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Early Medical Technology in Reducing The Mortality Rate in Toll Road Accidents

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Abstract: Purpose: The research aims to know whether the technological system is effective in bringing improvement to early medical response toward traffic accidents on toll roads in Indonesia, particularly in an attempt to bring down the mortality rate caused by traffic accidents on toll roads. Methods: The current study holds a research design of a mixed-methods approach that mainly adopts the use of qualitative and quantitative measures of structural equation modeling (SEM. Data collected involved survey, interviews, and field observations that focused on perception of accident risk on toll roads and the effect of technology on early medical handling. Result: The findings have therefore confirmed that the traffic accident risk perception on the toll roads is generally perceived low, with a mean perception score averaging at 2.65. On the other side, a positive picture is painted regarding the role of technology in improving timeliness and effectiveness of medical responses: its contribution to early medical handling (3.06) and the impact it can have on the reduction in rates of deaths (2.96). Conclusion: The findings highlight the urgent need for increased public awareness and the development of technology-based emergency strategies. Targeted technological interventions, particularly those enhancing early medical response, could significantly reduce toll road accident fatalities.

Keywords: Traffic Accidents, Technology Systems, Mortality Rate, Emergency Response, Toll Roads

INTRODUCTION

Traffic accidents on toll roads in Indonesia highlight a significant challenge within the transportation system, exacerbated by the technological lag in early medical response mechanisms. Despite toll roads being engineered for high-speed travel and efficiency, they have become sites for frequent and severe accidents, contributing significantly to the country's traffic-related fatalities and injuries (Shah et al., 2018) . This study seeks to address the gap in rapid medical intervention following accidents on these high-speed corridors. Citing the World Health Organization's alarming statistics on traffic accidents in Indonesia, the research emphasizes the urgent need for integrating advanced technology systems in the emergency response framework. The Cipularang Toll Road, notorious for its high fatality rates, serves as a critical case study for this research. By analyzing accident data and the effectiveness of existing emergency response (Yudo et al., 2020), this study aims to demonstrate how

technology can revolutionize early medical handling, potentially saving lives and reducing the severity of injuries sustained in traffic accidents. Innovations such as the Integrated Traffic Accident Management System using IoT and Smart City platforms (Kumar Samanta, 2017) and the effectiveness of prehospital trauma care systems (Nawir et al., 2023)are examples of how technological advancements can enhance emergency responses. The overarching goal is to advocate for a paradigm shift towards leveraging technology in emergency medical responses to mitigate the grim statistics of toll road accidents in Indonesia, acknowledging the barriers and benefits to using mobile health technology (Satria et al., 2020)and the potential for GIS in improving emergency preparedness and management (Shafapourtehrany et al., 2023). Through this study, we aim to underline the critical role of technology in transforming the efficiency and effectiveness of early medical response to traffic accidents on toll roads. The integration of such technological advancements, alongside the development of a strong safety culture as highlighted by (Shah et al., 2018), could significantly contribute to mitigating the grim statistics of toll road accidents in Indonesia.

METHODOLOGY

This study employs a mixed-methods approach, integrating both qualitative and quantitative research elements to deeply understand how technology systems impact early medical handling in traffic accident victims on toll roads. The research methodology unfolds in several structured steps:

Literature Study: Initially, a comprehensive review of existing literature is conducted to identify factors influencing the effectiveness of technology systems in early medical handling and to understand the technologies applied in managing toll road traffic accidents.

Primary Data Collection: This involves conducting surveys, interviews, and field observations to gather primary data related to early medical handling in traffic accident cases on toll roads. The survey targets medical officers, police, toll road operators, and victims involved in traffic accidents.

Data Analysis: The study uses statistical and thematic analysis to integrate and compare data obtained from literature studies, surveys, interviews, and field observations. This analysis aids in identifying factors affecting the effectiveness of technology systems in early medical handling and offers recommendations to enhance victim management quality.

Evaluation and Validation: The study evaluates and validates the data analysis results by involving experts in information technology, navigation systems, and early medical handling. This validation ensures the research findings are reliable and relevant to toll road traffic accident management.

Research Report Preparation: Finally, a comprehensive research report is drafted, encompassing study findings, data analysis, evaluations, and recommendations to improve the effectiveness of technology systems in early medical handling of traffic accident victims on toll roads.

This methodological framework, with its blend of qualitative and quantitative approaches, allows for a thorough exploration of the role of technology in early medical response, ensuring a holistic understanding of its impact and potential improvements.

