CHAPTER 8

Exploring Trustworthy AI in Nigeria: A Focus on Safety in Road Traffic

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Introduction

While Africa's realities and perspectives are grossly under-represented in artificial intelligence (AI) research, regulation, and ethics discourse (Eke et al., 2023; Jobin et al., 2019), AI systems like chatbots and autonomous drones are increasingly being adopted in many African countries to solve local problems (Borokini et al., 2023; Roberts, 2022). This is potentially problematic: African AI ethics experts have expressed concerns about the under-representation of African voices and contexts in trustworthy AI

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research and regulation (Rathenau Instituut, 2021). AI systems' performances rely on their training dataset's familiarity with their use cases. Hence, they tend to perform erroneously, discriminately, or harmfully when used in situations (NTSB, 2019) or populations that are under-represented in their training data (Buolamwini & Gebru, 2018; Koenecke et al., 2020). According to Abebe et al. (2021), a reason for their discriminatory or unsafe performances in such scenarios is the asymmetry in the voices shaping AI development and regulation. These make the safety and trustworthiness of AI in Africa questionable.

Trustworthy AI systems are systems in which the values, goals, and welfare of their users, stakeholders, and the societies in which they are deployed are integrated into their design (European Commission AI HLEG, 2019; Nevala, 2020). To guide AI systems' trustworthy development and use in different contexts, many agencies have published various trustworthy or ethical AI principles, including: *Recommendation on the ethics of artificial intelligence* (UNESCO, 2021) and *Ethics guidelines for trustworthy AI* (European Commission AI HLEG, 2019). For instance, the European Union's (EU) trustworthy AI guideline targets the development and use of AI systems in the EU, regardless of where they originate. Hence, it reinforces ***European values or ethics*** (European Commission AI HLEG, 2019). These efforts towards ensuring that AI systems are trustworthy is crucial in facilitating their large-scale adoption and ensuring they benefit society and individuals upon adoption. Although African values, goals, or welfare are currently under-represented in global trustworthy AI discourse, many African countries are working towards publishing trustworthy or ethical AI principles (GNA, 2022; Tijani, 2023; UN Global Pulse, 2019).

The trustworthiness of an AI system can only be adequately defined, understood, and evaluated when that system is considered with respect to environmental and social contexts that are representative of where it will be used. However, most trustworthy AI principles originate from Western contexts, and most AI systems are designed and trained for such contexts. In addition, most African cultures, ethics, and contexts differ significantly from Western contexts, yet many of these systems are deployed for use in Africa. It is, therefore, imperative that African perspectives are represented in trustworthy AI discourse.

To further this discussion, we will focus on safety as an example of key trustworthy AI requirements. AI safety has no standard definition, but is nevertheless a critical requirement for any AI system's use (House,

2023) and trust (Leslie, 2019). This is because AI systems have demonstrated their ability to be erroneous, exposing people to discrimination and dangers when carelessly used in unanticipated or under-represented real-world scenarios (NTSB, 2019; Staff, 2020). Ensuring AI safety in their deployed environments requires critically and holistically considering their safety implications in their potential use cases and deployed (social) environments and integrating these into their development and lifecycle. But how do we ensure AI safety in Africa?

In this chapter, we explore this question by adopting a sociotechnical lens to AI safety in Africa. This is because safety issues are sociotechnical and are relevant beyond AI technologies. We believe AI safety research can benefit from existing safety research and conversations in safety-critical sociotechnical systems like road transportation systems, which maintain well-established and tested safety cultures and mechanisms (Zachmann, 2014), and have continuously integrated new technologies. This chapter presents an African perspective on AI safety through a case study of the Nigerian road transport system, exploring the question: "What lessons can be learned about safety in the Nigerian road transport system to help ensure AI safety in Nigeria?"

We begin exploring this question by defining AI safety and safety approaches as documented in literature. Afterwards, we contextualise our discussion of the potential safety implications of AI systems in Nigerian social systems by presenting how some existing safety issues in the Nigerian road transport system can be traced to the design, introduction, and regulation of automobiles—widely adopted technological artefacts—in Nigeria, and then exploring AI safety in the context of AI-driven vehicles or autonomous vehicles (AV) in Nigeria. We conclude this chapter by highlighting lessons and recommendations that may aid AI systems' safety in Nigeria and similar countries.

We take Nigerian road traffic as the research focus because it is a high-risk multi-agent environment where conversations around safety are critical and ongoing. Nigeria is a dominant vehicle import market in Africa, where vehicles with AI-enabled features are increasingly being introduced (National Bureau of Statistics, 2021), thereby offering a useful case study for: (a) exemplifying how the large-scale adoption of technologies in sociotechnical systems can impact society, (b) demonstrating the importance of Africa's representation in AI safety and trustworthiness discourses, and (c) ensuring AI safe adoption in Nigeria and Africa by learning from past and current issues.

