Musculoskeletal impairment and road traffic injuries in Malawi

Leonard Banza Ngoie

Thesis for the Degree of Philosophiae Doctor (PhD)
University of Bergen, Norway
2023

UNIVERSITY OF BERGEN

Musculoskeletal impairment and road traffic injuries in Malawi

Leonard Banza Ngoie

Thesis for the Degree of Philosophiae Doctor (PhD)
at the University of Bergen

Date of defence: 05.05.2023

Year: 2023

Title: Musculoskeletal impairment and road traffic injuries in Malawi

Name: Leonard Banza Ngoie

Print: Skipnes Kommunikasjon / University of Bergen

Scientific environment

This study was conducted at Kamuzu Central Hospital (KCH) in Lilongwe, Malawi. A nation wide survey was carried out in all the three regions (Northern, Central, Southern) of Malawi and included villages in traditional authorities from all the 27 mainland districts of the country.

The study was exclusively funded by Norad through a NORHED Project supporting surgical specialist training in Malawi, a collaboration between the Department of Surgery at Kamuzu University of Health Sciences (KUHeS, formerly the University of Malawi, College of Medicine), Queen Elizabeth Central Hospital (QECH) and KCH in Malawi, and the University of Bergen and Haukeland University Hospital in Bergen, Norway. QECH and KCH are the two main teaching hospitals for KUHeS.

This study was supervised by: Dr Sven Young, Prof. Geir Hallan, Prof. Jan-Erik Gjertsen, Prof. Nyengo Mkandawire.

This thesis is a part of the PhD programme at the Department of Global Public Health and Primary Care, University of Bergen, Norway.

Kamuzu Central Hospital
Lilongwe, Malawi.

KAMUZU UNIVERSITY
OF HEALTH SCIENCES

Acknowledgements

I have been working on this PhD project since 2015. So many people have been of great support during this part of my journey and I would like to appreciate them.

To God Almighty, I give praise and honor for the gift of life and blessings that sustained me throughout.

Supervisors

I wish to thank my main supervisor Dr Sven Young. His patience, endeavor, positive attitude and helpfulness have been of so much help. He has been a great supervisor.

I am also grateful to my co-supervisors Professor Geir Hallan, Professor Mkandawire, and Professor Jan-Erik Gjertsen. You have given me invaluable and constructive feedback and support. Your encouragement, wealth of knowledge and scientific experience have been overwhelming. You have understood that all PhD students are not the same. Thank you for your availability and patience. I sincerely enjoyed working with you all.

To Professor Bente Elisabeth Moen, for your leadership, patience and kindness you have made this journey smooth. I am grateful.

Co-authors

Many thanks are due to the other co-authors Eva Dybvik and Carlos Varela. Eva's availability and statistical skills have been of great help. Carlos for being together in the field, up and down in the valleys and on the mountains, you have been a great colleague. Thank you for being together on this long journey.

Department of Surgery, Kamuzu Central Hospital, CBM International, KUHeS and Department of International Collaboration at Haukeland University Hospital

I would like to thank the hospital management at KCH for giving me permission to

conduct the study. Thank you to the head of research at the University of North Carolina (UNC) project at KCH, Professor Anthony Charles, for initiating the KCH trauma database and to Jared Gallaher for facilitating access to the data for my first study. I would also like to thank CBM International / Malawi Council for the Handicapped (MACOHA), my employer, for accommodating my research and giving me the opportunity to combine research in the field of disability and clinical activity. You deserve great credit.

I also would like to thank the Dean and the entire team at KUHeS for giving me the opportunity to do this study funded by Norad through the NORHED project.

Sincere thanks to Jon W. Dahl, Grete Marie Slotterø Eilertsen, and Camilla Skjelbred in the Department of International Collaboration at HUH for the great and tremendous support to my research project. I am greatly thankful.

The support of my kind colleagues of the orthopaedic, general surgery and research section, Kumbukani Manda, Boston Munthali, Cornelius Mukuzunga, Vincent Mkochi, Gift Mulima, Chifundo Kajombo, Linda Chokotho, Wakisa Mulwafu, Joel Kumwenda, Vincent Samuel, and all my colleagues Orthopaedic Clinical Officers (OCOs) is gratefully acknowledged. Some of you have done part of my clinical work during the research period.

Family and friends

I would like to thank my friends namely Gunhild Koldal, Tor and Maries Nedrebø, Neelam and family, Jim Harrison, Claude Martin, Mads Sundet, Lasse Efskind, Vibeke Rydland, Rachel Jiya, Tazirwa Munthali, Bertha Nibatete, Moses Msukuma, Bentry and Molly Kalanga, Jes Bates, Jonathan Ngoma, Kiran Agarwal-Harding, Willy Bulambo, Samuel Maina, Nicholas Lubega and Patrick Noah in supporting my efforts to complete this work. Thank you to my relatives Daniel and Wezzie Dibwe, Kyungu Musenge, and Nelly N'kulu Luba for giving me relentless support for so many years.

Dedication

This thesis is dedicated to Esperance my wife and my lovely and unique son Luke for being with me all the way through. It has been a long journey! I am so thankful for your tremendous support and encouragement.

List of abbreviations

A & E	Accident & Emergency
AT	Assistive Technologies
AU	African Union
BAC	Blood Alcohol Concentration
CBID	Community Based Inclusive Development
CBR	Community Based Rehabilitation
CBM	Christoffel-Blindenmission
CHAM	Christian Health Association of Malawi
COMESA	Common Market for Eastern and Southern Africa
COMREC	College of Medicine Research and Ethics Committee
COSECSA	College of Surgeons of East Central and Southern Africa
CP	Cerebral Palsy
CYP	Children and Young People
DALYs	Disability-Adjusted Life Years
DC	District Commissioner
DHO	District Health Officer
DPOs	Disabled People's Organisations
EHP	Essential Health Package
EQ-5D	European Quality of Life 5-Dimensions
FEDOMA	Federation of Disability Organisations in Malawi
FY	Fiscal Year
GBD	Global Burden of Disease
GDP	Gross Domestic Product
GNI	Gross National Income
HSA	Health Surveillance Assistant
HICs	High-Income Countries
HRQoL	Health-Related Quality of Life
HSSP	Health Sector Strategic Plan
ICD	International Classification of Diseases

ICF	International Classification of Functioning
ICHI	International Classification of Health Interventions
ICT	Information and Communication Technology
KCH	Kamuzu Central Hospital
KUHeS	Kamuzu University of Health Sciences
LDC	Least Developed Country
LICs	Low Income Countries
LMICs	Lower Middle-Income Countries
MACOHA	Malawi Council for the Handicapped.
M & E	Monitoring and Evaluation
MDHS	Malawi Demographic and Health Survey
MMR	Maternal Mortality Ratio
MoH	Ministry of Health
MR	Medical Rehabilitation
MSI	Musculoskeletal Impairment
NCDs	Non-Communicable Diseases
NGO	Non-Governmental Organization
NMR	Neonatal Mortality Rate
NORHED	Norwegian Programme for capacity Development in Higher Education and Research
NSO	National Statistics Office
OA	Osteoarthritis
OCOs	Orthopaedic Clinical Officers
OPD	Outpatient Department
OPDs	Organizations of Persons with Disabilities
PFP	Private for-Profit
PNFP	Private Not-for-Profit
P & O	Prosthesis and Orthosis
PPP	Purchasing Power Parity
QALY	Quality-Adjusted Life Year
QECH	Queen Elizabeth Central Hospital

QMD	Quality Management Directorate
QMO	Quality Management Office
RAM	Rapid Assessment of Musculoskeletal Impairment
RTCs	Road Traffic Crashes
RTIs	Road Traffic Injuries
SADC	Southern African Development Community
TB	Tuberculosis
THE	Total Health Expenditure
UHC	Universal Health Coverage
UK	United Kingdom
UN	United Nations
UNC	University of North Carolina
UNCRPD	UN Convention on the Rights of Persons with Disabilities
US	United States
WHA	World Health Assembly
WHO	World Health Organization
YLD	Years Lived with Disability
YLLs	Years of Life Lost

Abstract in English

Introduction

The global burden of musculoskeletal disease in low and middle-income countries is large, growing, and neglected. While there is considerable funding for the control of communicable disease, there has been little attention paid to either the prevention or the treatment of musculoskeletal impairment (MSI) in developing countries. Musculoskeletal disease is one of the major causes of physical disability globally, yet data regarding the magnitude of this burden in developing countries is scarce or lacking. Several studies have shown that the vast majority of those living with disability are children residing in Lower Middle-Income Countries (LMICs), but again, little research has been done in Malawi to establish the the actual burden of MSI in the population.

Musculoskeletal disease encompasses a wide range of conditions that vary from traumatic injury to congenital malformations, disabling arthritis to chronic low back pain, many of which benefit from surgical intervention. They affect a large portion of the world's population in one form or another, with non-traumatic musculoskeletal disease estimated to account for 6.8% of all disability adjusted life years lost according to the latest Global Burden of Disease studies. However, this 6.8% of disability-adjusted life years does not include those lost owing to musculoskeletal trauma.

Each year 5.1 million people worldwide die from injuries. 1.35 million of these deaths are due to road traffic accidents and ninety percent occur in developing countries. Africa has the highest rate of road traffic injuries (RTIs) in the world, despite being the least motorized of the world's 6 regions with only 2% of the world's registered vehicles. According to Global status Report on road safety 2018, there has been no reduction in number of road traffic deaths in any low-income country (LIC) since 2013. RTIs are the 8th leading cause of death for people of all age but are now the leading cause of death for children and young adults aged 5-29 years. For each person who dies from trauma, three to eight persons are permanently disabled and at least 20 persons survive

with injuries that need treatment. WHO estimates suggest Malawi has one of the highest mortality rates due to road traffic injuries (RTIs) in the world, but very little research has been done to map the actual situation on the ground. Whereas WHO estimates of road traffic mortality in Malawi have remained relatively static over the last years, as clinicians we have had the impression that there is a rapidly increasing burden of RTIs in Malawi.

The overall aim of this thesis was to assess the burden of MSI and to report the prevalence, causes, and treatment need among both adults and children, to evaluate the quality of life among people with MSI in Malawi and map the trend of RTIs in Lilongwe, Malawi.

Methods

This thesis is based on 3 papers. **Paper I** assessed the trend over 7 years (from January 2009 to December 2015) of the burden of road traffic related trauma presented to Kamuzu Central Hospital (KCH) in Lilongwe, one of the main referral hospitals in Malawi. This was an analysis of prospectively collected data from the KCH Trauma Registry. **Paper II** assessed the prevalence, impact, causes, and service implications of MSIs in Malawi. To achieve this we used a validated survey tool to randomly select clusters across the whole country that matched the national distribution of the population. Then adult individuals were screened and examined for MSI by survey field teams. The questionnaire and Rapid Assessment of Musculoskeletal Impairment (RAM 1 & RAM 2) tools were installed on 17 tablet computers for data collection. Quality of life was measured using EQ-5D. **Paper III** critically analysed the same survey data to estimate the prevalence of MSI and the need for different treatment modalities among children aged 16 years or less in Malawi, and described the causes of MSI in Malawian children.

Results

Paper I: The prospectively collected data from the KCH Trauma Registry showed that there was a 62.4% rise in the number of RTI victims treated at KCH from 2,447 in

2009 to 3,975 in 2015. If this trend continues, 7,997 patients will be expected to need treatment for RTIs at KCH in 2030, doubling the numbers seen in 2015 in just 15 years. The highest number of injuries occurred in pedestrians (32.3%) and cyclists (28.2%) and continually rose over the years studied. The length of hospital stay for RTIs increased from 6.4 (SD 9.1) days in 2009 to 15.0 (SD 19.4) days in 2015.

Paper II: During our national survey of MSI in Malawi, we travelled the whole country for 2 months. We enumerated 8,548 people and found that 810 were living with MSI, representing 9.5% of the population. Overall, 33.2% of MSIs were due to congenital causes, 25.6% were neurological in origin, 19.2% due to acquired non-traumatic non-infective causes, 16.8% due to trauma and 5.2% due to infection. Extrapolation of these findings indicated that there are approximately one million cases of MSI in Malawi that need further treatment. MSI had a profound impact on quality of life. Analysis of disaggregated quality of life measures using EQ-5D showed clear correlation with the International Classification of Functioning (ICF) class. A large proportion of patients with moderate and severe MSI were confined to bed, unable to wash or undress, or unable to perform usual daily activities.

Paper III: We estimated a total number of 112,000 (80,000-145,000) children in need of Prostheses and Orthoses (P&O), 42,000 (22,000-61,000) in need of mobility aids (including 37,000 wheel chairs), 73,000 (47,000-99,000) in need of medication, 59,000 (35,000-82,000) in need of physical therapy, and 20,000 (6,000-33,000) children in need of orthopaedic surgery. Low parents' educational level was one factor associated with an increased risk of MSI.

Conclusion

Paper I: There was a rapidly growing burden of RTIs at KCH in Lilongwe, Malawi, between 2009 and 2015, and projections based on our data show that this burden is likely to continue to rise, and could double by 2030. The absence of a clear strategy to meet the growing epidemic of injuries in Malawi will come at a huge cost to an already strained economy, and the largest portion of the burden of injury will continue to be borne by the poorest segment of the population. However, 7 years down the line new data is urgently needed to assess the trend of RTIs. Observing the current situation on

the ground, RTIs continue to rise and the hospital is struggling to cope up with the number of road traffic victims.

Paper II: Our study showed that a huge burden of musculoskeletal impairment in Malawi is mostly unattended and has a profound impact on a large proportion of the population. The prevalence of MSI in the country was found to be high, revealing an urgent need to scale up surgical and rehabilitation services in the country. Increasing age was one of the factors that was associated with an increased risk of having MSI. The quality of life of a large proportion of patients with moderate and severe MSI was considerably affected.

Paper III: This study also uncovered a large burden of MSI among children aged 16 and under in the country with an immense unmet need for treatment (P & O devices, physical & occupational therapy, and surgical services) of those affected children. A clear strategy should be made by policy makers to cope up with this burden of MSI in both adults and children and give the necessary support to those in need.

Abstract in Chichewa

ZOTSATILA ZA KAFUKUFUKU WA MATENDA AMINOFU NDI MAFUPA (MUSCULOSKELETAL)

Matenda okhuza minofu ndi mafupa (musculoskeletal) ndi imodzi mwa zinthu zimene zimayambitsa ulumali komanso imfa, makamaka mu LICs.

imakhuza gawo lalikulu la anthu padziko lonse lapansi mwanjira zosiyana siyana ndinso matenda osapweteka (non-traumatic musculoskeletal) pafupifupi 6.8% ya Disability-Adjusted Life (DALY) kutayika.

Kafukufuku wambiri wasonyeza kuti ambiri mwa omwe ali ndi ulumali ndi ANA omwe amakhala ku LMICs.

Kuvulala kwa ngozi za pamsewu kochuluka kwambiri ndipo kumakhala kwa chilengedwe mu LMICs.

Matenda a minofu ndi mafupa ndi chimodzi cha zifukwa zimene zikuyambitsa ulumali pa dziko lapansi, komabe zolembedwa zokhuzana ndi kukula kwa vutoli m'mayiko omwe akungotukuka kumene ikusowa. Cholinga chachikulu cha kafukufukuyu chinali kuyesa kufotokoza za kufalikira, zomwe zimayambitsa, chithandizo chamankhwala chimene chimapelekedwa pakati pa akulu-akulu ndi Ana. Komanso kuwunika moyo wa anthu omwe ali ndi MSI.

Njira Zomwe Tinatsatira Popanga Kafukufukuyu

Tatenga kuchokera mu mapepala atatu

Pepala loyamba

Linawunika momwe zipatala zikuyendera m'kupita kwa nthawi, padapezeka kuti chipatala cha Kamuzu Central Hospital, ndichimodzi mwa zipatala zazikulu zomwe zimalandira odwala ambiri kuchokera mu zipatala zina zozungulira ku chigawo cha pakati. Izi ndi zomwe tinapeza, kuchokera ku KCH Trauma Registry.

Pepala la chiwiri

Litawunikidwa, linanena za kufalikira, zotsatira, zoyambitsa ndi zotsatira za ntchito za MSI ku Malawi.

Kuti tikwaniritse izi tinasankha kugwiritsa ntchito njira ya kafukufuku yofufuzira yomwe inapangidwa ku Rwanda ndi Atijosan et al. [64]. Tinasankha magulu anthu m'dziko lonse molingana ndi kukula kwawo, zitsanzo zomwe zili ndi magawo awiri, akumidzi / ndi akutauni, (akulu-akulu ndi ana) anthuwa adawunikidwa m'mabanja awo ndi a kafukufuku. Gulu la ofufuzawa lidayang'ana onse omwe adatenga nawo gawo pa MSI powafunsa mafunso asanu ndi awiri okhuzana ndi zovuta zogwiritsa ntchito minofu ndi mafupa awo komanso kuti adakhala ndi zizindikiro izi kwa nthawi yayitali bwanji.

Mafunso ndi Kuwunika Mwachangu Kuwonongeka kwa Minofu (RAM 1 & RAM 2) adayikidwa mu ma kompyuta a mmanja okwana 17.

Pepala lachitatu

adawunika momwe chithandizo kwa Ana azaka 16 kapena kuchepera, ndikulongosola zomwe zimayambitsa MSI mwa Ana aku Malawi. Onse Mapepala la chiwiri ndi lachitatu,adagwiritsa ntchito njira imodzi yopangira kafukufukuyu.

ZOTSATIRA

Kuchokera mu 2009 mpaka 2015 panali kukwera kwa 62.4% kwa chiwerengero cha ozunzidwa ndi RTI ku KCH kuchokera 2,447 mu 2009 ndi 3,975 mu 2015. manambala omwe adawonedwa mu 2015 m'zaka 15 zokha. Chiwerengero chachikulu cha ovulala chinachitika mwa oyenda pansi (32.3%) ndi okwera njinga (28.2%) ndipo akukwera mosalekeza pazaka zomwe adaphunzira. Kutalika kwa nthawi yokhala m'chipatala kwa RTIs kudakwera kuchokera pa 6.4-9.1days mu 2009 kufika pa 15.0-19.4 mu 2015.

Ponseponse, 33.2% ya MSIs inali chifukwa cha zobadwa nazo, 25.6% inali chiyambi cha mitsempha, 19.2% chifukwa chopeza zomwe sizinali zowopsa, 16.8% chifukwa cha kuvulala ndi 5.2% chifukwa cha matenda. Kuwonjeza zomwe zapezazi zikuwonetsa kuti pali anthu pafupifupi miliyoni imodzi a MSI m'Malawi omwe akufunika chithandizo china. MSI idakhudza kwambiri moyo wabwino. Kuwunika kwa miyeso yosiyana ya moyo pogwiritsa ntchito EQ-5D kunawonetsa kulumikizana bwino ndi gulu la ICF. Odwala ambiri omwe ali ndi MSI yocheperako komanso yowopsa adagonekedwa mchipatala, osatha kuchapa kapena kuvula kapena osatha kuchita ntchito zamasiku onse.

Tikuyerekeza chiwerengero cha ana 112,000 (80,000-145,000) omwe akusowa Prostheses and Orthoses (P&O), 42,000 (22,000-61,000) osowa zothandizira kuyenda (kuphatikiza 37,000 wheelchairs0000-90), 73,000-90 mankhwala, 59,000 (35,000-82,000) ofunikira chithandizo chamankhwala, ndi ana 20,000 (6,000-33,000) ofunikira opaleshoni ya mafupa. Maphunziro a makolo otsika anali chinthu chimodzi chokhudzana ndi chiopsezo chowonjezeka cha MSI.

POTSILIZA

Mwachidule, kafukufuku adawonetsa kuchuluka kwa matenda a MSI m'Malawi komanso kukhuza kwake kwa kukulu kwa anthu.

Zomwe tapezazi zikusonyeza kuti MSI imakhuzika kwambiri pa umoyo wa tsiku ndi tsiku komanso zachuma m'dziko lopeza ndalama zochepa.

Moyo wa omwe ali ndi MSI umakhudzidwa kwambiri, ndipo amazunzika kwambiri, Vuto lalikulu la kufooka kwa minofu ndi mafupa m'Malawi nthawi zambiri chisamaliro chimasowa, zomwe zikuwonetsa kufunikira kolimbikitsa ntchito za opaleshoni ndi kukonzanso m'dziko muno.

Panali kuchulukira-chulukira kwa RTI ku KCH pakati pa 2009 ndi 2015 ndipo zoyerekeza malinga ndi zomwe tapeza zikuwonetsa kuti vutoli lidzawirikiza kawiri pofika mchaka cha 2030. idzafika pamtengo waukulu ku chuma chomwe chavuta kale, ndipo gawo lalikulu la zolemetsa zovulazazi lidzapitilirabe pakati pa anthu osauka.

List of Publications

This thesis is based on the following three papers:

1. **Ngoie LB, Gallaher J, Dybvik E, Charles A, Hallan G, Gjertsen JE, Mkandawire N, Varela C, Young S**. The rise in road traffic injuries in Lilongwe, Malawi. A snapshot of the growing epidemic of trauma in low income countries. *International Journal of Surgery Open 10 (2018) doi: 10.1016/j.ijso.2017.11.004*

2. **Ngoie LB, Dybvik E, Hallan G, Gjertsen JE, Mkandawire N, Varela C, Young S.** Prevalence, causes and impact of musculoskeletal impairment in Malawi: A national cluster randomized survey. *PLoS One. 2021 Jan 6;16(1):e0243536. doi: 10.1371/journal.pone.0243536. eCollection 2021.*

3. **Ngoie LB, Dybvik E, Hallan G, Gjertsen JE, Mkandawire N, Varela C, Young S** The unmet need for treatment of children with musculoskeletal impairment in Malawi. *BMC Pediatr. 2022 Jan 28;22(1):67. doi: 10.1186/s12887-022-03113-8.*

Contents

1. Introduction and background

1.1 Musculoskeletal impairment

1.1.1 What is disability?

An individual with a disability is defined as a person who has a physical or mental impairment that substantially limits one or more major life activities. There are many types of disabilities, such as those that affect a person's: vision, movement, thinking, remembering, learning, communicating, hearing, mental health, social integration and relationships amongst many aspects of life. The United Nations Convention on the Rights of Persons with Disabilities (UNCRPD) defines disability as the "long-term physical, mental, intellectual or sensory impairments which, in interaction with various barriers, may hinder [a person's] full and effective participation in society on an equal basis with others" [1].

According to the World Health Organization, disability has three dimensions:

Impairment in a person's body structure or function, or mental functioning. Examples of impairments include loss of a limb, loss of vision or memory loss.

Activity limitation, such as difficulty seeing, hearing, walking, or problem solving.

Participation restrictions in normal daily activities, such as working, engaging in social and recreational activities, and obtaining health care and preventive services [2].

1.1.2 WHO International Classification of Functioning (ICF)

The International Classification of Functioning, Disability and Health, known more commonly as ICF, is a classification of health and health-related domains. As the

functioning and disability of an individual occurs in a context, ICF also includes a list of environmental factors. ICF is the WHO framework for measuring health and disability at both individual and population levels. ICF was officially endorsed by all 191 WHO member states in the 54th World Health Assembly on 22 May 2001 (resolution WHA 54.21) as the international standard to describe and measure health and disability. ICF is based on the same foundation as International Classification of Diseases (ICD) and International Classification of Health Interventions (ICHI) and share the same set of extension codes that enable documentation at a higher level of detail [2].

1.1.3 Disability-Adjusted Life Years (DALYs)

The disability-adjusted life year is a measure of overall disease burden, expressed as the number of years lost due to ill-health, disability or early death. It was developed in the 1990s for the international burden of disease studies and is used extensively by the World Bank and the WHO as a way of comparing the overall health burden, or need, for different conditions in different countries. It can also be defined as a time-based measure that combines years of life lost (YLLs) due to premature mortality and years of life lost due to time lived in states of less than full health, or years of healthy life lost due to disability (YLDs) [3].

1.1.4 Musculoskeletal impairment and quality of life

The EQ-5D is a standardised measure of health-related quality of life developed by the EuroQol Group to provide a simple, generic questionnaire for use in clinical and economic appraisal and population health surveys. It consists of a health status part (EQ-5D) and a visual analogue scale (EQ-VAS). It has been validated in a number of countries and cultural settings [4].

The EQ-5D-3L descriptive system comprises the following five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Each dimension has

3 levels: no problems, some problems, and extreme problems. The patient is asked to indicate his/her health state by ticking the box next to the most appropriate statement in each of the five dimensions. This decision results into a 1-digit number that expresses the level selected for that dimension [4]. The digits for the five dimensions can be combined into a 5-digit number that describes the patient's health state. For example, a patient in health state 11223 would have no problems in mobility and self-care, some problems with usual activities, moderate pain/discomfort, and extreme anxiety or depression. [4]. A preference score (EQ-5D index score) can be generated based on the 5-digit number. The index score has a maximum score of 1 (best quality of life) and minimum score of 0 (death). There is one 3L and one 5L version (newer version from 2009). The 3L version is described here, because this was the one used in our survey.

EQ-5D index scores:

Each health state can potentially be assigned a summary index score based on societal preference weights for the health state. These weights, or utilities, are often used to compute quality-adjusted life-year (QALY) for use in health economic analyses. QALY is a measure of the value of health outcomes. Since health is a function of length of life and quality of life, the QALY was developed as an attempt to combine the value of these attributes into a single index number. Health state index scores generally range from less than 0 (where 0 is a health state equivalent to death; negative values are valued as worse than death) to 1 (perfect health), with higher scores indicating higher health utility, though health state preferences can differ between countries. QALYs are used in economic evaluation for cost utility analysis and the weights used for QALYs are the opposite of DALYs. For DALYs 0 is no disability, so the lower the score the better the state of the person [4].

Severity was determined using the parameters for the percentage of function outlined in the WHO reference book International Classification of Functioning (ICF) [2]. A loss of function of 5–24% was mild, 25–49% was moderate and 50–90% was severe.

1.2 Etiology of musculoskeletal impairment

Musculoskeletal disorders may be congenital or acquired, and may include deformities or other abnormalities. These disorders may involve the bones or major joints; the tendons, ligaments, muscles, or other soft tissues.

Congenital abnormalities can range from minor conditions such as an extra digit (polydactyly) or fused digits (syndactyly), to more severe congenital hand deformities, other congenital abnormalities of the upper limbs, developmental dysplasia of the hip, proximal focal femoral deficiency, congenital absence of all or part of tibia, congenital club foot, amniotic bands, arthrogryposis etc.

A one-year study on the prevalence of congenital anomalies in neonates in a tertiary care hospital of Eastern India (Kolkata) showed a prevalence of 2.22% of all congenital malformations. The predominant system involved was the musculoskeletal system (33.2%) and the gastro-intestinal (GI) system (15%). Clubfoot (17.1%) was the most common anomaly seen in the musculoskeletal group followed by cleft lip (6.6%) and cleft palate (3.5%) in the GI group [5].

Acquired and chronic MSI comprise conditions such as leprosy, developmental delay, spastic and non-spastic cerebral palsy, paraplegia, hemiplegia, quadriplegia, facial weakness, peripheral nerve palsy, poliomyelitis, degenerative joint disease, non infective non traumatic joint disease, bow legs, knock knees, bone tumour, hydrocephalus, skin / soft tissue tumour, spinal deformity – kyphosis, lordosis, scoliosis, spinal pain limiting function, limb pain limiting function, other joint deformity such as windswept deformity, other acquired non-traumatic conditions, amongst other conditions [6].

Acute and chronic infectious causes of MSI comprise conditions such as joint and bone infection (e.g septic arthritis, acute and chronic osteomyelitis), spine infection such as

tuberculosis (TB) or pyogenic infection, limb skin / soft tissue infection / cellulitis amongst other conditions [7].

MSI following injuries may be due to conditions such as burn contracture, fracture non-union, fracture mal-union, spinal injury, head injury, recurrent or chronic joint dislocation, post traumatic joint stiffness, tendon injury and pain, limb amputation amongst other causes.

1.3 The global burden of musculoskeletal impairment

1.3.1 Musculoskeletal impairment in adults.

Musculoskeletal conditions cover a spectre of more than 150 conditions that affect the locomotor system of individuals [8]. They range from those that arise suddenly and are short-lived, such as simple fractures, sprains, and strains, to lifelong conditions associated with ongoing function limitations and disability. Conditions are typically characterized by pain (often persistent) and limitations in mobility, dexterity, and overall level of functioning, reducing people's ability to work. Musculoskeletal conditions are also the highest contributor to the global need for rehabilitation. They are among the largest contributors to the need for rehabilitation [8].

According to GBD data, approximately 1.71 billion people globally have musculoskeletal conditions. Musculoskeletal conditions are also the biggest contributor to DALYs worldwide with approximately 149 million YLDs, accounting for 17% of all YLDs worldwide.

Low back pain is the main contributor to the overall burden of musculoskeletal conditions and is the single leading cause of disability in 160 countries worldwide [9,10]. Other contributors to the overall burden of musculoskeletal conditions include fractures with 436 million people globally, osteoarthritis (343 million), other injuries (305 million), neck pain (222 million), amputations (175 million), and rheumatoid arthritis (14 million) [9].

While the prevalence of musculoskeletal conditions increases with age, younger people are also affected, often during their peak income-earning years [10]. Low back pain, for example, is the main reason for a premature exit out of the workforce. The societal impact of early retirement in terms of direct health-care costs and indirect (i.e., work absenteeism or productivity loss) costs is enormous. Musculoskeletal conditions are also highly associated with significant mental health decline and deteriorated functioning. Projections show that the number of people with low back pain will increase in the future, and even more rapidly in low-income and middle-income countries [10]. The disability associated with musculoskeletal conditions has been increasing and is projected to continue to increase in the next decade (2020-2030) [9].

1.3.2 Musculoskeletal impairment in children

The vast majority of those living with disability are children residing in LMICs [11]. The needs of children and young people (CYP), and especially for those with MSI, are often overlooked - more so in countries with limited resources and paucity of specialists [12, 13]. Globally, there are many CYP with MSI; the majority living in the poorest and most populous countries in Asia, Africa, and South America [13, 14]. Delay in access to 'right care' is well reported [15] and increasingly important given advances in treatment options; the disparity is stark with worse clinical outcomes reported in countries with limited resources [16, 17]. The paucity of workforce capacity in the most populated and least resourced countries [18] further adds to the challenges and many CYP are unlikely to receive equivalent care to those living in well-resourced countries [19, 20].

1.4 Road traffic injuries and musculoskeletal impairment

Burden of road traffic injuries worldwide

According to the Global Status Report by the WHO an estimated 1.35 million lives were lost on roads globally in 2016 and up to 50 million people were injured. The impact on families, communities, countries, and health systems is extreme and the scale of the response does not match the scale of the problem. 54% of road traffic deaths are

pedestrians, cyclists and motorcyclists. Road traffic injuries are the 8th leading cause of death globally, and are the most frequent cause of death among children aged 5-14 and young adults aged 15-29.

Low Income Countries (LICs) have 1% of the world's vehicles and yet have 13% of road traffic deaths. On the other hand, High Income Countries (HICs) have 40% of the world's vehicles and only 7% of road traffic deaths. Many HICs have managed to break the link between rising motorization and road traffic deaths, with some managing to dramatically reduce such deaths [21]. These achievements are the result of making infrastructure safer, improving the safety of vehicles, and implementing a number of other interventions known to be effective at reducing road traffic injuries [22]

Road traffic injuries in Malawi

Malawi has a per-capita gross national income of only USD 550 [23] and is experiencing economic growth and a rapidly rising number of motor vehicles on the roads. Also, the number of roads and their quality is improving [21]. Thus more people use the roads, and the speed of motor vehicles increases. The road fatality rate is high compared to most other countries. WHO have estimated that death rates due to RTIs in 2016 was 31 per 100,000 inhabitants, among the highest in the world. The burden of RTIs and deaths is disproportionally borne by the poor in Malawi, with about 50% of the fatally injured road users being pedestrians and close to 16% cyclists [23]. Reports from front line staff in the emergency department at KCH indicated that the numbers of RTIs treated at KCH were rising since the early 2000s [24].

1.5 Physical disability in Malawi

Malawi lacks clear and official disability statistics. The National Statistics Office (NSO) obtained the 2018 data on the prevalence of disability through the population and housing census survey (decennial). Although the Washington Group Short Set of questions was not used, people were still asked if they had difficulties with walking/climbing, seeing, hearing, speaking or 'any other problem'. Those that

reported having difficulty in any of the above activities were considered to have had a disability [25]

1.5.1 Physical disability in adults

The 2008 NSO Census estimated the overall number of persons with disabilities to be 498,122 which represented a disability prevalence rate of 3.8 percent [25]. The 2018 Population and Housing Census indicates that there are 1,734,250 persons with disabilities in Malawi aged 5 years and above, representing about 11.6 percent of the total population aged 5 year and above. Further, it estimated the population of women with disabilities to be around 937,536 representing 6.2 percent of the total population. The major areas of disability were seeing (49%), walking/climbing (27%), hearing (24%), intellectual (16%), and speaking (9%) [25].

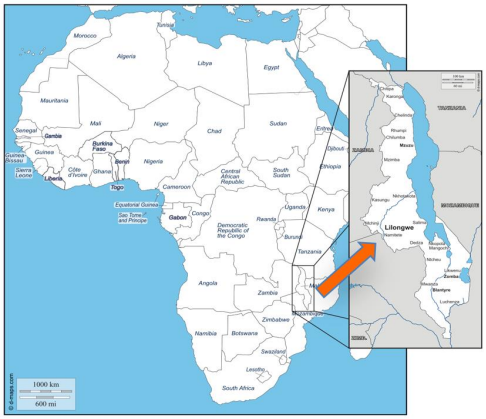
1.5.2 Physical disability in children

The 2018 NSO Census does not provide a clear picture of the estimated number of children with disabilities in Malawi. However, the 2008 NSO Census estimated children with disabilities aged 14 years or younger to be around 274,465 which represented 51.1 percent all persons with disabilities then [26]. However, this survey did not use disability measurement tools designed for children and there was no verification of self-reported functional limitations by clinical examination which limits its use in planning health and rehabilitation services. There have been studies in Malawi on childhood disability [27] and impact of musculoskeletal impairment (MSI) in the lives of children [28]. However, these surveys were done on a small scale.

1.6 Malawi and its health system

1.6.1 Malawi.

Figure 1. Map of Africa showing Malawi *(adapted from d-maps.com. Used with permission).*



Malawi is a landlocked country in Southeastern Africa. It is bordered by Zambia to the west, Tanzania to the north and northeast, and Mozambique to the east, south and southwest. Malawi spans over 118,484 km^2 (45,747 sq mi) and has an estimated population of 18.3 million (according to 2018 estimates) [29]. Malawi's capital (and largest city) is Lilongwe. Its second-largest is Blantyre, its third-largest is Mzuzu and its fourth-largest is its former capital, Zomba.