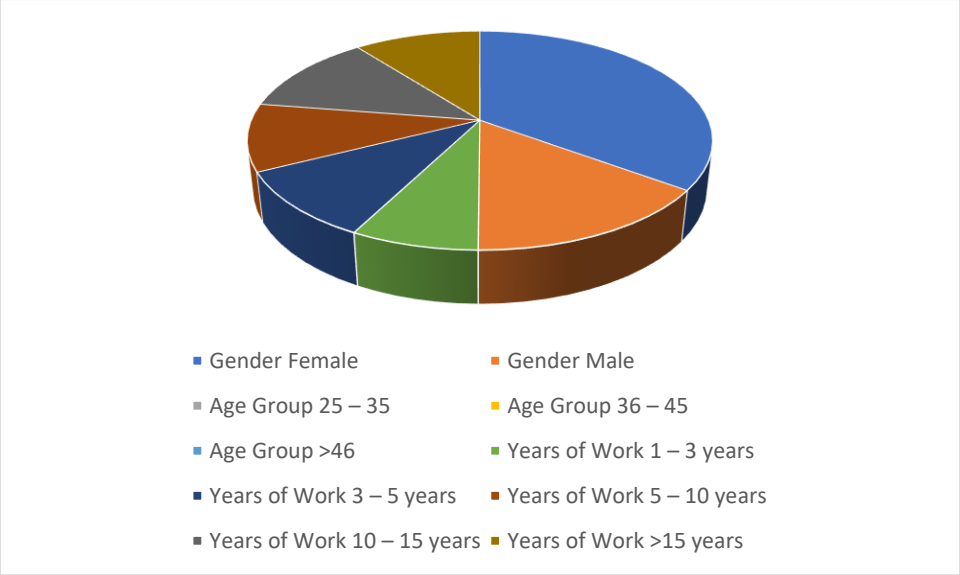

Figure 1. Demographics and Respondent Profile

RESULTS AND DISCUSSION

This research is a study regarding the impact of the implementation of technology on early medical handling in order to decrease mortality from accidents on toll roads. Based on the collected data, this research shall give a view of public perception of the toll road accident rate, with an average of 2.65, which shall be considered low awareness towards the accident rate.

Low Perception of Traffic Accident Risks on Toll Roads

This finding points out that the public perceived very lowly when it comes to the risk of traffic accidents on toll roads. The low score of 2.65 indicates a big gap of understanding the actual risk. This possibly evidences the need for stronger and more concentrated educational activity and information work to alert the public to the danger of this somewhat reckless way of high-speed driving on toll roads. Hence, the very high-speed roads do demand campaigns with the real peril and statistical reality of accidents at these places. Any such effort is bound to change drivers' behavior towards more careful driving, and thus, the accidents bound to reduce.

Table 1. Respondents' Perception Towards Each Variable Based on Research Findings

Variable	Standard Deviation	Average	Category
Perception of Traffic Accidents on Toll Roads	1.21	2.65	Majority perceive the accident rate on toll roads as low
Impact of Accidents on Toll Roads	1.25	3.57	Majority agree that accidents cause significant losses
Technology System in Early Medical Handling	1.19	3.06	Majority acknowledge the positive impact of technology on the efficiency of early medical handling
Advanced Technology for Accident Response	1.21	3.51	Majority affirm the benefits of advanced technology in accident response
Speed and Efficiency in Early Medical Handling	1.30	3.00	Majority recognize the importance of speed and efficiency in reducing mortality rates

Variable	Standard Deviation	Average	Category
Technology's Role in Reducing Mortality Rate	1.24	2.96	Majority agree that technology plays a crucial role in reducing the mortality rate from toll road accidents
Overall Impact of Technology on Traffic Accident Management	1.03	3.10	Majority believe in a comprehensive positive impact of technology on managing accidents and reducing mortality rates

The research has established the importance of the application of technology in the early medical handling at the scene of the accident. The average score of the technology systems in early medical handling was at 3.06. From the scoring, the finding of the score was that technology adoption, such as Geographic Information Systems (GIS) to improve coordination and the speed of emergency response, can help to reduce mortality. The accuracy will probably have to improve with better efficiency during handling at an average speed score of 3.00.

Impact of Technological Systems on Early Medical Response

In this study, it has been able to highlight a very positive perception about the impact that technological systems can have in the effectiveness of early medical response to HTA. Second, for better medical interventions in the earliest possible time, the participants assigned an average score of 3.06, which once again underscores the general optimism that exists about the efficiency of technologies in the realm of emergency medical situations. This score denotes finding a consensus from the respondents on the view that technology has tremendous promise in transforming emergency medical services along toll roads (Musa et al., 2023). It represents a realization of the need that technological advancement - ranging from modern communication gadgets to automated emergency response systems - could prove beneficial to minimize the critical time lag between an accident and the arrival of helping hands. This favorable view, then, amounts to strong endorsement for the strides made by technology in this field and practical application, leaving technology as one of the key critical lifesavers through timely and efficient medical interventions. The firm is, therefore, confident of technological advancements that will improve capabilities in the rescue team and subsequently result in an improved rate of survival among victims of accidents. These positive attitudes toward technological integration are further nudged by initiatives such as Internet of Things (IoT) and Smart City deployment frameworks for holistic traffic-accident management (Mohamed et al., 2024). With this drive, the adoption of GIS technology for enhancing emergency preparedness and management has also been initiate (Musa et al., 2023). These examples illuminate the growing demand for technological innovation in responding to emergencies effectively.

