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Public transport and health outcomes in rural sub-Saharan Africa – A synthesis of professional opinion



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ABSTRACT

Much of the recent transport focus in rural sub-Saharan Africa (SSA) has been on road building and upgrading as opposed to the provision of public transport. The literature reveals evidence of significant negative public health outcomes associated with crashes and pollution attributable to rural transport. We report the results of a synthesis of professional opinion obtained from in-person interviews and an internet survey on health issues related to the provision of public transport in rural SSA. Field interviews were conducted as semi-structured dialogues with some 40 transportation and public health professionals in the capital cities of Ethiopia, Ghana and Kenya. Additionally, 86 responses to an Internet survey were received from 38 African countries. Poor mechanical conditions of vehicles and risky driving behaviours were reported to be an important source of injury from rural road crashes. The factors contributing to unsafe rural public transport were attributable to economic barriers to proper operation. Although there was some mismatch among the survey and interview results and the literature, public transport was shown to be an important potential source of air pollution exposure. The overwhelming conclusion is the lack of true understanding of the health impacts of rural air pollution in relation to basic needs for provision of safe mobility. The findings reflect the awareness of various professional communities and emphasise the complexity of the relationship between rural public transport and public health. Transport and health relationships in places such as rural sub-Saharan Africa are further complicated by the fact that there is such significant potential for positive health outcomes attributable to transport through enhanced access to healthcare, education, commerce, etc. Systematic epidemiological research is needed to fully understand the trade-offs between rural mobility and its impacts to public health in rural sub-Saharan Africa.

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1. Introduction

Much of the recent transport focus in sub-Saharan Africa (SSA) has been on road building and upgrading. In all too many cases, however, these engineered roads provide physical connectivity (a road from here to there) that does not necessarily come with complimentary accessibility (no way to get there). Numerous researchers have documented how so much of everyday life in rural Africa is affected by the availability and quality of public transport and urged its further development (e.g., [Riverson and Carapetis, 1991](#); [Dawson and Barwell, 1993](#); [Howe, 1997](#); [Porter, 2002](#); [Bryceson et al., 2008](#); [Mengesha, 2010](#); [Porter, 2014](#)). The provision of public transport in rural SSA, however, is a complicated endeavour. The positive benefits of increasing mobility and accessibility are well documented ([Howe and Richards, 1984](#); [Ellis and Hine, 1998](#); [Starkey et al., 2002](#); [Starkey, 2007](#); [Starkey and Njenga, 2010](#); [Banjo et al., 2012](#); [Porter, 2014](#)). Several recent high-level studies, however, have documented a range of negative health outcomes associated with increased motorised travel ranging from injuries and death from road crashes to diseases attributable to air pollution generated from transport ([Downing and](#)

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Table 1
Organisations participating in field interviews.

Country	Organisations representation
Ethiopia	National Road Safety Council, Ministry of Transport Non-Governmental Organization (NGO) Transport Authority, Ministry of Transport Research and Development, Ethiopian Roads Authority Planning and Programming Management, Ethiopian Roads Authority (two individuals) Ethiopian Federal Police Commission Traffic Safety, Oromia Police Commission (two individuals) Addis Ababa Institute of Technology (two individuals) Ministry of Environment and Forestry World Health Organization Ministry of Health Private Consultant
Ghana	Building and Road Research Institute (four individuals) Kwame Nkrumah University of Science and Technology, Department of Roads and Transportation National Road Safety Commission (two individuals) Department of Feeder Roads (three individuals) Private Consultant University of Ghana, College of Public Health Ghana Health Service Ghana Highway Authority
Kenya	Environmental Protection Agency (two individuals) University of Nairobi, Dept. of Civil and Construction Engineering (three individuals) University of Nairobi, Institute of Development Studies African Development Bank, Nairobi International Forum for Rural Transport and Development, Nairobi Private Consultant Traffic Police Police Statistics Office Ministry of Transport and Infrastructure

Sethi, 2001; Freeman and Mathur, 2008; IHME, 2013). Indeed, road crashes and exposure to traffic-generated air pollution were recently reported to be among the top 10 leading causes of death throughout sub-Saharan Africa (GRSF, 2014).

