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Road Traffic Injury on Rural Roads in Tanzania: A study to determine the causes and circumstances of motorcycle crashes on low-volume rural roads/

FINAL REPORT, v1.1

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25th September 2014

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This project was funded by the Africa Community Access Programme (AFCAP) which promotes safe and sustainable access to markets, healthcare, education, employment and social and political networks for rural communities in Africa.

Launched in June 2008 and managed by Crown Agents, the five year-long, UK government (DFID) funded project, supports research and knowledge sharing between participating countries to enhance the uptake of low cost, proven solutions for rural access that maximise the use of local resources.

The programme is currently active in Ethiopia, Kenya, Ghana, Malawi, Mozambique, Tanzania, Zambia, South Africa, Democratic Republic of Congo and South Sudan and is developing relationships with a number of other countries and regional organisations across Africa.

This material has been funded by UKaid from the Department for International Development, however the views expressed do not necessarily reflect the department's or the managing agent's official policies.

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This study was carried out by Amend, a non-governmental organisation focused on road safety in sub-Saharan Africa.

Established in 2005, our mission is '*To develop, implement, and evaluate evidence-based interventions to reduce the incidence of road traffic injury among the most vulnerable road users in Africa today while working to help create an environment for long-term, sustainable injury reduction*.'

Sub-Saharan Africa has the world's most dangerous roads. And as economies grow, road networks are being improved and expanded, and the way people travel is changing. In light of this, efforts are needed to ensure that the economic and social benefits that roads bring are not undermined by an increase in road deaths and injuries.

This study aims to increase understanding of the causes and circumstances of motorcycle crashes on low-volume rural roads in Tanzania.

We are grateful for the support of all involved in this study, in particular AFCAP, DFID, Crown Agents, the Prime Minister's Office for Regional Administration and Local Government, the National Institute for Medical Research, and the Local Government Authorities and community members of the areas where the study was carried out.

For further information about Amend visit http://www.amend.org

Cover Photo: Parallel Concrete Strips on the Bago to Talawanda road

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Abstract/

By 2030, road traffic injury (RTI) is forecast to be the fifth largest killer worldwide. Sub-Saharan Africa has the world's most dangerous roads, and rates of RTI are increasing as roads are built and vehicles are imported into the continent. Improving roads can bring economic and social benefits. But these benefits must not be offset by an increase in RTI and the associated negative economic and social consequences.

The use of motorcycles is revolutionising rural access in many countries, including Tanzania. But this revolution has a price, with RTI rates among motorcycle drivers as high as 63 per 100 drivers per year.

Through detailed crash investigations, risk assessments, interviews and inspections, this research aimed to determine the causes and circumstances of motorcycle crashes on low-volume rural roads in Tanzania, to inform the development of targeted road safety policies and interventions.

This report identifies that motorcycle crashes on rural roads can be attributed to numerous factors, including those related to human behaviour and the road design and condition. Improving road safety requires coordinated efforts between policy-makers, engineers, police, community organisations and others. The report provides practical recommendations for road safety stakeholders to improve the safety of low-volume rural roads for motorcycles and other users.

The authors would like to thank and acknowledge the efforts of the study team: Simon Kalolo, Peter Amos, Hosseah Mabalwe, Allan Jones, Dr Bertha Maegga, John Chagula, Sam Mwita, George Malekela, Scola Odeyo, Stephen Kasoyaga, Aggrey Raymond, and Dr Alejandro Guerrero.

1. Executive Summary

By 2030, road traffic injury (RTI) is forecast to be the fifth largest killer worldwide. The majority of those deaths will be in low- and middle-income countries.

Sub-Saharan Africa already has the world's most dangerous roads, with a road traffic fatality rate of 24.1 per 100,000 people, despite it being the least motorised of the world's regions. As African countries' economies grow, supported by expanded road infrastructure, and as more and more vehicles are imported into the continent, the risk of RTI increases every day.

Tanzania is typical of many African countries: its economy is booming thanks to natural resources such as oil, gas and gold; motorisation rates are rapidly increasing; motorcycles are revolutionising mobility; RTI rates are increasing year-on-year; and the government and donor partners are developing ambitious programmes to upgrade rural roads to improve access to markets, education and healthcare.

It is well established that improving rural roads can bring economic and social benefits. However, these benefits must not be offset by an increase in road deaths and injuries and the associated negative economic and social consequences. Effective, evidence-based RTI prevention interventions must be researched, designed and implemented.

The research described in this report builds on previous work by Amend, which identified that almost 90% of motorised vehicles using low-volume rural roads are motorcycles, and that injury rates among motorcycle drivers can be as high as 63 injuries per 100 drivers per year. This compares to injury rates among the general populations living alongside rural roads of around 4 per 100 people per year.

This research aimed to determine the causes and circumstances of motorcycle crashes on low-volume rural roads in Tanzania. It did so through a number of different data collection activities, including detailed investigations of recent crashes, risk assessments by a motorcycle safety expert and a road safety engineer, interviews with motorcycle drivers and passengers and community members, and observations of road user behaviour.

The research investigated the factors that contribute to motorcycle crashes, including those related to road design and condition, road user behaviour and motorcycle condition.

Key findings of the research include:

- Road user behaviour, including that of motorcycle drivers and other road users, is the most common contributory factor in motorcycle crashes on low-volume rural roads
- The design and condition of low-volume rural roads are also common contributory factors
- Motorcycle drivers understand what constitutes risky behaviour, and understand actions that they can take to reduce risks, but many continue to drive dangerously

This report includes practical recommendations for actions to improve the safety of rural roads for motorcyclists, and other road users, through efforts to change road user behaviour and through improved engineering and maintenance. It strengthens the argument for motorcycles to be considered by those responsible for planning, designing and maintaining rural roads.

This report will be of use to all those involved in the development of rural roads in Tanzania and other developing countries.

2. Introduction

2.1 Context

Worldwide, around 1.24 million people are killed each year on the roads. Between twenty and fifty million more are seriously injured. Road traffic injuries (RTIs) are the number one leading cause of death for people aged between 15 and 29. For all age groups, RTIs are forecast to jump from the ninth to the fifth leading cause of death by 2030, higher than HIV/AIDS, malaria and tuberculosis[1].

Over 90 per cent of the world's traffic fatalities occur in low- and middle-income countries. Sub-Saharan Africa has the most dangerous roads in the world. It has a road fatality rate of 24.1 per 100,000 people, while the global average is 18.0 per 100,000 people[2]. It is estimated that the situation in sub-Saharan Africa will become worse in the upcoming years. By 2050, the population of Africa will grow by more than a billion people. Africa's rate of motorisation is one of the fastest in the world, with thousands of cars added to the roads every day. Globally, the number of private motor vehicles is forecast to triple by 2050. Two-thirds of this explosive growth will take place in non-OECD countries such as those in sub-Saharan Africa[3]. With more vehicles, there will be a greater risk of injury and death, unless effective measures are taken to improve road safety.

The goal of the Africa Community Access Programme (AFCAP) is to provide reliable access for poor communities in sub-Saharan Africa. In Tanzania, AFCAP's work supports the second phase of the Local Government Transport Programme (LGTP2), which aims to upgrade 25,500 kilometres of rural roads from poor to fair condition by 2017. In turn, LGTP2 will support the Government of Tanzania's poverty reduction strategy ('MKUKUTA II'), agricultural growth strategy ('Kilimo Kwanza') and the Development Vision 2025.

It is well-established that improving rural roads can bring economic and social benefits. However, improved roads also result in increased traffic and often in higher speeds, which can create safety risks. It is important that the benefits of improved roads are not offset by an increase in road deaths and injuries and the associated negative economic and social consequences.

The recent influx of affordable Chinese motorcycles into Tanzania and other African countries is creating a revolution in rural accessibility and mobility. Journeys that were previously made by foot or bicycle, or were simply not made, are now being made by motorcycle. But this revolution has a cost – increased motorcycle-related RTI.

Between 2008 and 2012, almost 500,000 new motorcycles were registered in Tanzania, with the number of registrations per year increasing from around 45,000 in 2008 to 109,000 in 2012. This coincided with the number of officially reported motorcycle deaths increasing from 309 in 2008 to 930 in 2012[4].

Previous AFCAP-funded research by Amend has found very high rates of motorcycle-related RTI on rural roads in Tanzania. This report details research investigating the causes of motorcycle crashes on low-volume rural roads.

The Terms of Reference for this study are included at Appendix A.

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[1] World Health Organization, 2013, *Global Status Report on Road Safety: Supporting a Decade of Action*

[2] World Health Organization, 2013, *Road Safety in the WHO African Region, The Facts*

[3] International Energy Agency, 2008, *Energy Technology Perspectives*, 2008, quoted in UNEP, 2010, *Share the Road*

[4] Tanzania Traffic Police, quoted in Daily News, 30th July 2013. http://www.dailynews.co.tz/index.php/local-news/20527-bodaboda-for-formal-registration

2.2 Research Study Background

Demonstration Sites for District Road Improvement in Tanzania (AFCAP and Roughton International)

Recent AFCAP-funded research has investigated different surfacing options for low-volume rural roads in Tanzania, with the aim of creating a design philosophy for such roads using cost-effective, environmentally-optimised designs to provide all-weather access. This research was carried out by Roughton International and is referred to in this report as the Surfacing Demonstration Project.

The Surfacing Demonstration Project is closely linked to this study into the causes and circumstances of motorcycle crashes on low-volume rural roads, and so a summary of Roughton International's work is provided here. The final report of Roughton's project was published in October 2013 and is available from AFCAP, together with a number of preceding project reports.

The overall objective of the Roughton's work was to assist in building district-level capacity to undertake durable and cost-effective improvements to district roads using solutions based on locally-available resources. This overall objective was set in recognition of the fact that earth and gravel are economically and practically unsustainable nowadays, particularly in Tanzania, for reasons including:

- Increasing costs of gravel, due to increasing scarcity and long haulage distances
- Resource-intensive maintenance requirements
- Poorly-resourced local government authorities

As a result of the current challenges surrounding gravel, there is a serious lack of maintenance of Tanzanian district roads, despite the recent increase in funding from the Roads Fund Board. The consequences are that socio-economic development potential is untapped and rural poverty continues.

The Tanzania Development Vision 2025 identifies the development of rural roads as being essential to rural development. It suggests that more durable and cost-effective pavement (and surface) standards are required on vulnerable sections of district roads, for reasons including:

- Reducing the demand for gravel
- Providing a smoother running surface to reduce vehicle operating costs
- Reducing road maintenance costs
- Reducing travel times
- Reducing dust pollution

Roughton International's research investigated the applicability of using the Environmentally Optimised Design and Spot Improvement philosophies to improve maintenance of Tanzania's district roads. Environmentally Optimised Design is a system of road design that considers the variation of different road environments, assessing local environments and locally-available materials. A Spot Improvement methodology is applied to Environmentally Optimised Design to ensure that the most suitable pavement type is used on each section of road, so that resources are not wasted by 'over-engineering' easily passable sections but instead are used to ensure all-weather access on more difficult sections of road.

As the research was intended to demonstrate the applicability of new philosophies, the road designs did not meet the standards set out in guidance applied to other road upgrading projects in Tanzania, such as the Pavement and Materials Design Manual (1999), the Road Geometric Design Manual (2011) and the Guide to Traffic Signing (2009).

The research project involved the construction of a number of different surface types on two low-volume rural roads: the Bago to Talawanda road in Bagamoyo District, Pwani Region, and the Lawate to Kibong'oto road in Siha District, Kilimanjaro Region. The different surface types were:

- Double Sand Seal: a bituminous surface using natural sand
- Slurry Seal: a bituminous surface using fine aggregate and cement
- Single Otta Seal with a Sand Seal: a bituminous surface using compacted aggregate and natural sand
- Double Surface Dressing: a bituminous surface using two layers of aggregate
- Penetration Macadam: a bituminous surface using coarse aggregate
- Hand Packed Stone Blocks: a surface consisting of large stones, the spaces between which are packed with smaller chips
- Paving Bricks: a surface made of pre-cast moulded bricks placed side-by-side, the spaces between which are filled with fine material
- Concrete Geocells: a surface using a cellular mat, the interstices of which are filled with concrete
- Concrete Slabs: placed directly on the subgrade. Both unreinforced slabs and slabs reinforced with steel were used
- Parallel Concrete Strips: placed directly on the subgrade in the wheel tracks of four-wheeled vehicles, with concrete chevrons placed at regular intervals between the strips to reduce erosion. Both unreinforced strips and strips reinforced with steel were used
- Gravel Wearing Course, an unpaved surface with a layer of natural gravel
- Engineered Natural Surface, an unpaved surface where the subgrade is naturally of good quality and requires no other surfacing

See pages 29 to 33 of Roughton International's Final Report for a detailed description of each of the surface types, and pages 49 to 51 for the chainages of the different sections on the two study roads.

The minimum width of the Bago to Talawanda road was 3.0 metres and of the Lawate to Kibong'oto road was 2.5 metres.

The performance of different surface types is currently being monitored using different techniques to measure, for example, roughness, rutting, cracking and strength. Monitoring started in September 2011 along the Bago to Talawanda road and in January 2013 along the Lawate to Kibong'oto road, and will continue to beyond 2020.

A summary of the findings, conclusions and recommendations of Roughton's research, based on the monitoring of the performance of the different surface types, is:

- There is no simple answer to which surface type is best-suited for a particular road or section of road
- However, Roughton International's general observations include:
    - The Paving Bricks have performed well and are suitable for sections of roads used by medium-sized trucks
    - The bituminous surfaces (other than the Slurry Seal, which was assumed to have been made with the wrong mix of materials and so has deteriorated quickly) performed well, but are dependent on materials either being available locally or being transported from elsewhere
    - Parallel Concrete Strips are suitable in flat or rolling areas, and make efficient use of concrete, and appear to offer a good solution, but thought needs to be given to the location and design of passing bays to ensure their safe use. They are not suitable for steep or curved sections due to safety issues of two vehicles passing each other

    - Concrete Geocells could be a highly effective solution, although local contractors would need to be trained in their construction techniques and they may be difficult to import into Tanzania
    - The roughness of the concrete surfaces provides skid resistance
    - Hand Packed Stone Blocks have proved to be very rough and are not preferable for roads carrying a significant number of motorised vehicles
    - Good drainage and maintenance of drains and culverts is important
- The engineer responsible for designing or upgrading a road should select the most appropriate surface for each section of road based on a knowledge of locally available materials, problematic and non-problematic sections of the road, and costing
- Further research should be carried out into the use of local materials in road construction, and this should be supported by the long-term monitoring of the performance of the Bago to Talawanda and Lawate to Kibong'oto roads

In Tables 59 to 74 of their Final Report, Roughton International give the Whole Life Costs for each of the different surface types. From most expensive to least expensive, these are ranked as follows (based on an average of the Tanzanian Design Method and Malawian Design Method, for a flat section of road (NPV = 6%, 20-year design life)):

1. Concrete Geocells = Most expensive
2. Parallel Concrete Strips
3. Paving Bricks
4. Concrete Slabs
5. Hand-Packed Stone Blocks
6. Double Sand Seal
7. Double Surface Dressing
8. Slurry Seal
9. Penetration Macadam
10. Single Otta Seal with Sand Seal
11. Gravel Wearing Course
12. Natural Engineered Earth = Least expensive

Previous Road Safety-Related Research in Rural Areas (AFCAP and Amend)

AFCAP-funded research, carried out by Amend in 2012/13 in the areas around the Bago to Talawanda and Lawate to Kibong'oto roads, and a second road in Bagamoyo District, found high and increasing crash and RTI rates, with the vast majority of injuries being incurred by drivers of motorcycles. In some areas included in the research, motorcycle drivers were found to suffer, on average, more than one crash per driver per year.

The final report of this previous research, entitled 'Three Studies into Road Traffic Injury on Rural Roads in Tanzania' is available directly from Amend or AFCAP.

During a workshop hosted by Roughton International in May 2013, it was identified that, while Amend's research found high motorcycle RTI rates, it did not identify whether the design of the road is a key contributory factor leading to crashes, or whether crashes occur as a result of driver error, or for some other reason. Due to this lack of knowledge, it is not possible to design evidence-based RTI prevention programmes. It is not possible to know whether the focus of RTI prevention programmes should be on the safe design, construction and maintenance of rural roads, or on changing the behaviour of drivers, on something else, or on a combination of measures.

The research project which is the subject of this report aims to identify the specific causes of motorcycle crashes on low-volume rural roads, with a focus on whether road design, in particular the different surfaces trialled during the Surfacing Demonstration Project, and driver behaviour, were contributory factors.

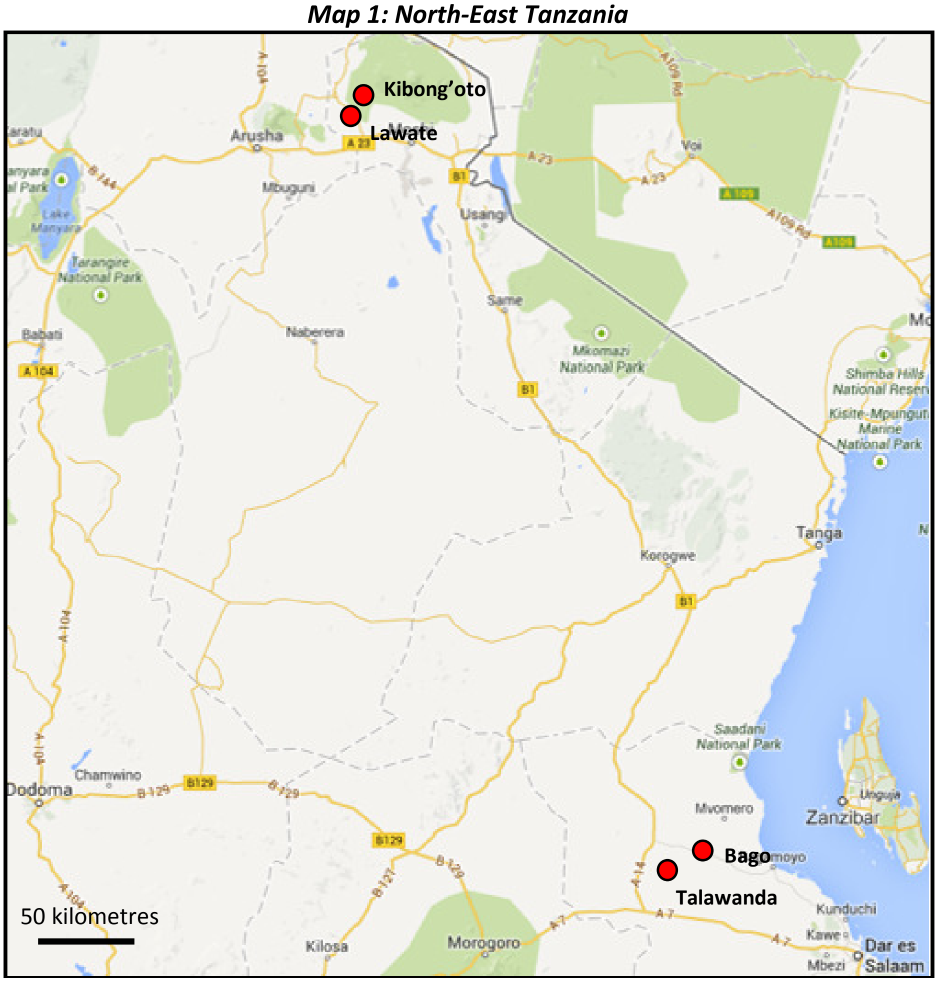
The results of this research will be of use to those responsible for the design, construction and management of rural roads in Tanzania and elsewhere in sub-Saharan Africa. It will contribute valuable information to the currently under-stocked library of knowledge on motorcycle safety in sub-Saharan Africa.

The research will support the goal and objectives of the UN-endorsed Decade of Action for Road Safety, 2011 to 2020, and Tanzania's National Road Safety Strategy.

2.3 Study Locations

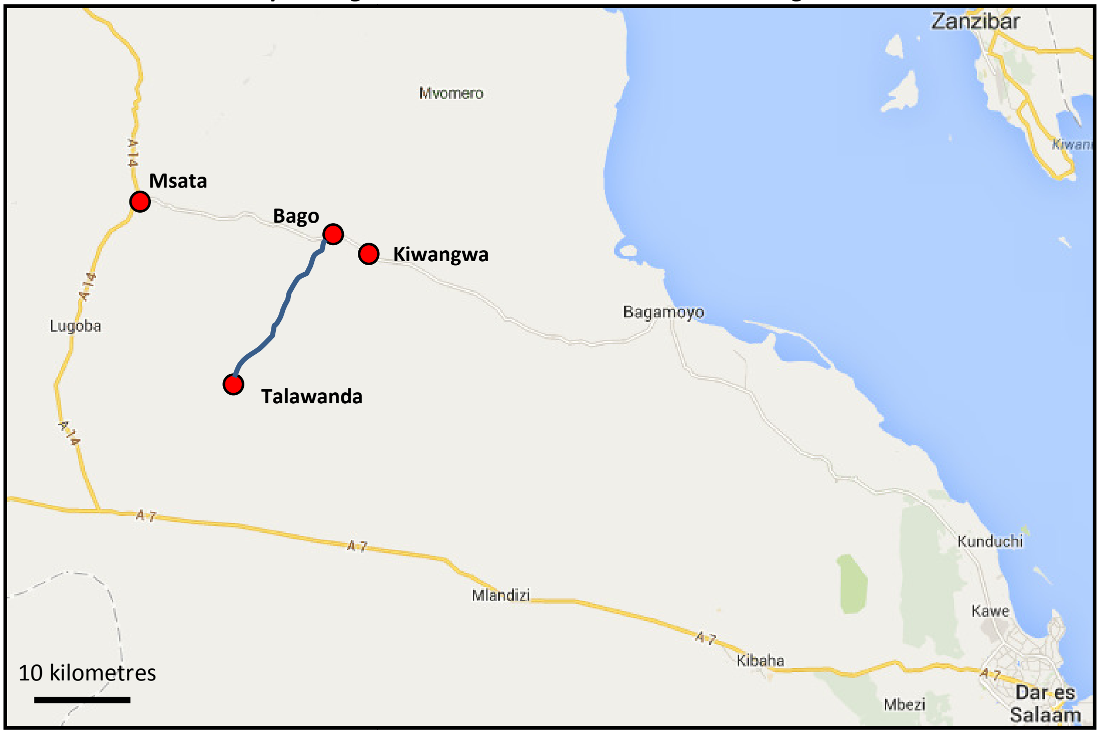
The maps below show the locations of the Bago to Talawanda and Lawate to Kibong'oto roads, and other places of interest. Throughout this report, the two roads are referred to as the 'study roads' and the areas around the roads are referred to as the 'study sites'.

Map 1: North-East Tanzania



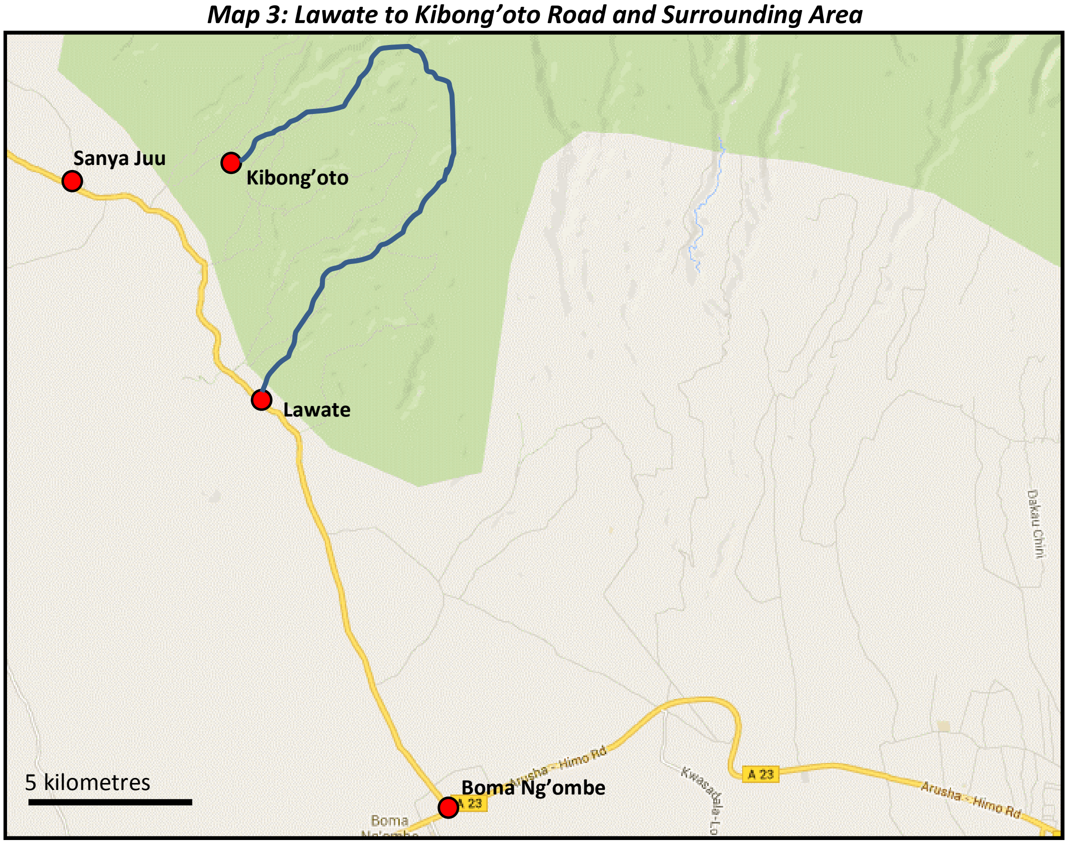
Source: Google Maps

Map 2: Bago to Talawanda Road and Surrounding Area



Source: Google Maps

Map 3: Lawate to Kibong'oto Road and Surrounding Area



Source: Google Maps

The Bago to Talawanda road is set in a dry area, with gentle rolling hills. The Lawate to Kibong'oto road is in the lush foothills of Mount Kilimanjaro, with steep hills and sharp curves. Detailed descriptions of the roads can be found in the report of Amend's previous AFCAP-funded research, entitled 'Three Studies into Road Traffic Injury on Rural Roads in Tanzania' is available directly from Amend or AFCAP.

2.4 Research Objectives

The high-level objective of this research study is:

- To determine the precise causes and circumstances of motorcycle crashes on low-volume rural roads in Tanzania

In support of this high-level objective, the research has the following low-level objectives:

- To review and summarise previous work related to the causes of motorcycle crashes on low-volume rural roads in developing countries
- To investigate the precise causes and circumstances of recent motorcycle crashes on the two roads included in the AFCAP-funded Surfacing Demonstration Project, and on other nearby low-volume rural roads
- To identify motorcycle safety risks associated with the different surfacing techniques and materials trialled in the AFCAP-funded Surfacing Demonstration Project research
- To identify motorcycle safety risks associated with driver behaviour and other factors

The results of this research will help the Tanzanian government, AFCAP and others to understand where to focus efforts on RTI prevention, be it on safe road design, or on improving driver behaviour, or on other measures. The research will assist in the decision-making process of policy-makers and advisors in the identification of the surfacing techniques and materials to be used for the upgrading of low-volume rural roads under LGTP2. It will assist in the development of the Tanzanian Design Manual for Low-Volume Roads, which is currently being developed through a separate AFCAP-funded project. It may assist in the development of a motorcycle driver training curriculum, tailored to address specific risk factors and causes of crashes.

