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Active travel to work in NSW: trends over time and the effect of social advantage

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Abstract

Issues addressed: Active travel can increase population levels of physical activity, but should be promoted equitably. Socio-economic advantage, housing location and/or car ownership influence walking and cycling (active travel) for transport. We examined active commuting over time in the Sydney Greater Metropolitan Region, and associations between active commuting and socioeconomic advantage, urban/rural location and car ownership at a Local Government Area (LGA) level across New South Wales (NSW).

Methods: Journey to work data from the 2001, 2006 and 2011 Australian Census were examined. Associations between levels of active commuting in each LGA in NSW and the Socio-Economic Index for Areas (SEIFA), Accessibility/Remoteness Index of Australia (ARIA) and car ownership were examined using negative binomial regression modelling.

Results: Between 2001 and 2011, active commuting increased in inner Sydney (relative increase of 24%), decreased slightly in outer Sydney (declined 5.1%) and declined in the Greater Metropolitan Region (down 15%). Overall, active commuting increased slightly (6.8% relative increase). After adjusting for the LGA age and sex profile and all other LGA variables, people living in NSW LGAs with high socioeconomic status, more rural areas and low car ownership were more likely to cycle or walk to work.

Conclusions: More needs to be done in NSW to increase levels of active commuting consistently across regions and socio-demographic groups.

So what? Despite small increases in active travel in the Sydney region, active travel patterns are not evenly distributed across locations or populations.

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Introduction

Regular physical activity has been shown to prevent and help manage over 20 chronic conditions, including coronary heart disease, stroke, type 2 diabetes, cancer, obesity, mental illness and musculoskeletal conditions.[1] Australian guidelines suggest that adults should get at least 30 min of moderate-intensity physical activity on most days,[2] but almost 60% of Australians aged 15 years and over do not meet these guidelines.[3] Promoting active commuting (walking or cycling to work) is one way to increase population physical activity and help realise public health benefits.

Governments have started to promote active commuting,[4,5] however overall rates of cycling or walking to work remain low in Australia.[6–8] Examining geographic areas within an urban environment where active commuting is increasing or decreasing may hold clues to the best methods to increase active travel, as does examining variations in active commuting by areas of social advantage/disadvantage. Further, if active travel is not equitably distributed among the population or across regions, there is potential to widen gaps in health outcomes.[9]

The influence of social advantage or disadvantage on active travel is not yet clear. Turrell *et al.* 2013 found that residents of socioeconomically disadvantaged neighbourhoods of Brisbane were more likely to walk for transport than their counterparts in advantaged neighbourhoods, which may actually contain or reduce neighbourhood inequalities in chronic disease.[10] For cycling a different relationship may exist. For example, registered users of

the public bicycle scheme in London were more likely to live in areas of low deprivation, and another health survey in New South Wales (Australia) found that people cycling to work had higher levels of education.[11,12] Similarly, greater income, habitual physical activity, and positive beliefs about physical activity were associated with utility and recreation only cycling among Brisbane residents.[13] Utility cycling was also associated with some or no vehicle access, part-time employment, and perceived environmental factors (such as little crime, few cul-de-sacs, nearby transport and recreational destinations). Buehler *et al*. found that there was much less variation in active travel among socioeconomic groups in Germany (a high active travel country) than in the U.S (a low active travel country).[14]

The relationship between housing location and active commuting also needs to be explored further. Factors associated with urban environments such as housing density, mixed land use (shops, community buildings and houses in close proximity), distance to destination and cycle paths are all well established environmental correlates of active travel.[15,16] However, Rissel *et al*. 2013 found that people living in rural and remote areas of NSW were more likely to walk to work than people in major cities.[12] Low car ownership may be directly associated with more active commuting, but it is likely that car ownership also mediates the relationship between active commuting and housing location. In the inner city, space is limited, parking is expensive and traffic congestion is common. Good public transport links and good walking and/or cycling infrastructure further reduce the need to own a car in the inner city.[10,16–19]

