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RESEARCH ARTICLE

Connecting through public transport: accessibility to health and education in major African cities

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ABSTRACT

Transport matters for health and education outcomes, by ensuring physical access to crucial facilities. Using spatial modelling techniques and routable public transport service data, this study assesses the effectiveness of mostly semi fixed-route public transport systems in connecting people to advanced healthcare and education facilities in African cities. Uncovering significant pockets of 'accessibility poverty' – travel times above an acceptable level – it underscores the inequality in access *within* the cities, disproportionately affecting poor populations. Proximity of public transport to homes matters but has limited impact, due to how the routes, operated mainly by informal service providers, are allocated across the urban space and the low technical performance. The low 'value added' of public transport compared to walking helps explain the prevalence of foot travel. Tailored policy interventions – improving the public transport systems and, equally importantly, ensuring more equitable spatial distribution of advanced healthcare facilities – emerge as crucial strategies for addressing accessibility poverty.

ARTICLE HISTORY

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KEYWORDS

Accessibility, urban transport, public transport, Transit oriented development, health, education

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摘要

通过公共交通实现连接: 非洲主要城市的医疗和教育可达性 *Area Development and Policy*. 交通运输通过确保人们能够实际使用重要设施， 对医疗和教育成果至关重要。本研究利用空间建模技术和可路由公共交通服务数据， 评估了非洲城市中大多数半固定路由公共交通系统在连接人们与先进医疗和教育设施方面的有效性。这项研究发现了大量的"交通贫困"地区——旅行时间超过可接受水平——它强调了城市内交通的不平等，对贫困人口的影响尤为严重。公共交通离家远近很重要，但影响有限，原因是主要由非正

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式服务提供商运营的线路在城市空间中的布局，且技术性能较低。与步行相比，公共交通的“附加值”较低，这也是步行出行普遍存在的原因。有针对性的政策干预——改善公共交通系统，以及同样重要的确保先进的医疗设施在空间上分布更加公平——成为解决交通贫困问题的重要策略。

关键词
可达性，城市交通，公共交通，交通导向型发展，医疗，教育

RESUMEN

Conectar a través del transporte público: accesibilidad a la salud y la educación en grandes ciudades africanas. *Area Development and Policy*. El transporte es importante para los resultados en salud y educación porque garantiza el acceso físico a instalaciones vitales. Con ayuda de técnicas de modelación espacial y datos de las rutas de los servicios de transporte público, en este estudio se evalúa en qué medida son eficaces los sistemas de transporte público, la mayoría con rutas parcialmente fijas, a la hora de conectar personas a centros sanitarios y educativos avanzados en ciudades africanas. Al revelar importantes focos de ‘pobreza de accesibilidad’ –los tiempos de viaje por encima de un nivel aceptable– se subraya la desigualdad del acceso en las ciudades, lo que afecta a las poblaciones pobres de una manera desproporcionada. La proximidad del transporte público a los hogares es importante, pero tiene un impacto limitado debido al modo en que se distribuyen las rutas en el espacio urbano, gestionadas sobre todo por empresas de servicios informales, y al bajo rendimiento técnico. El bajo ‘valor añadido’ del transporte público en comparación con los desplazamientos a pie nos permite explicar la prevalencia de los viajes a pie. Las intervenciones políticas personalizadas –para mejorar los sistemas de transporte público y, lo que es igualmente importante, asegurar una distribución espacial más justa de los centros de salud avanzados– se perfilan como estrategias fundamentales para abordar la pobreza de accesibilidad.

PALABRAS CLAVE

accesibilidad, transporte urbano, transporte público, desarrollo orientado al transporte, salud, educación

АННОТАЦИЯ

Связность посредством общественного транспорта: доступность здравоохранения и образования в крупных городах Африки. *Area Development and Policy*. Транспорт имеет большое значение для результатов в области здравоохранения и образования, обеспечивая физический доступ к важнейшим объектам. Используя методы пространственного моделирования и данные о маршрутах общественного транспорта, в этом исследовании оценивается эффективность систем общественного транспорта, в основном с полуфиксированными маршрутами, в обеспечении доступа людей к современным медицинским и образовательным учреждениям в городах Африки. Выявление значительных примеров бедности, обусловленной недоступностью – времени в пути, превышающего приемлемый уровень, – подчеркивает неравенство в доступности внутри городов, что непропорционально сильно сказывается на бедных слоях населения. Близость общественного транспорта к домам имеет значение, но имеет ограниченное влияние из-за того, что маршруты, которыми в основном управляют неофициальные поставщики услуг, распределены по городскому пространству, а также из-за низких технических характеристик. Низкая “добавленная стоимость” общественного транспорта по сравнению с пешими маршрутами помогает объяснить распространенность пеших путешествий. Целенаправленные политические меры – совершенствование систем общественного транспорта и, что не менее важно, обеспечение более справедливого территориального распределения современных медицинских учреждений – становятся важнейшими стратегиями борьбы с бедностью, обусловленной недоступностью.

КЛЮЧЕВЫЕ СЛОВА

Доступность, Городской транспорт, Общественный транспорт, Транзитно-ориентированное развитие, Здравоохранение, Образование

1. INTRODUCTION

Sub-Saharan Africa (SSA) is the fastest urbanising region in the world, and with the rapid growth of cities, physical access to schooling and healthcare is increasingly becoming an issue. Access to efficient public transport services plays a pivotal role in shaping both health and education outcomes. Transportation barriers lead to missed appointments, delayed care and reduced uptake of preventive services, particularly affecting lower income individuals. Additionally, a few studies have explored the impact of school accessibility on intermediate education outcomes, finding evidence that it is positive and especially so for the children on the edge of failing (Dickerson & McIntosh, 2013; Falch et al., 2013). At the same time, evidence on the levels of accessibility – and the inequality in accessibility – that exist within SSA's rapidly growing cities is still limited. A spatially detailed understanding of gaps in physical accessibility to schools and health centres is needed to better plan and target physical connectivity investments and policies, including public transport improvements and fare subsidy programmes, in order to ensure that a city's human capital potential can be realised. Focusing on accessibility to education and health also sheds light on the limitations of public transport systems that are mostly informal and therefore more likely to underserve less profitable routes while possibly also being more agile in responding to new emerging transport demand patterns.