While there exists a consensus on the negative health outcomes associated with transport, the lack of quality data (e.g., crashes/injuries, pollution levels/disease) limits the ability to develop truly effective, evidence-based solutions. And as noted above, the issues surrounding rural transport provision are complicated. In an effort to explore health and safety issues associated with transport in rural Africa, the African Community Access Programme¹ (AFCAP) commissioned a study to synthesise the results of an extensive literature review and expert opinion elicited through field interviews and an internet survey (Jones et al., 2014). In this paper, we summarise specific results from the AFCAP study related to the provision of public transport. In particular, the paper attempts to provide a narrative on road safety and exposure to air pollution in rural sub-Saharan Africa based on three sources of information: a literature review; interviews with 40 transport and public health professionals, and an internet survey of 86 other experts in the field.

2. Methodology

Hundreds of academic articles and research reports from the transportation, public health and global development communities were reviewed and some 170 were organised into an annotated bibliography (Jones et al., 2014). The results of the literature reviews were used to develop instruments for in-person dialogue interviews and an internet-based survey of professional opinion regarding the relationships between health and transport.

The field interviews were conducted as semi-structured dialogues in three study countries (Ethiopia, Ghana and Kenya) from 2 to 13 June, 2014 with some 40 local experts from a range of organisations (see Table 1). The three study countries were selected because of their participation on AFCAP programmes and, perhaps more importantly, the research team had professional connections in each. As such, interviewees were identified through snowball sampling. Some key potential interviewees were identified in the literature and others through professional contacts. They were contacted up to two weeks in advance of the interviews and, where possible, appointments were set (interviews were conducted via telephone/Skype in a few cases). Other interviewees were identified while research team members were in the field – interviewees suggested some and others had their colleagues join them.

Questionnaires (wording, tone, etc.) suggested by Starkey (2007) were used as a model for the developing the interview guides shown in Figs. 1 and 2. The interviewees generally followed the guides but allowed interviewees to expound on initial reactions. Throughout the interactions, the interviewees took notes and later transcribed them to summarise the discussions and highlight specific points raised. Input was transcribed as accurately as possible during the course of the interviews, but nonetheless there may be some minor inaccuracies. Therefore the unique perspectives offered by individual interviewees are provided in the following section as *indirect quotes*.

¹ Africa Community Access Programme (AFCAP) is a research programme, funded by UK Aid, with the aim of promoting safe and sustainable rural access for all people in Africa.

Rural Transport Safety – Dialogue Interview Guide

Our initial literature review indicated the following as key rural road safety concerns. *We realise that there is overlap among the items in the list below. Nonetheless, these represent distinct areas of emphasis for targeted safety programs and future research.*

1. What do you perceive to be the primary rural transport **safety issues** (e.g., driving behaviors, road conditions, vehicle operating conditions) associated with the following?
 - a. Motorcycles
 - b. Buses
 - c. Mini-buses
 - d. Bicycles
 - e. Pedestrians
2. What do you perceive to be the primary rural transport **health impact/issues** associated with the following?
 - a. Motorcycles
 - b. Buses
 - c. Mini-buses
 - d. Bicycles
 - e. Pedestrians
3. What do you perceive to be the primary **accessibility issues** associated with rural transport?
4. What do you perceive to be the primary **policy issues** associated with rural transport?
5. What do you perceive to be the primary **threats (or potential threats)** to rural transport?
6. Which of the following do you perceive to be the most critical issue with regards to rural transport safety? Feel free to rank them in order of priority.
 - a. Motorcycles
 - b. Transport Services (Buses & Mini-buses)
 - c. Vulnerable Road Users (Bicycles & Pedestrians)
 - d. Risky Driving Behavior
 - e. Enforcement
 - f. Data availability/quality
7. *What do you see as the most pressing research needs in the area of rural road safety?*
8. Other thoughts/comments

Fig. 1. Sample guide for field interviews with road safety experts.