Previous studies investigating the predictors of active travel have typically analysed data by individuals. Analysis at Local Government Area (LGA) level or city/county level is also appropriate because many active commuting interventions, such as improvements to infrastructure, are implemented at an LGA level,[4,5] and characteristics such as socio-economic status and distance to work are likely to be shared by local residents. Further, intangible predictors such as a 'culture of cycling' are often common to, and influenced by, a geographic area. Finally, trends in walking and cycling in Sydney mirror each other, indicating that some of the same environmental influences may be important at the Local Government Area (LGA) level.[6,7]

This study has two parts. First, we look at rates of active commuting by LGA in Sydney over time to examine trends in active commuting in different geographic areas. Second, we investigate associations between active commuting and Socio-Economic Index for Areas (SEIFA, an indicator of an area's socioeconomic status), Accessibility/Remoteness Index of Australia (ARIA, an indicator of housing location) and car ownership across NSW with LGAs as the unit of analysis.

Methods

Part 1 of our analysis looks at the Sydney area whereas part 2 includes all of NSW.

Part 1: Study variables

Journey to work data from the 2001, 2006 and 2011 Australian Census of Population and Housing were purchased from the Australian Bureau of Statistics (ABS). The dataset included all respondents whose place of enumeration (the location where they spent Census night) was an LGA in NSW, and who answered the question 'How did the person get to work on *xxx date*?' (Census day 2001, 2006 or 2011). Respondents who selected that they worked at home or did not go to work were excluded. For cycling, respondents were able to tick more than one mode of travel, so that a journey to work using bicycle may or may not have also involved another mode of travel, such as train or ferry. For walking, respondents who ticked 'walked' only were included in this dataset, thus excluding people who used multiple modes of transport, most notably walking combined with public transport. These results therefore under-represent the total number of people who walk as part of their journey to work. The decision was made to exclude walkers who combined their commute with other modes of transport because the walking 'leg' of a multiple-leg trip is poorly recorded and is best captured with a travel diary, which was not an option for this analysis. In contrast, use of a bicycle in Sydney for any part of the journey is more memorable.

In order to avoid release of identifiable Census data, the ABS use a technique that slightly adjusts all cells to prevent any identifiable data being exposed. These adjustments result in small introduced random errors. However, the information provided in the table as a whole is not compromised.[20]

Part 2: Study variables

Active travel data from the 2011 Census were used to calculate journey to work travel mode rates by each LGA in NSW. Population data for each LGA in NSW by age (5 year age groups) and sex from the 2011 Census were derived from ABS table-builder.[21]

Information about SEIFA[22] for each LGA in NSW was sourced from the ABS and categorised into population weighted quintiles (2012 data). Similarly, ARIA for each LGA in NSW was also sourced from the ABS and categorised into Major City, Inner Regional, Outer Regional, and Remote (2004 data).[23]

A measure of the average number of vehicles per household in each LGA was derived from the 2011 census information on the number of motor vehicles per household with the response categories 0, 1, 2, 3, >= 4. A weighted average was calculated for the entire LGA based on the relative proportion of each category.

Data analysis

Part 1: Trend analyses for Sydney and the Greater Metropolitan Region

Trends in active commuting over time were analysed for three regional groupings; 'inner Sydney' comprised LGAs mostly within a 10 km radius of Sydney Central Station ($n = 17$), representing an easily cyclable distance to the city centre; 'outer Sydney' LGAs

were the remaining Sydney metropolitan LGAs as defined by the Regional Development Regulation 2012 – Regulation 4[24] ($n = 23$), and the 'Greater Metropolitan Region' grouping compromised all the other LGAs in the Greater Metropolitan Region ($n = 13$) (see Table 1). While there have been minor changes to LGA boundaries between 2001, 2006 and 2011, this analysis was done using current (2011) boundaries.

The proportion of people actively commuting to work was calculated by dividing the number of journeys to work involving active travel by the total number of journeys to work. Change over time was calculated by dividing the difference at the two time points by the earlier time point. Differences in proportions of respondents reporting walking or cycling between 2001 and 2011 were tested using McNemar's test.[25]

