Journal of Transport & Health 3 (2016) 200–210

Contents lists available at ScienceDirect

Journal of Transport & Health

journal homepage: www.elsevier.com/locate/jth

Can the use of Bus Rapid Transit lead to a healthier lifestyle in urban South Africa? The SUN Study

Clare Bartels [a,*], Tracy Kolbe-Alexander [b], Roger Behrens [c], Sharief Hendricks [a], Estelle V Lambert [a]

[a] Division of Exercise Science and Sports Medicine, Department of Human Biology, Faculty of Health Sciences, University of Cape Town, PO Box 115, Newlands 7725, South Africa
[b] Centre for Research on Exercise, Physical Activity and Health, School of Human Movement and Nutrition Sciences, University of Queensland, Brisbane QLD 4072, Australia
[c] Centre for Transport Studies, Faculty of Engineering and the Built Environment, University of Cape Town, New Engineering Building, Room 3.40 Level 3, Nelson Mandela Circle, Upper Campus, Rondebosch, Cape Town 7701, South Africa

ARTICLE INFO

Available online 11 May 2016

Keywords:
Active travel
Physical activity
MVPA
BRT
South Africa

ABSTRACT

Background: There is a growing body of evidence that transport-related physical activity (PA) can positively contribute to population levels of PA, however limited data are available from Africa. Within South Africa, strategies and policies to support greater non-motorised and public transport use have been identified as a national policy priority, leading in part to the development of the MyCiTi Bus Rapid Transit (BRT) system in Cape Town. The aims of this study were to evaluate the difference in active travel choices between users and non-users of the MyCiTi services, and to determine the contribution of active travel towards total PA.
Methods: Intercept interviews using a short self-reported questionnaire were conducted with 1204 BRT passengers. A similar self-reported questionnaire was distributed to non-BRT users ($n=558$) employed at workplaces along the BRT feeder routes. In the final analysis, 1321 valid surveys were included.
Results: Cost savings and safety from crime were the main reasons reported for using MyCiTi services. Non-BRT users cited convenience of car travel and short travelling distances as the main reasons for not using these services. Commuting to work (75%) was the main trip purpose amongst BRT-users. Nearly all (92.6%) BRT-users walked as part of their travel journey. BRT-users accumulated significantly more active travel time ($ß=79.0$, 95% CI=59.6, 98.3) and total PA time ($ß=113.7$, 95% CI=34.4, 193.1) per week than non-users, after adjusting for confounding variables. In addition, 36% of BRT-users achieved the recommended guidelines of 150 min of moderate-vigorous intensity PA per week with active travel alone and were more likely to achieve the guidelines than non-users (OR=2.4, 95% CI=1.9, 3.0).
Conclusion: This study highlights the potential of BRT for increasing population-levels of PA in South Africa, as part of an inter-sectoral strategy to promote health and prevent non-communicable diseases.

1. Introduction

The continent of Africa has not been spared the emerging burden of chronic diseases, nor the multiple lifestyle and environmental risk factors contributing to the global pandemic of chronic non-communicable diseases (NCDs). In low-middle income countries (LMICs), 82% of deaths due to NCDs are premature (Sommer et al., 2015; World Health Organization, 2011; Abegunde et al., 2007). This increased burden has been attributed in part to economic and epidemiological transitions, and rapid urbanisation associated with changes in behavioural risk factors including obesity and unhealthy diet, tobacco use, harmful use of alcohol, smoking and insufficient physical activity (PA) (Institute for Health Metrics and Evaluation, 2013). This is particularly pertinent to Africa, as rapid urbanisation and the concomitant increase in sedentary behaviour place many at risk for NCDs. For instance, urban dwellers in Mozambique were found to

* Corresponding author. Tel.: +61 27 21 650 4561/+61 27 84 574 3501.
E-mail addresses: crtcla004@myuct.ac.za (C. Bartels), t.kolbealexander@uq.edu.au (T. Kolbe-Alexander), roger.behrens@uct.ac.za (R. Behrens), sharief.hendricks01@gmail.com (S. Hendricks), vicki.lambert@uct.ac.za (E. Lambert).

http://dx.doi.org/10.1016/j.jth.2016.04.003
2214-1405/

show a higher frequency of cardiovascular disease risk factors, physical inactivity, obesity and poor diet when compared to rural settings (Padrão et al., 2012). In Cameroon, Assah et al. (2011) found urban dwellers to have significantly lower PA energy expenditure than rural dwellers (44.2 $\pm$ 21.0 vs. 59.6 $\pm$ 23.7 kJ/kg/day, $P < 0.001$) and a higher prevalence of metabolic syndrome (17.7 vs. 3.5%, $P < 0.001$).

In Africa, PA is accrued predominantly through occupation- and travel-related activities (Padrão et al., 2012; World Health Organization, 2010). Volitional PA such as planned exercise may provide a negligible contribution towards total PA. For example, findings from the WHO 22 African countries study found that work- and travel-related PA accounted for nearly 50% of physical activity, respectively (Guthold et al., 2011). Despite the relatively high use of NMT in African countries and the fact that in South Africa, 60% of all commuting journeys involve active travel (Statistics South Africa, 2014), private car ownership throughout urban Africa is increasing steadily (Lightstone, PTY Ltd., personal communication; Voukas and Palmer, 2012). In urban Nigeria, Oyeyemi et al. (2013) found city dwellers less likely to be physically active if they owned a car (OR=0.38, CI=0.17–0.86). Similarly in urban South Africa, car owners spent significantly less time in moderate- to vigorous-intensity physical activity (MVPA) compared to persons who did not have access to a private motor vehicle (Shoham et al., 2015). Therefore, interventions that create opportunities for both incidental and utilitarian PA may be key in increasing an individual's daily levels of PA and meeting the recommended guidelines.

Transport policies and systems that prioritise public transport and active travel such as walking and cycling have shown to be ‘best investments’ to encourage and promote PA (Global Advocacy for Physical Activity, 2012; Heath et al., 2012). However, there is limited evidence from the African continent evaluating the impact of transport policies and interventions on physical activity generally, and more specifically active travel behaviour. In South Africa, the National Department of Transport has proposed Integrated Rapid Public Transport Networks (IRPTNs) in all metropolitan cities, including Bus Rapid Transit (BRT). Furthermore, non-motorised transport (NMT) has been identified as a policy priority (Department of Transport, 2008). At the municipal level, the City of Cape Town is one of two South African cities pioneering BRT and NMT infrastructure developments, and aims to place at least 75% of Cape Town's population within 500 m of this Integrated Rapid Transit (IRT) system (City of Cape Town, 2012).

The development of the MyCiTi Integrated Rapid Transit system in Cape Town began in 2008 and was launched in May 2011 in the form of BRT trunk (main station and route) and feeder services. The first phase of development included the inner city and airport services, and certain routes on the corridor between the inner city and Table View (Phase 1A) and Atlantis (Phase 1B), along the west coast of the Atlantic seaboard (Fig. 1). Phase 1 serves a region of high growth not served by rail, linking it to the Central Business District (CBD) and rail network (City of Cape Town, 2010). In 2013, the trunk route (main line) with a dedicated busway lane extended 16.5 km from Table View to the CBD and included 13 trunk stations. The residential suburbs intersected by the BRT along this corridor were largely of a higher socioeconomic index. In April 2014, the service extended further north to the suburb of Atlantis, 50 km outside of Cape Town CBD, with the full service routes completed in November 2014. The economic indices (income and employment) of this region ranged from ‘needy’ to ‘average’ (City of Cape Town, 2014, personal communication).

