular among those of younger age, those who were living in a shared housing arrangement and those who had no access to a motor vehicle/cycle. The median minutes of walking per week was highest among those who stated that the strategy would not increase their PT use, compared with those who stated the strategy would increase their PT use across the top five ranked strategies, except for the 4th ranked strategy (Free travel outside peak times).

Among full-time students (Supplementary Table 1a), the top five ranked strategies were consistently most popular among those of younger age, those with lower education levels, those who rated their health as 'good' and those who had no access to a motor vehicle/cycle. The median minutes of walking per week was highest among full-time students who stated that the strategy would increase their PT use compared with those who stated the strategy would not increase their PT use across the top four ranked strategies.

Across all three geographical areas ("Inner Hobart", "Outer Hobart" and "Other"), the top five strategies were consistently most popular among those who were not in the work force, those who did not speak English at home and those who had no access to a motor vehicle/cycle (Supplementary Tables 1b, 1c, 1d). The top five strategies were also consistently most popular among: those of younger age, those with lower education levels and those who were at least part-time students who lived in Inner Hobart; those who were at least part-time students and those who lived in a shared housing arrangement who lived in Outer Hobart; and those of younger age, those who were full-time students, those with lower education levels, those who lived in a shared housing arrangement, and those who had an injury/illness/disability limiting PA who lived in "Other". For those who resided in Inner or Outer Hobart, median minutes of walking per week were generally similar between those who stated that the strategy would increase their PT use and those who said it would not across the five top strategies. For those residing in "Other", across the top five strategies the median minutes of walking per week was highest among those who stated that the strategy would increase their PT use compared with those who stated the strategy would not increase their PT use.

3.2 Focus groups/interviews

Participants in the three focus groups (n=26) and individual interviews (n=5) were relatively similar to the survey sample, but purposeful selection resulted in the sample consisting of a greater proportion of men, older adults, part-time workers or retirees, non-students and those who rated their general health as less than excellent/very good when compared with the survey sample (Table 2).

The focus group discussions and interviews indicated that strategy preferences were consistent with the survey findings. Key themes that appeared to be driving the top-rated

strategies were certainty, efficiency and cost savings. However, improving bus reliability and expanding bus services were commonly raised as necessary for enhancing bus use and in their absence could undermine the impact of the strategies proposed.

The provision of real-time bus information was predominantly and generally positively discussed. Provision of real-time bus information was popular because it was seen to enable better planning of travel behaviour because there was more certainty, “the real time information is really more useful to me because I can better plan” (man, 25-34 years, Outer Hobart) and “...I’ve used it [real-time information] a lot overseas and there’s no doubt it makes it ... more attractive to use a bus if you can see... it’s... two minutes away. Rather than standing there thinking well, it may arrive in the next hour” (woman, 55-64 years, Outer Hobart). However, it was acknowledged that providing real-time information was not enough and improving PT reliability and frequency was also needed “...if the bus is only coming once every hour knowing that it’s 50 minutes away is not going to make it any more attractive” (woman, 45-54 years, Inner Hobart). Some participants also spoke about the certainty aspect of such an initiative adding a safety element to bus use, such as being able to avoid long waits in the dark or feeling more comfortable with their children using the service because they could determine exactly when the bus would be arriving, “It’s the loitering that you don’t want at the bus stops” (woman, 35-44 years, Outer Hobart).

Some participants highlighted the potential “...for a bit of exercise” (woman, 55-64 years, Other Tasmania) by having access to real time information, “...I think it [lack of real-time information] makes you more inclined to wait because you...think there’s one [bus] coming in 30 minutes ... or then you might think well, I’ll just walk to the next stop because it’s not that far away and I won’t miss it” (woman, 55-64 years, Inner Hobart). Another participant said that he had been at a bus stop without access to the time, but if he had known the bus “was like 45 minutes [away] then we would have gone on a walk” (man, 35-44 years, Outer Hobart). These findings indicate that providing real-time information in some instances may result in PA gain.

