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Access to the city: transport, urban form and social exclusion in São Paulo, Mumbai and Istanbul

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Abstract

Socio-spatial segregation of cities and inadequate urban transport provision are frequently pointed at as major barriers for improving urban livelihood conditions for disadvantaged groups, particularly in the developing world. A number of recent studies draw attention to the links between transport accessibility and urban poverty by examining differences in travel behaviour across different income groups. There is little research, however, that adopts a consistent methodology across a range of cities, allowing for comparison of urban spatial structure and transport provision and its impact on the distribution of accessibility among different socio-economic groups. Based on representative household surveys, this study analyses and compares accessibility levels across different socio-economic groups in three developing world megacities and their metropolitan regions; Istanbul, São Paulo and Mumbai. It finds that in São Paulo, the most disadvantaged groups are excluded from social and economic opportunities through a combination of peripheral residential location, poor public transport provision and urban development patterns oriented toward motorisation. In contrast, the transport system and socio-spatial organisation of Istanbul and Mumbai enable higher levels of accessibility for a broader range of groups, including the most disadvantaged. This study finds that these differences can be partly attributed to elements of urban structure, including residential location and public transport infrastructure provision. The findings have implications for policy, suggesting that policymakers aiming to address the broader social equity agenda need to improve mobility options for disadvantaged urban residents while also paying attention to the spatial structure of cities, including residential density, land-use mix and local availability of jobs and social services to ensure a more accessible city for all.

Introduction

Urban transport in many emerging economy cities is facing a severe crisis. Triggered by rapid motorisation, population growth and urban expansion contemporary transport developments are continuously increasing threats to health and safety, local pollution and global carbon emissions, congestion levels and social exclusion (Gakenheimer 1999, Vasconcellos 2001b, Kalthier 2002, Pucher et al. 2005, Rode et al. 2014). While many of these problems occur in cities all over the world, transport challenges in emerging economy mega-cities are of a different order of magnitude to those in higher-income cities. They also have sufficient commonality, despite a diversity of specific contexts across the developing world to be considered together and distinct from transport problems in wealthy cities (Gwilliam 2003, Dimitriou 2011, Cervero 2013). The negative social, environmental and economic externalities of urban transport are generally more acute (Kalthier 2002, Pojani and Stead 2017), rates of population growth are often far higher (UN DESA 2014), and institutional capacities for transport and urban growth management are much weaker (Gwilliam 2003, Rode et al. 2016). The spatial structure of emerging economy cities also differs from typical patterns in high-income cities, with often denser urban cores, rapid and unplanned development on the urban periphery and uncoordinated and inadequate provision of transport infrastructure being common characteristics (Cervero 2013).

An increasingly recognised component of the urban transport challenge in emerging economy megacities is the impact of low levels of accessibility among disadvantaged groups in significantly reinforcing social exclusion (Godard and Diaz Olvera 2000, Vasconcellos 2001a, Godard 2011). Despite little academic or policy attention to these problems until the late 1990s (Gannon and Liu 1997, Godard 2011), there is now widespread awareness that contemporary urban transport conditions and the configuration of urban territory contribute to social exclusion by limiting people's accessibility to key social services such as education and health, and to economic opportunities including employment (Gwilliam 2002). Furthermore, it is now well established that low levels of accessibility among disadvantaged groups also present very real problems in many high income cities (Church et al. 2000, Hine and Mitchell 2001, Social Exclusion Unit 2003, Cass et al. 2005, Dodson and Sipe 2007, Preston and Rajé 2007). However, in emerging economy contexts with higher levels of absolute poverty, wider income disparities and lower levels of access to motorised forms of transport, these are problems for a majority rather than minority of the population (Lucas 2011). Despite increasing awareness of the relationship between social exclusion and transport and land-use conditions, integrating these findings within poverty-alleviation and the social sustainability policy agenda continues to be challenging (Preston 2009, Godard 2011). In addition, transport policy and public infrastructure investments continue to support further motorization and are exacerbating problems for disadvantaged groups in many rapidly growing cities in Latin America, Africa and Asia (Kalthier 2002, Badami 2005, Cervero 2013). In this global context, this study compares socio-spatial structure and transport provision in three cities in low and middle-income countries with the aim of understanding how variations in urban development patterns and public transport provision can produce differential distributions of accessibility across different income groups.

1 Literature review

1.1 Accessibility and social exclusion in emerging economy megacities

This study uses measures of accessibility to assess the social distribution of the benefits arising from transport and land-use systems. Accessibility-based frameworks of analysis are useful in connecting transport, land-use patterns and social exclusion, but the concept is complex and requires clarification. Frequently contrasted with mobility-based frameworks that dominate urban transport policy (Litman 2008), accessibility draws attention to the interaction of transport conditions, land-use patterns and individual attributes in determining how easily residents of a city can access a range of social and economic opportunities. Improving accessibility may well involve improvements to people's levels of mobility through improved transport systems, however, the concept has advantages in opening up a wider range of policy responses for addressing transport problems, including changes to the spatial distribution of opportunities that bring activities closer to residents, rather than requiring increased mobility (Litman 2008, Farrington 2007, Rode 2016). Accessibility has been defined as: "the extent to which land-use and transport systems enable (groups of) individuals to reach activities or destinations by means of a (combination of) transport mode(s)" (Geurs 2004). Following a well-established literature (Hansen 1959, Handy and Niemeier 1997), this definition includes both a 'transport' and a locational 'activity' element, assessing both the quality of the transport system in allowing for ease of movement and the spatial distribution and overall quantity and quality of available destinations, 'activities' or 'opportunities' (Handy and Niemeier 1997). Opportunities within urban contexts may include jobs, educational facilities and social services such as healthcare as well as a broad range of less formal activities including cultural opportunities or visiting family and friends that are central to participation in everyday social life (Cass et al. 2005, Stanley and Vella-Brodrick 2009). Some definitions of accessibility additionally include 'temporal' and 'individual' components that consider how the availability of activities over different times of day and individual factors including 'needs, preferences and abilities' influence accessibility (Geurs and Van Wee 2004). These four components of transport provision, destination availability, temporal and individual factors point to the range of determinants of accessibility and associated diversity of policy responses available to improve overall accessibility.

Accessibility in this paper is treated as a normative concept that focuses attention on conditions of poor accessibility with the implication of an imperative to improve conditions for disadvantaged groups (Farrington 2007). It is also treated as an attribute of particular persons (or groups of persons), although accessibility measures are also often applied to describe conditions at certain spatial locations (Handy and Niemeier 1997, Kwan 1998). This paper's focus on 'personal accessibility' indicates the ease of a particular person reaching a range of destinations (activities or opportunities), while measures of 'place accessibility' indicate the ease with which a particular location can be reached from a range of other places (Kwan et al. 2003). Measuring personal accessibility allows for analysis of its distribution or variations in levels of accessibility among different social groups. While such analysis is limited in low and middle-income cities and the concept of accessibility has more often been used with reference to high-income contexts, some existing literature suggests promise in further applying accessibility-based frameworks to studying the social impacts of transport and land-use conditions in developing world cities (Godard and Diaz Olvera 2000). An important component of the transport crisis in these cities involves profound 'accessibility inequities' (Vasconcellos 2001a).

Uneven distributions of personal accessibility among different social groups reflect patterns of privilege and disadvantage. These uneven distributions can be progressive (when disadvantaged groups profit from better access to the city) or regressive (when income inequality is exacerbated by a similar distribution of accessibility levels). In the latter case, conditions of poor accessibility are not only an outcome of disadvantage, but also reinforce inequality by restricting access to the economic and broader social opportunities of cities (Godard and Diaz Olvera 2000, Farrington 2007). Accessibility inequities cut across multiple social dimensions, with uneven distributions of benefits across lines of gender and age (Hine and Mitchell 2001, Salon and Gulyani 2008, Schlyter 2010, Levy 2013). This paper, however, focuses on the distribution of accessibility across different educational attainment groups as a proxy for income levels. Low levels of accessibility can be seen as one dimension of a broadly conceived concept of poverty, that includes structural factors such as a person's spatial horizons alongside more easily defined individual attributes such as income (Church et al. 2000, Farrington 2007).