Rural Air Pollution – Dialogue Interview Guide

We know that there are serious issues with ambient pollution in urban areas. Attention is needed in rural areas as well. Our initial literature review indicated that in the rural environment, the primary transport related pollution issues are associated with particulate matter (e.g., PM2.5) associated with dust from unpaved roads and fugitive dust from vehicles. *We realise the list below is not exhaustive but we would appreciate any input you might have regarding these key items.*

1. What do you perceive to be the primary **threats (or potential threats)** to rural air quality?
2. Which of the following do you perceive to be the most critical issues warranting research with regards to transport-related air pollution in rural areas? Feel free to rank them in order of priority.
 - a. Estimation of the volume of dust generated from unpaved roads
 - b. Measurement and chemical speciation of traffic dust generated
 - c. Health impacts to road users (pedestrians, cyclists, motorcyclists, hawkers, etc.) exposed to pollutants
 - d. Health impacts to individuals living and working in the roadside environment exposed to pollutants
 - e. Health impacts to individuals traveling in vehicles (i.e., buses and minibus) exposed to pollutants
 - f. Impact and extent of damage to nearby agriculture
 - g. Contribution to roadway crashes due to limited visibility
 - h. Contribution or impact on vehicle operating costs
 - i. Overall environmental impacts
 - j. Data availability/quality
3. *What do you see as the most pressing research needs regarding transport-related air pollution in rural areas?*
4. What do you perceive to be the primary **policy issues** associated with air pollution in rural areas?
5. Other thoughts/comments

Fig. 2. Sample guide for field interviews with air pollution experts.

Sources of indirect quotes are not directly named but general characteristics of interviewees are presented to provide further context for the perspective offered.

The internet-based survey comprised 10 multiple-choice questions that allowed respondents to indicate (and rank) issues they deemed important. Most questions allowed simple Likert Scale responses to gauge the relative significance respondents placed on various related

Table 2
Respondent Background Summary for Internet Survey.

Professional affiliation	Professional speciality	Countries of experience represented	
Government Agency – 29	Road Safety – 27	Botswana – 4	Madagascar – 2
Research/academics – 15	Public Health – 3	Burkina Faso – 2	Malawi – 13
Private Consultancy – 19	Environmental Protection – 1	Burundi – 3	Mali – 2
Non-Profit/NGO – 11	Other – 53 (economics, rural access, social development, environmental science, capacity building, institutional development, regulation/policy, socio-economics, gender, etc.)	Cameroon – 1	Mozambique – 3
Public Safety/ Law Enforcement – 3		CAF – 1	Namibia – 4
Other – 9 (African Development Bank, other development bank, development agency, etc.)		Chad – 1	Niger – 1
		Cote d'Ivoire – 2	Nigeria – 3
		Congo – 1	Rwanda – 6
		DRC – 1	Senegal – 2
		Djibouti – 1	Sierra Leone – 1
		Eritrea – 1	Somalia – 1
		Ethiopia – 7	South Africa – 18
		The Gambia – 1	Sudan – 1
		Gabon – 1	South Sudan – 3
		Ghana – 7	Swaziland – 2
		Guinea – 2	Tanzania – 23
		Kenya – 14	Uganda – 14
		Lesotho – 3	Zambia – 5
		Liberia – 2	Zimbabwe – 11

Note: Many respondents reported experience in multiple countries.

Table 3
Summary of response related to relative danger of rural transport modes.

Transport mode	Survey responses			Weighted average
	Least dangerous (w=1)	Dangerous (w=3)	Most dangerous (w=5)	
Walking/ Cycling	29	21	23	2.84
Public transport	31	24	26	2.88
Motorcycles	11	33	32	3.55

factors. Comment fields were provided to allow respondents to provide additional input or expound on multiple-choice responses and are presented herein as direct quotes. The internet survey was administered to an audience of AFCAP² affiliated professionals and garnered 86 responses. The surveys were anonymous although descriptive professional information was elicited from respondents to provide context. Table 2 summarises the affiliation and speciality of respondents to the internet survey. To provide additional context, it also reports in which African countries respondents had professional experience and insight.