Several participants living in Inner and Outer Hobart discussed bus lanes as an opportunity to enhance bus reliability and to get from A to B quicker, “...for commuters... it’s good, it just speeds the whole thing up” (man, 35-44 years, Outer Hobart). However, some participants added that bus lanes alone were not enough and that other elements of service provision also

needed to be considered, such as overall reliability, cost and areas serviced, "...I'd probably [be] tempted to use it though if it was reliable and... I had the right services around it" (woman, 45-54 years, Inner Hobart). And "...if buses didn't get stuck in traffic jams, and if they all kind of go where I wanted to go – I'd definitely catch them" (woman, 25-34 years, Outer Hobart). One participant suggested that bus lanes would have limited effect because few roads in Hobart were wide enough to accommodate them, although using emergency lanes as bus lanes was an option proposed.

While in the survey rewards and incentives for bus use had some positive appeal, these themes were only discussed by a few participants (all working at least part-time). One participant who commuted to work by motor vehicle with her husband, because it was perceived to be the cheaper transport option, said "if they're [her employer] paying for it and it's there, I'd definitely use it [the bus]" (woman, 25-34 years, Outer Hobart). Another participant who paid for parking close to his workplace said that he would attempt to use such a scheme if it were available but his after work commitments meant that he often needed to commute by motor vehicle. Another who had a relevant scheme operating at her workplace said that she would participate in the initiative if bus services were more frequent in her local area.

There was some interest in Park and Ride or Bike and Ride facilities, particularly well designed and located parking facilities linked to frequent bus services. Although the discussion was predominantly about using such facilities for the commute to work and back, the value and use of Park and Ride when temporarily provided for mass community events, such as sporting events was acknowledged. Outside such events, several participants (all lived outside of Inner Hobart), indicated that they used a formal Park and Ride facility or, informally, that they currently park in a street close to a bus terminal and catch the bus, or that they would use such a facility if it were available in their area. Barriers mentioned to adopting Park and Ride included formal parking facilities being too small and so they "fill up very early" (woman, 35-44 years, Outer Hobart), having paid for parking in advance elsewhere, expansion of time limited street parking (e.g. two hours) imposed by local council, "...that will stop me from catching the bus basically, cause it's too hard..." (woman, 35-44 years, Outer Hobart), and formal parking facilities being an unappealing place to wait for a bus. One participant said that if there was a Park and Ride close by, she would use it on work

days rather than commuting fully by motor vehicle, but on the condition that the buses were regular enough.

Like real-time information the discussion regarding Park and Ride also highlighted potential for PA gain. For instance, it was suggested that an ideal location for a Park and Ride would be close to schools, which could provide opportunity for walking by both parents and children between the car park and the school, or for parents then walking to a bus stop after school drop off. One participant said on the occasion she does catch a bus, she parks her motor vehicle twenty minutes' walk away from the intended bus stop for the purpose of getting more PA.

The discussion regarding fare-based incentives was mostly about free travel before 7am which, like the survey findings (ranked 9), was unpopular. Journey complexity, competing demands, inadequate bus services or the time frames proposed not being suitable were cited as reasons for lack of support of fare-based incentives, "...the before 7:00 thing...it's not going to work...when you've got kids and you're getting them to school [Other participant: Yeah] (man, 65-74 years, Outer Hobart). One participant said the quality of the service was more of an issue than the fare, "I'm prepared to pay the fare if I get the service. If I'm not getting the service, then the fare seems a little unreasonable" (woman, 55-64 years, Inner Hobart). However, the cost of using PT when a motor vehicle was already owned or available was raised by several participants (of mixed demographic characteristics). For example, a few participants talked about it being cheaper to use their motor vehicle when they were also commuting with their partners. One participant said that if it became cheaper for her and her husband to take PT rather than use their motor vehicle and pay for parking, she would probably change her transport mode. Others suggested that using PT became more economical when travelling on a concession (e.g. having a Senior's card). Another said that if you had a motor vehicle it was a 'sunk cost' insinuating an imperative to use the motor vehicle rather than direct funds to other transport modes.