This study aims to generate knowledge on the state of accessibility and inequality of accessibility to advanced health services and schools in ten large African cities, selected based on their national importance and the availability of reliable spatial data on the public transport systems and health and education facilities, with an objective to allow for a comparative analysis of the role of urban structure – including the spatial distribution of education and health facilities – in ensuring good accessibility. It explores how well the existing public transport systems connect people to education and healthcare opportunities, and what is the 'value added' of public transport as compared to walking, still the predominant mode in most African cities. Second, the study assesses what are the drivers of inequality in accessibility *between* the cities, considering both land use and transport coverage, and whether there is significant variability in accessibility across the urban space *within* cities to the extent that some areas can be considered to be characterised by 'accessibility poverty' – travel times above an acceptable level.

The study uses spatial modelling techniques and routable public transport service data (General Transit Feed Specification, GTFS) and adopts a consistent definition of the area that constitutes the 'city'. The advanced healthcare facilities and schools were mapped based on a combination of existing spatial data sets and lists provided by the relevant government authorities.

The study finds that, even in the case of schools but especially so in the case of health facilities, there are significant pockets of 'accessibility poverty', indicating inequality in access *within* the cities, and the poor, on average, incur higher travel times than the city populations overall. Proximity of public transport to homes matters but only to a limited extent, possibly due to the uneven distribution of urban resources, the way public transport service providers – many of whom operate informally – allocate their routes across the urban space vis-à-vis the existing facilities, and the overall low travel speeds and frequencies. This also means that the 'value added' provided by public transport vis-à-vis walking is low in most cities.

The study offers significant contributions by concentrating on urban accessibility to health and education in SSA, going beyond the more common emphasis on job opportunities. Introducing the concept of 'value added' to accessibility from public transport networks, it underscores that access to public transport matters but only to a limited extent and advocates

for a greater focus on land use planning and the spatial distribution of urban resources in policy agenda setting. While some accessibility challenges persist across all cities, differentiated approaches in prioritising policy interventions are likely needed. These range from more limited, targeted interventions to address individual accessibility poverty pockets in cities like Douala, Conakry, Nairobi, Kampala and Kigali, to larger scale transport and health infrastructure investments in Harare, Ouagadougou, Bamako and Dar es Salaam.

2. LITERATURE REVIEW

'Spatial accessibility' is a frequently employed term in transportation geography literature, representing the measure of an individual traveller's capacity to reach destinations of significance (El-Geneidy & Levinson, 2006). It has put a strong emphasis on the transportation side of accessibility (see Andreasen & Møller-Jensen, 2017; Bocarejo & Oviedo, 2012; Delmelle & Casas, 2012; Guzmán & Oviedo, 2018; Saif et al., 2019, for a full literature review), albeit rarely studying the case of African cities where most travel takes place on foot and most public transport systems are dominated by informal service providers. Poverty and other socio-economic characteristics of urban populations and inequalities in terms of accessibility have received relatively limited attention (see Achuthan et al., 2010; Bocarejo & Oviedo, 2012; Guzmán & Oviedo, 2018; Hu, 2017; López-García & Baker, 2022).

Transport disadvantage and underlying exclusion were particularly studied in the early 2000s (Kenyon et al., 2002; Lucas, 2012; Murray & Davis, 2001), although research in this field is still underdeveloped in SSA. Accessibility to transportation systems from population centres has also been explored in relation to the broader concept of 'spatial equity' (Delmelle & Casas, 2012), with no standard definition of distributional equity for transportation benefits (Martens et al., 2012). One approach to defining transport equity, proposed by Litman (2007), distinguishes 'horizontal equity' from 'vertical equity'. Horizontal equity distributes benefits evenly to all groups, while vertical equity is concerned with distributing resources between individuals of different abilities and needs. Delbosc and Currie (2011) proposed a simple measure of transit system equity performance in the form of Lorenz curves that measure the relative supply of transit to the population and compare public transport supply for different social groups. Following a similar approach, Welch and Mishra (2013) propose a stylised connectivity measure with a Gini index for equity estimation at different levels such as stop, line, zone and area.

The review by Syed et al. (2013) finds evidence that lack of transport contributes to poor management of chronic illness and poor health outcomes, and health sector policymakers have cited transportation barriers as key obstacles to providing healthcare to low-income populations in particular (see, e.g., Rask et al., 1994; Silver et al., 2012). For example, variable uptake of available health interventions in SSA has been found to undermine healthcare programmes and to play an important role in child and maternal mortality (Rutherford et al., 2010). In the education field, a more limited number of studies have explored the impact of accessibility to schools. Falch et al. (2013) found that reduced commuting time had a positive effect on graduation from upper secondary schools, and this effect is larger for students with low academic achievement. Owen et al. (2012) concluded that transport gaps play a crucial role in exacerbating poor skills and low productivity.

Public transport in African cities is provided primarily, or in many cases entirely, by informal transport operators (also known as paratransit; Behrens et al., 2015; Kumar & Barrett, 2008). These operate with limited central planning and regulation, relying on independent drivers or small firms who themselves analyse market demand to develop their route networks as they compete for passengers. These systems are widely recognised for their negative externalities, including aggressive and competitive driving, harassment of women,

extremely long work days and precarious incomes for drivers working on exploitative daily-lease contracts (Barrett, 2003; Rizzo, 2017; Spooner, 2018). Despite this, they are also often considered effective at facilitating accessibility, as drivers and operators draw on local knowledge to provide a wide array of service niches showing commitment to the communities they serve (Alcorn & Karner, 2020; Cervero, 2000; Mateo-Babiano, 2016; Stucki, 2015).