Background

AI Safety and Safety Element Definitions

Generally, safety is defined as *freedom or security from danger, risk, loss, harm or when an agent or object is not likely to be harmed or cause harm* (Leveson, 2011; Merriam Webster, 2023). There are various descriptions of AI safety (Jobin et al., 2019), some of which we highlight here. The IEEE's Ethically Aligned Design (EAD) defined AI safety as *"the probability that a system will either perform its functions correctly or will discontinue its functions in a well-defined safe manner"* (Laplante, 2017). They essentially described safety as the prevention of errors from AI systems. In contrast, systems engineers noted that a system can perform its functions correctly or reliably and still be unsafe, and vice versa; and accidents can occur from the interaction of its various reliable and faultless components (Leveson, 2011; Sommerville, 2011). That is, system safety goes beyond reliability; it is a system-level property that emerges from the interactions of the system's parts. With AI systems, safety transcends technological failures and impacts; it includes *"social impacts on individual wellbeing and public welfare"* (Leslie, 2019), and preventing harmful outcomes from AI systems by ensuring they behave as intended when used (European Commission AI HLEG, 2019).

Risk-Based Approach to AI Safety

Leslie (2019) described ensuring AI safety in real-world environments—which are usually filled with uncertainties—as "a difficult and unremitting task" involving AI risk management. This view conforms with the predominant approach to AI safety in existing trustworthy AI guidelines (European Commission, 2021; Tabassi, 2023; UNESCO, 2021). A risk-based safety approach requires identifying and managing the potential risks and harms of AI systems to people, their communities, and the environment, and adopting safety mechanisms that reflect the scale of the identified risks for the AI system in various contexts and use cases (European Commission AI HLEG, 2019). The EU's AI Act adopts this approach; therein, AI systems were first categorised into levels based on their potential risks (minimal to unacceptable) and were then regulated based on their risk level. AI used in automobiles, medical devices, and law enforcement were categorised as high-risk AI systems—high-risk AI are used in high-risk or life-and-death scenarios where mistakes can result in deaths (NTSB, 2019)—and they recommended that humans are kept in the loop of their decision-making (European Commission, 2021; UNESCO, 2021).

Towards AI risk management, various AI risks have been identified. These include functional failures, erroneous or adversarial performances, malicious use of AI, cyberattacks, privacy breaches, national security, human rights violations, fatalities, and mass surveillance (European Commission, 2021; House, 2023; UNESCO, 2021). In addition, the potential harms of AI systems identified so far relate to physical, economic, social, political, cultural, or mental harms to humans, which can diminish people's trust in AI (European Commission AI HLEG, 2019; Leslie, 2019; Tabassi, 2023; UNESCO, 2021). Overall, AI safety and risk management mechanisms must reflect the safety factors in the diverse real-world environments where AI systems might operate, including their environments, the people and their values, and other technologies involved.

A Snapshot of Safety and Its Elements

From the highlighted descriptions above, we define AI safety as the security of humans and the environment from harms and risks stemming from the development and use of AI. We also present some recurring elements of AI safety. These elements relate to safety but are not safety. They are:

i. Risks—the probability of hazards resulting in harm (Sommerville, 2011).
ii. Hazards—conditions that can cause harm, such as failures (Leveson, 2011).
iii. Harm—loss or damages experienced by one or more individuals (Sommerville, 2011).
iv. Risk assessment—determines the possibility of harm and informs perceived safety (Sommerville, 2011).

The Need for African Realities and Values in Shaping AI Safety

While existing trustworthy AI guidelines like the EU's are good starting points, the values represented so far do not represent global human cultures or realities. The under-representation of African perspectives and African AI safety requirements in global trustworthy AI means that currently, there are no comprehensive guides to help stakeholders identify and manage AI risks and safety issues peculiar to Africa, and protect Africans' safety, values, and welfare; potentially exposing Africans to avoidable harm from AI systems. This is evidenced by findings relevant to AI-enabled AV. In 2017, Mercedes noted that South African road conditions introduce unique challenges for AV intelligence (Luchian, 2017). As such, there is a need to explore the safety of AI systems like Tesla's partial self-driving vehicles currently being manufactured overseas and sold to Africa (Okonkwo, 2023).

Exploring AI safety in African contexts presents an opportunity: adequately considering African realities and experiences in AI design and AI safety will diversify the research contexts informing the design and use of such technologies and may help identify new challenges of AI integration in society. This can facilitate the design of AI systems that are safer and more robust. In the following section, we explore Nigerian road traffic as an example of sociotechnical systems that are increasingly integrating AI-driven technologies. We highlight some of its safety practices and challenges towards identifying safety considerations for AI in Nigerian road traffic.

