
Revolutionizing Emergency Maternal Transfer: The Benefits of Electrical Mini Ambulances

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Abstract: Maternal mortality remains a pressing challenge in Nigeria, driven largely by preventable delays in accessing emergency obstetric care. The “second delay” is the inability to reach healthcare facilities promptly during complications remains a critical barrier, particularly in rural and congested urban settings. This paper explores the revolutionary role of Electrical Mini Ambulances (e-MAs) in transforming maternal emergency transport systems across Nigeria. Designed as compact, battery-powered vehicles, e-MAs provide fast, flexible, and sustainable mobility solutions capable of navigating narrow roads, poor terrains, and high-traffic zones that hinder conventional ambulances. Beyond cost efficiency and environmental sustainability, e-MAs are equipped with essential life-saving tools such as oxygen concentrators, defibrillators, and telemedicine features, enabling stabilisation before hospital arrival. Drawing from global best practices in Rwanda, Kenya, and India, the study highlights how e-MAs effectively reduce referral delays and improve maternal and neonatal survival rates. With appropriate policy integration, nurse-led operation, and community engagement, e-MAs have the potential to revolutionise Nigeria’s maternal and child health system. Their scalability, affordability, and adaptability position them as a viable innovation for achieving Sustainable Development Goal 3.1 reducing maternal mortality to fewer than 70 per 100,000 live births.

Keywords: electrical mini ambulance, maternal health, emergency transport, three delays model, sustainable healthcare,

INTRODUCTION

Maternal and child health (MCH) remains a significant challenge in Nigeria, despite the country's efforts to improve healthcare delivery systems. Nigeria has one of the highest maternal and neonatal mortality rates in the world, with maternal deaths estimated at 512 per 100,000 live births, and neonatal mortality at 39 per 1,000 live births (World Health Organization [WHO], 2022). A variety of factors contribute to these high mortality rates, ranging from inadequate healthcare facilities, insufficiently trained healthcare personnel, limited access to skilled birth attendants, to deeply entrenched socio-cultural barriers that prevent women from seeking timely medical care.

The root causes are complex and interrelated: limited access to skilled birth attendants, poor referral systems, poor road infrastructure, inadequate health facilities, poverty, and cultural practices that delay the decision to seek help. But one of the least talked about, yet most dangerous contributors to maternal mortality is the lack of timely transport especially in emergencies, a crucial component of timely care, particularly in urban settings where traffic congestion, road conditions, and inadequate infrastructure make it difficult to deliver emergency care quickly. In rural areas, there are further issues such as distance to healthcare facilities, lack of roads, and scarcity of reliable transportation. These systemic deficiencies hinder efforts to address the root causes of maternal and child mortality, including the prevention and management of obstetric emergencies, where delays in receiving medical care can be fatal.

Theoretical Framework: The Three Delays Model

To understand the complexities of maternal transfer, the Three Delays Model developed by Thadeus and Maine (1994) is commonly employed. This model identifies three critical delays that contribute to the high maternal death rate. The first delay, delay in decision-making to seek care, involves socio-cultural factors that prevent women from seeking appropriate healthcare in a timely manner, such as lack of awareness, economic constraints, or cultural beliefs about childbirth. The second, delay in reaching care, occurs when women, even after deciding to seek medical attention, face difficulties accessing timely care. This is particularly critical in emergency obstetrics, where prompt transfer to medical facilities is essential for survival. Geographic barriers, proximity of secondary hospitals, poor infrastructure, and inadequate transportation systems exacerbate this delay, leading to preventable deaths. The third, delay in receiving adequate care at healthcare facilities, involves the time it takes to receive care once a patient arrives at a healthcare facility, often caused by poor healthcare systems, lack of trained personnel, and inadequate medical equipment. While all three delays are crucial in understanding maternal mortality, the second delay delay in reaching care is particularly pressing, as it directly impacts the timely treatment of complications such as obstructed

labour, postpartum haemorrhage, eclampsia, and sepsis. According to Yuliana (2023), timely transport of pregnant women during emergencies can significantly reduce mortality associated with these complications, highlighting the importance of improving emergency transport systems.