However, to date, there has been limited empirical evidence on the accessibility impacts of these predominantly informal systems. Until recently, informal transport networks were difficult to understand at the city-wide level, but since originating in Nairobi in 2012, numerous African cities systems have been mapped (Digital Transport 4 Africa, 2019; Klopp & Cavoli, 2019), allowing new analyses from which a more complex picture of urban connectivity in SSA is beginning to emerge. Campbell et al. (2019), in an analysis of access to Nairobi hospitals, find highly uneven outcomes across the city. A comparison of 11 African cities in access to job locations also finds wide variability between and within cities, despite all being served by adaptable informal systems (Campbell et al., 2019; Peralta-Quiros et al., 2019; Nakamura & Avner, 2021).

This study seeks to contribute to this literature by generating evidence on the accessibility to health and education services in African cities, exploring the role effectively played by the existing public transport systems as compared to walking. It aims to uncover disparities both *between* cities and *within* them, identifying pockets of 'accessibility poverty' and drawing conclusions about the distribution of urban resources as an additional factor – besides public transport quality – that needs to be considered when striving for good accessibility.

3. METHODOLOGY

While accessibility may be measured in many ways (see Geurs & Van Wee, 2004, for a thorough review), this paper uses travel time to the nearest facility – in this case schools and health services – as the metric of choice.

The study geo-located health and education facilities in each of the cities through assembly of existing spatial datasets and manual geo-location of facilities based on lists provided by government entities. For each city, population distribution was mapped using World Pop 2020 data at a resolution of 100 m × 100 m, overlaying the locations of health facilities and schools and the public transport network data in GTFS format, the standard data used for mapping public transport routes and schedules, including information on stops, arrival times and headways. GTFS feeds were gathered from mapping carried out by private firms, academic institutions and non-governmental organisations (NGOs) for all cities except Ouagadougou, Kigali and Conakry; for the latter cities GTFS was generated purposely for this study from available transport network maps, integrating speed and headway information with route alignment and stop locations. The methods of mapping and capturing such data present some limitations: they are variable and always provide only an estimate of routes, frequencies, and travel times, as these change slightly day-to-day and more substantially over time. In some cases, routes may be missing, leading to underestimations in calculating accessibility measures, while in others, temporary or low-service routes may have made it into the GTFS, leading to over-estimation. However, major routes and locations of terminals were found to be accurately mapped. Stops for such services are generally not established but available in most locations where customers request. The stops modelled here in the transport network are obtained from the GTFS data collection and correspond to the most common stop locations, although slight variations may occur. Further research is needed as to the methodology and accuracy issues in collecting informal transport map and schedule data, in a newly-emerging field.

The study applied the GTFS and Network Analyst toolkits in ArcGIS Pro to estimate physical accessibility to schools and health facilities by public transport, also considering walk time to the nearest stop, the average expected wait time considering the GTFS-based information on headways, and the wait times associated with transferring between routes in the network. This is achieved by simulating, for each point of origin and for different times of the day, the journeys to the destinations of interest to generate an origin-destination matrix. For each origin-destination pair, the fastest route at the time of departure is determined based on an estimate of the paths travelled by vehicles in the surrounding transit system, as defined in the GTFS dataset, thus taking into account waiting time and including the possibility of connecting if this option proves to be faster. We also look separately at the travel times incurred by the poor population in cities where poverty maps were available or could be constructed. To better understand the patterns of accessibility inequality not only between but also within cities, the study derives accessibility-population curves to illustrate how access is distributed in terms of the share of the population that can reach the facility within a certain time threshold. The visualisation reveals what share of the population in each city and with respect to each type of health or education service is 'accessibility poor', here defined as the inability to reach even the nearest advanced healthcare facility within 60 minutes by any combination of walking and/or public transport (acceptable time for an occasional trip) or the nearest school within 30 minutes (acceptable time for a daily return trip).

Existing survey data suggests that the vast majority of children in African cities walk to school, especially at the primary school level; in this case this might be an optimal scenario, given the typically wide availability of primary school facilities across the urban space. Walking-based accessibility metrics were therefore separately derived for primary schools, assuming a walk time of 3 km/h following the street grid, which also helps to illustrate the extent to which the existing public transport systems provide 'value added' compared to walking. For secondary schools, where walking-based commuting is less optimal given more sparsely located facilities, the value-added of the public transport system is assessed in terms of the share of the public transport trip to the nearest secondary school that is actually spent in public transport as opposed to walking, and for how much of the population does the fastest access to the nearest school involve public transport at all. That is, even when public transport is available for a trip to relatively distantly located school, sometimes it is so infrequent or the nearest stop is so far away from either the origin or the destination that walking is still faster.

To help explain the differing accessibility levels across the cities, the study derives several land use indicators. The first is the degree to which development in the city is 'transit-oriented', as measured by the share of people living within walking distance (1 km, following the street grid) to a public transport route. The second is the extent to which education and health facilities are accessible from the public transport networks, as measured by the walking distance metric. Both of these are indicative of the degree of overall alignment between transport and land use. The third indicator is the extent of land use diversity or, more specifically, the direct presence of health facilities and schools in residential neighbourhoods.