Literature on transport-related 'disadvantage' (Hine and Mitchell 2001) and transport-related 'social exclusion' (Church and Frost 1999) has connected the concept of accessibility with social policy challenges by showing how lack of access caused by transport and land-use factors can prevent full participation in opportunities such as employment, healthcare and casual social networks that are necessary preconditions for working against poverty and other forms of disadvantage. The social exclusion framework has been most commonly used in studies within high income, and particularly, European contexts (Church et al. 2000, Social Exclusion Unit 2003, Cass et al. 2005, Preston and Rajé 2007), but has also been productively applied to investigations of conditions in low and middle-income cities (Olvera 2003, Lucas 2011). Social exclusion is a: "process which causes individuals or groups not to participate in the normal activities of the society in which they are resident" (Preston 2007). The concept is distinct from that of poverty (Church and Sullivan 2000), although in many (but not all) cases people in poverty will also be experiencing processes of social exclusion. Likewise, individuals may be socially excluded, but not necessarily in poverty. Seven types of exclusion related to transport and land-use conditions have been identified that limit individual's or groups' participation in society (Church et al. 2000)[1]. These factors range from physical barriers to the transport system experienced by children and the elderly, to spatial isolation in peripheral urban areas and high travel costs that limit access to labour markets. Highlighting 'exclusion' suggests that the problem is not a lack of social opportunities, but rather accessing these opportunities (Farrington 2007).

1.2 Empirical studies of inequities in urban transport accessibility

Considering the range of factors influencing levels of accessibility including land use, transport, temporal and individual components (Geurs and Van Wee 2004), inequities among social groups will result from a combination of poor transport systems, patterns of land-use, limited opening times for key social services and particular characteristics of individuals or groups such as disability or gender. Empirical studies that comprehensively document how this full range of factors influences the distribution of accessibility across different social groups in emerging economy cities are rare. However, a number of studies report on differences across social classes in travel behaviour, access to public transport and residential location within cities which are important in suggesting ways in which transport and land-use components impact on accessibility equity.

Literature investigating urban transport in emerging economy cities often begins from observations about rapid rates of motorisation (Gakenheimer 1999, Kenworthy 2011). Motorisation in its most limited sense refers to increasing rates of private motor vehicle ownership. However, in practice this is usually accompanied by shifts in the orientation of public policy and infrastructure investment toward catering for motor vehicles (Vasconcellos 1997, Ahmed et al. 2008), and accompanying changes in land use patterns and the spatial structure of cities that reinforce rising vehicle ownership (Angel et al. 2011, Cervero 2013). Rapid motorization in emerging economy cities not only impacts on environmental conditions (Wright and Fulton 2005), economic performance through traffic congestion (Gakenheimer 1999, Gwilliam 2003) and health and safety problems (Rode 2014), but also on the distribution of accessibility among different social groups. Vasconcellos argues that conditions of 'accessibility inequity' are profoundly related to motorization and the increasing use of transport energy this entails (Vasconcellos 2001a). With only a minority of residents able to afford private motorised transport, but with infrastructure and rapidly expanding urban form and land-use patterns increasingly oriented toward this system (Vasconcellos 1997), disadvantaged residents are left to depend on inadequate and far slower public transport and non-motorised modes that entail reduced access to the opportunities of their cities. The overall effect is a regressive shift in the distribution of accessibility among social groups.

Shifts toward increasingly motorised cities are reflected in changes to transport behaviour, with increasing proportions of passenger trips based on private motorcycles and cars, as well as motorised forms of public transport. Reliable statistics on changes in transport behaviour over time in emerging economy cities are rare; however dramatic increases in vehicle ownership provide a good proxy indicator. For instance, in São Paulo the motorised vehicle fleet increased six times between 1970 and 1996 (Vasconcellos 2005). Across India the number

[1] Physical exclusion, geographic exclusion, exclusion from facilities, economic exclusion, time-based exclusion, fear-based exclusion, space exclusion.

of motorcycles increased fourteen-fold between 1981 and 2002, from fewer than 3 million to 42 million (Pucher et al. 2007). In Shanghai, the modal share of walking and cycling combined dropped from 72% in 1986 to 54% in 2004 (Pucher et al. 2007). In Delhi, bicycle use has declined from 36% to 7% of all mechanized trips between 1957 and 1994 (Badami 2005). Information about differences in travel behaviour among social classes in emerging economy cities is far more limited than studies of aggregate travel behaviour of urban populations. The relatively low level of research in the field also makes it difficult to draw accurate comparisons between cities, with regard to travel behaviour indicators such as mode share. Nevertheless, a number of studies suggest that distinct patterns in poorer people's travel behaviour reflect widespread problems in access to the social and economic opportunities of cities.

Despite rising motorisation, poorer people and other disadvantaged social groups including women, children, and the elderly continue to rely on non-motorised forms of transport, to a far greater degree than more privileged groups. Household travel surveys in low-income cities including Delhi (Badami 2005) and Mumbai, India (Baker 2005), Nairobi, Kenya (Salon and Aligula 2012), Kampala, Uganda and Harare, Zimbabwe (Bryceson et al. 2003), Cairo, Egypt and Surabaya, Indonesia (Kalthier 2002) all confirm that poorer groups rely heavily on walking. For instance, a representative survey of 2105 households in Nairobi in 2004 found that among those regularly travelling to work or school locations outside their immediate neighbourhood, walking was the most frequent mode of travel for 40% of adults in the poorest group, but for only 10% of adults in the wealthiest group (Salon and Aligula 2012). Walking was the main mode of travel for 80% of children under the age of 16 in the poorest group, but just 20% of children in the wealthiest group. In Mumbai, a household travel survey in 2003/04 found similar results, with 61% of commuters in poor households walking to work, while 44% of the overall sample of households walked. Use of private motorised transport was very low, with 11% of the overall sample using their own two-wheelers or cars, but less than 1% of poor households using private motorised transport (Baker 2005). Travel behaviour in middle, rather than low-income cities unsurprisingly involves higher rates of motorised transport use across all social groups, however significant disparities still exist between richer and poorer residents. Travel behaviour patterns among different social groups including modal share between cars, motorcycles, buses and trains varies significantly depending on specific urban contexts (Schlyter 2010). However, a travel survey comparing residents of richer and poorer neighbourhoods in Xian, China and Hanoi, Vietnam showed that in both cases, poorer people walk more than wealthier people for their regular daily trip (Schlyter 2010).

Key elements of travel behaviour other than modal 'choice' including trip distance, trip purpose, travel times and daily trip rates also vary significantly between poorer and richer groups in low and middle-income cities. Poorer urban residents often live relatively low-mobility and spatially restricted lives, while wealthier groups with better access to motorised forms of transport travel greater distances and to wider variety of destinations across cities (Baker 2005). In Nairobi, for instance, a household travel survey found that only 49% of adults and 27% of children under 16 years of age travelled to a work or school location outside transportation zones immediately surrounding their home location (Salon and Aligula 2012). Based on higher levels of mobility for wealthier residents, it is suggested that many poorer people are 'mobility constrained' rather than deliberately adopting localized, low-mobility lifestyles. This 'tendency to retreat into the area of residence' has also been observed in other African cities including Bamako, Mali and Niamey, Niger (Olvera 2003). While in many low-income cities, poorer residents can simply not afford any form of motorised transport, in middle-income cities travel behaviour among different socio-economic groups can follow very different patterns. For instance, in Latin American cities, poorer groups are not necessarily confined to non-motorised modes, but instead travel long distances on slow forms of public transport. For the poorest groups in cities including Mexico City and Rio de Janeiro, workers can spend more than three hours per day commuting (Gwilliam 2002). While poorer workers living in peripheral locations spend more time travelling, even in highly motorised cities poorer people make a lower number of motorised trips, with higher income groups in São Paulo making four times the number of motorised trips and 2.5 times the number of overall daily trips than the poorest groups (Vasconcellos 2001a).

Differences in travel behaviour among socio-economic groups reflect not only different levels of access to motorised transport, but also the spatial structure of cities. In considering how levels of accessibility differ among urban social groups, it is not only the availability of various transport options that matters, but also spatial structure, including the respective location of work places, residential areas and social services. Accompanying motorization trends, many low and middle-income cities have grown enormously in their spatial area, often at rates well above levels of population growth (Angel et al. 2011). The urban area of Delhi, for instance, expanded five-fold between 1981 and 2005 (Badami 2005), while a global sample of 120 cities expanded at rates averaging double the population growth rate between 1990 and 2000 (Angel et al. 2011). Global trends show that while average urban densities in low and middle-income cities are much higher than high-income cities, density gradients are flattening more quickly with rapid decentralisation and sprawl led by both informal housing and new towns and employment sub-centre development (Angel et al. 2011, Cervero 2013). This spatial dynamic in cities is contributing to declining levels of overall accessibility and mobility in many low and middle-income cities, despite increasing penetration of both private and public forms of motorised forms of transport (Gakenheimer 1999).

