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Assessing heat-related health perceptions in the minibus taxi industry in Tshwane, South Africa

Global warming, the increase in heatwaves and periods of intense heat, is a major problem across the world, including in South Africa. Heat exposure has adverse health impacts, ranging from dehydration and heat stroke to death. The transport sector and its users are vulnerable to heat exposure both in vehicles and in places where they wait for transport. We investigated the heat perceptions and experiences of minibus commuters and the minibus taxi industry in minibus taxis and minibus taxi ranks to inform an intervention to prevent adverse health impacts from heat exposure in the City of Tshwane. Commuters (n = 279), drivers and marshals (n = 46) reported feeling hot in minibus taxis and minibus taxi ranks, experiencing sweating, headaches, exhaustion and dizziness. Some participants reported opening windows and doors, drinking water/cold drinks, removing a jersey and fanning themselves to try and cool down. All participants suggested solutions to address heat exposure in minibus taxis and minibus taxi ranks, including more shelters and trees for shade, the provision of water, benches and potentially an air-conditioned building for waiting/holding periods between trips. In consultation with our stakeholders, we prepared educational awareness materials about heat risks to health and actions to take when it is hot, and these were distributed through the minibus taxi sector in the City of Tshwane. Future research needs include measuring temperatures in these settings and rolling out large-scale interventions to protect health and well-being in a changing climate.

Significance:

Heat exposure has adverse health impacts, ranging from dehydration to death. The transport sector and its users are vulnerable to extreme heat. We investigated the heat experiences and perceptions of minibus commuters and the minibus taxi industry to inform an intervention to prevent adverse health impacts from heat exposure in the City of Tshwane. We prepared educational awareness materials about heat risks to health and actions to take when it is hot, and these were distributed through the minibus taxi sector. Future research needs include measuring temperatures in these settings and rolling out large-scale interventions to protect health and well-being in a changing climate.

Introduction

The Intergovernmental Panel on Climate Change (IPCC) Assessment Report 6 states that the average global temperature is projected to increase by 1.5–3 °C by 2050 and by 3–6 °C by 2100 compared to pre-industrial levels.[1] Extremely high temperatures and heatwaves have impacts on human health, including heat stroke, dehydration and respiratory problems, among other adverse effects.[2] Given these projections, it is crucial to study heat-related health impacts across various daily scenarios.

Heat exposure can be problematic in specific settings, such as in schools[3,4], outdoor work environments[5] and primary healthcare facilities[6]. It is also increasingly being recognised as a problem in the transport sector, especially inside public transport vehicles and at terminals/ranks.[7] Approximately 80% of the urban population in Africa use some form of public transport (minibus taxis, buses, moto-taxis, matatus, sept-place taxis, tro-tros, keke, danfo, boda boda, etc.).[8,9] There is a scarcity of studies that explore the health repercussions of heat exposure on populations using different modes of transport, particularly in Africa. Studies exploring the effects of climate change on health in the transport sector have focused on urban and transport planning predominantly in high-income countries[10] and on the analysis of air-pollutant emissions[11-14]. One area of research on heat-related impacts within the sector includes mortality of infants and young children left unattended in cars during periods of intense heat or on hot days in high-income countries[15-19] and in low- to middle-income countries[17,20]. However, there is a lack of studies examining reported deaths of this nature in Africa. A study analysing disease burden in the urban areas of Barcelona in Spain found that reducing motor vehicle usage, implementing green infrastructure and encouraging physical activity could enhance public health outcomes and reduce air pollution and heat exposure in cities, highlighting the potential benefits of similar interventions in the minibus taxi industry to mitigate heat exposure and improve health in urban settings.[21] In Phoenix, Arizona, in the USA, bus-stop infrastructure failed to adequately shield commuters from extreme heat[7], and planting trees near bus-stops were shown to lessen health risks[22]. There is an urgent need for comprehensive studies on the impact of heat exposure in the transport sector to inform effective policies and interventions targeting adverse health effects.