Exploring Safety in Nigerian Road Traffic

The Nigerian road transport system is a sociotechnical system that fulfils a societal function: safe mobility. Sociotechnical systems integrate humans, societal structures, infrastructure, networks, user practices, regulation, knowledge, technologies, and symbolic meanings to fulfil their function (Geels, 2005). This section discusses the societal aspect of the topic. It presents a brief history of automobiles in Nigeria and highlights existing safety challenges, factors, and mechanisms in road traffic based on a critical review of road safety literature, reports, and data from the Nigerian Federal Road Safety Corps (FRSC) and the National Bureau of Statistics (NBS).

Automobility Adoption in Nigeria—Why and How?

In the early 1900s, Nigeria's increasing population size, urbanisation, and progress in agriculture and manufacturing created challenges in its road transportation, such as poor traffic management, inefficient transport services, and inadequate infrastructure (Commerce & Wilken, 1964;

Ogunbodede, 2008; Pavoris, 2021). Automobiles, including lorries and motor cars from Britain, were introduced into the Nigerian road transport system to address these challenges. Afterwards, road networks were developed to facilitate the automobiles' smooth integration into society, connect railway stations with the major urban centres, and enhance the movement of extracted resources and the British colonial officers in Nigeria (Ogunbodede, 2008).

These developments enabled the large-scale adoption of vehicles in Nigeria, making road transportation Nigeria's primary mode of transportation (Asunloye, 2019). The transitions also introduced and amplified safety challenges and hazards like vehicle overloading, road degradation, road insecurities, and accidents. These were managed by establishing policies, regulations, and an automotive industry (Ede & Chamberlain, 2013), as well as road agencies such as the FRSC—created in the late 1980s to monitor and ensure road safety across Nigeria (FRSC, 2007)—and jobs like traffic police. Despite these efforts, Nigeria still records road safety challenges like a high road crash rate, indicating a gap between its current road safety mechanisms and its safety needs.

Safety Impacts of Automobility in Nigeria: Road Accidents and Hazards

Road Accident Causes

One of the major impacts and challenges of automobile adoption on Nigerian road traffic is its high accident rate. In 2022, the FRSC recorded 13,656 road crash cases and 45,836 road casualties (National Bureau of Statistics, 2023). To identify the causes of Nigerian road accidents, we analysed the 2022 Nigerian road transport data (National Bureau of Statistics, 2023). Therein, the FRSC identified accident causative factors (or road hazards) and categorised them into environmental (the road), mechanical (the vehicles), and human (road users) factors, and others (FRSC, 2022). As shown in Table 8.1, human factors constituted 14,273 (79.21%) of the 18,019 road crash causes recorded in 2022—disproportionately the highest cause of road crashes. Most human causative factors were speed violations, sign light violations, and dangerous driving, accounting for 51.99%, 7.61% and 5.93% of road crashes causes respectively (National Bureau of Statistics, 2023).

However, looking at road accident causes in isolation of their contexts is simplistic; it inherently omits how the interactions between the different

Table 8.1 Frequency distribution of road crash causative factors

Causative factors' category	*Frequency*	*Proportion*
Human	14,273	0.79211
Mechanical	1936	0.10744
Environment	85	0.00472
Others	1725	0.09573
Total	18,019	1

causative factors systemically contribute to road crashes. Taking a systems perspective, we drew on news articles to gather more context about road accident causes. This showed that while accidents caused by reckless driving are due to human factors, reckless driving is sometimes due to environmental factors like bad roads. On bad roads, drivers are forced to drive slowly or maneuver recklessly to avoid damaging their vehicles because of the deplorable state of the roads. Criminals may also lay ambush on motorists on such roads, exposing motorists to heightened insecurities and damages (Ajide, 2020; Boniface, 2021). In such situations, drivers may drive aggressively and break some traffic laws to avoid ambush and protect their lives and property (Naku, 2022). This demonstrates that: (a) road accidents are both hazards (can result in harm like death) and harm (an outcome of another hazard like reckless driving), and (b) road accident factors are systemic, as accidents are generally caused by a combination of these causative factors. Addressing road safety issues, therefore, requires systems approaches.

Other Road Hazards

Drawing on road safety manuals, news articles, and literature on Nigerian road users' safety experiences, we identified additional relevant road hazards that affect Nigeria's road safety that are not reported in the NBS' road transport data.