Disadvantaged social groups are disproportionately impacted by these changing urban forms, with poorer people having reduced access to private motor vehicles that for wealthier groups go some way to retaining accessibility in the face of increasingly dispersed destinations. In some urban contexts, many of the urban poor live in informal developments in peripheral areas of the city, distant from employment and other social opportunities and under-served by public transport services and infrastructure. While this is a far from universal characterization of socio-spatial patterns in low and middle-income cities it has been particularly noted in Latin American cities (Lima 2001, Gwilliam 2002, Lacabana 2003, Delmelle and Casas 2012). At the same time, however, the poor also live in very central locations, avoiding high transport costs by trading off housing conditions for walkable access to social opportunities (Gwilliam 2002, Pucher et al. 2005). While poorer social groups are not necessarily confined to urban peripheries, and in some cases may be spatially distributed throughout the city (Godard and Diaz Olvera 2000, Baker 2005), for poor people living in locations distant from work and other social opportunities the urban periphery can be a 'space of banishment' that contrasts with suburban landscapes of affluence common in high-income urban contexts (Ravalet 2010).

Relative levels of accessibility across different locations within a city are not only a function of distance from city centres. Improvements in accessibility are possible with effective public transport systems or with the distribution of key social services and employment locations throughout urban areas. However, in practice, peripheral urban development is in many cases haphazard and poorly integrated with effective and affordable public transport (Pucher et al. 2005). Even in the relatively rare cases where urban transport investment has been deliberately targeted at addressing socio-spatial inequalities, route planning and selection of projects such as new bus rapid transit lines have only had marginal impacts on improving relative levels of accessibility for the most disadvantaged.

2 Study design and data

This paper explores the unequal distribution of travel opportunities, choices and demand between different groups of different status in the three rapidly urbanizing cities São Paulo, Istanbul and Mumbai. This is done based on a comparative research design in order to investigate common and differential patterns of equity and transport in the three cities. The paper focusses on three dimensions of personal accessibility: residential location, trip duration and modal choice. Drawing on the Urban Age City Surveys conducted in these three cities between 2007 and 2010, the patterns of travel demand are compared across cities and sample groups. Differences and similarities in inequalities in personal accessibility are described in detail, on the basis of which potential future trajectories of the cities are outlined given their specific social and geographical conditions.

2.1 The survey

The data for the accessibility analysis of different socio-economic groups in São Paulo, Istanbul and Mumbai came from the Urban Age City Surveys,

	Target		Sample	
	Area (km^2)	Population	Sample	
São Paulo (MRSP)	7,944	20,605,102	1,000	Stratification
Istanbul	5,335	14,163,989	1,013	Geographical (city, region)
Mumbai (MMR)	4,420	18,893,059	1,001	Geographical (city, region)

Table 1: Sample in São Paulo, Istanbul and Mumbai

which were conducted by LSE Cities between 2008 and 2010. The polling was carried out by the local branches of global polling company Ipsos. Each survey targeted the metropolitan region of the three cities with a representative sample of about 1,000 interviews (see Table 1). Stratification of the selected households for interviews insured a proportional coverage across the different geographies of each city as well as across socio-economic profiles. Where interviewers were unable to follow the set quotas as a result of fieldwork difficulties, small adjustments to the dataset were conducted by weighting for gender, economic status, education level and area. Interviews in São Paulo were by phone and face-to-face. In Istanbul and Mumbai all interviews were face-to-face at the home of interviewed residents. The residential location of each interviewee was recorded and transferred to GIS.

The general information of each interviewee used for this analysis included the socio-economic information and residential location. In addition, the following key transport and accessibility parameters were recorded and analysed:

- Destination of main daily journey
- Trip origin and destination (city area) of main daily journey
- Legs of main daily journey including travel time and transport mode
- Vehicle ownership (car, motorbike, bicycle) within household
- Travel time to reach range of services and shopping facilities

The sample design is illustrated by the case of São Paulo where the survey was based on 1,000 interviews and was selected in two stages. In a first stage, the census tracts were selected: areas with around 300 households defined by Instituto Brasileiro de Geografia e Estatística (IBGE) during the national census survey. At every selected census tract 10 interviews were carried out. The selection of respondents in the chosen census tracts (second stage) was made according to the interviewer's criterion, with the restriction to complete interviews with people of a specific profile (quota), considering that the distribution of such variables of the sample as a whole can reflect the distribution of the population.

2.2 Choice of indicators and statistical method

The central interest of this study concerns measures that describe personal accessibility. As shown above, relevant aspects relate to the residential location of respondents, trip duration and mode choice. In the survey, geo-coding of sampling locations allow the development of distance measures to the central city. Here, the geographical centres of each city are used in order to determine each respondent's location from the city centre.

Residential location of respondents is also used to calculate the distance to the mass rapid transit network. This indicator reflects the degree to which a household has access to the transport network and is able to access the cities. Another measure related to residential location is access to services, the average travel time to a range of urban services, including shopping centres, markets, cultural facilities, parks and leisure.

Figure 1: The three case study cities and their sample regions

The trip duration is calculated based on respondents' estimations of each segment of their main trip. The questionnaire asks about the purpose of the main trip, which allows a distinction between work trips and non-work trips. Trip durations are estimated for different groups in the sample, including age, sex and educational attainment.

Finally, the mode choice is determined from the main trip. In the cases where multiple modes are used, a dominant mode is identified defined by the time spent on each mode. If the same time is spent on multiple modes, the fastest mode, i.e. the mode that is likely to cover a larger distance than the other mode is defined as the dominant one. Respondents' access to a car is also considered as part of potential mode choice.

Respondents are grouped by sex, decennial age bands, socio-economic status (SES) and educational attainment. SES and educational attainment correlate in each city; yet, there are differences with respect to the population in each SES category. Whereas in São Paulo and Istanbul there are only a few (between 2 and 23) respondents in the top (A) and bottom (E) categories, in Mumbai all categories A to E have a more equal share. This points towards different equality levels in each city and thereby complicates comparison. The groups are more evenly spread among classes of educational attainment, which has five categories (Table 2).

Educational attainment is more evenly distributed in all cities; only the group of no formal education in the Istanbul sample is very small. This group will need to be viewed with care in the subsequent investigation. Nevertheless, educational attainment is strictly speaking not a measure of social status, although certainly there are correlations with SES and income. Yet, groups with lower educational attainment can reside in higher status households. This caveat will need to be kept in mind when viewing the results. All analysis has also been tested for socio-economic status, which confirms the patterns found here.

Descriptive statistics and one way Analyses of Variance (ANOVA) tests are used to evaluate group differences in all accessibility indicators. Both absolute differences and ratios between groups of higher status (higher education) and lower status (no formal education) are calculated to measure the inequalities in accessibility. The software used is IBM SPSS.

(a) socio-economic status (SES)								
	E	D	C2	C	C1	B	A	total
São Paulo	14	201	249	0	261	252	23	1000
Istanbul	2	54	441	0	349	152	15	1013
Mumbai	198	233	0	250	0	183	137	1001

(b) educational attainment						
	no formal education	primary	secondary	high school	higher education	total
São Paulo	143	257	193	339	68	1000
Istanbul	16	394	209	300	94	1013
Mumbai	55	325	373	186	62	1001

Table 2: Population in each category of (a) socio-economic status and (b) educational attainment.

3 Introducing the case study cities

Below follows a brief comparative introduction of the three case study cities focusing on their patterns of urban density, their public transport infrastructures and the mobility behaviour of their residents. All three characteristics are of particular importance to the main issues addressed in this study. In addition, it is helpful to refer to the absolute wealth level and income inequality in the three cities upfront. Istanbul is the richest of the three with a GDP of US$ 24,867 per capita compared to US$ 20,650 in São Paulo and US$ 7,005 in Mumbai. The Gini coefficient of income inequality is highest in São Paulo with 0.60 compared to 0.45 in Mumbai (Maharashtra State Urban Areas) and 0.39 in Istanbul.