Malawi maintains positive diplomatic relations with most countries, and participates in several international organisations, including the UN, the Commonwealth of Nations, the Southern African Development Community (SADC), the Common Market for Eastern and Southern Africa (COMESA), and the African Union (AU).

Malawi is among the world's least-developed countries. In 2019 the country had a Gross National Income (GNI) per capita of USD 550 and an annual total health expenditure per capita of USD 39.8 according to the World Bank [10]. Its national budget in 2016 was about USD 1.6 billion. The economy is heavily based on agriculture and more than one-third of GDP and 90% of export revenues come from this [30]. It

has a largely rural and rapidly growing population. Around 85% of the population lives in rural areas. The Malawian government depends heavily on outside aid to meet its development needs, although the amount needed (and the aid offered) has decreased since 2000. The Malawian government faces challenges in its efforts to build and expand the economy, improve education, healthcare, and environmental protection, and become financially independent. Malawi was ranked the 119th safest investment destination in the world in the March 2011 Euromoney Country Risk rankings [31]. Malawi has a low life expectancy at birth (55 years) and high infant mortality. HIV/AIDS is highly prevalent (10% HIV in adult population aged between 15 and 49 years) which both reduces the labor force and requires increased government expenditures [29].

1.6.2 Health facilities and access

Health services in Malawi are provided by public, private for-profit (PFP) and private not-for-profit (PNFP) sectors. The public sector includes all health facilities under the Ministry of Health (MOH), district, town and city councils. Health services in the public sector are free-of-charge at the point of use. The PFP sector consists of private hospitals, clinics, laboratories and pharmacies. Traditional healers are also prominent and would be classified as PFP. The PNFP sector comprises religious institutions, non-governmental organisations (NGOs), statutory corporations and companies. 62% of health services are provided by the government, 37% are provided by the Christian Health Association of Malawi (CHAM), and a small fraction of the population receive health services through the private sector [32].

Table 1. Health facilities offering free services in Malawi. Source: UNICEF Health Facility Mapping Report (2016)

Facility Type	CHAM	Government	NGO	Private	Total
Dispensary	4	49	4	30	87
Health Centre	107	413	4	18	542
Health Post	18	132	2		152
Hospital	38	45	1	1	85
Outreach	968	4,008	43	71	5,090
Village Clinic		3,542			3,542
Total	**1,135**	**8,189**	**54**	**120**	**9,498**

Malawi's health system is organized at four levels namely: community, primary, secondary, and tertiary. These different levels are linked to each other through an established referral system. Community, primary, and secondary level care falls under district councils. The District Health Officer (DHO) is the head of the district health care system and reports to the District Commissioner (DC) who is the Controlling Officer of public institutions at district level [32].

From 2002 to 2011, the percentage of total government expenditures allocated to health increased from 13% to 18.5%. In 2017 89% of Malawian healthcare was provided through donors [33]. In Malawi's health profile, last updated in May 2013, the WHO reported that there were only 0.2 physicians and 3.4 nurses and midwives per 10,000 population [34]. Malawi's shortage of healthcare personnel is the most severe in the region. Additionally, the minimal body of health workers are not evenly distributed in the healthcare system. Challenges that lead to this shortage are low outputs from medical training institutions, health worker retention etc.

In 2005, Malawi began to implement its emergency human resource program which concentrates on increasing output of trained medical personnel, improving health worker compensation and retention [34].

In 2017, there were around 200 pharmacists in the country, of which fewer than 10 were in the country's hospitals. Most hospitals don't have a pharmacist, and they use up their annual drug allocation in six months [35].

Community level

At community level, health services are provided by Health Surveillance Assistants (HSAs). Each HSA is meant to be responsible for a catchment area of 1,000 and there are currently 7,932 HSAs supported by 1,282 Senior HSAs in post. HSAs mainly provide promotive and preventive health care through door-to-door visitations, village and outreach clinics and mobile clinics [36].

Primary level

At primary level, health services are provided by health centres and community hospitals. Health centres offer outpatient and maternity services and are meant to serve a population of 10,000. Community hospitals are larger than health centres. They offer outpatient and inpatient services and conduct minor procedures. Their bed capacity can reach up to 250 beds. The supervision and management are provided by senior HSAs, environmental health officers, community health nurses at the community hospitals, and nurses and medical assistants or clinical officers (mid-level practitioners) at the health centres [36].

Secondary level

The secondary level of care consists of district hospitals and CHAM hospitals of equivalent capacity. Secondary level health care facilities account for 9.5% of all health care facilities [36]. They provide referral services to health centres and community

hospitals and also provide their surrounding populations with both outpatient and inpatient services. The team at district hospitals comprises of one–four doctors, 5–15 clinical officers (also known as clinical associates) and medical assistants who have three and two years of clinical training, respectively. Other cadres and allied health professionals, such as laboratory technicians, radiographers, and physiotherapists [36].

Tertiary level

The tertiary level consists of central hospitals. They ideally provide specialist health services at regional level and also provide referral services to district hospitals within their region. In practice, however, around 70% of the services they provide are either primary or secondary services due to lack of a gate-keeping system [36]. Cadres at the tertiary level comprise both general medical officers and specialists in different medical fields, clinical officers (orthopaedics and general surgery), nurses or midwives, pharmacists, physiotherapists, dentists, radiographers, and laboratory technologists etc.

Ministry of Health headquarters

The functions of the central level include policy making, standards setting, quality assurance, strategic planning, resource mobilization, technical support, monitoring and evaluation and international representation. Five Zonal Quality Management Offices (QMOs) are an extension of the central level and provide technical support to districts.

District Health Offices

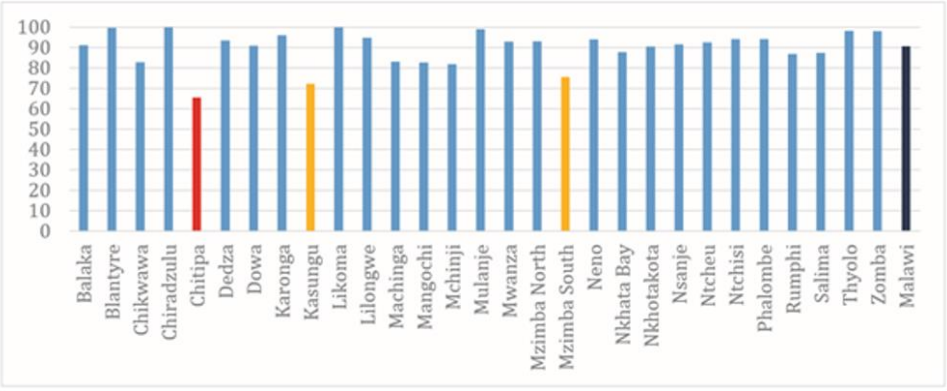
The functions of the district health offices (DHOs) include: managing all public health facilities at district level and directing provision of both primary and secondary level health services at district level. DHOs report to District Commissioners who are under Ministry of Local Government. At technical level, DHOs receive technical backstopping from Zonal Quality Management Office (QMDs) who are under the Ministry of Health.

Coverage

Limited access to health services in Malawi affects a large number of Malawians. Only 46% of citizens live within a 5km radius of any kind of health facility [34]. Despite most public health services being free for the patients, there are often costs associated with transportation to and from a facility [34]. These costs deter many individuals that may be in dire need of care but cannot afford to assume the costs of transportation. Additional transportation needs complicate matters when an individual is referred from either a rural hospital to a district hospital or a district hospital to a central hospital.

MOH policy is that every Malawian should reside within an 8km radius of a health facility. The proportion of the population living within 8km radius of health facility (health centres and hospitals) stands at 90% in 2016, an increase from 81% in 2011. This indicates that there is still a proportion of the population that is underserved; especially those residing in the rural and hard to reach areas and 56% of Malawian adult women still cite distance to health facility as a key barrier to health access when they are sick [37]. Most of the health facility infrastructure across both Government and CHAM is dilapidated due to long periods of lack of maintenance [36].

Figure 2. Proportion of population living within 8km of a Health Centre or Hospital. Source: UNICEF Health Facility Mapping (2016)



Most laboratory, imaging, and testing facilities are often only available at the major District Hospitals. Malawi has very few doctors (only one for every 88,300 people in Malawi). This means hospitals are staffed by Clinical Officers (trained for a minimum of four years, and who are very experienced practitioners), and Medical Assistants (trained for a minimum of three years). The Clinical Officers and Medical Assistants are usually in charge of their workplace, and manage any in-patient care. They diagnose, treat, and prescribe [38].

1.6.3 HSSP II and the road to Universal Health Care

The Health Sector Strategic Plan II (HSSP II) 2017-2022 is the health sector's medium term strategic plan outlining objectives, strategies and activities and guiding resources over the period 2017-2022. It succeeded the HSSP I (2011-2016). HSSP II builds on the successes achieved under the previous plan while addressing areas where targets were not met and progress was slow [39].

Under the HSSP I Malawi made substantial health gains. HSSP I targets for Under-5 mortality and infant mortality were surpassed, 63/1,000 live births against a target of 78/1,000 livebirths for the former and 42/1,000 livebirths against a target of 45/1,000 for the latter. There was also a steady decline in the maternal mortality ratio (MMR), which was estimated at 439/100,000 live births in 2016, down from 675/100,000 in 2010. Neonatal Mortality Rate (NMR) was estimated at 27/1,000 live births in 2016, down from 31/1,000 live births in 2010 [39]. Despite the progress, Malawi's MMR and NMR are among the highest in Sub-Saharan Africa. The HIV prevalence among women and men age 15-49 age decreased between 2010 and 2015-16 from 10.6% to 8.8%.

There was mixed progress with regard to development of health systems. The MoH promoted a total of 2,438 staff to more senior positions in the 2014/2015 fiscal year (FY), across many cadres. These promotions, however, did not extend to health staff working in CHAM facilities, which has created inequities across the workforce. There

is still a vacancy rate of 45%, however. During the HSSP I period, a total of 12 new health facilities (1 district hospital and 11 health centres) were constructed [36]

The health care system experienced shortages of essential medical products and technologies. This was due to many factors including inadequate funding, weak supply chain management and irrational use of medicines, leakage, and pilferage [36].

The HSSP II is being implemented by DHOs, central hospitals, development partners, civil society organisations, Non-Governmental Organisations (NGOs) and other health stakeholders. It will be monitored and evaluated using a set of National Health Indicators.

The goal of the HSSP II is to move towards Universal Health Coverage (UHC) of quality, equitable and affordable quality health care with the aim of improving health status, financial risk protection and client satisfaction [39]. However, on the road to Universal Health Care, the burden of road traffic injuries and musculoskeletal impairment in the country has been overlooked.

2. Aims of the study

The overall aim of this PhD project was to assess the burden of MSI in Malawi and report its prevalence, impact, causes, and service implications. As one of the main contributors to MSI we also wished to assess the perceived rising trend of musculoskeletal injuries due to road traffic crashes in Lilongwe, the capital city of Malawi.

In order to achieve this, we proposed to

- Identify people with MSI through a national cluster randomized survey
- Analyse prospectively collected data from the KCH trauma registry to assess the incidence of Road Traffic Injuries presenting to KCH over time.

The specific aims of the three papers included in the thesis were:

1. To use data from our national survey of MSI in Malawi to report the prevalence, impact, causes, and service implications of MSI in the adult Malawi population

2. To use data from the national survey of MSI in Malawi to estimate the prevalence and causes of MSI among children aged 16 years or less, and to use these data to estimate service needs for this population

3. To assess the increase in the burden of road traffic injuries over a 7-year period at a regional hospital in Malawi and model future projections for the rise in RTIs in the country

3. Methods

This section summarizes the methods used for the studies in **Papers I, II, and III**. A detailed description of the methods and analyses are explained in each paper

3.1 The rising burden of road traffic injuries (RTIs) in Malawi (Paper I)

This was a retrospective review of data prospectively collected from the Kamuzu Central Hospital Trauma Registry. KCH is a 1,200 + bed tertiary care public hospital in Lilongwe, the Capital City of Malawi. It has an estimated catchment population of 6 million. It serves as the referral hospital for eight district hospitals in the Central Region of Malawi, as well as a secondary care hospital for Lilongwe which has approximately 1.1 million inhabitants. The KCH Trauma Registry was established in 2008 to collect patient demographic information, clinical characteristics, and outcome data of all patients presenting to the emergency department with traumatic injuries. Trained data collection clerks track each trauma patient, from admission at the casualty department to final outcome. The database contains variables regarding injury type and anatomic location of up to 3 injuries per patient, with the most severe injury, as judged by the assessing clinician in casualty, entered as injury #1. The database undergoes periodic data cleaning and reconciliation by both the senior trauma clerk and the University of North Carolina surgical fellow on rotation at KCH.

Data was recorded on an intake form (Appendices 11.1, 11.2) and transferred to an electronic database. All patients who presented to the emergency department with injuries between January 2009 and December 2015 were included in this study. Mortality related to RTIs was defined as in-hospital mortality. The definition of a patient with a RTI in the KCH Trauma Registry was any driver, passenger, pedestrian, motor cyclist or pedal cyclist injured in a vehicle-related incident on a roadway. Linear regression curve estimations were calculated using IBM SPSS Statistics version 22

(IBM Corporation, New York, USA for policy makers' awareness and future treatment plans.

Figure 3. Kamuzu Central Hospital *(photo: Dr S. Young)*

3.2 Measuring the burden of MSI in Malawi (Papers II and III)

This study was conducted in the 3 administrative regions of the country: The Northern, Central, and Southern Regions. The Central and Southern regions are the most densely populated with 6.4 and 6.8 million respectively [40]. Malawi has 28 districts and a total of 48,233 registered settlements. The vast majority of these are in the rural areas. About 85% of the population live in rural areas [41]. We calculated a sample size of 1,481 households based on the calculation of household sample sizes [42] and taking into consideration the previous studies on MSI in the region [43]. We selected clusters across the whole country through probability proportional to size sampling with an urban/rural and demographic split that matched the national distribution of the population. The National Statistics Office provided a list of enumeration areas from the Malawi Census Board for 2008 national census records. These settlements were randomized through computer-generated random numbers, selecting 55 settlements as

enumeration areas from each district in Malawi for this survey. Two or four households were randomly selected in each settlement depending on size. The randomization was based on a ground bottle spin and selecting the third or fifth house in the direction of spin depending on the size of the settlement. Subsequently the bottle spinning was repeated after the household interview to select the next household in the new direction of the spin. The third household was then picked if in a smaller settlement, or fifth household if in a larger settlement, then repeating the process again to select the next household. All household members present were screened. For the youngest (age below five) household members, the guardian of the child was interviewed.

The survey tool used was developed in Rwanda by Atijosan et al. (2007) [44], Rwanda and Malawi being both developing countries and having similar environment and setting. This screening tool was developed by orthopaedic surgeons together with physiotherapists and has been shown to have 99% sensitivity and 97% specificity [44]. The team of data collectors screened all participants for MSI by asking them seven questions about difficulties using their musculoskeletal system and how long they had had these symptoms. Participants who answered “yes” to any of the questions were classified as cases, provided that the condition had lasted for more than one month or was considered permanent (Table 2). The questionnaire and other Rapid Assessment of Musculoskeletal Impairment 1 and 2 (Appendices 11.3, 11.4) were installed on 17 tablet computers (iPad 2, Apple Inc.), using File Maker Pro 12.0v3 (File maker Inc., USA) software for data collection in English. The data collectors visited households door-to-door and conducted the MSI screening in the household.

Fig 4. Data collectors in Chitipa district, North of Malawi. *(photo: Dr L. Banza)*

Table 2. Screening questionnaire.

Screening for musculoskeletal impairment	Yes	No
1. Is any part of your body missing or misshapen?	❍	❍
2. Do you have any difficulty using your arms?	❍	❍
3. Do you have any difficulty using your legs?	❍	❍
4. Do you have any difficulty using any other part of your body?	❍	❍
5. Do you need a mobility aid or prosthesis?	❍	❍
6. Do you have convulsions, involuntary movement, rigidity or loss of consciousness?	❍	❍
If any of the answers are "yes":		
7. Has it lasted more than one month or is it permanent?	❍	❍

Data were collected by third year medical students after a 14 days supervised training. A pilot study/training was carried out in rural areas of the capital city, Lilongwe. The aim was to assess the examination process, function of the computer tablets and procedures.

All cases were examined in more detail by the students using a standardized interview and physical examination protocol. Whenever in doubt, the students consulted a

supervisor physically or by phone (calls or pictures). Only those who were able to respond to all the five dimensions of the EQ-5D-3L questionnaire were eligible [45, 46]. The elements included in the interview and examination protocol are presented in Table 3.

Table 3. Standardized interview and examination protocol.

Elements	Definition
Physical assessment	Performance of physical tasks that required use of the musculoskeletal system, both lower and upper limb motor skills. (i.e. walking, standing, sitting, running etc.)
Anatomical location	Information of the affected part of the body (e.g leg) and the nature of the problem (e.g. tumour)
Duration	The duration of the MSI, classified into a long (> 1 month) or short (1 month) standing history
Aetiology	Initiation and cause of the impairment (infection, violence etc.)
Diagnosis	Diagnosis categorized as: neurological, traumatic, congenital, metabolic, infective, or acquired non-traumatic non-infective. Within these categories an algorithm was created and used to give a specific diagnosis. Up to two diagnoses were permissible per case [44]
Severity	Severity was determined using ICF parameters for the amount of function which was lost through the presence of the impairment. This was classified as ‘‘mild’’, ‘‘moderate’’ or ‘‘severe’’ (47)
Quality of life (EQ-5D)	The Malawian version of the EQ-5D-3L questionnaire (46)
Treatment received	Any known treatment given to the participant (medical or others) was recorded
Treatment needed	Treatment required by the participants was assessed according to Malawi standard treatment guideline

Barriers to treatment	Participants were asked one question about why they had not received treatment for their MSI. All responses (up to four options) were recorded on pre-coded forms

Data were collected from 1st July to 30th August 2016. Each data collector covered approximately two households per day (10–12 participants). 30–34 households were interviewed every day. Interviews took place in the interviewees' private homes. Data was checked and exported into the Excel (Microsoft 2010) pooled database at the end of each day, for data security and to assure the quality of the data collection [48]. A survey record was filled in for each eligible person that included: Demographic information (all participants), screening examination for MSI, a standardized interview and examination protocol for MSI, history of MSI (if not examined).

We used data from the same survey to analyse the burden, causes, and treatment need of MSI in children in Malawi (**Paper III**). For the youngest (age below 5) household members, the guardian of the child was interviewed. For all participants we also screened parents' educational level. The age cut off of 16 years and below was chosen for ease of comparison to a similar study done in Rwanda [49]. Also, people aged 17 and over are expected to be past or near skeletal bone maturity. According to cultural definitions of adulthood, the latter are usually considered as young adults in our setting. The standardized examination protocol used, if screening questions revealed any MSI, comprised the elements seen in Table 4.

Table 4. Standardized interview and examination protocol.

Elements	Definition
Diagnosis	Diagnosis categorized as: neurological, traumatic, congenital, metabolic, infective, or acquired non-traumatic non-infective. Within these categories an algorithm was created and used to give a specific diagnosis. Up to two diagnoses were permissible per each identified case of MSI [44]
Severity	Severity was determined using ICF parameters for the amount of function which was lost through the presence of the impairment. This was classified as ‘‘mild’’, ‘‘moderate’’ or ‘‘severe’’ [49]. Severity was determined using the parameters for the percentage of function outlined in the WHO reference book ICF [2]. A loss of function of 5–24% was mild, 25–49% was moderate, and 50–90% was severe
Treatment received	Any known treatment given to the participant (medical or other) was recorded
Treatment needed	Treatment required by the participants was assessed according to Malawi standard treatment guideline.

The specific diagnosis, and an allocation into 1 of 5 WHO diagnostic categories: congenital, traumatic, infective, neurologic or other acquired (ie, non-congenital, non-traumatic, non-infective and non-neurologic) was recorded. The severity of the impairment (mild, moderate or severe) according to the WHO ICF [2] was determined. The treatment received thus far and the treatment needed were recorded. The decision as to what treatment was needed was made by the surgeon. This pilot study was also used to ensure that the diagnostic categories were appropriately allocated. The definition of MSI that was used was developed from the WHO ICF

“…..a lack of normal structure or function, or an increase in pain or discomfort in the integument, muscles, bone or joints of the body of an individual, that has lasted at least 1 month and which limits function of the musculoskeletal system….”. [2]

Fig 5. Landcruiser with data collectors stuck in the mud for several hours. *(photo: Dr L. Banza)*

Fig 6. Data collectors on their way to different clusters in Nsanje. *(photo: Dr L. Banza)*

Fig 7. Data collectors having their meal after a long day drive on a bumpy road.
(photo: Dr L. Banza)

3.3 Statistical Analyses

Paper I.

IBM-SPSS Statistics, version 24.0 for Windows (IBM Corp, Armonk, NY, USA) and the statistical package R version 3.4.0 (http://www.R-project.org) were used to calculate linear regression curve estimations. Continuous variables were presented as mean values with standard deviations

Paper II.

The statistical analyses were performed using IMB-SPSS Statistics Version 24.0 for Windows (IBM Corp, Armonk, NY, USA) and the statistical package R version 3.4.0 (http://www.R-project.org). EQ-5D-3L index scores were calculated using the values from Zimbabwe [50, 51], as there are no values for Malawi, and Zimbabwe was considered the best match. MSI diagnosis from our randomized sample was extrapolated to the population of Malawi for both **Papers II and III**.

Paper III

IBM SPSS Statistics Version 26 (IBM Corp., Armonk, NY, USA) and the statistical package R (http://CRAN.R-project.org). The population of Malawi was 18.3 million according to 2018 estimates, and based on the age categories in the same census, we estimated that about 8.9 million were 16 years and younger [52].

P-values less than 0.05 were considered statistically significant. Chi-square test was used to test categorical variables. Odds ratios (ORs) were calculated with a linear regression model adjusted for age, gender, location and education. Categorical variables were analysed using a Pearson's chi square test, continuous variables were tested using independent t-test.

3.4 Ethical Considerations

The approval to conduct all the three studies was granted by the Malawi National Health Sciences Research Committee (approval # 813), the College of Medicine Research and Ethics Committee (COMREC) (approval # P.03/15/1712) and The Regional Committee for Medical and Health Research Ethics (REC Western Norway) (approval # 2016/1388/REK vest) in Norway. Another permission to conduct the study at KCH (**Paper I**) was obtained from the hospital research committee and The University of North Carolina Institutional Review Board (approval #11-0373).

In **Papers II and III** consent was obtained from the participants after explaining to them the goals and possible benefits of the study. Both verbal and written consent were obtained from adults (18 years of age and above), and assent were obtained from parents/guardians of children less than 18 years of age. Consent to survey the districts and clusters were granted respectively by the District Commissioner and village head for each visited district and cluster.

All participants found with MSI during our survey and in need of medical services or any other support were assisted accordingly (referred for surgery, medication, physiotherapy, P&O devices or counselling).

Data collection and handling followed national guidelines in line with the Declaration of Helsinki.

4. Summary of papers

Musculoskeletal disease is an important cause of morbidity and mortality, especially in LICs [53]. Some studies of the burden of non-traumatic musculoskeletal disease have been performed in high-income countries, with few population-based studies in low- and middle-income countries (53, 54). There have been several surveys of physical disability in Malawi in the past [27, 28]. However, these studies have targeted small cohorts of the population and focused on disability in general, which may have led to an underestimation of the burden of MSI in the community. None of these previous studies have evaluated the quality of life among people with MSI and data on the prevalence of MSI in Malawi is scarce or lacking. On the other hand the burden of traumatic musculoskeletal disease due to RTIs is on the rise the world over [55]. For each person who dies from trauma, three to eight more are permanently disabled [56, 57]. Malawi is among the most affected countries in the world [58] and the impact of the rising burden of injury on the health sector is considerable. However, there is not enough published national data. In view of the lack of accurate data we undertook this study to assess the burden of MSI in Malawi and the burden of injuries due to road traffic crashes in Lilongwe, one of the busiest and most densely populated cities in Malawi.

4.1 Paper I

Leonard Banza Ngoie, Jared Gallaher, Eva Dybvik, Anthony Charles, Geir Hallan, Jan-Erik Gjertsen, Nyengo Mkandawire, Carlos Varela, Sven Young

The rise in road traffic injuries in Lilongwe, Malawi. A snapshot of the growing epidemic of trauma in low income countries

International Journal of Surgery Open 10 (2018) 1-6
https://doi.org/10.1016/j.ijso.2017.11.004

Background: Road traffic injuries are major cause of death and disability globally, with a disproportionately high number occurring in developing countries [59]. RTIs are currently ranked 8th globally among the leading causes of disability adjusted life years lost, and the ranking is projected to rise to third by 2030 [21]. The problem is increasing at a fast rate in developing countries due to rapid motorisation and other factors. However, public policy responses to this epidemic have been muted at national and international levels [60]. Malawi is one of these countries with a population of 18.3 million and a Gross National Income per capita of USD 550 [23]. The impact of the rising burden of injury on the health sector is considerable. However, there is not enough data to demonstrate this development.

Methods: This was a retrospective analysis of data prospectively collected from the Kamuzu Central Hospital Trauma Registry. KCH is a 1,200 + bed tertiary care public hospital in Lilongwe the capital city. It has an estimated catchment population of 6 million. It serves as the referral hospital for eight district hospitals in the Central Region of Malawi, as well as a primary and secondary care hospital for Lilongwe which has approximately 1.1 million inhabitants. The Trauma Registry was established in 2008 to collect patient demographic information, clinical characteristics, and outcome data of all patients presenting to the emergency department with traumatic injuries. Trained data collection clerks track each trauma patient, from admission at the casualty department to final outcome. The database contains variables regarding injury type and anatomic location of up to 3 injuries per patient, with the most severe injury, as judged by the assessing clinician in casualty, entered as injury number one. The database undergoes periodic data cleaning and reconciliation by both the senior trauma clerk and the University of North Carolina surgical fellow on rotation at KCH. All patients who presented to the emergency department with injuries between January 2009 and December 2015 were included in the study.

Results: A 96,967 patients with injuries between 2009 and 2015 were registered in the Registry. The mean age of these patients was 23.3 years and 36.8% were children younger than 18 years. 25,193 (26.2%) patients had road traffic related injuries, of these

19,244 (76.4%) were men. There was a 62.4% rise in the number of RTI victims treated at KCH from 2,447 in 2009 to 3,975 in 2015. If this trend continues, based on linear regression curve estimates, 7,997 patients will be expected to need treatment for RTIs at KCH in 2030, doubling the numbers seen in 2015 in just 15 years. The highest number of injuries occurred in pedestrians (32.3%) and cyclists (28.2%) and continually rose over the years studied. The length of hospital stay for RTIs increased from 6.4 (SD 9.1) days in 2009 to 15.0 (SD 19.4) days in 2015.

Road traffic injuries are becoming more common in Lilongwe, overburdening the health system, and resulting in disability. While the volume of RTIs is rising fast, the severity of injuries may also be increasing, as reflected in the increasing length of hospital stays over the same period. The above results should be informing future policy development with a focus on addressing road traffic injuries by improving trauma and surgical care availability and quality, and prevention through legislation, enforcement and infrastructure improvement. Further research is also encouraged.

4.2 Paper II

Leonard Banza Ngoie, Eva Dybvik, Geir Hallan, Jan-Erik Gjertsen, Nyengo Mkandawire, Carlos Varela, Sven Young

Prevalence, causes and impact of musculoskeletal impairment in Malawi: A national cluster randomized survey

PLoS One. 2021 Jan 6;16(1):e0243536. doi: 10.1371/journal.pone.0243536. eCollection 2021.

Background: Musculoskeletal conditions are the leading cause of disability and have an enormous and growing impact worldwide [53]. The WHO prevalence estimate does not help plan services for specific national income levels or countries.

There is a lack of accurate information on the prevalence and causes of MSI in low income countries [61]. The aim of this study was to find the prevalence, impact, causes and factors associated with musculoskeletal impairment in Malawi.

Methods: A sample size of 1,481 households was calculated using data from the latest national census and an expected prevalence based on similar surveys conducted in Rwanda and Cameroon. Clusters across the whole country were randomly selected through probability proportional to size sampling with an urban/rural and demographic split that matched the distribution of the population. In the field, randomization of households in a cluster was based on a ground bottle spin. All household members present were screened, and all MSI cases identified were examined in more detail, using a standardized interview and examination protocol. Data collection was carried out from 1st July to 30th August 2016. Extrapolation was done based on study size compared to the population of Malawi. MSI severity was classified using the parameters for the percentage of function outlined in the WHO ICF. A loss of function of 5–24% was mild, 25–49% was moderate and 50–90% was severe. The Malawian version of the EQ-5D-3L questionnaire [48] was used, and EQ-5D-3L index scores were calculated using population values from Zimbabwe [50, 51], as a population value set for Malawi is not currently available. Chi-square test was used to test categorical variables. Odds ratio (OR) was calculated with a linear regression model adjusted for age, gender, location and education.

Results: A total of 8,801 individuals were enumerated in 1,481 households. Of the 8,548 participants that were screened and examined (response rate of 97.1%), 810 cases of MSI were diagnosed of which 18% (108) had mild, 54% (329) had moderate, and 28% (167) had severe MSI as classified by ICF. There was an overall prevalence of MSI of 9.5% (CI 8.9–10.1). The prevalence of MSI increased with age, and was similar in men (9.3%) and women (9.6%). People without formal education were more likely to have MSI [13.3% (CI 11.8–14.8)] compared to those with formal education levels [8.9% (CI 8.1–9.7), $p<0.001$] for primary school and [5.9% (4.6–7.2), $p<0.001$] for secondary school. Overall, 33.2% of MSIs were due to congenital causes, 25.6% were

neurological in origin, 19.2% due to acquired non-traumatic non-infective causes, 16.8% due to trauma, and 5.2% due to infection. Extrapolation of these findings indicated that there are approximately one million cases of MSI in Malawi that need further treatment. MSI had a profound impact on quality of life. Analysis of disaggregated quality of life measures using EQ-5D showed clear correlation with the ICF class. A large proportion of patients with moderate and severe MSI were confined to bed, unable to wash or undress or unable to perform usual daily activities.

These results showed a large number of people living with MSI in Malawi and quality of life measures confirmed that a large proportion these were severely disabled. A large portion of the burden of MSI in Malawi is potentially preventable, and many cases could be mitigated by surgery.

4.3 Paper III

Leonard Banza Ngoie, Eva Dybvik, Geir Hallan, Jan-Erik Gjertsen, Nyengo Mkandawire, Carlos Varela, Sven Young

The unmet need for treatment of children with musculoskeletal impairment in Malawi.

BMC Pediatr. 2022 Jan 28;22(1):67. doi: 10.1186/s12887-022-03113-8

Background: MSI in children is an under-recognised public health challenge. Although preventable, road injuries and other traumas continue to cause significant impairments to children worldwide. More than a billion people globally are living with disability and the prevalence is likely to increase rapidly in the coming years in LMICs [21]. Children residing in LMICs are among the vast majority of those living with disability [11]. There is little reliable data on the epidemiology of MSIs in children and even less is available for Malawi [59] Previous studies in Malawi on childhood disability and the impact of MSI on the lives of children have been done but on a small

scale [27,30]. Therefore in this study, we aimed to estimate the MSI prevalence, causes, and the treatment need among children aged 16 years or less in Malawi.

Methods: The study was carried out as part of a national cross sectional survey. Clusters were selected across the whole country through probability proportional to size sampling with an urban/rural and demographic split that matched the national distribution of the population. Clusters were distributed around all 27 mainland districts of Malawi. Based on age categories we estimated that about 8.9 million were 16 years and younger from a total population of 18.3 million. MSI diagnosis from our randomized sample was extrapolated to the population of Malawi, confidence limits was calculated using normal approximation.

Results: Of 3,792 children aged 16 or less who were enumerated, 3,648 (96.2%) were examined and 236 were confirmed to have MSI, giving a prevalence of MSI of 6.5% (CI 5.7–7.3). Extrapolated to the Malawian population this means as many as 576,000 (95% CI 505,000-647,000) children could be living with MSI in Malawi. Overall, 46% of MSIs were due to congenital causes, 34% were neurological in origin, 8.4% were due to trauma, 7.8% were acquired non-traumatic non-infective causes, and 3.4% were due to infection. We estimated a total number of 112,000 (80,000-145,000) children in need of Prostheses and Orthoses (P&O), 42,000 (22,000-61,000) in need of mobility aids (including 37,000 wheel chairs), 73,000 (47,000-99,000) in need of medication, 59,000 (35,000-82,000) in need of physical therapy, and 20,000 (6000-33,000) children in need of orthopaedic surgery. Low parents' educational level was one factor associated with an increased risk of MSI.

5. Discussion

5.1 Discussion of methods

5.1.1 Cross sectional survey

This was an all-age population-based nationwide survey with a cluster randomized design to obtain a representative sample of people of all ages who were enumerated and examined by well-trained medical students. The response rate of over 96% is very good for a survey in our setting. The sample was representative of the national population for both age and gender. This reduced the likelihood of selection bias. The survey contained multiple variables and our data could be used for other various types of research or studies. Another strength of this study was the fact that most diagnoses and surgical indications were made by one orthopaedic surgeon. This could strengthen the findings and implications. The outcome definition was undertaken by medical students, using an examination protocol and screening tool, which had been used in a similar study in Rwanda and Cameroon [44, 62]. However, the study also had some limitations on the probability proportional to size sampling; diagnostic tools were limited to history and physical examination, which restricted the identification of conditions that need complex investigations (such as CT, MRI scan etc), and data on other socio-economic factors were not collected. The risk for inter-observer disagreement was low because observers were closely monitored and supervised, but no inter-observer reliability study was performed. Due to the long distances in some areas, the call back at a few households where people were unavailable was not achieved. Finally, our demographic data were limited

In addition to clinical screening, participants were screened for PROMs using the EQ 5D-3L [46], which is a public domain health-related quality of life questionnaire. This generic questionnaire allowed us to assess the quality of life and severity levels according to ICF parameters, of all the participants diagnosed with MSI during the nationwide survey. This has helped assess the impact of MSI on the individuals and the society at large. The EQ-5D index score was, however, not combined with the EQ-5D visual analogue scale (EQ-VAS) [63]. Participants' health profile were provided on the

day of assessment and there was not a follow-up on population health status over time. This was a verbal interview and therefore participants could not complete the questionnaire themselves to provide information about their current health status and how this changed over time.