2.5 Approach

Data Collection Periods: Dry Season and Rainy Season

In order for the findings of this study to be useful to those responsible for planning, designing, constructing and maintaining Tanzania's rural roads, and similar roads elsewhere in Africa, it was necessary for data to be collected in all weather conditions. Therefore, data was collected during two separate times of year: during the dry season in September, October and November of 2013, and during the rainy season in April and May of 2014.

It should be noted that it did not rain consistently throughout the rainy season data collection activities. Rain conditions were variable, with it sometimes raining heavily for several hours in a day, sometimes raining on and off, sometimes raining only at night, and sometimes not raining at all for a day or more at a time. As such, it should not be assumed that it was actively raining or that road surfaces were wet at the time when each individual item of rainy season data was collected.

Rainfall charts for the duration of the rainy season data collection are included in Appendix B.

Data Collection Activities

Data was collected through nine different data collection activities, which were carried out along both of the study roads and in the surrounding areas.

The data collection activities used a mix of quantitative and qualitative methods. As is the case with mixed methods research, some of our qualitative data was organised and analysed such that it could be presented quantitatively, and the interpretations of our quantitative data took into account the knowledge gained through our qualitative methods.

Modifications to the data collection activities were made between the dry season and rainy season data collection periods, to ensure that during the rainy season we gained an understanding of the specific risks faced by motorcyclists during rain and while road surfaces are wet.

The table below lists the different data collection activities, together with during which seasons they were carried out, whether they involved quantitative or qualitative methods, and the number completed.

Table 1: Summary of Data Collection Activities

Data Collection Activity	*Rainy Season, Dry Season or Both?*	*Quantitative, Qualitative or Combination?*	*Number Completed*
Motor Cycle Investigations	*Both*	*Combination*	*45*
Road Safety Engineer Assessments of Surface Types and Cross Sections	*Both*	*Qualitative*	*4*
Motorcycle Safety Expert Risk Assessments as Driver	*Both*	*Qualitative*	*12*
Motorcycle Safety Expert Risk Assessments as Passenger	*Both*	*Qualitative*	*83*
Motorcycle Safety Risk and Protective Factors Questionnaires	*Dry Season only*	*Combination*	*20*
Motorcycle Drivers' Opinions of Road Surfaces Questionnaires	*Rainy Season only*	*Qualitative*	*190*
Motorcycle Speed Surveys	*Both*	*Quantitative*	*2,615*
Motorcycle Passengers Questionnaires	*Dry Season only*	*Qualitative*	*81*
Community Surveys	*Dry Season only*	*Qualitative*	*61*

The aim of the data collection activities was to provide as full a picture of rural motorcycle crashes as was possible within the timeframes and budget of the study. The aim was not to achieve statistical significance to show that any of the findings were representative of a broader population.

A more detailed explanation of the data collection methodologies, including the modifications between dry season and rainy season, can be found within the sections specific to each data collection activity, below.

All of the worksheets used for the data collection are included in the appendices to this report.

2.6 Study Team

Team Members

The study team comprised five members of Amend's permanent staff, three expert advisors, and six Project assistants.

The members of Amend's full-time staff were:

- Dr Alejandro Guerrero, as Principal Investigator
- Tom Bishop, as Team Leader
- Deepani Jinadasa, as Research Associate
- Simon Kalolo and Peter Amos Mwelelo, as Data Collection Team Leaders

The three expert advisors were:

- Allan Jones, as Road Safety Engineer
- Hosseah Mabalwe, as Motorcycle Safety Expert
- Dr Bertha Maegga, as Local Principal Investigator

Curricula Vitae for the three expert advisors are included in appendices to this report.

The Project Assistants were John Chagula, Sam Mwita, George Malekela, Scola Odeyo, Stephen Kasoyaga and Aggrey Raymond. All Project Assistants were young professionals or recent graduates in medical, research or other fields relevant to the study, and had previous experience of working with Amend on road safety studies or projects.

Transfer of Knowledge and Training

The Data Collection Team Leaders and the Project Assistants, all of whom are Tanzanian citizens, were fully involved in the design and piloting of the data collection activities, and received in-depth training prior to beginning data collection. This training covered topics including interview techniques, motorcycle inspections, use of speed measuring equipment, personal safety during data collection, and data entry and analysis using tools such as SPSS and Microsoft Excel.

Simon Kalolo also received training on presentation techniques, as he attended numerous workshops and conferences to present on the progress and findings of the study.

2.7 Purpose of this Report and Report Structure

This report provides a full write-up of the research study.

Following this introductory section is a summary of the tasks undertaken during the project. There is then a review of relevant past work related to this study.

The bulk of this report is made up of descriptions of the findings of each of the data collection activities. Through the study, a huge amount of data was collected. All data were analysed, and the most interesting and useful findings are detailed in this report.

Following the findings is a section on discussion and recommendations.

Following that is a description of how the results of this study have been, and will continue to be, disseminated to stakeholders.

Supporting documents are provided in a separate stand-alone document of appendices.

3. Tasks Undertaken

3.1 June 2013 to January 2014

The following is an outline of the tasks undertaken between June 2013 and January 2014, which included the dry season data collection period.

- 25th June: Receipt of extension of ethical clearance to carry out the study from the National Institute for Medical Research of Tanzania's Ministry of Health and Social Welfare
- 18thJuly: Submission of final, revised technical and financial proposals to AFCAP
- 22nd July: Study contract signed by AFCAP and Amend
- Week of 29thJuly: Introduction of study to key stakeholders
- Weeks of 29th July and 5th August: Initial visits to study sites with the Motorcycle Safety Expert and Road Safety Engineer
- Weeks of 5th, 12th, and 19thAugust: Review of relevant past work and development of study protocol and data collection worksheets and methodology
- Week of 19th August: Introduction of study to wider stakeholders
- Week of 2nd September: Initial piloting of data collection worksheets and methodology with Study Associate and one Project Assistant
- 6th September: Submission of Inception Report to AFCAP describing the findings of the review of relevant past work and detailing the study protocol
- Week of 9th September: Recruitment and training of two extra Project Assistants, and final piloting of data collection
- Weeks of 16th and 30th September: Set-up of communication network in the area around the Bago to Talawanda road, and first round of dry season data collection
- Week of 7th October: Set-up of communication network in the area around the Lawate to Kibong'oto road, and first round of dry season data collection
- Weeks of 14th and 21st October: Development of databases and data entry from first round of data collection at both sites
- 18th October: Submission of Progress Report to AFCAP describing progress between late June and mid-October
- Weeks of 28th October and 4th November: Second round of dry season data collection in the area around the Bago to Talawanda road

- Week of 11th November: Data entry from the second round of dry season data collection in the area around the Bago to Talawanda road

- Weeks of 18th and 25th November: Second round of dry season data collection in the area around the Lawate to Kibong'oto road

- Weeks of 2nd and 9th December: Data entry from the second round of dry season data collection in the area around the Lawate to Kibong'oto road

- Weeks of 16th December 2013 to 13th January 2014: Data analysis and writing of draft report

- Week of 13th January 2014: Submission of 6-monthly progress report to National Institute for Medical Research

- 17th January: Submission of draft report to AFCAP

- Week of 27th January: AFCAP suggest that the study could be extended to include the 2014 rainy season in order to collect data on crashes related to rain and wet road conditions. AFCAP and Amend agree that the results of the dry season data collection will not be circulated until data has also been collected and analysed for the rainy season

3.2 February to September 2014

The following is an outline of the tasks undertaken between February and September 2014, which included the rainy season data collection period.

- 6th February: Submission of a proposal to AFCAP for an extension of the study to cover the April-May 2014 rainy season

- 25th February: Contract covering the study extension signed between AFCAP and Amend

- Weeks of 24th February and 3rd March: Revision of data collection methodology and worksheets to ensure relevance to rain and wet conditions

- Week of 3rd March: Introduction of extended study to stakeholders

- Weeks of 10th, 17th and 24th March: Recruitment of extended study team

- Weeks of 31st March, 7th and 14th April: Re-training of study team and piloting of revised methodology. Development and implementation of system to monitor rainfall at study sites

- Weeks of 21st and 28th April and 5th May: Rainy season data collection at both study sites

- Weeks of 12th and 19th May: Data entry and analysis from rainy season data collection

- Weeks of 26th May and 2nd June: Writing of final report

- 6th June: Submission of first draft of final report to AFCAP for comments before distribution

- July and August: Report reviewed by AFCAP and other stakeholders, and comments provided to Amend
- September: Report revised for final submission

4. Review of Relevant Past Work

To inform the design of this study, relevant past work in the field of identifying the causes and circumstances of motorcycle crashes was reviewed. It was found that few detailed studies into the causes of crashes have been carried out in developing countries, but that more informative studies have been carried out in high-income countries.

Below is a summary of the past work which was reviewed and considered in designing this study.

4.1 On-scene, In-depth Motorcycle Crash Investigations

References:

Hurt, H.H.J., Ouellet, J.V., and Thom, D.R. (1981).*Motorcycle accident cause factors and identification of countermeasures, volume 1.*(NHTSA Report). U.S. Department of Transportation: Washington DC.

Motorcycle Accidents In-Depth Study (MAIDS), (2004). *In-depth investigation of accidents involving powered two wheelers.* The Association of European Motorcycle Manufacturers (ACEM).

The first comprehensive study on motorcycle crashes and their causes was published in 1981 by a team of researchers in California, USA, led by Henry Hurt. To reconstruct the exact crash circumstances and conditions, specialised research teams conducted on-scene investigations within 24 hours of a motorcycle crash using forensics, driver and witness interviews, and examining injuries and evidence. The so-called "Hurt Report" analysed data from 900 on-scene in-depth motorcycle crash investigations, 2,300 interviews with motorcyclists, and 3,600 police reports.

The data provided clarity on the types of crashes that occurred most frequently and their contributing factors, as well as the kinds of injuries that were most likely to occur. For instance, findings emphasized that an important reason for the occurrence of motorcycle crashes was that motorcycle drivers were not easily detected by drivers of other vehicles who therefore unknowingly violated their right of way. In addition, the research team uncovered that many motorcycle drivers were poorly trained and were unable to execute proper collision avoidance techniques. Furthermore, the report definitively showed that a motorcycle helmet did not limit drivers' senses, as had previously been thought, but in fact was the single most critical factor in the prevention and reduction of injuries. These findings from the Hurt report provided the evidence base for many motorcycle-related safety measures implemented in the United States.

A similar comprehensive, in-depth study into motorcycle crashes was published in 2004 in the form of the MAIDS report. This time conducted in multiple countries in Europe, researchers studied over 900 crash cases, building on the work of Hurt. Analysis of an extensive set of variables from the research identified information on human, environmental, and vehicle contributing factors to motorcycle crashes. A striking finding was that 40% of crashes were due to motorcycle driver error.

Our Crash Investigation Worksheet, which aimed to determine the contributory factors associated with motorcycle crashes on rural roads, was based on questions used by the Hurt and MAIDS researchers. The Amend study team reconstructed pre-crash and crash circumstances and conditions through a detailed interview with the driver of a crashed motorcycle and through observing the conditions at the crash location.

Unlike the Hurt and MAIDS methodologies however, our study team did not perform forensic analysis at the crash site, did not evaluate injuries and did not interview witnesses. To have included such activities would have significantly increased the budget requirement for this study, and would not have been feasible in all cases, for example because of a lack of witnesses. Rather than these activities, the Crash Investigations were supported by the study's risk assessments, surveys and questionnaires, to build up a full picture of the causes of motorcycle crashes on rural roads in Tanzania.

With a greater budget, activities such as forensic crash analysis and injury evaluation should be considered for inclusion in future studies.

4.2 Research on Risk and Protective Factors for Motorcycle Crashes

References:

Haworth, N. et al. (1997).*Case-control study of motorcycle crashes.* Federal Office of Road Safety: Canberra, Australia.

Motorcycle Accidents In-Depth Study (MAIDS) (2004).*In-depth investigation of accidents involving powered two wheelers.* The Association of European Motorcycle Manufacturers (ACEM).

Clarke, D. et al. (2004). *In-depth study of motorcycle accidents.* Department for Transport: London, UK.

Determining the modifiable factors that put drivers at risk of crashes is central to road safety public health research and programming. Therefore research into risk factors and protective factors is essential for motorcycle RTI research.

One methodology that researchers use to identify risk and protective factors in crashes is the case-control study. "Cases", motorcyclists who have crashed, are matched with "controls", motorcyclists who have not crashed. Case and control drivers are interviewed, and the data is analysed to determine which variables are different between them. The variables which are higher among the cases are considered risk factors for crashes, and those variables that are higher among the controls are considered protective factors.

Australian researchers – Haworth et al – conducted a motorcycle driver case-control study, interviewing cases of motorcyclists who had crashed, and matched controls – motorcyclists who rode by the crash location on the same day of the week and time of day unharmed. A questionnaire was administered to understand practices regarding driver behaviour, as well as factors regarding motorcycle condition and the road environment and characteristics. Among other things, the researchers found that unlicensed, inexperienced young people and those who had been drinking alcohol were most at risk of crashing.

As part of their in-depth study into motorcycle crashes, the MAIDS researchers also had a case-control component to their study. They interviewed over 900 cases and another 900 matched controls. This study design helped to identify the significant risk factors for motorcycle crashes in their research.

In addition to behaviours, attitudes and knowledge can also be risk factors for crashes. Researchers in the UK – Clarke et al – conducted an in-depth study into motorcycle crashes, asking questions about motorcyclists' behaviours, attitudes, and knowledge that might have been crash causation factors. Interesting components of their results were the motorcyclists' perceptions of risk when driving on the roads, and the blame they attributed for crashes. Motorcyclists tended to accept risk and blame, but also placed blame on other drivers who violated their right of way.

We incorporated questions from these studies into our Risk and Protective Factors Worksheet. While this component of the Amend data collection was not designed as a case-control study, it was influenced by this type of prior research. We interviewed both motorcyclists who had crashed and those who had not crashed with questions about behaviour, attitudes and knowledge with the aim of uncovering the most significant risk factors for crashes on rural roads.

4.3 Traffic Police Crash Investigations

References:

Road accident report form. Traffic Police of Tanzania, Tanzania.

Traffic accident statistical report form.(2008). Uganda Police, Uganda.

Traffic police accident and casualty form. Cambodia Traffic Police, Cambodia.

STATS19 Road accident injury statistics report form (2011). Department for Transport: United Kingdom.

Traffic police routinely collect information on road traffic crashes and injuries by visiting the scene and recording crash and casualty information on standardized reporting forms. Information is collected by speaking to anyone involved in the crash, as well as from eye witnesses and observations. As police are often unable to spend many hours investigating just one crash, these forms give insight into what the police consider to be the most noteworthy details of a crash and its most important contributory factors. These data often form the basis of national statistics on RTIs.

We incorporated questions from crash investigation forms used by traffic police in Tanzania, Uganda, Cambodia, and the UK into our own on-scene crash investigation forms. The reporting forms from Tanzania and Uganda helped us to ensure that our questions and response choices were relevant to conducting research in a rural Tanzanian context, for example by allowing for more than one motorcycle passenger. In addition, looking at the reporting forms used by the traffic police helped us to streamline our questionnaires to collect the most relevant information.

4.4 African Studies on Motorcycle Crash and Injury Risk Factors

References:

Ogunmodede, T.A. et al. (2012).*Factors influencing high rate of commercial motorcycle accidents in Nigeria.* American International Journal of Contemporary Research, 2(11):130-140.

Naddumba, E.K. (2004). *A cross-sectional retrospective study of* boda-boda *injuries at Mulango Hospital in Kampala, Uganda.* East and Central African Journal of Surgery, 9:44-47.

Chalya, P.L. et al. (2010).*Motorcycle injuries as an emerging public health problem in Mwanza City, north-western Tanzania.* Tanzanian Journal of Health Research, 12(4):214-221.

Wole, M. (2012). *An analysis of motorcycle traffic and crashes in Nigeria – a case study of Minna, Nigeria*. Nigerian Journal of Technological Research, 7(2).

Solagberu, B.A. et al. (2006). *Motorcycle injuries in a developing country and the vulnerability of riders, passengers, and pedestrians.* (Nigeria). Injury Prevention, 12:266-268. doi: 10.1136/ip.2005.011221.

The motorcycle research conducted in African settings is largely made up of short-term studies with the aim of characterizing motorcycle crashes, their related injuries, and determining risk factors for crashes and injuries. The studies employ a variety of methodologies, including:

- Interviews with commercial motorcycle drivers
- Interviews with road traffic injury patients at hospitals
- Studying injury patient records at hospitals

- Studying accident records from hospitals and government
- Traffic surveys

The risk factors for motorcycle crash injuries identified through these studies include being male, being young, alcohol influence, speeding, incorrect overtaking, road disrepair, lack of training, and lack of protective gear. While these studies have been able to identify general categories of risk factors, more detailed information on crash contributing factors has not been identified. The cross-sectional nature of the studies means that only the prevalence of factors among the study population can be determined. More in-depth studies are needed to be able to determine the relative risks of these factors between people who have experienced a motorcycle crash and those who have not.

The knowledge gained from these Africa-based studies helped to shape our own data collection methodology. Referencing these studies, we designed the questions in our research to be relevant to a rural African setting.

4.5 Action Plans for Governments

References:

Cambodia Transport Mainstreaming Partnership. (2006). *Final Report, Seacap 2.* SEACAP Programme: Phnom Penh, Cambodia.

Through the South East Asia Community Access Programme, a programme to improve rural communities' access to social services and economic opportunities, the problem of road traffic injuries was highlighted to the Cambodian government and other stakeholders. In particular, research showed that motorcycle-related crashes accounted for a majority of casualties on the roads. A detailed national priority action plan was developed with the objective of reducing RTIs and improving road safety. Several of the recommended actions are relevant to motorcycle-related research and prevention, including:

- Strengthening road accident data systems
- Conducting road safety audits
- Considering road environments in road design
- Tightening technical inspections
- Improving driver training and testing requirements
- Preparing public road safety campaigns

These actions taken at the national level are encouraging to our research, since our study addressed these issues in the local study area. For example, part of the research for our study was to conduct a motorcycle safety audit in which an expert motorcyclist rode on the study roads as both a driver and a passenger and commented on the driveability of the road, as well as the road environment and road user behaviours in terms of contributing to or detracting from road safety.

We designed our study drawing on this past body of work, with the aim of decreasing the knowledge gap on the causes of motorcycle crashes on rural roads in developing countries.

5. Investigations of Recent Motorcycle Crashes

Since the Hurt Report was published in 1981, and subsequently the MAIDS Report in 2004, on-scene, in-depth crash investigations have been recognised as a key tool in gathering data on road traffic crashes.

5.1 Purpose

The purpose of this study's in-depth crash investigations was to collect detailed information on recent motorcycle crashes on low-volume rural roads, to provide an understanding of the factors that contribute to crashes.

5.2 Methodology

Investigations were carried out during both the dry season and the rainy season data collection exercises.

Communication Network

Prior to the start of data collection, the study team met with local people at the study sites to explain the purpose of the study, and to establish a communication network. People included in this network were:

- Local leaders
- Local police
- Nurses in local clinics
- Local motorcycle drivers
- Local business owners
- Other members of the local communities

The purpose of this communication network was to ensure that we were informed of as many motorcycle crashes as possible which occurred locally within the study timeframes. Throughout the course of the study, this network was maintained and updated. Project Assistants distributed business cards with their telephone numbers, made daily telephone calls to follow-up with people who had heard of recent motorcycle crashes, and were always at the ready to find, meet, and interview a motorcycle driver who had crashed.

Initial Motorcycle Driver Contact

Upon initial contact with drivers who claimed to have been involved in a crash, the study team asked questions to ensure that the crash met the eligibility criteria (below) and to verify the truthfulness of the claim including:

- Basic details, for example when and where the crash had occurred
- If treatment was sought by anyone injured in the crash. If so, where?
- If the driver had any visible evidence of the crash that could be observed, such as physical wounds to himself or damage to the motorcycle

If, through the responses to these questions, the study team judged that the driver's claim of having been involved in a crash was true, and the crash had occurred within the previous four weeks, the driver was requested to accompany the study team to the scene of the crash to assist with the full Crash Investigation.

Eligibility Criteria

In order to be included in this study, crashes had to meet all of the following criteria:

- At least one motorcycle was involved in the crash
- At least one moving vehicle was involved in the crash
- An injury was suffered as a result of the crash, either by the motorcycle driver answering the survey questions, or by a third party, including passengers and other road users. (Severity of the injury was not an inclusion factor – minor injuries, such as scrapes and sprains, were included.)
- The driver of a motorcycle involved in the crash was able and willing to assist with the investigation at the scene of the crash
- The crash occurred no more than four weeks before the date of the investigation (as the accuracy of the driver's memory of the details of the crash was assumed to be unreliable after more than four weeks)
- The crash occurred on a low-volume rural road: either on one of the study roads itself, or within a 30-minute motorcycle ride (as estimated by the driver and verified by the study team's journey to the location) from the start (chainage 0.0) of the study road

It is important to note that it did not have to be raining and the road surfaces did not have to be wet for crashes to be eligible for investigation during the rainy season data collection exercises. All crashes identified during the rainy season data collection period, which met the criteria listed above, were investigated. It should not be assumed, however, that the number of crashes that we investigated represents the exhaustive number of motorcycle crashes that occurred in the study area during the study timeframe – there may have been crashes which occurred but which we did not hear about through our communications network.

Conducting Investigations

Investigations took place as soon as possible after the crash occurring.

Two members of the study team visited the scene of the crash with the motorcycle driver. One conducted an interview with the driver, asking questions about motorcycling habits, detailed crash circumstances, and injuries. The other member of the study team collected information on environmental and road factors, including taking photographs.

While the techniques used for carrying out the investigation – an interview with the driver and assessment of the local environment – are similar to those used by the Traffic Police to assess crashes, the level of detail collected through this study was far greater than that available in police reports, therefore allowing us to obtain a far more detailed picture of the causes and circumstances of crashes.

For the rainy season data collection, minor changes were made to the worksheet used during the dry season, to ensure that it captured information specific to how rain and wet conditions contributed to crashes. The crash investigation worksheet can be found at Appendix C, with the edits included for the rainy season data collection shown in red, bold and italicised text.

As an incentive for participation, drivers received a pair of clear plastic safety glasses for eye protection while motorcycling, as well as being paid for the motorcycle hire to get to and from the crash location.

Photo 1: Members of the Study Team Undertaking a Crash Investigation (Bago-Talawanda)

5.3 Findings

A total of 45 motorcycle crashes were investigated. Of these, 26 (58%) had occurred on or near to the Lawate to Kibong'oto road and 19 (42%) on or near the Bago to Talawanda road.

Of the 26 crashes in the Lawate to Kibong'oto road area, nine (35%) were investigated during the dry season and 17 (65%) during the rainy season. Of the 19 crashes in the Bago to Talawanda road area, eight (42%) were investigated during the dry season and 11 (58%) during the rainy season.

Demographics

The average age of the drivers who participated in the crash investigations was 25 years old, with the youngest stating their age as 18 years old, and the oldest stating 52 years. All 45 drivers were male. 53% were unmarried; the remaining 47% were married.

33 (73%) of the 45 drivers described their primary occupation as a motorcycle taxi driver – motorcycle taxis are common in Tanzania, and are known locally as '*boda-bodas*'. The remaining 12 (27%) of the 45 drivers described themselves as being farmers, small businessmen, labourers or having some other primary occupation.

58% of drivers had completed primary school, but only 9% had completed secondary school. 4% had received no formal education.

82% of drivers said that they had no driving licence. Of the eight who said that they have a licence, only four were able to present it to the study team.

73% of drivers first learned to ride a motorcycle from a friend or relative, with the 24% being completely self-taught. One driver learned to ride through a formal training course run by the Vocational Education and Training Authority (VETA) in 2008, although he did not complete the course.

Crash Descriptions

A brief description of each of the 45 crashes is included in Appendix D. While combined these are too long to present in the main body of this report, the reader is strongly encouraged to read at least a sample of these crash descriptions, to understand the nature of motorcycle crashes on low-volume rural roads.

Contributory Factors

A total of fifteen contributory factors were identified through the crash investigations, and these were divided into five categories:

Category 1 – Road User Behaviour:

- Motorcycle driver error
- Motorcycle passenger action
- Obscured driver vision (driver behaviour)
- High speed
- Other vehicle error
- Pedestrian error
- Weight-shifting of load

Category 2 – Road Design and Condition:

- Lack of signage
- Narrow road
- Obscured driver vision (road design)
- Road-way damaged or poorly maintained

Category 3 – Environmental Conditions:

- Poor road conditions due to rain
- Obscured driver vision (environmental)

Category 4 – Vehicle:

- Vehicle failure

Category 5 – Other:

- Animal

Through detailed discussion between the study team, one or more contributory factors was attributed to each crash, based on the information obtained from the motorcycle driver and the investigation of the scene of the crash. For each crash, one factor was identified as the primary contributory factor, while any others were attributed as secondary contributory factors.

Road crashes commonly have more than one contributory factor, and this was found to be true of the crashes that were investigated through this study.

Primary Contributory Factors

The table below shows the primary contributory factors for the crashes at each of the study sites, together with whether the crash occurred during the dry season or the rainy season.

Table 2: Crash Primary Contributory Factors

Contributory Factor	*# Crashes on or near to Bago to Talawanda road*			*# Crashes on or near to Lawate to Kibong'oto road*			*Total*		
	Dry	*Rainy*	*Total*	*Dry*	*Rainy*	*Total*	*Dry*	*Rainy*	*Total*
Motorcycle Driver Error	*1*	*2*	*3*	*1*	*5*	*6*	*2*	*7*	*9*
Other Vehicle Error	*4*	*2*	*6*	*1*	*2*	*3*	*5*	*4*	*9*
Pedestrian Error	*0*	*1*	*1*	*2*	*1*	*3*	*2*	*2*	*4*
Animal	*2*	*0*	*2*	*1*	*2*	*3*	*3*	*2*	*5*
Weight-Shifting of Load	*0*	*0*	*0*	*2*	*1*	*3*	*2*	*1*	*3*
Motorcycle Passenger Action	*1*	*0*	*1*	*0*	*1*	*1*	*1*	*1*	*2*
Roadway Damaged or Poorly Maintained	*0*	*3*	*3*	*1*	*1*	*2*	*1*	*4*	*5*
Poor Road Conditions Due to Rain	*0*	*3*	*3*	*0*	*4*	*4*	*0*	*7*	*7*
Vehicle Failure	*0*	*0*	*0*	*1*	*0*	*1*	*1*	*0*	*1*
Total	***8***	***11***	***19***	***9***	***17***	***26***	***17***	***28***	***45***

The table shows that Motorcycle Driver Error and Other Vehicle Error were the most common primary contributory factors, together being the primary contributory factor in 18 (40%) of all crashes.

Motorcycle Driver Error was the most common primary contributory factor in crashes along or near to the Lawate to Kibong'oto road, factoring in six of the 26 crashes (23%). Motorcycle Driver Error was a particularly common primary contributory factor during the rainy season, and in particular on or near to the Lawate to Kibong'oto road.

Other Vehicle Error was the most common primary contributory factor in crashes along or near to the Bago to Talawanda road, contributing to six of the 19 crashes (32%) that occurred there.