3.1 Urban density and spatial extent

Urban density for the three cities and their metropolitan regions is illustrated below in terms of the density of occupation over a twenty-four hour period in each km^2 of a 100 x 100 km urban area. Density is largely driven by topographical constraints and the location of public transport and other infrastructure, but also by each city's inherited traditions of urban planning and development. While high density is sometimes associated exclusively with poor and overcrowded urban environments, it can also enable a higher quality of life and reduce the environmental impact of cities by facilitating walking and cycling. In doing so, high density urban areas can enhance a city's vitality and make the provision of public transport and other amenities more viable. São Paulo, Istanbul and Mumbai demonstrate a wide range of differing density patterns – from the very high densities in the centres of Mumbai and Istanbul to the much lower density development patterns of São Paulo. São Paulo is also the city in which density levels remain the most constant, reaching half their maximum value around 25 km from the centre, while in Istanbul this occurs at a distance of roughly 15 km from the city centre.

In Istanbul, density levels are high, particularly when compared to other European cities. The city's peak density of 78,565 people per km^2 well exceeds that of most European and North American cities. Istanbul also displays a distinct difference between the European

European and Asian sides: while density levels on the European side vary considerably – the highest and also some of the lowest densities within the built-up area can be found here – the Asian side is much more homogeneous and is dominated by mid-range densities of around 20,000 people per km^2.

Mumbai constitutes a category on its own. The territorial constraints of this island city have created unusually high urban densities. The average density of the built-up area is 34,656 people per km^2, surpassing not only any of the other three cities but also New York, Delhi and even Hong Kong. Furthermore, it is not rare for the densest areas of Mumbai to feature ambient population densities well above 90,000 people per km^2 and residential densities higher than 130,000 residents per km^2.

São Paulo is an example for urban development primarily based on urban motorways for metropolitan-wide accessibility. It also has a small but growing metro system, and is crossed by major railway lines, reflecting the city's history as a centre for trade. While these railway corridors are dominated by freight, city transport planners are examining options for running more passenger services along them. The city has recently completed an orbital motorway network.

In recent years, Istanbul's metro network has expanded through both extensions of existing lines, and the construction of new ones. Now measuring 94 km, the metro has also been complemented by the opening of a 13 km rail link under the Bosphorous Strait in 2013 (Marmaray), which aims to eventually connect with the suburban rail lines operated by Turkish State Railways. The Metrobus Bus Rapid Transit (BRT) system opened in 2007, and has since been expanded to over 50 km in length. The Metrobus operates along a dedicated lane crossing the Bosporus Bridge between Avcilar on the European side, to Kadikoy on the Anatolian side. It continues from Avcilar to Beylikdüzü on the European side and its current daily use is approximately 750,000 passengers per day. Mumbai's public transport infrastructure is primarily regional rail based and the city can rely on one of the world's most high-capacity rail corridors connecting the city's peninsular with its hinterland. More recently, the city is embarking on the development of a metro system with a first cross-city line already in operation.

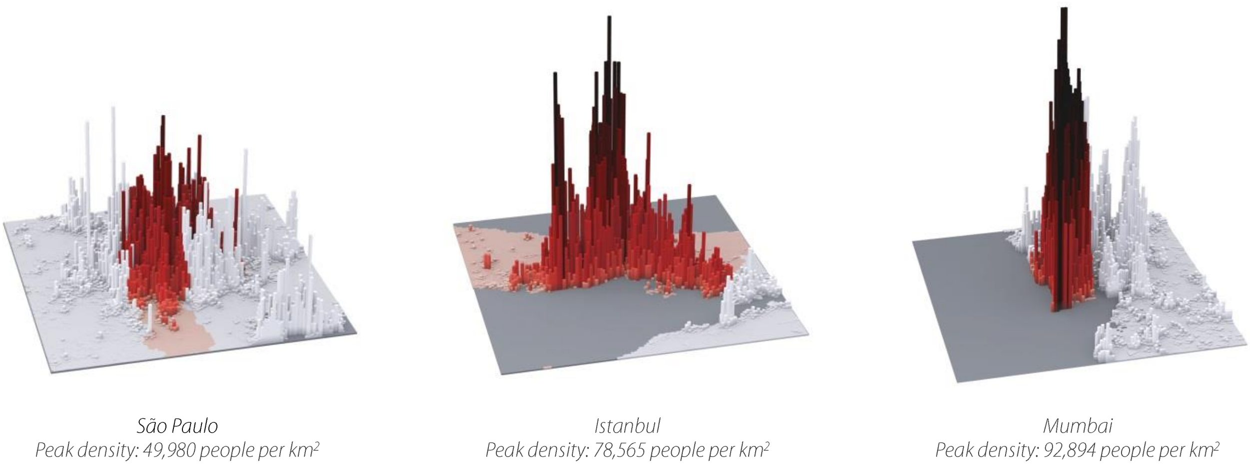

Figure 2: Ambient densities in São Paulo, Istanbul and Mumbai (red areas indicate those within the administrative boundaries of each city; grey areas are the wider metro regions)

3.2 Rapid transit infrastructure

Transport infrastructure is a critical driver of urban accessibility, enabling centralisation of economic functions and the accommodation of a growing population along metropolitan rail and bus routes. Where public transport infrastructure is not in place, either motorways dominate or there is a considerable lack of metropolitan-wide city access. Both usually result in more sprawling forms of development and congestion as private car use persistently runs ahead of road building. The three cities offer varying levels of transport infrastructure.