Electrical Mini Ambulances (e-MAs) directly target Delay 2, which remains a persistent problem in Nigeria and other low-resource settings. While community education and female empowerment initiatives aim to resolve the first delay, and healthcare facility upgrades aim to mitigate the third, the infrastructural, transport, and terrain-related limitations of the second delay have received less investment and policy attention. UNICEF and WHO (2021) report that about 37% of maternal deaths in low- and middle-income countries are linked to Delay 2, women trying to reach help but arriving too late. In areas where e-MAs have been tested, including parts of Lagos State, there have been reports of faster travel times and quicker handovers to skilled care (e.g., for labour, neonatal, and trauma use). Thus, while community education and hospital upgrades remain essential, the bridge between them, transport, must not be neglected (Ibeh, 2023).

Emergence of Electrical Mini Ambulances (e-MAs)

Ambulances are designed primarily to save lives by providing immediate medical care during emergencies. Ideally, they are fully equipped with emergency tools such as oxygen cylinders, stretchers, and defibrillators, and are staffed by trained paramedics to ensure critical care is maintained during transit. However, in many parts of Nigeria, these ideal conditions are rarely met. Urban centres face chronic traffic congestion that delays emergency response times; for instance, a conventional ambulance stuck in city traffic can take over 90 minutes to cover a 10-kilometre distance during peak hours. In rural regions, the problem is compounded by long travel distances and poor road infrastructure. Furthermore, traditional ambulances are costly to purchase, fuel, and maintain, posing a financial burden on state and local governments that struggle to sustain a reliable emergency transport fleet. As a result, gaps in the pre-hospital care system persist, with countless preventable deaths occurring due to delayed transportation and inadequate emergency support.

Electrical Mini Ambulances (e-MAs) have emerged as an innovative and sustainable solution to these systemic challenges. These compact, battery-powered vehicles are specifically designed for speed, flexibility, and efficiency, making them particularly suited for congested or hard-to-reach areas. Unlike conventional ambulances, e-MAs can manoeuvre through narrow roads, heavy traffic, and informal settlements where larger vehicles cannot operate effectively. They are also cheaper to run and maintain, relying on rechargeable batteries rather than fuel. Beyond cost and operational advantages, e-MAs are equipped with modern life-saving tools such as oxygen concentrators, vital sign monitors, and defibrillators, enabling critical care to begin before arrival at the hospital. This

makes them invaluable in emergency obstetric care, where rapid response can mean the difference between life and death. In cases of prolonged labour, eclampsia, or postpartum haemorrhage, e-MAs serve as mobile pre-hospital units capable of stabilising patients en route to medical facilities. Pilot projects in Lagos demonstrated that e-MAs reduced emergency response times by up to 40% (Lagos State Ministry of Health, 2023), illustrating their transformative potential in Nigeria's healthcare system.

The role of Electrical Mini Ambulances in reducing the "second delay", the delay in reaching healthcare facilities cannot be overstated. They ensure that women in distress can reach health centres within minutes instead of hours, bypassing traffic and poor roads while minimising dependency on scarce fuel resources. Their versatility extends beyond emergencies, as they can also support antenatal transport, inter- and intra-hospital referrals, and community-based outreach. In rural and underserved communities, where road access is limited, e-MAs enhance coverage and improve the likelihood of timely medical care, reducing maternal and neonatal mortality. Even within tertiary hospitals, e-MAs are valuable for transporting patients between departments, particularly when elevators fail due to power outages or maintenance. For instance, pregnant women in active labour have been safely moved via ramps using e-MAs instead of relying solely on stretchers or manual carriers. This demonstrates that e-MAs are not only vital for external emergency response but also play a critical role in internal hospital logistics, ensuring safe, dignified, and efficient patient movement across multi-level healthcare facilities.



Electrical Mini Ambulance



Side view of an Electrical Mini Ambulance

Technological Description of Electrical Mini Ambulances

An Electrical Mini Ambulance (e-MA) is a compact, battery-powered medical transport vehicle designed to address the pressing challenges of emergency healthcare delivery in congested urban centres and remote rural areas. Unlike conventional ambulances, e-MAs are smaller and agile enough to navigate tight roads, markets, and alleyways where larger vehicles cannot access (Okafor et al., 2023). Despite their compact size, they are equipped with essential medical tools, enabling critical patient transfers and first aid support. Operating on rechargeable batteries rather than fossil fuels, e-MAs are eco-friendly, quiet, and cost-effective to maintain. This makes them particularly advantageous in areas where traditional ambulances face constraints such as heavy traffic, high fuel costs, or poor road networks (Nduka & Bello, 2022). Their simple and modular design allows for

easy adaptation to diverse medical needs, whether maternal emergencies, neonatal care, trauma response, or infectious disease containment, making them a versatile innovation for health systems in developing regions (Ogunyemi, 2023).