3. Results and discussion

The study addressed two primary issues related to health and public transport – road safety and exposure to pollution. The majority of the results and discussion focus on safety. It was found in both the literature and in professional interactions that the primary focus in rural SSA is the provision of safe and efficient transport and that although a real public health concern, less emphasis is placed on rural air pollution issues. The results of the field interviews and internet survey are summarised by topic in the following sections. Relevant points from the literature review are included to support findings among the input from experts and to provide context.

3.1. Road safety

As of 2010, Africa reported 4% of the motor vehicles in the world yet exhibited more than 10% of global traffic-related fatalities (Chen, 2010). Road crashes are cited as a serious public health concern in rural parts of the continent (e.g., Hulme, 2010; Ae-Ngibise et al., 2012; Ogendi and Aysis, 2011; Mefire et al., 2013). In a study of national police data in Ghana from 1993 through 1998, Afukaar et al. (2003) concluded that more than 60% of fatalities and 52% of injuries from road crashes occurred in rural areas. Rural crashes are reported to be more severe than ones occurring in urban areas and more often result in fatal and serious injuries as a result of higher speeds and inaccessibility of trauma care (Kmet and Macarthur, 2005).

² The internet survey was administered online to the AFCAP Community of Practice listserve and posted on the AFCAP LinkedIn and Twitter feeds. A link to the survey was also distributed to the audience of the 7th Africa Transportation Technology Transfer Conference sponsored by the Association of Southern Africa National Road Agencies in Bulawayo, Zimbabwe (11–14 May, 2015).

Victims of road crashes can be broadly categorized as being public transport passengers, motorcyclists, and vulnerable road users (pedestrians and cyclists). One of the internet survey questions addressed the relative level of perceived dangerousness attributed to each of the three where relative dangerousness was expressed as: Most dangerous (weight=5), Dangerous (weight=3), and Least dangerous (weight=1). All 86 of the internet survey respondents provided answers to this question. The results (raw responses and weighted averages) are summarised in in [Table 3](#).

Respondents to the internet survey rated public transport similar to walking/cycling in terms of perceived dangerousness but substantially safer than motorcycles. The quantitative results were interesting when viewed in the context of some of the comments offered:

“[Public transport] are most dangerous for the following main reasons: unregulated and no enforcement (speed, overloading, poor driver training); insurance for vehicles but not for passengers (thus vehicles are replaced while passengers are not compensated for any injuries or fatalities).”

“Public transport has the highest fatality rates. Motorcycles have high incidences of injuries...”

Such insight is widely supported in the literature. [Nantulya and Reich \(2002\)](#) reported that 85% of global deaths from road crashes occurred in developing countries and that 96% of the children killed in road crashes were in developing countries. They reported that the poor disproportionately bear this burden and specifically called out the impact among passengers of buses and minibuses. [Osman et al. \(2003\)](#) showed that 60% of traffic-related injuries observed in rural northwest Ethiopia were associated with commercial vehicles including minibuses and other transport services vehicles. A separate study noted some that the likelihood of being killed as a passenger in Ethiopia is 30 times higher than in the U.S. ([Persson, 2008](#)). Interestingly, [Starkey et al. \(2013\)](#) noted that transport regulators in Tanzania rated safety compliance among rural bus operators as low (2 of 5 stars).

The majority of the interview discussions around public transport focused on the lack thereof. A common theme among the interviews was how the lack of adequate services and support for them creates a public transport environment that is not conducive to safety. More than one interviewee in Ethiopia noted the problem of public transport services only being available in some areas at night. They related the impairment of drivers due to drugs (e.g., chat) and alcohol to the relative obscurity of overnight hauls. Input from both Ghana and Kenya noted that the scarcity of rural public transport also leads to the overloading of passengers and, of particular concern, the mixing of passengers and goods haulage.

At other times, the interview comments were more policy-oriented or “big-picture” in nature:

Since the roads are bad they are not attractive to vehicular transport. But the provision of roads should be equalled with the availability of modes as a policy issue (Researcher, Building and Roads Research Institute, male, Ghana).