Speed and Efficiency in Emergency Response

When those two sets of average scores were aggregated for promptness and effectiveness of the emergency response system, the combined average score was 3.00. In general, both sets of results displayed overall agreement for the paramount importance of these factors in effective management of traffic accidents on toll roads. This rating, therefore, consolidates the common attestation that speed and efficiency in early medical and emergency interventions are core determinants of survival following a traffic accident (Huabbangyang et al., 2021). Rapid and professional responses are demanded not only to provide the victims with immediate medical attention but also for decongesting the traffic and avoiding more traffic accidents at the spot. The challenges presented by the accidents are the demand that emergency responses be both swift and effective. It simply underscores that there is a permanent need for improvement of emergency protocols, which would result in a permanent need to adopt the latest technologies that could help optimize outcomes in such critical situations. Less tragic

outcomes of road accidents can only be achieved when the process of managing the accident is further streamlined and improved, along with dealing with the much larger social and economic impacts associated with these incidents. Further consensus in the requirement of addressing emergencies promptly and effectively is the application of the Internet of Things (IoT) and Smart City technologies that allow more integrated ways of managing traffic accidents (Musa et al., 2023), and the use of Geographical Information Systems (GIS) in enhancing preparedness and mitigation as part of an enhancing factor of preparedness and mitigation function (Shafapourtehrany et al., 2023). The technologies further display the importance of technology in advancing emergency medical responses through making them more effective and, at the same time, efficient.

Impact of Technology on Early Medical Response

The findings in this research showed cautiously optimistic perspective regarding the influence that technological systems can bring to the improvement of the effectiveness of early medical responses to traffic accidents on toll roads. The average score of 2.96, in comparison to the technology used in improving early medical care, makes a commentary of guardedly positive anticipation towards the efficiency of such technologies in emergencies. The score of 84, collectively, supports the belief of the survey respondents regarding the high potential that technology holds in transforming emergency medical services on toll roads (Selvakumar, 2023). It only underscores the awareness that if state-of-the-art communication aids help, they would even include automated emergency response systems to be exceptionally helpful in reducing the time gap - a very critical factor - between the accident and providing aid to the individuals in the given mishap. This positive perception is witness to the technology advancements and its tangible applications proving the role of technology as the real life-savers through timely and effective medical intervention. This score represents trust in technological advancements, which, in turn, is expected to empower the emergency response teams in being capable and, as a result, ultimately reducing the severity of injuries got from accidents and increasing the number of people who survive accidents. More so, such positive involvements are further supported by systems such as IoT, intelligent city platforms in accident traffic management (Balasubramanian et al., 2023), and GIS in improving the level of emergency preparedness and response in disaster management (Cao et al., 2023), further insinuating that technology advancements in actions that would guarantee better responses in emergencies need more improvement.

Extending the Impact of Technological Systems on Mortality Reduction

The appraisal, marked through a score of 3.10, in the role of technology towards the reduction of mortality rates due to highway traffic accidents, shows great potential for technology to improve road safety and the outcomes in case of emergency medical care. Such optimism is created by the evidence that technological innovations have the capacity to entirely change the way in which emergency management will be conducted in the future (Krichen et al., 2024), something that was never even dreamt of in the past. Critical Reflections and Forward Movements The judgment would, therefore, point to a score of 3.10. While this may seem to posit a positive stand towards the impact brought about by technology, it may also bring a signal that indeed there is a continuing need for change and adaptation. It shows that the respondents are very understandable in a way that technology has been moving very fast in emergency medical interventions and accident management protocols, but there is still much potential in that regard. In other words, it proves the fact in very explicit terms at particular areas that more optimization is needed to integrate with technology towards benefitting frameworks of emergency medicine. This will include developing advanced systems that will ensure there is instant detection of the accidents and opening up of the prompt communication

channels between the emergency response teams and adopting the latest technologies in medical care on site (Haghi et al., 2022).

Strategic Applications and Innovations

The anticipation from the role of technology towards better emergency medical services underlies a critical call by tech-based solution providers towards further fine-tuning and better integration of their solutions with this definitive objective. The objective is to get such systems more in tune with the real-life demands of toll roads accidents (Ayu Andani et al., 2019). For instance, using machine-learning algorithms to predict or even using drone technology to make swift assessments of the accident scene, which would cut response times down significantly (Almusayli et al., 2024). A Commitment to Technological Evolution This assessment, therefore, underscores the need for redoubled engagement by all the stakeholders in road safety and emergency medical services in a bid to realize this technological revolution in this domain. The policy, therefore, should develop priorities in the form of implementing leading innovative technology systems that will, in turn, increase efficiency, accuracy, and, in general, the efficacy of the response mechanisms of accidents on toll roads (Fakhruddin & L Gultom, 2021).