The Siketha Ukuba Nempilo (SUN) (We choose to be healthy) Study is based on a natural experiment of the phased implementation of the MyCiTi BRT public transport system in Cape Town. This study aimed (i) to compare the underlying reasons given by users and non-

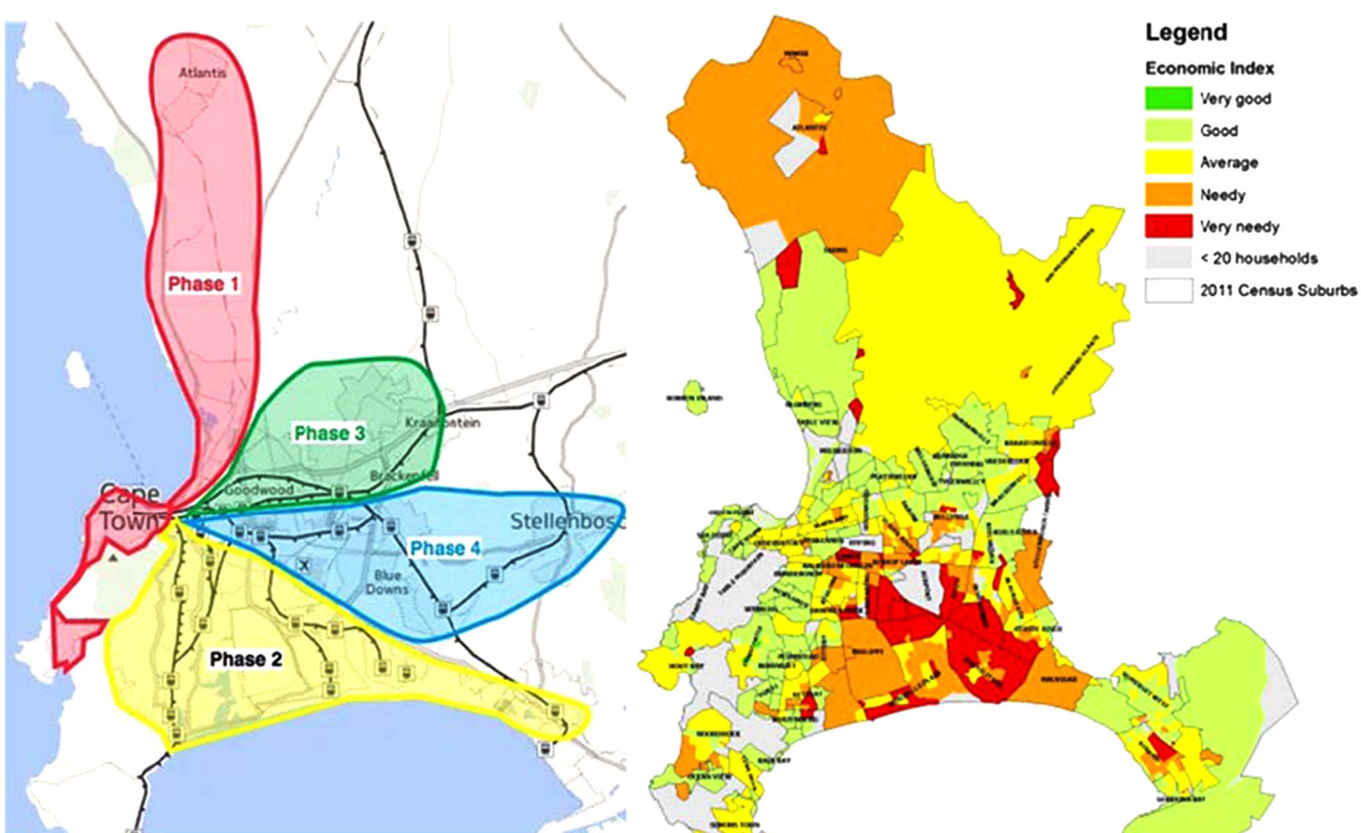

Fig. 1. MyCiTi expansion routes over the next 15–20 years and Socioeconomic Index by suburb for the city of Cape Town.
Source. Department of Development Information and GIS, City of Cape Town, 2014.

users for active travel choices regarding the BRT, (ii) to evaluate the difference in active travel between users and non-users of the MyCiTi BRT system, and (iii) to determine the extent to which travel-related PA associated with the BRT contributes towards total PA behaviour.

2. Materials and methods

2.1. Design and sample population

This study used cross-sectional intercept surveys completed by adult BRT-users and non-BRT users between the ages of 21 and 65 years. BRT-users were defined as those utilising the service regularly – at least once per week and who had been for a minimum of two weeks. Despite the operation of the BRT along the Phase 1 (A and B) corridors only, BRT passengers were from diverse geographical areas of the city. Non-BRT users were defined as those who had not used the service within the past 6 months but lived or worked within a 10–15 min walk of a MyCiTi stop (approximately 1 km).

2.2. Recruitment of sample and data collection

Prior to data collection, a pilot study was conducted from January to February 2013 to determine the most appropriate recruitment strategy, test the questionnaires and train the interviewers. The final recruitment strategy decided upon for BRT users were intercept interviews with passengers on the BRT system, while non-BRT users were recruited from nearby workplaces. BRT passengers were recruited between 6:00 am and 6:00 pm during the autumn (April), winter (July to August) and spring (September) of 2013, and the summer of 2015 (January). Recruitment was conducted during peak and off-peak times to ensure all trip purposes were captured, however passengers were not recruited on weekends.

During the period of April to September 2013, 1150 passengers utilising the BRT service were approached on the trunk route stations to complete the questionnaire either at the bus station while awaiting the bus or on the bus during their journey. The majority of passengers were approached at the first of the 13 trunk stations on route to the Cape Town CBD, stationed within the residential area of Table View, as well as the Cape Town CBD trunk station, the final trunk station on the route. Hence, the majority of passengers were travelling to or from the CBD. Passengers were mainly recruited from these two stations as they were the busiest stations out of the 13 trunk stations. Utilising the same recruitment strategy an additional 203 BRT-users were approached at the only trunk station in Atlantis. These users were recruited in January 2015, shortly after the BRT began operating in this area. Of the 1 353 passengers approached, intercept interviews were conducted with 1204 passengers, yielding a response rate of 89%.

Non-BRT users were recruited from workplaces within a 15 min walk (approximately 1 km) of the Table View trunk station or around the branching feeder routes during the period of April to December 2013. Workplaces, including businesses, schools and retail stores, were approached to participate in the study, a similar short questionnaire was distributed ($n=1014$) and collected one or two weeks later. Between January and March 2015, an additional 192 questionnaires were distributed in Atlantis utilising the same recruitment strategy. Of the 1206 surveys distributed, 558 surveys were returned, yielding a response rate of 46%.

2.3. Sample size

Sample size determination was based on the study by Lemoine and colleagues on the Transmilenio (TM) in Bogota Colombia (Lemoine et al., 2016). In order to detect a difference prevalence of persons meeting PA guidelines (assuming a prevalence of between 48% and 50% for non TM users and 58% for TM users), with an alpha level of 0.05 and statistical power of 0.90, a sample size of 600–839 would be required in each group. At a statistical power of 0.80, a sample size of between 454 and 633 persons per group was required.