Part 2: Associations between mode of travel to work and study variables

The association between active travel to work (number travelled/population for each age and sex category) and SEIFA, ARIA and car ownership of place of enumeration ($n = 152$ LGAs) were estimated using a negative binomial regression model (initial analysis indicated over-dispersion using a Poisson distribution), with adjustments for age and sex profile of the LGA. Due to the correlation between LGA level variables (e.g. SEIFA, ARIA+ etc.), we estimated these associations both unadjusted (only adjusted for age and sex profile of the LGA), and in a model that mutually adjusts for all of the LGA-level variables. Models were checked by distribution of residuals and against deviance from a fully-specified model. We also inspected the correlation among the parameters in our negative binomial regression models and found reasonably low levels (< 0.5) between parameters of different variables. Before the fully-adjusted model was estimated, the covariates were introduced in a stepwise fashion. The coefficients and variance of coefficients was monitored for any unusual changes when variables were added (such as a large changes in value or estimate:variance ratio); no unusual changes indicative of collinearity problems were detected and all models reached convergence.

Results

Trends in active commuting

Trends over time for inner Sydney, outer Sydney and the Greater Metropolitan Region

Between 2001 and 2011, the proportion of people walking to work in inner Sydney rose by 16% (relative rise), from an absolute rate of 8.71% to 10.12%, but fell by 7% in outer Sydney (from 2.79% to 2.59%), and by 14% in the Greater Metropolitan Region (from 3.44% to 2.94%).

A similar pattern occurred for cycling, with nearly all the increase in inner Sydney (relative rise of 83%, from 1.21% to 2.22%) being offset by declines in the Greater Metropolitan Region (19% relative decrease, from 1.13% to 0.92%).

The trends in walking and cycling over time are strikingly similar, and the pattern of active commuting overall reflects this. Between 2001 and 2011, active commuting increased in inner Sydney (relative increase of 24%, CI 24% to 45%), decreased slightly in outer Sydney (reduced by 5.1%, CI −5.1% to 8.9%) and declined in the Greater Metropolitan Region (declined 15%, CI −15% to −1.9%) (see Fig. 1).

Trends over time for the combined Sydney and Greater Metropolitan Region

For the combined Sydney and Greater Metropolitan Region (inner Sydney, outer Sydney plus the Greater Metropolitan Region), increased active commuting in inner Sydney slightly outweighed the declines in the Greater Metropolitan Region, resulting in a small but significant increase in proportion of people actively travelling to work between 2001 and 2011 (6.81% relative increase; CI 6.76–6.85%) (Fig. 2).

The proportion of people walking to work in the combined Sydney and Greater Metropolitan Region rose just 3% (relative rise), from 4.38% in 2001 to 4.52% in 2011. The proportion of people cycling increased by 25% (relative rise), from 0.85% in 2001 to 1.06% in 2011; however 1.06% of all journeys to work made by cycling is still

Table 1. Characteristics of Local Government Areas (LGAs) of inner Sydney, outer Sydney and the Greater Metropolitan Region and rest of NSW*

Inner Sydney LGAs $N = 17$	Outer Sydney LGAs[A] $N = 23$	Greater Metropolitan Region LGAs $N = 13$	Rest of NSW LGAs $N = 99$
Defined as a LGA that is mostly within a 10 km radius of Sydney Central Station.	Defined as LGA in the Sydney metropolitan area that is more than 10 km from Sydney Central Station.	Defined as LGA outside of the Sydney metropolitan area, but within the greater metropolitan region extending from the Blue Mountains, Newcastle and Wollongong areas	Rest of NSW
High population density Median = 4166 persons per km^2	Medium population density Median = 1215 persons per km^2	Low density Median = 172 persons per km^2	Very low population density Median = 2.04 per km^2
Median population size = 62,668	Median population size = 108,135	Median population size = 76,719	Median population size = 9,145
Small LGA size (Median = 12.3 km^2)	Medium LGA size (Median = 101.6 km^2)	Large LGA size (Median = 740.1 km^2)	Very large LGA size (Median = 4116.6 km^2)
Highly mixed land use zoning	Medium level of mixed use zoning	Low level of mixed use zoning	Very low level of mixed use zoning

[A]For actual suburb names, see report by Zander, Rissel and Bauman.[7]