To have a comparable frame of analysis between the cities, the study defines a uniform 'functional city' boundary for each of them, including all areas from which at least some jobs in the city can be accessed within an hour of travel by public transport and walking. Data on job locations used to define the boundaries was sometimes available directly, such as in the case of Kigali, Bamako and Dar es Salaam, while in the case of others a relative index of 'job-likeliness' was created by identifying Employment Opportunity Areas of different intensity. These were determined by scoring different indicators on 500-metre cells in a grid covering each city, with scores including the count of employment-related amenities – number of retail and financial establishments, proximity to major intersections, etc. – extracted from Google Maps and Open Street Maps (OSM), within each cell and its adjacent cells, as proposed by

Peralta-Quiros et al. (2019). The uniform approach to defining city boundaries based on how they truly function allows for a fairer and more direct comparison of the spatial indicators of accessibility among them. An exception here is Kampala, for which the available geo-located health facility data only covers the formal city limits rather than the full 'functional city'. Kampala's spatial planning and accessibility metrics presented in the paper are therefore not directly comparable to the other cities and are likely somewhat inflated compared to what they would be if the true – likely wider – definition of the 'functional city' were applied.

4. DATA DESCRIPTION

In most of the cities, public transport services are provided entirely by bus transport, and in many cases, these are mostly paratransit operators (Ouagadougou being an exception). Therefore, routes are rarely formally licenced and not preassigned. It is worth noting that also in cities where route licencing is more common – such as in Latin American countries – the GTFS data collected on the ground often reflects some diversions from the formally assigned routes and schedules.

In Ouagadougou, unlike in most other African cities, there are no public minibus services. The large-bus network is sparse, with only about 30 lines operating at a frequency of less than one bus every 30 minutes in most cases. In Conakry, the public transport system consists of only some ten routes, although these are concentrated in the most densely populated areas. Douala's public bus network consists of a network of 30 lines, of which only eight are in operation. In addition to the formal network, informal Yellow Taxis run on organised routes. The public transport system in Bamako is entirely dominated by minibus transport consisting of about 200 routes. The system provides a relatively good coverage of the city's more populated areas. In Dar es Salaam, the public transport system consists mostly of informal minibuses that provide a dense network across the city, as well as the relatively new Dar es Salaam Bus Rapid Transit system which currently serves only one corridor. Kigali's public transport services are ensured by bus transport, which operates on approximately 250 routes and is relatively well distributed across the 'functional city'. In Harare, the public transport network is extensive and covers the high-population-density areas relatively well. Kampala's public transport system, consisting primarily of about 230 informal minibus routes, covers much of the functional city. Maputo's public transport system consists of approximately 240 bus, minibus and rail lines that cover the city's most densely populated areas well but are much more sparse in the more peripheral areas. Nairobi's public transport system consists of six rail lines which operate only a few trips per day and just over 120 informal minibus routes that effectively cover the city's high-density areas.

In this analysis, only those cities were included where verified geo-locations of health and/or education facilities were available (see Tables 1 and 2). For a few cities, the facilities were geo-mapped using available official lists of facilities provided by the relevant government institutions. In several cities, only health facility geo-locations could be obtained.

Perhaps not surprisingly, advanced healthcare facilities are, on average, better served by public transport networks compared to either primary or secondary schools. In Harare and Maputo, all advanced care facilities are within walking distance of transit routes and in most other cities the share is around 95%. Only in Conakry is there a relatively high share of advanced health facilities (19%) not within walking distance of the public transport network.

In Ouagadougou and Douala, income-based poverty mapping was conducted as part of the study using available household survey data, while in several other cities (Kampala, Kigali and Harare), pre-existing poverty maps, prepared with World Bank assistance using household budget surveys and census data, were used to derive poor-specific accessibility indicators. In Ouagadougou, poverty estimates were generated from

Table 1. Data sources and definitions for 'advanced' health facilities.

City	Health facility definition	Sources
Ouagadougou	Medical centres with surgical capabilities (*centres médicaux avec antenne chirurgical*, CMA); Hospitals (centres hospitaliers universitaires, CHU)	Burkina Faso Government
Douala	Advanced health facilities	Douala City Council
Conakry	Private: polyclinics and clinics (with laboratories and inpatient treatment). Public: medical centres and hospitals	Guinea Ministry of Health; Health Focus Guinea, 2018
Bamako	Referral health centres (CREF); Hospitals	World Bank
Dar es Salaam	Health centres; Hospitals	Tanzania Ministry of Health Facility Registry
Kigali	Health centres (with advanced healthcare facility categorisation); Hospitals	Rwanda Ministry of Infrastructure
Kampala	Public and private facilities with surgical services	Kampala City Government
Harare	Hospitals; Polyclinics	Zimbabwe Ministry of Health and Child Care
Maputo	Type A urban health centres; Type I rural health centres; Hospitals	Mozambique Ministry of Health
Nairobi	Facilities with clinical officer and surgical capabilities	Kenya Ministry of Health, geo location based on ward information

Table 2. Data sources for schools.

City	Education facility	Sources
Ouagadougou	All schools	Burkina Faso Government
Douala	All schools	Douala City Council
Conakry	All schools, public/ private status	Guinea Ministry of Education
Bamako	All schools	World Bank
Harare	All schools	Zimbabwe Government; Google Earth
Maputo	Primary schools	Maputo municipality; Department of Education; Maputo Department of Urban Planning
Nairobi	All schools	Kenya Ministry of Education; Red Cross

the 2017/2018 Harmonised Survey on Household Living Conditions. Small-area estimation methods were then applied to estimate poverty at the city scale as well as at the level of individual administrative units (*secteurs*). To further increase the precision of poverty estimates, the team also incorporated additional geospatial data on land cover classification and the presence of forced displacement. In Douala, poverty incidence at the neighbourhood level was estimated using data from the 2005 Cameroon census,

combined with the Fourth Cameroon Household Survey (2014), which allows estimating poverty rates very precisely. The available poverty maps perform well in reflecting long-term poverty and asset ownership although may miss more recent, short-term monetary shocks.

5. MAIN RESULTS

5.1. Accessibility inequality and pockets of 'accessibility poverty'

Accessibility to healthcare facilities that provide advanced care services varies quite significantly across the cities. While the average resident of Kampala, Douala, Nairobi and Conakry can reach such a facility by public transport in less than 15 minutes, the residents of Harare have to travel over 35 minutes and in Ouagadougou nearly an hour (Figure 1 shows Douala and Harare, representing very different levels of accessibility).