Insecurity

Road insecurity refers to road users' exposure to dangers and crimes such as kidnapping, theft, and ambush from criminals (Ugwuoke et al., 2023). It is a major challenge on Nigeria's highways and has negatively impacted the transport sector and the nation's economy (Boniface, 2021). In the case of kidnapping, mass transit passengers are most vulnerable to being robbed or kidnapped by criminals who pretend to be commercial drivers

(Sahara Reporters, 2023). These criminals may attack the passengers and cause adverse physical, financial, or mental harm to them. Similarly, drivers may be attacked by road criminals, especially on isolated or bad roads, to rob, carjack, or potentially murder them (Boniface, 2021).

Non-compliance with Traffic Laws
Unskilled or reckless driving, which translates to traffic law non-compliance, is prevalent on Nigerian roads, especially from commercial drivers, motorcyclists, and tricyclists (Ayoyinka, 2023; Uzondu et al., 2022). While traffic laws exist to guide road users' safe interactions on roads, commercial drivers, motorcyclists, and tricyclists tend to disregard traffic laws and speed limits (Uzondu et al., 2022); thus, most accidents happen with commercial vehicles (National Bureau of Statistics, 2023).

Traffic Congestion and Pollution
The large-scale adoption of vehicles on Nigerian roads negatively impacts the environment and public health. Nigeria currently imports about 98% of its vehicles, most of which are used and old vehicles from Europe and the USA (National Bureau of Statistics, 2021). Used or old vehicles are hazardous as many of them are degraded, faulty, or discarded vehicles with expired parts from developed countries, and are prone to breaking down. Such imports are a form of e-waste dumping in Nigeria and Africa as a whole (UNEP, 2020a). These vehicles' usage heightens traffic congestion, accident rates, and they emit 90% more carbon than new ones (Segun, 2019; UNEP, 2020b). Smoke and gas emissions from vehicles significantly contribute to air pollution in Nigeria, which impacts the climate and the residents' health.

Existing Road Safety Mechanisms

Various safety mechanisms have been introduced to address the safety challenges that emerged from automobility adoption in Nigeria. Existing road safety mechanisms are designed around the three main categories of current road accident causes—humans, vehicles, and the environment. These mechanisms vary; they can be formal, technological, or cultural. The formal safety mechanisms in Nigeria are usually based on global standards and the safety mechanisms in the countries where the vehicles are from (FRSC, 2012). They are then adapted to fit the specificities of Nigerian road traffic. This section discusses some existing road safety mechanisms in Nigeria that are relevant to AI safety discourse.

Road Laws and Regulation
Laws and regulations are official safety mechanisms that ensure road users sense their environments, communicate with others, behave in accordance with the set standards, and manage commuters' shared expectations on roads. These regulations may be focused on technology and infrastructure engineering, or road users and their interactions (Admin, 2019; FRSC, 2012).

Vehicle design standards are examples of technology-focused regulations. They specify the mandated features in vehicles and dictate the standards for vehicle parts for them to be considered safe by design and roadworthy (iRAP, 2022). Since most of the vehicles used in Nigeria are imported and used, this means that the standards of these vehicles are primarily not defined in Nigeria. For instance, AI-enabled driver assistant features have been mandated in vehicles in the EU and USA since 2022—the two major suppliers of vehicles used in Nigeria (European Commission, 2019; NHTSA, 2016). This means that from 2022, cars imported from these regions to Nigeria may have AI-driven driving automation (Okonkwo, 2023), whether they are standardised and regulated in Nigeria or not.

Traffic laws are human-focused safety mechanisms that guide road users' behaviours and interactions towards ensuring their collective safety. Traffic laws' validity depends on the geographical levels they cover. They may be (1) global-level, e.g. the UN Geneva Convention on Road Traffic; (2) national-level, e.g. the Nigeria highway code; or (3) regional-level or state-level laws. National and regional traffic laws and road signages are usually designed to address the local road traffic and safety issues they regulate while considering their road users' communication styles and abiding by international and national standards (FRSC, 2012). Figure 8.1 depicts a state-level road sign that uses visual and textual instructions and local terms like "danfo"—which means commercial bus—to communicate what vehicles are allowed on a Lagos bridge to diverse road users with varying communication needs.

Education, Management, and Enforcement
To promote road law compliance and enhance road safety, the government draws on various mechanisms to educate road users, manage road

Fig. 8.1 A road sign specifying the vehicles banned on Lagos Lekki-Ikoyi Link Bridge

safety, and enforce road laws. They include: regulatory road signages; traffic control; vehicle safety checklist and checks; traffic policing and monitoring; traffic violation punishments; vehicle registration—which also enforces vehicle insurance; regular vehicle roadworthiness test; drivers' licensing; drivers' education on traffic laws, norms, vehicle safety checks; and public education (DRTS, 2018; FRSC, 2007, 2022). Non-compliance with traffic laws is consequential. It can result in fines, jail time, or licence revocation for those culpable. To enhance road law compliance, data and AI-driven road technologies such as smart traffic control lights, CCTV cameras, and automatic number plate recognition are increasingly being adopted for traffic management and law enforcement (Bolanle, 2023; Burt, 2022; Nwafor, 2023).