2.4. Measurements and outcome variables

Two self-report, self-completed questionnaires were designed for the purposes of the study, each taking no longer than five minutes to complete. All participants who completed the questionnaire were offered a fresh fruit for participating.

2.4.1. Demographics and socioeconomic status

Participants were asked to report demographic information including age, sex, employment status, home address (street name and nearest intersecting street) and suburb. Age was also categorised into <30 years, 31–40 years, 41–50 years and >50 years. Socio-economic Index data derived from the 2011 Census for each sub-place (sub-division of a suburb) within Cape Town was supplied by the City of Cape Town municipality after which each participant who provided their sub-place ($n=1251$) was allocated a SES score. According to the Cape Town Census 2011, SES was divided into five categories including (1) very good, (2) good, (3) average, (4) needy and (5) very needy, and was comprised of the sum of the household services index, the education index, the housing index and the economic index (City of Cape Town, 2014, personal communication). For the purposes of this study, the economic index (the sum of employment, income and economic dependency ratio) was included in analysis. Categories 1–2 (very good and good) were combined to represent higher economic level (HE) participants and categories 3–5 (average to very needy) were combined to represent low-middle economic level (LME) participants.

2.4.2. Travel-related measures

BRT-users were requested to report trip frequency on the BRT over a seven-day period, trip purpose, start date and reasons for using the BRT service. Non-users were asked how often they travelled per week for all purposes, the purposes of all weekly travel and the reasons for not using the BRT service.

Both groups reported their travel modes, pace of walking and time spent in active travel for that specific day's main journey. Specifically, BRT-users were asked what other modes of travel they utilised in conjunction with the BRT. Time spent in active travel (minutes per day) was defined as the sum of active travel from home to motorised transport, from motorised transport to the destination, and the same for the return journey. Active travel per week was the product of time spent in active travel per day and the frequency of travel per week. In BRT-users, frequency per week referred to travelling on the BRT. Only walking at a moderate pace, i.e. brisk walk, was included in the calculation of total MVPA. Those walking at a slow pace were given a zero value for time spent in active travel. Self-reported walking time (minutes) to the BRT was categorised according to the 2013 South African National Household Travel Survey of 1–5 min, 6–10 min, 11–15 min and more than 15 min (Statistics South Africa, 2014).

Geographical Information Systems (GIS) using ArcGIS 10.3.1 software (Redlands, California, USA) was used to determine the Euclidian (straight-line) distance between home and the nearest BRT stop for BRT-users. Distance to the BRT was further categorised into $\leq$ 500 m, 501–1000 m, 1001–3 000 m and $>$ 3 km (Djurhuus et al., 2014).

2.4.3. Physical activity

Four questions on non-transport-related MVPA were included in the survey. This referred to PA accumulated during work, recreation and household activities. Time spent (minutes per week) in both vigorous and moderate physical activities were reported as the duration per day and frequency per week. Total MVPA was recorded as the sum of moderate-paced active travel and non-transport related MVPA. To determine the percentage of BRT-users and non-BRT users achieving the recommended guidelines of 150 min per week, active travel and total MVPA were categorised as none, 1–149 minutes per week and $\geq$ 150 min per week.

2.5. Data cleaning and statistical analysis

All participants (BRT-users and non-BRT users) reporting high values of active travel ($>$ 30 min for one trip stage) and non-responses ($n=199$) who provided contact details were contacted to confirm or correct travel times. For respondents who could not be reached or without contact details, Google maps (URL https://www.google.co.za/maps?hl=en) was used to verify network walking time to the BRT or other public transport stop ($n=65$). Participants who reported a total MVPA value of greater than 16 h per day were excluded from the study.

Statistical analyses were conducted using Stata software, version 12.0 (StataCorp, Texas, USA). Data are represented as means, standard deviations and percentages. T-tests were used to assess differences in BRT-users and non-BRT users for age, economic index and Euclidian distance from home to BRT, as well as for time spent in active travel, non-transport MVPA and total MVPA per week. Chi-squared tests were used to assess associations between age group, sex, economic index categories and categories representing the distance to the BRT. Furthermore, *t*-tests and chi-squared tests were used to assess differences in the same variables between LME and HE BRT-users.

Table 1
Descriptive characteristics of BRT-users and non-BRT users in the SUN Project.

Characteristics	BRT-users ($n=929$)		Non-BRT users ($n=392$)	
	N	%	*N*	%
Age mean (SD) years ($n=1310$)	33.7	(10.6)	36.7	(11.5)**
Age group				
30 years or less	451	(48.6)	148	(37.8)**
30–39 years	266	(28.6)	104	(26.5)
40–49 years	105	(11.3)	76	(19.4)
50 years and older	107	(11.5)	64	(16.3)
Gender ($n=1310$)				
Male	396	(42.8)	89	(23.1)**
Female	529	(57.2)	296	(76.9)
Economic Index mean (SD) ($n=1\ 251$)	0.365	(0.11)	0.387	(0.12)*
Economic level				
Higher	624	(70.9)	233	(63.5)**
Middle	95	(10.8)	26	(7.1)
Lower	161	(18.3)	108	(29.4)
Education Index mean (SD) ($n=1\ 251$)	0.222	(0.13)	0.254	(0.14)**
Education level				
Higher	700	(79.8)	254	(68.8)**
Middle	92	(10.5)	68	(18.4)
Lower	85	(9.7)	47	(12.7)
Euclidian distance (km) from home to BRT mean (SD) ($n=958$)	1.3	(3.3)	3.9	(7.5)**
Euclidian distance from home to the BRT				
500 m or less	444	(68.4)	161	(52.1)**
501 m to 1 km	77	(11.9)	31	(10.0)
1–3 km	68	(10.5)	37	(12.0)
3 km or greater	60	(9.2)	80	(25.9)
Employment status				
Employed	730	(78.6)	392	(99.2)**
Not employed	199	(21.4)	3	(0.8)

Notes. data are reported as *N* and % unless otherwise stated.

* $P<0.05$.

** $P<0.001$.

Multilevel linear regression models were used to determine the association between use and non-use of the BRT service and active travel, non-transport MVPA and total MVPA. Models were adjusted for age, sex, cost and time factors. The latter control variables represented the reasons for using or not using the BRT service. Economic index and distance to the BRT were included as levels in the models. Multilevel logistic regression models were used to determine the association between use and non-use of the service and meeting the PA guidelines. These models included the same adjusted variables and levels (economic index and distance to the BRT) as the linear models. Data were reported as beta coefficient and 95% confidence intervals. Results were considered significant at $p < 0.05$.

2.6. Ethical considerations

The study was approved by the University of Cape Town Human Research Ethics Committee (reference number 468/2012). Fieldwork was conducted with the permission of the City of Cape Town municipality, the local municipal authority responsible for the development and management of the Integrated Rapid Transit (IRT) system in Cape Town.

3. Results

Of the 1762 questionnaires completed, 1321 questionnaires (75%) were valid for further analysis (929 BRT-users and 392 non-BRT users). BRT-users ($n=275$) were excluded from the study mainly due to incomplete surveys (59%), underage (24%) and over age (5%). 166 non-BRT users were excluded due to having used the service within the previous 6 months (78%), incomplete surveys (10%), and those under aged for the study (5%).