When it comes to accessibility issues, providing access does not solve the problem. The access needs to be followed by a reliable and safe transportation service. The government should try to facilitate the transportation means at least at the beginning so that private transport providers can start serving the rural areas. This can be done by making it easier to access credit for new owner/operators, or through some form of tax incentives or subsidisation. (Private consultant, male, Ethiopia).

While the availability of public transport clearly impacts safety, the very nature of the public transport provided is quite unsafe. For example, [Sobngwi-Tambekou et al. \(2010\)](#) and [Manyara \(2013\)](#) reported that vehicle defects/mechanical failures contributed to the majority of rural crashes (most of which involved public transport vehicles) in Cameroon and Kenya, respectively. Mechanical failures were also cited as being a primary contributor to crashes on rural roads in Burkina Faso ([Lord et al., 2003](#)).

Interviewees from both Ethiopia and Kenya noted that many of the public transport vehicles (mini-buses, mid-sized buses, and pick-up trucks) serving rural areas are older vehicles that have been “retired” from service in urban areas. They cited regular occurrences of crashes being attributed to failures of braking, steering and suspension systems. One interviewee noted the lack of basic safety features such as mirrors on many rural public transport vehicles. Moreover, many of the discussions cited the lack of awareness and understanding of the need for (and even what comprises) proper vehicle condition and maintenance.

Although there is some potential for education to positively impact vehicle conditions, it was widely agreed that improving this issue was a matter of regulation and enforcement. Conversations about these issues revealed myriad complexities. Insufficient inspection, regulation and enforcement of safe public transport vehicles results from lack of resources and geographic coverage in remote areas on the part of authorities. It was also recognised that improving the safe operating conditions of the vehicles would increase the cost of providing services that would ultimately be passed on to riders – and could ultimately impinge on much needed mobility. It is worth noting that more than one interviewee intimated that some potential costs that could be passed along would be those associated with service providers paying bribes during inspection and enforcement.

The internet survey results also clearly indicate that motorcycles are perceived as most dangerous among the choices – a point summarised by the following comment:

“Bus crashes make the headlines, because dozens of people die in one go. But the numbers that die in bus crashes are fewer than the numbers of [vulnerable road users] and motorcyclists who die. The influx of motorcycles into Tanzania is a relatively recent thing, so the numbers of deaths and injuries in this category has not been as high as pedestrians and cyclists in recent years. But motorcyclists will soon become the leading category.”

The results (and the comment) reflect a growing concern across much of Africa of the rapidly increasing prevalence of motorcycles, especially as public transport vehicles. Motorcycle taxis are becoming an increasingly important means of mobility throughout rural Africa for example: Uganda ([Bryceson et al., 2003](#)), Tanzania (Porter et al., 2013), Nigeria ([Olubomehin, 2012](#)). Motorcycle taxis are becoming increasingly ubiquitous throughout Africa ([Kumar, 2011](#)) at the same time that are being resisted and due to safety concerns and in some cases officially banned ([Egbunike, 2012](#); [BBC, 2013](#); [Porter, 2014](#)).

A comprehensive study of rural transport safety in Tanzania recently outlined issues related to the increased use of motorcycles for public transport ([Guerrero et al., 2013](#)). A recent study from a hospital in rural Nigeria indicated that most (54%) injuries coming into the emergency department were motorcycle-related. Males were more than three times likely to be injured in a crash as females and crash

injuries accounted for 25% of all deaths in the emergency department (Madubueze et al., 2011). Some 98% of vehicles registered in northern Ghana between 2004 and 2008 were motorcycles. As expected, motorcycle crashes have increased proportionally with increased ownership and usage. It was reported that these crashes have cost the region about \$1.2 million over the same period. About half of the estimated economic loss is from property damage and administration and administration while the remainder is associated with medical costs and lost productivity. Indeed, the author of the study commented that these motorcycle crashes are disproportionately affecting young working-age men in the region (Kudebong et al., 2011).