4. Discussion

This mixed-methods study aimed to determine Tasmanian adults' views on the acceptability and perceived impact of several hypothetical strategies aimed at increasing PT use for PA gain. Overall, there was strong support for the provision of real-time bus service information, followed by bus only lanes and employee incentives/rewards. Fare based incentives and Park

and Ride were moderately supported, whilst other information-based strategies (e.g. better written/web-based information or telephone assistance) were least popular. The qualitative discussion indicated that the perception of a strategy's potential to enhance bus service certainty (especially bus arrival time), travel-time efficiency, or to reduce transport costs were key in driving strategy ranking. However, expanding bus services and improving bus reliability were highlighted as necessary to maximise the impact of the proposed strategies. The qualitative data also indicated that certain strategies may lead to PA gain. For instance, participants stated that if they knew with certainty when the bus was arriving (through real-time bus arrival information), they would walk to the next bus stop/s if time permitted and that the location of a Park and Ride facility could provide further opportunities for walking. To our knowledge the relationship between PT use enhancing strategies is unexplored and is worthy of further investigation. Further, most studies have investigated the impact of PT improvements on a range of sustainability indicators, but not specifically PA (10,40,41).

The discussion regarding real-time information indicated that the enhanced certainty such technology would provide, could also lead to feeling safer catching a bus because of less loitering at bus stops. Safety was also raised regarding the location of Park and Ride facilities and their impact on reducing traffic congestion. Both personal safety and traffic density are correlates of PA so implementing certain PT use enhancement strategies could directly or indirectly lead to PA gain (5,42). Supporting these findings are international evaluations of real-time PT technologies that have demonstrated increased PT trips, enhanced feelings of safety, and health benefits associated with increased distance walked when using PT (43,44,45).

We found demographic differences in preferences for the strategies with main differences noted between full-time students and non-full-time students and between those living in outer suburbs of the capital city (Hobart) compared with those living in Inner Hobart and the remainder of the state. Those strategies providing a financial incentive were more popular among full-time students compared with the remaining sample. This finding likely reflects limitations in financial resources among this cohort, or their tendency to be more reliant on PT than non-students because of lack of access to a motor vehicle/cycle. We also found that those living in the outer suburbs of Hobart preferred infrastructure-based strategies such as Park and Ride and bus only lanes when compared with the remaining sample, likely reflecting the reduced level of PT service in outer suburbs and heightened concern about

journey times. Other demographic characteristics commonly influenced strategy ranking (e.g. age, employment status, education level and household composition) – a finding that confirms knowledge about travel behaviours, constraints and preferences across the life-course in other Australian jurisdictions (46,47,48). Focus group and interview participants exposed the complexities of travel mode choice and options for increasing PT usage and the need for well-integrated strategies that also addressed bus reliability, frequency, area serviceability and parking limitations. The findings further highlight the importance of tailoring PT initiatives, so they accord with target population contexts to have the best chance of success.

In the qualitative study it was highlighted that restricting parking can prevent PT use if Park and Ride opportunities are unavailable. Local parking supply, location and pricing can support or undermine PT take up and associated PA (49,50,51). If parking is plentiful or cheap within central activity zones (such as central business districts) it acts as an incentive for motor vehicle use (49,50,51). If parking is more constrained via supply or cost it acts as a disincentive to motor vehicle use, and if married with a high-quality PT service should encourage PT use (49). Local councils and regional planning authorities play an important role ensuring that parking strategies complement PT use and promote PA gain.

4.1 Relevance to policy-makers/practitioners

This study highlights how resources may be best allocated to enhance PT patronage through reduced motor vehicle use. Increasing PT use has individual, social and environmental benefits, including potential for PA gain, that are highly relevant to government and non-government sectors. To date PT-related decision making in Tasmania has largely focused on its role in providing PT services for those least able to use a motor vehicle (for managing traffic congestion in its capital city, Hobart) (52). Minimal attention has been given to PT investment for public health benefit, despite building knowledge about the benefits and advocacy from other organisations such as the Heart Foundation, the Tasmanian Bus Association, and the University of Tasmania (53,54,55).