3.1. Demographics and socioeconomic status

Table 1 provides the descriptive characteristics of BRT-users and non-BRT users. The mean age of BRT-users was 34 (SD=11.5) years, they more likely to be under the age of 40 years when compared to their older counterparts ($P=0.00$) and were more likely to be men ($P=0.00$). The majority of both the BRT-users (71%) and non-users (63%) resided in higher-economic (HE) suburbs. This was not unexpected as Phase 1A was purposively developed in middle-upper income suburbs along the west coast of Cape Town.

Table 2
Distance to the BRT and physical activity in BRT users and non-BRT users of the SUN Project.

Variables	BRT-users		Non-BRT users	
	N	%	*N*	%
Euclidian distance (km) from home to BRT mean (SD) ($n=958$)	1.3	(3.3)	3.9	(7.5)**
Euclidian distance from home to the BRT				
500 m or less	444	(68.4)	161	(52.1)**
501 m to 1 km	77	(11.9)	31	(10.0)
1–3 km	68	(10.5)	37	(12.0)
3 km or greater	60	(9.2)	80	(25.9)
Active travel time to the BRT (min) ($n=890$)				
< 1 min	114	(13)	–	–
1–5 min	439	(49)	–	–
6–10 min	195	(22)	–	–
11–15 min	78	(9)	–	–
> 15 min	64	(7)	–	–
Active travel mean (SD) min/wk ($n=1281$)	145.7	(126.9)	55.1	(118.8)**
Active travel (MVPA) min/wk ($n=1281$)				
0 min/wk	191	(21.2)	296	(78.1)**
1–149 min/wk	385	(42.7)	34	(9)
150 min/wk or greater	326	(36.1)	49	(12.9)
Non-transport MVPA mean (SD) min/wk (n= 1 278)	263.1	(362.8)	197.9	(336.4)*
Non-transport MVPA per week				
0 min/wk	309	(34.2)	160	(42.8)*
1–149 min/wk	160	(17.7)	61	(16.3)
150 min/wk or greater	435	(48.1)	153	(40.9)
Total MVPA mean (SD) min/wk (n=1 288)	413.6	(484.7)	266.6	(459)**
Total MVPA per week				
0 min/wk	82	(9.0)	119	(31.7)**
1–149 min/wk	194	(21.2)	69	(18.4)
150 min/wk or greater	637	(69.8)	187	(49.9)

Notes. Data are reported as *N* and % unless otherwise stated.

* $P < 0.05$.

** $P < 0.001$.

3.2. Proximity to the BRT and transport modes

Residential addresses were provided by 649 BRT-users, of which 444 (68%) represented passengers who resided within the 500 m BRT walking catchment. Sixty passengers (9%) resided more than 3 km from the BRT, representing those passengers residing in a suburb where the BRT was not within walking distance. Three hundred and nine non-BRT users provided their residential address, of which 161 (52%) resided within 500 m of the BRT (Table 2). Non-users residing closer to the BRT were more likely to report that the distances they travel are too short to use the bus than those residing further away from the BRT (> 1 km) ($P < 0.001$) and that travelling time is longer with the bus compared to private car use for trips made closer to home ($P=0.008$). Eight out of 19 non-users residing within 500 m of the BRT reported not using the service because they live too far from the BRT. However, BRT-users from LME sub-areas were more likely to live more than 500 m from the BRT, compared to the BRT-users from HE sub-areas (χ^2 (3)=181.1; $P < 0.001$).

Walking was the most common mode of travel to and from the BRT stop (93%) (Fig. 2). Few passengers utilised motorised transport in conjunction with the BRT: 15.5% used a private vehicle, the majority of whom resided within 500 m of the BRT, and 16.5% used public transport, the majority of these residing more than 500 m from the BRT. Only one male participant cycled as part of the journey.

The majority of non-BRT users travelled by private vehicle (71%). Two male participants cycled to work. One quarter (26%) walked as part of their trip. In these cases, public transport was the main mode of transport and these participants resided in an area where the BRT service was not available. BRT-users were therefore more likely to walk as part of their trip compared to non-BRT users ($P < 0.001$), who in turn were more likely to use a private vehicle ($P=0.00$).

3.3. Active travel and physical activity

The mean number of days per week that participants used the BRT was 4.9 (SD=1.5), with 75% of users travelling on the BRT five or more days per week. Walking constituted the main form of active travel. Mean reported walking time to a BRT stop was less than seven minutes while the mean walking time from a BRT stop to their final destination was 8.6 min. The mean active travel time for a single trip was 15 (SD=12.3) minutes. Categorised walking time showed that 62% of the sample walked under 5 minutes to the BRT. LME users had to walk further (> 10 min vs < 5 min) than BRT users from HE sub-areas (χ^2 (4)=56.9; $P < 0.001$).

BRT-users accumulated significantly more weekly active travel (145.7 min vs 55.1 min), non-transport MVPA (263.1 vs 197.9 min) and total MVPA (413.6 min vs 266.6 min) than non-users. In adjusted models, differences in active travel time (ß=79.0, 95% CI 59.6–98.3) and total MVPA (ß=113.7, 95% CI 34.4–193.1) remained significant, but non-transport MVPA was no longer significant (Table 3). Furthermore, men accumulated significantly more active travel time ($P=0.02$), non-transport MVPA ($P < 0.001$) and total MVPA ($P < 0.001$) than women while younger participants (under 40 years) accumulated significantly more active travel time ($P=0.04$), non-transport MVPA ($P=0.02$) and total MVPA ($P=0.009$) than those 40 years and older.

LME participants accumulated significantly more active travel time than HE participants (160.7 vs 99.1 min; $P < 0.001$), whereas HE participants accumulated more non-transport MVPA ($P=0.02$) and total MVPA (< 0.001). In adjusted models, only active travel time (ß=72.5, 95% CI 55.7–89.2) remained significantly different between LME and HE BRT-users (Table 4).

More than one third (36%) of BRT-users met the recommended PA guidelines by active travel, while only 13% of non-BRT users achieved the weekly recommended guidelines. Non-BRT users meeting physical activity recommendations of 150 min of MVPA per week through active travel, typically relied on other forms of public transport. In addition, only 21% of BRT-users did not engage in any form of active travel compared to non-BRT users (78%). Similarly, a greater percentage of BRT-users accumulated 150 minutes or more of total MVPA per week (70%) compared to non-users (50%). In adjusted models, the odds of achieving the PA guidelines were more than 2-fold greater in BRT-users (OR=2.4, 95% CI=1.9–3.0; P < 0.001) than non-BRT users. Paradoxically, BRT-users residing within 1 km (Euclidian distance)