Road Users' Situational Awareness and Communication

Road users' awareness of road traffic risks is essential for road safety as it enables them to detect impending danger and adjust their behaviours towards preventing harm. Appropriate and timely communication enhances road users' awareness of impending risks and is also important for maintaining road safety. Road traffic communications involve various channels, including road signs and markings (FRSC, 2022) as well as other aural, visual, oral, or written communication means; and road users from different countries, regions, or cultures prefer differing road traffic communication media (Nordfjærn et al., 2014). For instance, Nigerian road users are usually sensitive on roads and may alert one another of impending dangers by honking (Olasunkanmi et al., 2014) or headlight flashing.

Localised Safety Efforts by International Ride-Hailing Platforms

The introduction of ride-hailing platforms in Nigeria has provided passengers with options for commercial transit that enhance their safety and minimize their exposure to hazards like kidnapping (Olawole, 2022). These platforms increasingly roll out safety features that address safety issues encountered by their users—drivers and passengers—in Nigeria (Kansal, 2018). These include enabling passengers to:

(a) live share their location with close contacts for safety.
(b) assess the driver's skills prior to the trips based on their ratings.
(c) review drivers' performances or report drivers' misbehaviours after their rides and hold the drivers responsible for misconduct through the company.
(d) contact the companies for assistance and complaints both during and after a trip (Michael, 2023)

A Holistic View of Road Safety in Nigeria

The adoption of automobiles as a technological solution in the Nigerian road transport system introduced and amplified safety challenges that are still being managed by road transport stakeholders using various mechanisms, some of which are increasingly integrating AI-driven technologies to improve road safety. However, lessons from automobile adoption demonstrate that road safety goes beyond road collisions or accident avoidance, and it cuts across both road users' experiences and the road transport system. Road safety involves securing their lives, properties, environments, the climate, and public health from crimes and damages.

Therefore, developing AI systems that operate safely in their social environments similarly requires taking a sociocultural perspective on safety and considering social factors in AI design. In the case of Nigerian road transport, this will involve considering Nigerian road accident factors, the road environments, the road and societal cultures, and road users' behaviours and communication styles, and exploring AI design approaches and solutions that are sensitive to these. In this regard, the following section presents some sociotechnical and environmental factors for ensuring AI safety on Nigerian roads.

Considerations for AI Safety in Nigerian Road Traffic

In the last section, we presented safety considerations for Nigerian road transport systems as they currently are. In this section, we draw on that knowledge to highlight some likely safety considerations that might emerge on Nigerian roads as AV and other AI-driven transport technologies become more prevalent in Nigerian road traffic.

Nigeria's Environmental Factors

Despite NBS's (2023) report that poor weather contributes the least—approximately 0%—to Nigerian road crashes, studies have shown that Nigeria's poor weather conditions, like rain or harmattan—a dry season in West Africa—increase road accident frequency (Amidu & Oni, 2012). Coupled with evidence that poor weather negatively affects driving automation performance (Vargas et al., 2021), this suggests that environmental factors must be considered when thinking about the safe widespread adoption of AV in Nigeria. Currently, Nigerian climate or road scenarios are under-represented in AI training data, likely exacerbating AV's potential for harm when integrated into Nigerian road traffic to enhance road safety.

Situational Applications of Traffic Laws

In 2022, a driverless vehicle did not give way to a fire truck driving to an emergency in California, USA (Marshall, 2022). It is widely known that ambulances and fire engine trucks are legally allowed to disregard traffic lights and have the right of way when driving to an emergency, and the driverless vehicle's unawareness and disregard of this resulted in more damages from the fire incident. This example demonstrates the need to train AI systems to not only be aware of traffic laws, but also consider how they apply in real-world situations. For instance, in Nigeria, highly congested traffic may be controlled by both a traffic light and a human traffic warden. In such cases, commuters are expected to obey the traffic warden if the traffic warden's directive contradicts the traffic light. Considering these societal nuances in formal and tacit laws, which exemplify the complexity of real-world scenarios, is critical to ensuring that AI systems operate in a safe and socially acceptable manner.

Slow Down and Avoid Collisions—For Whose Safety?