Real-time information for PT services offer decision-makers who face pressure to increase PT take-up genuine investment priority options under limited budgets (43). However, real-time information will only benefit those with access to a good level of PT service so concomitant investment in PT service and infrastructure improvement more broadly is

recommended. Existing motor vehicle ownership or access is another barrier to PT use so seeking ways to reduce or delay motor vehicle purchase/access is another important policy consideration in areas of adequate PT provision (56).

While traffic congestion provides a strong impetus for PT investment and promotion, the health agenda provides another reason for PT investment. However, strategies implemented to increase PT patronage through less motor vehicle use should not facilitate less active transport use.

4.2 Strengths and Limitations

Although there was substantial heterogeneity in demographic characteristics and travel behaviours among survey respondents, comparison with Tasmanian population level data highlights that several demographic groups were over-represented, which may limit the generalisability of the findings. Respondents may have found other strategies appealing that were not listed in the survey, although the pragmatic strategies proposed resulted from consultation with key stakeholders, were informed by promising theories or existing practice, and there was opportunity in the survey to provide other comments. It is also possible that perceptions of transport use as an indicator of social status may have influenced strategy preferences and study participation. Survey questions regarding time spent engaging in PA related to the past seven days and may not reflect usual behaviour. It is possible that other relevant themes may not have been discussed in the focus groups or interviews although saturation of major themes was achieved and participants were given the opportunity to raise other matters. Participants in the qualitative study represented a mix of key demographic characteristics adding richness to the data. However, future research could target key demographic groups such as those unemployed and seeking work to enhance strategy tailoring. Preferences for or perceived impact of the strategies on PT use and PA may not necessarily reflect actual behaviour should such strategies be implemented. Future observational or intervention studies could address this potential limitation. Finally, this novel mixed methods study included a large survey sample and a nested qualitative study that provided opportunity to understand why strategies were appealing or otherwise and their potential impact on PA. The integration of the qualitative and quantitative studies has resulted in rich information for service providers, policy makers and future research, particularly for regional and small city settings.

4.3 Conclusions

Provision of real-time information, bus only lanes and employee incentives/rewards show the greatest promise for increasing PT use in this population. However, tailoring and integrating strategies according to the needs of target populations (e.g. full-time students, outer suburban residents) and addressing bus reliability and frequency is required for maximum effect. Some PT use enhancement strategies may lead to PA gain, which is an important consideration for transport planners and highlights the need for inter-sectoral action to influence population PA levels. Intervention studies to determine the impact of the proposed strategies on PT use and associated PA are warranted.

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Conflict of interest

The authors declare no conflicts of interest

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Table 1: The ten hypothetical strategies proposed to survey participants

Strategy type	Strategy	Reason for inclusion
Fare-based	Free travel outside peak times (before 7am, between 9am and 3pm and after 6.30pm)	Stakeholder driven strategy to address financial barriers to travel
	Free travel before 7am	Stakeholder driven strategy to address financial barriers to travel and planned for implementation
	Half price travel outside peak times (before 7am, between 9am and 3pm and after 6.30pm)	Stakeholder driven strategy to address financial barriers to travel
Incentive-based	A loyalty scheme where reward points can be converted to Greencard* credit (10 points for	Based on behavioural economics theory using a gain-framed approach to reward positive behaviour