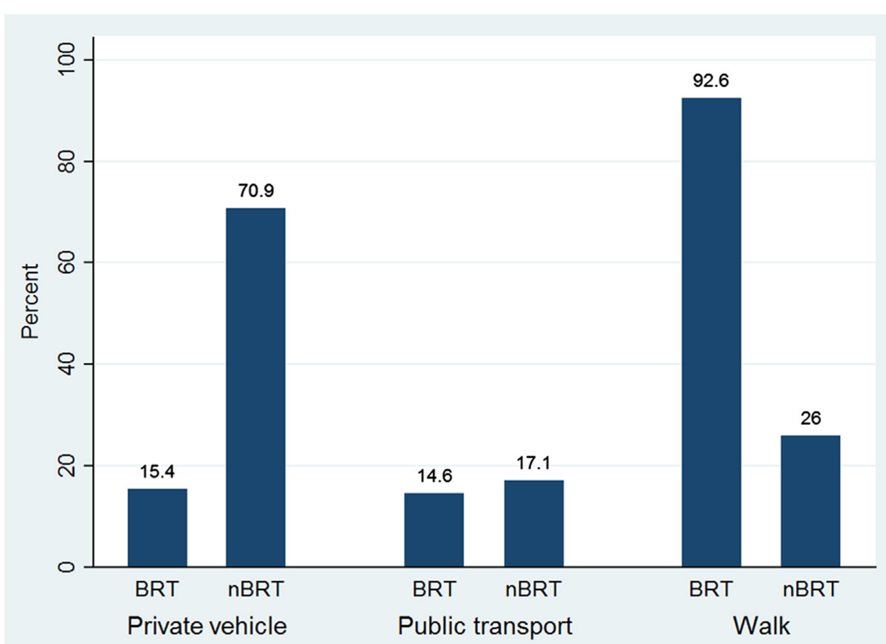

Fig. 2. Modes of transport used by BRT-users and non-BRT users in one return journey ($n=929$).

Table 3
Multilevel regression analysis of active travel, non-transport MVPA and total MVPA of BRT-users and non-BRT users.

	Unadjusted model		Adjusted model	
	ß (95% CI)	P	ß (95% CI)	P
Model 1: active transport per week [a]	90.6 (75.7–105.5)	< 0.001	79.0 (59.6–98.3)	< 0.001
Model 2: non-transport MVPA [b]	65.1 (22.3–108.0)	0.003	25.8 (−25.4 to 77.0)	0.323
Model 3: total MVPA [a]	147.0 (89.6–204.4)	< 0.001	113.7 (34.4–193.1)	0.005

[a] Adjusted for age, gender, cost savings and time savings.
[b] Adjusted for age and gender.

Table 4
Multilevel regression analysis of active travel, non-transport MVPA and total MVPA of HE and LME BRT-users.

	Unadjusted model		Adjusted model	
	ß (95% CI)	P	ß (95% CI)	P
Model 1: Active transport per week[a]	61.6 (46.2–77.1)	< 0.001	72.5 (55.7 to 89.2)	< 0.001
Model 2: Non-transport MVPA[b]	−50.3 (−93.2 to −7.5)	0.021	−28.6 (−81.0 to 23.8)	0.28
Model 3: Total MVPA[a]	−14.2 (−72.6 to 44.2)	< 0.001	21.7 (−48.4 to 91.8)	0.54

[a] Adjusted for age, gender, cost savings and time savings.
[b] Adjusted for age and gender.

Table 5
Multilevel logistic regression analysis of meeting physical activity guidelines and BRT use and non-use.

	Unadjusted model		Adjusted model	
	OR (95% CI)	P	OR (95% CI)	P
Model 1: active transport per week [a]	3.8 (2.7–5.3)	< 0.001	3.6 (2.–5.8)	< 0.001
Model 2: total MVPA [a]	2.4 (1.9–3.0)	< 0.001	1.9 (1.3–2.8)	< 0.001

[a] Adjusted for age, gender, cost savings and time savings.

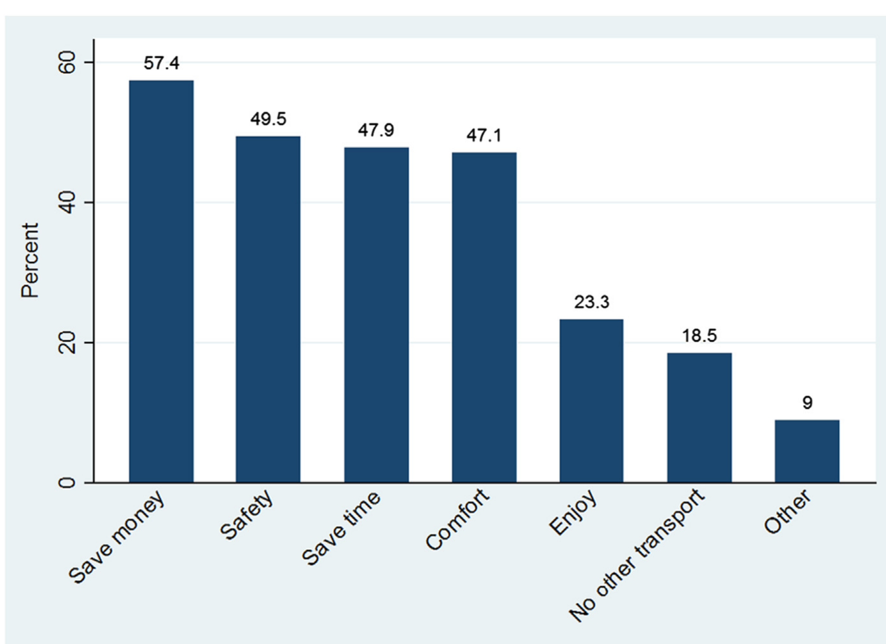

Fig. 3. Reasons of travel on the BRT (n=927). *Notes.* Participants could indicate all options that applied, and therefore percentages do not sum to 100%.

from the BRT were more likely to achieve the PA guidelines than those living more than 1 km from the BRT (χ^2 (3)=8.2; P=0.04). No significant association was shown between LME users and HE users in achieving the guidelines (Table 5).

3.4. Travel-related characteristics

3.4.1. Reasons for BRT use and non-use

The main reasons cited for using the BRT were (i) to reduce transport costs (57%), (ii) due to safety from crime (50%), (iii) greater time efficiency (48%) and (iv) greater comfort (47%) (Fig. 3). Nearly 60% of non-BRT users resided within walking distance of BRT services. These non-users cited short travelling distances and more efficient travel by car as the main reasons for not utilising the service (Fig. 4). Only 6% of non-users indicated that they resided too far from the BRT to use the service. Further analysis found BRT-users more likely to report cost-savings and time efficiency relative to other forms of transport, whereas less than 4% of non-BRT users indicated high cost as a factor in their decision not to use the service. There were no significant differences between men and women with respect to the reasons for using the service.

In HE BRT-users, cost (56%), time savings (49.4%) and comfort (45.8%) were the main reasons for using the BRT, while safety (61.6%), cost savings (60.5%), and comfort (51.2%) were cited as the main reasons in LME users. LME users were more likely than HE users to report safety (χ^2 (1)=18.98; $P<0.001$) as a reason for using the service.

3.4.2. Trip purpose

BRT passengers utilised the service predominantly for commuting to work (75%) while 20% used the service for meetings and appointments. The service was also utilised for shopping and errands (35.5%), as well as for social and recreational purposes, such as attending concerts and events (34.7%) and visiting friends and family (33%) (Fig. 5). Women were found to be more likely than men to use the BRT for work purposes (χ^2 (1)=4.6; P=0.03) and shopping and errands (χ^2 (1) = 8.5; P=0.004), whereas men were more likely to use the service for meetings and appointments (χ^2 (1)=6.0; P=0.01). LME users were more likely to use the service for work (χ^2 (1)=22.6; $P<0.001$), and visiting friends and family (χ^2 (1)=5.7; P=0.02) than HE users, while HE users were more likely to use the service for meeting and appointments (χ^2 (1)=8.8; P=0.003). As non-BRT users were recruited from workplaces, the main purpose of travel at the time of recruitment was commuting to work.