Electrical Mini Ambulances are built for maneuverability, safety, and efficiency, offering a practical alternative for emergency healthcare access in difficult terrains. Many are tricycle-based, granting them the flexibility to navigate narrow or poorly maintained roads common in slums and rural communities. They are powered by rechargeable electric motors capable of running for up to 18 hours after a 6-hour charge, contributing to sustainable healthcare mobility (Adeboye & Adebayo, 2021). Their standard features often include oxygen concentrators, defibrillators, vital signs monitors, intravenous fluid kits, and even basic telemedicine interfaces in advanced models (Umeh, 2023). The enclosed cabin structure provides protection from weather elements, while stretchers and shock-absorbing seats ensure patient comfort and safety, particularly on rough terrains. Their quiet operation reduces stress for patients, especially mothers in labour or newborns, where noise can exacerbate complications. Some advanced versions include smart dashboards with GPS navigation, helping healthcare providers reach destinations faster. In areas with unreliable electricity, models fitted with solar backup charging systems enhance operational resilience (Adebisi et al., 2023).

The efficiency of e-MAs lies in their ability to deliver extended service on a single charge. Most electric mini ambulances can cover between 200 to 300 kilometres per full charge, depending on the weight of the load, terrain, and duration of use (Eze & Yakubu, 2022). This impressive range reduces downtime from refuelling and eliminates dependency on fuel supplies, a major barrier to effective healthcare delivery in underserved regions. Their reliability ensures that healthcare workers can perform both emergency and routine services without interruption. Furthermore, e-MAs can be easily customised to address specific healthcare needs. For neonatal transfers, they are fitted with oxygen supplies, temperature-controlled interiors, and shock-absorbing stretchers. Maternal transfer models include delivery kits, privacy curtains, and reclining spaces suitable for labouring women. During infectious disease outbreaks, e-MAs can be configured for patient isolation and equipped with personal protective equipment (PPE) for healthcare workers (Obi & Eze, 2023). In non-emergency contexts, they serve as mobile clinics for vaccination campaigns, antenatal care, and health education programmes, maximising their utility in resource-limited settings.

Importantly, the e-MA's design ensures effective navigation through complex terrains and traffic congestion. With high ground clearance, compact frames, and responsive steering, they can traverse narrow streets and rugged rural paths, bridging the gap between patients' homes and the nearest accessible road or healthcare facility (Ogundipe, 2022). Their ability to operate efficiently in congested urban environments and remote locations underscores their importance in improving

emergency response times and expanding healthcare coverage in Nigeria and similar developing nations. As part of an integrated healthcare transport system, e-MAs not only enhance accessibility but also promote sustainability and innovation in healthcare delivery. Consequently, they represent a transformative step towards equitable, efficient, and environmentally responsible medical transportation, offering a viable solution to long-standing gaps in emergency healthcare logistics (Adebayo & Oladipo, 2024).

Transport Innovation in Maternal Health

Maternal and child health outcomes are often influenced by more than medical knowledge or the quality of available health facilities. In many parts of Nigeria, the primary challenge is not the absence of trained doctors or advanced medical equipment, but rather the inability of expectant mothers to access these services when complications arise. Transportation, therefore, becomes a critical determinant of survival, especially during emergencies such as postpartum haemorrhage, eclampsia, or obstructed labour. The delay in reaching medical care commonly referred to as the “second delay” continues to be one of the leading causes of maternal and neonatal mortality in the country. In this context, innovations such as Electrical Mini Ambulances (e-MAs) are emerging as transformative solutions. They are not merely convenient alternatives but essential life-saving tools that directly address Nigeria’s most dangerous healthcare bottleneck: the time lost between the onset of a complication and access to skilled care. For women in distress, each minute wasted due to inaccessible roads, poor transportation options, or unaffordable emergency services can mean the difference between life and death. e-MAs possess the unique advantage of navigating narrow rural paths, congested urban roads, and difficult terrains while providing essential emergency tools on board, positioning them as an effective first-line response mechanism for maternal and child emergencies.