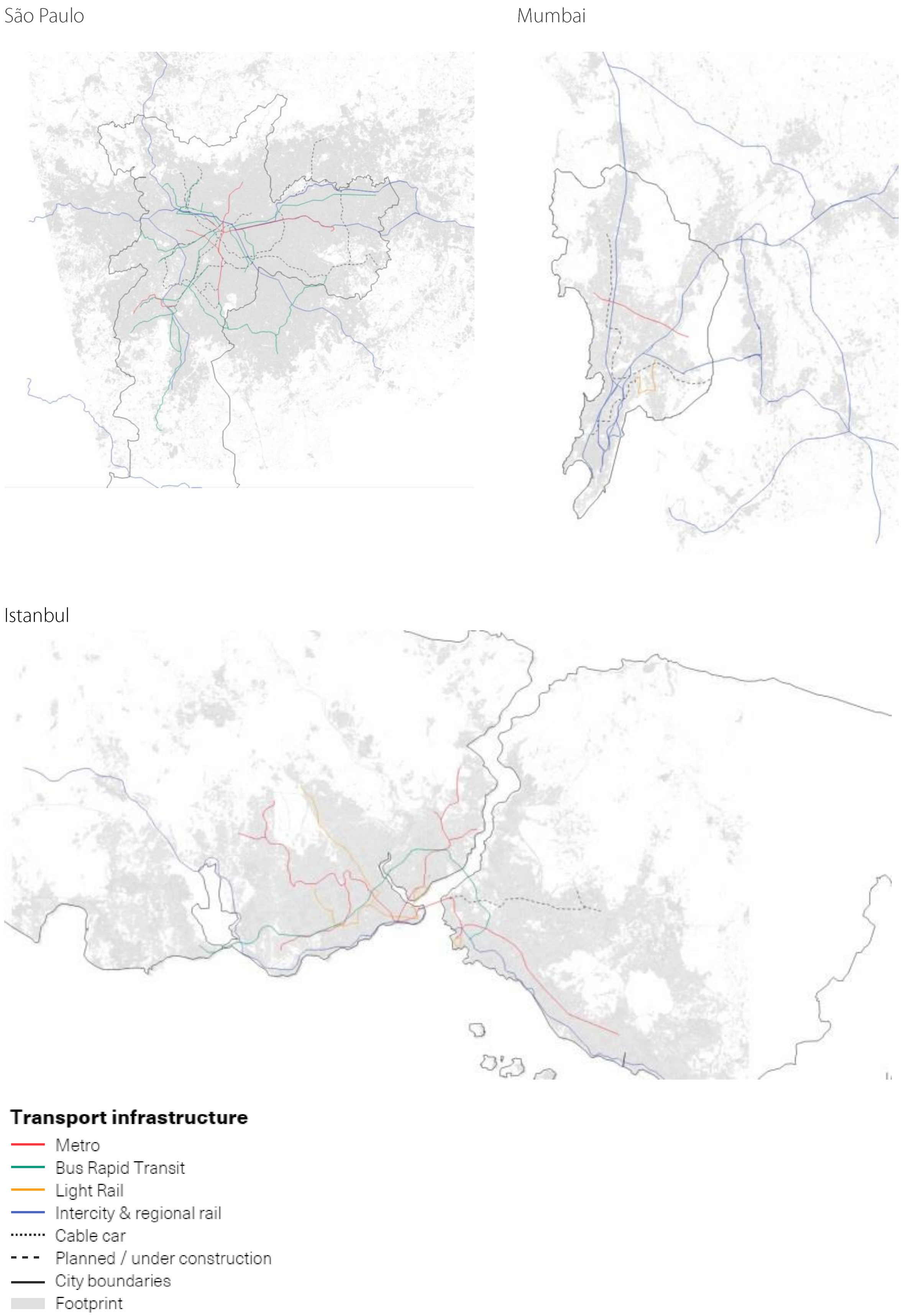

Figure 3: Rapid transit infrastructure in São Paulo, Istanbul and Mumbai

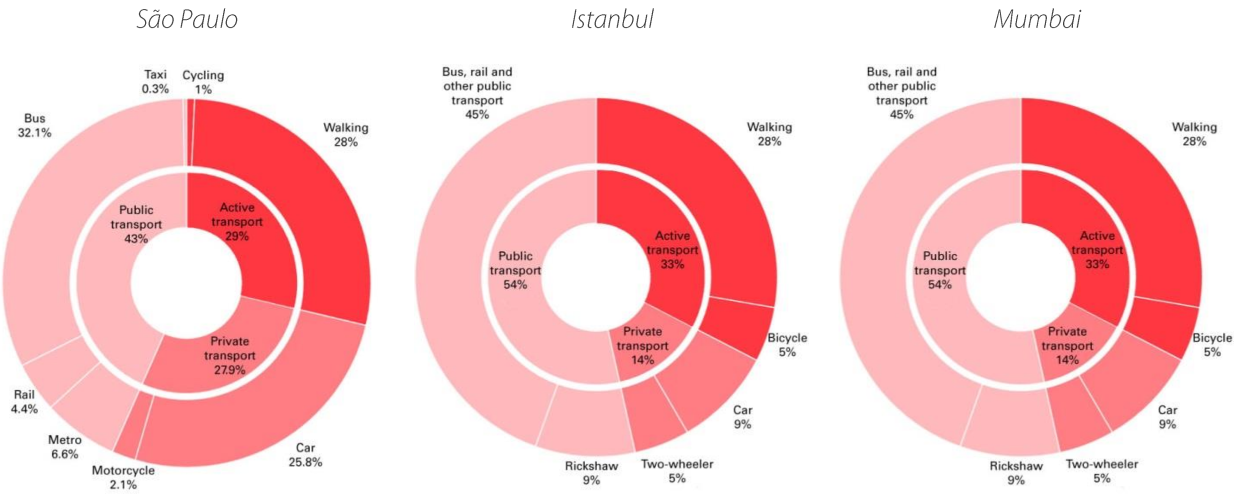

Figure 4: Modal splits in São Paulo, Istanbul and Mumbai

3.3 Mobility patterns

Looking at different ways in which people travel (modal splits) helps to understand the mobility behaviour in the three cities. Mumbai's compactness contributes to a more sustainable pattern than the other cities as a result of the very high numbers of people who walk or take public transport. In the Mumbai case, the high percentage of walking is a direct consequence of the proximity of residential locations (often slums) and workplaces in these high-density, mixed-use urban environments. Walking and public transport accounts for over 80% of all forms of travel, with cars barely making the 10 per cent mark.

By contrast, car use in São Paulo, similar to many South American cities, often exceeding that of cities like London, New York, Berlin and Shanghai. Driving makes up a quarter of all trips in São Paulo. Overall, São Paulo shows close to a three-way split between walking and cycling, public transport, and private car use. Istanbul's mobility pattern is less extreme. With 48 per cent of trips on foot, like Mumbai, it is a city where walking dominates. Public transport is also more developed than in São Paulo resulting in a share of 35 per cent.

4 Survey results

In this section, we present results of the surveys for all three cities. Adopting a comparative perspective, we highlight different dimensions of unequal accessibility across and within São Paulo, Istanbul and Mumbai. We focus on three dimensions of personal accessibility: residential location, trip duration and mode choice.

4.1 Residential location 1: distance from the city centre

As shown above, residential location is part of longer-term household decisions that significantly affect subsequent travel patterns and thus shape inequalities in accessibility and travel. In particular, inequalities arise around location, proximity to the city and proximity to services. The mean distance between survey respondents' homes and the city centre varies between the three cities. In São Paulo the mean distance for all education groups is 19.6km, while in Mumbai it is 15.6km and in Istanbul 14.3km (Table 3). On average, São Paulo respondents live four to five kilometres further away from the centre.

The geographic location of survey respondents' homes with respect to the city centre varies substantially across educational groups within all three cities. There is a clear and consistent pattern for all cities, with less educated people more likely to live at greater distances from the city centre than those

	mean	0 none formal	1 primary	2 secondary	3 high school	4 higher education	Abs.D.
São Paulo**	19.6	23.5	20.9	20.2	17.8	13.3	10.2
Istanbul*	14.3	19.0	15.4	14.0	13.6	12.1	6.9
Mumbai**	15.6	21.9	16.8	15.9	12.4	12.0	9.8

* sig. at p≤.050 ·

** sig. at p≤.001 · Abs.D. = Absolute difference between highest (4) and lowest group (0)

Table 3: Mean distance (km) between home and city centre for educational groups, São Paulo, Istanbul and Mumbai.

with higher education levels (Figure 5). Comparing the residential location of different educational groups within the city shows that the range with respect to the city mean is highest in Mumbai, and lowest in Istanbul (Table 4). In Mumbai, members of the least educated group live substantially further from the centre than the city mean while members of the two highest educational groups live much closer than the city mean. Members of the lowest educational group live an average of 1.4 times further from the centre than the sample mean, while members of the two highest education groups live an average of 1.2 times closer to the city centre than the sample mean.

In São Paulo, members of the three lowest education groups live further from the centre than the city mean, while members of the very highest education group live substantially closer. Members of the lowest education group live an average of 3.9km (1.20 times) further from the city centre than the mean, while members of the highest education group live considerably closer (6.3km or 0.67 times the city mean).

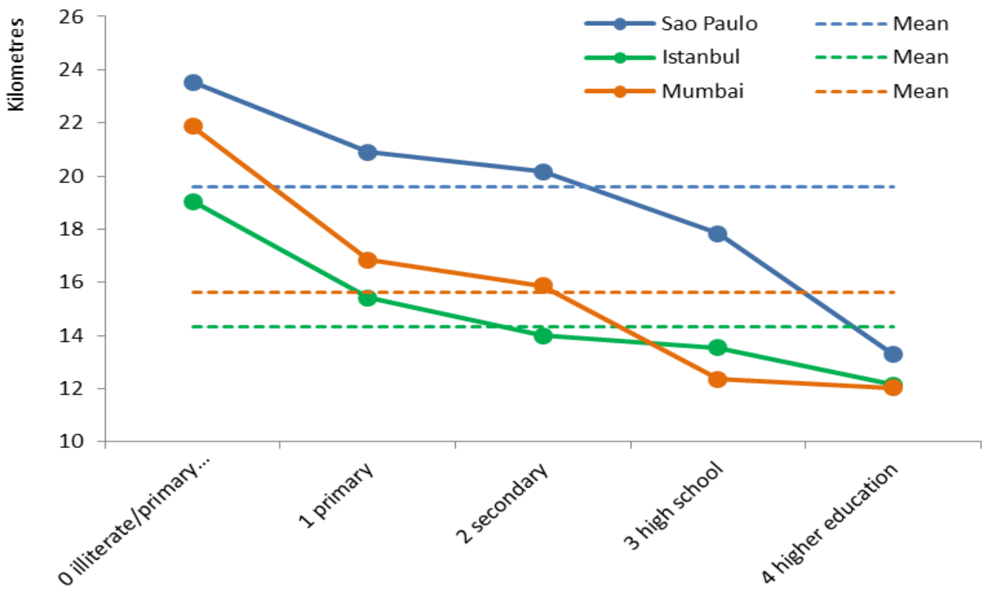

Figure 5: Mean distance between home and city centre for educational groups, São Paulo, Istanbul and Mumbai.