After Motorcycle Driver Error and Other Vehicle Error, the most common primary contributory factor was Poor Road Condition Due to Rain. This was the primary contributory factor in seven (16%) of the 45 crashes, all of which occurred during the rainy season.

Both Animals and Roadway Damaged or Poorly Maintained were the primary contributory factor in five (11% each) of the 45 crashes. Four (80%) of the five crashes in which Roadway Damaged or Poorly Maintained was the primary contributory factor occurred during the rainy season.

The table below shows the number of primary contributory factors by category, for the crashes on each of the study roads and the nearby area, again together with whether the crash occurred during the dry season or the rainy season.

Table 3: Crash Primary Contributory Factors by Category

Contributory Factor	*# Crashes on or near to Bago to Talawanda road*			*# Crashes on or near to Lawate to Kibong'oto road*			*Total*		
	Dry	*Rainy*	*Total*	*Dry*	*Rainy*	*Total*	*Dry*	*Rainy*	*Total*
Road User Behaviour	*6*	*5*	*11*	*6*	*10*	*16*	*12*	*15*	*27*
Road Design and Condition	*0*	*3*	*3*	*1*	*1*	*2*	*1*	*4*	*5*
Environmental Conditions	*0*	*3*	*3*	*0*	*4*	*4*	*0*	*7*	*7*
Vehicle	*0*	*0*	*0*	*1*	*0*	*1*	*1*	*0*	*1*
Other	*2*	*0*	*2*	*1*	*2*	*3*	*3*	*2*	*5*
Total	***8***	***11***	***19***	***9***	***17***	***26***	***17***	***28***	***45***

The table shows that Road User Behaviour is by far the most common category of primary contributory factors, being the case in 27 (60%) of all crashes. These crashes are divided fairly equally between the dry season (44%) and rainy season (56%).

Road Design and Condition and Environmental Conditions were the primary contributory factors in a total of twelve (27%) crashes. Of these twelve crashes, eleven (92%) occurred during the rainy season.

Other conditions, in all cases being animals, were the primary contributory factor in five (11%) crashes.

All Contributory Factors

The table below combines the primary and secondary contributory factors, to show the number of crashes in which each of the different factors contributed in some way (either as primary or secondary).

Table 4: Crash Primary and Secondary Contributory Factors Combined

Contributory Factor	*# Crashes on or near to Bago to Talawanda road*	*# Crashes on or near to Lawate to Kibong'oto road*	*Total*
Other Vehicle Error	*8*	*3*	*11*
Motorcycle Driver Error	*5*	*17*	*22*
Pedestrian Error	*1*	*5*	*6*
Animal	*2*	*3*	*5*
Weight-Shifting of Load	*0*	*6*	*6*
Motorcycle Passenger Action	*2*	*1*	*3*
Road-way Damaged or Poorly Maintained	*6*	*8*	*14*
Poor Road Conditions due to Rain	*4*	*4*	*8*
Vehicle Failure	*1*	*3*	*4*
Obscured Driver Vision (driver behaviour)	*2*	*0*	*2*
Obscured Driver Vision (road design)	*2*	*4*	*6*
Obscured Driver Vision (environmental)	*2*	*0*	*2*
High Speed	*6*	*8*	*14*
Narrow Road	*5*	*1*	*6*
Lack of Signage	*0*	*1*	*1*
Total	***46***	***64***	***110***

The table shows that the 45 crashes were caused by a combination of various factors, and tallying the multiple occurrences of the factors gives a total of 110 contributory factors. On average, each crash was attributed with between two and three contributory factors.

The table shows that Motorcycle Driver Error was the most common of all contributory factors, contributing in some way to 22 (49%) of the 45 crashes. Motorcycle Driver Error was a particularly common factor in crashes which occurred along or close to the Lawate to Kibong'oto road. The common occurrence of Weight-Shifting of Load along and close to the Lawate to Kibong'oto road may be explained by the steep hills and tight corners in this area.

High Speed and Roadway Damaged or Poorly Maintained were very common factors at both sites, each contributing to 14 (31%) of all crashes.

Other Vehicle Error was a common factor, especially along and around the Bago to Talawanda road. It was a factor in eight (42%) of the crashes at this site, while in only three (12%) of crashes along and near to the Lawate to Kibong'oto road.

Poor Road Conditions Due to Rain were a factor in eight (18%) of the 45 crashes.

The table below combines the primary and secondary contributory factors, to show the number of crashes in which each of the different categories of factors contributed in some way (either as primary or secondary). In calculating these numbers, if two or more contributory factors in the same category were attributed to a crash, the category was only counted once. For example, in some crashes, both Motorcycle Driver Error and Other Vehicle Error were identified as contributory factors. In such cases, the category Road User Behaviour was counted only once.

Table 5: Crash Primary and Secondary Contributory Factors by Category, Combined

Contributory Factor	*# Crashes on or near to Bago to Talawanda road*	*# Crashes on or near to Lawate to Kibong'oto road*	*Total*
Road User Behaviour	*16*	*25*	*39*
Road Design and Condition	*13*	*13*	*26*
Environmental Conditions	*6*	*4*	*10*
Vehicle	*1*	*3*	*4*
Other	*2*	*3*	*5*

Again, the table shows that Road User Behaviour was by far the most common contributory factor, contributing in some way to 39 (87%) of the 45 crashes. Factors related to Road Design and Condition were identified as contributing to 26 (58%) of the crashes.

Environmental Conditions were factors in ten (22%) of the crashes, the Vehicle in four (9%), and Other factors (all being animals) in five (11%).

Photo 2: A Motorcycle Carrying a Wide Load on a Narrow Road (B-T)

Study Roads

Of the total 45 crashes investigated, 21 (47%) occurred on one of the study roads, rather than a nearby road. Of these 21, 14 (67%) occurred on the Bago to Talawanda road and only seven (33%) occurred on the Lawate to Kibong'oto road.

In the area around the Bago to Talawanda road, the majority (14 of 19 (74%)) of the crashes investigated occurred on the study road itself, while only five (26%) occurred on nearby roads and tracks. While in the area around the Lawate to Kibong'oto road, the majority (19 of 26 (over 73%)) occurred on nearby roads and tracks, and only 7 (27%) occurred on the study road itself.

Road Surface Types

The table below shows the type of road surface on which the crashes occurred.

Table 6: Crash Road Surface Types

Road Surface	*# Crashes on or near to Bago to Talawanda road*		*# Crashes on or near to Lawate to Kibong'oto road*		*Total*		
	Study Road	*Other Road*	*Study Road*	*Other Road*	*Study Road*	*Other Road*	*Overall*
Engineered Natural Earth	*11*	*2*	*2*	*16*	*13*	*18*	*31*
Unengineered Unpaved Surface	*0*	*3*	*0*	*2*	*0*	*5*	*5*
Parallel Concrete Strips	*2*	*0*	*3*	*0*	*5*	*0*	*5*
Concrete Geocells	*0*	*0*	*1*	*0*	*1*	*0*	*1*
Concrete Slab	*0*	*0*	*1*	*0*	*1*	*0*	*1*
Sealed	*0*	*0*	*0*	*1*	*0*	*1*	*1*
Drift	*1*	*0*	*0*	*0*	*1*	*0*	*1*
Total	***14***	***5***	***7***	***19***	***21***	***24***	***45***

The table shows that by far the most common surface type upon which crashes occurred was Engineered Natural Earth, with 31 (69%) of the 45 crashes occurring on this surface. The Engineered Natural Earth category includes the study roads' gravel surfaces, which were generally in poor condition and often indistinguishable from other engineered earth roads.

The vast majority of roads in the areas around the study roads are Engineered Natural Earth and Unengineered Unpaved Surfaces. It cannot therefore be assumed that these surfaces are more dangerous than others, despite the fact that the majority of crashes investigated occurred on such roads.

Five (11%) of the crashes occurred on the Parallel Concrete Strips, two on the Bago to Talawanda road and three on the Lawate to Kibong'oto road. For three of these five crashes, some element of the design or maintenance of the road can be partially attributed as a factor in the crash. For more information, see the crash descriptions in Appendix D. Parallel Concrete Strips was the only one of the paved Surfacing Demonstration Project surfaces upon which more than one crash was identified.

For each of the Concrete Geocells, Concrete Slab and Sealed surfaces, and on a drift, one crash was identified. No crashes were identified as having occurred on the Hand-Packed Stone Blocks or Paving Bricks.

The crash that occurred on the Concrete Geocells can be partially attributed to the poor design and maintenance of the road surface, as an edge had been caused by erosion between the concrete and the adjacent earth surface, and this caused the motorcyclist to lose control.

The crash that occurred on the Concrete Slab cannot be attributed to the design or maintenance of the surface, but instead can be attributed to pedestrian behaviour and roadworks being carried out without any warning signs.

The crash on the sealed surface cannot be attributed to any aspect of the design or maintenance of the road surface.

The crash on the drift can be partially attributed to the narrowness of the drift.

For more detailed descriptions on each of the crashes, including those on the Surface Demonstration Project surfaces, see Appendix D.

Road Surface Condition

The table below shows the condition of the road surface that the crashes occurred on.

Table 7: Crash Road Surface Conditions

Road Surface	*# Crashes on or near to Bago to Talawanda road*		*# Crashes on or near to Lawate to Kibong'oto road*		*Total*		
	Study Road	*Other Road*	*Study Road*	*Other Road*	*Study Road*	*Other Road*	*Overall*
Dry with Loose Stones	*6*	*0*	*2*	*6*	*8*	*6*	*14*
Dry and Sandy	*1*	*2*	*0*	*0*	*1*	*2*	*3*
Dry and Smooth	*1*	*2*	*1*	*5*	*2*	*7*	*9*
Dry and Bumpy	*1*	*0*	*0*	*2*	*1*	*2*	*3*
Dry with Cracks	*0*	*0*	*1*	*0*	*1*	*0*	*1*
Muddy with Loose Stones	*0*	*0*	*0*	*1*	*0*	*1*	*1*
Muddy and Bumpy	*0*	*1*	*0*	*1*	*0*	*2*	*2*
Wet and Smooth	*1*	*0*	*2*	*3*	*3*	*3*	*6*
Wet and Bumpy	*2*	*0*	*1*	*1*	*3*	*1*	*4*
Wet and Sandy with Flowing Water	*2*	*0*	*0*	*0*	*2*	*0*	*2*
Total	***14***	***5***	***7***	***19***	***21***	***24***	***45***

The table shows that Dry with Loose Stones was the most common surface condition for crashes to occur on, being the case in 14 (31%) of the 45 crashes.

Overall, the road surface was dry when 30 (67%) of the crashes occurred, and either muddy or wet when the remaining 15 (33%) occurred.

15 (33%) of the crashes occurred on a smooth surface, either while it was dry or wet.

Other Crash Characteristics

Other interesting or common characteristics of crashes identified through these crash investigations include:

- Of the 45 crashes, 31 (69%) occurred on a trip during which the driver was alone, with no passenger. In twelve crashes (27%) the driver was carrying one passenger, and in two crashes (4%), he was carrying two passengers
- Of the 45 crashes, only thirteen (29%) occurred while the driver was driving a motorcycle which belonged to him personally. In the remaining 32 cases (71%), the driver was using a motorcycle that belonged to somebody else
- Of the 45 drivers who crashed, 33 (73%) had also experienced at least one previous crash in their lifetime. Only twelve drivers (27%) had never crashed before. Seven drivers (16%) had crashed three or more times previously
- Of the 45 crashes, four (9%) occurred when the driver had turned off the engine. Motorcycle drivers coasting downhill, in neutral or with their engines completely off, to save fuel, seems to be a common practice
- The narrowness of the road was identified as a contributory factor in six (13%) of the 45 crashes. The width of the road at the crash location in each of these cases was 4.0m, 4.0m, 3.2m, 2.6m, 2.5m and 2.2m
- The driver was injured in 43 of the 45 crashes (96%), with the most commonly injured part of the body being the legs. Medical attention was sought by the driver as a result of 28 (62%) of the crashes. The longest length of time any of the injured drivers was unable to work following the crash was 27 days

- Four females were injured as a result of the 45 crashes. All four were riding as passengers on the motorcycles that crashed
- In 41 of the 45 crashes (91%), the driver was very familiar with the road on which the crash occurred, using that road either every day or several times per week
- In 29 of the 45 crashes (64%), the driver was wearing a helmet at the time of the crash. In the remaining 16 (36%), the driver was not wearing a helmet
- One of the crashes occurred when the motorcycle driver was completely drunk. He is known by others at his *boda-boda* stand to drink heavily every day, yet he regularly transports passengers by motorcycle to earn a living
- Deep drainage canals newly built along the Lawate to Kibong'oto road featured in two of the motorcycle crashes that occurred along the study road. In an additional two crashes near the Lawate to Kibong'oto road, motorcycle drivers were injured when they fell into roadside ditches

6. Assessments of Road Surfaces and Geometric Design

The state of a road's surface and its geometric design are very important to motorcyclists. Because motorcycles are light and only have two points of contact with the ground they are more sensitive to surface type and condition than four-wheeled vehicles. Geometric design, such as carriageway width, shoulder width and side-drain geometry, influences motorcycles' stability and control, as well as how they drive along roads and how they interact with other road users.

Assessments of the safety risks associated with the study roads' surfaces and the geometric designs were carried out through two separate exercises. The first exercise involved assessments of the study roads' surfaces and geometry by the study's Road Safety Engineer, Mr Allan Jones. The second exercise involved a series of driver risk assessments, during which the study's Motorcycle Safety Expert, Mr Hosseah Mabalwe, drove motorcycles along the study roads under different conditions.

Curricula vitae for Mr Mabalwe and Mr Jones are included at Appendices M and N.

6.1 Purpose

The purpose of the Road Safety Engineer's Assessments was to assess motorcycle safety risks related to the different surface types and geometric design used along the study roads.

The purpose of the Driver Risk Assessments was to obtain the opinion of an expert motorcycle driver on risk factors associated with the road surface and other engineering and design factors from the point for view of a motorcycle driver.

6.2 Methodology

Road Safety Engineer's Assessments

The Road Safety Engineer assessed each of the different surface types and geometric designs along the study roads through visual inspection and with the help of straight edges and measuring tapes.

Skidding is a causal factor in many motorcycle crashes, so the skid resistance of each surface type was of particular interest. Skid resistance is difficult to assess without expensive equipment, so instead the 'Sand Patch Test' was used to measure the texture depth, which has been shown to be inversely correlated, though not strongly, with crash risk[5]. On each of the paved surfaces, five sand patch tests were carried out diagonally across the road at regular intervals to find the mean texture depth (MTD). The results were broadly similar to those of a similar test carried out by Roughton International (Tables 30 and 36, Final Report, October 2013).

[5] Viner et al, *Surface Texture Measurement on Local Roads, PPR148,* TRL 148

Photo 3: The 'Sand Patch Test' (Lawate-Kibong'oto)

Other surface-related safety concerns considered through the assessments were:

- Loose material (sand, gravel, spalled concrete, etc.) on the road surface
- Vertical drops at the edges and ends of surfaces
- Potholes
- Uneven surfaces (ruts, corrugations, depressions, etc.)
- Unexpected changes in surface type and quality

All of these can cause loss of control by a motorcyclist and make recovery more difficult.

Safety concerns associated with the study roads' cross-sections were also considered, for example carriageway width, shoulder condition, and side drain geometry.

The same approach to the assessments was used during both the dry season and rainy season data collection periods, using the worksheet included in Appendix E. However, during the rainy season data collection, the Road Safety Engineer looked specifically at how rain and wet conditions affect motorcycle safety in relation to the road surfaces and geometric design.

The safety assessments reported here should be regarded as indicative only, as this was not a scientific trial. The paved sections assessed in this study were mostly quite short, and it was not always possible to compare like with like. For example, some surface types were only used on hills, the paved width was not constant, and construction quality varied. Also, some of the surfaces are not as well-constructed as those that have been constructed elsewhere, for example hand-packed stone was successfully used in Laos under the South East Asia Community Access Programme (SEACAP), and sand seals have been used successfully in South Africa's Kruger National Park. To conduct a scientific trial, longer and more numerous sections of the different road surface types, with consistent design and quality, would have required assessment. Such roads do not currently exist in Tanzania.

Motorcycle Safety Expert's Assessments

For the Motorcycle Safety Expert's Assessments, he hired a motorcycle from a local *boda-boda* driver at one end of the study road, and drove it himself to the other end and back. Along the Bago to Talawanda road the return trip was a total of approximately 40 kilometres for each of the three rides, and for the Lawate to Kibong'oto road the return trip was a total of approximately 25 kilometres. He drove a round trip under each of the three following conditions:

- Daytime solo ride with no load
- Daytime solo ride with load
- Daytime ride with passenger

All rides were undertaken during daylight hours, as the Motorcycle Safety Expert was not confident to drive at night-time for personal security reasons.

The same assessment and methodology were used during both the dry season and rainy season data collection periods. During the rainy season however, the assessment was conducted with particular attention to the rain conditions and road surface wetness conditions during the ride. For example, during the dry season, the Motorcycle Safety Expert noted general factors related to the safety of each surface, whereas during the rainy season, the Motorcycle Safety Expert focused on factors specific to wet conditions.

The risk assessment worksheets for the dry season and rainy season data collection activities are included at Appendix F.

6.3 Findings on Sealed Surfaces

Road Safety Engineer's Assessment

The Road Safety Engineer made assessments of each of the sealed surfaces separately, described here.

Double Sand Seal

The surface was a little uneven with some slight rutting, some small potholes and a few places with small edge drops. Nevertheless, these imperfections would be unlikely to cause safety problems for motorcyclists.

The Sand Patch Test showed mean texture depth (MTD) to be 1.1mm, meaning that the surface might be a little slippery for motorcycles, especially when wet. The locally-available sand used in construction of this surface is finer than that which would normally be used in sand seals, which may explain the lack of texture.

Photo 4: Smooth and Wet Double Sand Seal Surface (B-T)

Slurry Seal

This surface was in poor condition. Roughton International's Final Workshop Report refers to design and construction problems and says that it should not be considered typical of slurry seals. The surface was therefore not included in the assessment as the findings would not be representative of other slurry seals.

Single Otta Seal with Sand Seal

A few surface irregularities were identified, including small potholes, but nothing that would cause a safety problem for motorcyclists. MTD of only 0.9mm suggests that skid resistance will be low, especially when the pavement is wet. As with the Double Sand Seal this result can be explained by the very fine locally-available sand used in construction.

Double Surface Dressing

This had a good uniform riding surface with no potholes, cracks or depressions. There were a very few places where the aggregate had come away, but this is considered to be of no significance for motorcycle safety.

The Sand Patch Test showed MTD on the Bago to Talawanda road of 2.4mm, which implies good skid resistance. On the Lawate to Kibong'oto road the MTD was 1.7mm – the mean being brought down by low values in the wheel paths, where there was a lot of bitumen showing and not much aggregate ('fatting up'). These wheel paths might become slippery in wet weather.

There can sometimes be a lot of loose aggregate on Double Surface Dressing pavements, and this was reported on a previous inspection by Roughton International. There was not a lot of loose aggregate on the traffic lane, but there was some on the shoulders, especially on the Lawate to Kibong'oto road. A motorcyclist riding onto the shoulder would be at risk of losing control.

Penetration Macadam

The Sand Patch Test showed that this surface had a coarse texture (MTD 2.1mm), suggesting good skid resistance. There were some 'fatty' patches, where a lot of bitumen was showing, and some loose material, but nothing to cause a significant problem to motorcyclists.

Motorcycle Safety Expert's Assessment

In general, the Motorcycle Safety Expert found the sealed surfaces to pose few safety risks as he drove along the study roads. The smoothness of the sealed surfaces reduces vibrations, making for a more comfortable and controlled ride than on other surfaces. The absence of dust on the road is a benefit as well.

However, there are some concerns with the sand seals. In hot weather, these become soft and slippery, and they can also be slippery when the surface is wet. If the driver is required to brake hard under these conditions, there is a risk of loss of control. The seals which use larger aggregate have more texture and so provide better skid resistance.

6.4 Findings on Concrete Surfaces

Concrete Geocells

Road Safety Engineer's Assessment

In several places along both study roads the Concrete Geocells surfaces were a little uneven, but not to the degree of being likely to cause safety problems for motorcycles. Along the Bago to Talawanda road the pavement was cracked along the Geocells, and at some of the cracks the concrete surface was starting to break up ('spalling'). If this continues there could be excess loose material on the surface, which could cause a safety risk to motorcycles.

At some places there was a significant level difference at the join between Concrete Geocells and other surfaces – especially on the Bago to Talawanda road. This was particularly the case where a paved surface ends and an unpaved surface begins, assumed to be due to erosion of the unpaved surface. Such differences in level create drops or steps, which are hazardous to motorcyclists. Erosion had also created edge drops at the sides of some sections of the Geocells surfaces, at the join between the concrete and the shoulders.

Photo 5: Edge Drop on Concrete Geocells (B-T)

Motorcycle Safety Expert's Assessment

The Motorcycle Safety Expert found the Concrete Geocells to generally be a good riding surface, with good grip in both dry and wet conditions. However, in places the surface had become rough with erosion in the interstices between the cells, and with some cracks. Excessive roughness causes vibration, creating tiredness in the driver's hands and the risk of loss of control.

The roughness of the surface is also likely to cause wear and tear on motorcycle tyres, especially in the case of heavy braking, which could create risk of a puncture. The roughness of the surface could also increase the severity of injury in the event of a motorcyclist falling on this section of road.

Photo 6: A Rough Concrete Geocells Surface (L-K)

A safety risk was also identified at the join between the Geocells and other surfaces, especially unpaved surfaces. In places there is a difference between the level of one surface and another, for example caused by erosion of an unpaved surface, a drop is created. Such a drop can create the risk of loss of control, and is especially dangerous for motorcycles ascending a steep gradient.

Concrete Slabs

Road Safety Engineer's Assessment

This surface was a little uneven, but not to the extent to cause significant problems for motorcyclists. In most places the concrete had been textured with transverse grooves, and so skid resistance should be good. However, sometimes these grooves were quite deep and there might be a risk of making a motorcycle unstable and creating excessive noise.

Photo 7: Excessive Grooving on Concrete Slabs (L-K)

Some cracking of the concrete slabs was evident, but again not to the degree that it would to cause problems for motorcyclists.

As with the Concrete Geocells, in places the difference in level at the join between the Concrete Slabs and an unpaved surface could create a risk for motorcyclists. Along the Lawate to Kibong'oto road, ascending drivers were observed driving along the shoulder and up onto the concrete at the side of the slab, to avoid the lip at the join of the slab and the engineered natural earth.

Motorcycle Safety Expert's Assessment

The Motorcycle Safety Expert found that the transverse grooves were deep and caused vibrations through the motorcycle's handlebars and into the driver's hands, similar, but to a greater degree than the roughness of the Concrete Geocells. These vibrations led to tiredness and if the handlebars are not gripped well, they could lead to a loss of control.

Again, as with the roughness of the Geocells, the deep grooves on the slabs could cause wear and tear on the motorcycle, including the risk of a puncture, and could increase injury severity in the event of a fall.

Also in the same way as the Geocells, the difference in level found between the concrete slab and adjacent surfaces could create the risk of loss of control.

Photo 8: Un-level Join between Surface Types (B-T)

Parallel Concrete Strips

Road Safety Engineer's Assessment

The Parallel Concrete Strips are approximately 750mm wide and are set 1m apart. Small chevron-shaped concrete blocks are set at 5m intervals between the strips in order to prevent erosion of the unpaved centre section, and they appear to have worked well in this regard. The concrete has been textured with transverse grooves, although in places these grooves appear to be excessively deep.

Motorcyclists face significant safety risks associated with these strips. Firstly, the distance from the outer edge of one strip to the outer edge of the other is only 2.5m, making it narrower than any of the other surface types. From observation, it appears that drivers of four-wheeled vehicles are less likely to move over to allow a motorcyclist to pass than they would be on the other surfaces. This means that when a motorcyclist meets an oncoming four-wheeled vehicle he is forced to go off the strip to get past. Having to move off the strip is made more hazardous by the presence of edge drops (see photo) and, very often, the absence of an adequate shoulder.

Photo 9: Severe Edge Drop on Parallel Concrete Strips (B-T)

Photo 10: Absence of Adequate Shoulder with Parallel Concrete Strips (B-T)

Photo 11: Chevron Piece is a Minor Obstacle (B-T)

Secondly, and less important, the chevron blocks (which have to be set slightly above the road surface in order to divert the run-off water) can act as an obstacle when motorcyclists are overtaking one another.

Motorcycle Safety Expert's Assessment

On the Parallel Concrete Strips, when able to drive continuously on one strip, the surface generally provides a good driving experience. The surface has texture, which provides good grip when braking and when the surface is wet, but is not overly rough.

However, difficulties are experienced when the motorcyclist needs to come off of a strip, either onto the shoulder, when encountering a four-wheeled vehicle coming in the opposite direction, or onto the unpaved section in between the two strips, when needing to overtake a slower moving motorcycle or other road user.

The shoulders are not of a consistent surface type, in places they are weak, and can be soft and slippery when wet. Also, the shoulders are sometimes sloped, covered by vegetation or have loose material on them, creating difficulty and risk when motorcycles use them.

In some places, there are edge drops down from the concrete strip where the shoulder has eroded. These drops increase risks for motorcyclists both when going off the strip and, more so, when coming back on. This is especially the case along the Bago to Talawanda road.

Chevrons have been placed in between the two parallel concrete strips, to assist drainage. However, these are often not level with the strips themselves or with the unpaved surface in between the strips. This is especially the case along the Bago to Talawanda road. Also, the unpaved section in between the two strips can be soft and slippery when wet.

These problems with the shoulders, the unpaved central strip and the chevrons create the risk of loss of control for motorcyclists when they come off a strip.

6.5 Findings on Block Surfaces

Paving Bricks

Road Safety Engineer's Assessment

This surface was used only on the section of road passing through the Lawate market-place. It is a good-looking pavement with no problems at all for motorcyclists.

Speed humps made from the bricks have been used to control speeds through the marketplace. The humps have kept their shape well, and are effective in controlling the speeds of four-wheeled vehicles. However the humps have ramped-down ends, and motorcyclists were observed driving around these ends without slowing down. At one point the carriageway at the end of one speed hump is much higher than the roadside and there is a vertical drop, creating a safety risk for motorcyclists.

Photo 12: **Boda-Boda** ***Passing around the End of a Speed Hump on Paving Bricks (L-K)***

Motorcycle Safety Expert's Assessment

The Motorcycle Safety Expert found no safety risks associated with the Paving Bricks. The surface is smooth, but with good grip created by the joins between the bricks, reducing the risk of skidding even in wet conditions.

Hand-Packed Stone Blocks

Road Safety Engineer's Assessment

Construction quality was poor resulting in a very rough surface, with some blocks missing. Motorcyclists use the shoulder in preference to the paved surface. This suggests that this construction technique is not suitable for motorcyclists unless a smoother surface can be achieved. It is also not suitable for areas prone to flooding – one section of the Bago to Talawanda road had been submerged by floodwater, and this had washed all the filling material away, causing even greater roughness and the risk of stones being dislodged.

Motorcycle Safety Expert's Assessment

The Hand-Packed Stone Blocks that have been used for this surface are large and rough and make for difficult driving for motorcyclists. The uneven surface is uncomfortable to drive over and sharp-edged stones create a puncture risk. Many drivers pass to one side of the road, which has led to the formation of a relatively smooth path along the very narrow shoulder. The shoulder is slippery when wet and is prone to collapsing.