Public transportation contributes significantly to global efforts to address climate change by reducing the number of vehicles on the road.[23] In addition, it is more affordable for families with lower incomes to use public transport. Thus, it remains imperative to improve public transport service delivery to meet the needs of the poorest populations.[24] A recent study spanning Uganda, Zambia and 15 other African countries highlighted the vital role of climate resilience and inclusive access to transport, emphasising the need for strong political will, cross-sector collaboration, inclusivity for vulnerable groups, and sufficient funding to develop climate-resilient

transport infrastructure across Africa.[25] Further studies are imperative to understand the health outcomes of heat exposure in transport systems, especially in Africa, to integrate climate resilience and inclusive transport infrastructure that meets the needs of vulnerable populations.

Despite the transport sector's heavy reliance on fossil fuels (99%), South Africa does not prioritise national adaptation strategies for this sector, despite the urgent need for decarbonisation in both passenger and freight transport.[26] In South Africa, 67% of public transport passengers use minibus taxis, and the industry is the most popular means of transport in South Africa, surpassing both trains (13%) and buses (20%).[27] The majority of users are the low-income population, who live in townships that are not well served by formal transportation, such as buses and trains.[28] Across the country, the minibus taxi industry has around 150 000 minibus taxi owners operating between 200 000 and 250 000 minibus taxis.[8] In addition, the minibus taxi industry employs about 300 000 drivers, 100 000 rank marshals, 100 000 car washers and 150 000 street sellers at minibus taxi ranks.[8]

Given the number of role players in the minibus taxi sector potentially exposed to extreme heat, this study aimed to understand the heat experiences and perceptions of commuters and employees of the minibus taxi industry to inform an intervention to mitigate against the adverse health impacts of heat exposure. Our objectives were to (1) conduct a survey among minibus taxi commuters and drivers to understand their experiences of heat exposure and (2) explore interventions they suggest could be implemented to help prevent adverse heat-related health impacts in minibus taxis and at taxi ranks. To the best of our knowledge, this is the first study to assess heat-related health perceptions among minibus taxi commuters, marshals and drivers in South Africa, and possibly Africa.

Methods

Study site

The site for the administration of the questionnaire survey was purposefully chosen, primarily for safety reasons. In collaboration with the City of Tshwane (CoT) and the Tshwane Taxi Industry (TTI), the Castle Gate Taxi rank (Figure 1) was deemed an appropriate, safe location to conduct the survey. It was acknowledged that this taxi rank was different from other ranks in that it had shade structures and seating, unlike some other ranks in the City; however, the commuters and drivers would be similar to those visiting other ranks.

Procedures

We carried out a cross-sectional survey study to assess heat-related experiences among commuters and the taxi industry. Fieldworkers spent 5 days (5–9 December 2022) at the Castle Gate minibus taxi rank and recruited people to participate in the survey. Participants were provided with an information sheet and provided informed consent prior to participation in the survey. Participants needed to be 18 years or older to participate in the study, and no other exclusion criteria were applied.

The questionnaire consisted of several questions:

- What gender are you (male, female)?
- What age are you (18–25 years, 26–35 years, 36–45 years, 46–55 years, 56–65 years, older than 66 years)?
- When travelling in a minibus taxi, do you feel hot (no, yes)?
- Do you feel hot when travelling in a minibus taxi at 11:00 in the morning (no, yes)?
- Do you feel hot when travelling in a minibus taxi at 15:00 in the afternoon (no, yes)?
- When you feel hot, do you do something to try and feel cooler (no, yes)?
- What do you do to try and feel cooler when you feel hot in a minibus taxi (open answers)?
- Have you ever experienced any of the following symptoms when you feel hot while in the taxi in the morning (sweating, heat cramps, headaches, a faster heartbeat, nausea/vomiting, heat rash / pimples or blisters on the skin, heat exhaustion / feeling tired or weak, dizziness / confusion, difficulties breathing, fainting and / or irritability[29])?
- Have you ever experienced any of the following symptoms when you feel hot while in the taxi in the afternoon (sweating, heat cramps, headaches, a faster heartbeat, nausea/vomiting, heat rash / pimples or blisters on the skin, heat exhaustion / feeling tired or

Figure 1: Minibus taxis parked at the Castle Gate Shopping Centre in Tshwane, South Africa.

weak, dizziness / confusion, difficulties breathing, fainting and / or irritability[29])?