In an important aspect for many of the city residents, the nearest advanced healthcare facility is not always a publicly operated one. In the five cities for which data on public versus private facilities is available, the nearest public facility is, on average, further away by public transport than the nearest private one. However, while in Nairobi, Kampala, and Dar es Salaam, the difference in average travel time by public transport to any facility versus a public facility is only about 8–10 minutes, in Conakry it is nearly an hour.

On average, accessibility to primary schools in the cities in scope is relatively good, with travel times to the nearest school in the range of 8–11 minutes in Conakry, Douala, Nairobi and Ouagadougou. Even in the cities with comparatively poorer accessibility – Maputo and Harare – a primary school is within reach, on average, within about 22 minutes. Across all the cities except Kigali, accessibility is worse – sometimes significantly so – to secondary schools (Figure 2), which is also partly explained by their relative sparsity in most cities. Similarly, to healthcare facilities, accessibility is also significantly lower to public compared to private schools. For example, in Ouagadougou, the most extreme case, the average resident has to travel 25 minutes to reach the nearest public secondary school, compared to half the time to reach a private secondary school.

There is also significant inequality in accessibility *within* the cities, especially so in Ouagadougou, where 38% of the population are estimated to be 'accessibility poor' with respect to advanced healthcare facilities (Figure 3). The diversity across cities is similar in terms of accessibility to schools. Only in Douala is no one accessibility poor (at the defined 30-minute

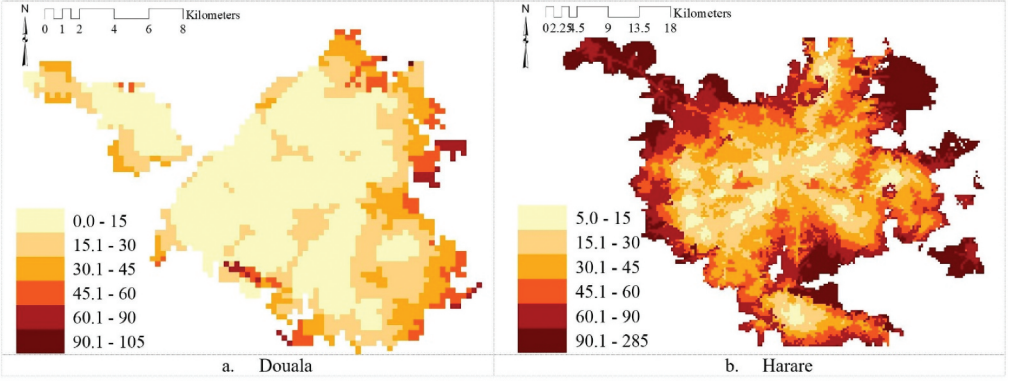


Figure 1. Travel time by public transport to nearest advanced healthcare facility in Douala vs. Harare (minutes). See the online supplemental data for other cities, https://doi.org/10.1080/23792949.2024.2364619

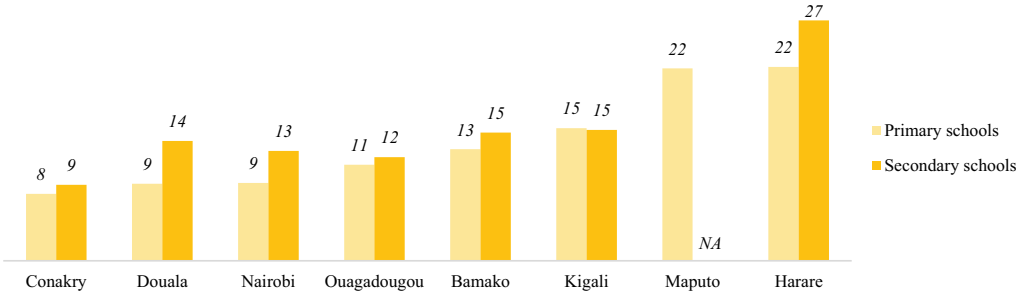


Figure 2. Average travel time by public transport to nearest school (minutes).

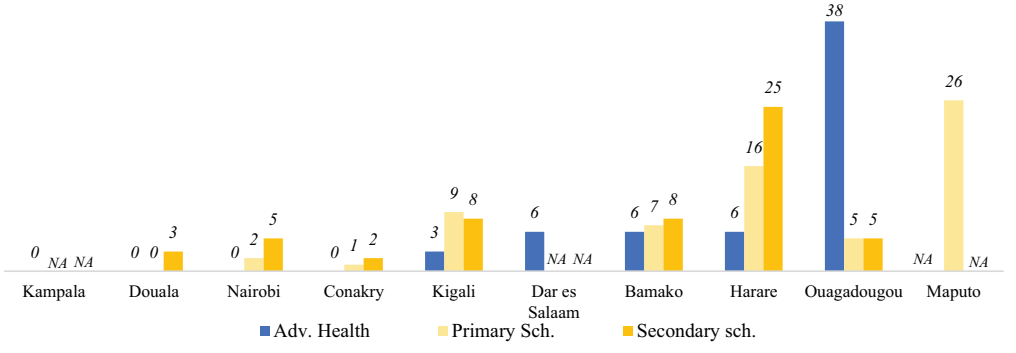


Figure 3. Share of population of the city that is 'accessibility poor', Assuming travel by public transport (%).

threshold) compared to between 1% and 10% in most of the cities and as many as 15–25% in Harare and Maputo. Another key metric indicating the extent of equity of accessibility to health facilities across space is the time threshold that corresponds to at least half of the population having access within a specific time threshold. While in Douala, Nairobi, Conakry and Kigali this time threshold is about 10 minutes, in Bamako and Harare it is closer to 25–30 minutes.