5.1.2 Strengths and limitations using medical registries

The large number of cases, prospectively collected data, and thorough and independent data registration procedures in the KCH Trauma Registry all add strength to this study and leave little doubt about the increasing epidemic of RTIs in Malawi in the study period. However, the limitations of this study are those inherent to any registry study including missing or unrecorded data. In addition, though all patients that arrived at the casualty department at KCH were registered in the trauma registry, some patients were missed. Patients that did not present at all due to minor injury, or patients that presented to other health care facilities or could not afford to attend the hospital were not captured in the registry, exposing the database to presentation bias. Most patients with an isolated fracture of a limb that did not require hospitalization were treated in the orthopaedic outpatient department (OPD) and were not registered in the KCH trauma registry as they did not present to the casualty department. There is need to make the trauma registry more comprehensive by capturing data from sections other that the casualty department. More than 13,000 patients are seen in OPD every year, so the number of missed patients could be quite large. There was lack of the finer details of the circumstances under which RTIs took place, such as the type of roads and setting (urban or rural), use of seat belt and mobile phone during driving, speed limits, blood alcohol content, socio-economic status etc.

5.1.3 Challenges with performing research in a LIC

Performing clinical research in developing countries has multiple challenges. There is lack of research funds in a very tight budget of competing needs in many LICs, although many of these countries, including Malawi, have research policies and research regulatory authorities. Therefore, research is less prioritised in most LICs with investment being <1% of their GDP [64]. They have limited human resources and

limited expenditure in areas of education and scientific research [65]. Most of these countries are still far behind in realizing the potential benefit that research could offer for economic growth and national development. Another issue that needs further exploration is that of externally funded research being driven by the interests of external donors even if local practisioners might wish to see different areas of research.

1. **Lack of funding**

   LICs are still struggling to meet the necessities of food, clothing, and shelter of their citizens. This leaves the government with only a few surplus resources to invest in research. Furthermore, LICs typically finance most of their research with public funds, unlike HICs where the business sector funds most research [86]. Research requires substantial financial investment [66]. LICs are more focused on those issues that have immediate results to society and the economy as a whole.

2. **Lack of infrastructure and equipment**

   Several factors are associated with declining scientific productivity in LICs. Some of them include restricted access to research grants, undersized laboratory infrastructures, inadequate budgets, limited equipment, and reagents etc [67].

3. **Inadequate remuneration and lack of financial incentives**

   Researchers' remuneration does not correspond to their education, knowledge, and societal contribution in LICs. Research enthusiasts in the LICs are faced with a highly restricted, competitive, and poorly funded research environment. For example, most medical doctors find it necessary to pursue clinical practice instead of engagement in research activities. The lack of adequate status, as reflected by relatively low salaries and inadequate career structure is a major deterrent to the proper advancement of research in many developing countries [67].

   In addition most external research funders prioritize their own agenda. Differential remuneration between local and expat researchers even if both may be at the same research grant, research funds being repatriated to donor countries

instead of being used in LICs where the research is actually happening. There is lack of motivation [68].

4. **Other barriers include:** lack of planning, shortage of time available for research; underdeveloped health informatics structure etc

5.2 Discussion of Results

5.2.1 Prevalence, causes and impact of musculoskeletal impairment

This is the first study to provide population-based information about the nationwide prevalence of MSI in Malawi. The survey uncovered a high prevalence estimate of MSI in Malawi of 9.5% (CI 8.9–10.1) and the need for more than one million interventions including medication, physical therapy, prosthetic orthotic devices, and surgery to alleviate the burden. Most cases of MSI were moderate (54%) or severe (28%) according to the ICF. These MSIs greatly affect people's quality of life, having impact on all five dimensions of quality of life in EQ-5D. The severity and scale of the burden of MSI in Malawi is likely to affect society at large [69, 70] and have a devastating impact on the development of Malawi as a country [69]. The overall prevalence of MSI in this study is almost double the 5.2% reported in Rwanda [53], but similar to the 11.6% reported in Fundong District, North-West Cameroon which used the same survey methods. The proportion of severe MSI was much higher in our study compared to what has been reported in Cameroon (2.4%) and Rwanda (8.4%). The reasons for this are unclear, but may, in part, reflect the long distances patients need to walk to seek medical attention in Malawi [71], and also the lack of medical expertise and equipment at the community, primary and secondary level of care in the country. A study by the College of Surgeons of East, Central, and Southern Africa (COSECSA) in 267 hospitals in east central and southern Africa has shown that current capacity to treat trauma and orthopaedic conditions is very limited, with particular areas of concern being manpower, training, facilities, and equipment [72]. Nevertheless, severe MSI deserves further attention and assessment in future studies. Musculoskeletal disease is known to be a major cause of morbidity and mortality, especially in LICs with non-

traumatic musculoskeletal disease estimated to account for 6.8% of all DALYs lost [61].

The main factors that were associated with increased risk of MSI were increased age and lack of formal education. In the former, this was the result of an increase in acquired non-traumatic non-infective degenerative conditions. These results were in line with the findings reported in a similar study in Rwanda [53]. Another study on disability transitions and health expectancies among adults 45 years and older in Malawi has shown that the risks of experiencing functional limitations due to poor physical health are high in this population, and that the onset of physical disabilities happens early in life [73]. Other studies of older person's health in Botswana and Malawi showed an increased probability of musculoskeletal disease and functional limitations [73, 74]. The burden of MSI is predicted to increase as the population of Malawi, and the rest of the world, is aging. As the prevalence of musculoskeletal disorders increases with age, there will be a significant increase in requirements for health care and community support in the future.

Lack of education is likely to coincide with manual subsistence farming as an occupation, rural location, hard work, and poor ergonomics that could lead to MSI. There was a tendency towards more MSI in rural areas. However, the low number of cases from urban areas could be due to the lower number of people recruited for the survey from the urban areas. The prevalence of MSI was similar in men and women. With regard to causes of MSI, congenital and neurological causes were the most common diagnostic categories in all age groups, followed by acquired non-infective non-traumatic causes, especially in the middle aged and elderly population. In the latter the most common individual diagnosis was joint problems (9% of MSI diagnoses). The Global Burden of Disease Study 2015 estimated that the most important contributors to global years lived with disability were musculoskeletal disorders (18.5%) [75]. A Cameroonian study showed that neck and lower back pain were estimated in 2013 as the leading cause of years lived with disability [76]. Projections show that the number of people with low back pain will increase in the future, and even more rapidly in low-

income and middle-income countries [61]. A recent study by the WHO showed that low back pain was the main reason for a premature exit out of the workforce. The societal impact of early retirement in terms of direct health-care costs and indirect (i.e., work absenteeism or productivity loss) costs is enormous [10]. Musculoskeletal impairment or disability related to trauma are also rapidly increasing in the future due to the rise in road traffic injuries in Malawi [77] and worldwide [75]. A study on long-term disability following road traffic accident showed that injuries associated with the highest incidence of long-term disability were soft tissue injuries to the cervical spine ('whiplash' injuries) and closed fractures of the lower limbs [78]. Another study from Benin found a prevalence of long term disability among road traffic accident victims of 9.6% [79]. Therefore, there is a need to recognize musculoskeletal conditions as a national and global public health priority. Solutions to fill this health service gap are needed.

Prosthetic and orthotic devices (P&O), physical therapy (rehabilitation), mobility aids, medication, and surgery were the most frequently recommended treatments for the people identified with MSI. These data have shown a significant treatment need for MSI in Malawi. With an estimated 42,000 orthopaedic surgical procedures needed, and only 11 orthopaedic surgeons in the country at the time of this study, it is obvious that Malawi is in dire need of scaling up surgical services rapidly, as supported by the earlier mentioned regional COSECSA study [72].

With the prevalence of MSI being higher among people living in rural areas, access to health services may be encouraged through health programs and support in rural communities. A wide range of ergonomically designed tools could be made available to ease agricultural work for those in need of this. Developing programs that serve populations at both primary and secondary level of care [80], where needs can be assessed, and resources identified, may improve access to preventive services and rehabilitation, and facilitate transfer to tertiary hospitals when needed. In our study some participants were very sick and there was no appropriate treatment to offer in our setting. However, counseling was provided to them and their relatives.

The data from this study provides important information that can be used to assist planning of P&O services, provision of mobility aids, rehabilitation, medical, and surgical services for persons with MSI in Malawi.

The nationwide survey of MSI in Malawi, also revealed that 6.5% of children, or an estimated 576,000 children, are living with MSI. Of these, 112,000 children could be in need of P&O devices and 42,000 in need of mobility aids (including 37,000 in need of wheelchairs) to help with ambulation or activities of daily living; 73,000 need medication; 59,000 could benefit from physical therapy, and approximately 20,000 were estimated to benefit from surgery. Currently it is estimated that there are only 14 Prosthetists & Orthotists, 200 physiotherapists and physiotherapy assistants, and 15 orthopaedic surgeons in the country (in 2022). A previous study on childhood disability in two districts of Malawi showed that physical impairment (39%) was the commonest impairment type [27], which is in line with our findings.

Studies done on MSI in children in Rwanda and in the Fundong District in North-West Cameroon have shown a prevalence of MSI in children of 16 years and younger of 2.6 and 2.9% respectively [49, 62]. This is less than half the 6.5% proportion of children with MSI in Malawi. The reason for this difference is unclear. However, a recent community based study on MSI in children in West Africa showed huge constraints preventing patients who are experiencing these conditions from receiving appropriate treatment. These many constraints include problems with human resources, finance, infrastructure, and education [81]. This could also be the case in Malawi where 85% of population live in rural communities with few resources and almost no health services available. Another survey's results at Korle Bu Teaching Hospital in Ghana implied that strong religious beliefs connote finding solutions to health problems through religious and spiritual means. Faith, religion, and other beliefs may be inextricably linked with musculoskeletal disease prevention, management, and cure [82]. This may refrain patient/guardian for seeking medical attention by staying home idle and expectant while the condition is worsening.

The extrapolated MSI treatment need estimates showed that approximately 20,000 children would benefit from surgery in Malawi against 50,000 in Rwanda. The reason for this difference could be that diagnoses and surgical indications in our survey were made by a surgeon, in contrast to the studies from Rwanda and Cameroon, where these were made by physiotherapists.

Most MSI diagnoses in our survey were due to congenital deformities (46%) or were neurological in nature (34.4%). There are few studies from the region to compare our numbers with, but a 5-year audit of all elective orthopaedic operations performed in children at a university hospital in Nigeria showed that congenital limb deformities alone accounted for 35.2% of the diagnoses [83].

The neurological conditions identified were predominantly cerebral palsy (CP) and epilepsy, which explains the need of medication, physiotherapy, and P&O devices in those affected children. CP is the most common motor disability in children worldwide, with an estimated prevalence of more than 2 per 1,000 in high-resource settings, and a higher prevalence of up to 10 per 1,000 reported in low resource settings [84, 85]. CP is known to be an important and common contributor to childhood disability in low-resource settings [86], as supported by another Malawian study [27]. The psychological and financial stress associated with cerebral palsy is known to affect families deeply. Further assessment on the aetiology of CP in Malawi is needed in future studies.

Furthermore our results showed that 47.5% of children had moderate MSI, 29.2% had severe MSI, and 23.3% had mild MSI. These findings support those of the World Bank where recent estimates suggest that 5% of all children – 93 million children globally – are living with moderate or severe disability as defined by the WHO [87]. Without any intervention, the negative impact on the society is enormous.

The results also showed that low education in the family was associated with more MSI among the family members. A literature review on disability has suggested that an educated individual with a disability is more likely to better cope with her/his disability

than those without education and that chronic health conditions may go improperly monitored by patients who are functionally illiterate and the overall well-being of these individuals may worsen overtime [88].

5.2.2 The rise in road traffic injuries in Lilongwe, Malawi

Our data uncovered a large and rapidly growing number of RTI victims treated at Kamuzu Central Hospital from 2009 to 2015 and according to our findings this burden of RTIs may double over the next 15 years. This could have negative impact on the country's economy. According to the *Global Status Report on Road Safety 2018*, though some reductions in road deaths have been seen among high- and middle-income countries, no LIC had reduced road deaths since the report in 2015. The risk of dying on the road is three times higher for those living in LICs than in HICs [89]. A national trauma surveillance data registry in Malawi has been in progress since September 2016 providing information on the epidemiology of injuries and how they are treated [78]. However, according to the WHO Global Status reports on road safety (2009, 2013, 2015 & 2018) there was an increase of more than 250% of registered vehicles in Malawi from 2007 to June 2017. According to the ministry of transport and public works in Malawi, even when there is no GDP growth, vehicle ownership will rise. This exponential growth of the number of vehicles and motorbikes in the country can likely explain much of the rise in road traffic injuries. The Malawi healthcare system, provided mainly through donor support [90], cannot currently manage the overall burden of disease and this is further compounded by the increasing burden of trauma [91, 92]. There is a severe lack of infrastructure and equipment as well as a shortage of human resources and drugs. The average total annual hospital budget for central hospitals has been increased (e.g. from USD 790,131 to USD 10 million from 2007 to 2020 for KCH), But the budget allocated to surgery and trauma has never been enough to cover the needs (e.g. orthopaedic hardware like external fixators). If we look ahead over the next decade, a rapid scale up of surgical trauma services (both human resources, infrastructure, and equipment) will be needed to meet the increasing burden

of RTIs in Malawi. With the rapid growth in the number of motor vehicles and motorbikes, serious measures for improvement of road safety will also need to be implemented.

Our results showed signs that the Malawian health system was not able to keep up with the rise in trauma. The fact that the length of hospital stay for RTI victims rose by 134% in 7 years can be explained in several ways. Previously, most patients at KCH that had a severe open fracture of the lower extremity ended up with an amputation. It has previously been shown that with modern orthopaedic surgery these patients rarely need this extreme measure at KCH anymore [93], but with limited access to operating theatres, increased waiting times and length of hospital stay are inevitable. Additionally, with increased emphasis on limb saving surgery, many other injury types of surgery that meet operative intervention criteria are delayed or deferred. This has also previously been shown to be the case with fractures of the femur that have increasingly needed to be treated non-operatively with skeletal traction at KCH, leading to very long hospital stays for these patients [94]. Other patients with non-unions after poorly treated fractures wait for weeks, sometimes months, on the wards before receiving necessary surgery for the same reasons (i.e., lack of operating theatre space and surgeons).

According to our findings nearly two thirds of RTI victims in Lilongwe, Malawi, were vulnerable road users such as cyclists and pedestrians. This suggests that road traffic trauma is a growing epidemic mostly of a particular segment of the population, those that can not afford private or public transport. Our findings showing that a large proportion of the road crash victims were pedestrians or cyclists support the findings in the Global Status Report on Road Safety 2018 that; “Road traffic injuries are now the leading killer of people aged 5-29 years. The burden is disproportionately borne by pedestrians, cyclists, and motorcyclists, in particular those living in developing countries” [21].

HICs have increasing numbers of privately owned vehicles yet a decrease in deaths due to better cars and better roads that are exclusively used by motorized vehicles and not

by pedestrians and bicyclists/motorcyclists. Also an increasing number of high speed roads have separate roads for each direction. Thus the most serious front-to-front collisions are avoided. Whereas the increasing speed and number of cars in the LMICs makes the roads increasingly dangerous for pedestrians and bicyclists, that use the same roads.

We found a decreasing number of patients who were drivers of private cars. This probably reflects a relatively new pool of cars with good safety features for the drivers. Also, most of the cars are used in towns where speeds generally are not high enough to cause serious injury to the driver, but are more than sufficient to injure vulnerable road users. On the contrary HICs have a high death number of drivers of private cars. According to WHO Global Status reports on road safety 2018, 39% of death victims were drivers of private cars in Norway [21]. The vulnerable road users benefit the least from policies designed for motorized travel, but bear the cost in terms of injury and death. More than half the Malawi population lives below the poverty line [95]. Estimates for most LMICs with a GNI per capita of more than USD 1,045 but less than USD 12,736 [76], suggest that 10-15% of RTA victims end up with a permanent disability of some kind [89].

Furthermore, results showed that most of the RTA victims were males (72%). With men often being the breadwinners in many families in Malawi, this has a negative impact on the whole household of the patient resulting in the financial vulnerability of the patients and their respective families and predisposition to extreme poverty [97, 98].

According to our findings more than one third (37%) of the total number of patients with injuries were under 18 years and of these 20% were related to RTIs. This again increases the negative impact on the entire community and future generations, as most of the victims are still young and productive members of the society. The data, however, suggests that preventive focus should be on the vulnerable road users. Information should focus on improved driver training, use of lights, pedestrian and

cyclist visibility, wearing of reflectors at night, and vehicle fitness. The Malawian government should insist on road design and standards that protect vulnerable road users. Standards should include physical separation of pedestrians and vehicles, through raised pavements or separate walk and cycle ways in towns. In addition to the policies and legislation needed to implement the suggestions above, consistent enforcement is needed for any interventions to succeed. This is unfortunately often lacking in our setting.

Once a road traffic injury has occurred, accessible quality health care is needed to save lives and reduce bad outcomes and disability. For the necessary scale up of trauma services in Malawi to be possible, long-term planning and build up of surgical training centers are essential. Surgery as a field has been neglected for too long in the global public health discussion. However, there is clear evidence emerging that surgery is as cost-effective as many well-funded interventions for communicable diseases and maternal health [99]. The Lancet Commission on global surgery actually found that it would cost more not to invest in surgery than to scale up surgery in LMICs over the coming years [100]. Building up and supporting surgical training centers can be a cost-effective and sustainable way to scale up to meet the increasing burden of injuries [91, 93].

A few years have already passed since the data for these studies was collected and more data are needed urgently to assess the currently developing trend of RTIs in Malawi. However, from observing the current situation on the ground at KCH, the number of RTIs continues to rise in Lilongwe and the hospital is struggling to keep up with the number of road traffic victims. With this trend, the country will experience an increase of burden of traumatic musculoskeletal impairment (MSI) in future with a negative impact on the society and by and large the country economy.

6. Conclusions

Studies have shown that musculoskeletal conditions, traumatic or nontraumatic, are a substantial contributor to the global burden of disease, mainly in LMICs and deserve attention by those who set the global health agenda [101,102,103]. We undertook a nationwide survey and a register study using data from a major referral hospital registry with the overall aim to assess the burden of MSI in Malawi and report its prevalence, impact, causes, and service implications; the treatment need for children with MSI and to assess the burden of musculoskeletal injuries due to road traffic crashes in Lilongwe, one of the busiest and most densely populated cities of Malawi.

The prevalence of MSI in Malawi was found to be high (9.5%), revealing an urgent need to scale up surgical and rehabilitation services in the country. The huge burden of MSI in Malawi is mostly unattended and its profound impact on a large proportion of the population. Increasing age and lack of formal education were factors associated with an increased risk of having MSI. The quality of life of a large proportion of patients with moderate and severe MSI was considerably affected. Overall, 33.2% of MSIs were due to congenital causes, 25.6% were neurological in origin, 19.2% due to acquired non-traumatic non-infective causes, 16.8% due to trauma, and 5.2% due to infection. MSI places considerable strain on social and financial structures in this country.

There was a large burden of MSI among children aged 16 and under in Malawi (6.5% of children living with MSI) with unmet need for treatment (P & O devices, physical & occupational therapy, and surgical services) of those affected children. Congenital and neurological conditions were the most predominant causes among this age group. We estimated a total number of 112,000 (80,000-145,000) children in need of Prostheses and Orthoses (P&O), 42,000 (22,000-61,000) in need of mobility aids (including 37,000 wheel chairs), 73,000 (47,000-99,000) in need of medication, 59,000 (35,000-82,000) in need of physical therapy, and 20,000 (6000-33,000) children in need of orthopaedic surgery. Clear strategies should be made by policy makers to

address this burden of MSI in both adults and children and give the necessary support to those in need.

We also found there was a rapidly growing burden of Road Traffic Injuries at KCH, a regional hospital in Lilongwe, Malawi, from 2009 to 2015. Projections based on data analysis demonstrated that the burden of RTIs at KCH could double again by 2030. With the rise in RTIs, we will be expecting increasing MSI related to RTIs in future if effective preventive measures are not implemented.

7. Clinical implications

The prevalence of MSI in Malawi was found to be high and there was a large burden of MSI among children aged 16 and under in the country with unmet need for treatment. The burden of RTIs was found to be rapidly increasing at KCH, a referral hospital in Lilongwe. With Projections based on data, this could double again by 2030.
Based on these research findings, clear and strong strategies with efficient preventive measures should be taken to mitigate the burden of traumatic and non-traumatic musculoskeletal disease in the country. This section of clinical implications will tackle findings from each paper and focus on specific preventive measures and strategies.

7.1 Road traffic injuries in Lilongwe (paper I)

The burden of RTIs in Lilongwe, Malawi grew rapidly between 2009 and 2015 and our data demonstrated that the burden could double again by 2030 [104]. Malawi has one of the highest road traffic fatality rates in the world [89]. Preventing traffic-related injury should be regarded as a priority public health issue. The costs of prolonged medical care, the loss of the family breadwinner, the cost of a funeral, and the loss of income due to disability can push families into poverty [97, 98]

If the UN's commitment to reduce by half the global number of deaths due to traffic accidents by 2030 is to be achieved, authorities, researchers, law enforcement officials and NGOs have to focus primarily on LMICs, where there has been a significant increase in RTIs for several years. These countries need help in implementing effective measures, in addition to financial and scientific support [105].

This burden of road traffic injuries in Lilongwe and Malawi as a country could have 3 main clinical implications: Road safety, scaling up trauma care, and capacity building for surgical training programmes.

7.1.1 Road safety

The following should be strongly enforced in the fight against the burden of road traffic injuries: managing speed, use of motorcycle helmets, increasing seat-belt use, reducing distracted driving, reducing drink–driving, and safer vehicles and roads.

With regard to reducing drink-driving, a recent study published by the Norwegian Institute of Public Health on "Road Traffic Injuries in Malawi – with special focus on the role of alcohol" has made a few recommendations such as lowering the Blood Alcohol Concentration (BAC) legal limit to 0.5g/L in accordance with recommendations from WHO [24-107]. This is in accordance with what most European countries, Canada, and other countries have done, as well as the state of Utah in the USA [106, 107]. The government should enforce laws and regulations of the Road Traffic Act on drunk driving, and allocate adequate resources to traffic police to ensure road traffic rules are followed. It is important that the authorities representing health, transport, police and education develop plans for a comprehensive information and educational campaign on alcohol use as an important risk factor for road traffic safety. Radio, newspapers, TV programs, and other type of informational media need to be engaged in such campaigns [108]. In addition, corruption should be discouraged and replaced with the rule of law and a culture of road safety.

As most injured or victims of road traffic accidents are pedestrians/cyclists, road design should be taken seriously by the government of Malawi. Road infrastructure has traditionally maximized mobility and economic efficiency at the expense of safety, particularly for non-motorized road users who are the most vulnerable. Indeed, as motorization increases worldwide, walking and cycling have become less common and more dangerous in many countries. The traffic mix in many countries means that pedestrians and cyclists share the road with high-speed vehicles, forcing them to negotiate dangerous situations and fast-moving traffic. Planning decisions have been made without sufficient attention to the needs of these groups – for example, cycle paths and footpaths are frequently not part of an integrated network. Unfortunately,

many road traffic campaigns were developed in high-income countries and sent to LIC without changing context or catering to the local environment and audience.

At the same time, traffic congestion resulting from rapid motorization means the transport and mobility demands of local communities are frequently not met. Changes are now required to optimize the movement of people and freight with road safety in mind. This optimization needs to take into account the mix and safety of all road users. In many industrialized countries these changes are already taking place, generally at a local level where communities have been involved promoting safe public transport and non-motorized means of transport [109]. Measures to promote walking and cycling are also in line with other global moves to fight obesity and reduce noncommunicable diseases (such as heart disease and diabetes) and improve the quality of urban life. These changes are more pertinent than ever for low- and middle-income countries, which are now moving rapidly towards much higher levels of motorization, increased levels of air pollution and more sedentary lifestyles.

Comparative data from 60 countries show that 82% of roads where pedestrians are present, and where speeds are 40 km/h or above, do not have footpaths. At speeds below 30 km/h, pedestrians and cyclists can mix with motor vehicles in relative safety [110].

A key strategy for achieving a safe traffic system for pedestrians and cyclists is to separate these different kinds of road use, eliminating conflicts between high-speed and vulnerable road users. Safety benefits of measures such as building separate cycle lanes are positive. Danish studies, for example, showed a 35% reduction in cyclist casualties after cycle tracks were constructed alongside urban roads [24]. Separating road users is also relevant for countries with high proportions of motorcyclists, notably those in the South-East Asian Region and the Western Pacific Region.

Moving towards more sustainable modes of transport has positive effects if the associated road safety impacts have been well managed. Aside from reducing road

traffic injuries, there are positive health benefits that are associated with increased physical activity, reduced pollution, noise levels and greenhouse gas emissions, reduced congestion and more pleasant cities. Safe road systems consider the needs of all road users. Improving road infrastructure is a key mechanism for making roads safer. In a number of high-income countries, decades of analysing the road network and determining where road crashes occur has helped identify how poor infrastructure contribute to road traffic injuries.

Poor roads are the norm in many of the countries where the risk of road traffic death is highest, and are often built without sufficient planning to take into consideration the safety needs of vulnerable road users and the communities through which they pass. Ensuring safety measures are integrated when road infrastructure projects are designed can result in important safety gains for all road users. Decisions made at the design stage of a project can have a significant impact on the level of death and injury on the road. Making the world's roads safer will not be possible unless the needs of vulnerable road users are considered in all approaches to road safety – including the way roads are built and the way vehicles are manufactured [89]. Prevention is an important component of public health efforts and for RTIs there is a huge potential for reduction in crashes involving vulnerable road users. However, in Malawi, much of the focus on prevention is on car drivers (speed reduction, use of seat belts etc).

7.1.2 Scale up the trauma care system and training programme

In June 2021 a local newspaper, The Nation reported: «*Malawi has lost 206 lives to motorcycle accidents within six months, from January to June this year (2021)",* with Homeland Security Minister Richard Chimwendo Banda describing the development as "worrisome". "*Hospitals, mostly in cities, are overwhelmed with accident victims,"* he said, adding that, "*in some cases, some accident victims lie in hospital corridors while awaiting medical assistance*" [111].

With the rise in road traffic injuries in Lilongwe and Malawi as a country [112], there is an urgent need to scale up our trauma care system to mitigate the burden resulting from these injuries. Malawi has no formal system of prehospital trauma care, and there is limited access to hospital-based trauma care, orthopaedic surgery, and rehabilitation. The majority of health services are offered by Ministry of Health facilities, and most services at public hospitals and clinics are free for patients. However, the other direct and indirect costs of injury care—transportation, lost income, and other expenses—make injuries costly to individuals and families and, by extension, to the country as a whole.

Prehospital trauma care on the scene of an accident, whether that is roadside care after a RTC, initial at-the-worksite care for serious traumas sustained at industrial workplaces, or first aid provided at other places where people have sustained traumatic injuries prior to transporting the victims to a healthcare facility, is typically offered by first responders who have no training and therefore lack the knowledge and skills to appropriately provide first aid to moderately or severely wounded people [113]. The lack of trained emergency medical technicians, ambulances, and other tools for providing skilled prehospital care means that some injured people who could have survived instead end up dying at the site where their injury occurred. Others end up with lengthy hospital stays and severe disabilities that could have been shorter and milder if they had received better first aid at the site of a trauma, such as having steps taken to support breathing, stop bleeding, and safely extricate people from damaged vehicles without causing greater physical damage.

Most Malawians also have limited access to hospital-based trauma care. While district hospitals can provide some emergency trauma care and surgeries, only central hospitals are equipped to provide advanced orthopaedic surgery [114]. There are only 4 central hospitals in Malawi, and they are located in urban areas. It may be impossible to transport an injured rural patient to a central hospital in time for surgical interventions to be save that individual's life. Furthermore, in-hospital care of injured persons is often sub-optimal at hospitals due to a lack of appropriate infrastructure, adequate numbers

of trained personnel, and the necessary equipment and supplies to provide life-saving and disability-preventing treatment [115]. These conditions are common across sub-Saharan Africa [116, 117].

In HICs, the establishment of inclusive trauma systems that provide a comprehensive spectrum of care to all injured patients within a well-defined geographic area has contributed to a reduction in injury-related mortality and disability [118]. Comprehensive trauma systems ensure access to the entire patient pathway from point of injury and prehospital care through emergency department resuscitation and, if required, specialist emergency surgical treatments followed by rehabilitation that allows for reintegration into the community [119]

7.1.3 Prehospital care

Malawi does not have a formal prehospital care system. Opportunities to address gaps in emergency care include providing first aid training for likely first responders, including community leaders and commercial drivers as well as police, fire fighters, and ambulance drivers. In addition implementing an emergency communication system with a reliably functioning telephone number and a coordinated response among emergency service providers will be necessary. Purchasing more ambulances to provide transportation to hospitals, and equipping those vehicles with critical supplies, including working radios and lifesaving devices is of paramount importance [120, 121]. At present, none of these structures for prehospital care (first aid training, a national hotline for calling for help, ambulances, and paramedics) are available in Malawi [113]. This lack of prehospital care is causing many unnecessary deaths each year. Deaths from preventable causes at any age are a tragedy, and there is especially high societal cost from injuries because the majority of injury deaths occur among young people who would otherwise have expected to live for several more decades while contributing to economic productivity through work and as caregivers for young children and older adults. The need to improve prehospital care system in Malawi cannot be overemphasised when considering changes to the health system.

Although it would be ideal to have professional emergency medical personnel available to provide prehospital care at every trauma scene, budgetary realities make this a distant goal in LICs like Malawi. However, there is an urgent need to take steps to improve prehospital trauma care to reduce trauma-related morbidity and mortality. A graduated development and upscaling of the prehospital system can accompany scaling up of the rest of the trauma care pathway in Malawi. A first step would be the development of a formal network of community leaders, police, commercial drivers, and other lay volunteers who are trained in basic first aid and equipped to respond to emergency trauma at the location of an injury as well as while the patient is being transported to a hospital. First aid training courses in sub-Saharan African countries has increased access to prehospital care in those places, and those training courses could be adapted for use both in Malawi and other countries [122, 123]. Ghana has deployed trained emergency management technicians across the country to improve the quality of prehospital emergency care [124]. Nigeria has increased the number of ambulances available to transport trauma patients [125]. The scaling up of first aid training in Malawi should be accompanied by improved communication between first responders and professionals and by better transportation options for injured people, which will need to be developed in a manner consistent with the local needs and capacities.

Malawi has since September 2016 a fracture care registry. Registry data can help researchers and clinicians to understand the epidemiology of fractures and treatment modalities, inform about prevention initiatives, and ensure that resources required for appropriate and timely fracture treatment are available where they are needed. Data-driven initiatives are more likely to have a positive impact in improving fracture care, thereby reducing associated morbidity and mortality. Without reliable information, it is difficult to allocate resources which will achieve the greatest impact in injury prevention, treatment, and rehabilitation of injured persons [116].

7.1.4 In-hospital care

Lack of appropriate infrastructure, trained personnel, and adequate equipment and supplies in most district and central hospitals has resulted in suboptimal care of injured

cases [115, 126]. The greatest strides in improving injury survival and recovery rates will likely be achieved if each health facility treating trauma patients has a dedicated accident and emergency (A&E) unit which is well equipped. This can be done in a phased approach starting with hospitals along M1 road that is the country's main highway and extends from the northern border of the country all the way to the southern border. The success of A&E units is dependent on all staff working in A&E units having received standardised emergency trauma management training as well as continuing education at frequent intervals [127, 128]. This will ensure standard and effective treatment of all trama patients presenting to hospitals with traumatic injuries. Most district and central hospitals have staffing and equipment shortages, and there is lack of trauma care training for clinical staff at central and district hospitals. However most clinicians at all levels of care, physicians and surgeons, clinical officers, nurses, and others are eager for opportunities to learn new skills that will let them better serve their patients. Opportunities for advanced training are likely to be welcomed and appreciated as well as effective at improving patient care [129, 130]. At this level, increasing the surgical capacity is imperative. This is dependent on a balance of several factors grouped in the categories of personnel, infrastructure and equipment [131]. The country should have one or two dedicated trauma centers well supplied with modern equipment and well trained clinicians (surgeons, nurses, anaesthetists etc) able to manage both intermediate and complex injuries. Due to severe shortage of qualified medical staff, Malawi should encourage and scale up in country surgical training programme to cover up the lack of specialist clinicians in both district and central hospitals. A recent study done in Malawi showed that long-term institutional collaboration in the training of surgeons in low-income countries is a sustainable and up-scalable model with great potential to reduce mortality and prevent disability in young people. Despite the obvious and necessary focus on the rural poor in low income countries, stakeholders must start to see the value of strengthening teaching hospitals to sustainably meet the growing burden of trauma and surgical disease [132].

7.1.5 Post-discharge care

The current demand for physiotherapy and rehabilitation services in Malawi cannot be met by the current workforce. Patients with severe injuries often experience lengthy periods of inpatient hospitalisation with prolonged bed rest, especially when they must wait for surgery due to demand for theatre time, lack of skilled personnel, or lack of needed surgical instruments and implants. Longer periods of physical inactivity delays recovery and leads to less favourable outcomes. A significant proportion of trauma patients become permanently disabled, and this is associated with a reduced quality of life for the individual as well as adverse economic consequences for the entire family [133]. Trauma registries that track long-term outcomes for injured individuals will help to quantify the unmet need for physiotherapy and rehabilitation as well as documenting the resources available for this level of care. The trauma care process cannot be considered complete until patients have received necessary rehabilitation care and regained the function necessary to return to their homes and to regular routines.

7.2 Implications of the study's findings on prevalence, causes and impact of MSI and the unmet need for treatment of children with MSI in Malawi (Paper II+III)

Paper II showed a high estimated prevalence of MSI in Malawi of 9.5% (CI 8.9–10.1) and the need for over one million interventions to alleviate the burden in both adults and children with prosthetic and orthotic devices, medication and physical therapy taking the lead. The need is immense and the demand for these services in Malawi cannot be met by the current human resources. There have been some effort made from both the public and private sectors to help improve the current ongoing situation.

7.2.1 Rehabilitation services in Malawi: current situation, challenges and initiatives

The challenging living conditions require a certain level of physical and mental abilities for survival. Any form of physical and mental disabilities will undoubtedly have an impact on an individual's level of independence, earning capacity and mental health. The impact of this could be far reaching especially if the individual is the main earner in the family. Timely access to rehabilitation services is not only valuable to the person concerned but also to their families and society as a whole.

The demand for rehabilitation services in Malawi has continued to rise due to high numbers of road traffic accidents, non-communicable diseases (NCDs), HIV and AIDS, congenital and developmental conditions; and more people seeking high standards of health care which includes functional restoration. At present, 1.5 million people have at least one type of disability [134].

While rehabilitation services exist in the country and are provided by both government and non-governmental organizations [including Organizations of Persons with Disabilities (OPDs)], it is worth noting that they are scarce, disproportionate to need and unequally distributed. The services remain inadequate to serve needs of the population, both in quantity and quality [135].

Some of the key challenges facing rehabilitation services at all levels of healthcare system in Malawi include: limited funding; insufficient rehabilitation work force, inadequate rehab services (poor accessibility, transport barriers, high out-of-pocket expenses, and long waiting times), lack of quality standards, inadequate monitoring and evaluation, limited assistive devices, limited purposely built medical rehab infrastructure, lack of data/information, and limited research in this field.