Photo 13: Rough Hand-Packed Stone Blocks (B-T)

The unevenness of the stones could increase the severity of injury in the event of a motorcyclist falling on this section of road.

6.6 Findings on Unpaved Surfaces

Gravel Wearing Course

Road Safety Engineer's Assessment

There was considerable variation in the gravel surfaces. On some sections of the Bago to Talawanda road, it was difficult to see any difference between gravel and the untreated natural earth sections of the road – they were bumpy and had loose material on them, including some fairly large stones. Along the Lawate to Kibong'oto road these sections, although a little rough and bumpy, were better and had less loose material on them.

Skid resistance in the wet might be low because there was a lot of earth showing and not much aggregate.

Motorcycle Safety Expert's Assessment

The Motorcycle Safety Expert found that the unpaved surfaces of both study roads were liable to defects such as potholes and rutting, and that these were more prevalent during the rainy season. The Bago to Talawanda road also has softer sections, such as sand.

The presence of such defects creates unevenness and unpredictability, and so causes risks for motorcycle drivers, especially if they do not modify their driving behaviour accordingly. Hitting a pothole or a soft, sandy section at high speed can result in loss of control and potentially cause a crash. When driving a motorcycle, it is necessary to zigzag to choose the safest line through and around the defects, and this can create risk when a encountering another road user.

When wet, unpaved road surfaces can become very slippery due to mud, and potholes can be filled with water, making it difficult for drivers to judge their depth or see large stones or debris.

However, where the gravel has been used effectively, it reduces skid risk in the wet, in comparison to the untreated surfaces.

Photo 14: Wet and Slippery Unpaved Surface (L-K)

6.7 Summary of Findings on Road Surface Types

Road Safety Engineer

All of the sealed surfaces are probably safer for a motorcycle than an unpaved road, assuming a constant speed. When in good condition and dry, none of the surfaces could be classed as dangerous, but, on the basis of these assessments, the Otta Seal and the Sand Seal may provide poor skid resistance in the wet. Double Surface Dressing gives a good, skid-resistant surface if it is as well-made as it was on the two study roads.

There are no major safety concerns with the surfaces constructed using the paving bricks, the Concrete Geocells, and the Concrete Slabs. The Parallel Concrete Strips are problematic, principally because of their narrow width, and the absence, on most sections, of an adequate shoulder.

There were construction problems with the Hand-Packed Stone Blocks and the Slurry Seal, so no conclusions can be reached regarding their safety. A conclusion on the safety of these surfaces based on only short sections which had been poorly constructed, would not have been justified.

The gravel sections were in typically poor condition, and provide little additional safety over an engineered earth road.

Motorcycle Safety Expert

At each of the two study roads, the Motorcycle Safety Expert gave a safety rating to the different surfaces that had been trialled as part of the Surfacing Demonstration Project. The safety ratings were based on his opinions of driving on the different surfaces, considering the following factors:

- Ease of driving and ability to maintain control
- Effect of surfaces on choice of driving line and other driver behaviour
- Surface performance under wet weather conditions
- Potential severity of injury in the case of a fall
- Level of safety when passing an oncoming vehicle

The table below shows the safety ratings given to the surface types of the two study roads during the dry season and the rainy season. The motorcycle rides in the dry season took place under dry conditions, while during the rainy season some of the road surfaces were wet.

The higher the number, the safer the surface was judged to be, with 10 being very safe and 1 being very dangerous.

Table 8: Motorcycle Safety Expert's Rating of Surface Types

Surface Type	*Safety Rating at Bago to Talawanda Road*		*Safety Rating at Lawate to Kibong'oto Road*	
	Dry Season	*Rainy Season*	*Dry Season*	*Rainy Season*
Engineered Natural Earth	*7*	*4*	*8*	*5*
Gravel Wearing Courses	*7*	*6*	*N/A*	*4*
Sealed (all seals)	*9*	*8*	*9*	*6*
Concrete Slabs	*N/A*	*N/A*	*8*	*8*
Concrete Geocells	*7*	*7*	*8*	*8*
Parallel Concrete Strips	*5*	*4*	*6*	*5*
Hand-Packed Stone Blocks	*6*	*6*	*N/A*	*N/A*
Paving Bricks	*N/A*	*N/A*	*10*	*10*

The table shows that the Paving Bricks were rated to be the safest surface for motorcyclists, in both dry and wet conditions. The Paving Bricks were followed by the sealed surfaces, although these were rated less safe in wet conditions, especially at the Lawate to Kibong'oto road.

The Concrete Geocells and Concrete Slabs were judged to be safe, with no difference in their rating between dry and wet conditions. The Parallel Concrete Strips were judged to be not very safe, especially during wet conditions, and especially at the Bago to Talawanda road.

The unpaved surfaces were judged to be safe during dry conditions but less safe during wet conditions.

The Hand-Packed Stone Blocks were rated as being not very safe, but with no difference to their rating between dry and wet conditions.

6.8 Findings on Geometric Design

Width

Road Safety Engineer's Assessment

The different surface types on the study roads have been constructed at different widths, which complicated the safety assessment. Average widths of the different surfaces are shown in the table below.

Table 9: Average Widths of Surfaces on Study Roads

Surface Type	*Average Width (m)*
Double Sand Seal	*4.7*
Slurry Seal	*4.7*
Otta Seal	*5.0*
Double Surface Dressing	*4.0 and 4.5*
Penetration Macadam	*5.0*
Hand-Packed Stone Blocks	*3.3*
Paving Bricks	*6.0*
Concrete Geocells	*3.5 and 4.5*
Concrete Slabs	*4.0*
Parallel Concrete Strips	*2.5 overall (2 x 0.75 with 1.0 between)*

According to Roughton International's Design Report all of the pavements except the parallel concrete strips and the paving bricks in Lawate were intended to be 3.0m wide.

The interaction between motorcycles and oncoming four-wheeled vehicles (most of which are cars) was of particular interest. Motorcyclists varied in how they tackled this interaction, often being more cautious when carrying a passenger. Through observation, it appeared that where the paved carriageway was less than about 3.5m motorcyclists left the paved surface and stopped on the shoulder. Car drivers tended not to reduce their speed or move over when encountering a motorcycle coming in the opposite direction. This would not be such a problem if there was a good unpaved shoulder, but in many places there was not.

Roughton International's Design Report referred to the provision of passing places, but it is not clear whether any were built. No passing places were seen during the assessment of geometric design.

Motorcycle Safety Expert's Assessment

The Motorcycle Safety Expert found that in many places the width of the study roads is insufficient for a motorcycle to safely pass a four-wheeled vehicle, unless both vehicles reduce to a very slow speed. However, often upon encountering a four-wheeled vehicle coming in the opposite direction, the motorcyclist is forced to slow down to a stop and to pull off the road, as larger vehicles very rarely reduce speed or give way to motorcycles.

Four-wheeled vehicles not making way for motorcycles is especially evident on the parallel concrete strips. Since a strip is wide enough only to accommodate the width of a tyre, most four-wheeled vehicles are reluctant to come off the strips, and motorcyclists are forced to get out of the way by coming off the strip and onto the shoulder, which creates an opportunity for loss of control and instability, especially if the shoulder is sloped or has loose material or vegetation.

Photo 15: Narrow Roads Create Difficulty for Motorcycles to Pass Other Vehicles (L-K)

Shoulders

Road Safety Engineer's Assessment

There were many sections of both study roads where the shoulders were inadequate for safe use by motorcyclists and other road users. Typical problems were: edge drops between the carriageway and the shoulder, excessive slope, loose material, and vegetation. The lack of adequate shoulders is a major safety concern. The risk of damage to unpaved shoulders through storm water run-off and trafficking is quite high, especially with narrow pavements and rudimentary drainage, so it is perhaps unrealistic to expect District Engineers to maintain unpaved shoulders in good condition at all times of the year.

Motorcycle Safety Expert's Assessment

Many sections along the Bago to Talawanda road and Lawate to Kibong'oto road lack clearly defined shoulders. This means that motorcyclists cannot safely pull off to the side of the road if a situation arises where it is necessary to leave the main carriageway, such as when encountering a four-wheeled vehicle coming in the opposite direction. Often, vegetation covers the area where there should be a shoulder, so it is impossible to tell what the ground underneath is like. Combined with the narrowness of the roads, the lack of adequate shoulders creates a safety risk.

Photo 16: Shoulders Covered By Vegetation (L-K)

Drainage

Road Safety Engineer's Assessment

Effective drainage is essential to maintain the condition of the road surface, but the side drains need to be forgiving. The deep lined drains on stretches of the Lawate to Kibong'oto road are dangerous for all road users, especially motorcyclists. It is doubtful whether they need to be so large.

Photo 17: Hazardous Drain (though it helps support the shoulder) (L-K)

Motorcycle Safety Expert's Assessment

Along many stretches of the Lawate to Kibong'oto road, deep rectangular drains have been constructed at the side of the road. Where these are present, they strengthen the shoulder of the road, creating a firm shoulder surface for motorcyclists to use if they encounter a four-wheeled vehicle coming in the opposite direction.

However, this is only beneficial in areas where the road is sufficiently wide for the motorcyclist to use the strengthened shoulder without driving too close to the drainage ditch. If the road is narrow and has a deep drain running alongside it, this creates the risk of a potentially serious injury if the motorcyclist crashes into it.

Lines of Sight

Road Safety Engineer's Assessment

In places along both study roads, lines of sight were reduced by vegetation.

Motorcycle Safety Expert's Assessment

Along both of the study roads, and especially along the Lawate to Kibong'oto road, motorcycle drivers' lines of sight are blocked, for example by trees and steep banks at corners.

Lines of sight are important to motorcycle drivers, to allow them to see potential hazards ahead, such as an oncoming vehicle or pedestrians or animals in the road. A short line of sight reduces the likelihood of the motorcycle driver to see and be seen, and creates a safety risk. The risk is greatest along the Lawate to Kibong'oto road, which has steep hills and tight corners.

Gradient

Road Safety Engineer's Assessment

It should be recognised that steep gradients are a far more challenging terrain for road builders than flat surfaces.

Motorcycle Safety Expert's Assessment

The gradients of the Lawate to Kibong'oto road are pronounced, creating steep uphill and downhill sections. On long, steep uphill sections, the challenge for drivers is to maintain speed to reach the top, especially when carrying a passenger or a load. On downhill sections, the challenge for drivers is to use the brakes, and engine-braking, effectively to maintain control.

6.9 Findings on Bridges and Drifts

Bridges

Road Safety Engineer's Assessment

The two bridges on the Bago to Talawanda road lack parapets, and there are no warning signs. There is evidence of marker posts, but most had been destroyed. The bridge on the Lawate to Kibong'oto road has simple concrete parapets.

It is likely that vehicles are approaching the bridges at too high a speed. Installation of speed humps on bridge approaches is likely to be very effective in reducing crash risk.

Motorcycle Safety Expert's Assessment

Along the Lawate to Kibong'oto road, the two bridges are on sections with tight bends and steep gradients. The short lines of sight do not enable drivers to know whether a vehicle is approaching from the opposite direction, which creates a safety risk. The narrowness of the bridges also creates a safety risk.

A bridge along the Bago to Talawanda road lacks parapets, which creates a risk of falling in to the river below.

Drifts

Road Safety Engineer's Assessment

The drifts might be hard to see, especially at night as there are no warning signs or marker posts.

In places, the edges of the drift slabs are not well defined, especially when there is water flowing. The masonry marker blocks are only on the downstream side.

Motorcycle Safety Expert's Assessment

There are several drifts along both of the study roads. While these are not deep, if encountered by an unaware motorcyclist at high speed, they could cause loss of control.

During the rainy season, when a drift is full of water it is difficult to gauge the depth and force of the water, and whether there is any submerged debris, which could cause a risk for motorcyclists.

Masonry blocks have been used to demarcate the downstream edge of drifts. These help motorcyclists to know the location of the drifts, but the blocks themselves may block floating debris which may then sit submerged within the path of the road passing across the drift.

6.10 Findings on Signage, Safety Barriers and Speed Bumps

During the dry season data collection, a lack of signage was identified along both study roads, and in particular along the Lawate to Kibong'oto road. This created a risk for motorcycle drivers, especially those driving along the road for the first time, as they would be unaware of what is ahead, for example a school, bridge, steep hill, village or speed bump.

However, during the rainy season data collection, it was observed that the Siha District Engineer had carried out significant safety work along the Lawate to Kibong'oto road, erecting road signs, safety barriers and speed bumps. No such improvements had been made along the Bago to Talawanda road.

Signage

Road Safety Engineer's Assessment

It would be unrealistic to expect a high standard of signing on a very low volume rural road, and arguably there is no need for many signs, as almost all road users will be very familiar with the road. Priority should be given to signing the major hazards, such as speed humps, awkward bends and gradients, and hard-to-see bridges and drifts.

There is no signing at all on the Bago to Talawanda road. The new signs erected on the Lawate to Kibong'oto road were helpful, although not of high quality.

Motorcycle Safety Expert's Assessment

The Motorcycle Safety Expert found the signs very useful when driving along the road, as they warned of hazards ahead. However, it was observed that some signs had been vandalised.

Safety Barriers

Road Safety Engineer's Assessment

It is questionable whether the new steel beam guardrail erected at two places on the Lawate to Kibong'oto road will be cost-effective for other low-volume rural roads. And it was observed that the installation had not been well done, with problems including: beams being set too high; beams being joined incorrectly, unsafe terminal pieces, and unshielded beam ends.

Provision of guard posts might have been a more appropriate solution.

Motorcycle Safety Expert's Assessment

The safety barriers had been placed on a steep section of the Lawate to Kibong'oto road, with tight bends and steep drops as the road winds down to a bridge across a river.

The Motorcycle Safety Expert thought that the barriers served as an effective warning to drivers that this section of the road is dangerous. However, he was concerned that the barriers narrow the road and increase the problems related to width when a motorcycle encounters a four-wheeled vehicle.

Speed Humps

Road Safety Engineer's Assessment

Crude but effective speed humps had been built by local people on the Bago to Talawanda road, in response to incidents involving speeding motorcyclists. There were no formal warning signs.

Photo 18: A Speed Hump Constructed By Local Community in Ludiga Village (B-T)

Some earth and concrete humps had been newly installed by the District Engineer on the Lawate to Kibong'oto road.

Photo 19: An Earth Speed Hump Constructed By the Siha District Engineer (L-K)

Photo 20: A Concrete Speed Hump on Parallel Concrete Strips (L-K)

Motorcycle Safety Expert's Assessment

The speed humps along both roads are effective at slowing motorcyclists down, although those along the Bago to Talawanda road are not signed and so have the potential to cause loss of control for motorcyclists who do not see them.

7. Assessment of Motorcycle Driver Behaviour

Driver error is globally recognised as being a key contributory factor in road crashes. The Tanzanian National Road Safety Policy, referring to police records, states that human behaviour accounts for around 80 per cent of crashes.

Assessments of driver behaviour were carried out by the Motorcycle Safety Expert.

7.1 Purpose

The purpose of the assessment of driver behaviour was to obtain the opinion of the Motorcycle Safety Expert on risk factors associated with the behaviour of motorcycle drivers.

7.2 Methodology

The Motorcycle Safety Expert hired a local *boda-boda* driver to carry him as a passenger, in order to observe his behaviour. The driver was not informed that he was being assessed as part of a study.

For some of the assessments, the *boda-boda* driver was asked to drive along the study roads themselves, to allow the observation of how they behave on the different surface types. For others, the driver was asked to use other nearby unpaved roads, with the focus of these assessments being on the drivers' skills.

The Motorcycle Safety Expert recorded observations on the type and condition of the motorcycle, clothing and personal protective equipment used by the driver, appropriateness of speed, gear-changing, braking, reaction to obstacles, distracted driving and interaction with other road users.

At the end of each ride, the Motorcycle Safety Expert gave a score of the driver's overall performance, so that different drivers' performances could be compared.

All rides were undertaken during daylight hours, as the Motorcycle Safety Expert was not confident to ride at night-time due to personal security reasons. During each assessment a minimum distance of ten kilometres was covered.

The methodology was modified from the dry season data collection to rainy season. During the dry season, the Motorcycle Safety Expert identified a lack of basic skills among drivers, and so in order to quantify this, a new section on rating various driving skills was added into the worksheet for the rainy season data collection.

The worksheet was also reworked between the dry season and the rainy season so that the Motorcycle Safety Expert could comment specifically on how motorcycle drivers performed on each particular surface, as opposed to how they performed generally. During the rainy season data collection therefore, the rides only took place on the study roads so that the Motorcycle Safety Expert could observe any changes in driving behaviour based on the different road surfaces and road surface conditions.

The worksheet used during the dry season and the rainy season data collection activities is included in Appendix G, with red, bold and italicised text used to indicate the questions that were included during the dry season but not during the rainy season.

7.3 Findings

A total of 83 assessments were carried out, with 39 along or near to the Bago to Talawanda road and 44 along or near to the Lawate to Kibong'oto road. Of the 39 Bago to Talawanda assessments, 19 took place during the dry season data collection and 20 took place during rainy season. Of the 44 Lawate to Kibong'oto assessments, 20 took place during the dry season and 24 took place during the rainy season.

Basic Driving Skills

Drivers who learn how to drive from professionals learn proper driving skills and techniques that help to avoid collisions and also lengthen the life of vehicles and their parts.

But the Motorcycle Safety Expert observed that drivers at the study sites rarely displayed good basic driving skills. For example, while many drivers were able to correctly change up through the gears when accelerating, very few were able to change down while decelerating or driving on gradients. Being in the wrong gear means that the driver has less control, and it also wears our motorcycle parts more quickly.

As well as this, other poor driving techniques observed were:

- Cornering – Drivers approached corners at speeds that were too high
- Braking – Most drivers did not use both brakes to slow the vehicle, using only the rear brake. Many drivers did not brake smoothly before speed bumps or obstacles
- Overtaking and undertaking – Drivers often overtook by passing to either the left or the right side of the other vehicle, and also cut back in sharply
- Coasting – Following a belief that they are saving fuel, it is common for drivers to switch off their engines or put the transmission into neutral and coast when they encounter downhill gradients. They then control the motorcycle with the rear brake, which leads to reduced control and heavy wearing of the brake pads. (In the view of the Motorcycle Safety Expert, the amount of money saved on fuel by coasting would be far outweighed by the amount spent on replacement of brake pads due to increased wear.)

For each basic skill, the 44 drivers assessed during the rainy season were graded by the Motorcycle Safety Expert as being either 'Very Good', 'Good', 'Poor', or 'Very Poor'. The results are shown in the table below.

Table 10: Ratings of Driver Skills during the Rainy Season

Skill	*Very Good*	*Good*	*Poor*	*Very Poor*
Cornering	*3 (7%)*	*25 (57%)*	*15 (34%)*	*1 (2%)*
Gear shifting - up	*3 (7%)*	*39 (89%)*	*2 (4%)*	*0 (0%)*
Gear shifting - down	*0 (0%)*	*30 (68%)*	*14 (32%)*	*0 (0%)*
Braking	*2 (5%)*	*19 (43%)*	*23 (52%)*	*0 (0%)*
Reacting to obstacles	*2 (5%)*	*6 (36%)*	*26 (59%)*	*0 (0%)*
Interacting with other road users	*4 (9%)*	*18 (41%)*	*21 (48%)*	*1 (2%)*

The table shows that those skills graded weakest were 'Reacting to obstacles' and 'Braking', with more than half of all drivers being rated 'Poor'. For the skill 'Interacting with other road users' half were rated either 'Poor' or 'Very Poor', with the other half rated 'Good' or 'Very Good'.

The strongest skill was 'Gear shifting – up', with 96% of drivers being rates as 'Good' or 'Very Good'. Drivers were weaker at 'Gear shifting – down', although over two-thirds (68%) were still rated as being 'Good' at this skill.

Almost two-thirds of drivers (64%) were rated as 'Good' or 'Very Good' at 'Cornering', with the remainder being rated 'Poor' or 'Very Poor'.

Not having the skills to properly drive a motorcycle means having less control of the motorcycle, and having a higher risk for collisions.

Speed

High speed is globally accepted to be a key risk factor in road crashes. In terms of the relationship between road width and speed, it is thought that narrower roads naturally lead to slower speeds. But this was observed to not be the case when motorcyclists are riding alone with the road to themselves. The Motorcycle Safety Expert observed that road width does not have a bearing on speed unless oncoming vehicles are present.

During 44 of the 84 assessments (52%), the Motorcycle Safety Expert was of the opinion that the driver used excessive speed, inappropriate for the road environment. During the dry season, this figure was 70%, while during the rainy season it was 39%.

The Motorcycle Safety Expert identified a connection between high speed and age, with younger motorcyclists driving faster and older motorcyclists driving more slowly.

The Motorcycle Safety Expert observed that motorcycle drivers drive fastest on the sealed road surfaces, as they are smooth and the surface is predictable without potholes and other obstacles. Many drivers do not change their speed when they encounter villages or other areas with more pedestrians, showing that they do not understand the need for appropriate speeds for different environments.

Distracted Driving

Sometimes motorcycle drivers engage in distracted driving. This includes talking to passengers, talking on or checking messages on a cell phone, listening to music, and making adjustments to the motorcycle, like the side mirrors. These behaviours take the focus of attention away from the driving task, and also put drivers in a position where they have less control, like driving with only one hand on the handlebars. These all lead to increased risk for a crash.

Defensive Driving

Defensive driving is a philosophy and set of skills that help drivers to avoid collisions. A lack of defensive driving skills makes drivers more susceptible to collisions.

The Motorcycle Safety Expert observed that drivers at the study sites did not display good defensive driving skills. One of the first principles of defensive driving is to drive at a speed that is slow enough to allow the driver to react to any obstacles or occurrences, but most drivers were observed to use excessive speeds and to not react well to obstacles.

Drivers were often seen to drive in the middle of the road, or even on the wrong side of the road, even when there is a poor line of sight. In particular this was found to be the case during the rainy season, when the parts of the road surface had standing water or potholes.

Many drivers did not use their horns before blind corners to alert potential oncoming drivers to their presence.

Defensive driving also includes the use of personal protective equipment such as helmets, gloves and long sleeves and trousers. However, it was observed to be common for drivers not to use such equipment, most notably along the Bago to Talawanda road.

Alcohol Use

One driver who participated in the assessments of driver behaviour, was identified, early on in the assessment, to be drunk and therefore unable to ride safely. The Motorcycle Safety Expert asked him to stop, explained to him the dangers of driving under the influence of alcohol, and discontinued the assessment.

However, apart than this one instance, the other 82 drivers who took part in the assessments were not observed to be under the influence of alcohol.

Different Behaviour when Riding Solo and with Passenger

During the two assessments at both of the study roads, the Motorcycle Safety Expert observed that drivers commonly vary their speeds and other driving behaviour depending on if they are riding solo, or with a passenger, or if they are carrying a load.

He observed that drivers go fastest, and practice other risky behaviours such as using the wrong side of the road and coasting down hills, when alone and with no load. They drive more slowly and carefully if they are carrying a load, and they are slowest and most careful when carrying a passenger.

Driving Uphill

The motorcycles found at the study sites have engines that are generally either 125cc or 150cc. They are not very powerful, and it is common for them to struggle on steep uphill gradients. This is especially the case when carrying a passenger or heavy load, or both. Drivers were observed trying to maximise their speed as they approach an uphill section, for fear of not making it to the top.

In places along the study roads, for example where a drift is used at the bottom of a hill or where the join between a concrete surface and an earth surface causes an edge, motorcycles are forced to reduce their speed before beginning an ascent. In such cases, it was observed that some drivers carrying passengers did not make it to the top of the hill, and were forced to stop and ask the passenger to dismount.

Coasting Downhill

Long downhill sections give opportunities for motorcyclists to coast, either with the gear in neutral, or with the engine turned off. This creates a high risk for loss of control, since the motorcycle can only be controlled through constant braking, and the brakes are less effective. As well as creating a safety risk, this also causes significant wear on brake pads and strain on cables.

Rain and Wet Conditions

The Motorcycle Safety Expert identified a number of common risky behaviours associated specifically with rain and wet conditions. These were:

Zigzagging

When the road surface is wet, drivers tend to zigzag, not maintaining a consistent driving line. This is especially the case on unpaved surfaces, which often have potholes and puddles. Drivers select the clearest line to avoid such obstacles, which includes driving on the wrong side of the road, putting themselves and other road users at risk.

Overtaking on Parallel Concrete Strips

Overtaking of motorcycles by motorcycles is common on the study roads, as drivers use different speeds, largely depending on whether they are carrying a passenger or load or not.

The Motorcycle Safety Expert highlighted the specific risks of overtaking during wet conditions on the Parallel Concrete Strips. The concrete strips themselves are a hard, good, predictable surface, but the central earth section between the strips is soft and slippery when wet. As the overtaking driver moves off the concrete strip onto the central earth section at high speed, they are at risk of losing control.

In addition to this, the concrete chevrons placed in the central earth section to aid drainage, act as obstacles. As motorcycles drive along the soft earth and then hit hard chevrons, they are at risk of loss of control.

Distracted Driving

Distracted driving is a problem during dry conditions, but during wet conditions the Motorcycle Safety Expert considers it to be the single biggest risk to the safety of drivers. During the rainy season, and specifically when it was actually raining while the assessment was taking place, the Motorcycle Safety Expert observed that it is common for drivers to drive with one hand, using the other to shield their eyes from the rain, or, if they are wearing glasses or a visor, to wipe rain off the surface.

Wet Handgrips

If the motorcycles handgrips are wet, and if – as was often observed to be the case – the driver does not wear appropriate gloves, his hands can slip, possibly causing him to lose control.

Increased Vegetation

During the rainy season, roadside vegetation grows more quickly than when it is dry. This means that road shoulders get overgrown more quickly, making them unusable by motorcycles, and that lines of sight can be blocked by trees and bushes encroaching into the road.

Understanding and Adherence to Signage

Several new road signs were erected along the Lawate to Kibong'oto road in between the dry season and rainy season data collection periods.

Photo 21: A New Road Sign along the Lawate to Kibong'oto Road (L-K)

The Motorcycle Safety Expert observed that most of the drivers who knew the road less well observed these signs and modified their behaviour accordingly, which usually meant reducing their speed in anticipation of an obstacle. However, he also observed that drivers who knew the road well did not adhere to the signs.

Along the Bago to Talawanda road, there are several speed bumps that have been built by local communities. These are not complemented by road signs, meaning that drivers who do not know the road will not be aware of them and may hit them at high speed causing loss of control.

8. Assessment of Motorcycle Safety Risk Factors and Protective Factors

As seen above in the section on motorcycle crash investigations, there are many factors that can contribute to crashes. Motorcyclists face many risks, including associated with their own behaviour, the behaviour of other, the road and wider environment, the vehicle they are driving, and more. Similarly, there are ways that drivers can protect themselves from these risks.

8.1 Purpose

The assessment of motorcycle risk factors and protective factors was designed to collect information on the factors that put motorcycle drivers at risk and the factors that protect motorcycle drivers from crashes and injuries while they drive on rural roads.

8.2 Methodology

The assessment of risk and protective factors was carried out only during the dry season data collection period as repeating it during the rainy season would not have provided new information that is specific to understanding motorcycling risks brought about by rain and wet conditions.