Another challenge we anticipate in AV is their lack of "common sense"—the ability to make good judgments, especially in unsafe road situations. Road traffic environments are not always safe. As highlighted previously, there are existing issues of insecurities and other hazards on some roads, and commuters may draw on their "common sense" and use a risk-based approach to make safety judgements. In theory, driving automation trained to always obey traffic laws or slow down to avoid collisions when approaching pedestrians are prioritising pedestrians' safety. In practice, these "safe" actions may result in additional harm to motorists, given that drivers sometimes escape dangerous highway scenarios where insecurity is prevalent by speeding or not slowing down (Naku, 2022). Deploying AV on roads without realistic and systemic consideration of the safety of those within and around the vehicles in such unsafe situations may result in harmful actions by the vehicles. Therefore, it is vital that AI engineers in automotive companies approach road safety systemically and consider road safety issues from various road stakeholders' perspectives, especially from multidisciplinary and multicultural perspectives.

Locally Unintelligent AI Sensing and Behaviours

AVs are typically trained in highly mapped and structured road traffic—and even there, they have been involved in some accidents that demonstrate their insufficient intelligence for the environments in which they work (Siddiqui et al., 2022). Urban Nigerian traffic scenarios that differ from these highly controlled road settings by density and composition are scarcely represented in AI training for real-world scenarios. This is dangerous for AV adoption in Nigeria, as their intelligent and safe operation in Nigerian contexts depends on their ability to rightly sense and interpret Nigerian road objects and communication cues from other road actors. This, in turn, hinges on the degree to which the Nigerian road traffic and road users' interactions are represented and considered in their AI design and training. Training AVs in local contexts prior to widespread introduction is therefore critical for ensuring public safety, and by extension, AV reliance and trustworthiness.

Emergent Road Safety Behaviours

In 2016, TechPlus deployed a remotely controlled self-driving car in Lagos. Some road users reacted with disbelief, while others intentionally walked in front of it to test if it could detect them and react appropriately (Techplusng, 2016)—a reaction that will typically not be observed with a human-driven vehicle but emerges from road users' interactions with a perceived AV. This indicates that in addition to understanding the current systems and how people interact, AI safety considerations also need to anticipate how the introduction of AI-driven agents into road traffic might unveil new, potentially unsafe behaviours from road users, transform current road norms, and how the AI-driven agents might behave in these situations.

AI/Software Safety Checks and Maintenance

In the introduction of AI systems to replace humans in performing some driving or road management functions, we also need to consider how this might affect existing safety mechanisms like vehicle roadworthiness tests, regular safety checks, car servicing, and repairs. Replacing the human driver with AI agents pushes additional safety responsibilities on those involved in carrying out mandatory vehicle safety checks and repairs in Nigeria, because in doing so, they are effectively testing and influencing both the car hardware and its AI driver. Given that driving automation may act independently in road traffic, which will have safety consequences, it is imperative that: (a) Nigeria's vehicle safety protocol assesses vehicles' AI components and their performances in varying realistic Nigerian road traffic, (b) car manufacturers consider how vehicle safety checks need to adapt to new AI components and communicate what this needs to look like in Nigeria, and (c) regulators and car manufacturers consider how Nigerian automobile owners, users, and repairers might easily upskill and access the required resources for maintaining, fixing, or checking the safety of these AI features and their future software update releases—an emerging issue for Tesla users in Nigeria (Olubi, 2023).

Broader Societal Impacts of AI Systemic Adoption

E-waste, Pollution, Public Health, and the Climate

The significant environmental impacts and dangers of Large Language Models (LLMs) (Bender et al., 2021) demonstrates why AI safety and trustworthiness considerations in Nigeria must also consider AI systems' footprints on their environments and the continent, as well as the potential health hazards of these. African countries are already disproportionately the most vulnerable to climate change impacts, even though Africa's contribution to global carbon emission is currently relatively insignificant—about 4% (AJLabs, 2023).

A quarter of global road accidents happen in Africa despite only utilising 2% of the global vehicle fleets (UN, 2023), demonstrating the disproportionate impact of automobility on Africa. Most of the vehicles in Africa are old used vehicles, which have been flagged as dangerous and a major source of emissions and pollution (UNEP, 2020a). Considering Africa's fast-rising population, the large-scale adoption of AV and other AI systems in Nigeria and across Africa may exponentially intensify the continent's carbon footprints and vulnerability to emissions and climate change impacts if not adequately managed, amplifying the continent's existing safety challenges. This indicates that designing AI systems that are environmentally sustainable is also crucial for AV and their AI safety impacts in Nigeria and other African countries.

Therefore, we urge relevant government and non-government stakeholders and regulators to proactively address the potential manifestations of e-waste dumping in AI and data-driven systems, as well as the longer-term environmental impacts of AI products like AV, especially in Nigeria and other African countries. Also, AI and automobile engineers should prioritise designing their products to be safe and sustainable throughout their lifecycle, especially in their end-of-life years, and develop sustainable plans for their safe decommissioning at their end-of-life stage.