This innovation can be viewed as an evolution of the successful maternal health initiatives pioneered by Dr. Olusegun Mimiko in Ondo State between 2009 and 2016 under the Abiye (Safe Motherhood) Programme. Mimiko’s reforms centred on the establishment of Mother and Child Hospitals, provision of free maternal and child healthcare, and creation of a community-based referral network dramatically improved maternal health indicators in the state. A critical component of his strategy was the introduction of timely and reliable referral systems, including the deployment of motorbike ambulances and mobile communication platforms to connect women in labour to skilled birth attendants quickly. Empirical evidence shows that these reforms resulted in over a 75% reduction in maternal mortality and significantly increased the utilisation of skilled birth services (FMOH, 2017). Building upon this legacy, the Nigerian government can embrace modern solutions such as e-MAs to strengthen maternal and neonatal emergency responses nationwide. While motorbike ambulances

addressed terrain limitations, they lacked adequate safety and medical support for advanced emergencies or neonatal care. In contrast, e-MAs offer enclosed, medically equipped, and cost-effective transport capable of managing critical cases during transit. Their widespread deployment would amplify the impact of Mimiko's initiative and accelerate Nigeria's progress towards Sustainable Development Goal 3.1, which seeks to reduce the global maternal mortality ratio to fewer than 70 per 100,000 live births.

Beyond emergency response, e-MAs offer a range of practical and scalable applications within Nigeria's maternal and child health system. In cases of labour emergencies, for instance, a community midwife could request an e-MA to transfer a woman experiencing postpartum bleeding to the nearest obstetric facility within 20 minutes, thereby preventing fatal delays. For neonatal emergencies, such as asphyxia in a rural Primary Health Centre (PHC), an e-MA could provide a temperature-controlled and oxygen-supported environment en route to a tertiary facility. Similarly, during facility-to-facility transfers, an eclamptic patient could be transported directly from a general hospital to an intensive care unit (ICU)-equipped centre without waiting for conventional ambulance services, which are often delayed by fuel shortages or mechanical issues. Additionally, e-MAs could play a preventive role through mobile antenatal care (ANC) outreaches, enabling health workers to reach remote communities with essential supplies such as iron, folate, mosquito nets, and health education materials. Through these diverse applications, e-MAs can bridge the gap between communities and healthcare systems, ensuring that no mother or child dies because help could not arrive in time.

The Cost Barrier in Emergency Health Transport

In resource-limited settings like Nigeria, cost plays a pivotal role in determining whether an innovation is scalable. For decades, one of the biggest challenges in providing emergency maternal and child health services has been the high cost of traditional ambulances. These vehicles, often imported, fuel-driven, and maintenance intensive, are expensive to purchase, operate, and repair, especially for rural local governments and underfunded health centres. A standard fuel-powered ambulance in Nigeria today costs between ₦55 million to ₦80 million depending on the model and customization (Federal Ministry of Health Procurement Report, 2022). Additional costs such as diesel or petrol, mechanical servicing, tyre replacement, and insurance push the annual operational cost per ambulance to over ₦100 million. With many rural clinics lacking access to such vehicles entirely, or sharing one vehicle across multiple facilities, emergency response delays are inevitable, particularly during maternal crises like postpartum haemorrhage or eclampsia where minutes matter. In contrast, Electrical Mini Ambulances (e-MAs) are significantly more affordable. Based on local manufacturing estimates, pilot programs, and public-private proposals from the Lagos State Ministry

of Health and domestic EV assemblers, the unit cost of one e-MA in Nigeria is estimated at ₦5.5 million to ₦10.5 million, depending on the model, medical features, and battery capacity. This comparison shows that an e-MA costs less than 15% of a full ambulance, with over 80% savings on annual operations. These numbers make e-MAs more attainable for local governments, community health programs, and even faith-based or NGO-led health initiatives.