Accessibility distribution within cities is similar with respect to secondary schools. Harare again stands out as having a larger share of population (25%) characterised by 'accessibility poverty'. The other cities are more comparable to one another, with the share of the accessibility-poor population ranging from 2% in Conakry to 8% in Bamako and Kigali.

In Ouagadougou and Conakry, the two cities where the disaggregated facility geo-locations are available, about 20–25% of the population are 'accessibility poor' with respect to *public* secondary schools specifically, compared to 6% and 1%, respectively, in the case of private secondary schools. The case of primary schools is similar, with 'accessibility poverty' in both cities being significantly higher with respect to public institutions compared to private ones.

5.1.1. Accessibility gaps in high-poverty neighbourhoods

There is significant overlap between areas characterised by 'accessibility poverty' and monetary poverty in three of the five cities for which poverty maps were available or could be constructed (Figure 4 illustrates the case of Ouagadougou). In Ouagadougou, the city with the highest 'accessibility poverty' with respect to advanced healthcare facilities, the sparse public transport network appears to reach the poorest parts of the city nearly as well as it does non-poor areas;

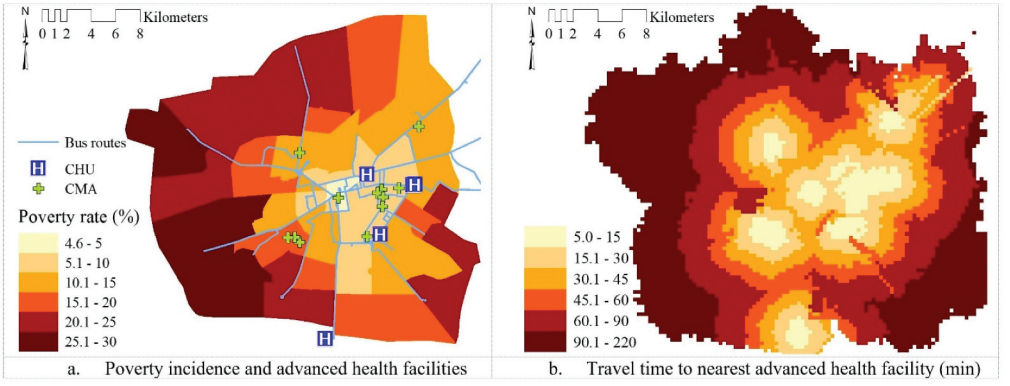


Figure 4. High overlap between poverty incidence and poor accessibility to advanced healthcare facilities in Ouagadougou.

however, due to the concentration of the facilities in the central (non-poor) areas, the poor face considerably higher travel times – they require about 15 minutes more, on average, to reach a hospital compared to the overall population. As shown in Figure 4, nearly all areas with high poverty rates are also characterised by 'accessibility poverty'. Similarly, also for accessing secondary schools, the poor are more likely to be 'accessibility poor'.

Kigali's poor population is estimated to face a large penalty in travel times to advanced healthcare facilities but less so to schools, with the difference between the poor and the overall population at 10 minutes. To reach primary and secondary schools, the poor, on average, have to travel 7–9 minutes longer.

Although 'accessibility poverty' in Douala is very low, the poor do incur higher travel times than the city's population overall: their nearest advanced healthcare facility is over 30 minutes away by public transport, compared to 25 minutes for the population overall. In the case of secondary schools, the city's poor in fact have shorter average travel times to the nearest private facility (albeit likely unaffordable to them) but slightly longer to a public one.

In light of the city's already relatively low accessibility, especially to advanced healthcare facilities, in Harare the poor do not appear to be particularly penalised: the average travel time to the nearest facility offering advanced care is 38 minutes by public transport for the poor compared to 35 for the overall population. The difference in average travel time is also about 3 minutes for travelling to the nearest primary school or the nearest secondary school of any kind.

Similarly, the average travel times to advanced healthcare facilities faced by the poor in Kampala are nearly the same as for the city's overall population. These findings are intuitive given the spatial distribution of poverty incidence, which appears to be relatively high in the more central parts of Kampala – areas that also have a high density of healthcare facilities. At the same time, when comparing to the other cities, these findings should be viewed in the context of the more limited definition of Kampala's extent compared to the other cities, whereby the outer areas of the true 'functional city' are not covered in the analysis but almost surely have high poverty pockets as well as a lower density of healthcare facilities.

5.2. The value added of public transport as compared to walking

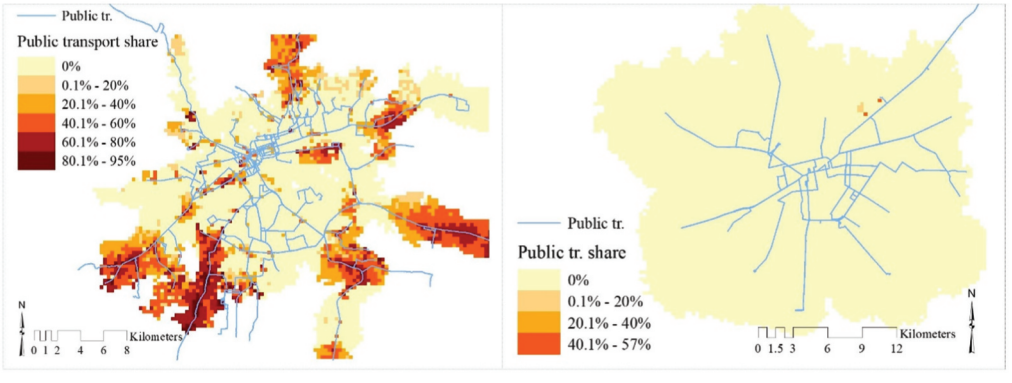
Across cities in SSA, much of the travel still takes place on foot, although the reasons for this may vary, ranging from convenience/explicit choice to lack of efficient and affordable alternatives (see Bianchi Alves et al., 2023 for Maputo; Deloitte, 2019 for Nairobi; and

MobiliseYourCity, 2023, for a comparison across several countries). The findings presented in this section aim to highlight the extent to which, for accessing primary and secondary schools in particular, the public transport systems in fact provide 'value added' (travel time savings) as compared to walking, the de facto dominant mode.