AI Responsibility and Accountability
Human-in-the-loop (where humans intervene in every AI decision cycle) as a recommended risk mitigation strategy for high-risk AI systems like AV (European Commission, 2021) raises concerns about the responsibility and accountability for consequential AI errors. Human-in-the-loop enables humans to draw on their domain knowledge, emotional intelligence, and situational awareness to enhance or correct AI performances. However, implementing human oversight in AV without proper governance can be unsafe for human drivers, as Nigerian traffic laws are yet to recognise AI agents as autonomous or accountable road actors and may hold the drivers responsible for the faults and inefficiencies of automation and their manufacturers. Therefore, it is important for AI stakeholders and regulators to critically explore what responsibility and accountability look like with AI as humans' collaborators or assistants in Nigeria and develop effective policies and mechanisms to manage their potential risks and impacts.

Lessons and Recommendations for AI Safety in Nigeria and Africa

Lessons from road transport have shown that safety is emergent, contextual, and collective. As observed with accidents, road safety emerges from road users' interactions, and ensuring road safety requires the cooperation of the road users as well as systemic efforts that transcend road traffic, as other road stakeholders—automobile manufacturers, lawmakers, and road safety agencies—play their part in promoting road safety through regulations, standardisation, traffic management, and designing and testing road technologies for safety.

Despite these, Nigeria records a high accident rate, indicating the ineffectiveness of these mechanisms. Most of Nigeria's formal road safety mechanisms originated from countries with varying social values and road systems than Nigeria, and likely do not represent Nigeria's indigenous values and cultures. Since laws and standards reflect societal values and desires (European Commission, 2021; Friedman & Hendry, 2019), this raises the questions: What would road safety mechanisms and their enactments look like if vehicles and their standards originated in Nigeria or other African countries? How would African values have shaped road safety design and regulations? And now, going beyond AI in road transport, how can AI regulations in Nigeria and Africa be rooted in Nigeria's and Africa's values and needs?

AI safety—a key trustworthy AI requirement—predominantly involves a risk-based approach, which inherently requires accounting for an AI system's diverse operational contexts and stakeholders in the adopted safety mechanisms. As our exploration of the Nigerian road transport system has illustrated, proper considerations of AI safety and trustworthiness require holistically considering both technical and social perspectives on safety and risk management, where the social perspective helps to consider and adequately design for the various operational contexts or environments of an AI system. Such perspectives must draw on contextual research and system-level approaches (Ibrahim et al., 2022; Pasandideh et al., 2022). In that vein, it is essential to define and foreground: (1) whose safety is being assured—the impacted stakeholders being considered, (2) the scope of analysis—e.g. individual versus collective, (3) the context or environment of use, (4) the AI system being deployed and its potential impacts, and (5) the stakeholders' values and welfare given the various AI use cases.

Recommendations for AI Safety in Nigeria and Africa

Drawing on the existing safety issues, mechanisms, and patterns observed in road transport, we make the following recommendations to support the development of safe and trustworthy AI systems for Nigeria and potentially other African countries:

Prioritise Africa's Safety in AI Systems

African countries are mostly consumers, rather than active producers, of foreign high technologies—and as the road system demonstrates, they pay a disproportionate price for this in the form of high accident rates. This indicates a need to prioritise African safety in technologies—including AI—developed globally: to design for Africa by default. As AI models are being integrated into various technologies, some destined to operate in safety-critical road contexts with potentially lethal consequences, we urge regulators, researchers, and engineers in Africa and beyond to proactively ensure the safety of these models and avoid them from causing disproportionate harm in Africa or to Africans. This work may benefit stakeholders beyond Africa: prioritising the safety of Nigerians and other Africans in AI systems developed or used there increases their robustness, sustainability, and trustworthiness.

AI Safety Can Benefit from Indigenous Values, Morals, and Approaches

Nigeria's and other African countries' current Data Protection Regulation and emission standards are based on the Europe's (Isa, 2023; UNEP, 2016), which indicates that AI regulation and trustworthiness requirements efforts from African governments might draw on the EU Act and trustworthy requirements. With AI safety, there is an opportunity for regulators to lean towards Nigerian and African indigenous safety traditions, morals, and values like communal care, interests, and duty (Ikuenobe, 2015) for establishing AI safety and trustworthiness requirements that are value-sensitive, resonate with the public, empower them, and effectively promote safety cultures in AI development and use.