The Risk and Protective Factors Questionnaire yielded information about various behavioural factors related to driving a motorcycle and was analysed to see if there were any behaviours that were significantly associated with experiencing a crash in the previous twelve months. Since the outcome variable is a crash within the past year, and a year includes both rainy and dry seasons, we would have been unable to parse out the seasonal effects on motorcycle crashes.

However, some of the safety concepts from the Risk and Protective Factors Questionnaire into the Driver Opinion Survey carried out during the rainy season data collection activities.

Eligibility

Any person who was a regular motorcycle driver with experience driving on low-volume rural roads was eligible to participate in the Risk and Protective Factors Questionnaire. It was not necessary for a motorcycle driver to be a commercial motorcycle-taxi driver (*boda-boda*), although most were.

Some drivers had previously participated in an AFCAP/Amend-sponsored licensing and training programme approximately one year prior to this research. Whether or not a driver had participated in the training programme did not impact their eligibility to participate in this survey.

We spoke to drivers who had experienced a crash and those who had not experienced a crash, to look for any possible differences between them. It was necessary for a driver to have his motorcycle on hand at the time of the interview and give permission to inspect it. It is common for drivers to share motorcycles amongst themselves; if a motorcycle had already been inspected, that motorcycle was not eligible to be inspected again, even if it was with a different driver. However, six motorcycles were unintentionally inspected twice under different drivers. The results of these were included in the analysis of the data, summarised in the Findings sub-section below.

All drivers were administered the same questionnaire.

Undertaking Questionnaires

We first solicited participation from motorcycle drivers along each of the study roads and at motorcycle stands at either end of the study roads. We then fanned out further from the study roads to recruit more participants. In

Bagamoyo, we carried out the questionnaires with motorcycle drivers between Msata and Kiwangwa. In Siha, we carried out the questionnaires with motorcycle drivers between Boma Ng'ombe and Sanya Juu.

Project Assistants approached motorcycle drivers to explain the purpose of the study and to ask for participation. Questionnaires covered demographic information, drivers' behaviours when motorcycling, knowledge, attitudes and opinions about motorcycling, and motorcycling safety.

Following the person to person interview, Project Assistants conducted a motorcycle inspection, looking at factors such as tyre tread depth, headlamp and indicator signal functionality, and brake quality. There were a total of 87 questions on the questionnaire, including the motorcycle inspection.

A copy of the questionnaire is included in Appendix H.

Having completed the questionnaire, the Project Assistants explained to the driver the state of the motorcycle, the importance of motorcycle maintenance, and where safety improvements could be made. All participating drivers received a pair of clear plastic safety glasses for eye protection while motorcycling, as well as being paid for the motorcycle hire.

Photo 22: An Interview with a Driver (B-T)

8.3 Findings

We completed a total of 210 questionnaires: 104 in the area around the Bago to Talawanda road, and 106 in the area around the Lawate to Kibong'oto road.

Introduction to Findings

The first 46 of the questionnaire's 87 questions related to the driver and their behaviour, and were asked during the interviews with drivers. Questions 47 to 87 related to the motorcycle and its condition, and were answered through an inspection of the motorcycle.

This section provides details of the most interesting findings. It presents frequencies and averages of responses given by the drivers and from the inspections of motorcycle condition.

It also presents the findings of comparing various behaviour-related questions to the question

"Have you experienced a road crash or injury on a rough road while driving your motorcycle in the past one year?"

to see if there are any associations between a particular behaviour – also known as risk factors or protective factors – and the outcome of having crashed on a rough road. We used a probability value of .05 or less to judge whether or not the association between the risk factors or protective factors and the outcome of having crashed was significant.

The use of the non-technical term "rough road" in this study is because the closest terms in Swahili to describe unpaved roads – *'barabara korofi'* or *'barabara ya vumbi'* – translate into 'rough road' and 'dust road' respectively. We wanted to use simple language to make it as easy as possible for study participants to understand the questions.

Since some of the questions asked in our questionnaire are of a sensitive nature, for example about alcohol and drug consumption, it may be possible that questionnaire respondents answered the questions untruthfully, or by portraying a lower level of risk in their behaviours than is the case. If the motorcycle drivers in our study population were likely to under-report the risk levels associated with their behaviours, then we may be observing less risky behaviour than is the case, and may not be identifying as many significant risk factors as we should in our dataset.

When reading these findings, it is important to note that the motorcyclists were asked about their habitual behaviour (which they presumably interpreted as their *current* behaviour) and whether they had experienced a crash within the twelve months prior to the date of the interview. It is possible that current behaviour could be different from past (pre-crash) behaviour. For example, suppose a motorcycle driver experienced a crash eight months prior to the interview. Prior to the crash, he may have had highly risky behaviours, but after the crash he changed his behaviour and drove more carefully. In his responses to the questionnaire questions, he would likely answer truthfully when he gave answers that fell into low-risk categories for our questions.

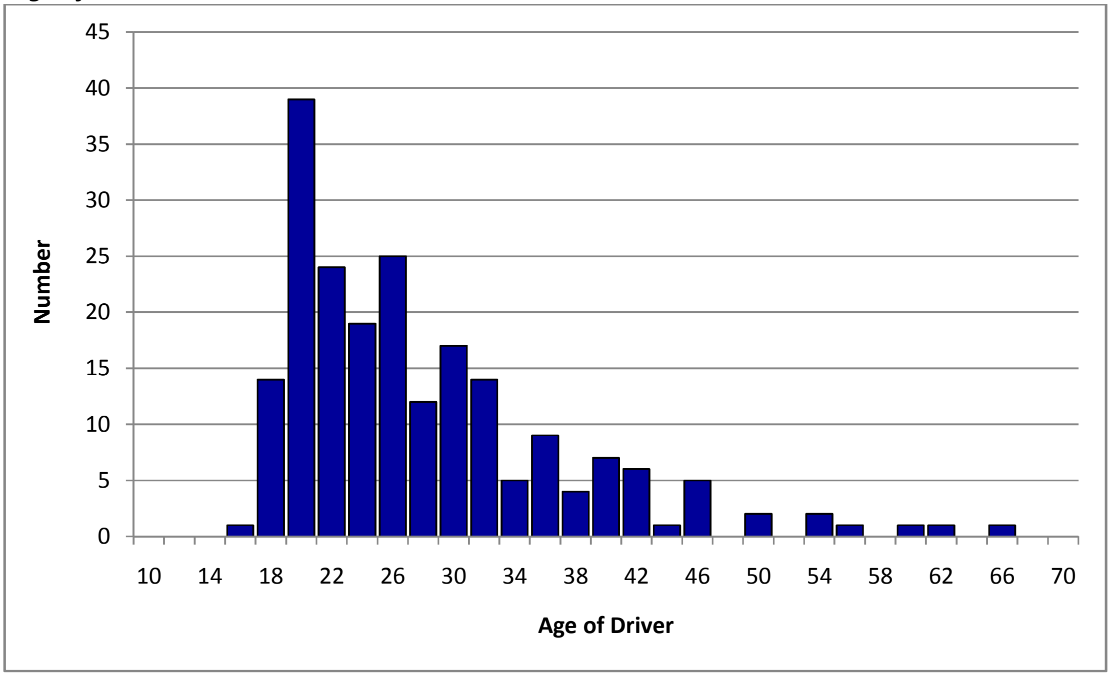
In our analysis, we would not then detect an association between high-risk behaviours and crashing. It is possible that experiencing a crash could have changed the kind of behaviour that led to the crash, and if these kinds of changes were likely to occur in our study population, then we may be observing less risky behaviour than is actually the case, and so may not be identifying as many significant risk factors as we should be in our dataset.

Motorcycle Drivers' Demographics

Gender and Age

All 210 motorcycle drivers were male. Their average age was 27 years old, with the oldest driver being 66 and the youngest stating their age as 16. The distribution of drivers' ages is shown in the chart below.

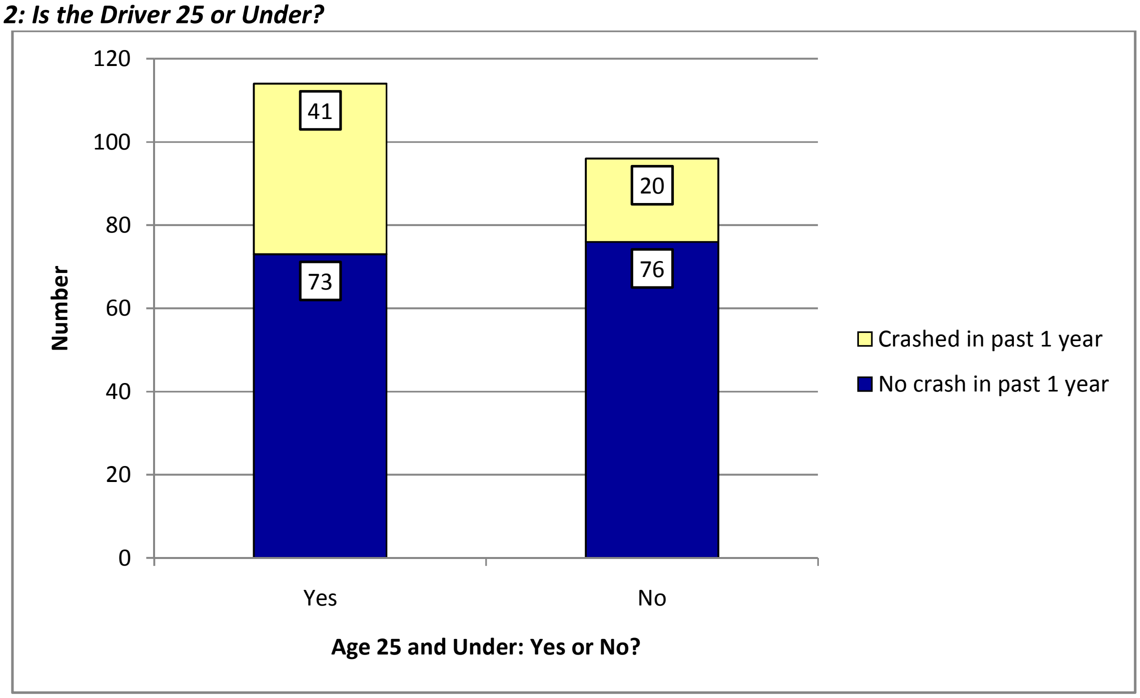
Chart 1: Age of Drivers



A statistically significant association was found between age (25 years and under versus over 25) and whether or not the driver had suffered a crash in the twelve months prior to the investigation.

The chart below shows the number of drivers aged 25 and under and over 25, with those who responded that they had not experienced a crash shown in blue and those who had experienced a crash shown in yellow.

Chart 2: Is the Driver 25 or Under?

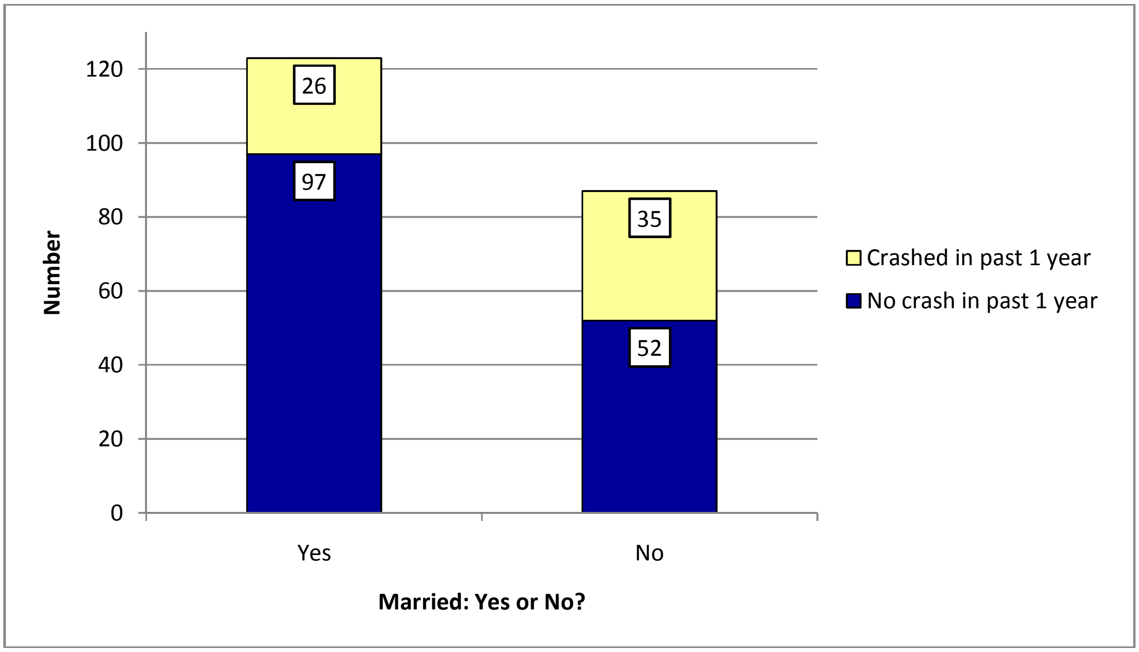


Younger drivers were more likely to have experienced a crash in the past twelve months. The chi-square probability value of 0.016 shows that this is a statistically significant association.

Marital Status

The majority (59%) of drivers interviewed were married. 41% were unmarried (including 3% who described themselves as either separated or divorced). The chart below shows the numbers of married and unmarried drivers, and those who had experienced a crash in the last twelve months.

Chart 3: Is the Driver Married?

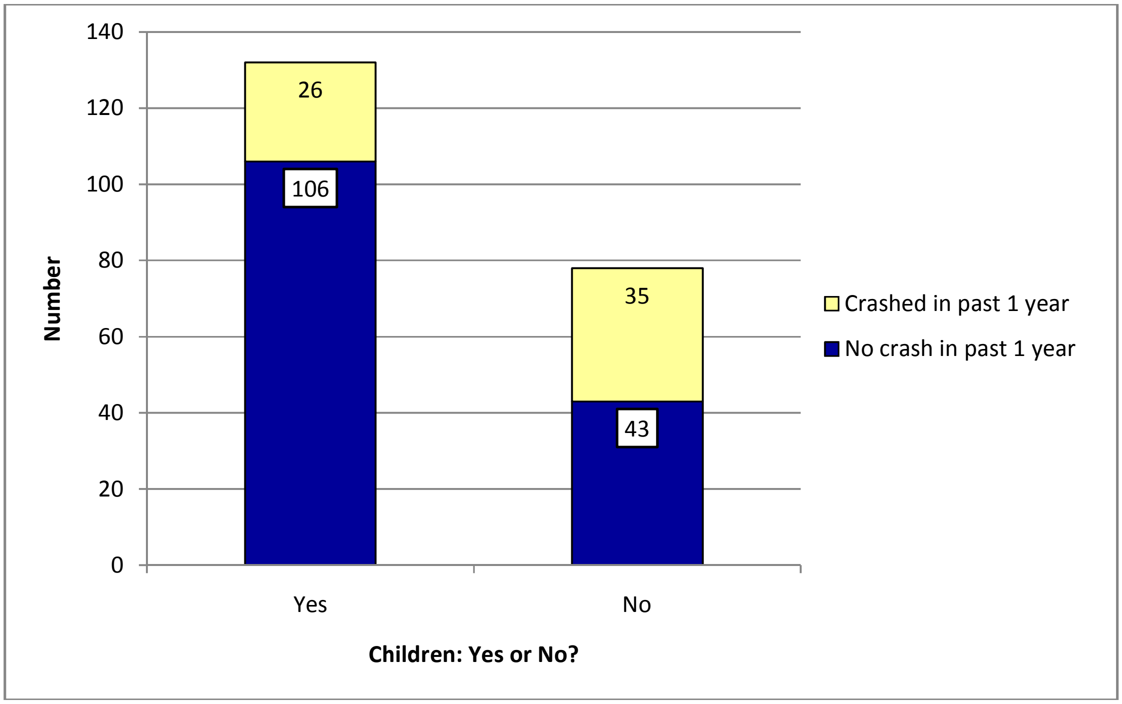


The association between marital status and whether or not the driver had experienced a crash within the twelve months prior to the investigation showed statistical significance. Statistical analysis showed that unmarried drivers are almost two times as likely to have experienced a crash than those who are married. The chi-square probability value of 0.003 shows that this is a statistically significant association.

Number of Children

The majority (62.9%) of the drivers interviewed had one or more children. 37.1% of drivers had no children. The chart below shows the number of drivers with and without children, and the number of those who have and have not experienced a crash.

Chart 4: Does the Driver Have Children?



Whether or not the motorcycle driver has children is significantly associated with whether or not they have experienced a crash in the past twelve months. Statistical analysis shows that those drivers without children are more than two times more likely to have experienced a crash than those who have one or more children. The chi-square probability value of less than 0.0001 shows that this is a statistically significant association.

Motorcycle Drivers' Behaviour

Training and Licensing

The majority (71%) of drivers said they did not have a driving licence. Of the 61 drivers who said that they do have a licence, only 25 (41%) of these were able to show it to the interviewer.

The majority (67%) said that they first learned to drive a motorcycle from a friend or relative. 29% said that they taught themselves, and only the remaining 4% said that they first learned from a professional trainer or as part of a training course.

Only 24% said that they had ever attended a training course. The remaining 76% said that they had never attended a training course.

All drivers were shown the below three road signs and were asked if they could explain their meaning.

Under 26% of the drivers correctly explained the meaning of all three signs. 48% explained the meaning of two, 16% only one sign, and 11% could not correctly explain the meaning of any of the signs.

There was no statistically significant association between whether the driver had experienced a crash on a rough road within the last twelve months and either possession of a driving licence, the method of learning or completion of a training course, or the ability to explain the meaning of road signs.

Driving Experience

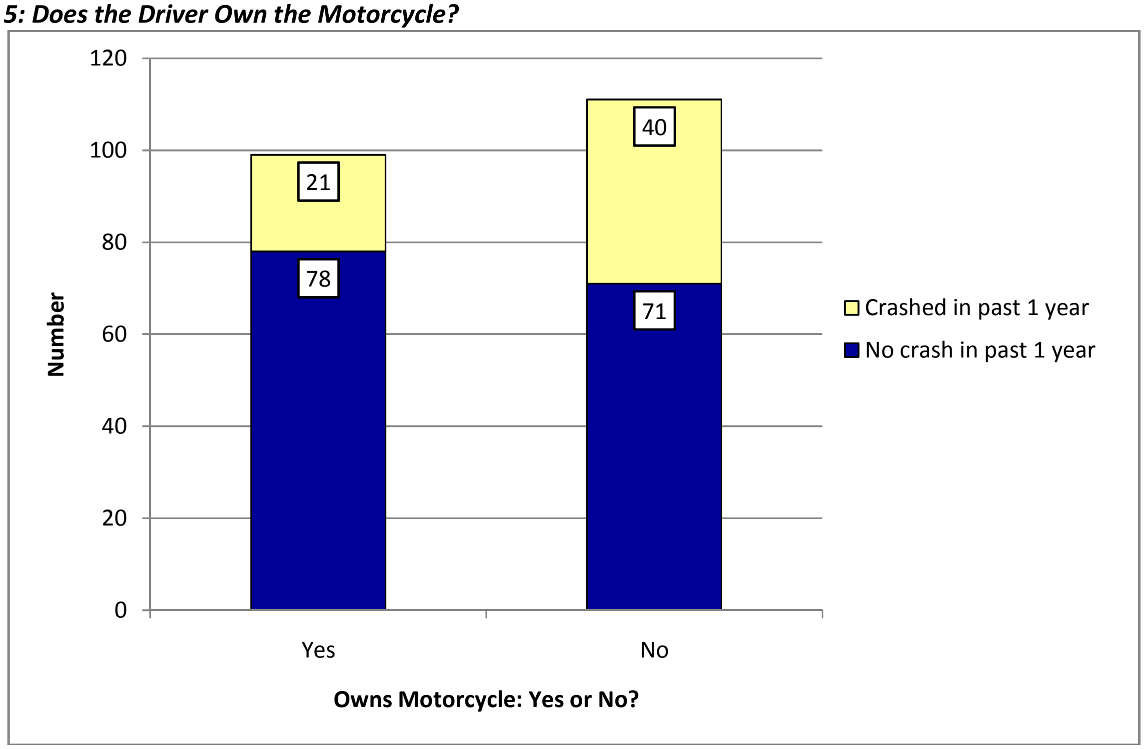
The average number of months of driving experience of the drivers who were interviewed was 26. There was no significant association between the length of experience and having experienced a crash within the twelve months prior to the questionnaire.

The majority (68.6%) of drivers said that they drive seven days per week. There was no significant association between the number of days driven per week and having experienced a crash.

Motorcycle Ownership, Use and Purpose

Just under 53% of drivers said that they do not own the motorcycle that they use. 47% said they do own the motorcycle. This is shown in the chart below, together with the numbers of drivers who have experienced a crash in the last twelve months.

Chart 5: Does the Driver Own the Motorcycle?



In the study areas, it is common for people to own a motorcycle as a means of business, renting it out to the driver, who will pay a daily fee and keep any amount that he earns above that as profit.

There is a statistically significant association between motorcycle ownership and having experienced a crash on a rough road within the twelve months prior to the interview. Of the 111 drivers who do not own the motorcycle that they use, 71 (64%) had crashed, while of the 99 who do own the motorcycle, only 21 (21%) had crashed.

Statistical analysis shows that those drivers who own their own motorcycle are less likely to have experienced a crash than those who do not own the motorcycle they use. The chi-square probability value of less than 0.018 shows that this is a statistically significant association.

Over 90% of the drivers interviewed said that they only regularly use one motorcycle. The remaining 10% said that they regularly use more than one motorcycle, even up to four. There was no significant association between the number of motorcycles regularly used and having experienced a crash.

Over 85% of the drivers interviewed said that the main purpose of their use of a motorcycle is to transport paying passengers, working as a motorcycle taxi (*boda-boda*) driver. The remaining 15% said that they mainly use their motorcycle for private use. There was no significant association between the purpose of use and having experienced a crash.

Approach to Driving

Over 80% of drivers said that they feel very confident driving a motorcycle. The remaining 20% said that they feel moderately confident. There is no association between confidence levels and having experienced a crash.

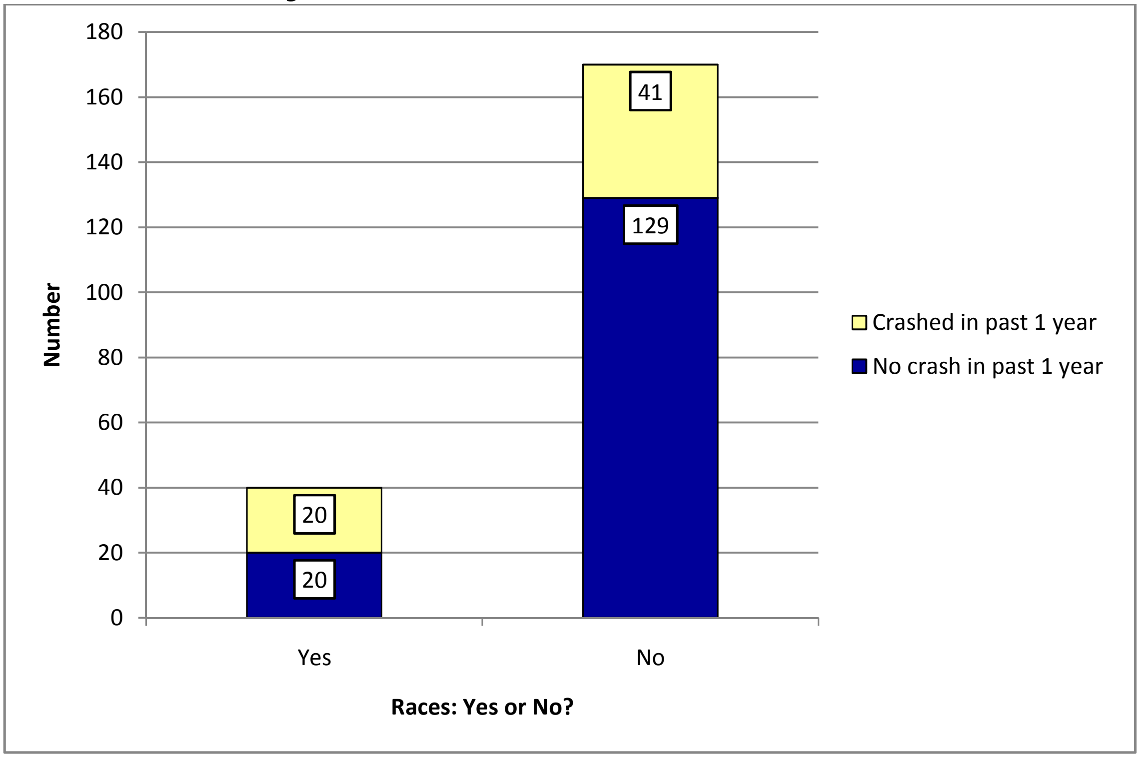
39% of drivers said that they sometimes or frequently feel in a hurry while driving their motorcycle. The remaining 61% said they rarely feel in a hurry. With a chi-square probability value of 0.053, this variable is just beyond the probability level cut-off for claiming a statistically significant association with having a motorcycle crash.

The vast majority (92%) of drivers said that they are very afraid of being involved in a crash. The remaining 8% said that they were either not afraid or only moderately afraid. Again, while not statistically significant (chi-square probability value = 0.055), there is an association, with those who are less afraid being more likely to have crashed.

The vast majority (90%) said that they do not enjoy driving their motorcycle at high speeds. The remaining 10% said they enjoy driving at high speeds sometimes or most of the time. There is no association between enjoying driving at high speeds and having experienced a crash.

The majority (81%) of drivers said that they never race against friends on other motorcycles, with 19% saying that they race sometimes or most of the time. This is shown in the chart below, together with the numbers of drivers who have experienced a crash in the last twelve months.

Chart 6: Does the Driver Race against Friends?



There is a significant association (chi-square probability value = 0.001) between those who race and having experienced a crash. Of the 40 drivers who said they race, either sometimes or frequently, 20 (50%) had suffered a crash on a rough road within the twelve months prior to the interview.

The majority (over 85%) of drivers said that they mostly use only the rear brake. Only 14% said they use both the front and rear brake together, and 1% said they use mostly the front brake. There is no significant association between brake use and having experienced a crash.