Partly due to the large number of schools and their relatively even distribution across the urban space in most cities, a high share of people live in direct proximity of a school. This is especially the case for primary schools, with over 90% of the population living within a kilometre of a school in Conakry, Douala and Nairobi, and above 70% of people in the other cities except Harare and Maputo (41–42%). The direct presence of secondary schools in residential neighbourhoods is slightly lower, with between 65% and 82% of people living within a kilometre of a school, except for Harare where the share is only 42% and Conakry where it reaches 96%.[1]

Across most cities, accessibility to primary schools by walking is good, with average travel times not much exceeding the average travel time by public transport. For example, in Douala, Nairobi, Conakry and Ouagadougou, the average person can walk to the nearest primary school within about 7–10 minutes, and the share of 'accessibility poor' does not exceed 5%, the same as if assuming the use of public transport. In contrast, the 'value added' of public transport as compared to walking is much higher in Maputo, where the average travel time penalty by walking as compared to public transport is 30 minutes and the share of the population that is 'accessibility poor' reaches 42%, against 26% if presuming the use of public transport. Similarly, in Harare, the share of 'accessibility poor' is notably higher at 23% when considering walking only than if assuming the use of public transport for at least a portion of the trip (16%).

For secondary schools, which are more sparse, the 'value added' of public transport is determined by estimating the share of the trip to the nearest facility that would actually be spent onboard, rather than walking to or from a public transport stop (in the case that public transport provides any time savings at all). In Ouagadougou, nearly all of the city's residents can reach the nearest secondary school faster by walking-only, and in the other cities the share is also high, ranging between 65% and 85%. In other words, public transport appears to offer very limited accessibility benefits, at least to reach the nearest secondary school. However, in a few cities using public transport can result in significant time savings for at least some portion of the population: in Bamako and Kigali, about 8–9% of the population would spend at least half of the trip duration in public transport if assuming the fastest route. Figure 5



a. Bamako b. Ouagadougou

Figure 5. Share of time spent travelling to nearest secondary school that would be spent onboard public transport if assuming the fastest route, Bamako (high) vs. Ouagadougou (low).

illustrates the cases of Bamako and Ouagadougou, which differ markedly in terms of the 'value added' of the public transport system.

6. DISCUSSION

It is clear that urban form and the quantity and spatial distribution of urban resources matter for accessibility in the analysed African cities, complementing and perhaps surpassing the role of public transport connectivity. Average travel times to the nearest school appear to be closely correlated with the presence of schools in the residential neighbourhoods. Cities with higher shares of population living within a kilometre of a primary school – Conakry, Douala and Nairobi – have distinctly lower average travel times to the nearest school and lower 'accessibility poverty'. Similarly, average travel times are lower in cities where a primary school exists per every two to three thousand inhabitants, as compared to cities like Harare and Maputo where population per primary school exceeds 12,000. Urban form – as proxied by the overall average population density of a city – also appears to be a predictor of accessibility to primary schools: average travel times increase as population densities decline, with the average residents of the denser cities like Conakry, Douala and Nairobi seeing distinctly lower travel times. Also, in the case of accessibility to secondary schools, there is a strong positive correlation with the share of population living within a walking distance to a secondary school – i.e., the direct presence of secondary schools within residential neighbourhoods. Accessibility to advanced healthcare facilities, similarly, is most clearly related to the direct presence of healthcare facilities within residential neighbourhoods as measured by the share of population able to reach at least one such facility within a 1-km radius. Travel times are by far the highest in Ouagadougou, Harare and Bamako, where only between 7% and 12% of the urban residents live directly near an advanced health facility, and the lowest in Kampala, Douala and Conakry, where over 80% do.

In contrast, there is only weak correlation between average travel times to schools and proximity to public transport, underscoring the generally low 'value added' of public transport for reaching these types of destination. In most of the cities, over 85% of the population live within 1 km of a public transport route, reaching nearly 95% in Nairobi. Dar es Salaam and Maputo have somewhat lower shares of people living near transit, despite relatively well-developed public transport networks. Finally, Conakry and, especially, Ouagadougou, stand out as having a large share of their populations living further away from the transit network, which is largely explained by the sparsity of the networks themselves. Overall, it appears that, while transit-oriented development is typically considered to promote urban accessibility and sustainable mobility, it does not appear to fulfil those functions in most of the cities considered. For example, neither of the two indicators capturing the extent of transit-oriented development – a high share of population living within walking distance of transit and a high share of primary schools located within walking distance of transit – appear to be clearly correlated with better accessibility. This might be at least partly due to the technical performance (slow speeds, long headways) of the public transport services, which reduce the value of being near a public transport route in some cities (e.g., Ouagadougou), and the sheer distances that have to be travelled in yet others (Harare, Maputo). Finally, the fact that population proximity to transport does not appear to translate into better primary school access may have to do with the way informal transport routes – which dominate many of the cities in scope – are allocating themselves, prioritising routes that are more profitable, such as to main economic activity centres, or only travelling on the rather sparse paved road networks to reduce the risk of damage to vehicles, which has been shown to be a preference for informal operators (see, e.g., Kelley et al., 2018; Venter et al., 2014). An overlay of the public transport

networks of the ten cities and their paved road networks as reported by the Global Road Inventory Project (GRIP) database suggest that at least the latter explanation holds.