4. Discussion

This study describes the characteristics and travel patterns, and compares active travel and PA, in a convenience sample of BRT-users and non-BRT users from Phase 1 of the MyCiTi BRT system in Cape Town. BRT-users represented adults utilising the service on a regular basis, while non-BRT users represented adults who worked or resided within a 15 min walk of the BRT but had not utilised the service within the past six months. While there is limited evidence from low-middle income countries evaluating the contribution of a public transport intervention on active travel and total PA, this is the first study in Africa to report such an intervention. Internationally, BRT has become a leading mode of urban transit (Deng and Nelson, 2011) due to its cost-effective nature (Rodríguez and Targa, 2004) and has been implemented in most continents, including Africa. Nigeria and South Africa are two Sub-Saharan African countries with an operational urban BRT system, while a number of east, west and southern African countries have BRT projects in various stages of development (Wright, 2010; Mobereola, 2009).

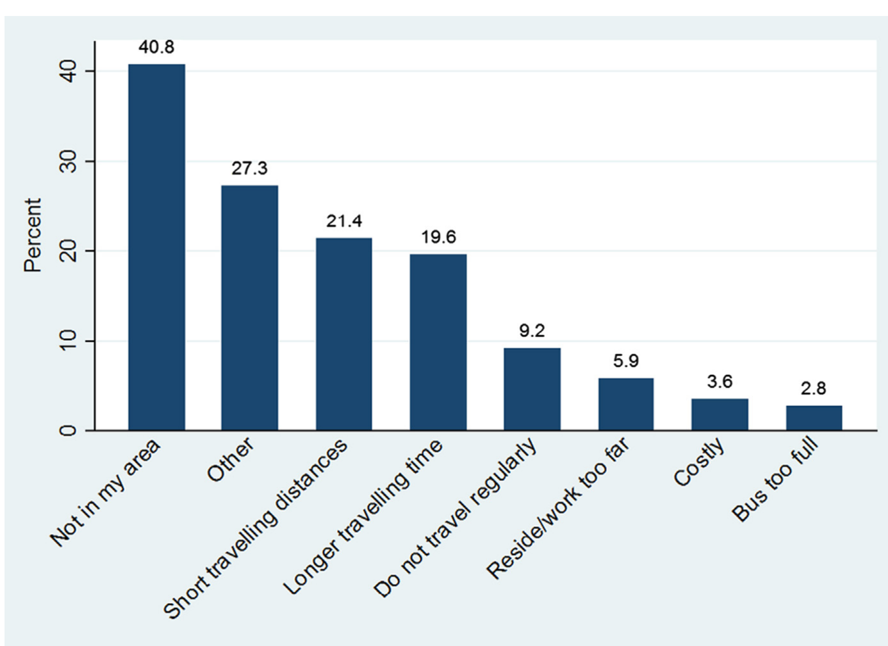

Fig. 4. Reasons for not using the BRT service (n=392). *Notes.* Participants could indicate all options that applied, and therefore percentages do not sum to 100%.

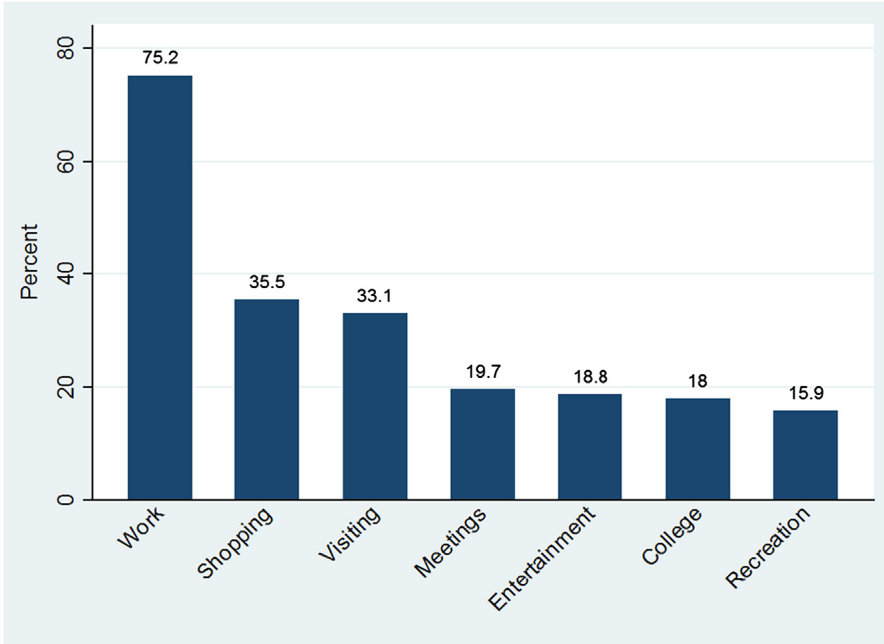

Fig. 5. Purpose of travel on the BRT (n=927). *Notes.* Participants could indicate all options that applied, and therefore percentages do not sum to 100%.

The key findings of this study corroborate evidence that BRT in an urban setting may impact positively on PA behaviour, specifically related to active travel and in an urban, African city. Self-reported active travel and total MVPA were significantly greater in BRT-users compared to non-BRT users, accumulating 79 min more active travel time and 114 min more total MVPA per week. BRT-users were also more likely to achieve the minimum PA guidelines.

The findings of this study suggest, however, that active travel in combination with BRT or other public transportation was associated with significantly more weekly PA, particularly when comparing this to private vehicle use. Similar findings were shown in the iConnect study, where commuters using a combination of motorised and active modes accumulated an additional 184.6 (95% CI=150.5–218.7) minutes per week of PA compared to those not engaging in active commuting (Sahlqvist et al., 2012). Furthermore, Oyeyemi et al. (2013) in Nigeria, and Shoham et al. (2015) in South Africa found car users engaging in less MVPA than those without a private vehicle. In the New South Wales Health Survey, car users were found to be less likely to achieve the guidelines than non-car users (56% vs 44%, $P<0.0001$) (Wen et al., 2006).

BRT-users from LME suburbs accumulated more active travel time than those from HE suburbs, due to walking farther distances from home to the BRT. Giles-Corti and Donovan (2002) found similar results in Australia where low SES residents were more likely to report walking for transport when compared to high SES respondents (OR=1.33; 95% CI, 1.25, 1.42). Similar findings were found by Ross, 2000 in the US. However, while self-reported non-transport MVPA and total MVPA were higher in MyCiTi BRT users from HE suburbs, no differences in achieving the guidelines were found between these two groups.