Weak collaboration and coordination among service providers and stakeholders coupled with ineffective and under-utilized referral pathways to rehabilitation have led to disjointed efforts in addressing the prevailing challenges.

For rehabilitation to reach its full potential, efforts should be directed towards strengthening the health system as a whole and making rehabilitation part of health care at all levels of the health system, and as part of universal health coverage.

In 2017, WHO launched the Rehabilitation 2030 initiative, which emphasizes the need for health system strengthening, and calls for all stakeholders worldwide to come together to work on different priority areas, including: improving leadership and governance; developing a strong multidisciplinary rehabilitation workforce; expanding financing for rehabilitation; and improving data collection and research on rehabilitation. In 2020 the government of the Republic of Malawi in line with the National Health Policy 2018, launched the National Medical Rehabilitation Policy that seeks to improve accessibility to medical rehabilitation services at all levels of healthcare system in Malawi. In October 2021, several partners / stakeholders interfaced with Ministry of Health (MoH) to further understand the rehabilitation gaps and needs – The identified gaps and needs can be seen in Table 5 (in order of importance).

Table 5: Rehabilitation gaps and needs.

1. Limited orthopaedic / rehab training infrastructure / fracture care
2. Limited orthopaedic / rehab services for children
3. Poor coordination among stakeholders / under utilized referral pathways
4. Limited provision of assistive devices (physical rehab)
5. Few physiotherapists / rehab technicians
6. Limited physio facilities / services / rehab supplies / procurement
7. Limited and uncoordinated CBR / community based services
8. Limited clinical social workers / psycho social support services

9. Limited club foot services
10. Limited participation of persons with disabilities and their organizations in planning and monitoring of these services
11. Poor national data system that does not contribute to monitoring of relevant national / district indicators
12. Poor accessibility of health services in Malawi
13. Lack of psycho social support for persons affected by disabilities (e.g. through clinical social workers)

In this regard the national medical rehabilitation (MR) policy will focus on the following priority areas: Institutional governance strengthening and coordination, financing for MR, human resources for MR, MR service delivery, assistive technology, MR infrastructure and equipment, MR information and research [135].

The policy statement made according to key priority areas are summarised as follows:

1. The policy shall ensure effective leadership, governance and accountability mechanisms in healthcare facilities.
2. The policy shall ensure that financial resources are efficiently mobilized and equitably allocated to MR services at all levels.
3. The policy shall ensure that MR personnel are trained, recruited, deployed and retained at all levels of health service delivery.
4. The policy shall ensure that MR services are accessible to all irrespective of their location or economic circumstances.
5. The policy shall ensure that assistive technologies (AT) are readily available to support MR services.
6. The policy shall ensure availability of adequate and appropriate infrastructures and equipment for MR services.
7. The policy shall ensure that an effective monitoring systems are available at all levels and it shall ensure promotion of research in MR [135].

Physical rehabilitation will usually include several different techniques and modalities, in order to slow progression of the disease, improve patients' activity levels and, in turn, decrease their level of disability. Some techniques used in rehabilitation include passive ranges of motion, where the therapist will move or manipulate the joint for the patient and thus increase the metabolism of the tissues. Rehabilitation can also include therapeutic exercises, which are controlled movements where the patient will perform active ranges of motion (i.e. the patient is self-motivated to move), achieving the same tissue metabolic and physical effects [136]. Patients (e.g. cerebral palsy) can be referred to a specialist for physical therapy and orthotics to improve posture and gait imbalances, which may not only prevent but improve musculoskeletal ailments that may ultimately result in injuries to cartilage and soft tissues [137].

7.2.2 Health promotion and prevention of MSI

With regard to lower back pain (being one of the common cause of musculoskeletal impairment in adults and that is increasing with age), some preventive strategies have been initiated in the district of Rhumpi and Nkhatabay but on a small scale by Health in Motion, one of the NGOs running this project in the country. Community members are trained to have a better understanding and knowledge of their spine, disc and supporting structures which are impacted in the ways we move. Once the knowledge is gained, the preventive strategies are taught in a 4-6 week guideline. Two strategies focus on adjustment of movement patterns while three strategies focus on home structures used to support daily activities (washing, cooking, farming etc). As the strategies are taught within a community, groups are formed to meet weekly, where time is spent practicing, reviewing and adopting into their daily lifestyle. So far this physical ergonomics has shown to be very effective and helpful to community members [138]. However, according to Health in Motion, these preventive strategies need to be applied on a large scale.

Studies have clearly shown that keeping a moderate level of physical activity is a key requirement for healthy ageing and maintaining musculoskeletal health [139]. WHO

recommendations suggest that healthy individuals should take around two hours a week of moderate physical activity or approximately 20 min a day of doing any kind of physical activity like brisk walking. This level of exercise, which involves elevation of heart-rate, has been associated with lower lifetime risk of cardiovascular disease in a 25-year longitudinal study of approximately 13,000 adults [140]. In addition to benefits for musculoskeletal health, improvements in cardiorespiratory fitness can be achieved by changing sedentary behaviour to achieve a low-intensity physical activity such as walking [141]. Furthermore, in patients with knee OA, improvement of locomotor function, including balance and strength, and a reduction in pain was seen following supplementation of home exercise with an eight-week class-based programme [142]. Patients suffering with chronic LBP who were given an exercise programme combining muscle strength, flexibility and aerobic fitness also reported a reduction in stiffness, which can result in back pain [143]. The idea of exercise for rehabilitation of musculoskeletal injuries has been widely accepted for many years now, and the idea of prescribing exercise as a preventative health measure is also more widely investigated, with guidelines around the type, frequency and duration of activity being considered [144]. Physical activity will not only increase musculoskeletal health but also decrease the risk of suffering from obesity-related diseases such as diabetes. Whilst ageing is inevitable, the benefits of exercise on the ageing body are numerous and, in some circumstances, can reduce the manifestations of ageing, particularly the "ageing phenotype" of the elderly. Physical exercise also has a positive impact on muscle mass and function in healthy subjects aged 60 and above, and improves muscle performance by increasing the ratio of type I to type II muscle fibres and increasing the cross-sectional area of type II muscle fibres [145]. Physical exercise reduces the risk of cardiovascular and metabolic comorbidities associated with joint diseases [141]. It is generally accepted that maintaining a healthy weight can help to improve musculoskeletal health and prevent degenerative diseases [146]. Obesity is thought to be a key co-morbidity of many musculoskeletal conditions and is closely related to the development of OA, one of the commonest musculoskeletal health issues. Reducing levels of obesity in the adult population may lead to reduced occurrence of OA and can alleviate some of the pain of the condition [147].

7.2.3 Orthopaedic services in Malawi

Some adults and children found to be having one or more MSI will need one or more orthopaedic procedures. The current status of orthopaedic services in Malawi is that there is a shortage of doctors and less than 15 fully trained orthopaedic surgeons, ie a population of over 1 million per surgeon. Orthopaedic clinical officers are currently being trained (since 1985) to provide adequate basic orthopaedic care (mostly non-operative fracture care) to the majority of the rural population in the country [148]. Malawi aims to continue training OCOs to meet the orthopaedic basic needs of the nation. At the same time the shortage of doctors in general and orthopaedic surgeons in particular is being addressed with the introduction of postgraduate orthopaedic training programs (since 1999). This dual approach model for training orthopaedic practitioners in Malawi will need to continue for the foreseeable future.

Training of doctors in general, and in orthopaedic surgery and its subspecialties should be intensified in Malawi and in the region, so that more surgeons are trained to provide specialist services at central and district hospitals. Orthopaedic services must be brought closer to the population in rural area where 85% of the population lives [148].

The country should also ensure availability of adequate and appropriate infrastructure and orthopaedic equipment for orthopaedic services. A recent study on “Essential fracture and orthopaedic equipment lists in low resource settings” made some recommendations that can facilitate in planning of appropriate equipment required in an institution which in turn has the potential to improve the capacity and quality of Trauma & Orthopaedic care in LMICs. The essential equipment lists provided can help direct where funding for equipment should be targeted. Those recommendations can help with planning and organising national Trauma & Orthopaedic care in LMICs to achieve appropriate capacity at all relevant levels of care [149]**.** Continued support of task shifting through the orthopaedic clinical officer program [150] at the district level should be encouraged until a sufficient number of surgeons have been trained. To scale up the surgical specialist service in a severely resource constrained country like

Malawi, specialist services need to be concentrated to a few training centres while these grow into sustainably sized units. These units can scale up production more rapidly and provide short stay trauma and orthopaedic services that serve the districts until enough surgeons can be trained also for the district hospitals.

Due to low level of education, culture, ignorance, and other beliefs some parents or guardians are not aware of these musculoskeletal conditions in children and others instead have conceded the verdict as the will of the creator and nothing can be done to reverse the equation. Considering the need for treatment of children with MSI in the country, the government of Malawi, in conjuction with MoH, stakeholders and other NGOs, should intensify awareness campaigns and assist these innocent children with MSI. Parents or guardians of children, in various communities, should be encouraged to seek medical advice. Those who are unable, should be assisted. The government should also adopt and implement inclusive policy for children with disability in the society. Previous studies in Malawi have highlighted the large number of children with MSI who are not attending school or do not have access to disability inclusive school resources [27]. Many parents and guardians have challenges to access health facilities and services due to the following reasons:

1. **Long distances to health facilities**

Most families stay far from health facilities that render it difficult for them to travel to access treatment or rehabilitation. It includes geographical factors like rivers and mountains. In addition, health infrastructure is concentrated in urban areas while the majority of the Malawi population lives in the rural area.

2. **Degree of sickness**

Some parents or guardians may not access health facilities because children are too sick to travel and have nobody to help them. Others although not too sick do not bother at all to seek treatment or rehabilitation services until it is too late.

3. **Preference for traditional healers**

Other families spend more time with traditional healers than seeking conventional health services. It may be because the healers know their families well, give more time to them or are more friendly than at health institutions.

4. **Cost implications**

When health services have to be paid for, most children with disabilities cannot access them due the cost. This is very true with facilities that belong to the Christian Health Association of Malawi (CHAM) that charge for health services.

5. **Attitudinal barrier**

Many parents or guardians of children with disabilities fail to access health facilities because of negative attitudes of the health workers that marginalizes them (e.g. cerebral palsy). Some of the workers are harsh and rude.

6. **Lack of medication/facilities**

Due to lack of medication and facilities in most health centres, persons including children with disabilities are not able to access treatment and rehabilitation among other interventions.

7. **Religious beliefs**

Religious reasons also play a role in access to health facilities. Some religious groups do not allow members of their congregation to receive or access health care [37]

The government of Malawi and other stakeholders have been dealing with these challenges for some time. However, there is still more that need to be done. Many families are living far from health facilities that render it difficult for them to travel to access free healthcare services. There are routine outreach clinics conducted by orthopaedic surgeons, OCOs, P&O staff, and physiotherapists in some district hospitals (70 to 80% coverage rate) treating children with MSI but this does not cover the whole country. The government and other stakeholders should provide psychological and

financial support to parents or guardians of children with chronic and severe MSI such as cerebral palsy. It should also encourage research on this condition and other many paediatric orthopaedic conditions.

MACOHA and the Federation of Disability Organizations in Malawi (FEDOMA) are both organisation of Disabled People's Organisations (DPOs) in Malawi. MACOHA designs, implements and monitors rehabilitation programmes and services for the socio-economic empowerment of persons with disabilities. MACOHA coordinates the National Community Based Inclusive Development (CBID) Programme through the National CBID Steering Committee. FEDOMA is represented in the committee and champions the empowerment component. The committee approves plans for implementation of disability programmes and services and gets reports on the same that involves FEDOMA mentioned above. In addition, persons with disabilities are involved at all levels, from the village, Traditional Authority Area, District up to the National level [37]. The government should then prioritise and plan the allocation of resources for health services for children with impairment to the above organisations and stakeholders so that they can achieve their goals.

8. Areas for future research

Malawi as a country is overwhelmed with the burden of both traumatic and non-traumatic musculoskeletal disease. Some, such as degenerative osteoarthritis and cerebral palsy, are more debilitating and of public health concern than others. With the burden of RTIs, little or nothing is said or done about the burden of degenerative joint disease. While hundreds of thousands of joint replacement surgeries are performed in HICs annually [we refer to annual reports from joint registries in the following countries such as Australia (Australian Orthopaedic Association National Joint Replacement Registry), UK (National Joint Registry), US (American Joint Replacement Registry), Norway (Norwegian Arthroplasty Register)] this type of surgical procedure is almost non-existant in Malawi. It is therefore, less clear how much of this burden of disease exists and the HRQoL.
Cerebral palsy was found to be the most common MSI due to some neurological disorders. This group in general has poor quality of life and it is a burden to the country as a whole. Therefore, more profound studies on cerebral palsy are needed for the establishment of preventive strategies.

Our study demonstrated a rapidly growing burden of RTIs and this could double again by 2030. Consequently, we are concerned and interested in the prevalence of traumatic musculoskeletal injuries in our region, the long-term outcome of the victims of RTI in terms of Health Related Quality of Life (HRQoL) and the impact on the country economy.

8.1 Documenting on quality of life following road traffic injury

It is known that most road injuries are musculoskeletal in nature, and several studies have shown the heavy burden of musculoskeletal injuries in Low and Middle Income Countries (LMICs) [151-152]. Our study demonstrated a rapidly growing burden of RTIs and linear regression projections based on our data demonstrate that the burden of RTIs at KCH could double again by 2030.

The available documentation describing the impact of road traffic injuries on health is well developed in terms of deaths and direct consequences, but it is less so in terms of long-term life consequences that arise as a result of RTIs. Police and hospital data reflect the direct and short-term health consequences of an injury following a crash but are silent regarding the long-term consequences, as this type of data only captures the acute phase of the crash [153, 154]. The immediate outcome of a road traffic injury might differ from the long-term outcomes. One way of summarizing the long-term outcome of an RTI is in terms of Health Related Quality of Life (HRQoL). The overall loss of HRQoL is known to be detrimental and long lasting for persons injured in road traffic crashes, and both physical and psychological consequences are considerable for those affected. It is important to note that it is not only the more severe injuries that are negatively associated with lower HRQoL following RTI; rather, all injury severity levels (minor, moderate, and severe injuries) have been shown to have a negative effect on HRQoL. Considering the rise in RTIs globally and mainly in LMICs, and most of these musculoskeletal injuries being managed non-operatively in our setting due to several factors, we need studies to assess the long-term outcomes on how injury severity is associated with HRQoL and the impact of age and gender.

8.2 Stimulating clinical research on prevalence and aetiology of cerebral palsy in Malawi

Our study on the prevalence of MSI found that 25% were neurological in origin and mainly cerebral palsy. Further analysis and results showed that this was the main cohort in dire need of medical treatment such as P&O devices, physical therapy, medication and surgery; but also a group with poor quality of life. In line with previous research in Malawi, physical impairment was the most common impairment type identified and cerebral palsy was the most common underlying health condition for children with physical impairment.

Cerebral palsy is a common motor disability in childhood that is often accompanied by sensory and cognitive dysfunctions and other medical conditions. Findings from national cerebral palsy registers and population based studies in Europe, Australia, and the USA indicate that the cerebral palsy prevalence is about 1.8–2.3 cases per 1,000 children [155, 150]. A systematic review [156] of 49 studies published between 1996 and 2013 included only one study [157] from a LMIC, showing the scarcity of epidemiological information from LMICs. Cerebral palsy has been suggested to be more prevalent in LMICs than in HICs [158, 159]. This increased prevalence could be due to risk factors affecting fetal and postnatal brain development (e.g preterm birth, obstetric complications, birth asphyxia, neonatal jaundice, cerebral infections, and convulsions).

There have been studies on cerebral palsy in Malawi but most of them emphasizing on the medical treatment, training of the therapists, Community Based Rehabilitation (CBR) workers and caregivers of children with cerebral palsy. More studies on the aetiology of cerebral palsy are needed for the establishment of preventive strategies.

8.3 Prevalence, quality of life and the treatment needs of patients with degenerative joint disease

MSI is increasing with age with degenerative joints disease leading the way. This has been shown by several studies including ours [52]. The Global Burden of Disease (GBD) study (2015) ranked osteoarthritis (OA) and diabetes highest in terms of largest increase in years lived with disability when compared to the other top causes of disability [160]. OA carries an excess mortality and financial burden both societally and to individuals suffering from it [161], and is a major contributor to the global disability burden, with an increase of 9.6% of the global age-standardised years lived with disability (YLD) between 1990 and 2017 [162].

Osteoarthritis is an important public health issue and is the most common type of arthritis [163], with 10% of the world's population aged 60 years and above having health problems attributed to OA [54,164]. The economic cost associated with it is enormous, ranging from direct treatment and care costs to lost work productivity [165-166]. To date, the majority of research on musculoskeletal disorders has been conducted in high-income settings, with limited data only from LMICs despite findings from the GBD 2010 study suggesting that the prevalence of arthritis may be higher in LMICs [167]. Furthermore, where evidence from LMICs is available it is typically from the upper middle-income group without much evidence from the lower middle income and the low-income countries that make up the remaining LMICs bloc.

People with degenerative joint disease often have joint stiffness, chronic pain, and swollen joints. It can become so debilitating that daily tasks become difficult. Cause of OA is thought to be related to ageing, whilst also associated with modifiable (trauma, obesity, lack of exercise) and non-modifiable risk factors (gender, age, genetics) [168] Malawi as a country is overwhelmed with the burden of road traffic injury which is on the rise. Very little or none is said or done about the burden of OA or degenerative joint disease which is becoming a growing epidemic in the aging population. It is less clear how much of this burden exists. Therefore, studies are needed to assess the prevalence, quality of life and treatment need in the general population.

9. References

1. The United Nations, Convention of the Rights of Persons with Disabilities and Optional Protocol. New York: United Nations; 2006.
2. Health Organization, International Classification of Functioning, Disability and Health (ICF) Geneva: 2001, WHO.
3. *"WHO | Metrics: Disability-Adjusted Life Year (DALY)"*
4. EuroQol: EuroQol—a new facility for the measurement of health-related quality of life. *Health Policy 1990;16:199–208*. https://doi.org/10.1016/0168-8510(90)90421-9
5. Agrawal D, Mohanty BB, Sarangi R, Kumar S, Mahapatra SK, Chinara PK. Study of Incidence and Prevalence of Musculoskeletal Anomalies in a Tertiary Care Hospital of Eastern India. *J Clin Diagn Res. 2014 May; 8(5): AC04–AC06*.
6. Solomon L, Warwick D, Nayagam S, Apley AG. (2010). Apley's system of orthopaedics and fractures (9th ed.). London: Hodder Arnold.
7. Rockwood CA, Green DP, Heckman JD, Bucholz RW. (2001). Rockwood and Green's fractures in adults. Philadelphia: Lippincott Williams & Wilkins.
8. WHO. Musculoskeletal conditions.

https://www.who.int/news-room/fact-sheets/detail/musculoskeletal-conditions

9. Cieza A, Causey K, Kamenov K, Hanson SW, Chatterji S, Vos T. (2020). Global estimates of the need for rehabilitation based on the Global Burden of Disease study 2019: a systematic analysis for the Global Burden of Disease Study 2019. *The Lancet, 396(10267), 2006-2017*.
10. Hartvigsen J, Hancock MJ, Kongsted A, et al. What low back pain is and why we need to pay attention. *Lancet 2018; 391: 2356–67*.

11. World Bank Country and Lending Groups [ONLINE]; 2017. Available at: https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups. Accessed 19 Sept 2017.
12. Henrickson M. Policy challenges for the pediatric rheumatology workforce: Part II. Health care system delivery and workforce supply. *Pediatric Rheumatology 2011;9(1):24*.
13. Henrickson M. Policy challenges for the pediatric rheumatology workforce: Part III. the international situation. *Pediatric Rheumatology 2011;9(1):26*.
14. Dave M, Rankin J, Pearce M, Foster HE. Global estimates of Clubfoot, Juvenile Idiopathic Arthiritis and Juvenile Systemic Lupus Erythematosus. *Pediatric Rheumatology 2020;18:49*. https://doi.org/10.1186/s12969-020-00443-8.
15. Foster HE, Rapley T. Access to pediatric rheumatology care -- a major challenge to improving outcome in juvenile idiopathic arthritis. *J Rheumatol. 2010;37(11):2199–202*.
16. Consolaro A, Giancane G, Alongi A, van Dijkhuizen EHP, Aggarwal A, Al-Mayouf SM, et al. Phenotypic variability and disparities in treatment and outcomes of childhood arthritis throughout the world: an observational cohort study. *The Lancet Child & Adolescent Health. 2019;3(4):255–63*.
17. Dobbs MB, Gurnett CA. Update on clubfoot: etiology and treatment. *Clin Orthop Relat Res. 2009;467(5):1146*.
18. Harper BD, Nganga W, Armstrong R, Forsyth KD, Ham HP, Keenan WJ, Russ CM. Where are the paediatricians? An international survey to understand the global paediatric workforce. *BMJ Paediatr Open. 2019 Jan 31;3(1):bmjpo-2018-000397*
19. Scott C, Webb K. Paediatric rheumatology in sub-Saharan Africa. *Rheumatology. 2014;53(8):1357–8*.
20. Sawhney S, Manners P. The place of pediatric rheumatology in India. *The Indian Journal of Pediatrics. 2010;77(9):993–6*.

21. Global status report on road safety 2018. Geneva: World Health Organization; 2018. IGO; https://creativecommons.org/licenses/by-nc-sa/3.0/igo
22. Peden M et al., editors. World report on road traffic injury prevention. Geneva, World Health Organization, 2004.
23. World bank. Gross Income per Capita ranking. Atlas Method and Purchasing Power and Parity; 2020
24. Samuel JC, Akinkuotu A, Baloyi P, Villaveces A, Charles A, *et al.* Hospital-based injury data in Malawi: strategies for data collection and feasibility of trauma scoring tools. *Trop Doct 2010 Apr; 40(2): 98-99.*
25. National Statistical Office (NSO) Population and Housing Census 2018: Final Report (2019) 4
26. Malawi National Statistics Office. Malawi population and housing census. Zomba: National Statistics office; 2008
27. Tataryn M, Polack S, Chokotho L, Mulwafu W, Kayange P, et al. Childhood disability in Malawi: a population based assessment. using the key informant method. *BMC Pediatrics 2017;17(1):198*. https://doi.org/10.1186/s12887-017-0948-z
28. Alavi Y, Jumbe V, Hartley S, Smith S, Lamping D, Muhit M, et al. Indignity, exclusion, pain and hunger: the impact of musculoskeletal impairments in the lives of children in Malawi. *Disability and Rehabilitation 2012; 34(20): 1736–1746*. https://doi.org/10.3109/09638288.2012.662260
29. "Malawi Population (2021) – Worldometer" . www.worldometers.info.
30. "Malawi". The World Factbook. CIA. Retrieved 2 September 2019
31. Euromoney Country Risk". Euromoney Institutional Investor PLC. Retrieved 15 August 2011
32. Kalinga, Owen (2012). Historical Dictionary of Malawi. The Scarecrow Press, Inc. ISBN 978-0-81085961-6.
33. "Health Observatory Data Repository". World Health Organization. *Retrieved 10 May 2013*

34. World Health Organization Regional Office for Africa. Archived from the original (PDF) on December 13, 2007. Retrieved 2013-10-18.
35. Scott David (4 July 2017). "Developing pharmacy in Malawi".
36. Malawi Ministry of Health. National AIDS. https://www.health.gov.mw/index.php/2016-01-06-19-58-23/national-aids
37. P.M.G. Ngomwa, "Action Plan on CBR Programme in Karonga A.D.D. (MACOHA) 1990-1992" Institute of Child Health, University of London; Alistair Munthali etal, "Barriers to Accessing, Health care Services Among People with Disabilities in Malawi," Centre for Social Research Malawi.
38. Ripple Africa.Healthcare in Malawi, Africa. https://rippleafrica.org/project/healthcare-in-malawi-africa/
39. Health Sector Strategic Plan I (2011-2016). https://www.resakss.org
40. Varela C, Young S, Groen R, Banza L, Mkandawire NC, Viste A. Untreated surgical conditions in Malawi: A randomised cross-sectional nationwide household survey. *Malawi Medical Journal 2017 Sept;29(3):231–236* https://doi.org/10.4314/mmj.v29i3.1
41. Makaula P, Bloch P, Banda HT, Mbera GB, Mangani C, et al. Primary health care in rural Malawi—a qualitative assessment exploring the relevance of the community-directed interventions approach. *BMC Health Services Research 2012, 12:328*. https://doi.org/10.1186/1472-6963-12-328
42. United Nations. Population Statistics. http://unstats.un.org/unsd/demographic/meetings/egm/Sampling_1203/docs/no_2.pdf
43. Biritwum RB, Devres JP, Ofosu-Amaah S, Marfo C, Essah ER. Prevalence of children with disabilities in central region, Ghana. *West Afr J Med 2001;20: 249–255*.
44. Atijosan O, Kuper H, Rischewski D, Simms V, Lavy C (2007) Musculoskeletal impairment survey in Rwanda: Design of survey tool, survey methodology, and results of pilot study (a cross sectional survey) *BMC Musculoskeletal Disorders 2007;8:30*. https://doi.org/10.1186/1471-2474-8-30

45. The EuroQol Group. EuroQol—a new facility for the measurement of health-related quality of life. *Health Policy 1990 Dec;16:199–208*. https://doi.org/10.1016/0168-8510(90)90421-9
46. Chokotho L, Mkandawire N, Conway D, Wu HH, Shearer DD, Hallan G, et al. Validation and reliability of the Chichewa translation of the EQ-5D quality of life questionnaire in adults with orthopaedic injuries in Malawi. *Malawi Med J. 2017 Jun;29(2):84-88*. https://doi.org/10.4314/mmj.v29i2.2
47. Chopra A. COPCORD—an unrecognised fountainhead of community rheumatology in developing countries. *J Rheumatol 2004;31:2320–2321*.
48. World bank. Gross Income per Capita ranking. Atlas Method and Purchasing Power and Parity; 2016.
49. Atijosan O, Kuper H, Rischewski D, et al. The orthopaedic needs in children in Rwanda: results from a national survey and orthopaedic services implications. *J.Pediatr Orthop 2009; 29(8): 948-51*
50. Jelsma J, Mhundwa K, WeerdtWDe, Cock P De, Chimera J, Chivaura V: The reliability of the Shona version of the EQ-5D. *Central African Journal of Medicine 2001, 47:8–11*.
51. Jelsma J, Chivaura V, De Cock P, De Weerdt W: A bridge between cultures: A report on the process of translating the EQ-5D instrument into Shona. *South African Journal of Physiotherapy 2000, 56:3–9*.
52. Ngoie LB, Dybvik E, Hallan G, Gjertsen JE, Mkandawire N, Varela C, Young S. Prevalence, causes and impact of musculoskeletal impairment in Malawi: A national cluster randomized survey. *PLoS ONE 2021 Jan;16(1):e0243536*. https://doi.org/10.1371/journal.pone.0243536
53. Atijosan O, Rischenwski D, Simms V, et al. A national survey of musculoskeletal impairment in Rwanda: prevalence, causes and service implications. *PLoS One, 2008; 3(7): e2851*. https://doi.org/10.1371/journal.pone.0002851
54. Woolf AD, Pfleger B. Burden of major musculoskeletal conditions. *Bull World Health Organ.* 2003;81(9):646–656.

55. Murray CJL, et al. Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet.* 2012;380:2197–2223. doi: 10.1016/S0140-6736(12)61689-4. [PubMed] [CrossRef] [Google Scholar] [Ref list]

56. Kobusingye O, Guwatudde D, Lett R. Injury patterns in rural and urban Uganda. Inj Prev. 2001; 7:46–50. https://doi.org/10.1136/ip.7.1.46 PMID: 11289535

57. Daar AS, Rizvi SA, Naqvi SA. Surgery with limited resources. In: Morris PJ, Wood WC, editors. Oxford textbook of surgery. 2nd ed. New York: Oxford University Press; 2000. p 3386.

58. Patton GC, Coffey C, Sawyer SM, Viner RM, Haller DM, Bose K, et al. Global patterns of mortality in young people: a systematic analysis of population health data. Lancet 2009;374(9693):881e92.

59. Bethge M, von Groote P, Giustini A, Gutenbrunner C. The World Report on Disability: a challenge for rehabilitation medicine. *Am J Phys Med Rehabil. 2014Jan; 93 (1Suppl 1): S4-11.*

60. Abegaz T, Berhane Y, Worku A, Assrat A. Effectiveness of an improved road safety policy in Ethiopia: an interrupted time series study. BMC Publ Health 2014;14:539. https://doi.org/10.1186/1471-2458-14-539

61. Elliott IS, Groen RS, Kamara TB, Ertl A, Cassidy LD, Kushner AL, Gosselin RA. The Burden of Musculoskeletal Disease in Sierra Leone. *Clin orthop Relat Res 2015 Jan;473(1):380– 389*

62. Smythe T, Mactaggart I, Kuper H, et al. Prevalence and causes of musculoskeletal impairment in Fundong District, North-West Cameroon: results of a population-based survey. *Trop Med Int Health. 2017;22(11):1385–93.*

63. Feng Y, Parkin D, Devlin NJ. Assessing the performance of the EQ-VAS in the NHS PROMs programme. *Quality of Life Research. 2014;23(3):977–989.*

64. Gaillard J. Measuring research and development in developing countries: main characteristics and implications for the frascati manual. *Sci. Technol. Soc. 2010;15: 77–111*. http://www.doi.org/10.1177/097172180901500104
65. Helmy M, Awad M, Mosa KA. Limited resources of genome sequencing in developing countries: challenges and solutions. *Appl. Transl. Genomics 2016; 9: 15–19*. http://www.doi.org/10.1016/j.atg.2016.03.003
66. Gonzalez-Brambila CN, Reyes-Gonzalez L, Veloso F, Perez-Angón MA. The scientific impact of developing nations. *PLoS ONE 2016; 11(3):e0151328*. http://www.doi.org/10.1371/journal.pone.0151328
67. Ciocca DR, Delgado G. The reality of scientific research in Latin America; an insider's perspective. *Cell Stress Chaperones 2017; 22:847–852*. http://www.doi.org/10.1007/s12192-017-0815-8
68. Clark N, Chataway J. Below the radar: a fresh approach to innovation and development policy. *Int. J. Technol. Manage. Sustain. 2009 Dec; 8:171–175*. http://www.doi.org/10.1386/ijtm.8.3.171/2
69. Disability and development in Malawi. http://www.rodra.co.za
70. World Bank.2017. The High Toll of Traffic Injuries: Unacceptable and Preventable. World Bank.
71. Varela C, Young S, Mkandawire N, Groen RS, Banza L, Viste A. Transportation barriers to access health care for surgical conditions in Malawi a cross sectional nationwide household survey. *BMC Public Health 2019; 19(1), 264*. https://doi.org/10.1186/s12889-019-6577-8
72. Chokotho L, Jacobsen KH, Burgess D, Labib M, Le G, Lavy CB, et al. Trauma and orthopaedic capacity of 267 hospitals in east central and southern Africa. *Lancet. 2015 Apr 27; 385 Suppl 2:S17*. https://doi.org/10.1016/S0140-6736(15)60812-1
73. Payne CF, Mkandawire J, Kohler HP. Disability transitions and health expectancies among adults 45 years and older in Malawi: a cohort-based model. *PLoS Med* 2013: 10: e1001435. https://doi.org/10.1371/journal.pmed.1001435

74. Clausen T, Romoren TI, Ferreira M, Kristensen P, Ingstad B, Holmboe-Ottesen G. Chronic diseases and health inequal- ities in older persons in Botswana (southern Africa): a national survey. *J Nutr Health Aging* 2005: 9: 455–461.
75. Global Burden of Disease Study 2013 Collaborators. Global, regional, and national incidence, prevalence, and years lived with disabil- ity for acute and chronic diseases and injuries in 188 countries, 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet 2015: 386: 743–800*. https://doi.org/10.1016/S0140-6736(15)60692-4
76. GBD 2015 Disease and Injury Incidence and Prevalence Collaborators. Global, regional, and national inci- dence, prevalence, and years lived with disability for diseases and injuries, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet 2016: 388: 1545–1602.* https://doi.org/10.1016/S0140-6736(16)31678-6
77. Ngoie LB, Dybvik E, Hallan G, Gjertsen JE, Mkandawire N, Varela C, Young S. The unmet need for treatment of children with musculoskeletal impairment in Malawi. *BMC Pediatrics 2022;22(1):67*
78. Schade AT, Mbowuwa F, Chidothi P, et al. Epidemiology of fractures and their treatment in Malawi: Results of a multicentreprospective registry study to guide orthopaedic care planning. *PLoS One 2021 Aug 4;16(8):e0255052*. http://www.doi.org/ 10.1371/journal.pone.0255052.
79. Glèlè-Ahanhanzo Y, Kpozèhouen A, Paraïso NM, Makoutodé P, Biaou COA, Remacle E, Ouendo EM, Levêque A. Disability and Related Factors among Road Traffic Accident Victims in Benin: Study from Five Public and Faith-Based Hospitals in Urban and Suburban Areas. *Open Journal of Epidemiology, 8, 226-241*. http:/www.doi.org/10.4236/ojepi.2018.84018
80. Cook C, Qureshi B. VISION 2020 at the district level. *Common Eye Health 2005: 18: 85–89*.
81. Adebajo A, Gabriel SE. Addressing Musculoskeletal Health Inequity in Africa. *Arthritis Care Res (Hoboken) 2010 Apr;62(4):439-41*. http://www.doi.org/10.1002/acr.20032

82. Olawale OA, Deih AN, Yaadar RK. Psychological impact of cerebral palsy on families: The African perspective. *J Neurosci Rural Pract. 2013 Apr-Jun; 4(2): 159–163*
83. Akinyoola AL, Adegbehingbe OO, Ogundele OJ. Factors influencing the outcome of elective paediatric orthopaedic operations in Ile-Ife, Nigeria. *Tanzania J Health Res. 2008;10(2):68–72*.
84. Bax M, Goldstein M, Rosenbaum P, et al. Proposed definition and classification of cerebral palsy, April 2005. *Dev Med Child Neurol. 2005;47:571–6*.
85. Donald KA, Samia P, Kakooza-Mwesige A, Bearden D. Pediatric cerebral palsy in Africa: a systematic review. *Semin Pediatr Neurol. 2014;21:30–5*.
86. Monokwane B, et al. Risk Factors for Cerebral Palsy in Children in Botswana. *Pediatr Neurol. 2017;77:73–7.*
87. World Health Organization & World Bank. World Report on Disability. Geneva: Switzerland World Health Organization; 2011.
88. OECD. New ways of Adressing partial work capacity. In: OECD thematic Reiview on sickness, disability and work Isues, paper and Progress report; 2007 https://www.oecd.org/social/soc/38509814.pdf.
89. WHO. Global status report on road safety 2015. Geneva: World Health Organization; 2015.
90. UNICEF-Malawi-2020-2021-Health-Budget-Brief. https://www.unicef.org
91. Kendig C, Tyson A, Young S, Mabedi C, Cairnes B, Charles A. The effect of a new surgery residency program on case volume and case complexity in a Sub-Saharan African Hospital. *J Surg Educ 2015 Jul-Aug;72(4):e94-9*. https://doi.org/10.1016/j.jsurg.2014.09.011.
92. Samuel JC, Akinkuotu A, Villaveces A, Charles AG, Lee CN, Hoffman IF, et al. Epidemiology of injuries at a tertiary care center in Malawi. *World J Surg 2009;33(9):1836e41*.
93. Young S, Banza L, Mkandawire N. The impact of long term institutional collaboration in surgical training on trauma care in Malawi. *SpringerPlus 2016;5(1):1-5*.