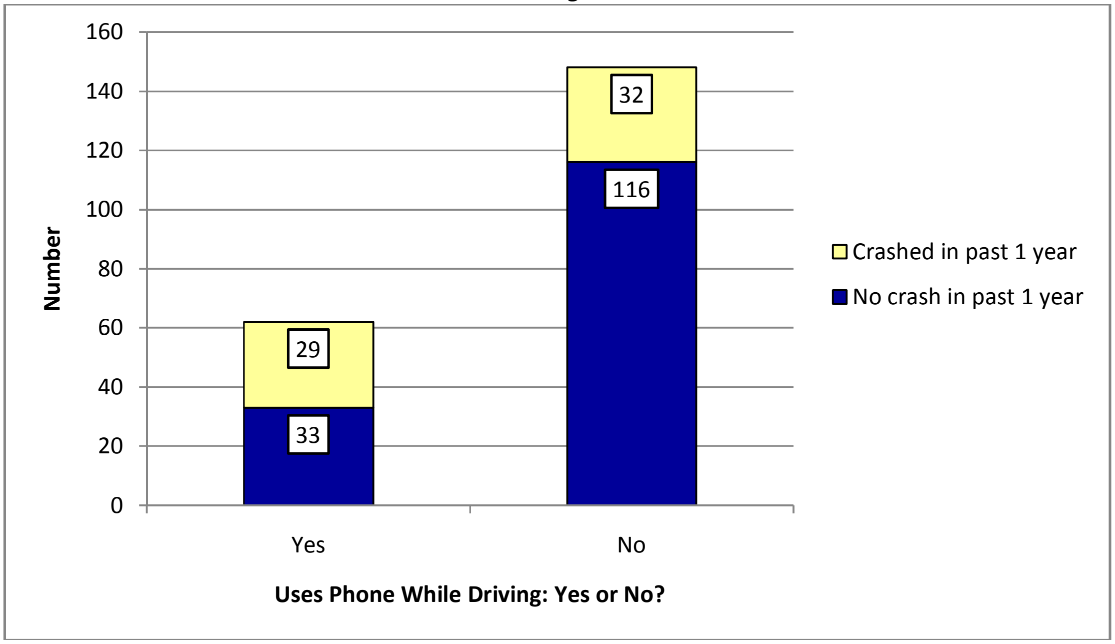
Driving Distractions

Of the 210 motorcycle drivers interviewed, the vast majority (93%) said that they never drank alcohol before driving. The remaining 7% said that they did drink before driving, either rarely, sometimes or frequently. There is no significant association between reported alcohol use and having experienced a crash.

All 210 drivers said they had never driven their motorcycle after using drugs.

The majority (70%) of drivers said that they never use their mobile phone while driving their motorcycle. The remaining 30% said that they use their mobile phone sometimes (which includes rarely and many times). This is shown in the chart below, together with the numbers of drivers who have experienced a crash in the last twelve months.

Chart 7: Does the Driver Use a Mobile Phone while Driving?



Statistical analysis shows a significant association between those who use their mobile phone and those who have experienced a crash. Drivers who use their mobile phone are more than two times more likely to have experienced a crash during the twelve months prior to the interview than those who said they never used their mobile phone while driving. A chi-square probability value of less than 0.0001 shows a statistically significant association.

Of the 210 drivers, the majority (83%) say that they never listen to music while driving. The remaining 17% say that they rarely, sometimes or frequently listen to music while driving. There is no significant association between listening to music and having crashed.

Use of Personal Protective Equipment

Of the 210 drivers interviewed, the majority (74%) said that they wear a helmet either all the time or most of the time. The remaining 26% said that they wear a helmet either only sometimes or never. While there was not a statistically significant association between helmet use and having experienced a crash, a chi-square probability value of 0.065 shows quite a strong association, with drivers who wear a helmet less likely to have experienced a crash.

The majority (61%) of drivers said that they wear eye protection (either a visor or glasses) always or most of the time while driving a motorcycle. Over 28% said that they sometimes wear eye protection, and the remaining over 10% said that they never wear eye protection. There was no association between wearing of eye protection and having experienced a crash.

80% of drivers say that they never wear reflective clothing while driving. There is no association between the use of reflective clothing and having suffered a crash.

Crashes and Injuries

Of all 210 drivers interviewed, almost half (49%) said that they had experienced a crash on a rough road at some point in their lifetime. The other 51% said they had never experienced a crash on a rough road.

For the 61 drivers who had experienced a crash on a rough road in the twelve months prior to the interview, they described the main cause of the crash as shown in the table below.

Table 11: Main Cause of Crash, according to Driver

Main Cause of Crash	*Number*	*Percentage*
Roadway damage or obstacle	*15*	*24.6%*
Other vehicle error	*14*	*23.0%*
Weather conditions	*10*	*16.4%*
Animal	*7*	*11.5%*
Motorcycle driver (self) error	*7*	*11.5%*
Vehicle failure	*6*	*9.8%*
Passenger behaviour	*1*	*1.6%*
Unintentional shifting of load	*1*	*1.6%*

The table shows that roadway damage or an obstacle in the roadway was most frequently cited by the drivers, followed by another vehicle. Only 11.5% of drivers described their own error as the main cause of the crash.

The most common type of injury suffered as a result of the crash was a scrape or scratch (36%). Other types of injury included burns, cuts, sprains and general pain. In 26% of crashes, no injury was suffered.

Of those who suffered injury, the most commonly injured body part was the legs (70%), followed by the arms (26%). Other drivers suffered injuries to their head, neck and back.

Motorcycle and Condition

Motorcycle Make

Twenty different makes of motorcycle were identified as being used by the drivers who participated in the questionnaire. By far the most popular was SANLG. The table below shows the numbers and percentages of motorcycles identified.

Table 12: Motorcycle Makes

Make of Motorcycle (Ranked 1-10)	*Number (and Percentage)*	*Make of Motorcycle (Ranked 11-20)*	*Number (and Percentage)*
1. SANLG	***95** (45.2%)*	*11. LIFAN*	***2** (1.0%)*
2. TOYO	***40** (19.0%)*	*12. SHINERAY*	***1** (0.5%)*
3. KINGLION	***16** (7.6%)*	*13. SKYMARK*	***1** (0.5%)*
4. HONDA	***10** (4.8%)*	*14. SANYA*	***1** (0.5%)*
5. FEKON	***8** (3.8%)*	*15. SUNLG*	***1** (0.5%)*
6. T-BETTER	***7** (3.3%)*	*16. YAMAHA*	***1** (0.5%)*
7. SKYGO	***7** (3.3%)*	*17. KINFAN*	***1** (0.5%)*
8. SRM	***6** (2.9%)*	*18. MTR*	***1** (0.5%)*
9. DAZ	***5** (2.4%)*	*19. HUASHA*	***1** (0.5%)*
10. BOXER	***5** (2.4%)*	*20. LINGKEN*	***1** (0.5%)*

Many of the most popular makes, including SANLG and KINGLION, are made in China. They are available in Tanzania for under 800 US dollars, which makes them affordable to an increasing portion of the population.

All 210 motorcycles had engine sizes of 150cc or less. The majority (61.9%) of motorcycles had engines of 125cc. Neither motorcycle make nor engine size were significantly associated with having experienced a crash in the last twelve months.

Drivers' Opinion of Motorcycle Condition

The table below shows the opinions of the 210 drivers' on the condition of various aspects of the motorcycles they were with at the time of the interview.

Table 13: Drivers' Opinions of Motorcycle Condition

Part of Motorcycle	Good Condition / Functioning Properly	Poor Condition / Functioning Improperly	Don't Know
Brakes	***193*** *(91.9%)*	***17*** *(8.1%)*	***0*** *(0.0%)*
Tyres	***178*** *(84.8%)*	***32*** *(15.2%)*	***0*** *(0.0%)*
Lights	***182*** *(86.7%)*	***27*** *(12.9%)*	***1*** *(0.4%)*

Of the 210 motorcycle drivers interviewed, 17 (8%) said that their brakes did not function properly. Of these 17, eight (47%) of the drivers had experienced a crash on a rough road within the 12 months prior to the inspection. Of the 193 drivers who said their motorcycles had properly functioning brakes, 53 (38%) of the drivers had experienced a crash. While the difference between the 47% and 38% is interesting, perhaps suggesting that drivers who think their motorcycles have improperly functioning brakes are more likely to have experienced a crash, the association is not statistically significant.

There was no association between the drivers' opinions on the condition of their motorcycle's lights and tyres and having experienced a crash.

Physical Inspection of Motorcycle Condition

The table below shows the condition of various parts of the 210 inspected motorcycles, as judged through a physical inspection by our trained Project Assistants, using technical equipment such as tyre depth and pressure gauges.

Table 14: Condition of Motorcycle Parts

Part of Motorcycle	Good Condition / Functioning Properly / At or Above Recommended Standard	Poor Condition / Functioning Improperly / Below Recommended Standard	Don't Know / Unable to Determine
Front Brake Free-Play	***111*** *(52.9%)*	***99*** *(47.1%)*	***0*** *(0.0%)*
Rear Brake Free-Play	***119*** *(56.7%)*	***91*** *(43.3%)*	***0*** *(0.0%)*
Headlight	***200*** *(95.2%)*	***10*** *(4.8%)*	***0*** *(0.0%)*
Tail Light	***138*** *(65.7%)*	***70*** *(33.3%)*	***2*** *(1.0%)*
Rear Brake Light	***100*** *(47.6%)*	***109*** *(51.9%)*	***1*** *(0.5%)*
Indicators (all (front and rear, left and right))	***114*** *(54.3%)*	***96*** *(45.7%)*	***0*** *(0.0%)*
Front Tyre Tread Depth	***138*** *(65.7%)*	***72*** *(34.3%)*	***0*** *(0.0%)*
Rear Tyre Tread Depth	***169*** *(80.5%)*	***41*** *(19.5%)*	***0*** *(0.0%)*
Front Tyre Pressure	***19*** *(9.0%)*	***191*** *(91.0%)*	***0*** *(0.0%)*
Rear Tyre Pressure	***123*** *(58.6%)*	***87*** *(41.4%)*	***0*** *(0.0%)*
Shock absorbers	***201*** *(95.7%)*	***8*** *(3.8%)*	***1*** *(0.5%)*
Chain	***56*** *(26.7%)*	***92*** *(43.8%)*	***62*** *(29.5%)*
Horn	***179*** *(85.2%)*	***31*** *(14.8%)*	***0*** *(0.0%)*
Accelerator	***165*** *(78.6%)*	***45*** *(21.4%)*	***0*** *(0.0%)*
Clutch	***148*** *(70.5%)*	***61*** *(29.0%)*	***1*** *(0.5%)*
Sprocket gear	***117*** *(55.7%)*	***30*** *(14.3%)*	***63*** *(30.0%)*
Driver foot pedals	***184*** *(87.6%)*	***26*** *(12.4%)*	***0*** *(0.0%)*
Passenger foot pedals	***202*** *(96.2%)*	***8*** *(3.8%)*	***0*** *(0.0%)*
Mirrors (both)	***162*** *(77.1%)*	***48*** *(22.9%)*	***0*** *(0.0%)*

The most commonly identified defect of the motorcycles inspected was the incorrect pressure of the front tyre, which was often seen to be under pressure and with tread depth below the recommended standard.

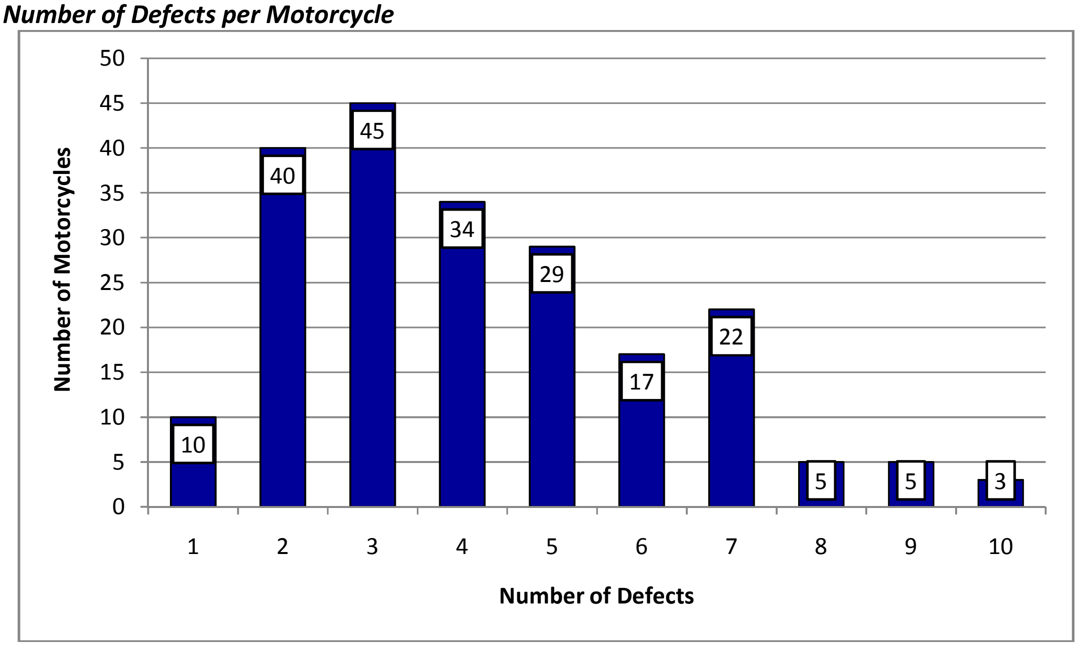
Brakes were often seen to be in poor condition, either being too tight or too loose, and the rear brake lights were not working on more than half of the motorcycles inspected.

There was no statistically significant association between any one defect and the driver of the inspected motorcycle having experienced a crash on a rough road within the twelve months prior to the interview and motorcycle inspection.

Categorising the defects as follows, the chart below shows the number of defects that each of the 210 inspected motorcycles had:

- Brakes (including both front and rear)
- Lights (including headlight, tail light and brake light)
- Indicators (all)
- Tyres (including both tread and pressure)
- Chain
- Horn
- Accelerator
- Clutch
- Sprocket gear
- Pedals (including both driver and passenger)
- Mirrors

Chart 8: Number of Defects per Motorcycle



The chart shows that 160 of the 210 motorcycles had three or more defects. There was no statistically significant association between the number of defects that a motorcycle had and the driver having experienced a crash on a rough road within the twelve months prior to the interview and motorcycle inspection.

Photo 23: A Project Assistant Inspecting a Motorcycle (B-T)

Driver Knowledge of Motorcycle Maintenance

Of the 210 drivers, the majority (89.5%) said that they know how to perform basic maintenance checks themselves. The remaining 10.5% said that they did not know.

There was no significant association between drivers' self-reported knowledge of basic maintenance and having experienced a crash.

Drivers' Perceptions on Road Safety

Drivers were asked for their opinions on what they believed were the most likely causes of motorcycle crashes on rough roads, and what they believed to be the three main factors to prevent those crashes. The top ten responses from the 210 drivers are given in the tables below (note that columns do not add up to 100% because more than one response was given by each driver).

Table 15: Drivers' Perceptions of Main Causes of Crashes

Rank	Causes of Crashes	Number of Drivers who Mentioned this Cause	Percent of Drivers who Mentioned this Cause
1	Driving at high speed / Overspeeding	152	72%
2	Poor road surfaces / Road conditions not well maintained for motorcycle driving (e.g. due to stones, sand, potholes etc.)	92	44%
3	Lack of driving skills / Lack of driving experience	62	30%
4	Vehicle/ mechanical problems (e.g. chain coming off, breakdown, tyre burst, worn tyres, defective horn, defective lights/signals, defective brakes)	53	25%
5	Driving under the influence of drugs / alcohol	32	15%
6	Animals crossing the roads	22	10%
7	Dust	18	9%
8	Sharp corners – cannot see oncoming traffic	17	8%
9	Narrow roads	17	8%
10	Other road users going into motorcyclists' right of way / Motorcyclists being ignored on the road	16	8%

The table shows that motorcycle drivers believed that driving at high speed was by far the most likely cause of a crash. It also shows that the poor condition of roads is a key concern for drivers.

Of the factors that could prevent crashes from occurring, the top 10 reasons cited by the 210 drivers are presented in the table below.

Table 16: Drivers' Opinions of Ways to Prevent Crashes

Rank	Crash Prevention Measures	Number of Drivers who Mentioned this Prevention	Percent of Drivers who Mentioned this Cause
1	Driving at appropriate speed / Reducing speed	127	60%
2	Concentrating on driving task / Being careful when driving	50	24%
3	Clearing roads of stones/sand/potholes/ Improve road surface	48	23%
4	Be competent and skilled in driving / Get professional driving training	44	21%
5	Regular & proper motorcycle maintenance / Ensure motorcycle parts are functioning	40	19%
6	Refrain from alcohol or drug use when driving	27	13%
7	Install road bumps to reduce speeds	26	12%
8	Put road signs	25	12%
9	Wear helmet/eye protection/face shield/other personal protective equipment	25	12%
10	Pay attention to other road users	18	9%

This data shows that motorcycle drivers are aware of both the dangers and safety measures associated with motorcycling, including their own risky behaviours and poor road conditions.

When asked which type of road user most frequently causes motorcycles to crash, the drivers gave the responses in the table below. (Note that this question did not specify that it referred to crashed on rough roads.)

Table 17: Drivers' Perceptions of Vehicles Most Likely to Cause Crash

Type of Road User	*Number of Drivers who Mentioned this Cause*	*Percent of Drivers who Mentioned this Cause*
Lorry, truck or bus	*55*	*26.2%*
Car	*31*	*14.8%*
Any type of road user (unspecified)	*28*	*13.3%*
The motorcycle driver himself	*26*	*12.4%*
Another motorcycle driver	*24*	*11.4%*
Pedestrian	*22*	*10.5%*
Bicyclist	*21*	*10.0%*
Motorcycle passenger	*3*	*1.4%*

The table shows that four-wheeled vehicles are most commonly blamed for causing motorcycles to crash.

When asked about the type of crash that they feel at risk of, the majority (84%) of drivers said that they are most at risk of being involved in a collision with another vehicle. 7% said they are at risk of experiencing a crash due to a problem with the motorcycle, 5% said due to the weather, environment or road condition. Only 4% said that they are at risk of a loss of control caused by their own error or some aspect of passenger behaviour.

9. Motorcycle Drivers' Opinions

9.1 Purpose

The purpose of the motorcycle drivers questionnaire on road surfaces was to obtain the opinions of motorcycle drivers on safety-related aspects of different road surfaces. We sought opinions specifically on the different surfaces trialled through the Surfacing Demonstration Project, as well as how the drivers feel wet conditions affect their safety.

9.2 Methodology

The opinions of drivers were collected using a survey questionnaire. To administer this questionnaire, a Project Assistant hired a motorcycle driver and rode as a passenger along the length of the study road. The Project Assistant had the driver stop after passing each of the different surface types and asked questions about how he drove on the different surfaces, and what risks he faced. Basic demographic information was also recorded.

The Drivers' Opinion Survey was intended to be carried out during the dry season data collection period, but due to the time-intensive nature of administering the survey, a total of only six participants were interviewed. During the rainy season data collection, more time was allocated to allow for the collection of drivers' opinions. A total of 190 drivers were surveyed during the rainy season: 100 at the Bago to Talawanda road and 90 at the Lawate to Kibong'oto road.

Eligibility to participate in the survey was governed by self-report of familiarity with the study road and regular practice of driving motorcycles.

As an incentive for participation, participating drivers received a pair of clear plastic safety glasses for eye protection while motorcycling, and were paid for the motorcycle hire.

The questionnaire can be found at Appendix I.

9.3 Findings

Demographics

The average age of the 190 motorcycle drivers who participated in the survey was 26 years, with the oldest being 58 years old and the youngest being 16. All drivers were male. Over two-thirds (129 (68%)) described '*boda-boda* driver' as their primary occupation. Almost one-quarter (45 (24%)) described themselves as 'farmers', with the remaining 8% mentioning other occupations.

On average, participants had 2.5 years of experience driving motorcycles, with the most experienced participant having over 15 years' experience and the least experienced having only two months. Only 68 of the 190 drivers (36%) said that they have a licence to drive a motorcycle, and of these, less than half had their licence with them at the time of the survey. The remaining 122 (64%) said that they do not have a driving licence.

72% of participants said they drive a motorcycle every day, and 95% said they drive at least five days per week. 39% said that they had crashed within the last year.

Opinions of Sealed Surfaces

Drivers commonly said that they like sealed surfaces and go fast on them, some saying they go up to 100 KPH. They like the smoothness and predictability, and say they are confident and relaxed on these surfaces.

Drivers commonly said that, when they encountered a four-wheeled vehicle coming in the opposite direction on sealed surfaces, they slow down and move to the side, but do not come to a complete stop.

The most common responses given by drivers at both study sites related to them being less confident in wet conditions because of the sealed surfaces becoming slippery and brakes not functioning as well as they do in dry conditions.

Opinions of Concrete Surfaces

Concrete Geocells

At both sites, drivers were in agreement that this surface was good to drive on, and that it allows them to drive at high speeds, although not as fast as on the sealed surfaces. They like the predictability of the surface.

At the Lawate to Kibong'oto road some drivers complained that, because the surface is rough, it wears the motorcycle tyres. However, they also said that the roughness helps tyres to grip the road, and that this means there is no difference in the driving experience when the road is wet.

The majority of drivers said that they would leave the carriageway and come to a complete stop if they encountered a four-wheeled vehicle coming in the opposite direction.

Concrete Slabs

Concrete Slabs were not used on the Bago to Talawanda road. On the Lawate to Kibong'oto road they were used on steep gradients.

The majority of drivers said that they like this surface, as it enables them to go fast downhill.

As with the Geocells, a small number complained that the roughness causes wear on motorcycle tyres, but they recognised that this helps with grip when the road surface is wet. Where the Concrete Slabs have not been scoured, they become slippery when wet.

The majority of drivers said they would leave the road and come to a complete stop if they encountered a four-wheeled vehicle coming in the opposite direction.

Parallel Concrete Strips

The most common comments made by drivers on Parallel Concrete Strips all related to the narrowness of the road, and how this makes it difficult to pass oncoming four-wheeled vehicles, both during dry and wet conditions. This difficulty increases during wet conditions.

There was a difference of opinion between drivers on how to drive on Parallel Concrete Strips. Some said that they are very confident and can go very fast, while others were concerned about the narrowness of each strip and how going from a strip onto the unpaved area between the strips can cause them to lose control. All drivers said they would completely leave the road and stop if they encountered a four-wheeled vehicle coming in the opposite direction. One driver specified that four-wheeled vehicles do not leave the strips to accommodate for motorcycles coming in the opposite direction.

Opinions of Block Surfaces

Hand-Packed Stone

Hand-Packed Stone Blocks were not used on the Lawate to Kibong'oto road – they were used only on the Bago to Talawanda road.

Drivers said that they go very slowly on this section because the road is rough. They complained of big stones with sharp edges and large spaces between the stones which can lead to loss of control and serious injury in the case of a crash.

Drivers commented that the hand-packed stones are more difficult to drive on during wet conditions, as the surface has become rougher since it was flooded and some stones have been dislodged. As well as being rough, the drivers commented that the stones can be slippery. These problems, combined with the narrowness of the carriageway, make it difficult for motorcycles to pass oncoming vehicles, in particular four-wheeled vehicles.

The majority of drivers said that they would leave the road completely and come to a complete stop if they encountered a four-wheeled vehicle coming in the opposite direction.

Paving Bricks

Paving Bricks were not used on the Bago to Talawanda road – they were used only at the Lawate market-place on the Lawate to Kibong'oto road.

All drivers said that they like this surface because it is predictable and smooth but has good grip. The driving experience is no different in wet conditions compared to dry.

They also like it because it is wide enough to not have to worry about vehicles coming in the opposite direction. They do not fear experiencing a crash here, but recognise the need to go slowly when there are a lot of pedestrians around. A small number of drivers said that it was good that speed bumps were used to encourage lower speeds.

Opinions of Unpaved Surfaces

The unpaved surfaces on the study roads are Engineered Natural Earth and Gravel Wearing Courses.

There was a big difference of opinion between drivers on how to drive on unpaved surfaces. Some said that they are very confident and can go very fast, while others said that they drive more slowly than on paved surfaces because of the unpredictability of encountering potholes and other defects.

Unpaved surfaces were particularly unpopular with drivers who use the Bago to Talawanda road. They complained about:

- Small stones creating a skid risk
- Larger stones creating risk of loss of control
- Potholes and other defects
- The surface becoming slippery when wet
- Their vision being obscured by dust when they pass another vehicle

Drivers who use the Lawate to Kibong'oto road were more positive about unpaved surfaces, saying that good drainage keeps the road clear of standing water. The only problem identified was that small stones create a skid risk.

The majority of drivers said that they would pull off the road and come to a complete stop if they encountered a four-wheeled vehicle coming in the opposite direction on this surface, although a small number say that they move to the side of the road and keep going.

Opinions of Bridges

The majority of drivers said that they go slowly across bridges because they are narrow and at dips and bends in the road, making it difficult to see if any vehicles is coming in the opposite direction. Drivers at the Lawate to Kibong'oto road said that the barriers on either side of the bridge were good, protecting them from going off the sides, and one specifically mentioned that it is good that these barriers were recently painted to alert drivers. Drivers at the Bago to Talawanda road complained that the bridge had no barriers. All drivers said that they would have to stop completely before the bridge if they encountered a four-wheeled vehicle coming in the opposite direction, to wait for it to pass.

Drivers also mentioned that the surfaces of bridges can be slippery when wet.

Opinions of Drifts

All drivers said that they have to slow down significantly to cross a drift, as the sudden dip in the road can cause them to lose control if encountered at high speed. Drivers noted that the concrete drifts are good because they make stretches of road passable, when previously they were impassable after rain.

Drivers at both study roads commonly said that they have to be very careful when crossing the drifts when there is standing or flowing water. They said they are not confident in passing through the water, and have to reduce to a slow speed.

Drivers commonly said that the blocks used to demarcate the downstream edge of the drifts are useful, and some suggested that these should be increased in height to ensure that they are not submerged, creating a hazard. Suggestions also included that reflectors be placed on these blocks to help them to be seen at night.

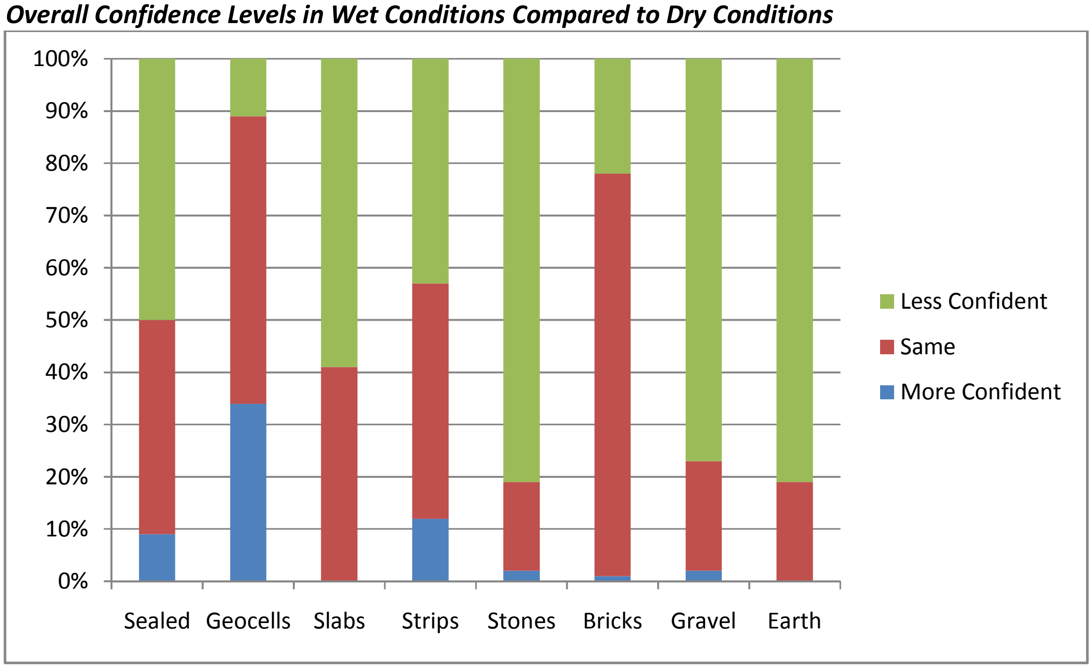
All drivers said that they would have to stop completely before the drift if they encountered a four-wheeled vehicle coming in the opposite direction.