Accessibility to advanced healthcare facilities is somewhat more correlated at least with the share of people living within walking distance of transit. Average travel times to the nearest facility are among the lowest in cities like Kampala, Douala and Nairobi, where the vast majority of residents live near at least one public transport route, and it is by far the highest in Ouagadougou, where less than half of the population can reach a bus route within a 1-km radius from home. This might be indicative of the 'value added' of public transport services specifically for reaching the more centrally located advanced healthcare facilities as compared to schools that are widely distributed; however, it could also be just a spurious correlation, in that the same cities in which many people live near transit also have wider availability of advanced healthcare facilities as measured by the average population per facility. For example, in Ouagadougou, the very long average travel times are likely only partly due to the lack of transit-oriented development of the urban area and are at least to some extent driven by the sheer sparsity of advanced healthcare facilities.

Intuitively, the distribution of urban facilities and the extent to which development is transit oriented also influence the share of the trip duration that would actually be spent in public transport as opposed to walking. For example, the average share of the trip spent in public transport when travelling to the nearest secondary school is the highest in cities such as Kigali and Bamako where less people live near a secondary school (65–68%) but a higher share of people (>80%) and over 90% of secondary schools are within walking distance of transit.

6.1. Study limitations

While the study constructs a robust methodology for comparing ten African cities in terms of access to health and education, based on the latest available data, it does have certain limitations. To begin with, the comparison of different cities requires the use of diverse data sources specific to local contexts. Depending on the quality of the data, this can lead to inaccuracies in the results, particularly with regard to GTFS data representing the informal transport networks. Further research is needed as to the methodology and accuracy issues in collecting informal transport map and schedule data. African cities are also evolving rapidly, particularly in terms of urban sprawl. Despite efforts to define a comparable definition of a 'functional city' rather than focusing on administrative boundaries, the significant demographic growth of cities in SSA necessarily leads to rapid changes in the urban landscape, with the adopted definition of the city boundaries thus possibly becoming outdated as time passes. Finally, certain local phenomena can be difficult to explain. They call for further development of the literature on accessibility in African cities, to be able to draw on local case studies.

7. CONCLUSION

This study provides new evidence on the extent to which the public transport systems in major African cities effectively ensure accessibility to health and education facilities. The analysis finds that public transport connectivity to advanced healthcare facilities in particular remains low in some of the cities. Average travel times to schools are lower, although are consistently higher for secondary schools than primary ones. Moreover, there is sometimes significant spatial inequality *within* the cities, with at least several percent of the city populations facing extremely long travel times, or 'accessibility poverty'. Because of the spatial patterns of cities, in which the poor neighbourhoods are sometimes located on their outer edges, across all the cities for which detailed poverty maps were available or could be constructed monetary poverty appears to correlate with 'accessibility poverty'. Thus, the existing analytical frameworks that rely on average accessibility metrics may fall short of capturing the nuances of accessibility

gaps. For example, this appears to apply to cities such as Dar es Salaam, where average travel times to advanced healthcare facilities are reasonable but nevertheless about 6% of the population is 'accessibility poor'. Similarly, Bamako and Kigali illustrate the case where travel times to secondary schools average only 15 minutes but yet 8% of the population is 'accessibility poor', unable to reach the nearest school even within half an hour. Understanding the spatial distribution of the remaining or emerging pockets of 'accessibility poverty' can inform the planning of public transport networks and the siting of additional facilities.

When compared to travelling to schools on foot, the existing public transport systems appear to offer only limited 'value-added', shaving off only a few minutes of travel time in most cities. To some extent this is also the case for advanced healthcare facilities. This may run counter to some common assumptions in the literature that informal transport services have a strongly adaptive nature that makes them particularly well-suited to residents' needs, as independent operators are free to search out areas of local demand, rather than being constrained by the biases and fixity of formal systems (Goldwyn, 2018; Ndibatya & Booysen, 2020). However, this research suggests that there may be limitations to this assertion, as profitability, trip lengths, fuel costs, road grids and density of demand may be failing to create the right circumstances for the provision of service in some locations. Furthermore, this study shows the great variability in the level of accessibility provided by the predominantly informal transport systems in different cities. Despite superficial similarities in terms of organisation and regulation, it appears that local conditions mean each informal system can arrive at a very different distribution of routes, at least with regard to access to the facilities considered here. This calls for dedicated research in different cities, and in particular, dedicated policy responses that do not make a-priori assumptions about how well the informal systems capture local travel needs, or whether mixed land use means that public transport connectivity is less essential, as in the case of primary school access.

It should also be noted that, while spatial accessibility, accounting for travel speeds and headways, is the focus of this study and an important condition for people to be able to access health and education opportunities, other factors such as reliability, cost, comfort or safety represent further obstacles to the actual *use* of public transport for certain groups.

While some accessibility challenges persist across all ten cities, different approaches in prioritising policy interventions are likely needed depending on the specific accessibility landscape. The first group of cities includes those – such as Douala, Conakry, Nairobi, Kampala and Kigali – where average accessibility to not only schools but also advanced healthcare facilities is relatively good, but where there are individual 'accessibility poverty' pockets or evidence that socio-economic groups are not able to afford transport services. In these cities, policy interventions should be more specifically targeted to those spatial areas or groups of people. These could include, for example, localised reforms and investments in transport system coverage, investment in data gathering to understand why existing transport operators do not serve these locations, and provision of targeted incentives to encourage transport operators to expand their services to these areas. In the second group of cities – such as Ouagadougou, Harare and Bamako – also *average* travel times to the nearest advanced healthcare facility are high, even if accessibility to schools is better. In these cities, there is a more immediate need for an expansion of urban resources (facilities) to ensure their more equitable distribution, as well as for investment in the expansion of efficient transport services and possibly new public transport solutions. While new, high-capacity public transport routes may be needed in some cases, the policy makers should also work with the existing (mostly informal) transport service providers to increase their capacity to provide a high-quality service, bearing in mind the objective of accessibility for the most disadvantaged communities.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the author(s).

NOTE

1. Data on secondary school locations was not available for Maputo.

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