94. Young S, Banza LN, Munthali BS, Manda KG, Gallaher J, Charles A. "The impact of the increasing burden of trauma in Malawi on orthopaedic trauma service priorities at Kamuzu Central Hospital". *Acta Orthop 2016 Dec;87(6):632-6*.
95. Ferreira F, Jolliffe DM, Prydz EB. The international poverty line. World Bank; 2015.
96. World bank (2015) http://www.worldbank.org/en/topic/health/brief/malaria
97. Haug L, Wazakili M, Young S, Van den Bergh G. Longstanding pain and social strain: patients 'and health care providers' experiences with fracture management by skeletal traction; a qualitative study from Malawi. *Disabil Rehabil 2017;39 (17):1714-21*.
98. Kohler RE, Tomlinson J, Chilunjika TE, Young S, Hosseinipour M, Lee CN. "Life is at a standstill" Quality of life after lower extremity trauma in Malawi. *Qual Life Res 2017 Apr;26 (4):1027-35*. https://doi.org/10.1007/s11136-016-1431-2
99. Grimes CE, Henry JA, Maraka J, Mkandawire NC, Cotton M. Cost-effectiveness of surgery in low- and middle-income countries: systematic Review. *World J Surg 2014 Jan;38(1):252-63*. http://www.doi.org/10.1007/s00268-013-2243-y
100. Meara JG, Leather AJM, Hagander L, Alkire BC, Alonso N, Ameh EA, et al. Global Surgery 2030: evidence and solutions for achieving health, welfare, and economic development. *Lancet 2015;386(9993):569-624*.
101. Bae JY, Groen RS, Kushner AL. Surgery as a public health intervention: common misconceptions versus the truth. *Bull World Health Organ.* 2011;89:394.doi: 10.2471/BLT.11.088229. [PMC free article] [PubMed] [CrossRef] [Google Scholar]
102. Farmer PE, Kim JY. Surgery and global health: a view from beyond the OR. *World J Surg.* 2008;32:533–536. doi: 10.1007/s00268-008-9525-9. [PMC free article] [PubMed] [CrossRef] [Google Scholar]
103. Grimes CE, Bowman KG, Dodgion CM, Lavy CB. Systematic review of barriers to surgical care in low-income and middle-income countries. *World*

J Surg. 2011;35:941–950. doi: 10.1007/s00268-011-1010-1. [PubMed] [CrossRef] [Google Scholar]

104. Banza L, Gallaher J, Dybvik E, Charles A, Hallan G, Gjertsen JE, Mkandawire N, Varela C, Young S. The rise in road traffic injuries in Lilongwe, Malawi. A snapshot of the growing epidemic of trauma in low income countries. *International Journal of Surgery Open 10 (2018) 1-6*.

105. Hyder AA, Paichadze N, Toroyan T, Peden MM. Monitoring the Decade of Action for Global Road Safety 2011–2020: An update. *Glob Public Health 2017, 12, 1492–1505.*

106. FMCSA. Implementation Guidelines for Alcohol and Drug Regulations - Chapter 7. Washington, DC: Federal Motor Carrier Safety Administration. Available:at:https://www.fmcsa.dot.gov/regulations/drug-alcohol-testing/implementation-guidelines-alcohol-and-drug-regulations-chapter-7

107. ETSC. Blood alcohol content (BAC) drink driving limits across Europe. Brussels, Belgium: European Transport Safety Council; 2019. Available from: https://etsc.eu/issues/drink-driving/blood-alcohol-content-bac-drink-driving-limits-across-europe/

108. Road Traffic Injuries in Malawi – with special focus on the role of alcohol. Christophersen AS, Bogstrand ST, Gjerde H, Sundet M, Wyller EH.ISBN (digital): 978-82-8406-191-7.

109. Erke A. Effects of electronic stability control (ESC) on accidents: a review of empirical evidence. *Accident Analysis and Prevention. 2008;40:167–173*.

110. Pedestrian safety: a road safety manual for decision-makers and practitioners. Geneva: World Health Organization; 2013.

111. The Nation: A Malawi Nation Newspaper; June 2021.

112. Jacobs G, Aeron-Thomas A, Astrop A. Estimating global road fatalities. Crowthorne: Transport Research Laboratory; 2000 (TRL Report 445).

113. Chokotho L, Mulwafu W, Singini I, Njalale Y, Maliwichi-Senganimalunje L, Jacobsen KH. First responders and pre-hospital care for road traffic accidents in Malawi. *Prehospital Disaster Med 2017; 32:14-19*.

114. Lavy C, Tindall A, Steinlechner C, Mkandawire N, Chimangeni S. Surgery in Malawi: a national survey of activity in rural and urban hospitals. *Ann R Coll Surg Engl 2007; 89:722-724*.

115. Chokotho L, Mulwafu W, Singini I, Njalale Y, Jacobsen KH. Improving hospital-based trauma care for road traffic injuries in Malawi. *World J Emerg Med 2017; 8:85-90*.

116. Chokotho L, Jacobsen KH, Burgess D, Labib M, Le G, Peter N, Lavy CBD, Pandit H. A review of existing trauma and musculoskeletal impairment (TMSI) care capacity in east, central, and southern Africa. *Injury 2016; 47:1990-1995*.

117. Chokotho L, Jacobsen KH, Burgess D, Labib M, Le G, Lavy CBD, Pandit H. Trauma and orthopaedic capacity of 267 hospitals in east, central, and southern Africa. *Lancet 2015; 385(Suppl 2):S17*.

118. Cameron P, Gabbe B, Cooper D, Walker T, Judson R, McNeil J. A statewide system of trauma care in Victoria: effect on patient survival. *Med J Aust 2008; 189:546-550*.

119. Lendrum RA, Lockey DJ. Trauma system development. *Anaesthesia 2013; 61(Suppl 1):30-39*.

120. Beuran M, Paun S, Gaspar B, et al. Prehospital trauma care: a clinical review. *Chirurgia 2012; 107:564-570*.

121. Sasser S, Varghese M, Kellerman A, Lormand JD. Prehospital trauma care systems. Geneva: World Health Organization; 2005.

122. Jayaraman S, Mabweijano JR, Lipnick MS, Caldwell N, Miyamoto J, Wangoda R, et al. First things first: effectiveness and scalability of a basic prehospital trauma care program for lay first-responders in Kampala, Uganda. *PLoS One 2009;4:e6955*. http://www.doi.org/10.1371/journal.pone.0006955

123. Sangowawa AO, Owoaje ET. Building capacity of drivers in Nigeria to provide first aid for road crash victims. *Inj Prev 2012;18:62- 5*. http://www.doi.org/10.1136/injuryprev-2011-040134

124. Martel J, Oteng R, Mould-Millman NK, Bell SA, Zakariah A, Oduro G, et al. The development of sustainable emergency care in Ghana: physician, nursing and prehospital care training initiatives. *J Emerg Med 2014;47:462-8*. http://www.doi.org/10.1016/j.jemermed.2014.04.041

125. Adewole OA, Fadeyibi IO, Kayode MO, Giwa SO, Shoga MO, Adejumo AO, Ademiluyi SA. Ambulance services of Lagos state, Nigeria: a six-year (2001-2006) audit. *West Afr J Med 2012;31:3-7*.

126. Moroz PJ, Spiegel DA. The World Health Organization's action plan on the road traffic injury pandemic: Is there any action for orthopaedic trauma surgeons? *J Orthop Trauma 2014; 28(Suppl 1):S11-14*.

127. Quansah R, Abantanga F, Donkor P. Trauma training for nonorthopaedic doctors in low- and middle-income countries. *Clin Orthop Relat Res 2008; 466:2403-2412*.

128. Grimes CE, Mkandawire NC, Billingsley ML, Ngulube C, Cobey JC. The cost-effectiveness of orthopaedic clinical officers in Malawi. *Trop Doct 2014; 44:128-134*.

129. Nogaro MC, Pandit H, Peter N, et al. How useful are primary trauma care courses in sub-Saharan Africa? *Injury 2015; 46:1293-1298*.

130. Fielder S, Mpezeni S, Benjamin L, Cary I. Point of view: physiotherapy in Malawi: a step in the right direction. *Malawi Med J 2013; 25:83-85*.

131. Meara JG, Leather AJ, Hagander L, Alkire BC, Alonso N, Ameh EA, Bickler SW, Conteh L, Dare AJ, Davies J, M risier ED. Global Surgery 2030: evidence and solutions for achieving health, welfare, and economic development. *The Lancet. 2015 Aug 8;386(9993):569-624*.

132. Young S, Banza L, Mkandawire N. The impact of long term institutional collaboration in surgical training on trauma care in Malawi. *SpringerPlus 2016;5:407*. https://doi.org/10.1186/s40064-016-2050-7

133. Kohler RE, Tomlinson J, Chilunjika TE, Young S, Hosseinipour M, Lee CN. Life is at a standstill: quality of life after lower extremity trauma in Malawi. *Qual Life Res 2017; 26:1027-1035*

134. 2018 Malawi Population and Housing Census. https://malawi.unfpa.org

135. Malawi Growth Development Strategy 2017-2022. https://www.afidep.org

136. Dycus DL, Levine D, Marcellin-Little DJ. Physical rehabilitation for the Management of Canine hip Dysplasia. *Vet Clin North Am Small Anim Pract.* 2017;**47**(4):823–850. [PubMed] [Google Scholar]

137. Sigurdsson SO, Austin J. Using real-time visual feedback to improve posture at computer workstations. *J Appl Behav Anal.* 2008;**41**(3):365–375. [PMC free article] [PubMed] [Google Scholar]

138. Health in Motion-Transforming life through movement. https://healthinmotionafrica.com/

139. Ekelund U, Steene-Johannessen J, Brown WJ, Fagerland MW, Owen N, Powell KE, Bauman A, Lee IM. Lancet physical activity series 2 executive C, lancet sedentary behaviour working G: does physical activity attenuate, or even eliminate, the detrimental association of sitting time with mortality? A harmonised meta-analysis of data from more than 1 million men and women. Lancet. 2016. [PubMed]

140. Kubota Y, Evenson KR, MacLehose RF, Roetker NS, Joshu CE, Folsom AR. Physical Activity and Lifetime Risk of Cardiovascular Disease and Cancer. Med Sci Sports Exerc. 2017. [PMC free article] [PubMed]

141. Van der Velde JH, Koster A, van der Berg JD, Sep SJ, van der Kallen CJ, Dagnelie PC, Schram MT, Henry RM, Eussen SJ, van Dongen MC, et al. Sedentary behavior, physical activity, and fitness-the Maastricht study. Med Sci Sports Exerc. 2017. [PubMed]

142. McCarthy CJ, Mills PM, Pullen R, Richardson G, Hawkins N, Roberts CR, Silman AJ, Oldham JA. Supplementation of a home-based exercise programme with a class-based programme for people with osteoarthritis of the knees: a randomised controlled trial and health economic analysis. *Health Technol Assess.* 2004;**8**(46):iii–iiv. [PubMed] [Google Scholar]

143. Gordon R, Bloxham S. A Systematic Review of the Effects of Exercise and Physical Activity on Non-Specific Chronic Low Back Pain. Healthcare (Basel). 2016;4(2). [PMC free article] [PubMed]

144. Warburton DE, Nicol CW, Bredin SS. Prescribing exercise as preventive therapy. *CMAJ.* 2006;**174**(7):961–974. [PMC free article] [PubMed] [Google Scholar]

145. Lundberg IE, Nader GA. Molecular effects of exercise in patients with inflammatory rheumatic disease. *Nat Clin Pract Rheumatol.* 2008;**4**(11):597–604. [PubMed] [Google Scholar]

146. Nicklett EJ, Semba RD, Xue QL, Tian J, Sun K, Cappola AR, Simonsick EM, Ferrucci L, Fried LP. Fruit and vegetable intake, physical activity, and mortality in older community-dwelling women. *J Am Geriatr Soc.* 2012;**60**(5):862–868. [PMC free article] [PubMed] [Google Scholar]

147. Mobasheri A, Batt M. An update on the pathophysiology of osteoarthritis. *Ann Phys Rehabil Med.* 2016;**59**(5–6):333–339. [PubMed] [Google Scholar]

148. Mkandawire N, Ngulube C, Lavy C. Orthopaedic Clinical Officer Program in Malawi: A Model for Providing Orthopaedic Care. *Clin Orthop Relat Res. 2008 Oct;466(10):2385-91*. http://www.doi.org/10.1007/s11999-008-0366-5

149. Chan Y, Banza L, Martin Jr C, Harrison WJ. Essential fracture and orthopaedic equipment lists in low resource settings: consensus derived by survey of experts in Africa. *BMJ Open. 2018; 8(9): e023473*.

150. Van Naarden Braun K, Doernberg N, Schieve L, Christensen D, Goodman A, Yeargin-Allsopp M. Birth prevalence of cerebral palsy: a population-based study. *Pediatrics 2016; 137(1):1-9*.

151. Agarwal-Harding KJ, Meara JG, Greenberg SLM, et al. Estimating the global incidence of femoral fracture from road traffic collisions: a literature review. *The Journal of bone and joint surgery American volume. 2015;97(6):e31-e*.

152. Afukaar FK, Antwi P, Ofosu-Amaah S. Pattern of road traffic injuries in Ghana: Implications for control. *Injury Control and Safety Promotion. 2003;10(1-2): 69-76*.

153. Berg HY, Ifver J, Hasselberg M. Public health consequences of road traffic injuries—Estimation of seriously injured persons based on risk for permanent medical impairment. *Transportation Research Part F 2016;38:1-6.* https://doi.org/10.1016/j.trf.2015.12.007

154. Cubí-Mollá P, Herrero C. Quality of life lost due to non-fatal road traffic injuries. *Health Econ. 2012 May;21(5):528-50.* https://doi.org/10.1002/hec.1729

155. Smithers-Sheedy H, McIntyre S, Gibson C, et al. A special supplement: findings from the Australian Cerebral Palsy Register, birth years 1993 to 2006. *Dev Med Child Neurol 2016; 58 (suppl 2): 5–10*.

156. Oskoui M, Coutinho F, Dykeman J, Jette N, Pringsheim T. An update on the prevalence of cerebral palsy: a systematic review and meta-analysis. *Dev Med Child Neurol 2013; 55: 509–19*.

157. Were FN, Bwibo NO. Two year neurological outcomes of very low birth weight infants. *East Afr Med J 2006; 83: 243–49*.

158. Graham HK, Rosenbaum P, Paneth N, et al. Cerebral palsy. *Nat Rev Dis Primers 2016; 2: 15082*.

159. Couper J. Prevalence of childhood disability in rural KwaZulu-Natal. *S Afr Med J 2002; 92: 549–52*.

160. GBD 2015 Disease and Injury Incidence and Prevalence Collaborators. Global, regional, and national incidence, prevalence, and years lived with disability for 310 diseases and injuries, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet 2016 Oct 8;388(10053):1545-1602.*.

161. Palazzo C, Nguyen C, Lefevre-Colau M-M, et al. Risk factors and burden of osteoarthritis. *Ann Phys Rehabil Med.* 2016;59(3):134–138.

162. Safiri S, Kolahi A-A, Smith E, et al. Global, regional and national burden of osteoarthritis 1990–2017: a systematic analysis of the Global Burden of Disease Study 2017. *Ann Rheum Dis.* 2020;79(6):819–828.

163. Picavet HS, Hazes JM. Prevalence of self reported musculoskeletal diseases is high. *Ann Rheum Dis.* 2003;62(7):644–650.

164. Cross M, Smith E, Hoy D, et al. The global burden of hip and knee osteoarthritis: estimates from the global burden of disease 2010 study. *Ann Rheum Dis.* 2014;73(7):1323–1330.

165. GBD 2016 DALYs and HALE Collaborators. Global, regional, and national disability-adjusted life-years (DALYs) for 333 diseases and injuries and healthy life expectancy (HALE) for 195 countries and territories, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet 2017;390 (10100):1260–1344*.

166. Altman RD. Early management of osteoarthritis. *American J Manag Care* 2010;16:41.

167. Storheim K, Zwart JA. Musculoskeletal disorders and the Global Burden of Disease study. *Ann Rheum Dis. 2014;73(6):949–950*.

168. Haq I, Murphy E, Dacre J. Osteoarthritis. *Postgrad Med J. 2003;79 (933): 377–383*

International Journal of Surgery Open 10 (2018) 1–6

Contents lists available at ScienceDirect

International Journal of Surgery Open

journal homepage: www.elsevier.com/locate/ijso

The rise in road traffic injuries in Lilongwe, Malawi
A snapshot of the growing epidemic of trauma in low income countries

Leonard Ngoie Banza [a, b, f, *], Jared Gallaher [d], Eva Dybvik [e], Anthony Charles [d], Geir Hallan [c], Jan-Erik Gjertsen [c, f], Nyengo Mkandawire [b, g], Carlos Varela [a, b, f], Sven Young [a, b, c]

[a] Department of Surgery, Kamuzu Central Hospital, P.O. Box 149, Lilongwe, Malawi
[b] Department of Surgery, College of Medicine, University of Malawi, Blantyre, Malawi
[c] Department of Orthopaedic Surgery, Haukeland University Hospital, 5021 Bergen, Norway
[d] Department of Surgery, University of North Carolina, Chapel Hill, NC, USA
[e] The Norwegian Arthroplasty Registry, Haukeland University Hospital, Bergen, Norway
[f] Institute of Clinical Studies (K1), University of Bergen, Bergen, Norway
[g] School of Medicine, Flinders University, Adelaide, Australia

ARTICLE INFO

Article history:
Received 27 July 2017
Received in revised form
16 November 2017
Accepted 19 November 2017
Available online 7 December 2017

Keywords:
Road traffic injuries
Low income countries
Scaling up trauma system
Increasing burden of injuries

ABSTRACT

Introduction: Road traffic injuries (RTIs) and death are a major public health issue worldwide. Unless appropriate action is taken urgently, the burden of RTIs will continue to increase globally. This will be particularly pronounced in developing countries where rapid motorization is likely to continue over the next decades. Malawi is one of these countries with a population of 17.2 million and a Gross National Income per capita of 340 US$. The impact of the rising burden of injury on the health sector is considerable. However, data to demonstrate this development is lacking.

Methods: This study is an analysis of data from the Kamuzu Central Hospital (KCH) Trauma Registry. KCH is a 900-bed tertiary care public hospital in Lilongwe, the capital city of Malawi. The KCH Trauma Registry was established to collect patient demographic information, clinical characteristics, and outcome data for all patients presenting to the emergency department with injuries. All patients who presented to the emergency department with injuries between January 2009 and December 2015 were included in the study.

Results: A 96,967 patients with injuries between 2009 and 2015 were registered in the KCH Trauma Registry. The mean age of these patients was 23.3 years and 36.8% were children younger than 18 years. 25,193 (26.2%) patients had road traffic related injuries, of these 19,244 (76.4%) were men. There was a 62.4% rise in the number of RTI victims treated at KCH from 2447 in 2009–3975 in 2015. If this trend continues, 7997 patients will be expected to need treatment for RTIs at KCH in 2030, doubling the numbers seen in 2015 in just 15 years. The highest number of injuries occurred in pedestrians (32.3%) and cyclists (28.2%) and continually rose over the years studied. The length of hospital stay for RTIs increased from 6.4 ± 9.1days in 2009 to 15.0 ± 19.4 in 2015.

Discussion: There was a rapidly growing burden of RTIs at KCH in Lilongwe, Malawi, between 2009 and 2015, and projections based on our data show that this burden will double by 2030. It is essential that surgical trauma services are scaled up to meet this challenge in Malawi. There is also a large potential for prevention of injuries involving vulnerable road users. Road traffic campaigns should focus on improved driver training, use of lights, pedestrian and cyclist visibility, and vehicle fitness. Standards should include physical separation of pedestrians and vehicles, through raised pavements or separate walk and cycle ways. The absence of a clear strategy to meet the growing epidemic of injuries in Malawi will come at a huge cost to an already strained economy, and the largest portion of the burden of injury will continue to be borne by the poorest segment of the population.

* Corresponding author. Department of Surgery, Kamuzu Central Hospital, P.O. Box 149, Lilongwe, Malawi.
E-mail address: leonardbanza2014@gmail.com (L.N. Banza).

https://doi.org/10.1016/j.ijso.2017.11.004

1. Introduction

Each year 5.1 million people worldwide die from injuries. 1.25 million of these deaths are due to road traffic accidents [16] and ninety percent occur in developing countries [2,4]. More people die from road traffic injuries than from Malaria; and more people die from injuries than those that die from malaria, HIV/AIDS and tuberculosis combined [11]. This, however, is just the tip of the iceberg. It is estimated that for every death, there is at least 20 more people that, survive with injuries that need treatment [11]. Worldwide over 50 million people are injured annually in road traffic crashes alone.

Africa has the highest rate of road traffic injuries (RTIs) in the world [16], despite being the least motorized of the world's 6 regions with only 2% of the world's registered vehicles. The incidence of RTI death in the WHO African Region as a whole, is estimated to be 24.1/100,000 population year [12]. This stands is stark contrast to the rate in several developed countries such as the US (10.6/100,000) and the UK (2.9/100,000) [13]. The majority of the people killed on Africa's roads are young adults, often the breadwinners of family. 62% are aged between 15 and 44 years and 3 out of 4 deaths are of males. According to the World Bank it is estimated that malaria reduces GDP growth by approximately 1.3% per year in some African countries [17], whereas road traffic accidents and their consequences are estimated to cost African governments between 0.8% and 9% of their GDP [12].

Road Traffic Injury trends observed in high-income countries have shown a rapid reduction over the last three to four decades, while a substantial increase has been reported from a number of developing countries [11]. The problem may grow further in the coming decades due to the rapid rise in vehicle ownership associated with economic growth in developing countries [1]. Globally the burden of RTIs is growing rapidly and the WHO predicts RTIs will be the fifth most frequent cause of death worldwide by 2030 [15].

Malawi is a low-income country with a per-capita gross national income of only 340 US$ [18], but it is experiencing economic growth and a rapidly rising number of motor vehicles on the roads. The estimated rate of road traffic deaths in the country is 35 per 100,000 people per year [16], the second highest in the world, with an estimated economic impact up to 5% of GDP [7]. There have been only limited injury prevention efforts to help attenuate the rising morbidity and mortality due to road traffic injury in Malawi.

The WHO projects road traffic injury to continue to rise towards 2030 [16]. However, there is a paucity of data to verify this projected trend. At Kamuzu Central Hospital (KCH) in Lilongwe, Malawi, we established a trauma surveillance registry in 2008, which captures all trauma patients presenting to the emergency department [14]. Despite subjectively experiencing an overwhelming increase in the burden of trauma at the hospital, no local research has shown this trend over time. We therefore sought to use available data in the KCH Trauma Registry to assess rising annual numbers and model future projections for the rise in RTIs in Malawi.

2. Methods

This study is an analysis of prospectively collected data from the KCH Trauma Registry. KCH is a 900-bed tertiary care public hospital in Lilongwe the capital city, which serves as a referral center for approximately 6 million people in the central region of Malawi. The KCH Trauma Registry was established in 2008 to collect patient demographic information, clinical characteristics, and outcome data of all patients presenting to the emergency department with traumatic injuries. Data is recorded on an intake form and transferred to an electronic database. All patients who presented to the emergency department with injuries between January 2009 and December 2015 were included in this study.

Mortality related to RTIs was defined as in-hospital mortality. The definition of a patient with a RTI in the KCH Trauma Registry was any driver, passenger, pedestrian, motor cyclist or pedal cyclist injured in a vehicle-related incident on a roadway.

2.1. Statistics

Continuous variables are presented as mean values with standard deviations (SD). Linear regression curve estimations were calculated using IBM SPSS Statistics version 22 (IBM Corporation, New York, USA). Fig. 1 as made using the statistical package R version 3.0.2 (http://www.R-project.org). All other statistical analysis was performed using Stata SE 13.1 (Stata- Corp LP, College Station, TX). The level of statistical significance was set at 5%. The University of North Carolina Institutional Review Board (approval # 11–0373) and the Malawi National Health Sciences Research Committee approved this study (approval # 813).

3. Results

From 2009 to 2015 Kamuzu Central Hospital (KCH) registered a total of 96,967 patients with injuries (72% male) in the KCH Trauma Registry (Table 1). The mean age of these trauma patients was 23.3 years (SD 16) and 37% were younger than 18 years. Males had a mean age of 24.2 years (SD 15.2) whereas mean age for females was 20.8 years (SD 17) $p < 0.001$.25,193 (26.2%) patients had road traffic related injuries with 19,244 (76.4%) being men. The mean age for RTI victims was 28.6 years (SD 14.9), 29.5 years (SD 15) for men compared to 26.0 years (SD 16) for females ($p < 0.001$).

3.1. Number of RTIs by year

The total number of injuries treated at KCH rose by 62% from 2447 in 2009 to 3975 in 2015. The red dots (Fig. 1) represent the observed number of RTI victims treated over the last 7 years. The linear regression line shows the projected increase in RTIs over the coming years towards 2030 and the shaded area marks the 95% confidence bands of the regression line. A significant regression equation showing this increasing trend was found ($F(1,5) = 16.957$, $p = 0.009$), with a R^2 of 0.772. If this trend continues, 7997 patients will be expected to need treatment after RTIs at KCH in 2030.

3.2. Mechanism of injury

Curves representing the annual number of road traffic injuries treated at KCH according to mechanism of injury are shown in Fig. 2. Injuries in all categories of RTI mechanisms increased in the study period, except injuries to drivers of private cars, which actually declined by 36% from 796 in 2009 to 507 in 2015. The highest number of RTIs occurred in pedestrians ($n = 8,141$, 32%) and cyclists ($n = 7,100$, 28%). 79% of pedestrian and cyclist RTI victims were males.

3.3. Length of hospital stay

The mean length of hospital stay (LOS) for RTI victims was plotted year by year (Fig. 3). The LOS rose by 134% from 6.4 (SD 9.1) days in 2009 to 15.0 (SD 19.4) days in 2015. A significant linear regression equation confirmed the apparent increase ($F(1,5) = 11.215$, $p = 0.020$, R^2 of 0.692).

4. Discussion

In this study we found that there was a large and rapidly growing number of RTI victims treated at Kamuzu Central Hospital

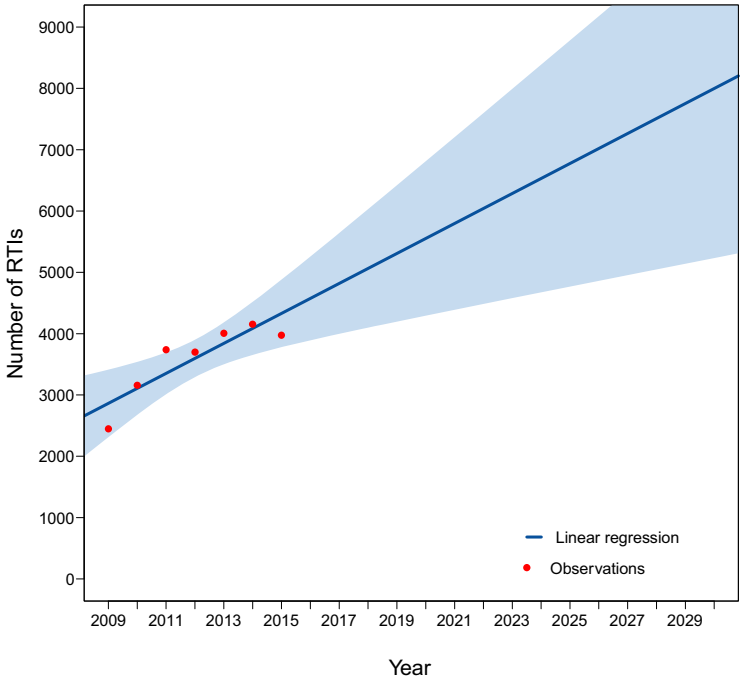


Fig. 1. The observed and projected increase in RTIs at KCH. The red dots represent the observed number of RTIs at KCH over the last 7 years. The linear regression line (dark blue) shows the projected increase in RTIs over the coming years towards 2030. The shaded area marks the 95% confidence bands of the regression line (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

Table 1
RTIs in KCH Trauma Database 2009 to 2015.

	Patients, n (%)	Male, n (%)	Mean Age years (SD)	Age under 18 n (%)	Admissions n (%)	Mean LOS days (SD)	Mortality, n (%)
Total no. injuries	96,967 (100)	69,901 (72.1)	23.3 (15.7)	35,638 (36.8)	16,192 (16.7)	13.3 (18.5)	1797 (1.9)
Non RTI	70,975 (73.8)	50,060 (70.5)	21.3 (15.6)	30,378 (42.8)	10,445 (14.7)	13.1 (17.6)	927 (1.3)
Road traffic injuries	25,193 (26.2)	19,244 (76.4)	28.6 (14.9)	5050 (20.1)	5638 (22.4)	13.7 (19.6)	838 (3.3)
Pedestrian	8141 (32.3)	5948 (73.1)	25.0 (16.2)	2677 (32.9)	1864 (23.0)	15.5 (22.8)	413 (5.1)
Cyclist	7100 (28.2)	6081 (85.7)	29.9 (15.8)	1376 (19.4)	1418 (20.1)	13.4 (22.8)	142 (2.0)
Driver or passenger in car	4574 (18.2)	3227 (70.6)	29.9 (12.0)	466 (10.2)	1013 (22.3)	10.9 (14.8)	132 (2.9)
Passenger on truck/lorry bed	1464 (5.8)	1033 (63.1)	31.5 (13.1)	146 (10.0)	388 (26.5)	12.7 (18.6)	53 (3.6)
Driver or passenger in minibus	1638 (6.5)	1033 (63.1)	30.9 (13.3)	166 (10.1)	329 (20.1)	14.0 (17.9)	39 (2.4)
Motorcycle	907 (3.6)	816 (90.0)	33.9 (11.4)	37 (4.1)	259 (28.6)	14.2 (18.3)	29 (3.2)
Other RTI	1369 (5.4)	1112 (81.2)	30.2 (12.3)	182 (13.3)	367 (27.2)	13.1 (16.6)	30 (2.2)

from 2009 to 2015 and a projected new doubling of the burden of RTIs at KCH over the next 15 years. This is bound to have a devastating impact on a country with one of the lowest gross national incomes per capita in the World, at only 340 US$ [18].

A national trauma surveillance data registry in Malawi is in progress. However, according to the WHO Global Status reports on road safety (2009, 2013 & 2015) there were 130,000 vehicles registered in Malawi in 2007, 173,800 in 2011 and 437,416 in June 2014. This exponential growth of the number of vehicles in the country can likely explain much of the rise in road traffic injuries. The Malawi health system cannot currently support the overall burden of disease and this is further compounded by the increasing burden of trauma [8,14]. There is a severe lack of infrastructure and equipment as well as shortage of human resources and drugs. Between 2009 and 2015 Kamuzu Central Hospital had the same number of beds, staff, theatre and theatre sessions. The average total annual hospital budget has fluctuated between USD 680,164 and USD 790,131. The budget allocated to Surgery/Trauma has never been enough to cover the needs (e.g. orthopaedic hardware like exfix). If we look ahead over the next decade, a rapid scale up of surgical trauma services will be needed to meet the increasing burden of RTIs in Malawi. With the rapid growth in the number of motor vehicles, serious measures for improvement of road safety will also need to be implemented.

Our study shows signs that the Malawian health system was not able to keep up with the rise in trauma. The fact that the length of hospital stay for RTI victims rose by 134% in 7 years can be explained in several ways. Previously most patients at KCH that had a severe open fracture of the lower extremity ended up with an amputation. With modern orthopaedic surgery these patients rarely need this extreme measure [19], but with limited access to operating theatres, increased length of hospital stay is inevitable. Additionally, with increased emphasis on limb saving surgery, many other injury types that meet operative intervention criteria

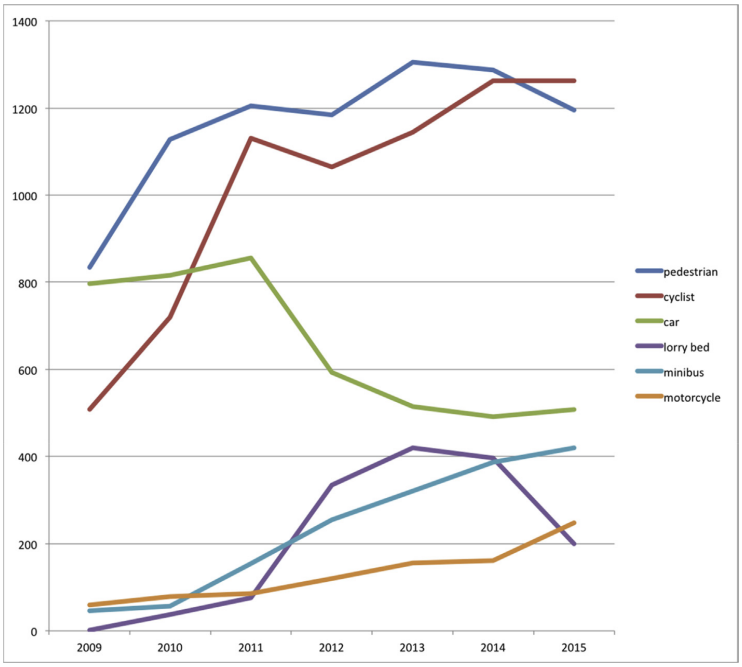


Fig. 2. The different mechanisms of injury's contribution to the rise in RTI victims. While pedestrians and cyclists were increasingly being injured, the frequency of drivers of private cars getting injured decreased from 2009 to 2015.