Driver Behaviour in Wet Conditions

As part of the survey, drivers were asked to compare their experiences of driving on the study road in wet conditions with their experiences of driving on the study road in dry conditions, using a simple rating scale. The three charts below show how the drivers described the following:

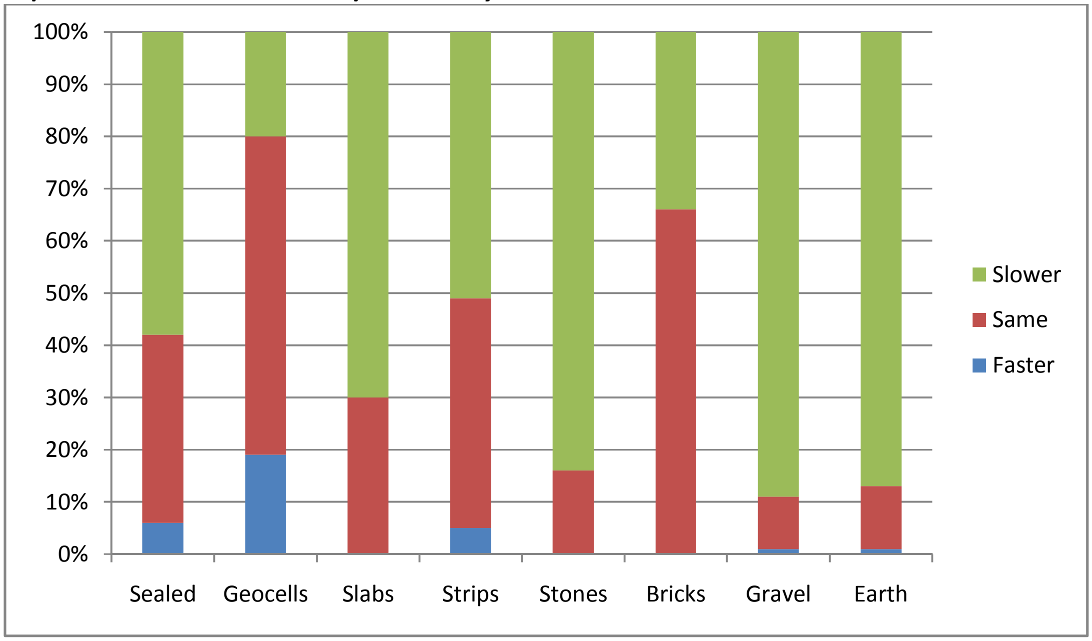
- Their overall confidence in wet conditions compared to dry
- Their driving speed in wet conditions compared to dry
- Their confidence in passing an oncoming four-wheeled vehicle in wet conditions compared to dry

Chart 9: Overall Confidence Levels in Wet Conditions Compared to Dry Conditions



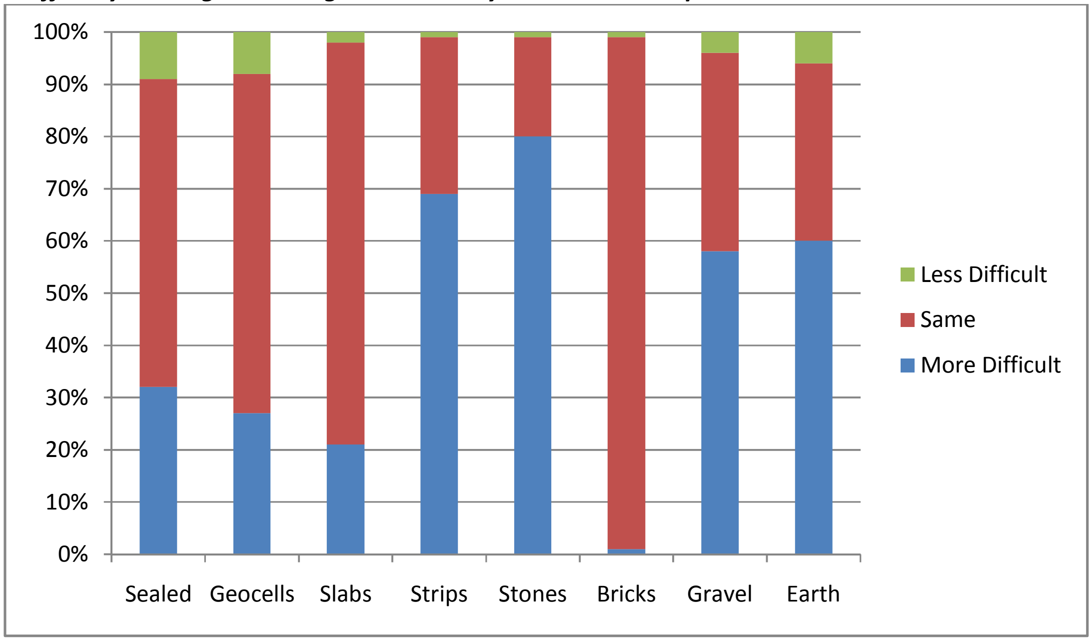
The chart shows that drivers are far less confident on the unpaved surfaces, and also on the Hand-Packed Stones, in wet conditions than they are in dry conditions. More than half of the drivers are also less confident on the Concrete Slabs and on the sealed surfaces in wet conditions. On the Paving Bricks, Parallel Concrete Strips and Concrete Geocells, the majority of drivers said their confidence levels did not change in wet conditions compared to dry. On the Geocells, over a third of drivers said that they were more confident in wet conditions than in dry conditions.

Chart 10: Speed in Wet Conditions Compared to Dry Conditions



The chart generally shows that speed is associated with the overall confidence levels shown in Chart10 above. Drivers say that they go more slowly during wet conditions on the unpaved surfaces, the Hand-Packed Stones and the sealed surfaces, which are the surfaces that they said they feel less confident on during wet conditions. Similarly, drivers also say that they go faster on the Concrete Geocells during wet conditions, which is consistent with them saying that they feel more confident on this surface.

Chart 11: Difficulty Passing Oncoming Vehicle in Dry Conditions Compared to Wet Conditions



The chart shows that the majority of drivers say that it becomes more difficult to pass an oncoming vehicle in wet conditions, compared to dry conditions, on the Parallel Concrete Strips, Hand-Packed Stones and the unpaved surfaces. On the sealed surfaces, Concrete Geocells, Concrete Slabs and Paving Bricks, the majority of drivers say that there is no difference in the difficulty of passing between wet and dry conditions.

Other findings related to driver behaviour in wet conditions are:

- 88% said that they are less likely to drive their motorcycle during wet conditions. 1% said they are more likely, and 11% said they are no less likely to drive in wet conditions compared to dry
- 17% said that they are more likely to wear a helmet during wet conditions. 2% said they are less likely, and 81% said they are no less likely to wear a helmet in wet conditions compared to dry
- 49% said that they are more likely to zigzag, not holding a steady driving line, during wet conditions. 41% said they are less likely, and 10% said they are no more likely to zigzag in wet conditions compared to dry
- 94% said that they considered themselves more likely to experience a crash during wet conditions. 1% said they are less likely, and 5% said they are no more likely to experience a crash in wet conditions compared to dry

Other Comments

Drivers commonly said that when driving a motorcycle, they must yield to larger vehicles. Some drivers also mentioned that they expect cyclists and pedestrians to yield to motorcycles.

10. Assessment of Motorcycle Speed Surveys on Different Surface Types

Speed is globally recognised as a risk factor in road traffic crashes.

10.1 Purpose

The main purpose of the speed surveys was to record motorcycle speeds on the different surface types along the study roads.

Supplementary information was collected on gradient, road surface condition, weather conditions, direction of travel, motorcycle passengers and driver distraction.

10.2 Methodology

For each road surface type, a location was chosen that afforded an unobstructed line of sight in both directions. Readings and observations were taken by a Project Assistant who stood to one side of the road, roughly half way between the two ends of the section of road. It was assumed that using the half-way point would give the motorcyclist coming in either direction adequate time to reach the speed that he considered appropriate for the surface type.

Due to the hilly environment through which both study roads pass, it was not possible to ensure that all survey locations were flat; some of the survey locations had a gradient that may have influenced the speed on that section. Also, if other road users were present at the survey location, it is possible that their presence could have influenced speed.

Motorcycles speeds were recorded using a speed radar gun, at the point just after having passed the Project Assistant. The reading was taken as the driver was moving away from the Project Assistant, in order to minimise driver distraction caused by the Project Assistants themselves.

Photo 24: A Project Assistant Carrying Out a Speed Survey (B-T)

Any driver distraction, such as use of mobile phone or talking to a passenger, was also observed and recorded, as was whether the driver was carrying one or more passengers. Whether or not it was raining, and whether or not the road surface was wet or dry, were also recorded, as was the road gradient.

The speed surveys were carried out during both the dry season and rainy season data collection periods, with the same methodology and the same survey locations used both times. The survey worksheet was modified slightly for the rainy season data collection, to ensure that it was relevant to wet conditions. The worksheet is included in Appendix J, with red, bold and italicised text used to show the minor differences between the dry season and the rainy season.

At each of the different types of road surface, during both the rainy season and the dry season, we took readings for a minimum of 30 motorcyclists travelling in each direction.

10.3 Findings

A total of 2,615 readings were taken. During the dry season, 620 readings were taken along the Bago to Talawanda road, and 627 were taken along the Lawate to Kibong'oto road. During the rainy season, 697 readings were taken along the Bago to Talawanda road, and 671 along the Lawate to Kibong'oto road.

Motorcycle Speeds and Surface Types

The table below shows the average speeds on each of the different road surface types at the two study roads, in three different weather and road conditions: No rain and dry road surface; No rain but wet road surface, and; Rain and wet road surface.

Table 18: Average Motorcycle Speeds on Different Road Surface Types, in Different Conditions

Surface Type	*Road Location*	*Road Gradient*	*Average speed (KPH): No rain, dry surface*	*Average speed (KPH): No rain, wet surface*	*Average speed (KPH): Rain, wet surface*	*Average speed (KPH): Overall*
Engineered Natural Earth	*Bago to Talawanda*	*Flat*	*39*	*36*	*36*	*38*
	Lawate to Kibong'oto	*Flat*	*32*	*N/A*	*N/A*	*32*
	Average		***36***	***36***	***36***	***36***
Sealed	*Bago to Talawanda*	*Flat*	*36*	*33*	*30*	*35*
	Lawate to Kibong'oto	*Flat*	*36*	*20*	*20*	*32*
	Average		***36***	***27***	***25***	***34***
Concrete Slabs	*Bago to Talawanda**	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
	Lawate to Kibong'oto	*Gentle Slope*	*31*	*16*	*17*	*24*
	Average		***31***	***16***	***17***	***24***
Parallel Concrete Strips	*Bago to Talawanda*	*Gentle Slope*	*40*	*N/A*	*N/A*	*40*
	Lawate to Kibong'oto	*Steep Slope*	*35*	*23*	*20*	*28*
	Average		***38***	***23***	***20***	***33***
Concrete Geocells	*Bago to Talawanda*	*Flat*	*37*	*36*	*43*	*37*
	Lawate to Kibong'oto	*Gentle Slope*	*29*	*18*	*20*	*25*
	Average		***33***	***27***	***32***	***31***
Paving Bricks	*Bago to Talawanda**	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
	Lawate to Kibong'oto	*Flat*	*24*	*N/A*	*N/A*	*24*
	Average		*24*	***N/A***	***N/A***	***24***
Hand-Packed Stone Blocks	*Bago to Talawanda*	*Flat*	*27*	*N/A*	*N/A*	*27*
	*Lawate to Kibong'oto**	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
	Average		***27***	***N/A***	***N/A***	***27***
Bridge	*Bago to Talawanda*	*Flat*	*24*	*19*	*17*	*22*
	Lawate to Kibong'oto	*Flat*	*17*	*11*	*11*	*16*
	Average		***21***	***15***	***14***	***19***
Drift	*Bago to Talawanda*	*Dip*	*32*	*16*	*N/A*	*23*
	Lawate to Kibong'oto	*Dip*	*25*	*12*	*N/A*	*18*
	Average		***29***	***14***	***N/A***	***21***
TOTAL	*Bago to Talawanda*		*35*	*25*	*32*	*33*
	Lawate to Kibong'oto		*29*	*19*	*18*	*26*
	Average		***32***	***22***	***25***	***29***

**Surface type not present at study road*

Note – 'N/A' is used either where the specific road surface type was not present at the study road, or where insufficient readings were taken under the specific weather and road surface conditions to provide a reliable average.

The table shows that generally, average motorcycle speeds were faster during dry conditions than in wet conditions (either when it is raining or when the road surface is wet). The only exception to this is on the Concrete Geocells along the Bago to Talawanda road, where higher average speeds were recorded during rain and on a wet road surface than during dry conditions.

The average speed of 43 KPH recorded during rain on wet Geocells along the Bago to Talawanda road was the highest average recorded on any road surface and during any conditions.

Along the Bago to Talawanda road, in dry conditions, there is little variation in the average speeds on different road surface types when motorcyclists are able to drive freely: 38 KPH on Engineered Natural Earth, 35 KPH on Sealed surfaces, 40 KPH on Parallel Concrete Strips, and 37 KPH on Concrete Geocells. This may indicate that drivers do not change their speed greatly depending on which surface type they are driving on. The lower average speeds on the bridges and drifts, and the largely unpopular Hand-Packed Stone Blocks, indicates that drivers slow down for significant obstacles.

Similarly, while speeds were generally lower along the Lawate to Kibong'oto road, again there is little variation in speeds on surfaces where motorcyclists are able to drive freely.

Somewhat surprisingly, the average speeds are higher when it is raining and the road surface is wet than when it is not raining but the road surface is wet. One explanation could be that motorcycle drivers go faster to reach their destination more quickly when it is raining than when it is not raining.

Overtaking of Motorcycles by Motorcycles

The average speed at which motorcycle drivers travelled on the study roads overall was approximately 30 KPH, with a standard deviation of 12 KPH. We observed a large range between high and low speeds, with a maximum observed speed of 80 KPH and a minimum of 7 KPH. This wide variation in speed demonstrates that there are high levels of overtaking of motorcycles by motorcycles along the study roads.

Motorcycle Speeds and Passengers

Of all 2,615 motorcycles observed, 1,455 (56%) were carrying one or more passengers, with the remaining 1,160 (44%) not carrying any passengers.

The average speed of all 1,455 motorcycles carrying passengers was 28 KPH, while the average speed of the 1,160 motorcycles not carrying passengers was 31 KPH.

Motorcycle Speeds and Driver Distraction

Of all 2,615 motorcycles observed, 2,060 of the drivers (78%) were not distracted. Of the 555 (21%) who were distracted in some way, the greatest form of distraction was talking to the passenger. Other forms of distraction included using a mobile phone, listening to music and adjusting clothing or mirrors, etc.

Only 16 drivers (less than 0.7%) were observed to be using a mobile phone while driving.

Those drivers who were distracted had a lower average speed (25 KPH) than those who were not distracted (30 KPH). The average speed of those who were talking to their passenger was 23 KPH, of those who were using a mobile phone was 23 KPH, and of those with another form of distraction was 30 KPH.

11. Motorcycle Passengers' Opinions

11.1 Purpose

The purpose of this activity was to obtain the opinions of *boda-boda* passengers in relation to safety and to understand their behaviour as passengers.

11.2 Methodology

The motorcycle passenger survey was carried out only during the dry season data collection period. This exercise was time-consuming and the information obtained was not as valuable as that obtained through other data collection activities. For these reasons, we decided not repeat it during the rainy season.

Project Assistants first sought to find passengers at *boda-boda* stands near the to study roads, but since these were places where people tended to be in a hurry, the Project Assistants also went to households to enquire whether people travelled using *boda-bodas*. If they responded positively, household members were asked to participate in the Motorcycle Passenger Questionnaire. The Project Assistants asked respondents questions about their experiences as motorcycle passengers, for example riding behaviours as passenger, opinions about motorcycle drivers' driving behaviours, and opinions on the safety of rural roads.

The Motorcycle Passenger Questionnaire is included at Appendix K.

11.3 Findings

We completed interviews with a total of 81 passengers: 49 in the area close to the Bago to Talawanda road and 32 in the area close to the Lawate to Kibong'oto road. All of the interviews

Demographics

The average age of the passengers was 36 years, with the youngest being 18 years old and the oldest being 80. Forty-three (53%) of the respondents were female and 38 (47%) were male.

Of the 81 passengers surveyed, 43 were female (53%) and 38 were male (47%).

The majority (58%) of respondents described themselves as using a boda-boda 'a few times a week'. 27% said they use a boda-boda 'a few times a month'. Small numbers said they used boda-bodas either less or more frequently than this.

Of the 81 passengers who participated in the Motorcycle Passenger Questionnaire, eight said that they had been involved in a crash within the past twelve months (six males and two females). This is a crash rate of 11 per 100 passengers per year.

Passenger Behaviour

84% of male passengers and 83% of female passengers said that they never wear a helmet. 13% of all passengers (13% of males and 14% of females) said that they sometimes or rarely wear a helmet, and only 4% of passengers overall said that they always wear a helmet.

The vast majority (100% of males and 93% of females) said that they sit facing forwards, with only three females saying that they sit sideways.

The majority - 79% of females and 82% of males - said that they prefer to travel as a passenger on a motorcycle that has a back-rest.

When asked how often passengers know the driver of the *boda-boda* they use, the most common answer was 'Most of the time', with 31% giving this answer. 23% said that they always know the driver. Only 4% said that they never know the driver. The remaining 42% said that they sometimes or rarely know the driver. Approximately equal numbers of males and females gave the same responses when asked this question.

The vast majority (over 91%) of respondents said that they feel comfortable and relaxed either 'Always' or 'Most of the time' while riding as a *boda-boda* passenger. The remaining less than 9% said that they only 'Sometimes' or 'Rarely' feel comfortable and relaxed. Again, the responses of male and female passengers were about equal.

19% of respondents (24% of males and 16% of females) said that they use a mobile phone while riding as a *boda-boda* passenger either 'Sometimes' or 'Most of the time'. 74% said that they never use a mobile phone while riding, with the remaining 7% saying 'Rarely'.

The vast majority (over 92%) said that they never or rarely tell their driver to go faster. Only 2% said that they always or frequently tell their driver to go faster, with the remaining 6% responding 'Sometimes'.

57% of respondents (50% of male passengers and 63% of female passengers) said that they never or rarely talk to their driver while he is driving, while the remaining 43% said that they sometimes or always talk to their driver.

Passenger Observations and Opinions of Driver Behaviour

When asked how often they feel their *boda-boda* driver is over-speeding, the passengers' most common response was 'Sometimes', given by 35% of passengers overall (37% of male and 33% of female passengers). 26% said 'Never' (18% of males and 33% of females), 20% said 'Frequently' or 'Most of the time' (29% of males and 12% of females), and the remaining 19% said 'Rarely' (16% of males and 23% of females). It appears that male passengers either more frequently noticed or more frequently experienced overspeeding by *boda-boda* drivers compared to female passengers.

The majority (62%) said that their *boda-boda* driver wears a helmet either always or most of the time. Only 4% said that their driver never wears a helmet, with the remaining 34% saying 'Sometimes'.

The majority (72%) said that they had never ridden as a passenger with a driver who they felt was under the influence of alcohol or drugs. Only 1% of respondents said that they felt drivers are frequently under the influence of alcohol or drugs. 19% said 'Sometimes' or 'Rarely', and the remaining 8% said that they did not know.

Only 37% of respondents said that they felt their driver was always in control. 54% said that their driver was in control 'Most of the time', although this would also imply that they were not in control for some of the time. 9% thought that their driver was only 'Sometimes', 'Rarely' or 'Never' in control. Roughly equal numbers of male and female passengers shared the same views.

When asked about aspects of drivers' behaviour which they considered to be dangerous, the following responses were given, in order of popularity:

- Overspeeding
- Use of alcohol and drugs before driving
- Not wearing a helmet while driving
- Talking on a mobile phone while driving
- Carrying more than one passenger at the same time

- Not slowing down at corners
- Driving a motorcycle with defective or missing parts
- Racing with other motorcycle drivers

When passengers were asked to mention one thing that could help to improve the safety of *boda-bodas*, the most popular response was for drivers to reduce their speed, with some passengers mentioning the use of speed bumps to encourage this. The second most popular response was to provide training and licensing to drivers.

When passengers were asked about aspects of road design and condition that they consider to be dangerous, the following responses were given, in order of popularity:

- Loose stones
- Potholes
- Narrowness, leading to difficulty for motorcycles to pass four-wheeled vehicles
- Dust
- Slipperiness, especially when wet
- Lack of road signs
- Lack of speed bumps

When passengers were asked about aspects of road design and condition that they consider should be improved to improve safety, the following responses were given, in order of popularity:

- The entire road surface should be sealed
- The road should be widened
- The road should be repaired
- Speed bumps should be installed
- Road signs should be erected
- Drainage should be improved
- Visibility at corners should be improved

12. Community Opinions

12.1 Purpose

To understand community members' opinions related to safety and changes in behaviour of motorcycle drivers since the improvements to the Bago to Talawanda road and Lawate to Kibong'oto road.

12.2 Methodology

The community survey was carried out only during the dry season data collection period. This exercise was time-consuming and the information obtained was not as valuable as that obtained through other data collection activities. For these reasons, it was not repeated during the rainy season.

Project Assistants approached individual community members by going from house to house along different sections of each study road.

Community members were asked to recall what road traffic conditions were like before the road improvements, and were asked to compare them to traffic movements currently, especially with respect to motorcycles. They were also asked what they thought about the safety of pedestrians and children since the road improvements, and whether they knew of any motorcycle-related crashes that had happened since the road was improved. The survey included open questions, with Project Assistants engaging respondents in discussion, allowing them to discuss any relevant issues.

The Community Survey is included at Appendix L.

12.3 Findings

We completed interviews with a total of 61 community members along the study roads: 30 along the Bago to Talawanda road and 31 along the Lawate to Kibong'oto road.

The average age of the community members was 38 years, with the youngest being 14 years old and the oldest being 76. 51% of the respondents were female and 49% were male.

Opinions on Motorcycle Number and Speeds

The table below summarises the responses to the speed-related questions of the community survey.

Table 19: Community Responses Related to Speed

Question	*Bago to Talawanda Road*		*Lawate to Kibong'oto Road*	
	'Yes' Responses	*'No' Responses*	*'Yes' Responses*	*'No' Responses*
Has the number of motorcycles using the road increased since the improvements?	***30*** *(100%)*	***0*** *(0%)*	***29*** *(94%)*	***2*** *(6%)*
Has there been an increase in the number of other vehicles using the road since the improvements?	***17*** *(57%)*	***13*** *(43%)*	***10*** *(32%)*	***21*** *(68%)*
Has there been an increase in motorcycle speeds along the road since the improvements?	***26*** *(87%)*	***4*** *(13%)*	***23*** *(74%)*	***8*** *(26%)*

In the communities along the Bago to Talawanda road, all members of the local community who were interviewed thought that the number of motorcycles using the road had increased since the improvements. 94%

of community members living along the Lawate to Kibong'oto road also felt there had been an increase in motorcycle numbers.

The same was not the case for other types of vehicles with a little over half of community members saying that these had increased along the Bago to Talawanda road, and the majority saying that the numbers had not increased along the Lawate to Kibong'oto road.

At both sites, the majority of community members interviewed thought that motorcycle speeds had increased.

During the interviews, other interesting points made by members of the communities include:

- Four people said that the Lawate to Kibong'oto road is now passable all year, even when it rains
- Two people said that since the improvements to the Bago to Talawanda road, they can now reach the main road and beyond more quickly
- Two people living along the Bago to Talawanda road said that local people have been selling land to get money for buying a motorcycle

Photo 25: A Project Assistant Speaking to a Member of the Community at Lawate (L-K)

Opinions on Interaction between Motorcycles and Other Road Users

Community members were asked how they think motorcycles interact with other road users, in particular with pedestrians.

The community living alongside the Bago to Talawanda road gave the following opinions:

- The majority think that motorcycle drivers do not reduce their speed when they encounter pedestrians
- Similarly, the majority thought that motorcycle drivers do not respect pedestrians. People said that pedestrians are in danger because of overspeeding motorcycles
- However, the vast majority said that motorcycles do use their horns when approaching pedestrians

- Community members said that pedestrians must be very careful and must be responsible for their own safety when walking along the road
- They said that pedestrians run off the road when they hear a motorcycle approaching, to avoid being hit

The community living alongside the Lawate to Kibong'oto road gave the following opinions:

- The majority think that motorcycle drivers do not reduce their speed when they encounter pedestrians
- However, the majority said that motorcycles do use their horns when approaching pedestrians
- Community members said that pedestrians must be very careful and must be responsible for their own safety when walking along the road
- But some people said that motorcycle drivers drive safely and interact well with pedestrians
- A few people blamed poor interaction between motorcycles and pedestrians on the roads being too narrow
- Others said that motorcycle drivers sometimes drive on the wrong side of the road

13. Discussion and Recommendations

13.1 The Big Picture: Culture, Poverty and Safety

Roads operate within systems of cultural norms. People's behaviour on roads reflects their behaviour in other aspects of life, and is greatly influenced by the culture within which they live. Cultural norms, such as hierarchies, apply on the roads in the same way that they apply in other areas of life.

One example of how this plays out on low-volume rural roads in Tanzania is that the right of way is given to the larger vehicle by the smaller vehicle. The predominant expectation, albeit informal, of such roads is this: cars yield to trucks; motorcycles yield to cars and trucks; bicycles yield to motorcycles, cars and trucks; and pedestrians yield to bicycles, motorcycles, cars and trucks. In the absence of enforcement of any official traffic laws, it is this cultural expectation that influences the behaviour of road users. When this expectation is not met, the smaller vehicle is at risk of being hit or run off the road.

Also, poverty cannot be overlooked when discussing issues of road safety. For many people living in rural Tanzania, poverty is a day-to-day reality. Money is tight, and individuals and families have difficult decisions to make on how to use scarce resources, on things like food, water, clothing, transport and children's education. Non-essential items and things that are considered to be luxuries will be prioritised below the essentials. Formal employment is scarce, and opportunities to make money are few. Education levels and literacy rates are low. Access to social services and transport services are also low.

When viewed through the lens of economics and culture, the increase in motorcycle ownership and usage, and in motorcycle-related crashes and injuries, is understandable. Examples of how poverty relates to motorcycle safety include:

- *Boda-bodas* are often the only available and affordable means of motorised transport for many people in rural areas
- Work as a *boda-boda* driver is popular among young uneducated males
- Drivers and passengers may not be able to afford personal protective equipment
- Motorcycle training and licensing services can be far away, meaning that drivers' skill levels can be low
- Drivers earn more the more trips they make, which may mean they choose to drive quickly

Safety may not be high on the list of priorities, both of drivers and passengers.

Comprehensive and sustainable improvements to rural road safety in Tanzania require systemic changes, which will only be achievable as part of a significant acceleration in the country's development. Improvements are needed in infrastructure, education, healthcare, law enforcement and many other areas. This is a long-term vision.

In the shorter term, there are practical efforts that different stakeholders can make to improve rural road safety.

13.2 Making Road Users Safer through Behaviour Change

Road user error was the most common factor in the crashes that were investigated as part of this research, contributing to 87% of all crashes. These errors were not only made by the motorcycle drivers themselves, but also by their passengers and by other road users such as drivers and passengers of other vehicles and pedestrians. This suggests that targeting all types of road users with efforts to improve their road use behaviour will be necessary to reduce motorcycle-related RTI.