Ackaah and Afukaar (2010) reported on the impact of motorcycle crashes in northern Ghana (Tamale region) and commented on the lack of helmet usage exacerbating the injury severities. In a recent study, motorcyclists and their passengers in rural areas of Ghana were shown to be seven times less likely to wear a helmet than those observed in urban areas (Akaateba et al., 2014). Similarly, some 95% of 363 motorcycle crash victims recorded at three hospitals across Nigeria were shown to not be wearing helmets (Oluwadiya et al., 2009).

The results of the dialogue interviews reinforced findings from the literature review. The interviews reflected the interviewees own knowledge and experience in relation to his or her country. For example, one of the interviewees from Ethiopia ranked motorcycles as the lowest among the safety issues and then went on to explain in detail that motorcycles were not common in most parts of the country except in the border regions. Internet survey respondents from southern countries, especially South Africa, made similar assertions that motorcycles were not prevalent in rural areas. Conversely, interviewees and respondents from elsewhere cited the use of motorcycles and motorised three-wheelers as public transport and ranked them as the most important rural transport safety issue – for example, the following detailed account from Ghana:

Another emerging trend in the North is the use of motorised three wheelers as passenger transport... They fill the gap in transport supply, carrying up to about 15 passengers exclusively, sitting on benches or about 5 passengers sitting on their goods. The three wheelers are often operated by unlicensed individuals, posing safety risks to the occupants and other road users. Their operation needs serious regulation. Their safety concern is so bad that a whole ward at the Tamale teaching hospital is dedicated to motorcycle and three wheeler casualties. (Engineering Professor, male, Ghana).

Many of the discussions reflected the positive aspects of the relatively affordable and flexible mobility offered by motorcycles. The tone sometimes, however, was one of resignation (or inevitability) of motorcycles being an important rural transport mode, especially in remote areas:

How to mitigate the negative effects of the motorcycle as a rural transport mode while encouraging it as an alternative mode for rural transport (Engineer, male, Ghana).

Study motorcycles as a source of income and affordable public transport to the rural communities in Kenya (Engineering Professor, male, Kenya).

In some cases, discussions followed lines of larger policy needs rather than specific motorcycle safety:

Unemployment in the rural community forces the young high school graduates to resort to motorcycles as an immediate employment in the public transport sector. Job opportunities should be created to absorb high school graduates to contain the rate of growth of motorcycle in public transport (Police Inspector, male, Kenya).

Other recommendations tended more towards safety management topics such as assessing the financial impacts (e.g., hospital fees, productivity losses, net worth estimates of injuries and fatalities) associated with motorcycle crashes. It was noted that such detail is needed to fully appreciate the true benefit (accessibility) versus costs (including financial impacts of crashes) of motorcycles and rural public transport.

The issues that seem to dominate discussions around motorcycles as public transport vehicles are the lack of training/regulation of motorcycle riders leading to risky driving behaviour.

Safety is extremely affected by road user knowledge and skill. This particularly applies to motorcycles and to some extent mini buses and matatus. Motorcycles have been widely accepted for public transport in most rural communities in Kenya. The service is offered by private individuals who own the motorcycles. There are no schools to train drivers in the rural community. Drivers begin operating motorcycles and mini buses with insufficient knowledge and skills. As a result, the interaction between the road and the road users is extremely compromised. (Police Inspector, male, Kenya).

Indeed, risky driving behaviour was widely reported in the literature and interview discussions as the primary contributor to rural crashes among all public transport vehicles types. The survey asked respondents to rank five risky driving behaviours according to the following scale:

- 1 – Very unimportant (has already been adequately addressed or is not a major issue)
- 2 – Unimportant (warrants continued study as opportunities arise)
- 3 – Moderately Important (should be included in future research plans)
- 4 – Important (should be addressed within the next 5 years)
- 5 – Very Important (requires immediate attention)

The results from the 84 responses to this question are presented in Table 4.

Although similar (and related), issues of poor (i.e., untrained, inexperienced, and unregulated) driving and aggressing (i.e., taking risks such as speeding and overtaking) received the highest quantitative rankings. These two categories were frequently addressed in the respondent comments as was the recurring issue of a lack of adequate data to fully develop causal relationships to crashes and severities on which to formulate and implement specific, evidenced-based actions and, eventually develop safety management programmes.