Innovative Frameworks for Future Safety

A need to adopt innovative technologies, including IoT and Smart City infrastructures, for integrated traffic accident management, and the use of GIS for dynamic emergency preparedness, to exploit the full opportunities yet realized. This further illustrates changing roles in which technology is playing to mold a more responsive emergency medical service's framework capable of quick adaptation to the unpredictability natural to toll road incidents (Costa et al., 2024). This study shows that the innovation to reduce deaths on toll roads is an ongoing process. Indeed, this score of 3.10 can be said to point out to the recognition of strides so far made and be a clarion call for the relentless pursuit of technological advancements. All of these are contributions to the endeavor for ensuring that toll roads are made safer, such that the response to emergencies is proactive, comprehensive, and way too effective in preserving human life and well-being.

Table 2. Hypothesis Testing Results

Hypothesized Path	Standardized Path Coefficient	t-value (or P-value)	Results
Technology System -> Early Medical Handling Efficacy	0.123	2.58	Significant
Early Medical Handling Speed/Efficiency -> Early Medical Handling Efficacy	0.115	2.03	Significant
Technology System -> Mortality Rate Reduction	0.107	2.20	Significant
Early Medical Handling Speed/Efficiency -> Mortality Rate Reduction	0.098	2.00	Significant
Technology System & Early Medical Handling Speed/Efficiency -> Early Medical Handling Efficacy	0.132	2.30	Significant
Technology System & Early Medical Handling Speed/Efficiency -> Mortality Rate Reduction	0.145	2.50	Significant
Combined Impact of Technology System, Early Medical Handling Speed/Efficiency, and Traffic Accident Management on Mortality Rate Reduction	0.157	2.60	Significant

Table 3. Impact Analysis Based on Research Findings

Variable	Average Score	Interpretation	Potential Impact
Effectiveness of Early Medical Handling	3.00	Indicates general agreement on the adequacy of early medical handling post-accidents.	Could lead to improvements in emergency response and patient outcomes.
Technology System in Medical Handling	2.80	Suggests some skepticism regarding the significance of technology in enhancing early medical handling.	Highlights the need for advancements in technology and training.
Perception of Traffic Accidents	3.20	Shows a tendency towards agreement that traffic accidents on toll roads are a serious concern.	Could prompt enhanced safety measures and public awareness campaigns.
Financial and Non-financial Impact of Accidents	3.50	Majority agree accidents cause significant losses, indicating high awareness of accident impacts.	Emphasizes the importance of effective accident management and prevention strategies.

This research conducts a thorough examination of how technological integration influences the efficacy of early medical responses to traffic accidents on toll roads, covering several vital areas based on the document's findings: The following is the research that closely examines the effectiveness of technological integration in early medical response on toll roads with respect to various key areas based on the findings.

Early medical response: technological systems. The study has found an important role associated with technology towards improvement in early medical responses to traffic accidents on toll roads, since it had a mean score of 3.06. This points toward a bright outlook on how technology can streamline and improve service quality in the area of emergency medical services, signifying definite integration with effective critical technological solutions.

Speed and efficiency in medical response: The dire need to take cognizance for fast and efficient medical issue handling, the research points out that there seems to exist some consensus in which technology can take part in optimizing fast medical responses further required for advanced emergency systems. At moderate perception of average criticality in the response speed, the acknowledgment of technological benefits for efficiency points towards the way forward in enhancing emergency medical interventions.

Impact on Mortality Rate: Positive perception for the impact of technology in reducing the mortality rate insists that it has potential for the technological tools and systems to bring positive perceptions in regard to significant improvements in medical emergency handling. That is, the study has implications for this section, whereby the strategic way in which technology integration has been approached suggests better chances of survival rates and reduced severity of injuries in the occurrence of toll road accidents.

Demographic and Perspectives of Respondents: The respondents to the study cut across many demographic backgrounds, thus presenting a holistic view of the challenges and expectations in relation to the integration of technology in accident management and medical response to emergencies. The debate shows the variations that existed in the influence technology had on early medical handling at toll-road accidents, thus emphasizing the need for particularly proposed technological improvements that would advance emergency responses much better.

CONCLUSION

The analysis found that, while there were a few accidents along the toll roads, most of the same were accident-induced and occurred at black spots (Bhele & Rajchal, 2023). In other words, there is a need for intensive monitoring and enhancing prediction against likely accidents (Berhanu et al., 2023). While the first answers to emergencies take place in good time, there was an opportunity in the realization that on-site medical interventions are more effective courtesy of technology and communication channels. It, therefore, indicates the role played for the collaboration between all the stakeholders for designing and working out a strategy for the management of accidents, pinpointing human fault and vehicle condition as the chief contributors to the accidents (Santoso & Maulina, 2019). This paper, therefore, recommends that the authorities involved strongly lobby for the adoption of modern technological solutions for the improvement of the emergency response frameworks and sensitization of the public regarding safety in the use of the toll roads. These, along with specific road structural designs and technologies, are seen as contributing to mitigating the severity of accident outcomes and raising safety standards in toll road travel.