More than 90% of BRT-users engaged in walking as part of their travel journey, travelling on the system for five or more days per week. Since walking is a common, accessible and inexpensive form of PA in adult populations (Hallal et al., 2012), the results of this study implies that regular utilitarian walking to and from the BRT may ensure regular accumulation of PA throughout the day, particularly in those from LME suburbs. In Lagos, Nigeria, a study on accessibility to the BRT found only 25% of passengers walking to the BRT, an average distance of 0.36 km (Olawole, 2012). Furthermore, MyCiTi BRT-users had greater odds of achieving the 150 minutes per week guidelines than non-users. Similarly, Lemoine and colleagues found TransMilenio BRT users in Bogota more likely to report active travel of ≥ 150 minutes per week than non-users (57.6% vs. 48.1%; adjusted OR 1.5, 95% CI 1.1–2.0) (Lemoine at al., 2016). In addition, BRT-users living in closer proximity to the BRT were more likely to achieve the guidelines. This is in line with results from the Danish National Health Survey, in which the odds of being an active commuter and meeting the recommended PA guidelines were greater, the closer the residential proximity to bus stops and the greater density of the bus stops (Djurhuus et al., 2014).

The main reasons regarding travel choice on the BRT were found to be related to cost savings, perceived safety and greater time efficiency. This finding supports the 2013 South African National Household Travel Survey, in which households reported travel time (32.6%) and travel cost (26.1%) as the largest determinants for transport mode choice (Statistics South Africa, 2014). Bopp et al. (2012) also found that economic savings was a significant motivator for active commuting (OR=1.52, 95% CI=1.19–1.93, $P<0.05$), although significance was lost in multivariate analysis. Reasons for MyCiTi use such as personal safety and comfort can be partly attributed to poor public transport service delivery in the country (Ferro et al., 2013), particularly for LME users. This suggests that BRT provides an opportunity for modal shift for people residing in both higher income and low-middle economic suburbs. In addition, only 46% of users cited time efficiency as a reason for using the BRT. This also suggests that more than half of users were willing to travel longer times, with a possibility of a longer walking time to the BRT, in order to travel safely and save money. One in every five BRT-users used the service due to no other means of transport. This is possible due to the phasing out of existing scheduled bus and mini-bus taxi services, which is being replaced by the new MyCiTi system (City of Cape Town, 2010). Although the extent of modal shift from private vehicle is unknown, the estimated modal shift of 80% is encouraging. In a study by Deng and Nelson, 12.4% ($n=65$) of the sample shifted from private vehicle use to BRT, and when asked the main reason for shifting, half of passengers cited it was more convenient than a car trip (Deng and Nelson, 2012). In other studies, a modal shift of less than 20% was found (Callaghan and Vincent, 2007; Fastrack Delivery Executive, 2006).

Finally, the results of this study showed that BRT-users from Phase 1 were more likely to be younger adults and male, and using the service predominantly to save money and time. Commuting to work was the most common reason for travel, given that the recruitment was conducted during the week only, however users from LME suburbs were more likely to use the service for a variety of other purposes, including social activities. A greater proportion of purposes for the utilising the BRT service in addition to commuting may have been reported if recruitment was conducted on weekends.

4.1. Limitations

This study used self-report data using a cross-sectional study design. A pre-post implementation evaluation of the BRT including objective measures of PA would have allowed for more accurate reflection of the impact of the BRT on PA, and would have created an opportunity for causal inferences for the associations found. However, the strength of this study lies in the feasible replication of the design in other LME countries, where funding for longitudinal studies and objective measures may not always be cost-effective.

High levels of self-reported non-transport MVPA per week were shown in both BRT-users and non-BRT users. This observation may be due to over-reporting or suggests high levels of recreational and/or work-related PA, given that the majority of participants are from HE suburbs.

The overall low response rate by non-BRT users, along with missing data or incomplete responses in both groups, led to unequal sample size between the BRT-users and non-BRT users. Attempts were made to reduce missing or incomplete surveys by contacting those participants who provided contact details. Although non-BTR users comprised predominantly of private vehicle users, it also consisted of other public transport and active travellers. A larger sample size of non-BRT users would have all allowed for comparison between three groups of BRT-users, other public transport users and private vehicle users.

4.2. Conclusions

It is well established that walking forms part of a public transport journey. As a new rapid mode of transit in South Africa, the impact of BRT use on PA however is yet to be explored. With over 1.4 million passenger journeys to date, this study has shown that the BRT system in Cape Town has attracted individuals for a number of reasons, who in turn travel on the system for multiple purposes. Use of the BRT is associated with higher levels of walking related to active travel and total PA compared to non-BRT users, especially when compared to private vehicle users. This public transport system therefore has more benefits to offer than transport-related benefits alone. As the MyCiTi service expands across the city of Cape Town, these results support national and local government's campaign to promote the use of public transport and active mobility for sustainable transport, and concurrently, is a source of regular PA which may impact on health in the long term. In African cities, efforts to increase PA in urban areas can be addressed through transport interventions that promote or sustain active travel. Therefore, studies evaluating active travel associated with BRT use, and the contribution towards total MVPA in relation to the other PA domains should be explored. These transport interventions may help to address the increasing levels of physical inactivity as well as overweight and obesity rates in South Africa and the continent at large.

Acknowledgements

The authors wish to acknowledge the National Research Foundation of South Africa, Grant number 96982, for funding support. We would like to thank the City of Cape Town municipality for their assistance and continued support of this study. We would also like to thank the staff at the Geographical Information Systems Lab at the University of Cape Town's Environmental and Geographical Science Department for their assistance in determining the Euclidian distances.

References

Abegunde, D.O., Mathers, C.D., Adam, T., Ortegon, M., Strong, K., 2007. The burden and costs of chronic diseases in low-income and middle-income countries. Lancet 370, 1929–1938.
Assah, F.K., Ekelund, U., Brage, S., Mbanya, J.C., Wareham, N.J., 2011. Urbanization, physical activity, and metabolic health in Sub-Saharan Africa. Diabetes Care 34, 491–496. http://dx.doi.org/10.2337/dc10-0990.
Bopp, M., Kaczynski, A.T., Besenyi, G., 2012. Active commuting influences among adults. Prev. Med. 54, 237–241.
Callaghan, L., Vincent, W., 2007. Preliminary evaluation of metro orange line Bus Rapid Transit project. Transp. Res. Rec. 2034, 37–44.
City of Cape Town, 2014. Cape Town Census 2011 Socio-Economic Index. Personal communication: Development Information & GIS, City of Cape Town, December 10, 2015.
City of Cape Town, 2012. 2012 MyCiTi Business Plan. Retrieved from City of Cape Town Government: ⟨https://www.capetown.gov.za/en/irt/Documents/MyCiti_BusinessPlan_2012_Final_with_ExecSum1.pdf⟩ (accessed 11.01.16).
City of Cape Town, 2010. Business Plan for Phase 1A of Cape Town's MyCiTi Integrated Rapid Transit system. Retrieved from City of Cape Town Government: ⟨http://www.capetown.gov.za/en/irt/Documents/MyCityBusinessPlanV2_UL23082010.pdf⟩ (accessed 16.12.15).
Deng, T., Nelson, J.D., 2011. Recent developments in Bus Rapid Transit: a review of the literature. Transp. Rev. 31 (1), 69–96. http://dx.doi.org/10.1080/01441647.2010.492455.
Deng, T., Nelson, J.D., 2012. The perception of Bus Rapid Transit: a passenger survey from Beijing Southern Axis BRT Line 1. Transp. Plan. Technol. 35 (2), 201–219.
Department of Transport, 2008. Draft National Non-Motorised Transport Policy. Available at: ⟨http://unpan1.un.org/intradoc/groups/public/documents/cpsi/unpan037583.pdf⟩ (accessed 14.12.14).
Djurhuus, S., Hansen, H.S., Aadahl, M., Glümer, C., 2014. The association between access to public transportation and self-reported active commuting. Int. J. Environ. Res. Public Health 11, 12632–12651. http://dx.doi.org/10.3390/ijerph111212632.
Fastrack Delivery Executive, 2006. Could not Improve Any More - What More Could Want? Available at: ⟨http://connectedcities.eu/downloads/conferences/london_fastrack.pdf⟩ (accessed 09.07.2015).
Ferro, P., Behrens, R., Wilkinson, P., 2013. Hybrid urban transport systems in developing countries: portents and prospects. Res. Transp. Econ. 39, 121–132.
Giles-Corti, B., Donovan, R.J., 2002. Socioeconomic status differences in recreational physical activity levels and real and perceived access to a supportive physical environment. Prev. Med. 35, 601–611.
Global Advocacy for Physical Activity (GAPA), The International Society for Physical Activity and Health (ISPAH), 2012. NCD prevention: investments that work for physical activity. Br. J. Sports Med. 46, 709–712.