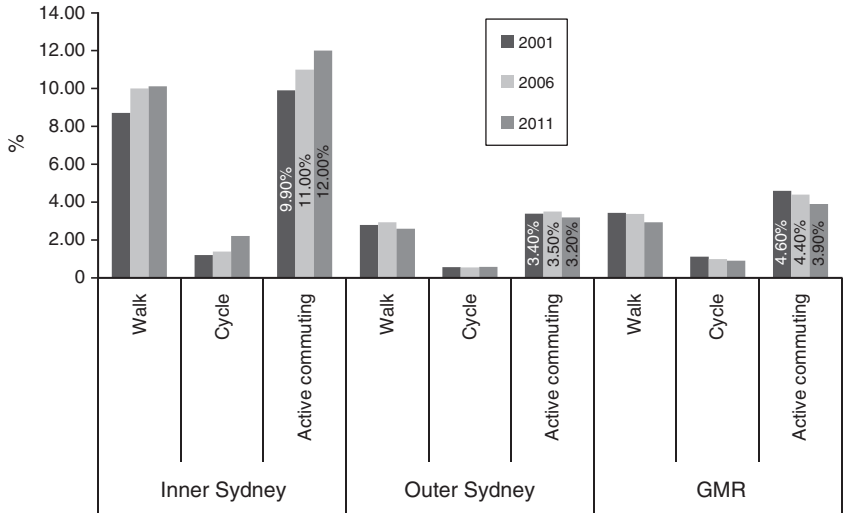

Fig. 1. Proportion of journeys to work made by walking, bicycle and overall active commuting (walking and cycling) in 53 local government areas in inner Sydney, outer Sydney and the Greater Metropolitan Region (GMR) by Census year.

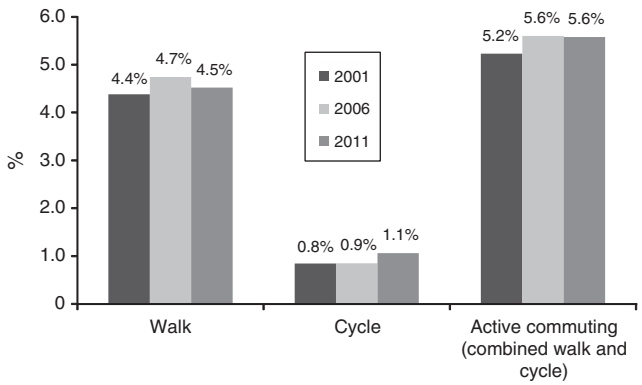

Fig. 2. Proportion of journeys to work made by walking, bicycle and active commuting in the combined Sydney and greater metropolitan region by Census year.

extremely low compared with other modes of transport and an increase of 0.2 percentage points makes negligible impact.

LGA characteristics associated with mode of travel to work on Census day 2011

SEIFA

In unadjusted analysis, there was a relationship between SEIFA and active commuting, such that residents of LGAs with higher SEIFA quintiles (higher SES) cycled to work more and walked to work less than those with a lower SEIFA quintile (Table 2).

Upon adjusting for all other variables, the dose–response relationship between cycling to work and SEIFA band became more pronounced, with residents of those LGAs with the highest SEIFA quintile being over three times more likely to ride to work than those in the lowest quintile. The negative relationship between walking to work and SEIFA was attenuated in all bands except quintile 4 (Table 2).

ARIA

When unadjusted for either SEIFA or vehicle ownership, it appeared that areas outside a major city were associated with less cycling to work, but more walking to work (Table 2); however after adjusting for these variables, our model showed that residents of LGAs with an ARIA band outside a major city were more likely to cycle and/or walk to work.

In the adjusted model, residents living outside a major city, whether inner regional, outer regional and rural, were around one and a half times more likely to ride to work, however no dose–response gradient between cycling and remoteness was evident (Table 2). The switch in association between ARIA and cycling from negative to positive under the unadjusted and adjusted model indicates that this relationship is heavily confounded by SEIFA and/or car ownership.

A clear dose–response relationship exists, however, between remoteness and walking to work, with residents in very remote areas being around four and a half times more likely to walk to work, those in outer regional areas being around two and a half times more likely to walk and those in inner regional areas around one and a half times more likely to walk to work than those in a major city (Table 2).

Car ownership

In unadjusted analysis, there was a strong positive association between low car ownership and high cycling rates, and a weaker association between car ownership and walking, not being significant until a household had less than one car (the lowest car ownership category) (Table 2).

When fully adjusted, the model showed that residents of LGAs with low car ownership were significantly more likely to both ride and/or walk to work than residents of LGAs with higher car ownership.