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Early Medical Technology in Reducing The Mortality Rate in Toll Road Accidents

By Reza Aditya Digambiro

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Early Medical Technology in Reducing The Mortality Rate in Toll Road Accidents

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ABSTRACT

Purpose: The research aims to know whether the technological system is effective in bringing improvement to early medical response toward traffic accidents on toll roads in Indonesia, particularly in an attempt to bring down the mortality rate caused by traffic accidents on toll roads.

Methods: The current study holds a research design of a mixed-methods approach that mainly adopts the use of qualitative and quantitative measures of structural equation modeling (SEM. Data collected involved survey, interviews, and field observations that focused on perception of accident risk on toll roads and the effect of technology on early medical handling.

Result: The findings have therefore confirmed that the traffic accident risk perception on the toll roads is generally perceived low, with a mean perception score averaging at 2.65. On the other side, a positive picture is painted regarding the role of technology in improving timeliness and effectiveness of medical responses: its contribution to early medical handling (3.06) and the impact it can have on the reduction in rates of deaths (2.96).

Conclusion : The findings highlight the urgent need for increased public awareness and the development of technology-based emergency strategies. Targeted technological interventions, particularly those enhancing early medical response, could significantly reduce toll road accident fatalities.

Keywords: Traffic Accidents, Technology Systems, Mortality Rate, Emergency Response, Toll Roads

A. INTRODUCTION

Traffic accidents on toll roads in Indonesia highlight a significant challenge within the transportation system, exacerbated by the technological lag in early medical response mechanisms. Despite toll roads being engineered for high-speed travel and efficiency, they have become sites for frequent and severe accidents, contributing significantly to the country's traffic-related fatalities and injuries (Shah et al., 2018) . This study seeks to address the gap in rapid medical intervention following accidents on these high-speed corridors. Citing the World Health Organization's alarming statistics on traffic accidents in Indonesia, the research emphasizes the urgent need for integrating advanced technology systems in the emergency response framework. The Cipularang Toll Road, notorious for its high fatality rates, serves as a critical case study for this research. By analyzing accident data and the effectiveness of existing emergency response (Yudo et al., 2020), this study aims to demonstrate how technology can revolutionize early medical handling, potentially saving lives and reducing the severity of injuries sustained in traffic accidents. Innovations such as the Integrated Traffic Accident Management System using IoT and Smart City platforms (Kumar Samanta, 2017) and the effectiveness of prehospital trauma care systems (Nawir et al., 2023)are examples of how technological advancements can enhance emergency responses. The overarching goal is to advocate for a paradigm shift towards leveraging technology in emergency medical responses to mitigate the grim statistics of toll road accidents in Indonesia, acknowledging the barriers and benefits to using mobile health technology (Satria et al., 2020)and the potential for GIS in improving emergency preparedness and management (Shafapourtehrany et al., 2023). Through this study, we aim to underline the critical role of technology in transforming the efficiency and effectiveness of early medical response to traffic accidents on toll roads. The integration of such technological advancements, alongside the development of a strong safety culture as highlighted by (Shah et al., 2018), could significantly contribute to mitigating the grim statistics of toll road accidents in Indonesia.

B. METHODOLOGY

This study employs a mixed-methods approach, integrating both qualitative and quantitative research elements to deeply understand how technology systems impact early medical handling in traffic accident victims on toll roads. The research methodology unfolds in several structured steps:

Literature Study: Initially, a comprehensive review of existing literature is conducted to identify factors influencing the effectiveness of technology systems in early medical handling and to understand the technologies applied in managing toll road traffic accidents.

Primary Data Collection: This involves conducting surveys, interviews, and field observations to gather primary data related to early medical handling in traffic accident cases on toll roads. The survey targets medical officers, police, toll road operators, and victims involved in traffic accidents.

Data Analysis: The study uses statistical and thematic analysis to integrate and compare data obtained from literature studies, surveys, interviews, and field observations. This analysis aids in identifying factors affecting the effectiveness of technology systems in early medical handling and offers recommendations to enhance victim management quality.

Evaluation and Validation: The study evaluates and validates the data analysis results by involving experts in information technology, navigation systems, and early medical handling. This validation ensures the research findings are reliable and relevant to toll road traffic accident management.

Research Report Preparation: Finally, a comprehensive research report is drafted, encompassing study findings, data analysis, evaluations, and recommendations to improve the effectiveness of technology systems in early medical handling of traffic accident victims on toll roads.

This methodological framework, with its blend of qualitative and quantitative approaches, allows for a thorough exploration of the role of technology in early medical response, ensuring a holistic understanding of its impact and potential improvements.