	every trip so 100 points = \$5 Greencard credit)	
	Employers provide incentives/rewards to employees for bus travel to and from work (e.g. Greencard credit)	Based on behavioural economics theory using a gain-framed approach to reward positive behaviour within the work setting
Information-based	Written or electronic information on how to make the most of bus services (brochures, better website information)	Existing practice elsewhere. Provision of information (established behaviour change technique)
	Speaking to someone by telephone to help you plan your journey and answer any questions	Existing practice elsewhere. Provision of information (established behaviour change technique)
	Provision by bus service providers of real-time information (electronic signs or smart phone apps that tell you when the next bus is due to arrive)	Existing practice elsewhere. Provision of information (established behaviour change technique)
Infrastructure-based	'Park and Ride' or 'Bike and Ride' facilities (where formal motor vehicle parking and bicycle storage facilities connect to high frequency bus services in outer urban areas)	Existing practice elsewhere. Stakeholder driven strategy targeting residents in outer suburbs whose access to bus services may be limited
	Bus only lanes along high frequency bus service corridors during peak periods so buses can travel quicker than the traffic (e.g. 7am to 9am and 3pm to 6.30pm)	Existing practice elsewhere. Stakeholder driven strategy to reduce service travel time

* A Greencard is Metro Tasmania's travel smartcard

Table 2: Characteristics of the quantitative survey and qualitative focus group and interview sample

Characteristic	% (n)		
	Survey (n=1,091)	Focus group and interviews (n=31)	2016 Census - Tasmania

Gender			
Man	31.9 (348)	41.9 (13)	48.3 (193,516)
Woman	67.0 (731)	54.8 (17)	51.7 (207,261)
Other*	1.1 (12)	3.2 (1)	-
Age group (years)			
18-24	19.0 (207)	3.2 (1)	10.5 (41,965)
25-34	23.4 (255)	25.8 (8)	14.5 (58,030)
35-44	22.6 (247)	12.9 (4)	14.9 (59,822)
45-54	18.9 (206)	12.9 (4)	17.5 (70,046)
55-64	11.5 (125)	22.6 (7)	18.0 (72,150)
≥ 65	4.7 (51)	22.6 (7)	24.6 (98,750)
Employment status			
Full-time (≥ 35hrs per week)	44.4 (484)	29.0 (9)	30.3 (121,379)
Part-time (20-34 hrs per week)	16.5 (180)	25.8 (8)	-
Part-time (<20hrs per week)	14.7 (160)	16.1 (5)	-
Not employed (looking for work)	7.42 (81)	3.2 (1)	3.7 (14,952)
Not employed (not looking for work)	9.4 (103)	6.5 (2)	37.1 (148,878)
Retired	4.4 (48)	16.1 (5)	-
Not able to work	1.7 (18)	0 (0)	0
Other (includes volunteers)	1.6 (17)	3.2 (1)	9.6 (38,614)
Student			
Full-time student	23.7 (258)	12.9 (4)	4.5 (18,206)
Part-time student	10.9 (119)	9.7 (3)	3.4 (13,687)
Not enrolled as student	65.4 (714)	77.4 (24)	84.5 (338,645)
Education attainment			
≤ Year 10	5.4 (59)	6.5 (2)	9.1 (36,374)
Year 12	17.1 (186)	6.5 (2)	33.4 (133,939)
Trade/apprenticeship	1.9 (21)	0 (0)	0
Certificate/diploma	23.0 (251)	32.3 (10)	28.3 (113,527)
University bachelor degree	32.5 (355)	48.4 (15)	11.7 (46,931)
Higher university degree	20.1 (219)	6.5 (2)	3.3 (13,408)
Household Type			
Couple with children (≤ 18 years) at home	26.8 (292)	29.0 (9)	
Couple without children (≤ 18 years) at home	26.1 (285)	35.5 (11)	
One parent family	5.6 (61)	3.2 (1)	

Other family	2.1 (23)	3.2 (1)
Group (adults living together)	20.1 (219)	9.7 (3)
Lone person	18.5 (202)	16.1 (5)
Other†	0.8 (9)	3.2 (1)

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Language usually spoken at home

English	97.6 (1,065)	100.0 (31)	87.9 (352,104)
Other	2.4 (26)	0 (0)	5.4 (21,701)

General health

Excellent	20.1 (219)	9.7 (3)
Very good	38.3 (418)	29.0 (9)
Good	30.5 (333)	38.7 (12)
Fair	9.1 (99)	22.6 (7)
Poor	2.0 (22)	0 (0)