Table 2. Associations between Socio-Economic Index for Areas, number of vehicles per household and Accessibility/Remoteness Index of Australia of Local Government Area ($n = 152$) and mode of travel to work in New South Wales

Variable	Level	Population	Cycling			Walking		
			Count	Rate ratio (age and sex adjusted)	Rate ratio (fully adjusted)	Count	Rate ratio (age and sex adjusted)	Rate ratio (fully adjusted)
SEIFA[A] quintile	1Q Lowest	122303	313	Reference	Reference	3300	Reference	Reference
	2Q	490887	970	1.04 (0.8–1.36)	1.33 (1.02–1.73)	9314	0.83 (0.74–0.94)	1.06 (0.94–1.19)
	3Q	5338883	1591	1.26 (0.97–1.65)	1.60 (1.23–2.09)	11098	0.79 (0.7–0.89)	1.00 (0.89–1.13)
	4Q	2135991	6980	1.66 (1.29–2.14)	2.33 (1.77–3.06)	27529	0.43 (0.39–0.49)	0.85 (0.74–0.96)
	5Q Highest	2723178	17315	2.61 (2.04–3.34)	3.24 (2.40–4.38)	76633	0.61 (0.54–0.68)	1.13 (0.98–1.31)
ARIA[B] Index	Major city	3269418	18658	Reference	Reference	79771	Reference	Reference
	Inner regional	2017704	6588	0.68 (0.59–0.79)	1.64 (1.36–1.98)	28703	0.87 (0.81–0.94)	1.54 (1.39–1.71)
	Outer regional	671723	1795	0.43 (0.37–0.5)	1.44 (1.15–1.80)	16826	1.55 (1.44–1.66)	2.64 (2.35–2.97)
	Remote	52397	128	0.46 (0.34–0.62)	1.57 (1.11–2.21)	2574	2.83 (2.53–3.18)	4.60 (3.97–5.34)
Average number of vehicles	1.9 or more	376469	727	Reference	Reference	4992	Reference	Reference
	1.7–1.8	1612528	4383	1.42 (1.14–1.77)	2.09 (1.65–2.65)	25412	1.03 (0.92–1.16)	0.91 (0.82–1.01)
	1.5–1.6	2451547	8872	2.64 (2.13–3.27)	4.19 (3.30–5.31)	36430	0.88 (0.79–0.99)	0.84 (0.76–0.94)
	1.3–1.4	1003090	4140	2.50 (1.96–3.18)	3.67 (2.77–4.88)	20858	0.87 (0.77–1)	1.29 (1.12–1.48)
	Less than 1.3	567608	9047	8.41 (6.38–11.09)	11.27 (8.21–15.45)	40182	1.51 (1.29–1.76)	2.66 (2.27–3.13)

[A]Socioeconomic index for areas.
[B]Accessibility/remoteness index of Australia.

A clear dose–response gradient exists between car ownership and riding to work in NSW, with lower car ownership being associated with higher cycling rates. Residents of LGAs where the average car ownership was less than 1.3 cars per household were around 11 times more likely to ride to work, and around two and a half times more likely to walk to work than LGAs with car ownership 1.9 or more (Table 2).

Discussion

Between 2001 and 2011, active commuting increased in inner Sydney, decreased slightly in outer Sydney and declined in the Greater Metropolitan Region. Overall, the increases in inner Sydney were mitigated by the declines in the Greater Metropolitan Region, so active commuting for the combined Sydney and greater metropolitan area remained stable. Similar patterns were observed for both walking and cycling.

After adjusting for age, sex and all other LGA variables, people living in LGAs with high socioeconomic status, higher rurality and low car ownership were more likely to cycle or walk to work. A clear dose–response relationship was found between cycling and socio-economic status and car ownership, and between walking and rurality.

Our analysis found that active travel to work is low and decreasing in outer Sydney and the Greater Metropolitan Region, despite increases in inner Sydney. This decline should not be considered an inevitable consequence of urban development. In the UK, three towns provide good case studies for successful travel behaviour change programmes in outer areas. Worcester, Peterborough and Sutton implemented a suite of strategies including strong marketing and branding, walking, cycling and public transport strategies, and parking and road network strategies, in conjunction with the overarching travel demand management strategy and lead to reduction in car trips by between 6% and 9%, increases in walking by between 3% and 14% and increases in cycling by between 12% and 75%. These results are achievable in outer and Greater Metropolitan Sydney if a similar suite of programs were implemented,[26] and programs must focus on these areas to promote equity.