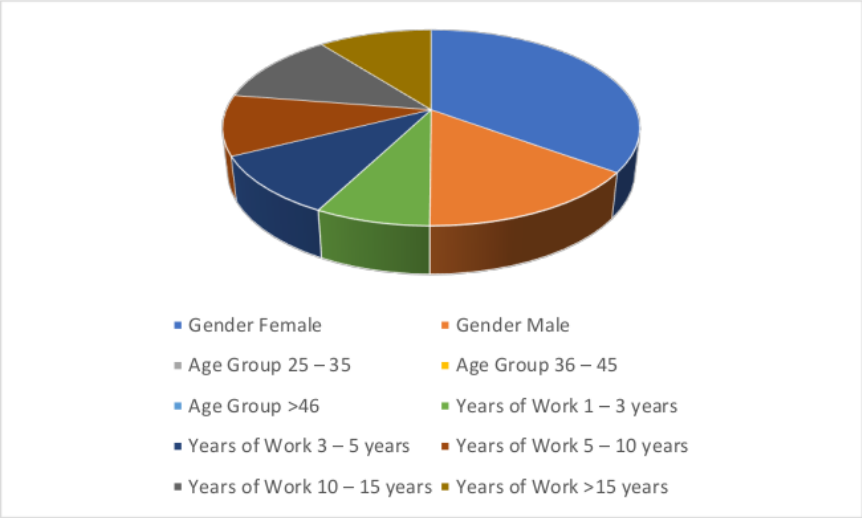

Figure 1. Demographics and Respondent Profile

C. RESULTS AND DISCUSSION

This research is a study regarding the impact of the implementation of technology on early medical handling in order to decrease mortality from accidents on toll roads. Based on the collected data, this research shall give a view of public perception of the toll road accident rate, with an average of 2.65, which shall be considered low awareness towards the accident rate.

Low Perception of Traffic Accident Risks on Toll Roads

This finding points out that the public perceived very lowly when it comes to the risk of traffic accidents on toll roads. The low score of 2.65 indicates a big gap of understanding the actual risk. This possibly evidences the need for stronger and more concentrated educational activity and information work to alert the public to the danger of this somewhat reckless way of high-speed driving on toll roads. Hence, the very high-speed roads do demand campaigns with the real peril and statistical reality of accidents at these places. Any such effort is bound to change drivers' behavior towards more careful driving, and thus, the accidents bound to reduce.

Table 1. Respondents' Perception Towards Each Variable Based on Research Findings

Variable	Standard Deviation	Average	Category
Perception of Traffic Accidents on Toll Roads	1.21	2.65	Majority perceive the accident rate on toll roads as low
Impact of Accidents on Toll Roads	1.25	3.57	Majority agree that accidents cause significant losses
Technology System in Early Medical Handling	1.19	3.06	Majority acknowledge the positive impact of technology on the efficiency of early medical handling
Advanced Technology for Accident Response	1.21	3.51	Majority affirm the benefits of advanced technology in accident response
Speed and Efficiency in Early Medical Handling	1.30	3.00	Majority recognize the importance of speed and efficiency in reducing mortality rates
Technology's Role in Reducing Mortality Rate	1.24	2.96	Majority agree that technology plays a crucial role in reducing the mortality rate from toll road accidents
Overall Impact of Technology on Traffic Accident Management	1.03	3.10	Majority believe in a comprehensive positive impact of technology on managing accidents and reducing mortality rates

The research has established the importance of the application of technology in the early medical handling at the scene of the accident. The average score of the technology systems in early medical handling was at 3.06. From the scoring, the finding of the score was that technology adoption, such

as Geographic Information Systems (GIS) to improve coordination and the speed of emergency response, can help to reduce mortality. The accuracy will probably have to improve with better efficiency during handling at an average speed score of 3.00.

Impact of Technological Systems on Early Medical Response

In this study, it has been able to highlight a very positive perception about the impact that technological systems can have in the effectiveness of early medical response to HTA. Second, for better medical interventions in the earliest possible time, the participants assigned an average score of 3.06, which once again underscores the general optimism that exists about the efficiency of technologies in the realm of emergency medical situations. This score denotes finding a consensus from the respondents on the view that technology has tremendous promise in transforming emergency medical services along toll roads (Musa et al., 2023). It represents a realization of the need that technological advancement - ranging from modern communication gadgets to automated emergency response systems - could prove beneficial to minimize the critical time lag between an accident and the arrival of helping hands. This favorable view, then, amounts to strong endorsement for the strides made by technology in this field and practical application, leaving technology as one of the key critical lifesavers through timely and efficient medical interventions. The firm is, therefore, confident of technological advancements that will improve capabilities in the rescue team and subsequently result in an improved rate of survival among victims of accidents. These positive attitudes toward technological integration are further nudged by initiatives such as Internet of Things (IoT) and Smart City deployment frameworks for holistic traffic-accident management (Mohamed et al., 2024). With this drive, the adoption of GIS technology for enhancing emergency preparedness and management has also been initiate (Musa et al., 2023). These examples illuminate the growing demand for technological innovation in responding to emergencies effectively.