Motorcycle Drivers

This research has identified that many motorcycle drivers lack proper training and have no more than the most basic driving skills. Many examples of unsafe road behaviour by motorcycle drivers were identified, including:

- Driving at speeds inappropriate for road conditions
- Not driving defensively
- Not slowing down in settlements and other areas with many pedestrians
- Driving erratically, including zigzagging and using the wrong side of the road
- Driving too close to the vehicle in front
- Coasting down hills
- Accelerating fast and braking hard
- Failing to use the front brake
- Overloading the motorcycle, especially on roads with steep gradients, or poorly attaching loads
- Failing to keep both hands on the handgrips
- Being easily distracted
- Failing to use protective clothing and equipment

It is important that curricula developed as part of rural motorcycle driver training programmes address these common behaviours among rural drivers. In addition, behaviour change communication programmes must address the multi-factorial risks that rural motorcycle drivers engage in.

This study's Risk and Protective Factors Questionnaire has shown that drivers have a basic awareness of the risks that they take, and understand how to reduce those risks. But many still engage in risky behaviour.

As discussed above, motorcycle drivers' behaviours are mediated by a wide and complex range of inputs, which means that even if they have the knowledge or intentions to act safely while riding a motorcycle, they may not always do so.

Simple one-off education or awareness campaigns are insufficient to enact long-lasting behaviour change among motorcycle drivers. In addition to the fact that motorcycle drivers already have some basic knowledge of the basics of motorcycle driving, safety, and injury prevention - as we have seen in the Risk and Protective Factors Questionnaire, simple education programs fail to take into account the wider context that motorcycle riders operate in. Well-researched and well-presented on-going training programs are a more appropriate platform for promoting behaviour change interventions, and should be pursued in favour of one-time visits and simple messages. It seems that most motorcycle drivers are cooperative and want to do the right thing, but they must be slowly but surely nudged towards safe road use.

Greater attention should be paid to understanding behavioural motivations and where they come from, understanding how priorities are formed when resources are few, and the context in which decisions are made.

Rather than simply dictating messages to drivers, saying 'Don't do this', and 'Don't do that', efforts to change behaviour could focus on, for example, reinforcing notions of responsibilities to wives and children, understanding how to effectively target young drivers, reminding drivers of the potential social and financial impacts of being injured and damaging the motorcycle, and highlighting the prestige of being a skilled, licensed driver.

Underlying all of this are the essential components of practical training and enforcement of laws. Improving a motorcyclist's driving ability also improves their awareness and appreciation of safety risks, thus any discussion on improving behaviour to improve road safety must consider how to deliver effective driver training programmes at reasonable cost to rural motorcycle drivers.

Concurrently, effective police enforcement of existing traffic laws is required to reinforce safety behaviours such as helmet wearing (among both drivers and passengers), obeying speed limits and drink-driving. Comprehensive and sustainable improvements to the behaviour of motorcycle drivers are a long-term objective, requiring government commitment and a multi-sectoral approach. This will be discussed further below.

Other Road Users

The same complexities that exist for motorcycle drivers are also present for other road users, where stronger priorities, or lack of full awareness of the impact of road traffic injury, may result in safety being given inadequate consideration.

Motorcycle passengers have more power and control than they perhaps realise regarding the safety of a motorcycle journey. In our research, we observed that motorcycle drivers ride more slowly when they are transporting passengers. Motorcycle drivers also tend to follow their passengers requests. Behaviour change programmes aimed at motorcycle passengers can focus on empowering them with knowledge and strategies to be able to choose a safe driver and to ask a driver to drive safely. Passengers demanding safer driving standards present an opportunity to bring motorcycle safety up to a higher level.

Road safety for pedestrians and children is not an easy matter given that much of public life in rural communities can play out very close to a road. In addition, improving safety for pedestrians can be difficult given their place at the very bottom of the road user hierarchy in Tanzania. Yet, behaviour change programmes have a role to play in empowering pedestrians and children to be safer on the roads. Road safety programmes should be introduced in roadside communities and road safety education in schools should be improved.

For drivers of four-wheeled vehicles, road safety initiatives should focus on the need to consider more vulnerable road users, including reducing their speed when encountering a motorcycle coming in the opposite direction, and giving the motorcycle space to pass safely.

13.3 Making Roads Safer through Engineering and Maintenance

Previous research by Amend in Bagamoyo and Siha Districts has shown that almost 90% of the motorised vehicles using low-volume rural roads are motorcycles. Official figures show that the number of motorcycles in Tanzania is increasing rapidly. This study's Community Survey found that almost all community members said that motorcycle numbers, and speeds, have increased since the improvements of the Bago to Talawanda and Lawate to Kibong'oto roads.

The findings of this research, in particular that 1) The Road Safety Engineer and Motorcycle Safety Expert found certain specific elements of road design and condition to create risk for motorcycles, 2) Road design and condition was attributed as a contributory factor in 26 of the 45 crashes investigated, 3) 44% of drivers perceive road condition to be the main cause of crashes, and 4) Drivers said that, due to narrowness they are often forced off the road when they encounter a vehicle coming in the opposite direction, suggest that low-volume rural roads could be made safer through engineering and maintenance.

This provides a strong argument for planners and engineers to take motorcycles into account as new roads are built and existing roads are upgraded and maintained. Safer roads are more forgiving of poor road user behaviour.

However, it is recognised that road improvements inevitably involve compromise, balancing cost against specifications, including those related to safety. Tanzania is a vast country, requiring major investments in road infrastructure. Inevitably, the money will not be enough, and so resources will need to be allocated carefully. The design must be affordable but safe. Lower cost designs mean that more rural roads can be improved, but should not compromise safety. Effective preventive maintenance can increase the life of roads and increase safety.

The Environmentally Optimised Design and Spot Improvement philosophies proposed by Roughton International appear to be suitable approaches for low-volume rural roads in Tanzania. In applying these, engineers select the most suitable road surface type for each section of road based on an assessment of the local environment and locally-available materials, so as to not 'over-engineer' rural roads.

Here, we provide some recommendations for relatively simple, low-cost options available to engineers, which could complement the Environmentally Optimised Design and Spot Improvement approaches, to improve the safety of motorcyclists.

(It should be noted that the implementation of any of these recommendations that fall outside current guidance, such as that in the Tanzanian Pavement and Materials Design Manual (1999), the Tanzanian Road Geometric Design Manual (2011), and the Tanzanian Guide to Traffic Signing (2009), should follow the correct procedures for approval and authorisation.)

Road Geometric Design

A road's geometric design is inevitably a compromise, balancing cost against specifications, including those for safety. On low-volume, single-track roads the road width is critical for motorcycle safety, and is arguably more important than the surface type.

Recommendations related to cross-section design for improving motorcycle safety are:

- The carriageway (traffic lanes and shoulder) must be wide enough to take the traffic (including the occasional passing of two vehicles) but not so wide as to encourage excessive speeds
- On very low volume roads (Annual Average Daily Traffic (four-wheeled vehicles) <100) the design event should be a car passing a motorcycle at low speed. This implies a total width of between 4.3m and 4.5m, including the shoulder, assuming:
    - Car width 2.0m
    - Motorcycle width 1.0m
    - Clearance between vehicles 0.5m
    - Clearance to edge (shoulder) 0.4 to 0.5m
    - Four-wheeled vehicles do not move over to allow motorcycles to pass

  It is critically important that the road formation is at least 4.3m wide. Side slopes, cut slopes and drains must start at or beyond this limit. A road width of 4.3m will also enable two cars to pass each other at very low speed
- At those places where the road needs to be paved to provide all-year-round accessibility, there is a good case for paving the full width (4.3m), particularly in view of the difficulties that District Engineers face in maintaining unpaved shoulders in good condition. Where this is not affordable, the construction of a 3.8m wide paved carriageway (with narrow unpaved shoulders) will allow most motorcyclists to pass a car at low speed without having to leave the paved carriageway
- On roads with paved carriageways it is essential that any unpaved shoulders are built to a good standard and are well maintained – the narrower the paved carriageway the more important this becomes. Shoulders should be strong and kept free of overgrowth and loose material. Excessive crossfall must be avoided

- Effective drainage is recognised as being very important, but side drains should not present a hazard to motorists and vulnerable road users, including motorcyclists. Shallow, wide drains are more forgiving, although it is acknowledged that, if their capacity is lower, there may have to be more culverts or discharge points. If deep drains are used, they should be covered. In some situations lined drains can provide structural support to the shoulder
- It is unclear whether the provision of passing bays on very low-volume rural roads would have a positive impact on motorcycle safety. If passing bays are provided, they should be frequent, well-signed and adequately dimensioned

Road Surfaces

Most of the road surfaces trialled by Roughton International through the Surfacing Demonstration Project can be safe if they are well-designed and are complemented by supporting infrastructure and effective maintenance.

Below we look at the key safety concerns of each surface type, and provide recommendations on how these may be addressed.

Sealed Surfaces

The key safety concern on sealed surfaces is the smoothness of their texture and the resulting lack of skid resistance, especially when wet. This was especially the case on the Sand Seals and in parts of the surfaces where 'fatting up' had occurred.

Another concern is the speed at which sealed surfaces allow motorcycles and other vehicles to travel, although this concern is not exclusive to sealed surfaces.

Recommendations to address these concerns are:

- Smooth surfaces with a mean texture depth of less than about 1.5 mm should be avoided as they may be slippery when wet
- For the bituminous surfaces, the correct mix of bitumen and aggregate should be used to prevent 'fatting up', where the most-used sections of the surface become slippery
- If Slurry Seals are to be further considered as an appropriate surface, a safety assessment should be undertaken of a well-constructed surface, as the surface assessed in this study was of poor quality
- Speed humps should be considered for use on sealed surfaces, especially where they are used through villages or in other areas with a high level of interaction with pedestrians

Concrete Geocells

There are three key concerns with Concrete Geocells:

- The roughness of the surface on some sections, which can cause vibrations through a motorcycle's handlebars into the driver's hands, and
- Drops at the edges and joins of the concrete surface with earth shoulders and carriageways
- The speed at which the surface allows motorcycles and other vehicles to travel

Recommendations for addressing these concerns are:

- Further experimentation with this surface type should be carried out in Tanzania, to identify the correct design technique to avoid excessive roughness. For example, the roughness on some of the sections on the Lawate to Kibong'oto road could be related to the steep gradient. The balance needs to be found between roughness and smoothness
- In places along the study roads, where concrete sections meet earth sections, the end of the concrete surface has been angled downwards to create a smooth ramp rather than a sharp edge or drop. This solution may also be applied to the edges between the concrete and the shoulders. Maintenance, discussed below, is also required to prevent differences in level occurring at the joins between surface types
- Speed humps should be considered for use on Concrete Geocells, especially where they are used through villages or in other areas with a high level of interaction with pedestrians

Spalling, where the concrete breaks up, possibly leaving loose material on the surface, could become a concern with time. Any loose material should be brushed off.

Concrete Slabs

The same three concerns that apply to the Concrete Geocells also apply to the Concrete Slabs, although on the Slabs the roughness is caused by grooves used to add texture. It is recommended that these grooves are used, but they are made not too deep.

The recommendations related to where concrete sections meet earth sections and earth shoulders, and related to speed humps, also apply to Concrete Slabs. Spalling could also become a concern.

Parallel Concrete Strips

The key safety concerns related to the Parallel Concrete Strips are:

- The strips giving a sense of 'ownership' to the drivers of four-wheeled vehicles, meaning that they are unlikely to move for motorcycle
- The speed at which the strips enable drivers to use (although this is not unique to the strips) and the risk of losing control if coming off the strip onto a rough surface at the side or in the middle of the strips
- Erosion of the shoulders and the central portion of the road, resulting in edge drops and steps

To mitigate these risks, where Parallel Concrete Strips are used, we would recommend the following:

- They should only be used on straight stretches of road where motorcycle drivers are able to see approaching vehicles from afar, to allow drivers time to safely pull off to the side of the road and stop. They should be avoided on corners and at the brows of hills
- The roadway needs to be sufficiently wide (see the recommendations on Road Cross-Sections above) to allow a motorcycle to stop at the side of the road for a four-wheeled vehicle to pass, assuming that the four-wheeled vehicle will not leave the Parallel Concrete Strips
- Speed humps should be considered for use on Concrete Geocells, especially where they are used through villages or in other areas with a high level of interaction with pedestrians
- Maintenance, discussed below, should prevent the formation of edge drops between the concrete and the earth shoulder

Hand-Packed Stone Blocks

The Hand-Packed Stone Blocks section assessed in this study had not been well-constructed, and the quality of the surface was made worse during flooding that occurred shortly before the rainy season data collection period. This surface was identified as being unpopular with motorcycle drivers. Safety risks of this surface include:

- Large stones and sharp edges, with large spaces in between the stones, which can lead to loss of control
- A fall on such large stones, even at a low speed, can result in serious injury

To mitigate these risks, where Hand-Packed Stone Blocks are used, we would recommend the following:

- Construction should avoid sharp edges and large spaces between stones
- If a surface friendly to motorcyclists cannot be achieved but this construction method is to be used, a narrow smoother pathway should be designed into the surface on either side of the roadway, for use by motorcycles
- Avoiding using this surface in flood-prone areas

Paving Bricks

There are no safety concerns related to this surface type.

The use of speed humps is appropriate in a location like the marketplace at Lawate, although this should extend to the edge of the road to ensure that motorcyclists do not put themselves at risk by trying to bypass them.

Unpaved Surfaces

Of the 45 crashes investigated through this study, 16% were attributed to poor road conditions due to rain on unpaved surfaces. Unpaved surfaces can be very slippery when wet. The worst sections, which can become impassable during the rainy season, should be upgraded using the most appropriate of the other surfaces.

Gravelling, if done well and regularly, can improve unpaved surfaces in both dry and wet conditions, although use of overly large stones should be avoided.

When unpaved surfaces are in good condition, motorcyclists have been observed to use high speeds. The use of speed humps should be considered where unpaved surfaces approach potential hazards.

Join between Two Surfaces

The join where one surface type meets another can pose a safety risks to motorcyclists, for example if the height of one surface is different to that of the adjoining surface, or if one surface requires lower speeds than the adjoining surface. As well as through maintenance, which is addressed below, recommendations for reducing these risks are:

- The surface type should only change at places with good forward visibility and a safe stopping sight distance
- The surface type should never change at the top of a hill, on steep gradients or on curves
- Marker posts should be used to inform drivers of a change in surface types

Road Maintenance

Maintenance is a key factor in ensuring the successful operation of a road. Not only can poor maintenance or a lack of maintenance make a road impassable, it can also make a road dangerous.

In Tanzania, road maintenance poses a significant challenge, due to the significant proportion of the road network which is unpaved and due to the impact that the rainy seasons have on such roads. It is recognised that significant improvements have been made to the road maintenance system in recent years, at both national and local government levels, although challenges remain. Maintenance is an important part of LGTP2.

However, the strategic approach of LGTP2 is to give priority to the maintenance of infrastructure in good or fair condition, while for roads in poor condition, the priority of maintenance should be to increase passability. This may mean that road safety is not seen as a priority for maintenance activities.

We have seen through this study how poorly maintained roads can increase the risk of crashes for motorcycles and other road users, especially during the rainy season. We have also identified how maintenance activities can reduce risks and increase motorcycle safety. These maintenance activities are:

- Preventing excessive erosion of earth surfaces where they join with more weather-resistant sealed, concrete or block surfaces, to prevent the formation of a drop or step
- Preventing the creation of edge drops between concrete surfaces and softer earth shoulders, and between the Parallel Concrete Strips and chevrons and the softer earth section between the strips
- Maintaining shoulders in good condition, for example keeping them strong and flat, and clearing vegetation and loose stones
- Keeping carriageways and shoulders free of aggregate and large loose stones through regular brushing, to minimise skid risk
- Properly compacting gravel to reduce loose stones and minimise erosion
- Regularly re-packing dislodged stones on Hand-Packed Stone Block sections, and ensuring that pathways used by motorcycles are clear of large loose stones
- Grading unpaved sections to reduce bumps, potholes and grooves

In planning and designing road improvements, District Engineers should make a realistic assessment of their ability to maintain the roads in the condition to which they will be improved. Doing so may help District Engineers to identify which surfacing type and which geometrical design to adopt. Maintenance considerations should include maintenance related to safety.

If the capacity for maintenance is low, a surface type which requires high levels of maintenance, such as Parallel Concrete Strips, should be avoided.

Speed Humps

Where roads pass through settlements and other places of pedestrian activity, such as near schools and marketplaces, it may be necessary to control the speeds of motorcycles and other vehicles using speed humps. For many reasons, it is preferable to include speed humps during the design stage, rather than including them as an after-thought. As speed humps generally benefit poorer communities without education or influence, it is important that engineers consider them when designing and improving roads.

Not providing speed humps can result in an incident such as that along the Bago to Talawanda road, where a child was hit by a motorcycle, leading the local community to break the road and erect their own informal speed humps. Informally constructed speed humps pose a safety risk for motorcyclists, as they create an unpredictable road surface and are usually not signed. They also damage the road, resulting in the need for unplanned maintenance.

District Engineers should liaise with local communities to understand safety concerns and implement road safety measures at the design stage. It is possible that the local people will not understand the need for speed humps before the road is built, so the engineer should take the lead in the process of identifying where they should be located.

Speed humps should be included as standard on roads where drivers are able to use speeds in excess of around 40 KPH, where these roads pass through settlements, or approaching other potential hazards such as bridges and drifts. This includes on unpaved roads.

Speed humps should be signed and complemented with bollards (painted and with reflectors) to warn of their presence and to prevent motorcycles from passing around the side of them.

Signage

Signs should be restricted to situations where there is a real need to inform road users – either about priorities (a junction with a main road, for example) or a significant hazard that is not easily seen or understood (a speed hump, for example).

Warning of minor hazards, such as bridges, drifts, large culverts, sharp bends, roadside drop-offs, and changes in surface, is best given by marker posts (with a reflector), although an upright sign might be necessary if a marker post could not be seen from a distance. Safety barriers are not normally cost-effective on low volume rural roads, and guard posts (large diameter marker posts) may provide a better option.

Temporary signage should be used when roadworks are being carried out.

It is understood that the Association of Southern African National Road Agencies (ASANRA) is currently developing guidelines for dealing with the problem of vandalism and theft of road signs. These guidelines should be reviewed for appropriateness in the design of signs for rural roads in Tanzania.

Blind Corners

Cutting back vegetation and earth banks in order to improve and maintain forward visibility should be an important part of any maintenance programme. Vegetation grows particularly quickly during the rainy season.

Bridges

Bridges should be protected by barriers on each side. They should be painted and signed, to alert drivers of their presence.

As bridges are often at a low point of the road, with slopes leading down to and up from them, with bends and with vegetation, drivers' vision is often obscured. Efforts should be made to keep vegetation cut back, to allow longer lines of sight on the approach to a bridge.

Drifts

Drifts should be bounded by bollards or masonry blocks on either side, to mark the location of the road at times when they are covered with water. These bollards or masonry blocks should have reflectors and should be of sufficient height to be seen during times of flood.

Roadsides

An effort should be made to provide a soft, forgiving roadside if this can be achieved at low cost, and without damage to the environment. Large hard objects, such as large trees and rocks, should be removed from the roadside, so that in the event of a crash, motorcyclists are more likely to collide with soft vegetation.

13.4 Longer-Term: Making Roads Safer through Systemic Changes

Comprehensive and sustainable reductions in motorcycle-related RTI rates are a long-term vision, dependent on numerous sectors and institutions. In developed countries, RTI rates did not come down overnight – it took decades – and systemic changes should not be expected overnight in sub-Saharan Africa either.

However, the recent progress on the formation of a National Road Safety Agency for Tanzania is a positive step forward, and it is hoped that this agency will lead and coordinate all stakeholders to bring about the necessary systemic changes.

Potential changes, the need for which is either identified or supported by the findings of this research, include:

Improvements to Motorcycle Training, Testing and Licensing System

This study identified that very low numbers of motorcycle drivers possess driving licences, and even lower numbers have ever received any kind of formal training. Most drivers are either taught by their friends and relatives, or are self-taught.

Our previous work has revealed the challenges that exist within the current system of training, testing and licensing, for example long distances between testing centres, low-quality training, undemanding testing, and delays and lack of clarity within the administrative process.

Opportunities for improving this system should be investigated.

Include Community Road Safety Programmes in Road Improvement Projects

It has become increasingly common in recent years for road safety programmes to be incorporated into projects for the construction or upgrading of major highways. However, this is not currently the case for improvements to low-volume rural roads.

This research has shown how the numbers of motorcycles using such roads is increasing rapidly, including on roads which have recently been upgraded to being passable year-round. The drivers of these motorcycles need to be encouraged and enabled to keep themselves and other road users safe. Likewise, citizens who will use or live near the improved roads need to understand the new risks they face with changes to their environment.

To maximise the benefits of such programmes, further research is needed into the most effective design and implementation approach. They need to promote a culture of safety.

Increase Road Safety Capacity within Local Government Authorities

Local Government Authorities currently do not have a member of staff responsible for road safety. At a local level, some road safety activities may be carried out by the Traffic Police, but these tend to be uncoordinated and implemented on a very small scale.

The appointment of a Road Safety Officer within Local Government Authorities should be investigated. Their role could include coordinating all activities within the district or ward, organising regular mobile training, testing and licensing events, and managing the implementation of community road safety programmes.

Involve Local Communities in Road Maintenance

During the course of this research, we identified how communities are willing to contribute their own time, energy and money to improving the safety of local roads. At one village along the Bago to Talawanda road, villagers had bought cement and constructed three speed bumps after a child was hit by a speeding motorcycle.

Harnessing this commitment and spirit of volunteerism, which exists in some communities, could help Local Government Authorities with simple tasks such as filling pot-holes, cutting back vegetation to maintain lines of sight, and keeping shoulders clear and free of loose material.

Further investigation would need to be carried out to understand how this could be implemented and managed.

Improving the Practice of Renting of Motorcycles for Use as *Boda-Bodas*

This research has shown a statistically significant association whereby *boda-boda* drivers who do not own their own motorcycle, but ride a motorcycle that they rent or borrow from someone else, are more likely to crash than those who ride their own motorcycle.

Investigations should be made into this practice, and how safety surrounding rented motorcycles can be improved, for example by supporting *boda-boda* drivers to collectivise to demand regular maintenance and to minimise the pressure to drive at high speeds.

Enforcement of Laws

Ultimately, what makes roads safer is the adherence to a set of rules which treat all road users equally. It is only when the culture of priority being assumed by the larger vehicle or road user is changed, and when all road users begin to respect each other, that Tanzania’s roads will become systematically safer.

To change this culture requires the application and enforcement of traffic laws which protect all road users. Laws should be made and enforced based to address known risk factors.

13.5 Further Research and Pilot Programmes

While the results of this study and other studies have begun to build the knowledge base around the causes and impact of motorcycle crashes in sub-Saharan Africa, much remains to be understood.

Likewise, many lessons can be learned about effective, evidence-based motorcycle injury prevention measures from elsewhere in the world and from work conducted in sub-Saharan Africa to date, but there is still a long way to go.

Given the scale of the impact of motorcycle crashes in rural Africa and the speed at which motorcycles are proliferating across the continent, it is pressing that more work is done to understand the causes of crashes and injuries, their impact on public health and economies, and ways to prevent them.

Necessary further work includes:

- Research into the design, implementation and scaling of effective motorcycle training programmes. The cultural context must be taken into consideration, and lessons from elsewhere in sub-Saharan Africa would be particularly relevant. There is need to develop an effective, highly-tailored programme of driver licensing and training that builds on research, such as that described in this report

- Population-based control studies (including cohort studies) to evaluate the impact of any road safety interventions. For instance, following groups of motorcycle drivers over multi-year time frames to determine programme effectiveness. Population-based control studies of any programme element that seems promising are essential in order to build the argument for evidence-based injury prevention work

- Economic studies to understand both the economic impact of RTIs on families and communities, and the economic benefit of injury prevention programmes

- Condensed versions of the Tanzanian AFCAP/Amend studies in other countries in sub-Saharan Africa in order to determine the relative nature of the problem across the continent. During this process, local solutions to the RTI problem may be discovered that could be applied across Africa

- Systems research. For example, research into how the licensing system works by documenting/mapping it, and identifying where the opportunities for corruption and shortcuts are. Also, research into how the system of motorcycle renting works. Likewise, understanding more clearly how the Traffic Police operate in rural areas. All of this research would be conducted with an eye to opportunities for changes that could reduce injury rates

- Engineering research. Continued research into road surfaces and designs that are cost-effective and safe for the sub-Saharan African environment, including considering the increasing numbers of motorcycles in the continent

- Behavioural research. Understanding better, for instance, what drives the behaviour of motorcycle taxi drivers and passengers. Learning why they undertake risky behaviour with an eye to determining how to change that behaviour

- The piloting of advocacy programmes that aim to deliver systemic changes (such as more rigorous drivers licensing), improved enforcement around risk factors (such as overspeeding) and potential legislation around risk factors (such as motorcycle rental). Since affecting this sort of change on a national level can be slow going, we would suggest perhaps obtaining permission from the government to pilot programs at a regional level that, if proven successful, could be scaled up first nationally and perhaps continent-wide

14. Dissemination of Results

The results of this research have been and will continue to be disseminated through the following channels.

14.1 To the Target Populations and Key Stakeholders at the Study Sites

Following analysis of the data, having identified key issues related to motorcycle safety on rural roads, the Motorcycle Safety Expert and one Project Assistant visited both study sites. They gathered together small groups of *boda-boda* drivers and gave them simple practical lessons on how to keep themselves safe. These included messages about their own behaviour and that of other road users, how to identify appropriate speeds and practical demonstrations on motorcycle maintenance.

A total of approximately 260 drivers attended these sessions over four days, two at each site. The majority of *boda-boda* drivers who attended these sessions had participated in the study in some way.

14.2 To Tanzanian and African Road Safety Stakeholders

During April and May 2014, the preliminary results of this research were presented by different members of the study team at the following events:

- A workshop on rural transport, hosted by HelpAge International in Dar es Salaam
- A workshop on the Surfacing Demonstration Project, hosted by Roughton International in Kibosho, close to the Lawate to Kibong'oto road
- A workshop on the preparation of the Tanzanian Design Manual for Low-Volume Roads, hosted by IT Transport in Dar es Salaam
- A seminar for West African rural roads stakeholders, hosted by AFCAP in Accra, Ghana

In September 2014, with the support of AFCAP, the results were presented at a conference hosted by the South African Roads Federation at CSIR in Pretoria.

We are currently preparing a fact sheet for this research. Following approval by AFCAP, this will be distributed to key Tanzanian and African road safety stakeholders.

14.3 To the Global Road Safety Community

The fact sheet will also be distributed to our database of over 1,000 global road safety stakeholders – which range from NGOs, to governments, to private sector actors. Additionally, we will distribute the study fact sheet at a United Nations Road Safety Collaboration (UNRSC) meeting. Amend is a member of UNRSC. UNRSC meetings are held twice a year and bring together over 100 global leaders from road safety from across all sectors.

14.4 To the Academic and Scientific Community

We intend to prepare an academic paper with the working title of 'Characteristics and risk factors of motorcycle crashes on low-volume rural roads in Tanzania', for submission for publication to a peer-reviewed journal.

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