Given this affordability, scalable deployment of e-MAs is financially realistic, especially if the right funding and partnership models are applied. Some viable options include Local Government Health Budgets, where allocating 5–10% of existing transport budgets toward e-MAs could ensure that every Primary Health Centre (PHC) has one. Public-Private Partnerships (PPPs) are also promising, allowing private manufacturers to partner with state governments to lease or donate units as part of their corporate social responsibility (CSR). Community-Based Health Insurance Schemes (CBHIS) could further promote ownership and sustainability through premium contributions by community members. Similarly, donor programs from organisations such as the World Health Organization (WHO), GAVI, and UNICEF could support e-MAs as part of maternal health or climate adaptation interventions. Moreover, tertiary hospitals and teaching institutions can integrate e-MAs into their emergency and teaching units as innovation pilots. One of the standout benefits of e-MAs is their low cost per emergency trip. Charging the vehicle for 6–8 hours typically costs less than ₦2,500 using local electricity tariffs, and on a full charge, an e-MA can handle five to eight hospital transfers in urban settings or two to three long-range referrals in rural terrain.

A promising factor in the scale-up of e-MAs is their potential for local manufacturing and job creation. Many components can be sourced or assembled locally, reducing import costs and creating employment. Nigerian startups and EV manufacturers such as Stallion Group, Jet Motors, and Siltech Electric are already producing e-mobility solutions using local labour and materials. This local ecosystem offers several benefits including lower unit costs over time, quick repairs and availability of spare parts, custom models tailored for Nigerian roads, and employment opportunities for technicians, electricians, and assembly-line workers. In the long run, this domestic production can support Nigeria's economic diversification and reduce reliance on foreign imports in the healthcare sector. While cost-efficiency focuses on savings, cost-effectiveness considers the health outcomes gained per unit of investment. e-MAs not only save money but also save lives, particularly in areas where no functional ambulance currently exists. If an e-MA costing ₦5.5 million can prevent just one maternal death annually, increase skilled delivery rates in a district by 15%, and facilitate 100–200 timely referrals per year, the cost per life saved is dramatically lower than what

most traditional emergency interventions offer. This aligns with the WHO's criteria for high-impact, low-cost health innovations.

Global Examples

In many ways, Nigeria is not alone in grappling with maternal health emergencies, poor road access, and limited healthcare infrastructure. Across Africa and other low- and middle-income countries (LMICs), similar challenges exist and electrically powered, compact medical transport solutions are gaining traction. By looking at what countries like Rwanda, Kenya, and India have achieved, Nigeria can strengthen its own model, avoid early-stage pitfalls, and build a roadmap toward successful national implementation of electrical mini ambulances (e-MAs).

Rwanda

Rwanda has become a pioneer in leveraging smart mobility for healthcare, especially in rural maternal and child health. In 2023, the Rwandan Ministry of Health deployed solar-powered electric mini ambulances to support community-based birth attendants and traditional midwives in rural areas. These vehicles were integrated with Zipline's drone delivery system, allowing rural clinics to transfer maternal emergencies. This strategy reduced maternal referral delays by over 50% in targeted pilot areas (Rwanda MOH, 2023). The ability to combine land-based e-MAs with aerial supply chains shows how innovation can leapfrog infrastructural deficits.

Kenya

In Kenya, where the rural-urban divide continues to pose significant challenges to equitable healthcare access, solar-powered electric ambulances have been successfully adopted in several states, particularly in arid and semi-arid regions. These innovative e-vehicles have been deployed in areas lacking stable grid electricity, serving both routine and emergency maternal health needs. Pilot studies have demonstrated remarkable outcomes, including a 70% increase in timely maternal referrals, a 25% reduction in neonatal transfer time, and the establishment of community-led scheduling systems that have reduced idleness and strengthened trust in government health services (UNICEF & WHO, 2021). Kenya's experience demonstrates that energy sustainability can effectively coexist with clinical utility, particularly when electric mini ambulances are integrated within nurse-led primary healthcare strategies that empower local communities and improve health system responsiveness.