“Drivers operating public transport vehicles are young, aggressive and reckless.”

Table 4

Summary of response related to risky driving behaviours.

Risky driving behaviour	Survey responses					Weighted Average
	Very unimportant (w=1)	Somewhat unimportant (w=2)	Moderately important (w=3)	Important (w=4)	Very important (w=5)	
Impaired driving	4	2	16	23	36	3.05
Distracted driving	2	7	26	21	26	3.76
No safety equipment	3	4	16	32	28	3.94
Aggressive driving	2	1	10	25	43	4.31
Poor driving	1	2	10	21	49	4.39

“Risky driving behaviour – it is all about maximising profit, drivers are not afraid of doing anything unlawful.”

“Drivers behave with impunity and there is too much corruption on the enforcement end.”

“All are important. Fortunately we know what the impact of these things are (perhaps with the exception of the first and last) ... but what we don't have is good quality data on prevalence of these behaviours and what can be done to effectively fix these issues.”

“All need immediate attention. At the moment there's not enough data to know how to target behaviour change interventions. But our research has shown that, of the different behaviours listed, poor driving and aggressive driving are the areas in greatest need of being addressed.”

“With more roads being built for example in Uganda, with the absence to training and behaviour changing communications, road users in SSA are living the recipe for disaster. Urgent action is needed. The research has been done, we know what needs to be done, it's just effective implementation of recommendations that is lacking.”

The issue of poor driving was reinforced during the interviews with specific focus on driver training and education. In addition to consensus that there is a lack of sufficient traffic control devices in rural areas, there was much discussion around the lack of understanding of traffic control and laws contributing to an unsafe lack of compliance. Again, however, issues of negative financial incentivizing were introduced:

Police investigations have also shown that drivers are inadequately trained. Driving schools are owned and operated by the private sector whose main objective is to maximise profit without much concern about the quality of training offered. As a result, these drivers do not appreciate the need to obey traffic rules; they do not understand traffic signs their focus is to maximise the number of round-trips made per business day (Engineering Professor, Kenya).

There is a need to develop a curriculum for training of public transport drivers. Currently, drivers are trained by private institutions that use different curriculum and are more profit oriented that there is no focus on the quality of training being offered (Police Inspector, Kenya).

Road safety issues around rural public transport are clearly complex. One of the most overwhelming results from the investigations was the relationship between the supply and demand of rural public transport and the prevalence of unsafe conditions.

Although difficult to single out a root cause for most of the above, it is obvious that combination of lack of transport service, proper enforcement and regulation are major issues. Passengers will take any form of transport service because they don't have alternatives. Drivers will try to maximise their benefit by over loading and speeding knowing that the rural people don't have enough transport service. Drivers know they won't be caught by traffic police officers if they drive during night. So it is a complex issue. This issue may be solved (or at least reduced) with a working policy and proper enforcement of rules and regulations and provision of transport service (NGO Director, Ethiopia).

3.2. Air pollution

Early focus on the pollution costs of road transport in Africa can be traced back to the mid-1990s (Mwase, 1996; Tanimowo, 2000). The air pollution and health literature typically refers to solid particulate matter (PM) that is smaller than 2.5 µm in diameter as PM_{2.5} while some literature also refers to larger particulate matter PM₁₀ (i.e., smaller than 10 µm in diameter) as also having deleterious health effects (Smith, 1993; McMichael, 2000; Colvile et al., 2001; Anenberg et al., 2010; Rao et al., 2012). PM can be a very localised traffic emission as it is associated with exhaust from combustion engines, mechanically generated dust (e.g., brakes), chemical laden dust entrained from roadways and even fugitive dust disturbed along the roadways themselves – especially unpaved ones (Mkoma et al., 2009). Greening and O'Neill (2010) reported data from a US study that estimated 40% of fugitive atmospheric dust attributable to unpaved roads (typical in rural areas) and another 8% from paved roads.