Current injury, illness, disability

limiting physical activity

Yes	13.2 (144)	19.4 (6)
No	86.8 (947)	80.7 (25)

Area/region

Inner Hobart	39.0 (425)	32.3 (10)
Outer Hobart	48.3 (527)	51.6 (16)
Other Tasmania	12.7 (139)	16.1 (5)

Access to motor vehicle/motorcycle

Yes	81.6 (890)	93.6 (29)
No	18.4 (201)	6.5 (2)

Total minutes walking/week

Median	150	180
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653 * includes 'transgender' and 'prefer not to specify' options; † includes 'visitor only', other
654 household compositions not listed in the survey and unclear response

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672 **Table 3: Level of agreement with the likelihood of hypothetical strategies increasing public transport use among survey respondents**
673 **(n=1,091), for the whole sample and by student status and region**

Strategy	Whole sample % (n)		Whole sample	Rank*				
	Extremely likely/ likely	Not sure/Maybe Not likely Not likely at all		Student Status			Region	
				Non- full-time students	Full-time students	Inner Hobart	Outer Hobart	Other Tasmania
Real-time bus information	51.6 (563)	48.4 (528)	1	1	1	1	1	1
Bus only lanes	44.9 (490)	55.1 (601)	2	2	5	3	2	6
Employee incentives for bus travel to and from work	42.4 (463)	57.6 (628)	3	3	6	4	3	5
Free bus travel outside peak times	42.3 (461)	57.8 (630)	4	4	2	2	6	4
Bus travel loyalty scheme	39.1 (426)	61.0 (665)	5	6	4	6	5	3
Park and Ride or Bike and Ride facilities	35.8 (390)	64.3 (701)	6	5	7	7	4	7
Half price travel outside peak times	35.7 (389)	64.3 (702)	7	7	3	5	7	1
Written or electronic information on using bus services	20.2 (220)	79.8 (871)	8	8	9	8	8	8
Free travel before 7am	19.4 (212)	80.6 (879)	9	9	8	9	9	9
Telephone assistance to aid bus service use	7.9 (86)	92.1 (1005)	10	10	10	10	10	10

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675 *Rank is based on combined percentage of 'extremely likely' and 'likely' categories

676 **Table 4a: Factors associated* with top five hypothetical strategies considered by non-full-time students (n=833) to be 'extremely likely'**
 677 **or 'likely' to increase public transport use**

Factor	Strategy (from most preferred)				
	% (n)				
	Real-time information	Bus only lanes	Employee incentive scheme	Free travel outside peak times	Park and Ride or Bike and Ride
Gender, p	0.608	0.619	0.947	0.963	0.439
Man	48.0 (129)	39.4 (106)	38.3 (103)	34.6 (93)	36.1 (97)
Woman	46.1 (257)	41.2 (230)	38.5 (215)	34.4 (192)	33.3 (186)
Age group (years), p	0.000	0.000	0.000	0.002	0.324
18-24	66.1 (39)	67.8 (40)	61.0 (36)	55.9 (33)	37.3 (22)
25-34	55.2 (101)	46.5 (85)	49.2 (90)	38.8 (71)	38.8 (71)
35-44	46.1 (106)	41.3 (95)	37.4 (86)	32.2 (74)	33.0 (76)
45-54	40.4 (78)	37.8 (73)	35.8 (69)	30.1 (58)	35.8 (69)
≥ 55	38.7 (65)	27.4 (46)	23.8 (40)	31 (52)	28.6 (48)
Employment, p	0.016	0.978	0.122	0.000	0.877
Full-time (≥ 35 hrs per week)	44.1 (207)	40.3 (189)	40.5 (190)	27.7 (130)	34.1 (160)
Part-time (≤ 35 hrs per week)	45.6 (104)	40.4 (92)	36.8 (84)	35.1 (80)	33.8 (77)
Not in the labour force	58.7 (71)	41.3 (50)	30.6 (37)	57.9 (70)	36.4 (44)
Student status, p	0.630	0.084	0.399	0.312	0.136