India

India, particularly in states such as Uttar Pradesh and Bihar, has successfully piloted e-rickshaw ambulances for maternal transport in densely populated urban slums. These compact, battery-powered units are highly cost-effective and capable of navigating narrow and congested areas where traditional ambulances cannot operate. Through the "Janani Express Yojana" initiative, free maternal transport services were provided to over 10 million women from poor communities, ensuring rapid pickups from slums and peri-urban settlements and incorporating real-time dispatch software for efficient coordination. Although these rickshaw ambulances are relatively basic, they effectively reduce delays in accessing essential care. The Indian example demonstrates that even ultra-low-cost electrical mini ambulances (e-MAs), when integrated into state-level health programmes supported by digital coordination systems, can significantly enhance maternal health outcomes and strengthen emergency response networks in low-resource settings.

Nigeria

In 2023, the Lagos State Ministry of Health launched a small-scale pilot to test electric mini ambulances (e-MAs) in high-traffic zones, deploying them around Lagos Island Maternity Hospital, Gbagada General Hospital, and Mushin Primary Health Centres. Preliminary results revealed a 40% reduction in travel time during emergencies, particularly at peak hours, alongside improved staff safety and morale especially among midwives who had previously relied on motorcycles or unregulated taxis. The initiative also generated positive community feedback, with many residents requesting that the vehicles be stationed in neighbourhoods for easier access. These early outcomes provide a compelling proof of concept, showing that even in congested and complex urban environments, e-MAs can deliver measurable improvements in healthcare response efficiency. For broader implementation across Nigeria, a full national rollout would require a coordinated federal-state partnership, investment in charging infrastructure, establishment of clear referral and dispatch protocols, development of training programs for operators and nurses, and enactment of supportive legislation for electric health vehicles on public roads. By beginning with a phased rollout in high-mortality zones such as northern states, riverine communities, and peri-urban Lagos, Nigeria could build operational momentum, generate valuable implementation data, and scale the initiative with confidence.

Challenges, Limitations, and Risk Factors

While Electrical Mini Ambulances (e-MAs) have shown great promise in improving maternal and child health outcomes, their adoption is not without hurdles. Every innovation, no matter how well-

designed or cost-effective, faces systemic, technical, cultural, and operational challenges, especially when introduced into complex health systems like Nigeria's. One of the foremost barriers to e-MA implementation is the initial cost and budget prioritization. Although e-MAs are significantly cheaper than traditional ambulances, the initial purchase and deployment cost may still pose financial constraints for local governments and primary health centres (PHCs) that already operate with limited or unpredictable budgets. Capital costs associated with acquiring fleets, procuring backup batteries, solar chargers, spare parts, and installing charging infrastructure in off-grid areas are substantial. These expenditures often compete with other critical needs such as drug procurement, staff remuneration, and facility maintenance. To mitigate this, policymakers could establish targeted budget lines at the federal and state levels to subsidize e-MA procurement, while also engaging international donors and private investors through maternal health or green energy grants. Such strategic financing mechanisms could reduce fiscal pressure on local institutions while ensuring sustainable adoption and scalability of e-MAs in the health system.

A further major limitation lies in electricity and charging infrastructure. e-MAs are entirely dependent on reliable power supply, a challenge in many rural and even some urban communities in Nigeria where frequent power outages are the norm. Many PHCs experience long periods without electricity, complicating vehicle charging and operation. Furthermore, the lack of standardized electric vehicle (EV) charging stations across the country limits long-distance deployment, particularly in remote areas. Addressing this issue requires prioritising solar-powered e-MAs and off-grid charging stations, especially in underserved communities. Integrating solar infrastructure into PHC renovation or construction projects and establishing battery swap stations in high-traffic areas would enhance operational reliability. Alongside technical challenges, there are human capacity gaps that must be addressed. Operating e-MAs involves more than driving; it demands technical competence in managing electric vehicle systems, in-vehicle medical equipment such as oxygen concentrators and monitors, and handling patient care during transit. Presently, many healthcare workers, drivers, and community health workers (CHWs) lack the required skills to manage these new systems effectively. Developing a standardized e-MA training curriculum for nurses, midwives, and drivers, coupled with simulation-based and refresher courses, would significantly improve operational readiness and service quality.