Elevated levels of traffic generated air pollution inside public transport vehicles is known to be a health concern and is well documented in the literature (e.g., Chan et al., 2002; Kaur et al., 2007; Knibbs et al., 2011). Although the measurements were made in an urban environment, Both et al. (2013) documented PM_{2.5} levels in public transport vehicles higher than those measured in private cars in Jakarta, Indonesia. Similarly, Ekpenyong et al. (2012) documented exposure to high air pollution levels among taxi drivers in Uyo, Nigeria. Greening and O'Neill (2010) discussed various dust (i.e., PM 2.5 and PM 10) exposure pathways in the rural roadway environment in Africa. They specifically cite high exposure rates for people travelling in minibuses, on motorcycles, and in the back of trucks. They also note that rural residents in developing countries often build houses and/or operate businesses close to roads to access passing trade and to reduce their own access times when travelling.

An internet survey question allowed respondents to indicate which of three groups: occupants of roadside residences or business, individuals in the roadway (e.g., pedestrians, cyclists, hawkers), or vehicle passengers were most vulnerable at air pollution exposure:

Table 5
Summary of Response related to vulnerability to air pollution exposure by different roadway user groups.

Groups at risk due to air pollution	Survey responses			Weighted average
	Least vulnerable (w=1)	Vulnerable (w=3)	Most vulnerable (w=5)	
Vehicle passengers	47	14	8	1.87
Individuals in roadway environment	5	30	30	3.77
Occupants of roadside residences and businesses	7	27	38	3.86

Most vulnerable (weight=5), Vulnerable (weight=3), and Least vulnerable (weight=1). The results of the 78 responses to the air pollution question are summarised in Table 5.

Internet survey respondents perceive vehicle passengers as the least vulnerable to air pollution exposure. Interestingly, these results disagree with some of the pragmatic opinions expressed in the field interviews.

The vehicles in the rural areas are very dilapidated and dust even leaks into the vehicles. The vehicles themselves pose a health risk. (Public Health Official, Ghana)

All transport modes driven on unpaved road generate dust, which is a major health threat to the drivers, passengers, pedestrians, as well as people living adjacent to the roadside. (Ministry of Health Official, Ethiopia).

The interviews and discussions reflected the overall understanding and emphasis found in the literature with regard to rural air pollution as an issue. All of the interviewees that represented environmental or public health agencies were quick to concur that rural air pollution and its health impacts were poorly understood and research was needed.

Rural vehicle emissions are quite minimal and so has not been a target. The focus has been in the urban centres. (Environmental Protection Agency Officer, Ghana).

This office is not aware of any effort or practice that has tried to link respiratory patients in rural areas with dust exposure – where they live, how they travel, or what type of road they travel (Ministry of Health Director, Ethiopia).

The lack of emphasis on air pollution in the research literature was echoed among the expert opinions surveyed – one interviewee even downplayed the need for focusing on air pollution in relation to greater concerns over basic mobility and safety for rural Africa:

“Talking about dust and emissions is like a storm in a teakettle. There are bigger issues (Transport Researcher, Ghana).”

Thus, the research concluded that the immediate, acute issue of road safety currently dominates the health-related concerns associated with public transport in rural sub-Saharan Africa.

4. Conclusions

A synthesis of professional opinion and relevant literature was developed to identify health issues related to the provision of rural public transport. Poor mechanical conditions attributed to vehicles and lack of maintenance was documented to be an important source of injury from rural road crashes. The most significant contributor to crashes was deemed to be poor driving, whether from lack of training or risky behaviours. Ultimately, the factors contributing to unsafe rural public transport were attributable to economic barriers to proper operations.

Although there was some mismatch among the survey and interview results and the literature, public transport was shown to be an important potential source of air pollution exposure. The overwhelming conclusion is the lack of true understanding of the health impacts of rural air pollution in relation to basic needs for provision of safe mobility.

Such findings reflect the awareness of various professional communities and emphasise the complexity of the relationship between rural public transport and public health. Transport and health relationships in places such as rural sub-Saharan Africa are further complicated by the fact that there is such significant potential for positive health outcomes attributable to transport through enhanced access to healthcare, education, commerce, etc. Systematic epidemiological research is needed to fully understand the trade-offs between rural mobility and its impacts to public health in rural sub-Saharan Africa.

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