	0 none formal	1 primary	2 secondary	3 high school	4 higher education	ratio
São Paulo	1.20	1.07	1.03	0.91	0.68	1.77
Istanbul	1.33	1.08	0.98	0.95	0.85	1.57
Mumbai	1.40	1.08	1.02	0.79	0.77	1.82

ratio = Ratio between highest (4) and lowest group (0)

Table 4: Distance between home and city centre, variance from city mean for different educational groups, São Paulo, Istanbul and Mumbai.

Istanbul has the lowest range of variation from the overall mean across different educational groups. Nevertheless, members of the very lowest educated group live in considerably more peripheral locations than other groups, with homes an average distance of 19.0km from the city centre, 4.7km (1.33 times) further from the centre than the sample mean. Members of the highest educated group are located at 0.85 times the sample's mean distance to the centre.

Both Mumbai and São Paulo have substantial differences in residential location between the highest and lowest educated groups (Figure 6). In both these cities, there is an approximately 1.8-fold difference in distance between members of the lowest and highest educational group (Table 4). In Istanbul, the variation between the highest and lowest educational groups is less. However, in this city, members of the lowest educated group still live in substantially more peripheral locations: they tend to live nearly 1.6 times

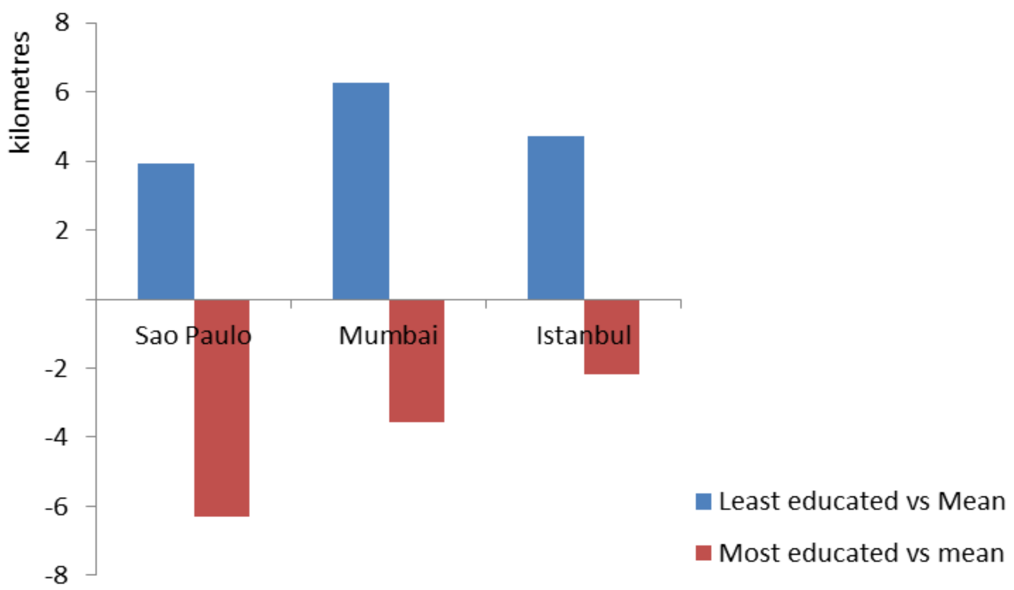

Figure 6: Mean distance between home and city centre, variance from mean for least and most educated groups São Paulo, Istanbul and Mumbai.

	mean	0 none formal	1 primary	2 secondary	3 high school	4 higher education	Abs.D.
São Paulo**	3.1	4.4	3.7	3.5	2.2	1.2	3.2
Istanbul*	2.8	3.4	3.1	2.9	2.4	1.7	1.6
Mumbai**	0.8	1.2	1.0	0.8	0.5	0.4	0.8

* sig. at p≤.050 ·

** sig. at p≤.001 · Abs.D. = Absolute difference between highest (4) and lowest group (0)

Table 5: Mean distance (km) between home and rapid transit station for educational groups, São Paulo, Istanbul and Mumbai.

further away from the centre than the highest educated group.

4.2 Residential location 2: distance to rapid transit

Distance to rapid transit is an indicator of a household's connectivity to the wider urban transport network; a measure of how easily an individual can participate in opportunities distant from home. Vice versa, the measure is affected by the coverage of the transit network, which can be limited in some cities. The indicator thus reflects conscious choice as well as ability to live in well-connected locations. The average distance of survey respondents' homes to their closest rapid transit station varies between the three cities. In Mumbai, respondents live closest to rail or bus rapid transit stations, at an average distance of 0.8km, while in Istanbul the equivalent distance is 2.8km and in São Paulo 3.1km (Table 5).

For all three cities, there is a clear and consistent pattern of variation between educational groups in

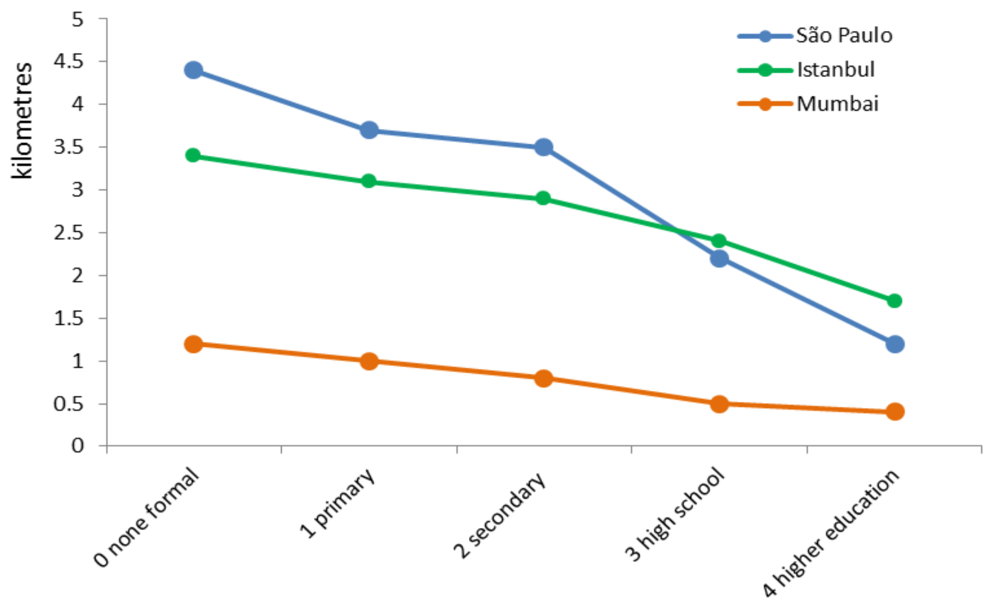

Figure 7: Mean distance between home and rapid transit station for educational groups, São Paulo, Istanbul and Mumbai.

	0 none formal	1 primary	2 secondary	3 high school	4 higher education	ratio
São Paulo	1.42	1.19	1.14	0.72	0.40	3.53
Istanbul	1.23	1.14	1.05	0.89	0.63	1.95
Mumbai	1.54	1.22	0.99	0.63	0.53	2.93
ratio = Ratio between highest (4) and lowest group (0)						

Table 6: Distance between home and rapid transit stations, percentage variation from the city mean for educationa groups. São Paulo, Istanbul and Mumbai.

the average distance to rapid transit stations. In all cities, members of higher educational groups live closer to rapid transit stations than members of lower educational groups (Table 5). Comparing each educational group to the sample mean shows that the range of variation between groups is similarly high in relative terms in both São Paulo and Mumbai (). With regard to variation in absolute distance from rapid transit stations, variation is highest in São Paulo and lowest in Mumbai. The sample mean distance to rapid transit is much lower in Mumbai, explaining the lower variation in absolute terms. In São Paulo, the average distance between home and rapid transit station for members of the least educated group is 1.3km (1.42 times) further than the city mean, while members of the highest educated group have a considerable locational advantage, living at a distance to the network of 0.4 times the sample mean. In Mumbai, the least educated group live 0.4km (1.54 times) further away from rail stations than the city mean, while the two most educated groups live closer with 0.63 and 0.53 times the mean. Istanbul has the least variation in percentage terms across educational groups. The two least educated groups live 1.23 and 1.14 times further from rapid transit stations than the sample mean, while the most educated group enjoy a substantial advantage in living an average of 1.0km closer than the sample mean.