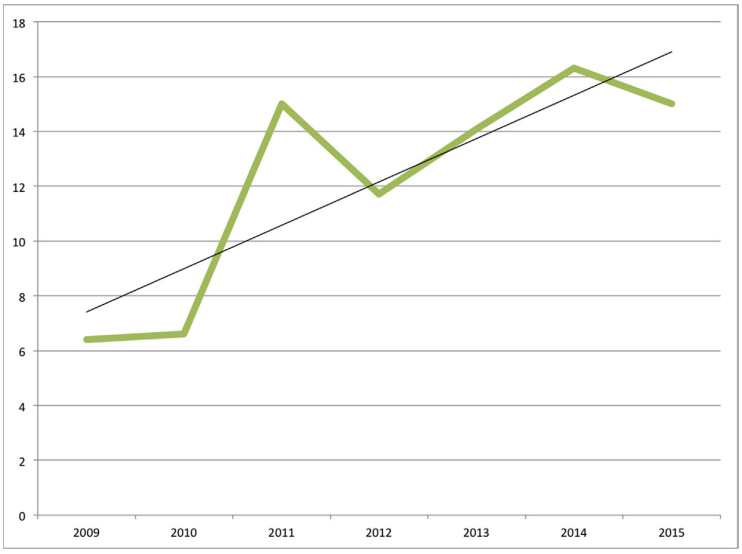


Fig. 3. Length of Hospital Stay. Mean length of hospital stay (LOS) for all RTI victims at KCH plotted year by year. The straight line is the linear regression line.

are delayed or deferred. Fractures of the femur, for example, have increasingly needed to be treated non-operatively with skeletal traction at KCH, leading to very long hospital stays for these patients [20]. Other patients with non-unions after poorly treated fractures wait for weeks, sometimes months, in the ward before receiving necessary surgery for the same reasons.

According to our findings nearly two thirds of RTI victims in Lilongwe, Malawi were vulnerable road users. Cyclists and

pedestrians were the most frequent victims of RTI. This suggests that road traffic trauma is a growing epidemic mostly of a particular segment of the population. In fact, we found a decreasing number of patients who were drivers of private cars. This probably reflects a relatively new pool of cars with good safety features for the drivers. Also, most of the cars are used in towns where speeds generally are not high enough to cause serious injury to the driver, but are more than sufficient to injure vulnerable road users. Our findings showing that a large proportion of the road crash victims were pedestrians or cyclists support the findings in the WHO "World report on road traffic injury prevention" [16]. Vulnerable road users benefit the least from policies designed for motorized travel, but bear a disproportionate share of the perils of motorization in terms of injury.

Malawi has an annual total health expenditure per capita of only 29 US$, the lowest in the world (World bank 2015), and 85% of the population depend on subsistence farming. More than half the population lives below the poverty line [3]. Estimates for most LMICs (with a GNI per capita of more than $ 1045 but less than $ 12,736; [17]) suggest that 10–15% of RTA victims end up with a permanent disability of some kind [16]. Our results showed that most of the RTA victims were male (72%). With men often being the breadwinners in many families in Malawi, This has a negative impact on the whole household of the patient resulting in the financial vulnerability of the patients and their respective families and predisposition to extreme poverty [6,9].

According to our findings more than one third (37%) of the total number of patients with injuries were under 18 years and of these 20% were related to RTIs. This again increases the negative impact on the entire community and future generations, as most of the victims are still young and productive members of the society.

For the necessary scale up of trauma services in Malawi to be possible, long-term planning and build up of surgical training centers are essential. Surgery as a field has been neglected for too long in the global public health discussion. However, there is clear evidence emerging that surgery is as cost-effective as many well-funded interventions for communicable diseases and maternal health [5]. The Lancet Commission on global surgery actually found that it would cost more *not* to invest in surgery than to scale up surgery in Low and Middle Income Countries over the coming years [10]. Building up and supporting surgical training centers can be a cost-effective and sustainable way to scale up to meet the increasing burden of injuries [8,19].

Prevention is an important component of public health efforts and for RTIs there is a huge potential for reduction in crashes involving vulnerable road users. Unfortunately, many road traffic campaigns were developed in high-income countries and sent to LIC without changing context or catering to the local environment and audience. In Malawi, much of the focus on prevention is on car drivers (speed reduction, use of seat belts etc.). Our data, however, suggests that preventive focus should be on the vulnerable road users. Information should focus on improved driver training, use of lights, pedestrian and cyclist visibility, and wearing of reflectors at night, and vehicle fitness. Foreign contractors build many of the Malawian roads in Malawi with foreign aid. The Malawian government should insist on road design and standards that protect vulnerable road users. Standards should include physical separation of pedestrians and vehicles, through raised pavements or separate walk and cycle ways in towns.

The limitations of this study are those inherent to any registry study including missing or unrecorded data. In addition, though all patients that arrived at the casualty department at KCH were registered in the trauma registry, some patients were missed. Patients that did not present at all due to minor injury, or patients that presented to other health care facilities or could not afford to attend the hospital were not captured in the registry, exposing the database to presentation bias. Most patients with an isolated fracture of a limb that did not require hospitalization were treated in the orthopaedic outpatient department (OPD) and were not registered in the KCH trauma database. More than 13,000 patients are seen in OPD every year, so the number of missed patients could be quite large. However, the available data leaves little doubt about the increasing epidemic of RTIs in Malawi.

5. Conclusion

This study demonstrated a rapidly growing burden of Road Traffic Injuries at KCH in Lilongwe, Malawi, from 2009 to 2015. Linear regression projections based on our data demonstrate that the burden of RTIs at KCH could double again by 2030. More than 60% of this burden of injury and disability is borne by vulnerable road users. A national strategy to scale up trauma care is imperative. With investment in trauma centers and established surgical training programs, this challenge can be met in a timely, cost-effective and sustainable manner.

Ethical approval

The University of North Carolina Institutional Review Board (approval # 11-0373) and the Malawi National Health Sciences Research Committee approved this study (approval # 813).

Funding

We did not have any sources of funding for this research.

Author contribution

As stated in my comments, all co-authors have contributed in both editing and writing of this article.

Conflict of interest

There is no conflict of interest for this article.

Guarantor

All 9 people have accepted full responsibility for the work and the conduct of the study.

Research registration number

We did not register this study.

References

[1] Abegaz Teferi, Berhane Yemane, Worku Alemayehu, Assrat Abebe. Effectiveness of an improved road safety policy in Ethiopia: an interrupted time series study. BMC Publ Health 2014;14. https://doi.org/10.1186/1471-2458-14-539.
[2] Beveridge M, Howard A. The burden of orthopaedic disease in developing countries. J Bone Jt Surg Am 2004;86-A:1819–22. 86/8/1819.
[3] Ferreira F, Jolliffe DM, Prydz EB. The international poverty line. World Bank; 2015.
[4] Gosselin RA, Spiegel DA, Coughlin R, Zirkle LG. Injuries: the neglected burden in developing countries. Bull World Health Organ 2009;87. 246–246a. DOI S0042-96862009000400002.
[5] Grimes Caris E, Henry Jaymie Ang, Maraka Jane, Mkandawire Nyengo C, Cotton Michael. Cost-effectiveness of surgery in low- and middle-income countries: systematic Review. World J Surg 2014. https://doi.org/10.1007/s00268-013-2243-y.
[6] Haug L, Wazakili M, Young S, Van den Bergh G. Longstanding pain and social strain: patients 'and health care providers' experiences with fracture

management by skeletal traction; a qualitative study from Malawi. Disabil Rehabil 2017;39(17):1714–21.
[7] Jacobs G, aeron-Thomas A, Astrop A. Estimating global road fatalities. Crowthorne: Transport Research Laboratory; 2000 (TRL Report 445).
[8] Kendig Claire, Tyson Anna, Young Sven, et al. "The effect of a new surgery residency program on case volume and case complexity in a Sub-Saharan African Hospital". J Surg Educ 2015 Jul-Aug;72(4):e94–9. https://doi.org/10.1016/j.jsurg.2014.09.011.
[9] Kohler RE, Tomlinson J, Chilunjika TE, Young S, Hosseinipour M, Lee CN. "Life is at a standstill" Quality of life after lower extremity trauma in Malawi. Qual Life Res 2017 Apr;26(4):1027–35. https://doi.org/10.1007/s11136-016-1431-2.
[10] Meara JG, Leather AJM, Hagander L, Alkire BC, Alonso N, Ameh EA, et al. Global Surgery 2030: evidence and solutions for achieving health, welfare, and economic development. Lancet 2015;386(9993):569–624.
[11] Patton GC, Coffey C, Sawyer SM, Viner RM, Haller DM, Bose K, et al. Global patterns of mortality in young people: a systematic analysis of population health data. Lancet 2009;374(9693):881–92.
[12] Peden M, Kobusingye O, Monono ME. Africa's roads: the deadliest in the world. South Afr Med J 2013;103(4):228–9. https://doi.org/10.7196/SAMJ.6866.
[13] Peden M. World report on road traffic injury prevention. Geneva: World Health Organization; 2004.
[14] Samuel JC, Akinkuotu A, Villaveces A, Charles AG, Lee CN, Hoffman IF, et al. Epidemiology of injuries at a tertiary care center in Malawi. World J Surg 2009;33(9):1836–41.
[15] WHO. Global status report on road safety: time for action. Geneva: World Health Organization; 2009.
[16] WHO. Global status report on road safety 2015. Geneva: World Health Organization; 2015.
[17] World bank (2015) http://www.worldbank.org/en/topic/health/brief/malaria.
[18] World bank. Gross Income per Capita ranking. Atlas Method and Purchasing Power and Parity; 2016.
[19] Young S, Banza L, Mkandawire N. The impact of long term institutional collaboration in surgical training on trauma care in Malawi. SpringerPlus 2016;5(1):1–5.
[20] Young S, Banza LN, Munthali BS, Manda KG, Gallaher J, Charles A. "The impact of the increasing burden of trauma in Malawi on orthopaedic trauma service priorities at Kamuzu Central Hospital". Acta Orthop 2016 Dec;87(6):632–6.

PLOS ONE

RESEARCH ARTICLE

Prevalence, causes and impact of musculoskeletal impairment in Malawi: A national cluster randomized survey

Leonard Banza Ngoie[1,2]*, Eva Dybvik[3], Geir Hallan[1,2,3,4], Jan-Erik Gjertsen[1,2,4], Nyengo Mkandawire[5,6], Carlos Varela[1,2,5], Sven Young[1,2,4,5,7]

1 Department of Surgery, Kamuzu Central Hospital, Lilongwe, Malawi, **2** Department of Clinical Medicine (K1), University of Bergen, Bergen, Norway, **3** The Norwegian Arthroplasty Register, Haukeland University Hospital, Bergen, Norway, **4** Department of Orthopaedic Surgery, The Norwegian Arthroplasty Register Haukeland University Hospital, Bergen, Norway, **5** Department of Surgery, College of Medicine, University of Malawi, Blantyre, Malawi, **6** School of Medicine, Flinders University, Adelaide, Australia, **7** Department of Orthopaedic Surgery, Haukeland University Hospital, Bergen, Norway

* leonardbanza2014@gmail.com

Citation: Ngoie LB, Dybvik E, Hallan G, Gjertsen J-E, Mkandawire N, Varela C, et al. (2021) Prevalence, causes and impact of musculoskeletal impairment in Malawi: A national cluster randomized survey. PLoS ONE 16(1): e0243536. https://doi.org/10.1371/journal.pone.0243536

Editor: Subas Neupane, University of Tampere, FINLAND

Received: February 21, 2020

Accepted: November 24, 2020

Published: January 6, 2021

Peer Review History: PLOS recognizes the benefits of transparency in the peer review process; therefore, we enable the publication of all of the content of peer review and author responses alongside final, published articles. The editorial history of this article is available here: https://doi.org/10.1371/journal.pone.0243536

Data Availability Statement: All relevant data are within the manuscript and its Supporting Information files.

Abstract

Background

There is a lack of accurate information on the prevalence and causes of musculoskeletal impairment (MSI) in low income countries. The WHO prevalence estimate does not help plan services for specific national income levels or countries. The aim of this study was to find the prevalence, impact, causes and factors associated with musculoskeletal impairment in Malawi. We wished to undertake a national cluster randomized survey of musculoskeletal impairment in Malawi, one of the UN Least Developed Countries (LDC), that involved a reliable sampling methodology with a case definition and diagnostic criteria that could clearly be related to the classification system used in the WHO International Classification of Functioning, Disability and Health (ICF)

Methods

A sample size of 1,481 households was calculated using data from the latest national census and an expected prevalence based on similar surveys conducted in Rwanda and Cameroon. We randomly selected clusters across the whole country through probability proportional to size sampling with an urban/rural and demographic split that matched the distribution of the population. In the field, randomization of households in a cluster was based on a ground bottle spin. All household members present were screened, and all MSI cases identified were examined in more detail by medical students under supervision, using a standardized interview and examination protocol. Data collection was carried out from 1st July to 30th August 2016. Extrapolation was done based on study size compared to the population of Malawi. MSI severity was classified using the parameters for the percentage of function outlined in the WHO International Classification of Functioning (ICF). A loss of function of 5–24% was mild, 25–49% was moderate and 50–90% was severe. The Malawian version of the EQ-5D-3L questionnaire was used, and EQ-5D index scores were calculated

Funding: This study was funded by Norad through the Norhed programme. However the funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Competing interests: The authors have declared that no competing interests exist.

using population values from Zimbabwe, as a population value set for Malawi is not currently available. Chi-square test was used to test categorical variables. Odds ratio (OR) was calculated with a linear regression model adjusted for age, gender, location and education.

Results

A total of 8,801 individuals were enumerated in 1,481 households. Of the 8,548 participants that were screened and examined (response rate of 97.1%), 810 cases of MSI were diagnosed of which 18% (108) had mild, 54% (329) had moderate and 28% (167) had severe MSI as classified by ICF. There was an overall prevalence of MSI of 9.5% (CI 8.9–10.1). The prevalence of MSI increased with age, and was similar in men (9.3%) and women (9.6%). People without formal education were more likely to have MSI [13.3% (CI 11.8–14.8)] compared to those with formal education levels [8.9% (CI 8.1–9.7), p<0.001] for primary school and [5.9% (4.6–7.2), p<0.001] for secondary school. Overall, 33.2% of MSIs were due to congenital causes, 25.6% were neurological in origin, 19.2% due to acquired non-traumatic non-infective causes, 16.8% due to trauma and 5.2% due to infection. Extrapolation of these findings indicated that there are approximately one million cases of MSI in Malawi that need further treatment. MSI had a profound impact on quality of life. Analysis of disaggregated quality of life measures using EQ-5D showed clear correlation with the ICF class. A large proportion of patients with moderate and severe MSI were confined to bed, unable to wash or undress or unable to perform usual daily activities.

Conclusion

This study has uncovered a high prevalence of MSI in Malawi and its profound impact on a large proportion of the population. These findings suggest that MSI places a considerable strain on social and financial structures in this low-income country. The Quality of Life of those with severe MSI is considerably affected. The huge burden of musculoskeletal impairment in Malawi is mostly unattended, revealing an urgent need to scale up surgical and rehabilitation services in the country.

Introduction

Musculoskeletal disease is one of the major causes of physical disability globally, yet data regarding the magnitude of this burden in developing countries is lacking [1]. One reason for this is the absence of a universal understanding of the definition of physical disability. The difficulty in defining physical disability stems from its many anatomical, physiological and pathological presentations and causes, and its intimate relation to society and the environment [2]. There have been many attempts to reach a common understanding of disability, and the World Health Organization's (WHO) publication of the International Classification of Functioning, Disability and Health (ICF) is a major step forward. The ICF classifies impairment of body structure and function, and also includes domains that measure activity and participation in society. Musculoskeletal impairment (MSI) is according to the ICF defined as "*. . .a lack of normal structure or function, or an increase in pain or discomfort in the integument, muscles, bone or joints of the body of an individual, that has lasted at least 1 month and which limits function of the musculoskeletal system*. . ." [2].

The UN Convention on the Rights of Persons with Disabilities (UNCRPD) defines disability *as "long-term physical, mental, intellectual or sensory impairments which, in interaction with various barriers, may hinder [a person's] full and effective participation in society on an equal basis with other"* [3].

There is also a lack of accurate information on the prevalence and causes of physical disability due to the lack of surveys in low-income countries (LICs) [4, 5]. The WHO estimates that the prevalence of all types of disability on a global level is around 10% [6], but this estimate does not help plan services in specific situations or countries. Realizing the challenge, Helander developed a 'Rapid Calculation of Disability Prevalence' for less developed regions of the world and estimated that 4.8% of a population will need some rehabilitation service [7].

Musculoskeletal disease encompasses a wide range of conditions resulting from various etiologies such as traumatic, infectious, inflammatory, metabolic, congenital, developmental and degenerative condition; many of which benefit from surgical interventions. Musculoskeletal disease is an important cause of morbidity and mortality, especially in LICs [8], affecting a large portion of the world's population in one form or another, with non-traumatic musculoskeletal disease estimated to account for 6.8% of all Disability-Adjusted Life Years (DALY) lost [1]. Most road injuries are musculoskeletal in nature [9], and several studies have shown the heavy burden of musculoskeletal injuries in Low and Middle Income Countries (LMICs) [10, 11]. For each person who dies from trauma, three to eight more are permanently disabled [12, 13]. Estimates from a nationwide survey in Rwanda suggested a prevalence of musculoskeletal impairment of 5.2% [8]. A similar study in Fundong district, North-West Cameroon found a prevalence of 11.2% [14, 15]. Data on the prevalence of MSI in Malawi is scarce.

There have been several surveys of physical disability in Malawi in the past [16, 17]. However, these studies have targeted small cohorts of the population and focused on disability in general, which may have led to an underestimation of the burden of MSI in the community in general. None of these previous studies has evaluated the quality of life among people with MSI. Therefore, it is imperative to use a survey methodology to estimate the prevalence of MSI in Malawi that can be extrapolated on a national level and compared to data from other countries. This data is needed for informing policy development, service delivery, and evidence-based advocacy for people with MSI in Malawi.

In view of the lack of accurate data on the prevalence and causes of MSI in Malawi, we conducted a survey of MSI using a reliable sampling methodology with a case definition and diagnostic criteria that could clearly be related to the classification system used in the ICF. The aim of this study was to assess to report the prevalence, impact, causes and service implications of MSI in Malawi. Data gathered will inform policy on advocacy and lobbying for appropriate resource allocation for MSI. To achieve this we chose to use a new survey tool developed in Rwanda by Atijosan et al. (2007).

Methods

Setting

Malawi has an estimated population of about 18.3 million (Nation estimates 2018 census). The country is divided in 3 administrative regions: The Northern, Central, and Southern Regions. The Central and Southern regions are the most densely populated with 6.4 and 6.8 million respectively [18]. Malawi has 28 districts and a total of 48,233 registered settlements. The vast majority of these are in the rural areas. About 90% of the population live in rural areas and are dependent mostly on subsistence farming [19].

Sample selection

A sample size of 1,481 households was derived based on the following formula for calculation of household sample sizes:—$n_h = (84.5)(1\text{-}r)/(r)(p)$ [20] and assuming 95 percent level of confidence, a sample design effect of 2.0, a non-response multiplier of 1.1, an average household size of 6, and a margin of error of 10%. Based on estimates from Rwanda and Cameroon, r (a key indicator to be measured by the survey, being prevalence of musculoskeletal impairment for this study) is 5.4% [4] and since all the population will be targeted, p = 1. The formula therefore gives a sample size of $n = (84.5)(1–0.054)/(0.054)(1.0) = 1{,}481$ households.

We selected clusters across the whole country through probability proportional to size sampling with an urban/rural and demographic split that matched the national distribution of the population. Then individuals (both adults and children) were examined in their households by survey field teams.

The National Statistics Office provided a list of enumeration areas from the Malawi Census Board for 2008 national census records. These settlements were randomized through computer-generated random numbers, selecting 55 settlements as enumeration areas from each district in Malawi for this survey. Two or four households were randomly selected in each settlement depending on size. The randomization was based on a ground bottle spin and selecting the third or fifth house in the direction of spin depending on the size of the settlement. Subsequently the bottle spinning was repeated after the household interview to select the next household in the new direction of the spin. The next thirds household was then picked if in a smaller settlement, or fifth household if in a larger settlement, then repeating the process again to select the next household. All household members present were screened. For the youngest (age below five) household members, the guardian of the child was interviewed. People were eligible for inclusion if they lived in the household at least three months of the year. All the individuals in the final household were interviewed, and the number of people needed to complete the survey in the settlement was randomly selected for inclusion (e.g. if the final household included six people but only two were required to complete the number for the settlement then two out of the six were randomly selected for inclusion). If an eligible participant was absent the survey team paid one more visit to the household to examine him/her before leaving the area. If not found, information about his/her presumed MSI status was collected from relatives present.

Musculoskeletal impairment assessment

The survey tool developed in Rwanda by Atijosan et al. (2007) fulfilled the proposed criteria and aims, and was therefore chosen for this study [21]. This screening tool was developed by orthopaedic surgeons together with physiotherapists and has been shown to have 99% sensitivity and 97% specificity with inter-observer Kappa scores of 0.90 for the diagnostic group. The team of data collectors screened all participants for MSI by asking them seven questions about difficulties using their musculoskeletal system and how long they had had these symptoms. Participants who answered ''yes" to any of the questions were classified as cases, provided that the condition had lasted for more than one month or was considered permanent (Table 1). The questionnaire and other Rapid Assessment of Musculoskeletal Impairment (RAM 1& RAM 2) were installed on 17 tablet computers (iPad 2, Apple Inc.), using File Maker Pro 12.0v3 (File maker Inc., USA) software for data collection in English (see Appendix of S1 and S2 Files).

The fieldworkers visited households door-to-door and conducted the MSI screening in the household. The survey team was assisted in the village by a village guide, appointed by the

Table 1. Screening questionnaire.

Screening for musculoskeletal impairment	Yes	No
1. Is any part of your body missing or misshapen?	❍	❍
2. Do you have any difficulty using your arms?	❍	❍
3. Do you have any difficulty using your legs?	❍	❍
4. Do you have any difficulty using any other part of your body?	❍	❍
5. Do you need a mobility aid or prosthesis?	❍	❍
6. Do you have convulsions, involuntary movement, rigidity or loss of consciousness?	❍	❍
If any of the answers are "yes":		
7. Has it lasted more than one month or is it permanent?	❍	❍

https://doi.org/10.1371/journal.pone.0243536.t001

village leaders. The purpose of the study and the examination procedure were explained to the subjects and verbal consent was obtained before examination.

Screening for musculoskeletal impairment

Standardized interview and examination protocol. All cases were examined in more detail by the students using a standardized interview and physical examination protocol. Whenever in doubt, the students consulted a supervisor physically or by phone (calls or pictures). Only those who were able to respond to all the five dimensions of quality of life (EQ-5D-3L) were eligible.

The standardized examination protocol assessed the area affected, duration, etiology, diagnosis, severity, quality of life of the participants and treatment received and needed. The elements included in the interview and examination protocol are presented in Table 2

Quality of life: The EQ-5D-3L is a public domain quality of life questionnaire from the Euro-Qol group, which has been validated in a number of countries and cultural settings [24]. It allows the participant to indicate their health state by indicating the most applicable statement in five parameters, including mobility, self-care, usual activities, pain/discomfort, anxiety/depression, with a maximum score of 100 (best quality of life) and minimum score of 0

Table 2. Standardized interview and examination protocol.

Elements	Definition
Physical assessment	Performance of physical tasks that require use of the musculoskeletal system, both lower and upper limb motor skills. (i.e. walking, standing, sitting, running etc.)
Anatomical location	Information of the affected part of the body (e.g. leg) and the nature of the problem (e.g. tumour)
Duration	The duration of the MSI, classified into a long (> 1 month) or short (<1 month) standing history
Etiology	Initiation and cause of the impairment (infection, violence etc.)
Diagnosis	Diagnosis categorized as: neurological, traumatic, congenital, metabolic, infective, or acquired non-traumatic non-infective. Within these categories an algorithm was created and used to give a specific diagnosis. Up to two diagnoses were permissible per case [21].
Severity	Severity was classified as "mild", "moderate" or "severe according to ICF "[22].
Quality of life (EQ-5D)	The Malawian version of the EQ-5D-3L questionnaire [23].
Treatment received	Any known treatment given to the participant (medical or others) was recorded
Treatment needed	Treatment required by the participants was assessed according to Malawi standard treatment guideline
Barriers to treatment	Participants were asked one question about why they had not received treatment for their MSI. All responses (up to four options) were recorded on pre-coded forms

https://doi.org/10.1371/journal.pone.0243536.t002

(death). Severity was determined using the parameters for the percentage of function outlined in the WHO reference book International Classification of Functioning (ICF) [2]. A loss of function of 5–24% was mild, 25–49% was moderate and 50–90% was severe. The Malawian version of the EQ-5D-3L questionnaire was used [23]

Data collection

Data collection was done by 32 third-year medical students. They all underwent a 14 days training supervised by two orthopaedic surgeons and two senior orthopaedic clinical officers on how to assess persons with musculoskeletal impairment and the use of the questionnaire and computer tablet. A pilot study/training was carried out in rural areas of the capital city, Lilongwe. The aim was to assess the examination process, function of the computer tablets and procedures. A second round of training was carried out as a refresher after the pilot study in preparation for the national survey.

Data were collected from 1st July to 30th August 2016. In some areas, local translators were hired to secure good communication between the interviewer and the household member. Each data collector covered approximately two households per day (10–12 participants), therefore 30–34 households were interviewed every day. Interviews took place in the interviewees' private homes. Data was checked and exported into the Excel (Microsoft 2010) pooled database at the end of each day, for data security and to assure the quality of the data collection [18]. A survey record was filled in for each eligible person that included: Demographic information (all participants), screening examination for MSI, a standardized interview and examination protocol for MSI, history of MSI (if not examined).

Statistical analysis

Extrapolation was done based on study size compared to the population of Malawi. Chi-square test was used to test categorical variables. Odds ratio (OR) was calculated with a linear regression model adjusted for age, gender, location and education. EQ-5D index scores were calculated using the values from Zimbabwe [25, 26], as there are no values for Malawi, and Zimbabwe was considered the closest country. The statistical analyses were performed using IMB-SPSS Statistics, version 24.0 for Windows (IBM Corp, Armonk, NY, USA) and the statistical package R, version 3.4.0 (http://www.R-project.org). P-values less than 0.05 were considered statistically significant.

Ethical approval

The approval to conduct this survey was granted by the College of Medicine Research and Ethics Committee (COMREC) and The Regional Committee for Medical and Health Research Ethics (REC Western Norway) in Norway. Consent to survey the districts and clusters were granted respectively by the District Commissioner and village head for each visited district and cluster.

Consent was obtained from the participants after explaining to them the goals and possible benefits of the study. Both verbal and written consent were obtained from adults (18 years of age and above), and assent were obtained from parents/guardians of children less than 18 years of age.

Data collectors were allowed to take photographs for teaching and discussion purposes after a verbal consent was granted from the participant. All those with manageable MSI were referred either to the MACOHA (Malawi Council of Handicapped) field workers (in the central region) or to district hospitals in the northern and southern region of Malawi for

appropriate action such as Physiotherapy, prosthetic and orthotic devices, mobility aids and orthopaedic surgery.

This study was funded by Norad through the Norhed programme.

Results

The total number of included households was 1,481, with a total of 8,886 persons enumerated (with an average household size of six). 85 participants were excluded due to missing data. Among the 8,801 persons properly enumerated, 16 participants were not able to communicate (adequately), 64 refused to participate, and 173 were absent. Finally, 8,548 persons were screened or examined (response rate of 97.1%). The response rate was similar in women (97.5%) and men (96.7%). Among the participants that were enumerated, but not examined, eight (3.2%) were believed to have MSI. The age and gender distribution of the sampled population was similar to that of the national population (Table 3). During the national population and housing census enumeration process, the enumerators estimate the age of persons with unknown age based on past events or events of national interest (Nation estimates 2008 census).

Prevalence of MSI

Of the 8,548 participants that were screened, 810 cases of MSI were diagnosed. This gave an overall prevalence of MSI of 9.5% (CI 8.9–10.1) (Table 2). The prevalence of MSI was higher among participants aged between 31 and 60 years (OR = 1.9, 1.5–2.5) and those over 60 years (OR = 5.7, 4.2–7.7) compared to the three youngest groups together (Fig 1). The prevalence of MSI was similar in men (9.3%) and women (9.6%). Persons without formal education were more likely to have an MSI (13.3%) compared to those with formal education levels (Table 4). The odds ratios were derived from logistic regression analyses (adjusted for age group, gender, location and education level).

Prevalence of MSI by severity, and quality of life

MSI had an impact on the patients' quality of life. Patients with severe MSI had lower quality of life compared to patients with mild MSI (Table 5). Table 6 shows that all 5 dimensions of the EQ-5D were influenced by the degree of MSI. Some 25–30% of patients with severe MSI were

Table 3. Age and gender composition of national and screened sample population.

Age groups	Male			Female			Total		
	National	Enumerated Sample (%)	Screened Sample (%)	National	Enumerated Sample (%)	Screened Sample (%)	National	Enumerated Sample (%)	Screened Sample (%)
0–10	3,282,887	1,163 (26.7%)	1,132 (26.8%)	3,197,698	1,050 (23.7%)	1,033 (23.9%)	6,480,585	2,213 (25.1%)	2,165 (25.3%)
11–20	1,992,015	1,265 (29%)	1,217 (28.8%)	2,054,034	1,179 (26.6%)	1,131 (26.1%)	4,046,049	2,444 (27.8%)	2,348 (27.5%)
21–30	1,380,453	690 (15.8%)	660 (15.6%)	1,452,729	772 (17.4%)	755 (17.4%)	2,833,182	1,462 (16.6%)	1,415 (16.6%)
31–40	928,658	451 (10.3%)	441 (10.5%)	1,002,444	535 (12.1%)	526 (12.2%)	1,931,102	986 (11.2%)	967 (11.3%)
41–50	587,303	337 (7.7%)	330 (7.8%)	635,670	333 (7.5%)	325 (7.5%)	1,222,973	670 (7.6%)	655 (7.7%)
51–60	332,188	188 (4.3%)	182 (4.3%)	365,001	243 (5.5%)	237 (5.5%)	697,189	431 (4.9%)	419 (4.9%)
>60	326,567	239 (5.5%)	233 (5.5%)	393,988	317 (7.1%)	312 (7.2%)	720,555	556 (6.3%)	545 (6.4%)
Unknown*		29 (0.7%)	24 (0.6%)		10 (0.2%)	10 (0.2%)		39 (0.4%)	34 (0.4%)
Total	8,830,071	4,362 (100.0)	4,219 (100.0)	9,101,564	4,439 (100.0)	4,329 (100.0)	17,931,635	8,801 (100.0)	8,548 (100.0)

*participants with unknown age.

https://doi.org/10.1371/journal.pone.0243536.t003

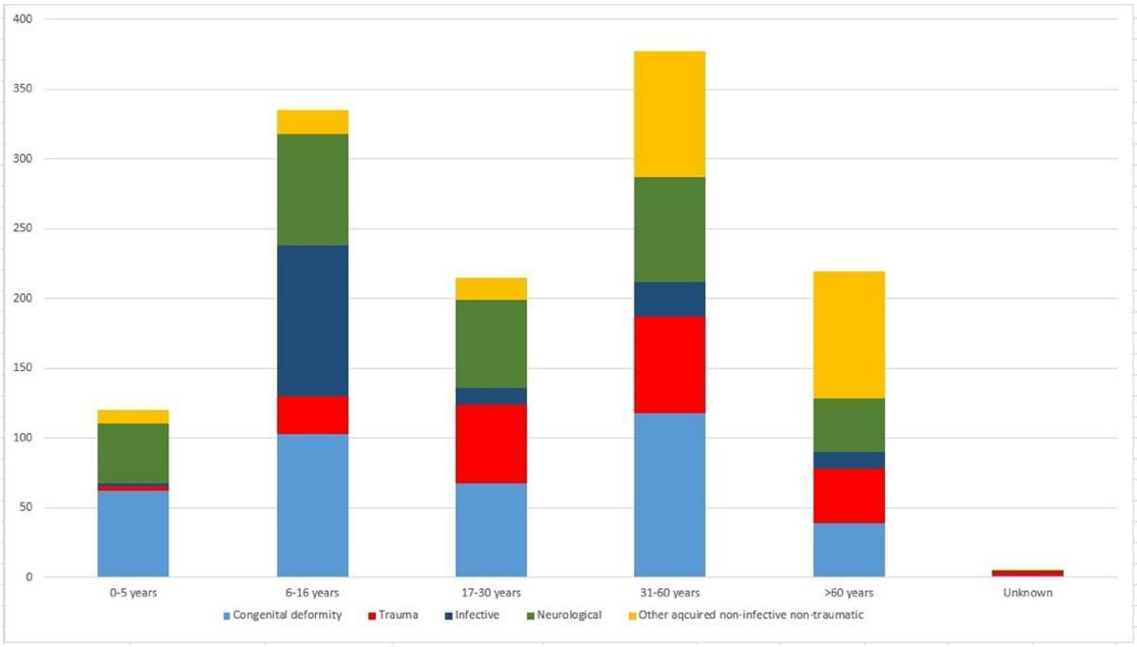


Fig 1. Number and diagnostic categories of MSI, by age group. Y-axis: Number of cases.

https://doi.org/10.1371/journal.pone.0243536.g001

confined to bed, unable to wash or undress or unable to perform usual activities (Table 6). Further, a large proportion of patients with severe MSI had pain or anxiety/depression.

MSI diagnoses

There were a total of 1,174 diagnoses for 810 individuals with MSI diagnosed (Table 7). Overall, 33.2% of MSIs were due to congenital causes, 25.6% were neurological in origin, 19.2% were acquired non-traumatic non-infective causes, 16.8% were due to trauma, and 5.2% due to infection. Congenital and neurological diagnoses remained relatively constant in all age groups. Acquired non-traumatic non-infective diagnoses were common in participants 31 years of age and above. However, trauma diagnoses were uncommon in participants 5 years of age and below.

Treatment needed

In total, 503 treatments were needed for the 1,174 diagnoses (Table 8). The most common treatments needed were prosthetic and orthotic devices (33.1%), medication (26.6%), physical therapy (15%) and surgery (4%). Extrapolating these estimates to the entire population of Malawi, approximately 1,054,000 treatments are required, including 350,000 prosthetic and orthotic devices; 281,000 courses of medicine; 159,000 courses of physical therapy and 42,000 operations.

Discussion

The main findings of this study are the high estimated prevalence of MSI in Malawi of 9.5% (CI 8.9–10.1) and the need for over one million interventions including medication, physical

Table 4. Prevalence of MSI by age, gender, location and educational level of head of household.