- In hot weather, when you are standing at or walking through the minibus taxi rank, do you feel hot (no, yes)?
- Have you ever experienced any of the following symptoms when you feel hot while in the minibus taxi rank (sweating, heat cramps, headaches, a faster heartbeat, nausea/vomiting, heat rash / pimples or blisters on the skin, heat exhaustion / feeling tired or weak, dizziness / confusion, difficulties breathing, fainting and / or irritability[29])?
- What do you think can be done to make minibus taxis and minibus taxi ranks cooler and more comfortable when it's hot (open answers)?

Statistics

Fieldworkers used tablets to record answers from study participants. Participants' answers were recorded using REDCap[30,31] software installed on each tablet. REDCap is a secure web application designed for the collection and management of research data.[31] It is a versatile and efficient tool, widely adopted by researchers to streamline their data workflows and ensure high-quality, compliant research practices. All data were processed for quality control prior to being imported into Stata version 10[7] for analysis. Descriptive statistics were calculated, and open answers were collated by themes identified from the participants' responses. The results of this study will serve as a basis for future studies examining the heat-health effects when travelling or working in minibus taxis. Thus, descriptive statistics were used for the effectiveness in summarising and presenting the survey data, ensuring data quality, and providing actionable insights into the heat-related experiences of commuters and the taxi industry.

Results

A total of 324 participants (279 commuters and 46 members of the minibus taxi industry) completed the questionnaire survey (Table 1). Most participants reported that they felt hot when travelling in a minibus taxi, regardless of whether it was in the morning or the afternoon. Participants said that when they felt hot inside a minibus taxi, they would open a window (87%), drink water (78%) or cold drinks (15%), fan themselves with their hand or a make-shift fan, and remove a jersey.

Results showed that, among the 324 participants, the most common health complaints when it was hot were sweating (~between 50% and 80%), heat exhaustion / feeling tired or weak (~20%), headaches (~30%) and dizziness (20%).

Heat exposure and health effects among commuters

A substantial percentage of commuters (75%) reported feeling hot sometimes when travelling in a minibus taxi, with an additional 22% always feeling hot. At 11:00 in the morning, 65% of commuters sometimes felt hot, while at 15:00 in the afternoon, the percentage of those who sometimes or always felt hot increased to 94%. To cool down, 81% of commuters reported taking some action, with 87% opening a window and 78% drinking water. Common heat illness symptoms experienced in the morning included sweating (72%), headaches (27%) and dizziness/confusion (16%) (Figure 2). In the afternoon, sweating (77%), headaches (32%) and dizziness/confusion (19%) remained prevalent (Figure 2). When standing at or walking through the minibus taxi rank in hot weather, 89% felt hot, experiencing symptoms such as sweating (84%), headaches (32%) and heat exhaustion (21%) (Figure 2).

Heat exposure and health effects among drivers

When travelling in a minibus taxi, 63% of drivers reported sometimes feeling hot, and 30% always felt hot. At 11:00 in the morning, 65% sometimes felt hot, whereas, at 15:00 in the afternoon, this reduced slightly to 50%. To alleviate the heat, 93% of drivers took actions such as drinking water (89%) and opening a window (82%). In terms of heat illness symptoms in the morning, sweating (56%) and dizziness/confusion (19%) were most common. While in the taxi ranks, 93% of drivers reported feeling hot, with sweating (67%), headaches (17%) and heat exhaustion (21%) being the predominant symptoms. These findings indicate that heat exposure is a significant concern for drivers, affecting their comfort and health both during transit and while waiting at the ranks.