São Paulo has the highest variation in distance to rapid transit between the highest and lowest educated groups. Mumbai also has substantial variation between these social extremes, while in Istanbul variation is much lower. In São Paulo, members of the lowest educated group live in locations an average of 3.5 times more distant from rapid transit than the highest educated (Table 6). While members of the lowest educated group must travel an average of 4.4km from home to a rapid transit station, the highest educated need only travel 1.2km. In Mumbai, the difference in absolute distance between these educational groups is far less, however the lowest educated groups are still on average almost triple the distance (1.2km vs 0.4km) from rapid transit than the most educated. In Istanbul, variation is least among the three cities in percentage terms, with the least educated living double the distance from rapid transit than the most educated (3.4km vs 1.7km).

4.3 Travel time 1: key services

Travel time is an expression of accessibility, which is closely tied to residential location in relation to key services as well as the transport network. The average travel time to key services varies between the three cities. The surveyed São Paulo residents report average travel times of 34 minutes to reach a range of key services including libraries, cinemas, public offices, hospitals, museums, shopping malls/markets, theatres/concert halls and public parks. São Paulo's average travel time to services is over double that reported by Mumbai residents (16 minutes) and well above that for Istanbul's residents (19 minutes) (Table 7). Variations in travel time to key services across educational groups do not follow the same consistent patterns across all cities. In São Paulo travel time is slightly higher than the sample mean for the lowest two educational groups and substantially

	mean	0 none formal	1 primary	2 secondary	3 high school	4 higher education	Abs.D.
São Paulo**	34	38	38	35	31	25	9
Istanbul	19	18	20	20	18	19	1
Mumbai	16	16	16	17	15	17	-1

* sig. at p≤.050

** sig. at p≤.001

Abs.D. = Absolute difference between highest (4) and lowest group (0)

Table 7: Travel time in minutes between home and key services for educational groups, São Paulo, Istanbul and Mumbai.

lower for the very highest educational group. Members of the two lowest educated groups report average travel times of 4 minutes (1.11 times) higher than the city mean, while members of the highest educated group report times 9 minutes lower (0.72 times) than the mean (Table 8). In Istanbul and Mumbai, average travel times to services do not vary among different educational groups, with all groups within a two minutes respective sample difference of the means. Consequently, the differences are not statistically significant at the 5% level.

In Mumbai and Istanbul there is no meaningful difference in average travel time to services between the lowest and highest education groups, with all groups spending 15-17 and 18-20 minutes respectively to reach key services. In São Paulo, however, members of the lowest educated group travel on average 1.5 times longer (38 vs 25 minutes) than the highest educated to reach key services (Figure 8).

	0 none formal	1 primary	2 secondary	3 high school	4 higher education	ratio
São Paulo	1.11	1.11	1.03	0.91	0.72	1.54
Istanbul	0.94	1.02	1.05	0.95	0.97	0.97
Mumbai	0.99	0.97	1.05	0.95	1.04	0.95

ratio = Ratio between highest (4) and lowest group (0)

Table 8: Travel time in minutes to key services, percentage variation from city mean for different educational groups, São Paulo, Istanbul and Mumbai.

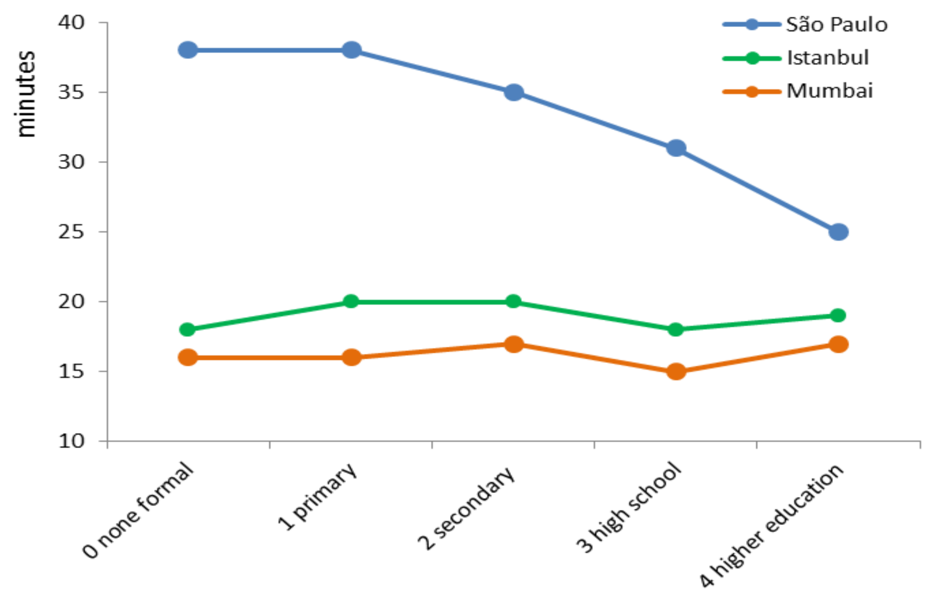

Figure 8: Travel time in minutes between home and key services for educational groups, São Paulo, Istanbul and Mumbai.

4.4 Travel time 2: workplace

Travel time is an expression of accessibility, which is closely tied to residential location in relation to workplaces as well as the transport network. Longer travel times to the workplace indicate disadvantage as they limit daily time budgets for other productive or recreational activities. Reported average travel time to regular daily workplaces varies between the three cities. Survey respondents in São Paulo report the longest average travel time at 40 minutes, while Istanbul respondents average 34 minutes and Mumbai respondents 27 minutes (Table 9).

There are few consistent patterns across the three cities with regard to variation in average travel times across educational groups (Figure 9). Travel time to work does not follow the same strong regressive pattern evident for other indicators. In São Paulo, people with the lowest level of education report much shorter average travel times to work than members of all other education groups. The group with no formal

	mean	0 none formal	1 primary	2 secondary	3 high school	4 higher education	Abs.D.
São Paulo	40	28	41	39	41	41	-13
Istanbul*	27	48	23	25	28	34	14
Mumbai*	34	36	30	33	35	43	-7

* sig. at p≤.050

** sig. at p≤.001

Abs.D. = Absolute difference between highest (4) and lowest group (0)

Table 9: Travel time to work (minutes) for educational groups, São Paulo, Istanbul and Mumbai.

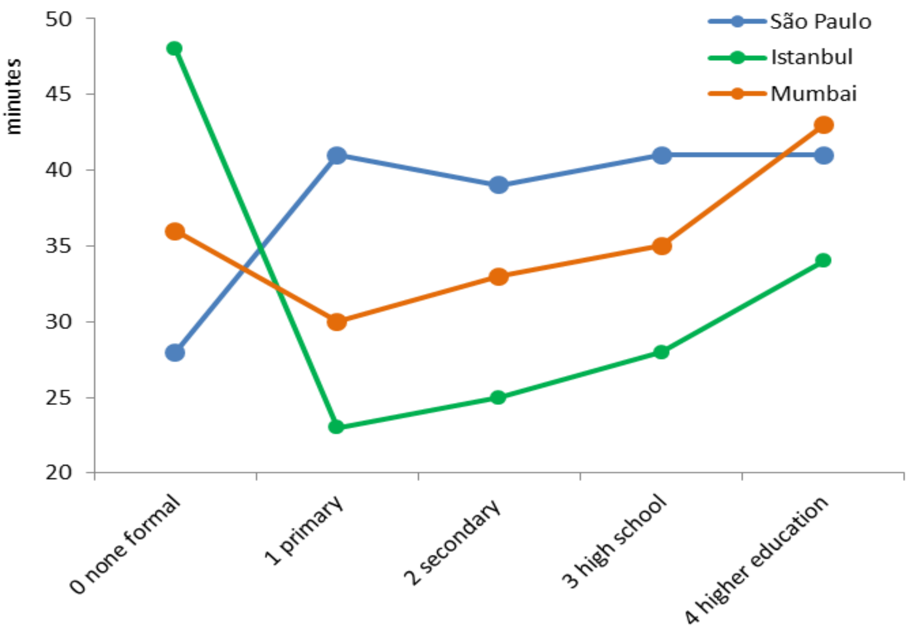

Figure 9: Travel time to work for educational groups, São Paulo, Istanbul and Mumbai.

qualification have an average travel time of 27 minutes, around 0.7 times the four other education groups all with average times between 39 and 41 minutes.