Categories		Total no Screened	No of MSI cases	Prevalence of MSI (95% CI)	Age and gender adjusted Odds Ratios (95% CI)
	Total	**8,548**	**810**	**9.5 (8.9–10.1)**	
Age groups, years	0–5	1,109	76	6.9 (5.4–8.3)	1.0 (0.8–1.3)
	6–16	2,539	160	6.3 (5.4–7.2)	0.9 (0.7–1.2)
	17–30	2,280	154	6.8 (5.2–7.8)	1
	31–60	2,041	254	12.4 (11.0–13.9)	2.0 (1.6–2.4)
	>60	545	161	29.5 (25.7–33.4)	5.8 (4.5–7.4)
	Unknown*	34	5	14.7 (2.8–26.6)	2.4 (0.9–6.2)
Gender	Male	4,219	393	9.3 (8.4–10.2)	1
	Female	4,329	417	9.6 (8.8–10.5)	1.0 (0.8–1.1)
Location	Rural	8,058	773	9.6 (8.9–10.2)	1
	Urban	415	33	8.0 (5.3–10.6)	0.9 (0.6–1.2)
	Mobile, urban/ rural	75	4	5.3 (0.2–10.4)	0.5 (0.2–1.4)
Education level of head of household**	No formal education	2,074	276	13.3 (11.8–14.8)	1
	Primary school	5,025	449	8.9 (8.1–9.7)	0.7 (0.6–0.8)
	Secondary school	1,249	74	5.9 (4.6–7.2)	0.4 (0.3–0.6)
	University / college	98	7	7.1 (2.0–12.2)	0.5 (0.2–1.0)
	Unknown	102	4	3.9 (0.2–7.2)	0.3 (0.1–0.8)

* Participants with unknown age.

** The education number of the head of household accounted for each of the screened participants.

https://doi.org/10.1371/journal.pone.0243536.t004

therapy, prosthetic orthotic devices and surgery to alleviate the burden. Most cases of MSI were moderate (54%) or severe (28%) according to the ICF classification. These MSIs greatly affect people's quality of life, having impact on all five dimensions of EQ-5D. The severity and scale of the burden of MSI in Malawi is likely to affect society at large [27, 28] and have a negative impact on the development of the communities and of Malawi as a country [27].

The factors that were associated with increased risk of MSI were increased age and lack of formal education. In the former, this was the result of an increase in acquired non-traumatic non-infective degenerative conditions. These results were in line with the findings reported in a similar study in Rwanda [8]. Another study on disability transitions and health expectancies among adults 45 years and older in Malawi has shown that the risks of experiencing functional limitations due to poor physical health are high in this population, and the onset of physical disabilities happens early in life [29]. Lack of education is likely to coincide with farming as an occupation, rural location, hard work and poor ergonomics that could to lead to MSI. There was a tendency towards more MSI in rural areas. But the low number of cases from urban

Table 5. Impact of MSI on quality of life.

MSI status	Number	Mean EQ-5D index score	Std Error of the mean	95% CI
Mild MSI	108	81.6	1.63	78.4–84.8
Moderate MSI	329	69.4	0.98	67.4–71.3
Severe MSI	167	49.2	2.15	45.0–53.4
Total	604*	66.0	0.96	64.1–67.9

*Out of 810 cases of MSI, 604 participants were able to respond to all the five dimensions of the EQ-5D-3L.

https://doi.org/10.1371/journal.pone.0243536.t005

Table 6. Distribution of patients in each level of the 5 dimensions of EQ-5D-3L according to MSI severity level.

EQ-5D	Mild MSI	Moderate MSI	Severe MSI	p-value*
Mobility				<0.001
• No problems in walking about	82 (64.1%)	117 (32.9%)	31 (16.6%)	
• Some problems in walking about	44 (34.4%)	224 (62.9%)	110 (58.8%)	
• Confined to bed	2 (1.6%)	15 (4.2%)	46 (24.6%)	
Self-care				<0.001
• No problems with self-care	104 (82.5%)	211 (59.1%)	56 (31.1%)	
• Some problems with self-care	19 (15.1%)	124 (34.7%)	77 (42.8%)	
• Unable to wash or dress	3 (2.4%)	22 (6.2%)	47 (26.1%)	
Usual activities				<0.001
• No problem in performing usual activities	72 (63.7%)	105 (30.5%)	21 (12.1%)	
• Some problem in performing usual activities	40 (35.4%)	216 (62.8%)	98 (56.6%)	
• Unable to perform usual activities	1 (0.9%)	23 (6.7%)	54 (31.2%)	
Pain/Discomfort				<0.001
• No pain or discomfort	64 (53.8%)	126 (35.6%)	63 (34.4%)	
• Some pain or discomfort	51 (42.9%)	206 (58.2%)	81 (44.3%)	
• Extreme pain or discomfort	4 (3.4%)	22 (6.2%)	39 (21.3%)	
Anxiety/Depression				<0.001
• Not anxious or depressed	82 (70.1%)	139 (40.3%)	45 (25.3%)	
• Moderately anxious or depressed	33 (28.2%)	185 (53.6%)	81 (45.5%)	
• Extremely anxious or depressed	2 (1.7%)	21 (6.1%)	52 (29.2%)	

* p-values were calculated using the Chi square.

https://doi.org/10.1371/journal.pone.0243536.t006

areas could be due to the lower number of people living in the urban areas. However the prevalence of MSI was similar in men and women.

With regard to causes of MSI, congenital and neurological causes were the most common diagnostic categories in all age groups, followed by acquired non-infective non-traumatic causes, especially in the middle aged and elderly population. In the latter the most common individual diagnosis was joint problems (9% of MSI diagnoses). The Global Burden of Disease Study 2015 estimated that the most important contributors to global years lived with disability were musculoskeletal disorders (18.5%) [30]. Neck and Lower back pain were estimated in 2013 as the leading cause of years lived with disability in Cameroon [31]. The prevalence of MSI was shown to be increasing with age in our study. This finding supports studies of older person's health in Botswana and Malawi that showed an increased probability of musculoskeletal disease and functional limitations [29, 32]. As the prevalence of musculoskeletal disorders increases with age, there will be a significant increase in requirements for health care and community support in the future.

Musculoskeletal disease is known to be a major cause of morbidity and mortality, especially in LICs with non-traumatic musculoskeletal disease estimated to account for 6.8% of all Disability-Adjusted Life Years (DALY) lost [1]. The overall prevalence of MSI in this study is almost double the 5.2% reported in Rwanda [8], but similar to the 11.6% reported in Fundong District, North-West Cameroon which used the same survey methods. The proportion of severe MSI was much higher in this study compared to what has been reported in Cameroon (2.4%) and Rwanda (8.4%). The reasons for this are unclear, but may, in part, reflect the long distances patients need to walk to seek medical attention in Malawi [33], and also the lack of medical expertise and equipment in the district hospitals and in the country overall. A study conducted by The College of Surgeons of East, Central, and Southern Africa (COSECSA) in 267 hospitals in east central and southern Africa has shown that current capacity to treat trauma and orthopaedic conditions is very limited, with particular areas of concern being manpower, training, facilities, and equipment [34]. However, the assessment of severe MSI deserves further attention in future studies.

Table 7. Cause of MSI in survey, and extrapolated to population of Malawi.

Diagnosis	Number	Total in category (%)	Extrapolated number of that diagnosis in Malawi to nearest 1000
Congenital deformity		**390 (33.2%)**	818,000
Syndactyly	43		
Polydactyly	74		
Other Upper Limb deformity	32		
Club foot	41		
Other Lower Limb deformity	56		
Spine deformity	125		
Other congenital deformity	19		
Trauma		**198 (16.8%)**	415,000
Burn contracture	24		
Fracture non-/ malunion	48		
Spine injury	1		
Head injury	6		
Tendon/nerve injury	45		
Amputation	46		
Joint chronic dislocation	21		
Other chronic joint injury	7		
Neurological		**299 (25.6%)**	627,000
Epilepsy	106		
Polio (sequelae)	33		
Para/quadra/Hemiplegia	61		
Cerebral palsy	65		
Peripheral nerve palsy	12		
Other neurological MSI	22		
Infective		**62 (5.2%)**	130,000
Bone infection limb	19		
Joint infection	12		
Spine infection	16		
Soft tissue infection	15		
Other acquired non-infective non- traumatic		**225 (19.2%)**	472,000
Angular limb deformity	24		
Degenerative and other Joint problem	108		
Spine pain	3		
Skin/ soft tissue/ bone swelling	19		
Limb swelling	57		
Limb pain	6		
Other acquired spine deformity	8		
Total	**1174**		

https://doi.org/10.1371/journal.pone.0243536.t007

Prosthetic and orthotic devices (P&O), physical therapy (rehabilitation), mobility aids, medication and surgery were the most frequently recommended treatments for the people identified with MSI in this study. These data have shown a significant treatment need for MSI in Malawi. With estimated 42,000 surgical operations needed, and only 11 orthopaedic surgeons in the country, it is obvious that Malawi is in dire need of scaling up surgical services rapidly and this concurred with the COSECSA study [34]. Some participants were very sick and there was no appropriate treatment to offer in our setting. However, counseling was provided to them and their relatives.

Table 8. Treatment needed among cases with MSI in survey and extrapolated to population of Malawi.

Treatment modality	Number of cases in survey needing that treatment modality	Extrapolated number in country needing that treatment modality (based on 2016 population estimates)
Medication	134	281,000
Physiotherapy	76	159,000
Appliance	36	75,000
Prosthesis	72	151,000
Orthosis (splints/ braces)	95	199,000
Surgery	20	42,000
Wheelchair /Tricycle	39	82,000
Permanent care	6	3,000
None	25	52,000
Total	503	

https://doi.org/10.1371/journal.pone.0243536.t008

The burden of MSI is predicted to increase as the population of Malawi, and the World, is aging. Musculoskeletal impairment or disability related to trauma are also rapidly increasing in the future due to the rise in Road Traffic Injuries in our country [35] and worldwide [30]. Therefore, there is a need to recognize musculoskeletal conditions as a national and global public health priority. Solutions to fill this health service gap are needed. With the prevalence of MSI being higher among people living in rural areas, access to health services may be encouraged through health programs and support in rural communities. A wide range of ergonomically designed tools could be made available to ease agricultural work for those in need of this. Developing programs that serve populations at the district level [36], where needs can be assessed, and resources identified, may improve access to preventive services and rehabilitation, and facilitate transfer to tertiary hospitals when needed. Continued support of task shifting through the orthopaedic clinical officer program [37] at the district level is a natural part of this until a sufficient number of surgeons have been trained. However, to rapidly scale up the surgical specialist service in a severely resource limited country like Malawi, specialist services need to be concentrated to a few training centres while these grow into sustainably sized units. These units can scale up production more rapidly at lower investment costs and provide short stay trauma and orthopaedic services that serve the districts until enough surgeons can be trained also for the district hospitals.

This population-based survey used a standardized examination protocol to provide estimates of musculoskeletal impairment in the country. The data from this study provides important information to assist planning of P&O services, provision of mobility aids, rehabilitation, medical, and surgical services for persons with MSI in Malawi. The need for medical services such as surgery, drug supply, and rehabilitation has been be estimated, and the more detailed need for equipment and other assistive devices (e.g. appliances, orthoses, prostheses and wheelchairs) can be estimated from this information.

This study did have some limitations on the probability proportional to size sampling; diagnostic tools were limited to history and clinical examination, which restricted the identification of conditions that need complex investigations and data on other socioeconomic factors like occupational status/ type of occupation were not collected. Due to the long distances in some areas, the call back at a few households where people were unavailable was not achieved. Our demographic data were very limited. However, this study was a nationwide survey with a representative sample of people of all ages who were enumerated and examined. The response rate was high, and the sample was representative of the national population for both age and

gender. This has reduced the likelihood of selection bias. The outcome definition was undertaken by well-trained medical students, using an examination protocol and screening tool, which was used in a similar study in Rwanda [21]. The inter-observer agreement between the data collectors was high as all were closely monitored and supervised.

Conclusion

This study has uncovered a high prevalence of MSI in Malawi and contributed data to the epidemiology of MSI nationally and globally. The Quality of Life of those with severe MSI was considerably affected. Increasing age and lack of formal education were factors that were associated with an increased risk of having MSI. The huge burden of musculoskeletal impairment in Malawi is mostly unattended, revealing an urgent need to scale up orthotics & prosthetics, physical & occupational therapy and surgical services in the country.

Supporting information

S1 File. Rapid assessment of Musculoskeletal impairment.
(PDF)

S2 File. Rapid assessment of Musculoskeletal impairment.
(PDF)

Author Contributions

Conceptualization: Leonard Banza Ngoie, Geir Hallan, Sven Young.

Data curation: Leonard Banza Ngoie, Geir Hallan, Jan-Erik Gjertsen, Nyengo Mkandawire, Sven Young.

Formal analysis: Eva Dybvik, Jan-Erik Gjertsen.

Investigation: Leonard Banza Ngoie.

Project administration: Leonard Banza Ngoie.

Writing – review & editing: Leonard Banza Ngoie, Eva Dybvik, Geir Hallan, Jan-Erik Gjertsen, Nyengo Mkandawire, Carlos Varela, Sven Young.

References

1. Elliott Iains S., Groen Reinou S., Kamara Thaim B., Ertl Allison, Cassidy Laura D., Kushner Adam L., et al. The Burden of Musculoskeletal Disease in Sierra Leone. Clin orthop Relat Res (2015) 473:380–389; https://doi.org/10.1007/s11999-014-4017-8 PMID: 25344406
2. World Health Organisation (2001) International Classification of Functioning disability and Health. Geneva: World Health Organisation.
3. The United Nations, Convention of the Rights of Persons with Disabilities and Optional Protocol. New York: United Nations; 2006.
4. Biritwum RB, Devres JP, Ofosu-Amaah S, Marfo C, Essah ER (2001) Prevalence of children with disabilities in central region, Ghana. West Afr J Med 20: 249–255. PMID: 11922161
5. Tamrat G, Kebede Y, Alemu S, Moore J (2001) The prevalence and characteristics of physical and sensory disabilities in Northern Ethiopia. Disabil Rehabil 23: 799–804. https://doi.org/10.1080/09638280110066271 PMID: 11762882
6. World Health Organisation (2002) Disability and Rehabilitation: Future Trends and Challenges in Rehabilitation. Geneva: World Health Organisation
7. Helander E (1999) Prejudice and Dignity: an introduction to Community Based Rehabilitation. New York: UNDP.

8. Atijosan O., et al., A national survey of musculoskeletal impairment in Rwanda: prevalence, causes and service implications. PLoS One, 2008. 3(7): p. e2851. https://doi.org/10.1371/journal.pone.0002851 PMID: 18682849

9. Peden M, Scurfield R, Sleet D, Mohan D, Hyder A A. Jarawan E, et al. World report on road traffic injury prevention. 2004. http://apps.who.int/iris/bitstream/ 10665/42871/1/9241562609.pdf. Accessed 2016 Jul 20.

10. Spiegel DA, Gosselin RA, Coughlin RR, Joshipura M, Browner BD, Dormans JP. The burden of musculoskeletal injury in low and middle-income countries: challenges and opportunities. J Bone Joint Surg Am. 2008 Apr; 90(4):915–23. https://doi.org/10.2106/JBJS.G.00637 PMID: 18381331

11. Elliott IS, Groen RS, Kamara TB, Ertl A, Cassidy LD, Kushner AL, et al. The burden of musculoskeletal disease in Sierra Leone. Clin Orthop Relat Res. 2015 Jan; 473(1):380–9. Epub 2014 Oct 25. https://doi.org/10.1007/s11999-014-4017-8 PMID: 25344406

12. Kobusingye O, Guwatudde D, Lett R. Injury patterns in rural and urban Uganda. Inj Prev. 2001; 7:46–50. https://doi.org/10.1136/ip.7.1.46 PMID: 11289535

13. Daar AS, Rizvi SA, Naqvi SA. Surgery with limited resources. In: Morris PJ, Wood WC, editors. Oxford textbook of surgery. 2nd ed. New York: Oxford University Press; 2000. p 3386.

14. Atijosan O, Rischewski D, Simms V, Kuper H, Lavy C. The Orthopaedic Needs of Children in Rwanda: Results from a National Survey and Orthopaedic Service Implications. J Pediatr orthop 2009; 29:-951. https://doi.org/10.1097/BPO.0b013e3181c18962 PMID: 19934715

15. Smythe T, Mactaggart I, Kuper H, Oye J, Sieyen N.C, Lavy C et al. Prevalence and causes of musculoskeletal impairment in Fundong District, North-West Cameroon: results of a population-based survey. Tropical Medicine and International Health. Vol. 22 no 11 pp 1385–1393, Nov 2017 https://doi.org/10.1111/tmi.12971 PMID: 28881434

16. Tataryn M., Polack S., Chokotho L., Mulwafu W., Kayange P., Banks L. M., et al. (2017). Childhood disability in Malawi: a population based assessment using the key informant method. BMC Pediatrics, 17 (1), 198. https://doi.org/10.1186/s12887-017-0948-z PMID: 29179740

17. Alavi Y., Jumbe V., Hartley S., Smith S., Lamping D., Muhit M., et al. (2012). Indignity, exclusion, pain and hunger: the impact of musculoskeletal impairments in the lives of children in Malawi. Disability and Rehabilitation, 34(20), 1736–1746. https://doi.org/10.3109/09638288.2012.662260 PMID: 22409227

18. Varela Carlos, Young Sven, Groen Reinou, Banza Leonard, Mkandawire Nyengo C., Viste Asgaut. Untreated surgical conditions in Malawi: A randomised cross-sectional nationwide household survey. Malawi Medical Journal 29 (3):231–236 Sept 2017 https://doi.org/10.4314/mmj.v29i3.1 PMID: 29872512

19. Makaula Peter, Bloch Paul, Banda Hastings T, Mbera Grace Bongololo, Mangani Charles, Alexandra de Sousa, et al. Primary health care in rural Malawi—a qualitative assessment exploring the relevance of the community-directed interventions approach. BMC Health Services Research 2012, 12:328. https://doi.org/10.1186/1472-6963-12-328 PMID: 22995125

20. http://unstats.un.org/unsd/demographic/meetings/egm/Sampling_1203/docs/no_2.pdf

21. Atijosan O, Kuper H, Rischewski D, Simms V, Lavy C (2007) Musculoskeletal impairment survey in Rwanda: Design of survey tool, survey methodology, and results of pilot study (a cross sectional survey) BMC Musculoskeletal Disorders 8: 30. https://doi.org/10.1186/1471-2474-8-30 PMID: 17391509

22. Chopra A (2004) COPCORD—an unrecognised fountainhead of community rheumatology in developing countries. J Rheumatol 31: 2320–2321. PMID: 15570627

23. Chokotho L., Mkandawire N., Conway D., Wu H.-H., Shearer D. D., Hallan G., et al. (2017). Validation and reliability of the Chichewa translation of the EQ-5D quality of life questionnaire in adults with orthopaedic injuries in Malawi. Malawi Medical Journal: The Journal of Medical Association of Malawi, 29(2), 84–88. https://doi.org/10.4314/mmj.v29i2.2 PMID: 28955412

24. EuroQol: EuroQol—a new facility for the measurement of health-related quality of life. Health Policy 1990, 16:199–208. https://doi.org/10.1016/0168-8510(90)90421-9 PMID: 10109801

25. Jelsma J, Mhundwa K, Weerdt W De, Cock P De, Chimera J, Chivaura V: The reliability of the Shona version of the EQ-5D. Central African Journal of Medicine 2001, 47:8–11.

26. Jelsma J, Chivaura V, De Cock P, De Weerdt W: A bridge between cultures: A report on the process of translating the EQ-5D instrument into Shona. South African Journal of Physiotherapy 2000, 56:3–9.

27. Global Surgery 2030: evidence and solutions for achieving health, welfare, and economic development. The Lancet 2015 Apr 28, Vol. 386, No. 9993, p569–624

28. World Bank.2017. "The High Toll of Traffic Injuries: Unacceptable and Preventable. © World Bank"

29. Payne CF, Mkandawire J, Kohler HP. Disability transitions and health expectancies among adults 45 years and older in Malawi: a cohort-based model. PLoS Med 2013: 10: e1001435. https://doi.org/10.1371/journal.pmed.1001435 PMID: 23667343

30. Global Burden of Disease Study C. Global, regional, and national incidence, prevalence, and years lived with disabil- ity for 301 acute and chronic diseases and injuries in 188 countries, 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet 2015: 386: 743–800. https://doi.org/10.1016/S0140-6736(15)60692-4 PMID: 26063472

31. Collaborators GBoD. Global, regional, and national inci- dence, prevalence, and years lived with disability for 310 diseases and injuries, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. Lancet 2016: 388: 1545–1602. https://doi.org/10.1016/S0140-6736(16)31678-6 PMID: 27733282

32. Clausen T, Romoren TI, Ferreira M, Kristensen P, Ingstad B, Holmboe-Ottesen G. Chronic diseases and health inequal- ities in older persons in Botswana (southern Africa): a national survey. J Nutr Health Aging 2005: 9: 455–461. PMID: 16395518

33. Varela C., Young S., Mkandawire N., Groen R. S., Banza L., & Viste A. (2019). Transportation barriers to access health care for surgical conditions in Malawi a cross sectional nationwide household survey. BMC Public Health, 19(1), 264. https://doi.org/10.1186/s12889-019-6577-8 PMID: 30836995

34. Chokotho L, Jacobsen KH, Burgess D, Labib M, Le G, Lavy CB, et al. Trauma and orthopaedic capacity of 267 hospitals in east central and southern Africa. Lancet. 2015 Apr 27; 385 Suppl 2:S17. https://doi.org/10.1016/S0140-6736(15)60812-1 Epub 2015 Apr 26. PMID: 26313063.

35. Banza L, Gallaher J, Dybvik E, Charles A, Hallan G, Gjertsen J.E, et al. The rise in road traffic injuries in Lilongwe, Malawi. A snapshot of the growing epidemic of trauma in low income countries. International Journal of Surgery Open 10 (2018) 1e6.

36. Cook C, Qureshi B. VISION 2020 at the district level. Commun Eye Health 2005: 18: 85–89.

37. Mkandawire N., Ngulube C., & Lavy C. (2008). Orthopaedic clinical officer program in Malawi: a model for providing orthopaedic care.

BMC Pediatrics

RESEARCH

Open Access

The unmet need for treatment of children with musculoskeletal impairment in Malawi

Leonard Banza Ngoie[1,2,3*], Eva Dybvik[4], Geir Hallan[2,5], Jan-Erik Gjertsen[2,6], Nyengo Mkandawire[7,8], Carlos Varela[1,2,7] and Sven Young[1,6,7]

Abstract

Background: More than a billion people globally are living with disability and the prevalence is likely to increase rapidly in the coming years in low- and middle-income countries (LMICs). The vast majority of those living with disability are children residing in LMICs. There is very little reliable data on the epidemiology of musculoskeletal impairments (MSIs) in children and even less is available for Malawi. Previous studies in Malawi on childhood disability and the impact of musculoskeletal impairment (MSI) on the lives of children have been done but on a small scale and have not used disability measurement tools designed for children. Therefore in this study, we aimed to estimate the MSI prevalence, causes, and the treatment need among children aged 16 years or less in Malawi.

Methods: This study was carried out as a national cross sectional survey. Clusters were selected across the whole country through probability proportional to size sampling with an urban/rural and demographic split that matched the national distribution of the population. Clusters were distributed around all 27-mainland districts of Malawi. Population of Malawi was 18.3 million from 2018 estimates, based on age categories we estimated that about 8.9 million were 16 years and younger. MSI diagnosis from our randomized sample was extrapolated to the population of Malawi, confidence limits was calculated using normal approximation.

Results: Of 3792 children aged 16 or less who were enumerated, 3648 (96.2%) were examined and 236 were confirmed to have MSI, giving a prevalence of MSI of 6.5% (CI 5.7–7.3). Extrapolated to the Malawian population this means as many as 576,000 (95% CI 505,000-647,000) children could be living with MSI in Malawi. Overall, 46% of MSIs were due to congenital causes, 34% were neurological in origin, 8.4% were due to trauma, 7.8% were acquired non-traumatic non-infective causes, and 3.4% were due to infection. We estimated a total number of 112,000 **(**80,000-145,000**)** children in need of Prostheses and Orthoses (P&O), 42,000 (22,000-61,000) in need of mobility aids (including 37,000 wheel chairs), 73,000 (47,000-99,000) in need of medication, 59,000 (35,000-82,000) in need of physical therapy, and 20,000 (6000-33,000) children in need of orthopaedic surgery. Low parents' educational level was one factor associated with an increased risk of MSI.

Conclusion: This survey has uncovered a large burden of MSI among children aged 16 and under in Malawi. The burden of musculoskeletal impairment in Malawi is mostly unattended, revealing a need to scale up both P&O services, physical & occupational therapy, and surgical services in the country.

Keywords: Musculoskeletal impairment, Childhood disability, Cluster randomized survey, Malawi

Introduction

More than a billion people globally are living with disability [1], and the prevalence is likely to increase rapidly in the coming years in low- and middle-income countries

*Correspondence: leonardbanza2014@gmail.com
[1] Department of Surgery, Kamuzu Central Hospital, P.O. Box 149, Lilongwe, Malawi
Full list of author information is available at the end of the article

(LMICs) [2, 3]. The vast majority of those living with disability are children residing in LMICs [4]. There is increasing evidence that children with disabilities are more likely to come from poorer households, are substantially less likely to attend school and experience poorer health compared to their non-disabled peers [2, 5]. Fewer than 10% of children with disabilities are estimated to attend school in Africa [3]. Disability is argued to have a greater impact on access to education than gender, economic status, or rural/urban residence, and is associated with long-term poverty [6].

In 2003, the WHO published a report highlighting the burden of musculoskeletal conditions in low resource countries [7]. In Africa, conservative estimates state that 11% of the total burden of disease, and 25 million disability-adjusted life years (DALYs) (38/1000 population), are due to surgical conditions [8]. There is very little reliable data on the epidemiology of musculoskeletal impairments (MSIs) in children or the consequences of disability on people with MSI in LMICs [1], and even less is available for Malawi.

A national survey in Rwanda estimated that 2.58% of children under 16 year old have one or more MSIs, of which 43% are moderate or severe [9]. There have been studies in Malawi on childhood disability [10] and impact of musculoskeletal impairment (MSI) in the lives of children [11]. However, these surveys were done on a small scale and did not use disability measurement tools designed for children. Also, there was no verification of self-reported functional limitations by clinical examination.

There is an urgent need to plan appropriate and accessible services for children with MSI in Malawi, and for evidence-based advocacy for funding of this. The authors carried out a national cluster-randomized household survey in 2016, revealing an overall prevalence of MSI of 9.5% (CI 8.9–10.1) in the Malawian population [12]. Using data from this survey, we aimed to estimate the prevalence and the treatment need among children aged 16 years or less in Malawi, and to describe the causes of MSI in Malawian children.

Methods

This study was based on a cross sectional survey. A list of enumeration areas from the Malawi Census Board for the 2008 national census records was received from the National Statistic Office. Clusters were selected across the whole country through probability proportional to size sampling with an urban/rural and demographic split that matched the national distribution of the population. Clusters were distributed around all 27 mainland districts of Malawi, many at very remote locations with poor roads, and it took the team 2 months, from 1st July to 30th August 2016, to reach all the selected villages by car. Depending on the size of the village, two to four households were randomly selected by spinning a bottle. All individuals present were examined in their households by survey field teams. The standardized selection, interview and examination protocol has been described in detail previously [13] but is outlined here. The definition of MSI that was used was developed from the WHO International Classification of Function (ICF) [14]:

> *" … .a lack of normal structure or function, or an increase in pain or discomfort in the integument, muscles, bone or joints of the body of an individual, that has lasted at least 1 month and which limits function of the musculoskeletal system … "*

Data collection was done by 32 third-year medical students. They all underwent a 14 days training supervised by two orthopaedic surgeons and two senior orthopaedic clinical officers on how to assess persons with musculoskeletal impairment and the use of the questionnaire and computer tablet. All participants were screened for MSI by asking them seven questions about difficulties using their musculoskeletal system and how long they have had these symptoms. The age cut off of 16 years and under was chosen for ease of comparison to a similar study done in Rwanda [9]. Also, children aged 17 and over are expected to be past or near skeletal bone maturity. According to cultural definitions of adulthood, the latter are usually considered as young adults in our setting.

The screening tool called "Rapid Assessment of Musculoskeletal Impairment" (see Appendix) was developed by researchers and clinical staff at the University of Oxford and the London School of Hygiene and Tropical Medicine for a previous survey in Rwanda, and has been shown to have 99% sensitivity and 97% specificity with interobserver Kappa scores of 0.90 for the diagnostic group [15]. For the youngest (age below 5) household members, the guardian of the child was interviewed. For all participants we also did screen parents' educational level.

The standardized examination protocol used, if screening questions revealed any MSI, comprised the elements seen in Table 1:

All children identified as having impairment in the study were referred to field workers of a community-based rehabilitation (CBR) program for appropriate action such as physiotherapy, prosthetic and orthotic (P&O) devices, or mobility aids. Children found in need of surgery (indication made by the orthopaedic surgeon on the survey team) were referred to a specialist facility for treatment.

Categorical variables was analyzed using a Pearson's chi square test, continuous variable was tested using

Table 1 Standardized interview and examination protocol

Elements	Definition
Diagnosis	Diagnosis categorized as: neurological, traumatic, congenital, metabolic, infective, or acquired non-traumatic non-infective. Within these categories an algorithm was created and used to give a specific diagnosis. Up to two diagnoses were permissible per each identified case of MSI [15].
Severity	Severity was determined using ICF parameters for the amount of function which was lost through the presence of the impairment. This was classified as "mild", "moderate" or "severe" [13]. Severity was determined using the parameters for the percentage of function outlined in the WHO reference book International Classification of Functioning (ICF) [14]. A loss of function of 5–24% was mild, 25–49% was moderate and 50–90% was severe
Treatment received	Any known treatment given to the participant (medical or other) was recorded
Treatment needed	Treatment required by the participants was assessed according to Malawi standard treatment guideline.

independent t-test. The population of Malawi was 18.3 million according to 2018 estimates, and based on the age categories in the same census, we estimated that about 8.9 million were 16 years and younger [12]. MSI diagnosis from our randomized sample was extrapolated to the population of Malawi, confidence limits were calculated using normal approximation. The statistical analyses were performed in the statistical package IBM SPSS Statistics Version 26 (IBM Corp., Armonk, NY, USA) and the statistical package R (http://CRAN.R-project.org). *P*-values less than 0.05 was considered statistically significant.

The approval to conduct the survey was granted by the University of Malawi College of Medicine Research and Ethics Committee (COMREC) and The Regional Committee for Medical and Health Research Ethics (REC West) in Norway. Data collection and handling followed national guidelines in line with the Declaration of Helsinki. Consent to survey the districts and clusters were granted respectively by the District Commissioner and village head for each visited district and cluster. Informed consent to participate in the study was obtained from a parent or guardian before examination. No names of participants, or locations of surveyed households within a cluster were registered in the survey data. Data collectors were allowed to take clinical photographs for teaching and discussion of follow up after a verbal informed consent was granted from the parent or guardian. If a child was found to have a condition needing treatment, a referral to the correct institution was made by the first author, and data kept separate from, and with no linkage to, the study data.

Results

Of 3792 children aged 16 or less who were enumerated, 3648 (96.2%) were examined. 3.8% of children were not available during the first screening or at one more subsequent visit to the household. Of the 3648 examined participants, 236 were confirmed to have MSI, giving a prevalence of MSI in the 16 and under age group of 6.5% (CI 5.7–7.3). Extrapolated to the Malawian population this means that as many as 576,000 (95% CI 505,000-647,000) children could be living with MSI in Malawi.

Among children found to have MSI, there was no significant difference in the prevalence between children aged 5–16 and those under 5 years of age ($p=0.56$). Boys were found to have marginally more MSI than girls (7% vs 6%) ($p=0.046$).

Using the ICF classification the MSIs were classified as moderate or severe in more than 3 out of 4 of the children with MSI. Low parents' educational level was associated with more MSI among the family members (Table 2).

A total of 358 diagnoses were registered in the 236 individuals diagnosed with MSI. The diagnoses are summarized in Table 3 with extrapolated numbers of affected children in Malawi. Overall, 46% of MSIs were due to congenital causes, 34.4% were neurological in origin, 8.4% were due to trauma, 7.8% were acquired non-traumatic non-infective causes and 3.4% were due to infection.

Of the 236 children diagnosed with MSI, 46 were judged to be in need of prosthetic and orthotic (P&O) services, 17 in need of mobility aids (including wheelchairs), 30 in need of medication, 24 in need of physical therapy, and 8 in need of orthopaedic surgery. Extrapolating these findings to the population of Malawi, we estimated a total number of 112,000 (80,000-145,000) children in need of P&O, 42,000 (22,000-61,000) in need of mobility aids (including 37,000 wheel chairs), 73,000 (47,000-99,000) in need of (mainly anti-epileptic) medication, 59,000 (35,000-82,000) in need of physical therapy, and 20,000 (6000-33,000) children in need of orthopaedic surgery (Fig. 1).

Discussion

This first countrywide survey of MSI in Malawi revealed that 6.5% of children, or an estimated 576,000 children are living with MSI. Of these, 112,000 children could be in need of P&O devices and 42,000 in need of mobility

Table 2 Baseline table for the 3648 children

	Total ($N=3648$)	MSI ($N=236$)	No MSI ($N=3412$)	*p*-value
Gender				0.046*
Male	1917	137 (7%)	1780 (93%)	
Female	1731	99 (6%)	1632 (94%)	
Age				0.56
0–5 yr	1109	76 (7%)	1033 (93%)	
5–16 yr	2539	160 (6%)	2379 (94%)	
Location				0.36
Rural	3270	25 (6.5%)	3245 (93.5%)	
Urban	151	11 (7%)	140 (93%)	
Missing	27	0 (0%)	27 (100%)	
Parents educational level				0.005
None	1073	94 (9%)	979 (91%)	
Primary	2240	127 (6%)	2113 (94%)	
Secondary	260	10 (4%)	250 (96%)	
University	25	2 (8%)	23 (92%)	
Missing	50	3 (6%)	47 (94%)	
Severity MSI**				
Mild	55	55 (23.3%) *	0	
Moderate	112	112 (47.5%) *	0	
Severe	69	69 (29.2%) *	0	
Missing	3412	0	3412	

*Percent of the 236 MSI cases

**According to the WHO International Classification of Function

aids (including 37,000 in need of wheelchairs) to help with ambulation or activities of daily living; 73,000 need medication; 59,000 could benefit from physical therapy, and approximately 20,000 were estimated to benefit from surgery. Currently it is estimated to be only 14 Prosthetists & Orthotists, 200 physiotherapists and physiotherapy assistants, and 15 orthopaedic surgeons in the country.

Studies done on MSI in children in Rwanda and in the Fundong District in North-West Cameroon have shown a prevalence of MSI in children of 16 years and younger of 2.58 and 2.9% respectively [9, 16]. This is less than half the 6.5% proportion of children with MSI in Malawi. The reason of this difference remains unclear. However, extrapolated MSI treatment need estimates in our study have shown that approximately 20,000 children would benefit from surgery in Malawi against 50,000 in Rwanda. The reason for this difference could be that diagnoses and surgical indications in our survey were made by a surgeon, in contrast to the studies from Rwanda and Cameroon, where these were made by physiotherapists.