Speed and Efficiency in Emergency Response

When those two sets of average scores were aggregated for promptness and effectiveness of the emergency response system, the combined average score was 3.00. In general, both sets of results displayed overall agreement for the paramount importance of these factors in effective management of traffic accidents on toll roads. This rating, therefore, consolidates the common attestation that speed and efficiency in early medical and emergency interventions are core determinants of survival following a traffic accident (Huabbangyang et al., 2021). Rapid and professional responses are demanded not only to provide the victims with immediate medical attention but also for decongesting the traffic and avoiding more traffic accidents at the spot. The challenges presented by the accidents are the demand that emergency responses be both swift and effective. It simply underscores that there is a permanent need for improvement of emergency protocols, which would result in a permanent need to adopt the latest technologies that could help optimize outcomes in such critical situations. Less tragic outcomes of road accidents can only be achieved when the process of managing the accident is further streamlined and improved, along with dealing with the much larger social and economic impacts associated with these incidents. Further consensus in the requirement of addressing emergencies promptly and effectively is the application of the Internet of Things (IoT) and Smart City technologies that allow more integrated ways of managing traffic accidents (Musa et al., 2023), and the use of Geographical Information Systems (GIS) in enhancing preparedness and mitigation as part of an enhancing factor of preparedness and mitigation function (Shafapourtehrany et al., 2023). The technologies further display the importance of technology in advancing emergency medical responses through making them more effective and, at the same time, efficient.

Impact of Technology on Early Medical Response

The findings in this research showed cautiously optimistic perspective regarding the influence that technological systems can bring to the improvement of the effectiveness of early medical responses to traffic accidents on toll roads. The average score of 2.96, in comparison to the technology used in improving early medical care, makes a commentary of guardedly positive anticipation towards the efficiency of such technologies in emergencies. The score of 84, collectively, supports the belief of the survey respondents regarding the high potential that technology holds in transforming emergency medical services on toll roads (Selvakumar, 2023). It only underscores the awareness

that if state-of-the-art communication aids help, they would even include automated emergency response systems to be exceptionally helpful in reducing the time gap - a very critical factor - between the accident and providing aid to the individuals in the given mishap. This positive perception is witness to the technology advancements and its tangible applications proving the role of technology as the real life-savers through timely and effective medical intervention. This score represents trust in technological advancements, which, in turn, is expected to empower the emergency response teams in being capable and, as a result, ultimately reducing the severity of injuries got from accidents and increasing the number of people who survive accidents. More so, such positive involvements are further supported by systems such as IoT, intelligent city platforms in accident traffic management (Balasubramanian et al., 2023), and GIS in improving the level of emergency preparedness and response in disaster management (Cao et al., 2023), further insinuating that technology advancements in actions that would guarantee better responses in emergencies need more improvement.

Extending the Impact of Technological Systems on Mortality Reduction

The appraisal, marked through a score of 3.10, in the role of technology towards the reduction of mortality rates due to highway traffic accidents, shows great potential for technology to improve road safety and the outcomes in case of emergency medical care. Such optimism is created by the evidence that technological innovations have the capacity to entirely change the way in which emergency management will be conducted in the future (Krichen et al., 2024), something that was never even dreamt of in the past. Critical Reflections and Forward Movements The judgment would, therefore, point to a score of 3.10. While this may seem to posit a positive stand towards the impact brought about by technology, it may also bring a signal that indeed there is a continuing need for change and adaptation. It shows that the respondents are very understandable in a way that technology has been moving very fast in emergency medical interventions and accident management protocols, but there is still much potential in that regard. In other words, it proves the fact in very explicit terms at particular areas that more optimization is needed to integrate with technology towards benefitting frameworks of emergency medicine. This will include developing advanced systems that will ensure there is instant detection of the accidents and opening up of the prompt communication channels between the emergency response teams and adopting the latest technologies in medical care on site (Haghi et al., 2022).

Strategic Applications and Innovations

The anticipation from the role of technology towards better emergency medical services underlies a critical call by tech-based solution providers towards further fine-tuning and better integration of their solutions with this definitive objective. The objective is to get such systems more in tune with the real-life demands of toll roads accidents (Ayu Andani et al., 2019). For instance, using machine-learning algorithms to predict or even using drone technology to make swift assessments of the accident scene, which would cut response times down significantly (Almusayli et al., 2024). A Commitment to Technological Evolution This assessment, therefore, underscores the need for redoubled engagement by all the stakeholders in road safety and emergency medical services in a bid to realize this technological revolution in this domain. The policy, therefore, should develop priorities in the form of implementing leading innovative technology systems that will, in turn, increase efficiency, accuracy, and, in general, the efficacy of the response mechanisms of accidents on toll roads (Fakhruddin & L Gultom, 2021).