Unfortunately, for the question 'Have you ever experienced any of the following symptoms when you feel hot while in the minibus taxi in the afternoon?' posed to the taxi industry drivers, the data were not recorded and are missing.

Comparative analysis between the experiences of drivers and commuters

There are notable differences and some similarities between the experiences of drivers and commuters regarding heat exposure and its effects. All 46 drivers surveyed were men, whereas commuters were more gender diverse (54% male and 46% female). Drivers were more evenly distributed across age groups, while most commuters were aged 26–35 years (53%). A larger percentage of drivers (30%) reported 'always feeling hot while travelling in a minibus taxi' compared to commuters (22%). At 11:00 in the morning, 20% of drivers 'never felt hot', compared to only 12% of commuters. In the afternoon at 15:00, 41% of drivers

Table 1: Results of the questionnaire administered to the minibus taxi commuters, marshals and the drivers ($N = 324$)

	Commuters $N = 279$		Drivers $N = 46$	
	Frequency		Frequency	
Question	**Number (*n*)**	**Percentage (%)**	**Number (*n*)**	**Percentage (%)**
Gender				
Male	152	54	46	100
Female	127	46	0	0
Age				
18–25 years	41	15	1	2
26–35 years	148	53	13	28
36–45 years	66	23	14	30
46–55 years	17	6	13	28
56–65 years	6	2	4	8
Older than 66 years	1	<1	1	2

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Table 1 continued...

	Commuters $N = 279$		Drivers $N = 46$	
	Frequency		Frequency	
Question	**Number (*n*)**	**Percentage (%)**	**Number (*n*)**	**Percentage (%)**
When travelling in a minibus taxi, do you feel hot?				
Never	9	3	3	7
Sometimes	208	75	29	63
Always	61	22	14	30
Missing	1	<1	0	0
Do you feel hot when travelling in a minibus taxi at 11:00 in the morning?				
Never	34	12	9	20
Sometimes	176	65	28	65
Always	60	22	6	13
Missing	9	3	3	6
Do you feel hot when travelling in a minibus taxi at 15:00 in the afternoon?				
Never	16	6	1	2
Sometimes	101	38	23	50
Always	149	56	19	41
Missing	13	4	3	6
When you feel hot, do you do something to try and feel cooler?				
No	6	2	3	7
Yes	228	81	43	93
Missing	45	45	0	0
What do you do to cool down when it's hot in a minibus taxi?				
Drink water	218	78	41	89
Drink cold drinks / fizzy drinks	44	15	10	21
Open a window	244	87	38	82
Other (discussed in text)				
Have you ever experienced any of the following symptoms when you feel hot while in a minibus taxi in the morning?				
Sweating	200	72	26	56
Heat cramps	11	4	3	6
Headaches	76	27	6	13
A faster heartbeat	12	4	0	0
Nausea/vomiting	24	8	1	2
Heat rash / pimples or blisters on the skin	21	8	5	10
Heat exhaustion / feeling tired or weak	46	16	5	10
Dizziness / confusion	45	16	9	19
Difficulties breathing	21	8	2	4
Fainting and / or irritability	6	2	0	0

...Table 1 continues on next page

Table 1 continued...