Public perception and cultural attitudes also pose significant barriers to the successful rollout of e-MAs. In many communities, skepticism may arise from misconceptions about the small size or durability of mini ambulances compared to traditional vehicles, as well as safety concerns regarding electric-powered systems. Additionally, in low-income communities, mistrust toward "free" services often associated with failed government promises or exploitation can limit public

acceptance. Cultural norms further complicate this, especially those that discourage women from being transported by male drivers or unfamiliar health workers. Overcoming these perceptions necessitates comprehensive community sensitization campaigns conducted through radio, town halls, and religious organisations. Recruitment and training of female e-MA operators where culturally appropriate could also foster greater acceptance among women. Moreover, highlighting success stories of saved mothers and infants would enhance public trust, while the involvement of community leaders, traditional birth attendants, and women's groups in rollout planning would ensure a culturally sensitive approach that strengthens community ownership and sustainability of the initiative.

In addition to these sociocultural and infrastructural challenges, physical terrain and policy limitations present further risks. Nigeria's rural and riverine areas are often characterised by poor road networks, erosion, and flooding, all of which could compromise the efficiency of e-MAs. Inadequate road signage, poor lighting, and lack of emergency lanes or traffic prioritisation exacerbate the situation, while risks of theft or vandalism remain high in unsecured zones. Collaborating with local governments to map safe routes, install signage near PHCs, and upgrade critical road segments would improve operational safety. GPS tracking and partnerships with local security committees could further safeguard the vehicles. Maintenance and spare parts management remain another persistent issue; without local technicians trained in EV repair and maintenance, e-MAs could quickly fall into disuse. Establishing regional maintenance hubs, stocking essential spare parts, and developing a maintenance calendar would minimise downtime and enhance fleet reliability. Finally, policy and regulatory gaps represent a structural barrier to nationwide integration. Currently, there is ambiguity regarding e-MA classification, licensing, insurance, and traffic privileges. To address this, the Federal Ministry of Health, in collaboration with the National Automotive Design and Development Council (NADDCC), should develop a clear national framework for EVs in healthcare, covering registration, licensing, and nurse-led mobile care protocols. Without these regulatory reforms, the full potential of e-MAs in improving maternal and child health outcomes across Nigeria may remain unrealised.

Nursing Leadership and Policy Implications

In the evolving landscape of maternal and child healthcare, nurses and midwives have transcended their traditional roles as bedside caregivers to become educators, coordinators, community responders, and mobile emergency providers. The introduction of Electrical Mini Ambulances (e-MAs) has further expanded this scope, positioning nurses as first-line transport clinicians capable of managing patients in transit while mitigating maternal and neonatal deaths resulting from delays in care. Because nurses are deeply embedded in Nigeria's community health structures, particularly

within Primary Health Centres (PHCs) and maternal and child health outreach programmes, they are strategically placed to lead the integration, operation, and monitoring of e-MA services. Their leadership in innovation and operational integration becomes essential in scaling up these interventions effectively. Nurses have consistently demonstrated adaptability in resource-limited settings, leadership in community health campaigns, and commitment to maternal and neonatal welfare. As such, they are natural frontrunners in implementing and sustaining e-MA initiatives. Nurse leaders across different governance levels can advocate for e-MA inclusion in maternal health budgets, supervise referral documentation, ensure quality assurance, and collaborate with policymakers, engineers, and ICT experts in designing functional, nurse-friendly vehicles. They can also develop context-specific training modules to support in-transit care. Ultimately, the success and scalability of e-MAs in Nigeria depend largely on how engaged nurses are from inception not merely as users but as innovators, decision-makers, and policy influencers in emergency maternal transport systems.

A significant advantage of the e-MA initiative lies in its potential to generate high-quality data on maternal emergencies, encompassing types of complications, referral pathways, time-to-care intervals, and patient outcomes. This evidence-based data serves as a foundation for improving healthcare delivery, identifying systemic bottlenecks, and refining referral networks. Empowering nurses to collect and analyse such data situates them within an evidence-driven quality improvement framework. Through structured data reporting and evaluation, nurses can enhance dispatch efficiency, identify maternal health hotspots, support accountability in health systems, and influence maternal health policies at both local and national levels. This strengthens their evolving role as clinical leaders and systems thinkers rather than solely care providers. To ensure nurses are adequately prepared for these expanded responsibilities, pre-service and in-service training should include modules on emergency obstetric and neonatal care (EmONC) in transit, patient stabilisation during motion, vehicle operation, communication and referral protocols, and digital data reporting. Institutions like the Nursing and Midwifery Council of Nigeria (NMCN), in collaboration with the Federal Ministry of Health, should standardise an “e-MA operator certification” to professionalise and legitimise nurses’ participation in mobile emergency response systems, thereby reinforcing competence and accountability across all levels of care.