In both Istanbul and Mumbai, respondents with 'primary' education (the second to lowest education group) have the shortest travel time, but the lowest education group had considerably longer travel times. This is particularly the case in Istanbul where the average travel time for the lowest education group is 1.77 times higher than the sample mean and more than double that for the second lowest education group (48 vs 23 minutes). In both Istanbul and Mumbai, travel time to work increases consistently with education level, if the lowest education group is excluded. For these four groups, travel times vary between 23 and 34 minutes in Istanbul and 30 and 43 minutes for Mumbai.

Travel time to work for members of the highest educational group is 1.26 times higher than the sample mean for Istanbul and 28% higher than the sample mean for Mumbai (Table 10). Only in Istanbul is average travel time in the lowest educational group longer than for the highest educational group – 1.41 times higher. In both São Paulo and Mumbai, the very lowest education groups

	0 none formal	1 primary	2 secondary	3 high school	4 higher education	ratio
São Paulo	0.71	1.03	0.99	1.05	1.02	0.69
Istanbul	1.77	0.85	0.94	1.04	1.26	1.41
Mumbai	1.06	0.88	0.97	1.03	1.26	0.84

ratio = Ratio between highest (4) and lowest group (0)

Table 10: Travel time to work, variance from city mean for different educational groups, São Paulo, Istanbul and Mumbai.

	0 none formal	1 primary	2 secondary	3 high school	4 higher education	total
São Paulo**	40.0%	57.1%	63.4%	71.9%	79.8%	63.4%
Istanbul**	3.0%	22.9%	33.5%	36.9%	61.0%	30.3%
Mumbai**	25.5%	32.0%	47.5%	39.8%	56.5%	40.4%

* sig. at p≤.050 · ** sig. at p≤.001

Table 11: Percentage of work trips in São Paulo, Istanbul and Mumbai.

have lower average travel times than the highest educated groups with a ratio of 0.69 and 0.84 respectively of the highest educated group's travel time.

4.5 Travel time 3: non-work destinations

Travel time to non-work destination indicates the ease with which individuals can access opportunities that are not related to work. This is indirectly an indicator of some form of individual welfare mediated through personal accessibility. Since the survey asks about the purpose of the main trip only, it is important to note the distribution of work and non-work trips among educational groups. The distribution of main trip purpose differs across all cities (Table 11).

In São Paulo, nearly two thirds of respondents go to workplaces in their main trip; in Istanbul and Mumbai only 30 and 40 per cent respectively. In all cities, the group that reports least often the workplace as the destination of their main trip is the one with no formal education. The main trip's purpose of those groups is 'shopping' (51 per cent in Mumbai, 38 per cent in Istanbul), followed by health services. As a general rule, the dominance of work trip among main trips

	mean	0 none formal	1 primary	2 secondary	3 high school	4 higher education	Abs.D.
São Paulo	27	30	26	30	27	24	6
Istanbul*	19	16	17	22	21	25	-9
Mumbai*	17	15	16	17	17	25	-11

* sig. at p≤.050

** sig. at p≤.001

Abs.D. = Absolute difference between highest (4) and lowest group (0)

Table 12: Travel time (minutes) to non- work for different educational groups, São Paulo, Istanbul and Mumbai.

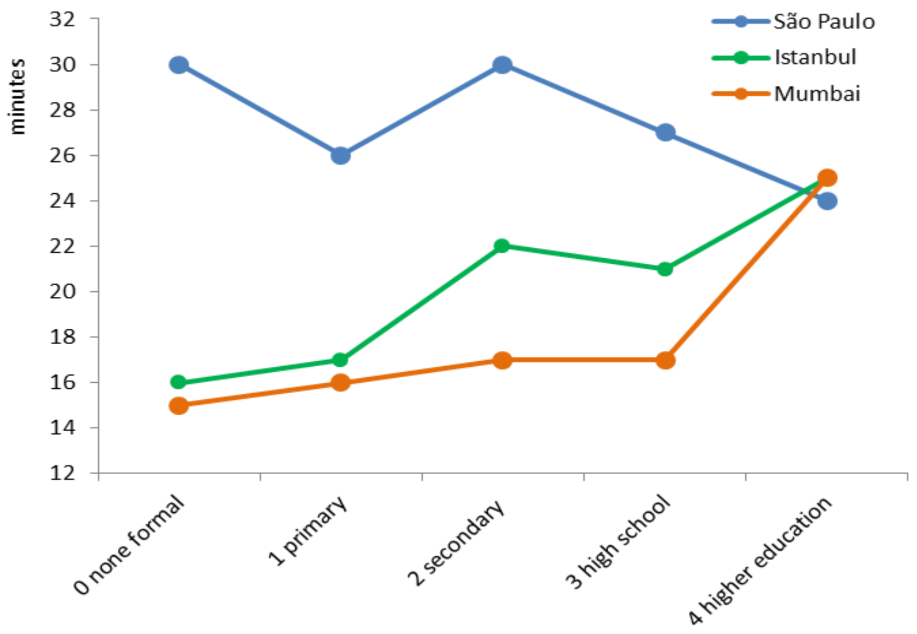

Figure 10: Travel time to non- work destinations for educational groups, São Paulo, Istanbul and Mumbai.

rises with increasing educational attainment. Travel time to regular daily non-work destinations is longest in São Paulo, averaging 27 minutes across the five educational groups. Istanbul respondents report average travel time of 19 minutes and Mumbai respondents 17 minutes (Table 12). Patterns of variation across education groups are similar for both Istanbul and Mumbai, but distinct for São Paulo. In Istanbul and Mumbai, travel times to non-work destinations are generally longer for those with higher levels of education. However, in São Paulo the highest education group has lower average travel times than all other education groups (Figure 10).

In Mumbai, average travel times for those in the highest education group are 8 minutes (1.5 times) longer, and for the least educated 2 minutes (0.86 times) shorter, than the sample mean. A similar pattern exists in Istanbul where average travel time for the highest educated group is 7 minutes (1.34 times) longer, but for the lowest educated group 4 minutes shorter than (0.8 times) the sample mean. In São Paulo, average travel times for regular non-work activities are similar across all education groups except the very highest, with average times among the four groups within 0.9 and 1.1 times the sample

	0 none formal	1 primary	2 secondary	3 high school	4 higher education	ratio
São Paulo	1.09	0.93	1.07	1.01	0.83	1.32
Istanbul	0.80	0.90	1.07	1.08	1.34	0.59
Mumbai	0.86	0.96	1.02	0.98	1.50	0.57
ratio = Ratio between highest (4) and lowest group (0)						

Table 13: Travel time to non- work destinations, variance from city mean for different educational groups, São Paulo, Istanbul and Mumbai.

mean. For the highest educated group, average travel time is 0.83 times the sample mean.

In all three cities there is substantial variation in travel times to non-work destinations between the most and least educated groups. However, while in Istanbul and Mumbai the least educated have shorter travel times, in São Paulo this group has longer travel times. Travel times to non-work destinations for members of the least educated group average 15 minutes in Mumbai and 16 minutes in Istanbul. In both cities this is less than two thirds of the travel time for members of the most educated group for whom it averages 25 minutes in Mumbai and 26 minutes in Istanbul.

Across all three cities average travel time for the most educated group is very similar (between 23 and 26 minutes). However, travel times to non-work destinations for the least educated in São Paulo at 30 minutes are double the average for that group in Mumbai and Istanbul and 1.32 times higher than average times for the most educated in São Paulo (Table 13).

5 Conclusions

The analysis above clearly indicates that the wider metropolitan urban form and related transport infrastructures have a considerable effect on accessibility patterns across socio-economic groups. Overall the least accessible urban system in terms of time and distances is São Paulo, most likely a result of its overall lower density levels and a considerable reliance on road-based transport. It is also in São Paulo, the most unequal of the three cities in terms of income distribution, where urban accessibility patterns are reinforcing rather than mitigating such inequalities. Both Istanbul and Mumbai are considerably more 'just' in offering fairly equal accessibility to residents irrespective of their socio-economic status.

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