	Commuters $N = 279$		Drivers $N = 46$	
	Frequency		Frequency	
Question	**Number (*n*)**	**Percentage (%)**	**Number (*n*)**	**Percentage (%)**
Have you ever experienced any of the following symptoms when you feel hot while in the minibus taxi in the afternoon?				
Sweating	215	77	–#	–#
Heat cramps	11	4	–	–
Headaches	90	32	–	–
A faster heartbeat	20	7	–	–
Nausea/vomiting	24	8	–	–
Heat rash / pimples or blisters on the skin	26	9	–	–
Heat exhaustion / feeling tired or weak	62	22	–	–
Dizziness / confusion	54	19	–	–
Difficulties breathing	16	6	–	–
Fainting and / or irritability	6	2	–	–
In hot weather, when you are standing at or walking through the minibus taxi rank, do you feel hot?				
No	31	11	3	7
Yes	244	89	43	93
Have you ever experienced any of the following symptoms when you feel hot while in the minibus taxi rank?				
Sweating	236	84	31	67
Heat cramps	16	5	2	4
Headaches	91	32	8	17
A faster heartbeat	15	5	1	2
Nausea/vomiting	16	6	3	6
Heat rash / pimples or blisters on the skin	31	11	4	8
Heat exhaustion / feeling tired or weak	58	21	10	21
Dizziness / confusion	54	19	7	15
Difficulties breathing	20	7	2	4
Fainting and / or irritability	4	1	3	3

Note: # missing data

'always felt hot', compared to 56% of commuters. A high percentage of both drivers (93%) and commuters (81%) reported taking action to cool down. Common actions included drinking water (89% drivers, 78% commuters) and opening windows (82% drivers, 87% commuters). Both groups reported sweating as the most common symptom in the morning (56% drivers, 72% commuters), followed by headaches (13% drivers, 27% commuters) and dizziness/confusion (19% drivers, 16% commuters). Only commuters' data are available for afternoon symptoms, showing high incidences of sweating (77%) and headaches (32%). A larger proportion of drivers (93%) felt hot at taxi ranks compared to commuters (89%). Symptoms at ranks were similar, with sweating being the most common (67% drivers, 84% commuters), followed by headaches (17% drivers, 32% commuters) and heat exhaustion (21% for both groups).

Participant suggestions for improving comfort in minibus taxis and taxi ranks

Several responses were provided to the question 'What do you think can be done to make minibus taxis and minibus taxi ranks cooler and more comfortable when it's hot?'. These included: adding shade / more shelters with benches, extending existing shelters, planting more trees, providing access to drinking water/taps, providing a building with air conditioning to wait inside, and having water mist sprays.

Participants also suggested eating ice, keeping the minibus taxi door open while the minibus taxi is waiting at the minibus taxi rank, using an umbrella for shade when waiting for a minibus taxi, and spending time looking at WhatsApp messages.[4,32]

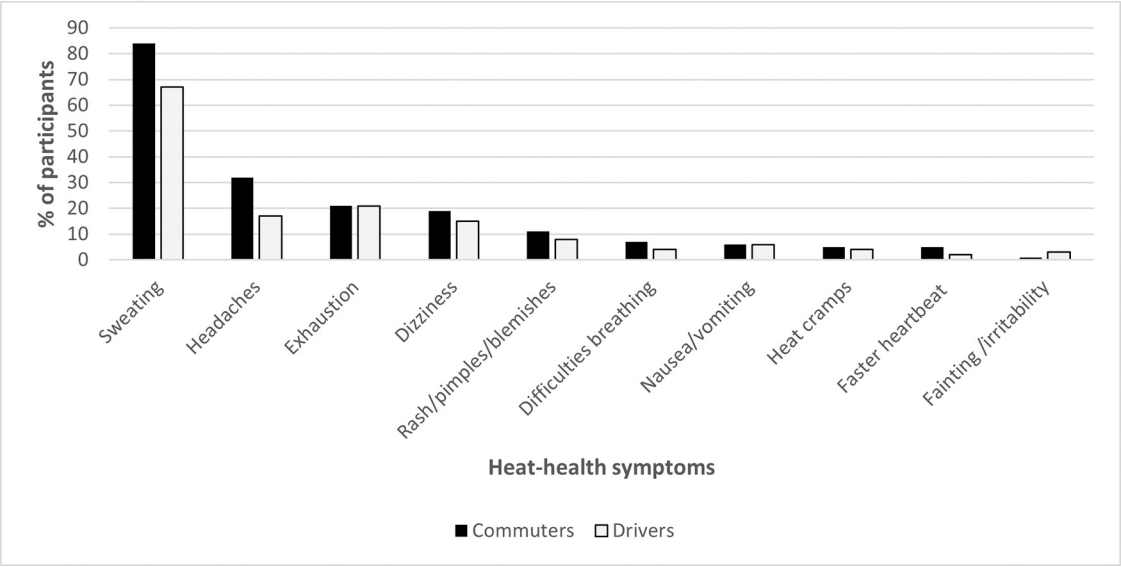

Figure 2: Reported heat-health symptoms among participants in the study.