Innovative Frameworks for Future Safety

A need to adopt innovative technologies, including IoT and Smart City infrastructures, for integrated traffic accident management, and the use of GIS for dynamic emergency preparedness, to exploit the full opportunities yet realized. This further illustrates changing roles in which technology is playing to mold a more responsive emergency medical service's framework capable of quick adaptation to the unpredictability natural to toll road incidents (Costa et al., 2024). This study shows that the innovation to reduce deaths on toll roads is an ongoing process. Indeed, this score of 3.10 can be said to point out to the recognition of strides so far made and be a clarion call for the relentless pursuit of technological advancements. All of these are contributions to the endeavor for ensuring that toll roads are made safer, such that the response to emergencies is proactive, comprehensive, and way too effective in preserving human life and well-being.

Table 2. Hypothesis Testing Results

Hypothesized Path	Standardized Path Coefficient	t-value (or P-value)	Results
Technology System -> Early Medical Handling Efficacy	0.123	2.58	Significant
Early Medical Handling Speed/Efficiency -> Early Medical Handling Efficacy	0.115	2.03	Significant
Technology System -> Mortality Rate Reduction	0.107	2.20	Significant
Early Medical Handling Speed/Efficiency -> Mortality Rate Reduction	0.098	2.00	Significant
Technology System & Early Medical Handling Speed/Efficiency -> Early Medical Handling Efficacy	0.132	2.30	Significant
Technology System & Early Medical Handling Speed/Efficiency -> Mortality Rate Reduction	0.145	2.50	Significant
Combined Impact of Technology System, Early Medical Handling Speed/Efficiency, and Traffic Accident Management on Mortality Rate Reduction	0.157	2.60	Significant

Table 3. Impact Analysis Based on Research Findings

Variable	Average Score	Interpretation	Potential Impact
Effectiveness of Early Medical Handling	3.00	Indicates general agreement on the adequacy of early medical handling post-accidents.	Could lead to improvements in emergency response and patient outcomes.
Technology System in Medical Handling	2.80	Suggests some skepticism regarding the significance of technology in enhancing early medical handling.	Highlights the need for advancements in technology and training.
Perception of Traffic Accidents	3.20	Shows a tendency towards agreement that traffic accidents on toll roads are a serious concern.	Could prompt enhanced safety measures and public awareness campaigns.
Financial and Non-financial Impact of Accidents	3.50	Majority agree accidents cause significant losses, indicating high awareness of accident impacts.	Emphasizes the importance of effective accident management and prevention strategies.

This research conducts a thorough examination of how technological integration influences the efficacy of early medical responses to traffic accidents on toll roads, covering several vital areas based on the document's findings: The following is the research that closely examines the effectiveness of technological integration in early medical response on toll roads with respect to various key areas based on the findings.

Early medical response: technological systems. The study has found an important role associated with technology towards improvement in early medical responses to traffic accidents on toll roads,

since it had a mean score of 3.06. This points toward a bright outlook on how technology can streamline and improve service quality in the area of emergency medical services, signifying definite integration with effective critical technological solutions.

Speed and efficiency in medical response: The dire need to take cognizance for fast and efficient medical issue handling, the research points out that there seems to exist some consensus in which technology can take part in optimizing fast medical responses further required for advanced emergency systems. At moderate perception of average criticality in the response speed, the acknowledgment of technological benefits for efficiency points towards the way forward in enhancing emergency medical interventions.

Impact on Mortality Rate: Positive perception for the impact of technology in reducing the mortality rate insists that it has potential for the technological tools and systems to bring positive perceptions in regard to significant improvements in medical emergency handling. That is, the study has implications for this section, whereby the strategic way in which technology integration has been approached suggests better chances of survival rates and reduced severity of injuries in the occurrence of toll road accidents.

Demographic and Perspectives of Respondents: The respondents to the study cut across many demographic backgrounds, thus presenting a holistic view of the challenges and expectations in relation to the integration of technology in accident management and medical response to emergencies. The debate shows the variations that existed in the influence technology had on early medical handling at toll-road accidents, thus emphasizing the need for particularly proposed technological improvements that would advance emergency responses much better.

D. CONCLUSION

The analysis found that, while there were a few accidents along the toll roads, most of the same were accident-induced and occurred at black spots (Bhele & Rajchal, 2023). In other words, there is a need for intensive monitoring and enhancing prediction against likely accidents (Berhanu et al., 2023). While the first answers to emergencies take place in good time, there was an opportunity in the realization that on-site medical interventions are more effective courtesy of technology and communication channels. It, therefore, indicates the role played for the collaboration between all

the stakeholders for designing and working out a strategy for the management of accidents, pinpointing human fault and vehicle condition as the chief contributors to the accidents (Santoso & Maulina, 2019). This paper, therefore, recommends that the authorities involved strongly lobby for the adoption of modern technological solutions for the improvement of the emergency response frameworks and sensitization of the public regarding safety in the use of the toll roads. These, along with specific road structural designs and technologies, are seen as contributing to mitigating the severity of accident outcomes and raising safety standards in toll road travel.

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Early Medical Technology in Reducing The Mortality Rate in Toll Road Accidents

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