Part-time student	48.7 (58)	47.9 (57)	42.0 (50)	38.7 (46)	40.3 (48)
Not enrolled as student	46.4 (331)	39.5 (282)	38.0 (271)	33.9 (242)	33.3 (238)
Education level, p[†]	0.177	0.019	0.367	0.003	0.370
Low	53.2 (67)	48.4 (61)	43.7 (55)	47.6 (60)	31.0 (39)
Medium	42.9 (100)	33.9 (79)	36.1 (84)	33.9 (79)	37.8 (88)
High	46.8 (222)	42.0 (199)	38.4 (182)	31.4 (149)	33.5 (159)
Household type, p	0.232	0.093	0.480	0.001[‡]	0.534 [‡]
Family with children (≤ 18 years) at home [§]	42.7 (135)	39.6 (125)	37.0 (117)	28.5 (90)	33.2 (105)
Couple without children (≤ 18 years) at home	46.3 (112)	37.6 (91)	37.2 (90)	35.1 (85)	33.9 (82)
Group (adults living together)	53.6 (59)	48.2 (53)	46.4 (51)	47.3 (52)	40.0 (44)
Lone person	51.4 (75)	45.2 (66)	37.7 (55)	39.7 (58)	34.9 (51)
Other	42.1 (8)	21.1 (4)	42.1 (8)	15.8 (3)	21.1 (4)
English spoken at home, p[¶]	-	-	-	-	-
Yes	46.6 (386)	40.6 (336)	38.5 (319)	34.8 (288)	34.3 (284)
No	60.0 (3)	60.0 (3)	40.0 (2)	0.0 (0)	40.0 (2)
General health, p	0.510	0.387	0.196	0.048	0.881
Excellent	42 (73)	41.4 (72)	33.9 (59)	29.9 (52)	36.2 (63)
Very good	46.9 (144)	38.8 (119)	40.1 (123)	31.9 (98)	34.2 (105)
Good	48.4 (123)	44.5 (113)	42.1 (107)	37.0 (94)	32.7 (83)
Fair or poor	50.0 (49)	35.7 (35)	32.7 (32)	44.9 (44)	35.7 (35)
Injury/illness/disability limiting PA, p	0.840	0.354	0.313	0.107	0.521
Yes	47.5 (58)	36.9 (45)	34.4 (42)	41.0 (50)	36.9 (45)

No	46.6 (331)	41.4 (294)	39.2 (279)	33.5 (238)	33.9 (241)
Area/region, p	0.000	0.000	0.001	0.007	0.000
Inner Hobart	52.4 (145)	42.2 (117)	37.9 (105)	41.2 (114)	28.2 (78)
Outer Hobart	48.3 (214)	45.2 (200)	42.7 (189)	32.7 (145)	41.5 (184)
Other Tasmania	26.6 (30)	19.5 (22)	23.9 (27)	25.7 (29)	21.2 (24)
Access to motor vehicle/cycle	0.000	0.000	0.000	0.000	0.765
Yes	42.4 (311)	37.0 (271)	35.2 (258)	29.1 (213)	34.5 (253)
No	78.0 (78)	68.0 (68)	63.0 (63)	75.0 (75)	33.0 (33)
Total minutes walking/week, p	0.945**	0.782**	0.088**	0.113**	0.241**
Median (likely to increase public transport use)	150	150	150	180	150
Median (unlikely to increase public transport use)	175	155	175	150	175

679 * Chi square analysis unless otherwise stated; † Low = Year 12 or less; Medium = Trade/apprenticeship or Certificate/Diploma; High = University
680 qualification; ‡ Fisher's exact test; § Includes 'one parent family'; || includes 'other family', 'visitor only', other household compositions not listed in the
681 survey and unclear responses; ¶ Test unreliable because only five participants did not speak English **Kruskal-Wallis test

683 Figure legend 1

684 Schematic of the three geographical Tasmanian areas defined for analysis

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