Local Empowerment and Research to Guide AI Adoption and Regulations

Representing African voices and values in global trustworthy AI discourse through the development of trustworthy AI principles, requirements, and regulations that protect Africa's interests needs to be powered by research and development originating in Africa. Local research and efforts that consider African realities, challenges, values, and ethics in identifying AI safety requirements and procedures for Africa. African governments can facilitate this through empowering policies and investments that foster thriving environments for local AI research, interdisciplinary and intracontinental collaborations, education, and public debates that publicly drive critical discourses about AI ethics and AI impacts on the continent. Offering opportunities that enable AI research and developments that are sensitive to Africa's sociocultural environments and needs, fostering the development of ethical or trustworthy AI that Africans can identify with; and equipping academic researchers, policymakers, and other relevant experts with the skills and resources to critically examine the safety and trustworthiness of AI systems, promptly inform or propose AI safety standards or requirements, and protect the welfare and values of Africans.

Diversity and Localisation Are Key for Global AI Trustworthiness
The design of global AI safety and trustworthiness standards is a complicated endeavour that can benefit from localisation. As seen with the diversification and localisation of international road safety standards and mechanisms in Nigeria's road transport, developing AI safety requirements and standards that reflect the diversity of its potential contexts and cultures is an enormous task that requires inputs from global communities. AI researchers and regulators can borrow this communal approach to navigate how to design AI systems, their standards, and safety mechanisms in ways that are inclusive, empowering, and adaptable to diverse environments and communities—especially those who are most vulnerable to AI's negative impacts. This should involve inviting various (potentially) impacted communities to the conversation to understand their values, welfare, and effective approaches for protecting them, and ensuring that their contributions are well represented in global AI principles. We also urge the global AI ethics communities to continuously reflect on and critique their assumptions of what safety and trustworthiness are, their viewpoints—e.g. individual versus communal view, and their limitations, and create spaces for engaging and learning from diverse communities and their cultures.

Recommendations for AI Safety Globally
AI Safety Requires Systemic Approaches
Road safety—an emergent property of a sociotechnical system—requires systemic approaches that consider road users' overall experiences, interactions, cultures, environments, and their impacts on infrastructures, the climate and ecosystem, and public health. Similarly, designing for safety in AI systems requires considering their potential unsafe situations or interactions upon deployment, and designing to mitigate against such possibilities. That is, systemically considering AI systems' diverse environments, cultures, stakeholders and their values, and designing for them accordingly. With the awareness that the introduction of automation into an environment can manifest unanticipated actions from people and change some of the existing processes or cultures, AI systems should be proactively designed to encourage safe and desirable actions and prevent or discourage unsafe and undesirable actions from their users and those in their environments (Davis, 2020; Penzenstadler et al., 2018).

Public Awareness and Accountability
Human-in-the-loop as a critical risk management strategy for high-risk AI systems like AV comes with accountability caveats. To avoid holding the "human" in the loop responsible for AI mistakes and their consequences, we urge regulators to proactively explore AI systems' risk management, governance, and accountability in society. This may be facilitated by creating public awareness on AI systems' capabilities, limitations, and possibilities to misbehave or make mistakes, as well as creating comprehensive AI risk management frameworks that hold companies accountable for deploying unsafe AI products for public use. Developing such AI systems' risk management framework and regulations should be informed by diverse AI stakeholders such as government agencies, industries, activists, AI experts, the public, and others. Lastly, existing laws and risk management frameworks in the various contexts or sectors in which AI systems are being adopted should also be assessed and amended to sufficiently integrate AI risks.

Conclusion

Safety is contextual, subjective, cultural, and situational; it is systemic and sociotechnical. The lack of adequate representation of trustworthy AI principles and safety requirements from African nations presents a blind spot in AI developers' and regulators' abilities to ensure Africans' welfare and safety in AI systems development and use. This potentially excludes Africans from the benefits of AI while disproportionately exposing them to harm. Hence, there is a need for more African values-informed trustworthy AI guidelines and definitions that systematically consider the diverse African histories, cultures, ethics or morals, realities, as well as existing and future challenges. These should ideally be co-designed by diverse stakeholders—from the public to the government. Ensuring AI safety and trustworthiness in Africa requires a communal approach, as well as commitments from the local and global AI stakeholders to (1) Prioritise Africa's and Africans' safety in AI systems; (2) Treat safety and trustworthiness of such systems as systemic properties shaped by the current and future sociocultural environments in which they are deployed; (3) Empower African researchers and regulators—both locally and globally—to systematically create robust research and regulations that are for Africa and by Africans; (4) Respect African values, approaches, agency, experiences, and contributions to global AI discourse; and finally (5) Create avenues for public awareness, debates, and communal contributions to AI safety in Africa. AI systems cannot be truly trustworthy for global use if Africa and Africans' safety are not considered and integrated in their design and use, and considering Africans' safety requires including African perspectives, values, experiences, and environments.

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