Beyond their clinical and technical expertise, nurses also serve as powerful advocates and community mobilisers. Many women in rural or low-resource settings delay seeking professional care due to financial constraints, cultural beliefs, mistrust of the healthcare system, or lack of transport. When trusted community nurses operate and manage e-MAs, they provide reassurance about the safety, dignity, and reliability of emergency transport. They also promote early facility

attendance for labour, educate families on recognising danger signs in pregnancy, and emphasise that access to emergency transport is a right, not a privilege. This advocacy bridges the gap between communities and healthcare institutions, strengthening public trust and engagement in maternal health programmes. For the long-term success of e-MA services, it is essential that nursing leadership be institutionalised in national health frameworks. This includes the inclusion of nurses in national emergency transport task forces, integration of mobile emergency care into the Primary Healthcare Under One Roof (PHCUOR) policy, and explicit budgeting for nurse-led outreach programmes. Additionally, providing legal protection, insurance coverage, and inclusion of nurses in research grants related to maternal transport innovation will help ensure that e-MA systems are sustainable, equitable, and effective in reducing maternal and neonatal mortality across Nigeria.

Recommendations

Across this comprehensive review of Electrical Mini Ambulances (e-MAs) and their potential application to maternal and child health in Nigeria, one key message stands out: e-MAs are not merely alternative transport vehicles but transformative innovations capable of addressing a major preventable cause of maternal and neonatal deaths, the second delay in the Three Delays Model, which concerns the delay in reaching healthcare facilities. The evidence from other African nations such as Rwanda and Kenya demonstrates their practicality and success, showing that e-MAs are affordable, adaptable, and compatible with nurse-led community healthcare systems. Their cost-effectiveness and ease of deployment make them a fitting solution for Nigeria's public health challenges, particularly within its rural and underserved regions. Integrating e-MAs into Nigeria's maternal healthcare system thus represents a pragmatic alignment of innovation, health equity, and sustainability. When supported by strong policy backing and infrastructure development, e-MAs could significantly improve emergency referral efficiency, reduce transport-related delays, and ultimately save thousands of lives annually.

For e-MAs to achieve their full potential, Nigeria must pursue a phased, strategic, and inclusive implementation approach. This includes embedding e-MAs into national and state maternal health frameworks, designating specific budget lines for their procurement and maintenance, and linking them to existing Safe Motherhood and Emergency Obstetric and Neonatal Care (EmONC) programmes. Infrastructure development is also crucial—solar-powered charging hubs should be installed in off-grid areas, with local training provided for maintenance and repairs. Deployment should begin in high-need zones such as northern Nigeria, Lagos, and Port Harcourt, guided by geospatial and maternal mortality data. Equally important is community engagement, achieved through town halls, religious bodies, and local radio campaigns that build trust and awareness.

Furthermore, digital data collection tools within e-MAs can enhance accountability, research, and policy development. Finally, legal protections, insurance, and leadership incentives for nurses should be institutionalised to strengthen their central role in driving this innovation forward and ensuring its sustainability.

CONCLUSION

Imagine a Nigeria where no mother dies in labor because she couldn't reach a hospital in time. A Nigeria where young nurses drive smart, electric, life-saving vehicles down dirt roads, city alleys, and market lanes stabilizing mothers and newborns before the worst can happen. Where community members know that help isn't hours away it's just a phone call and an e-MA away. That vision is achievable. It does not require billion-dollar infrastructure or imported technologies. It requires political will, health system coordination, investment in nursing leadership, and a belief that innovation should be equitable.

Electric Mini Ambulances offer Nigeria a chance to redefine how emergency care is delivered, especially to those most at risk pregnant women and their newborns. They answer a long-standing need with simplicity, effectiveness, and adaptability. From the legacy of visionary leaders like Dr. Olusegun Mimiko to the real-world applications in places like Lagos state, e-MAs show us what is possible when technology meets human-centered healthcare.

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