Guthold, R., Louazani, S.I., Riley, L.M., Cowan, M.J., Bovet, P., Damasceno, A., Sambo, B.H., Tesfaye, F., Armstrong, T.P., 2011. Physical activity in 22 African countries: results from the World Health Organization stepwise approach to chronic disease risk factor surveillance. Am. J. Prev. Med. 41 (1), 52–60.
Hallal, P.C., Andersen, L.B., Bull, F.C., Guthold, R., Haskell, W., Ekelund, U., 2012. for the Lancet Physical Activity Series Working Group, 2012. Global physical activity levels: surveillance progress, pitfalls, and prospects. Lancet, Phys. Act. Ser. 380 (9838), 247–257. http://dx.doi.org/10.1016/S0140-6736(12)60646-1.
Heath, G.W., Parra, D.C., Sarmiento, O.L., Andersen, L.B., Owen, N., Goenka, S., Montes, F., Brownson, R.C., 2012. for the Lancet Physical Activity Series Working Group, 2012. Evidence-based intervention in physical activity: lessons from around the world. Lancet, Phys. Act. Ser. 380, 45–54. http://dx.doi.org/10.1016/S0140-6736(12)60816-2.
Institute for Health Metrics and Evaluation, 2013. The Global Burden of Disease: Generating Evidence, Guiding Policy. IHME, Seattle, WA.
Lemoine, P.D., Sarmiento, O.L., Pinzón, J.D., Meisel, J.D., Montes, F., Hidalgo, D., Pratt, M., Zambrano, J.M., Cordovez, J.M., Zarama, R., 2016. TransMilenio, a scalable Bus Rapid Transit System for promoting physical activity. J. Urban Health . http://dx.doi.org/10.1007/s11524-015-0019-4.
Mobereola, D., 2009. Africa's first Bus Rapid Transit scheme. The Lagos BRT-Lite System. Sub-Saharan Africa Transport Policy Program. Available at: ⟨http://documents.worldbank.org/curated/en/2009/09/11944411/africas-first-bus-rapid-transit-scheme-lagos-brt-lite-system⟩ (accessed 12.10.15).
Olawole, M.O., 2012. Accessibility to Lagos Bus Rapid Transit (BRT LITE) bus stops: An empirical study. In: Proceedings of the CODATU XV conference: The Role of Urban Mobility in (Re)shaping Cities. Available at ⟨https://trid.trb.org/view.aspx?id=1250457⟩ (accessed 11.04.16).
Oyeyemi, A.L., Oyeyemi, A.Y., Jidda, Z.A., Babagana, F., 2013. Prevalence of physical activity among adults in a metropolitan Nigerian city: a cross-sectional study. J. Epidemiol. 23 (3), 169–177. http://dx.doi.org/10.2188/jea.JE20120116.
Padrão, P., Damasceno, A., Silva-Matos, C., Prista, A., Lunet, N., 2012. Physical activity patterns in Mozambique: urban/rural differences during epidemiological transition. Prev. Med. 55, 444–449. http://dx.doi.org/10.1016/j.ypmed.2012.08.006.
Rodríguez, D.A., Targa, F., 2004. Value of accessibility to Bogotá's Bus Rapid Transit System. Transp. Rev. 24 (5), 587–610.
Ross, C.E., 2000. Walking, exercise, and smoking: does neighbourhood matter? Soc. Sci. Med. 51, 265–274.
Sahlqvist, S., Song, Y., Ogilvie, D., 2012. Is active travel associated with greater physical activity? The contribution of commuting and non-commuting active travel to total physical activity in adults. Prev. Med. 55, 206–2011.
Shoham, D.A., Dugas, L.R., Bovet, P., Forrester, T.E., Lambert, E.V., Plange-Rhule, J., Schoeller, D.A., Brage, S., Ekelund, U., Durazo-Arvizu, R.A., Cooper, R.S., Luke, A., 2015. Association of car ownership and physical activity across the spectrum of human development: Modeling the Epidemiologic Transition Study (METS). BMC Public Health 15, 173. http://dx.doi.org/10.1186/s12889-015-1435-9.
Sommer, I., Griebler, U., Mahlknecht, P., Thaler, K., Bouskill, K., Gartlehner, G., Mendis, S., 2015. Socioeconomic inequalities in non-communicable diseases and their risk factors: an overview of systematic reviews. BMC Public Health 15, 914. http://dx.doi.org/10.1186/s12889-015-2227-y.
Statistics South Africa, 2014. National Household Travel Survey 2013. Available at: ⟨http://www.statssa.gov.za/publications/P0320/P03202013.pdf⟩ (accessed 14.12.14).
Voukas, Y., Palmer, D., 2012. Sustainable transportation in East Africa: The Bus Rapid Transit evolution in Addis Ababa, Ethiopia. Paper presented at the Conference CODATU XV: The role of urban mobility in (re)shaping cities, Ethiopia. Available at: ⟨http://www.codatu.org/wp-content/uploads/Y.-Voukas-D.-Palmer-ARTICLE-Codatu-XV-2012-EN.pdf⟩.
Wen, L.M., Orr, N., Millett, C., Rissel, C., 2006. Driving to work and overweight and obesity: findings from the 2003 New South Wales Health Survey, Australia. Int. J. Obes. 30, 782–786.
World Health Organization, 2011. Global Status Reports on Non-communicable diseases. Geneva, Switzerland. Available at: ⟨http://whqlibdoc.who.int/publications/2011/9789240686458_eng.pdf⟩ (accessed 07.02.15).
World Health Organization, 2010. Global Recommendations on Physical Activity for Health. Geneva, Switzerland. Available at: ⟨http://apps.who.int/iris/bitstream/10665/44399/1/9789241599979_eng.pdf⟩ (accessed 02.05.14).
Wright, L., 2010. Bus Rapid Transit in Africa. UN Forum on Climate Change Mitigation, Fuel Efficiency and Sustainable Urban Transport, Seoul, Republic of Korea, 16 March 2010. Available at: ⟨https://sustainabledevelopment.un.org/content/dsd/susdevtopics/sdt_pdfs/meetings2010/egm0310/presentation_Wright.pdf⟩ (accessed 10.12.15).