Most MSI diagnoses in our survey were due to congenital deformities (46%) or were neurological in nature (34.4%). There are few studies to compare our numbers with, but a 5-year audit of all elective orthopaedic operations performed in children at a university hospital in Nigeria showed that congenital limb deformities alone accounted for 35.2% of the diagnoses [17]. A previous study on childhood disability in two districts of Malawi showed that physical impairment (39%) was the commonest impairment type [10], which is in line with this study.

The neurological conditions identified were predominantly cerebral palsy (CP) and epilepsy, which explains the need of medication and P&O devices in those affected children. CP is the most common motor disability in children worldwide, with an estimated prevalence of more than 2 per 1000 in high-resource settings, and a higher prevalence of up to 10 per 1000 reported in low-resource settings [18, 19]. CP is known to be an important and common contributor to childhood disability in low-resource settings [20], as supported by another Malawian study [10].

47.5% of children in our survey had moderate MSI, 29.2% had severe MSI and 23.3% had mild MSI. These findings support those of the World Bank where recent estimates suggest that 5% of all children – 93 million children globally – are living with moderate or severe disability as defined by the World Health Organization (WHO) [2]. Our study also showed that low education in the

Table 3 MSI Diagnosis and Extrapolation to Malawi population

Diagnosis	Number	Total in category (%)	Extrapolated number of that diagnosis in Malawi to nearest 1000 (95% CI)
Congenital deformity		165 (46%)	403,000 (343,000–463,000)
Syndactyly	13		32,000 (15,000-49,000)
Polydactyly	29		71,000 (45,000-96,000)
Other UL deformity	19		46,000 (26,000-67,000)
Club foot	19		46,000 (26,000-67,000)
Other LL deformity	28		68,000 (43,000-94,000)
Spine deformity	43		105,000 (74,000-136,000)
Other congenital deformity	14		34,000 (16,000-52,000)
Trauma		30 (8.4%)	73,000 (47,000-99,000)
Burn contracture	6		15,000 (3000-26,000)
Fracture non/ malunion	7		17,000 (4000-30,000)
Spine injury	0		
Head injury	2		5000 (0–12,000)
Tendon/nerve injury	6		15,000 (3000-26,000)
Amputation	5		12,000 (2000-23,000)
Joint chronic dislocation	4		10,000 (0–19,000)
Other chronic joint injury	0		
Neurological		123 (34.4%)	300,000 (248,000-353,000)
Epilepsy	43		105,000 (74,000-136,000)
Polio (sequelae)	11		27,000 (11,000-43,000)
Para/quadra/Hemiplegia	15		37,000 (18,000-55,000)
Cerebral palsy	46		112,000 (80,000-145,000)
Peripheral nerve palsy	0		
Other neurological MSI	8		20,000 (6000-33,000)
Infective		12 (3.4%)	30,000 (13,000-46,000)
Bone infection limb	2		5000 (0–12,000)
Joint infection	3		7000 (0–16,000)
Spine infection	2		5000 (0–12,000)
Soft tissue infection	5		12,000 (2000-23,000)
Other acquired non-infective non- traumatic		28 (7.8%)	68,000 (43,000-94,000)
Angular limb deformity	11		27,000 (11,000-43,000)
Joint problem	3		7000 (0–16,000)
Spine pain	0		
Skin/ soft tissue/ bone swelling	2		5000 (0–12,000)
Limb swelling	11		27,000 (11,000-43,000)
Limb pain	0		
Other acquired spine deformity	1		403,000 (343,000–463,000)
Total	**358**		

LL Lower limbs, *UL* Upper Limbs

family was associated with more MSI among the family members. A literature review on disability has suggested that an educated individual with a disability is more likely to better cope with her/his disability than those without education and that chronic health conditions may go improperly monitored by patients who are functionally illiterate and the overall well-being of these individuals may worsen overtime [21].

In common with all population surveys, our study had some limitations. The probability proportional to size sampling, diagnostic tools were limited to history and clinical examination, which restricted the identification

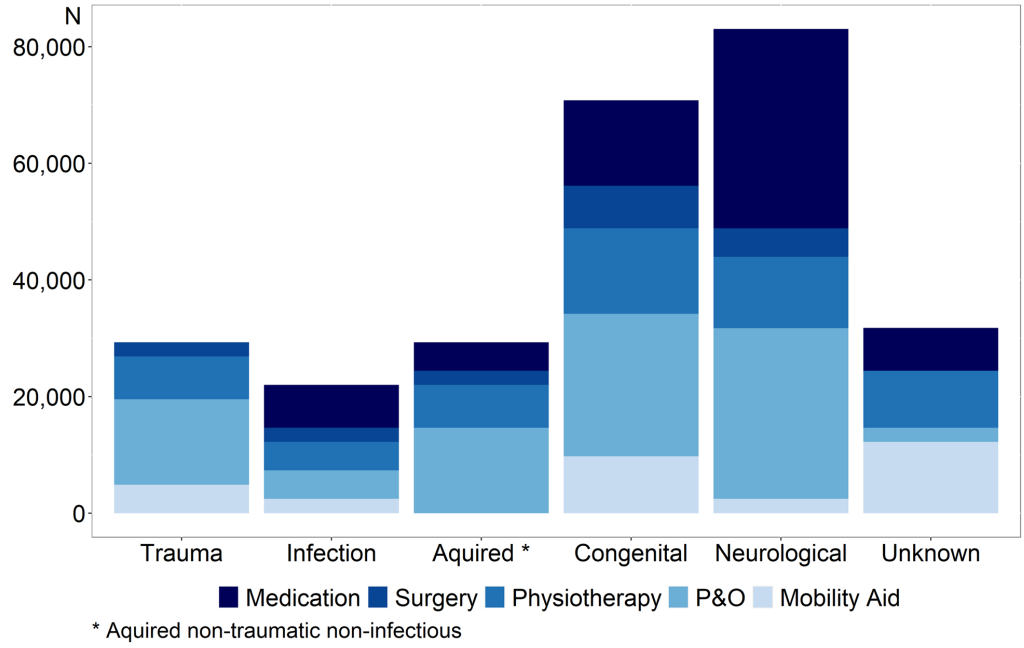


Fig. 1 The extrapolated need of treatment for MSI in children in the Malawi population. P&O: Prosthesis and Orthosis

of conditions that needed complex investigations. Other limitations were that data on other aspects, such as previous treatment received (some participants were unable to recall their previous treatment) and locations were not collected, and our demographic data were limited. Due to long travel distances in some areas, the call back at a few households where people were unavailable at the initial visit was not achieved. Extrapolations are always associated with some uncertainty and we have been careful to give 95% confidence limits. The study also had several strengths. The response rate of over 96% is very good for a survey in our setting, with the added strength that the study was a nationwide survey with a cluster randomized design to obtain a representative sample of children aged 16 years and younger. The fact that most diagnoses and surgical indications were made by one orthopaedic surgeon, also strengthens the findings and implications in our opinion.

In Malawi, a country with limited resources for health, it is unlikely that the unmet needs for treatment among these children will be met fully in near future. However, the estimates provided in this study should be useful in development of policy and for planning of services in Malawi. With 85% of the Malawian population living in rural areas, access to health and other services may be improved through community-based rehabilitation programs in rural communities. In addition, the development of programs that serve populations at the district level, where needs can be assessed and resources identified, may improve access to preventative services and rehabilitation.

Regarding CP, being one of the most common disabilities among the children, further studies are needed with regard to causes, types, socioeconomic status, education, severity, and other associated medical conditions.

Conclusion

This survey has uncovered a large burden of MSI among children aged 16 and under in Malawi. Lack of formal education in the family was one factor associated with an increased risk of MSI. The burden of musculoskeletal impairment in Malawi is mostly unattended, revealing a need to scale up prosthetics and orthotics, physical & occupational therapy, and surgical services in the country.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12887-022-03113-8.

Additional file 1. Appendix: Rapid Assessment of Musculoskeletal Impairment (RAM 1 & RAM 2).

Acknowledgements
Not applicable.

Authors' contributions
Conceptualization: LBN, GH, SY. Data curation: LBN, NM, GH, JE, SY. Investigation: LBN, SY. Project administration: LBN. Data analysis: ED, JE. Writing, review and editing: LBN, CV, NM, GH, ED, JE, SY. The author(s) read and approved the final manuscript.

Funding
This study was funded by Norad through the Norhed programme (data collection).

Availability of data and materials
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The approval to conduct the survey was granted by the University of Malawi College of Medicine Research and Ethics Committee (COMREC) and The Regional Committee for Medical and Health Research Ethics (REC West) in Norway. Data collection and handling followed national guidelines in line with the Declaration of Helsinki. Informed consent to participate in the study was obtained from a parent or guardian before examination. Data collectors were allowed to take clinical photographs for teaching and discussion purposes after a verbal informed consent from the parent or guardian.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests

Author details
[1]Department of Surgery, Kamuzu Central Hospital, P.O. Box 149, Lilongwe, Malawi. [2]Department of Clinical Medicine, University of Bergen, Bergen, Norway. [3]Centre for International Health, University of Bergen, Bergen, Norway. [4]The Norwegian Arthroplasty Register, Haukeland University Hospital, Bergen, Norway. [5]Department of Orthopaedic Surgery, The Norwegian Arthroplasty Register Haukeland University Hospital, 5021 Bergen, Norway. [6]Department of Orthopaedic Surgery, Haukeland University Hospital, 5021 Bergen, Norway. [7]Department of Surgery, College of Medicine, University of Malawi, Blantyre, Malawi. [8]School of Medicine, Flinders University, Adelaide, Australia.

Received: 14 April 2021 Accepted: 5 January 2022
Published online: 28 January 2022

References

1. Bethge M, von Groote P, Giustini A, Gutenbrunner C. The World Report on Disability: a challenge for rehabilitation medicine. Am J Phys Med Rehabil. 2014;93(1Suppl1):S4–11. https://doi.org/10.1097/PHM.0000000000000016.
2. World Health Organization & World Bank. World report on disability. Geneva: Switzerland World Health Organization; 2011.
3. Banza L, Gallaher J, Dybvik E, Charles A, Hallan G, Gjertsen JE, et al. The rise in road traffic injuries in Lilongwe, Malawi. A snapshot of the growing epidemic of trauma in low income countries. Int J Surg Open. 2018;10:1e6.
4. World Bank Country and Lending Groups; 2017. Available at: https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups. Accessed 19 Sept 2017.
5. Kuper H, Monteath-van Dok A, Wing K, Danquah L, Evans J, Zuurmond M, et al. The impact of disability on the lives of children; cross-sectional data including 8,900 children with disabilities and 898,834 children without disabilities across 30 countries. Plos One. 2014;9(9):e107300.
6. Atijosan O, Rischewski D, Simms V, Kuper H, Lavy C, Foster A, et al. Poverty and musculoskeletal impairment in Rwanda. https://doi.org/10.1016/j.trstmh.2008.02.023.
7. Woolf A, Pfleger B. Burden of major musculoskeletal conditions. Bull World Health Organ. 2003;81:646–56.
8. Reshamwalla S, Gobeze A, Ghosh S, Crimes C, Lavy C. Snapshot of surgical activity in rural Ethiopia: is enough being done? World J Surg. 2012;36:1049–55.
9. Atijosan O, Rischewski D, Simms V, Kuper H, Lavy C. the orthopaedic needs of children in Rwanda: results from a national survey and orthopaedic service implications. J Pediatr Orthop. 2009;29(8):948–51.
10. Tataryn M, Polack S, Chokotho L, Mulwafu W, Kayange P, Banks LM, et al. Childhood disability in Malawi: a population based assessment using the key informant method. BMC Pediatr. 2017;17(1):198. https://doi.org/10.1186/s12887-017-0948-z.
11. Alavi Y, Jumbe V, Hartley S, Smith S, Lamping D, Muhit M, et al. Indignity, exclusion, pain and hunger: the impact of musculoskeletal impairments in the lives of children in Malawi. Disabil Rehabil. 2012;34(20):1736–46. https://doi.org/10.3109/09638288.2012.662260.
12. Ngoie LB, Dybvik E, Hallan G, Gjertsen JE, Mkandawire N, Varela C, et al. Prevalence, causes and impact of musculoskeletal impairment in Malawi: A national cluster randomized survey. PLoS ONE. 2021;16(1):e0243536. https://doi.org/10.1371/journal.pone.0243536.
13. Chopra A. COPCORD—an unrecognised fountainhead of community rheumatology in developing countries. J Rheumatol. 2004;31:2320–1.
14. World Health Organisation. International classification of functioning disability and health. Geneva: WHO; 2001.
15. Atijosan O, Kuper H, Rischewski D, Simms V, Lavy C. Musculoskeletal impairment survey in Rwanda: design of survey tool, survey methodology, and results of pilot study (a cross sectional survey). BMC Musculoskelet Disord. 2007;8:30.
16. Smythe T, Mactaggart I, Kuper H, Oye J, Sieyen NC, Lavy C, et al. Prevalence and causes of musculoskeletal impairment in Fundong District, North-West Cameroon: results of a population-based survey. Trop Med Int Health. 2017;22(11):1385–93.
17. Akinyoola AL, Adegbehingbe1 OO, Ogundele OJ. Factors influencing the outcome of elective paediatric orthopaedic operations in Ile-Ife, Nigeria. Tanzania J Health Res. 2008;10(2):68–72.
18. Bax M, Goldstein M, Rosenbaum P, et al. Proposed definition and classification of cerebral palsy, April 2005. Dev Med Child Neurol. 2005;47:571–6.
19. Donald KA, Samia P, Kakooza-Mwesige A, Bearden D. Pediatric cerebral palsy in Africa: a systematic review. Semin Pediatr Neurol. 2014;21:30–5.
20. Monokwane B, et al. Risk Factors for Cerebral Palsy in Children in Botswana. Pediatr Neurol. 2017;77:73–7 A.L.
21. OECD. New ways of Adressing partial work capacity. In: OECD thematic Reiview on sickness, disability and work Isues, paper and Progress report; 2007. www.oecd.org/els/disability.

Publisher's Note

Trauma ID No: _____

1. Date_____ (day/month/year)

2. Patient's Name
(first)_____(last)_____

3. Phone: ❑ Yes ❑ No ❑ Unknown
Phone Number:_____

Note: Please add up to four (4) addtl. contacts in the margins of this form. Include first and last name, relationship, and phone #

4. Gender ❑ Male ❑ Female

5. Age_____ years _____ months _____days
**month/day if pt is 2 years or younger*

6. Is this a readmission: ❑ Yes ❑ No
**for same previous injury, within the last month*

7. Previous ID Number: _____❑ Trauma ❑ ACS

8. Residence: District/Country_____Area #____
T.A._____Village_____

9. HIV Status at Admission:
❑ Negative, Date_____ ❑ Positive ❑ Unknown

10. Occupation

❑ (0)Peasant Farmer
❑ (1)Construction
❑ (2)Driver/Conductor
❑ (3)Student/Pupil
❑ (4)Unemployed
❑ (5)Housewife
❑ (6)Tailor/Artist
❑ (7)Teacher
❑ (8)Police/Soldier
❑ (9)Pastor
❑ (20)Laborer
❑ (10) Large business owner/manager
❑ (11) Small business owner/manager
❑ (12) Mechanic/Technician
❑ (13) Child/Baby
❑ (14) Office/Bank worker
❑ (15)Plumber/Electrician
❑ (16)Baker/Cook/Restaurant
❑ (17) Housekeeper/Gardener/Guard
❑ (18) Salesman/woman
❑ (19)Healthcare worker
❑ (99) Other _____

11. Time Sequences (DD/MM/YY/time)
Injury date/time_____
Patient's arrival date/time_____
Doctor's arrival date/time_____

12. Was the injury:
❑ (0) Unintentional ❑ (1) Assault ❑ (2) Self-inflicted

13. Place Where Injury Occurred:
District/Country:_____Area#_____
T.A._____Village_____

❑ (0)Home
❑ (1)Work
❑ (2)Road/street
❑ (3)School
❑ (4)Farm
❑ (5)Sport/recreation
❑ (6)Public space
❑ (7) Lake/river
❑ (8) Field/forest
❑ (99) Other

14a. Mechanism of injury
If Traffic Related, patient was:

Pedestrian hit by:
❑ (0)Car
❑ (1)Bicycle
❑ (2)Motorcycle
❑ (3)Minibus/pickup
❑ (4)Bus/lorry
❑ (5) Ox cart
❑ (6) Tuk tuk (tricycle)
❑ (99) Other_____

Driver/Passenger in a:
❑ (7)Car
❑ (8)Cab of lorry
❑ (9)Minibus
❑ (10)Bus
❑ (11)Open bed of lorry
❑ (12)Motorcycle
❑ (13)Bicycle
❑ (14)Ox cart
❑ (15) Tuk tuk (tricycle)
❑ (99)Other_____

15. If driver/passenger, was another vehicle involved in the accident? ❑ No ❑ Yes
If Yes: ❑(1)Car ❑ (2)Lorry ❑ (3)Minibus ❑ (4)Bus ❑ (5)Motorcycle ❑ (6)Bicycle ❑ (7)Ox cart ❑ (99)Other _____

14b. Mechanism of injury
If Non-Traffic Related:

❑ (16)Bite from animal by _____
❑ (17)Bite from human
❑ (18)Gunshot wound
❑ (19)Foreign body
❑ (20)Fall, ____meters
❑ (21) Electric shock/Lightning
❑ (22) Occupational injury/Machine
❑ (23)Burn by_____ and_____ %TBSA
❑ (25)Collapsed structure:
❑ (26)Drowning
❑ (27)Laceration (non-assault)
❑ (28)Hanging
❑ (29)Poisoning
❑ (24)Assaulted, with:
❑(0)Hands/Feet ❑(1)Blunt Object
❑(2)Knife/Sharp Object ❑(3)Gun
❑(4)Sexual Assault ❑(99) Other____
❑ (99) Other_____

16. If assaulted, assaulted by? ❑(0) Wife/Husband ❑(1) Parent ❑(2) Child ❑(3) Other Relative ❑(4) Friend ❑(5) Thief/Robber/Thug ❑(6) Police/Soldier ❑(99) Other _____

17. Did alcohol use by the patient or another individual contribute to the injury? ❑(0)No ❑(1)Yes ❑(2)Suspected

18. Mode of transport to hospital:

❑ (0)Minibus
❑ (1)Bus
❑ (2)Motorcycle
❑ (3)Bicycle
❑ (4)Private Vehicle
❑ (10)Tuk tuk (tricycle)
❑ (5)Ambulance → EMS? ❑ N ❑ Y
❑ (6)Walked
❑ (7) Company Car
❑ (8) Police → Station/Phone #:_____
❑ (9) Lorry
❑ (99) Other_____

19. Clinical Data:

AVPU Score:
❑ (4)Alert ❑ (3) Responds to voice
❑ (2)Responds to pain ❑ (1) Unresponsive

Vitals on Admission
Heart rate_____ beats per minute
Temperature _____ ℃
Blood pressure_____ /_____mm Hg
Respiratory rate_____ breaths/minute
Oxygen saturation _____%
Radial pulse: ❑ (0)No ❑ (1) Yes

Glasgow Coma Score:
Eyes: ❑(4)Open Spontaneously ❑(3) Open to voice ❑(2) Open to pain ❑(1) Does not open
Voice: ❑(5)Oriented/normal conversation ❑(4) Confused/disoriented ❑(3)Incoherent words ❑(2)Incomprehensible sounds ❑(1)Makes no sounds
Motor: ❑(6)Follows commands ❑(5) Localizes to painful stimuli ❑(4)Flexion/withdrawal to pain ❑(3) Abnormal flexion to pain ❑(2)Abnormal extension to pain ❑(1)Makes no movement
Total_____(3-15)

20. Patient Disposition

❑ (0)OPD (treated & sent home)
❑ (1)Admitted to ward_____
❑ (2)Admitted to SHDU
❑ (3)Admitted to CWHDU
❑ (4)Admitted to ICU
❑ (5)Died in casualty
❑ (6)Brought in dead (BID)
❑ (7)Admitted to medicine
❑ (8)Ophthalmology admission
❑ (9)Straight to OR
❑ (10)Eye Ward
❑ (11)Ethel

21. Was the patient transferred to this hospital?
❑ (0)No ❑(1)Yes, transferred from_____
If from Salima DH; SDH trauma reg #: _____

22. Reason for transfer: ❑(0)Specialist ❑(1)Equipment ❑(2)Complication ❑(4)ICU/HDU ❑(6)Further Mgt ❑(5)Unknown ❑(99) Other:_____

	Type		Type
0	Contusion	13	Traumatic amputation
1	Laceration	14	Drowning
2	Abrasion	16	Crush Injury
3	Fracture	17	Soft Tissue Injury
4	Bite	18	Sprain
5	Burn	19	Poisoning
6	Penetrating Wound/Stab	99	Other_____
7	Dislocation		
8	Gun Shot Wound		
9	Injury to Internal Organ		
10	Head Injury		
11	Spine Injury		
12	Foreign Body		

	Location		Location
0	Head or Skull	13	Buttocks
1	Face, Ears, Eyes, Nose	14	Hip
2	Neck or Cervical Spine	15	Thigh or Femur
3	Shoulder or Clavicle	16	Knee
4	Arm or Humerus	17	Leg or Tib/Fib
5	Forearm or Radius/Ulna	18	Ankle
6	Wrist	19	Foot
7	Hand	20	Toes
8	Fingers	21	Jaw/Mandible
9	Chest or Ribs	22	Elbow
10	Abdomen	23	Perineum
11	Flank	24	Back and Spine
12	Pelvis	99	Other_____

If fracture is present: ❑ (0) Open ❑ (1) Closed

Write one number in each box, for up to 3 injuries.
If there are more than 3 injuries, list the 3 most severe.

Did the patient have more than 3 injuries?
❑ (0)No ❑ (1)Yes

Injury	Type	Location	Serious?
#1 (most severe)			**Yes No**
#2			**Yes No**
#3 (least severe)			**Yes No**

Radiology done in Casualty:

Imaging:
❑ **X-ray (write dates of XR on line)**
❑Chest_____
❑Abdomen_____
❑Head_____
❑C-Spine (neck)_____
❑T-Spine (chest)_____
❑L-Spine (back)_____
❑Pelvis_____
❑Arm_____
❑Leg_____
❑Hand_____
❑Foot_____
❑Other _____
spec:_____

❑ **FAST** date:____/____/_____
Done by: ❑Tech ❑Intern ❑Registrar
❑Consultant ❑CO ❑Other_____
Result: ❑Positive ❑Negative
❑**Other ultrasound: (write dates on line)**
❑ECHO/heart_____
❑Abdomen _____
❑Groin/scrotum_____
❑Chest_____
❑Arm_____
❑Leg._____
❑Head_____
❑Other _____
spec:_____

Procedures done in Casualty:

Surgeries Done: (write dates on line)
❑None(0)
❑Chest Tube(1):_____
❑Laceration Repair/Wound debridement(7):_____
_____
❑Casting/slab(18) :_____
❑Wound Dressing(21) :_____
❑Traction(19) :_____
❑ Skin ❑Pin
❑Joint Aspiration(28):_____
Amputation Specify:
❑Arm(10) ❑R ❑L:_____
❑Leg(11) ❑R ❑L:_____
❑Hand(12) ❑R ❑L:_____
❑Foot(13) ❑R ❑L:_____
❑Fingers/Toes(14) ❑R ❑L:_____
❑Other Orthopedic Procedure(15)
Type:_____
Date/Time_____
❑Other Surgery(99) Type:_____
Date/time:_____

Role of Provider Performing First Surgery if Multiple:
❑MD ❑CO ❑MA ❑Nurse ❑Maid
❑MD ❑CO ❑MA ❑Nurse ❑Maid
❑MD ❑CO ❑MA ❑Nurse ❑Maid
❑MD ❑CO ❑MA ❑Nurse ❑Maid
❑MD ❑CO ❑MA ❑Nurse ❑Maid
❑MD ❑CO ❑MA ❑Nurse ❑Maid
❑MD ❑CO ❑MA ❑Nurse ❑Maid
❑MD ❑CO ❑MA ❑Nurse ❑Maid
❑MD ❑CO ❑MA ❑Nurse ❑Maid
❑MD ❑CO ❑MA ❑Nurse ❑Maid
❑MD ❑CO ❑MA ❑Nurse ❑Maid
❑MD ❑CO ❑MA ❑Nurse ❑Maid
❑MD ❑CO ❑MA ❑Nurse ❑Maid
❑MD ❑CO ❑MA ❑Nurse ❑Maid

****

Person completing this form_____

☐ If this box is marked then complete a full assessment on this individual.

RAPID ASSESSMENT OF MUSCULOSKELETAL IMPAIRMENT

A. GENERAL INFORMATION

Year - month: ☐☐☐☐ - ☐☐

Cluster: ☐☐☐ Household Number: ☐☐ Individual no: ☐☐ Age (years): ☐☐

Examination status:
Examined: O (1)
Not available: O (2)
Refused: O (3)
Unable to communicate: O (4)
→ Go to Section G

Sex: Male: O (1) Female: O (2)

Location: Rural: O (1) Urban: O (2)

Level of education of head of household:
None: O (1)
Primary: O (2)
Secondary: O (3)
University: O (4)

B. SCREEN FOR MUSCULOSKELETAL IMPAIRMENT

Screen by eligible person: O (1)
Screen by proxy: O (0)

Use this prefix for 5 and under (by proxy): Compared to other children	Yes	No	**Duration**	yes	no
1. Is any part of your body missing or misshapen?:	O	O	Has it lasted>1m?	O	O
2. Do you have any difficulty using your arms?:	O	O	Is it permanent?	O	O
3. Do you have any difficulty using your legs?:	O	O			
4. Do you have any difficulty using any other part of your body?:	O	O			
5. Do you need a mobility aid or prosthesis?:	O	O			
6. Do you have convulsions, involuntary movement, rigidity or loss of consciousness?:	O	O			

Screen Case: O (1)
Not Screen case: O (0)

C. OBSERVATION OF ACTIVITIES

		Yes	No
Position	Squat/sit bending knees:	O	O
	Stand up straight on natural legs:	O	O
	Hold arms straight above head, fingers straight:	O	O
Mobility	Walk along the 11 metre rope:	O	O
	Do it in less than 10 secs:	O	O
	Do it without limping:	O	O
Right hand function	Touch Nose:	O	O
	Pick up coin and put in cup:	O	O
	Tip coin into bowl:	O	O
Left hand function	Touch Nose:	O	O
	Pick up coin and put in cup:	O	O
	Tip coin into bowl:	O	O

D. SEIZURE HISTORY

No history of seizure: O (0)
History of seizure: O (1)

3 or more seizures

Number of episodes in last year:
0: O (1)
1-2: O (2)
3-10: O (3)
>10: O (4)
Not applicable (never had seizure): O (5)

Type of seizure (tick one only)
Absences: O (1)
Convulsions: O (2)
Not applicable (never had seizure): O (3)

E. DURATION AND CONSANGUINITY

Age at impairment:
Since birth: O (1)
after birth-1 year: O (2)
1-5 years O (3)
6-15 years: O (4)
16-39 years: O (5)
>40 years: O (6)
Not applicable (No impairment:) O (7)

	yes	no
Consanguinity:	O	O

F. AETIOLOGY

Tick one only for each impairment

	Impairment no:	**1**	**2**	
	Family history:	O	O	(1)
	Congenital but no family history:	O	O	(2)
	Perinatal hypoxia:	O	O	(3)
Trauma	War:	O	O	(4)
Trauma	94 war:	O	O	(5)
Trauma	RTA:	O	O	(6)
Trauma	Civil violence:	O	O	(7)
Trauma	Domestic violence:	O	O	(8)
Trauma	Deliberate self harm:	O	O	(9)
Trauma	Other inc accidents:	O	O	(10)
	Developmental / Nutritional:	O	O	(11)
	Infection:	O	O	(12)
	Neoplasm:	O	O	(13)
	Iatrogenic:	O	O	(14)
	Traditional	O	O	(15)
	Unknown:	O	O	(16)
	Other:	O	O	(17)

Specify……
Not applicable (No impairment:) O O (18)

G. HISTORY IF NOT EXAMINED

Subject believed to be:
Not MSI impaired: O (1)
MSI impaired with treatment: O (2)
MSI impaired without treatment: O (3)
Not applicable (examined): O (4)

H. STRUCTURE AND FUNCTION

Region	Structure affected Yes	Structure affected No	Laterality	Nature of change	Magnitude
1. Head and Neck	O	O			
2. Shoulder region	O	O			
3. Upper arm	O	O			
4. Elbow Joint	O	O			
5. Forearm	O	O			
6. Wrist Joint	O	O			
7. Hand	O	O			
8. Hand/Finger Joints	O	O			
9. Whole arm	O	O			
10. Pelvis	O	O			
11. Hip joint	O	O			
12. Thigh	O	O			
13. Knee Joint	O	O			
14. Lower leg	O	O			
15. Ankle Joint	O	O			
16. Foot	O	O			
17. Foot/Toe Joints	O	O			
18. Whole Leg	O	O			
19. Trunk	O	O			
20. C-spine	O	O			
21. T-spine	O	O			
22. L-spine	O	O			
23. Whole body	O	O			

I. DIAGNOSTIC CASE CONFIRMATION

Case: O (1)
Not case: O (0)

J CASE SEVERITY

Case severity: Mild O (1)
Moderate: O (2)
Severe: O (3)

L. CASE DIAGNOSIS

Diagnosis 1. Code 1

Diagnosis 2 Code 2

M. TREATMENT INFORMATION

	Previous Treatment Yes	*Previous Treatment* No	*Needed Treatment* Yes	*Needed Treatment* No
1. None:	O	O	O	O
2. Medication:	O	O	O	O
3. Plaster/Splintage:	O	O	O	O
4.Physiotherapy	O	O	O	O
5. Special Seating:	O	O	O	O
6. Mobility aid:	O	O	O	O
7. Tricycle:	O	O	O	O
8.Appliance:	O	O	O	O
9. Orthosis	O	O	O	O
10. Prosthesis:	O	O	O	O
11.Wheelchair:	O	O	O	O
12.Surgery:	O	O	O	O
13. Permanent care:	O	O	O	O
14. Traditional medicine:	O	O	O	O
15 Other: Specify:	O	O	O	O

K. DIAGNOSIS DECISION ALGORITHM

Is it congenital? Yes → a. CONGENITAL/GENETIC
No → Is it due to an infection? Yes → b. Infective
No → Is it due to trauma? Yes → c. ACQUIRED TRAUMA
No → Is it neurological in cause or nature? Yes → d. NEUROLOGICAL
No → e. ACQUIRED NON-TRAUMATIC

a. CONGENITAL/GENETIC

UPPER LIMB
- O (01) Polydactyly
- O (02) Syndactyly
- O (03) Other congenital hand deformity
- O (04) Other congenital absence of all or part of upper limb
- O (05) Other congenital abnormality of upper limb

LOWER LIMB
- O (10) Developmental dysplasia of hip
- O (11) Proximal focal femoral deficiency
- O (12) Congenital absence of all or part of tibia
- O (13) Congenital absence of all or part of fibula
- O (14) Other congenital absence of all or part of lower limb
- O (15) Club foot
- O (16) Other congenital abnormality of lower limb

UPPER AND LOWER LIMB
- O (20) Amniotic bands
- O (21) Arthrogryphosis

SPINE
- O (30) Congenital deformity of cervical spine
- O (31) Congenital deformity of thoracolumbar spine

HEAD AND NECK
- O (40) Cleft lip
- O (41) Cleft lip and palate
- O (42) Other congenital deformity of head or face

GENERAL
- O (50) Multiple congenital abnormalities
- O (51) Sickle cell disease
- O (52) Osteogenesis imperfecta
- O (53) Haemophilia
- O (54) Muscular Dystrophy

b. Infective

- O (01) Joint Infection
- O (02) Bone infection limb
- O (03) Bone infection spine
- O (03) Skin/soft tissue infection/wound

c. ACQUIRED TRAUMA

- O (01) Burn contracture
- O (10) Fracture non unioin
- O (11) Fracture malunion
- O (12) Spinal injury
- O (13) Head injury
- O (20) Recurrent/chronic dislocation
- O (21) Post traumatic joint stiffness
- O (30) Tendon problem
- O (31) Muscle problem
- O (32) Peripheral nerve problem
- O (40) Amputation
- O (50) Other Trauma

d. NEUROLOGICAL

- O (01) Epilepsy
- O (02) Leprosy
- O (03) Developmental delay
- O (04) Cerebral palsy - spastic
- O (05) Cerebral palsy - other
- O (06) Paraplegia
- O (07) Hemiplegia
- O (08) Quadriplegia
- O (09) Facial weakness
- O (10) Peripheral nerve palsy
- O (11) Polio
- O (12) Other neurological

e. ACQUIRED NON-TRAUMATIC

- O (01) Degenerative joint disease
- O (02) Non infective non traumatic joint disease
- O (03) Bow legs
- O (04) Knock knees
- O (05) Other joint deformity
- O (11) Bone tumour (benign or malignant)
- O (21) Skin/Soft tissue tumour
- O (40) Spinal deformity-kyphosis
- O (41) Spinal deformity-lordosis
- O (42) Spinal deformity-scoliosis
- O (43) Spinal pain limiting function
- O (44) TB spine/spine infection
- O (50) Limb pain limiting function
- O (60) Lymphoedema
- O (70) Other acquired non traumatic

f. NO DIAGNOSIS

- O (01) No Diagnosis

O. EQ-5D

1. Mobility
- I have no problems in walking about O (1)
- I have some problems in walking about O (2)
- I am confined to bed O (3)

2. Self-care
- I have no problems with self-care O (1)
- I have some problems washing or dressing O (2)
- I am unable to wash or dress myself O (3)

3. Usual activities
- I have no problems with performing my usual activities O (1)
- I have some problem with performing my usual activities O (2)
- I am unable to perform my usual activities O (3)

4. Pain/discomfort
- I have no pain or discomfort O (1)
- I have moderate pain or discomfort O (2)
- I have extreme pain or discomfort O (3)

5. Anxiety/depression
- I am not anxious or depressed O (1)
- I am moderately anxious or depressed O (2)
- I am extremely anxious or depressed O (3)

Responders own health state today

N. WHY I HAVE NOT HAD (FURTHER) TREATMENT

- Unaware of Impairment O (1)
- Believes it to be a curse O (2)
- Services not available or very far O (3)
- No / delayed information about services O (4)
- Cannot afford treatment O (5)
- No one to accompany O (6)
- No time available / other priorities O (7)
- Old age and need not felt O (8)
- Adequate function / need not felt O (9)
- Fear of treatment O (10)
- Not applicable O (11)

COMPLETION SIGNATURES

Physiotherapist

Name
Signature
Initials

Graphic design: Communication Division, UiB / Print: Skipnes Kommunikasjon AS

uib.no

ISBN: 978-82-308-7070-9 (PRINT)
978-82-308-7159-1 (PDF)