The relationship between a person's income and cycling remains unclear, with different countries reporting different relationships;[27] however in our study population which is part of a low cycling prevalence country, residents of LGAs with higher socioeconomic status were more likely to cycle to work. This is consistent with the profile of registered users of the public bicycle scheme in London, who tend to live in areas of low deprivation and high cycling prevalence.[11] Steinbach *et al*. argue that the identities of some professional (largely White) men and women could be bolstered by cycling, but that 'the aesthetic and symbolic goals of cycling were less appealing to those with other class, gendered and ethnic identities'[28].

Our findings may be partly explained by living in the inner city, proximity to workplace and car ownership i.e. people who live in the inner city (close to many workplaces) are likely to be well off (housing is expensive) and have fewer cars (car parks are rare, and there is access to good public transport). People living in high socioeconomic status LGAs may also be better educated, both generally and in health-related matters and therefore better understand the importance of physical activity. Education, one component of socioeconomic status, has been shown to be

independently associated with active travel on an individual level,[12] and may partly explain the association because it may be a marker of health literacy. The situation may be quite different in In those countries in which cycling is very common, such as Belgium and the Netherlands, where women cycle more and there is little difference in the socioeconomic profile of those cycling.[27]

The higher level of active commuting in rural and remote areas is consistent with previous Australian research,[12] but is harder to explain. In the Netherlands, small- and medium-sized cities have higher bicycle share than large cities,[29,30] probably as a result of the proximity of the destinations involved,[27] and this may also be the case in rural and remote Australian towns. It is also possible that roads in rural areas are less hostile environments for active commuting. Dill and Voros (2007) found that cyclists have a negative perception of roads with high-traffic intensities, but smaller towns are likely to have fewer cars and wider footpaths and may therefore be more attractive to walkers and cyclists.[31]

Limitations

The Census is a complete enumeration of active commuting behaviour in Australia; however results may be influenced by population-level variations in circumstances, for example bad weather or local events influencing transport choice on Census day. It is well known that active travel is affected by rain and other weather variables.[27,32] The Census is conducted in August, which is winter in NSW, so the timing of this data collection may have underestimated active commuting over the whole year. Similarly, the data report on only one day, which may not be representative of regular modes of travel. Finally, the data do not account for individual level factors associated with active commuting.

These data do not include activities besides walking and cycling, or walking or cycling for recreation, sport or other utility journeys and therefore underestimates total physical activity. Additionally, past research has shown that roughly half of all kilometres walked are associated with a public transport trip.[33] As this dataset excluded all walking journeys with more than one mode of transport, it is likely also to have significantly underestimated total transport walking. Further, each LGA may be quite large, and is unlikely to be homogeneous in terms of SES. Readers should bear this in mind when interpreting findings of this study. Finally, as the census is a cross-sectional survey, our results show associations between active commuting and descriptive factors, but this remains a statistical association, rather than a causal relationship.

The association between SEIFA and ARIA is well known[34] and is evident in our adjusted and unadjusted models; however these variables are commonly used together in various models as additional information is gained through their use.[35,36] The switch in association between ARIA and cycling from negative to positive under the unadjusted and adjusted model indicates that this relationship is heavily confounded by SEIFA and/or car ownership.

Conclusion

Increasing active travel is a priority for the NSW Government[37] because of the benefits to cities as well as to individuals. Reduced traffic congestion and improved public amenity go hand in hand with health benefits such as lower Body Mass Index[12] and reduced risk of diabetes;[38] however our research shows that more needs to be done to ensure that the benefits of active travel are distributed equitably to Australians with lower SES, and policies also include outer Sydney and metropolitan regions. A combined approach to travel management which includes marketing, transport strategies, and parking and road network strategies would be a start. Achieving change clearly requires input from multiple agencies, including roads infrastructure, public transport and health promotion, but successfully normalising active commuting in Australia may well achieve levels of population physical activity that have rarely been reported in purpose-designed physical activity interventions.

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