Discussion

Despite the improvement of life expectancy in Africa, the continent still has the highest rates of many preventable, non-communicable, infectious diseases and chronic illnesses.[33] Low-income populations are widely recognised as being particularly vulnerable to adverse health effects arising from extreme heat.[34] Studying the effects on all African communities that could potentially be exposed to heat-related health problems is therefore imperative. We set out to understand heat-related health perceptions among minibus taxi commuters, marshals and drivers in the CoT.

We found that heat exposure is perceived as a problem that has impacts on human health. Moreover, people have found ways to adapt to heat exposure when in minibus taxis and ranks, although they still experience adverse heat-related symptoms, suggesting that more should be done to protect them from heat-related impacts. People in this transport sector also have many sector-relevant suggestions on how to improve heat-related conditions in minibus taxis and ranks. Moreover, despite the existing shading at the study site, commuters indicated a need for additional trees and shade structures to address the persistent heat-related issues. Thus, enhancing shading infrastructure across all ranks is essential to mitigate heat exposure effectively, especially at taxi ranks that lack trees and shading.

A crucial part of our analysis was the perceptions of taxi drivers in the study, as these individuals are exposed to extreme heat in taxis throughout the day. A previous study analysing the health of taxi drivers in Tshwane showed that they are prone to obesity, hypertension and type II diabetes, linked to unhealthy lifestyle habits.[35,36] Importantly, heat illness has been shown to exacerbate underlying conditions and chronic illnesses such as respiratory and cardiovascular disease.[37,38] Our results on the taxi drivers heat-health perceptions underscore the significant risk imposed on taxi drivers' overall health and well-being. In addition, the health and thermal comfort of taxi drivers ultimately affects commuters who sit in the taxis being driven by them.

Previous studies elsewhere in the world have considered different types of commuters and environmental health risks.[7,22,39] For instance, in the USA, the number of commuters on subways was lower under extreme temperatures compared to cooler days.[40] In South Africa, where so many households rely on minibuses for transport, it is unlikely that their use will decline. Instead, we need to 'heat-proof' the industry, including inside minibus taxis and ranks. We also need to raise awareness among communities about the risks of heat exposure and actions that can be taken to reduce risks.

While our study provides valuable insights into the prevalence and nature of heat-related symptoms among minibus taxi passengers, it is important to acknowledge certain limitations. One key limitation is the potential for misattribution of symptoms to heat exposure. Although the questionnaire was designed to ask participants about symptoms experienced 'when they feel hot in the minibus taxi', it is possible that some reported symptoms could have other underlying causes not related to heat exposure. The reliance on self-reported data may introduce bias, as participants might not accurately recall or attribute their symptoms correctly. Furthermore, while the symptoms listed in our questionnaire are recognised indicators of heat illness (sweating, heat cramps, headaches, faster heartbeat, nausea/vomiting, heat rash, heat exhaustion, dizziness/confusion, difficulties breathing, fainting and irritability), they can also be associated with other conditions. Therefore, care should be taken not to draw definitive causal relationships between the reported symptoms and heat exposure based solely on this questionnaire. To address this limitation, future studies could incorporate objective measures of heat exposure and physiological responses, such as temperature and heart rate monitoring, to more accurately determine the impact of heat on passengers' health. Additionally, longitudinal studies could help establish clearer causal links between heat exposure and specific health outcomes.

Participants suggested several interventions to make minibus taxis and taxi ranks cooler, including more shelters with benches, planting trees, installing water taps, providing air-conditioned waiting areas, and using water mist sprays. Notably, some participants recommended using WhatsApp for disseminating information, which sparked the idea for an education campaign and awareness materials (Figure 3). We proposed all the participants' suggestions for interventions to the CoT and the TTI, each with its pros and cons (Table 2). The CoT and TTI recommended an education campaign to raise awareness about heat-related health risks and mitigation strategies for minibus taxi commuters and drivers. This led to the development of the 'Throw Shade on Heat this Summer' campaign, which included five materials: a car licence sticker, a pull-out banner, a long sticker for above the minibus taxi door (Figure 3), a 2024 calendar, and a four-page flyer. The content was derived from the existing literature[4,32] and previous studies in South Africa and emphasised carrying water, wearing loose clothing, opening windows while travelling, recognising heat illness symptoms, using umbrellas or hats, and caring for vulnerable individuals. These materials were distributed to minibus taxi commuters, drivers, marshals and owners by the CoT and TTI. Although the materials were well received, planned follow-up focus group discussions with the CoT and TTI were not possible due to unforeseen circumstances affecting the relationship between the parties at that time.

Figure 3: The long sticker designed to go above the main, large door of a minibus taxi.

Table 2: Pros and cons of each of the participant's suggested interventions to combat heat in minibus taxis and minibus taxi ranks

Intervention	Pros	Cons
More shelters / extend shelters	Reliable shade	Costly
	Also rainproof	May not cast shade in the appropriate place
	Accommodates many people	May be vandalised
	Could paint roofs white to reflect heat	May attract homeless people
More trees	Casts shade all year round (evergreen trees)	Roots damage tar and paving
	Well-established, mature trees are available	Need water and fertiliser
		Might be cut down for firewood
Access to drinking water / ice	Best way for people to stay healthy during hot weather is to drink water	Costly
	Accessible water encourages people to drink more water	Difficult to maintain infrastructure
	Drinking fountains exist	Difficult to ensure clean water and a continuous supply
		People may take a look to meet daily needs rather than just to quench thirst
		Difficult to protect
		People need a bottle or cup
Keep minibus taxi door open when minibus taxi is waiting at the rank / holding zone	Simple	Safety and security concerns
	Easy	Exposure to air pollution
	Allows through-breeze	Driver's choice
		Might not help if the weather is very hot
		Difficult to enforce
Receive a heat-related health warning	Messages are easy to make and disseminate	Regularity can lead to messages being 'normalised' and ignored
	Can be in multiple languages	Some actions may be difficult, e.g. water accessibility is an issue
	Prompts people to act, e.g. open a window, remove a jersey	

Future research is required to measure temperatures in minibus taxis and minibus taxi ranks to quantitatively assess heat-related health risks to commuters, marshals and drivers. Moreover, more elaborate interventions, such as infrastructural changes, are likely needed to protect the health and well-being of the residents of the CoT, and communities elsewhere, from the risks associated with heat exposure. In addition, intervention studies have the potential to inform urban planning, design and climate change adaptation strategies.

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Data availability

The data supporting the results of this study are available upon request to the corresponding author.

Declarations

We have no competing interests to declare. We declare that no AI was used in the production of this manuscript. Research ethics clearance for the study was granted by the South African Medical Research Council Ethics Committee (EC019-9/2022). Each participant was given a ZAR150 shopping voucher for their participation, and hence, we were holding multiple vouchers on each day of the study. A requirement of the ethics approval was that participants be provided with a token of appreciation in the form of a shopping voucher.

Authors' contributions

C.Y.W.: Conceptualisation, methodology, data collection, sample analysis, validation, data curation, writing – the initial draft, writing revisions, student supervision, project leadership, project management, funding acquisition. T.K.: Methodology, student supervision. N.M.: Student supervision. N.N.: Student supervision. C.W.: Student supervision. All authors read and approved the final manuscript.

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