Road Traffic Injury in Africa

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Introduction

The problem is preventable death and disability. The solutions are surgical capacity and injury prevention.
Epidemiology

Over 1.2 million people die from road traffic injury each year – about 3,300 per day around the world. Another 50 to 60 million suffer disabling injuries. Over ninety percent of road traffic deaths occur in low and middle income countries, despite the face that over fifty percent of registered vehicles are in high income countries (1). While high income countries might be safer today, the initial effects of economic growth are to worsen the road traffic burden. The most dramatic example of this was a doubling of the car crash death rate in East Germany the year after the Berlin Wall came down. A careful analysis of current trends yields the prediction that road traffic will be the third leading cause of death and disability worldwide by 2030, up from ninth place today (1).

People of all ages are victims of the road traffic injury pandemic. In Africa children, middle aged adults, and the elderly all suffer more from road trauma than they should. The road death rate in Africa is estimated as 32 per 100,000 people per year, compared with 13 per 100,000 in the high income countries in the Americas and only 8 per 100,000 in Europe (1).

Children are vulnerable as pedestrians in poorly planned traffic environments and are often not appropriately restrained when they are passengers. Adults of working age are exposed to more traffic than other age group, so comprise the numerical majority of road casualties. The elderly are more likely to be involved in crashes, and less likely to survive their injuries, as the changes of senescence occur. The road traffic injury pandemic is an entirely man-made problem. Solutions are known, but are not implemented. The solutions are surgical capacity and injury prevention. Surgeons need to understand and advocate for both types of solutions. Cardiologists have done at least as much good with advances in the prevention of coronary disease as they have done with advances in its treatment. A public health approach to road traffic will recognize the role of both prevention and treatment, and surgeons can be involved in both.

According to WHO estimates, the financial burden of road traffic injuries (including treatment costs and lost income) is currently equivalent to 1% of GDP in low income countries, and is expected to rise in coming years. In Africa, the total economic burden from road traffic crashes was recently estimated at $3.7 billion per year (1). Half the victims are in the 15 to 44 year old age group, peak earning years, and so the financial burden on families is high.

Africa is far from uniform across the vast continent – settings range from very urban to very rural, from affluent to poor, from highly to sparsely populated. No single description captures the richness and detail of the local problems and solutions regarding road injury. Discouragingly, the most affluent and urban of the sub-Saharan nations also has the most dangerous roads. This is not surprising. The road traffic injury epidemic is driven by availability of kinetic energy – vehicles, fuel, and roads all become more available with economic growth.

Treatment

Prehospital Care

Trauma care starts before arrival at the hospital. A prehospital care system needs to provide safety at the scene, assessment and triage of trauma victims, and safe efficient transport to the most appropriate point of care. Many African countries lack formal prehospital care for trauma. Successful interventions built around lay first responders, including police and taxi drivers, have been described in Uganda (2,3).

Trauma Teams

A team approach to trauma resuscitation can be implemented in hospitals of all sizes. The Advanced Trauma Life Support course, taught by the American College of Surgeons, is the most popular framework for the systematic management of trauma resuscitation. Introduction of ATLS in Trinidad and Tobago was followed by a marked reduction in inhospital trauma mortality, from 279 of 413 to 134 of 400 after ATLS (Ali J trauma 1993). Specific trauma team protocols and training manuals aimed at small district hospitals in Africa have been developed by the Injury Control Centre, Uganda and are available from them.

Trauma Systems

Organization of the health care system with regional networks of trauma care has been shown effective in reducing trauma mortality overall, and especially trauma mortality due to road traffic (4). A system wide approach to trauma care involves providing straightforward lifesaving resuscitation in the closest hospital, with an organized system for communication and triage to allow more serious casualties to be transferred to regional trauma centers for definitive care.

Cost Effectiveness

Surgical care compares very favourably with other more traditional 'public health' approaches. The cost of surgical interventions in Africa has been estimated at $33 per disability adjusted life year averted, considerably less than the cost of many interventions which the African governments and the international community support (5,6).

Prevention

Prevention of road traffic injuries works in a complementary way to treatment to reduce the societal burden. Injuries which are fatal at the roadside, typically major CNS or circulatory system trauma, are not retrievable even given the best of hospital systems. Central nervous system injuries and some major orthopaedic trauma will produce lifelong severe disability even with the best of care and even if accompanying life threatening injuries.
are treated. Finally, prevention of traffic injuries frees up hospital facilities and health care personnel to treat other things.

The Haddon Matrix is a useful way of thinking systematically about prevention of any road traffic injury. Dr. Haddon considered three time periods – pre event, during the event, and after the event. He also considered the host, the injury agent, and the environment in which injury occurs. Any combination of time and person is likely to yield a prevention strategy. Preventing the crash from occurring in the first place is primary prevention – for example increasing the visibility of a cyclist. Preventing damage to human tissue during the crash is secondary prevention – for example putting a helmet on a cyclists head, or strapping a passenger into a car with a seatbelt. Reducing the consequences of a given set of crash injuries is tertiary prevention. For example, a prehospital and hospital system that can triage and transport someone with a pneumothorax during the ‘golden hour’ and have a life saving intervention performed is tertiary prevention.

Combining interventions at different levels has synergistic effects. If we prevent ten percent of motorbike crashes from occurring by a visibility intervention (for example, always on headlights) and we further prevent seventy percent of head injuries in motorcycle crashes (for example by mandating helmets) and we further prevent ten percent of secondary brain injury morbidity (for example by improving trauma care), then the remaining motorcycle head injury burden will only be 24% of what we started with (.9 times .3 times .9). Even modest preventive effects, when applied at different levels and combined, greatly reduce the overall injury burden.

Vulnerable road users include pedestrians, cyclists, and motorcycle riders – anybody not protected by a vehicle frame. Because we are all pedestrians, and because vulnerable road users account for the majority of traffic casualties in Africa, we will discuss vulnerable road users first.

Road User Groups

Pedestrians

Pedestrians [add numbers] are the most vulnerable of vulnerable road users. Children lack the experience and judgement to cross a road safely. The child’s head is more likely to be struck by the front or hood of a vehicle and suffer direct force. The elderly may lack the physical capacity to cross roads quickly or to respond to rapidly approaching vehicles, and they are more frail so more likely to die of their injuries. Despite this, the vast majority of killed and injured pedestrians are working age adults simply because they spend much more time on and around roads during their daily activities.

Separation from Traffic

If cars and pedestrians did not share space, there could be no pedestrian injuries. Separating vehicular traffic from pedestrians is probably the most powerful tool in pedestrian injury prevention. Not all traffic is equally dangerous to pedestrians, and the key is to protect people from high speed and high energy traffic (see speed section under common risk factors for more information). In urban areas this is done by limiting the overall speed of traffic, providing sidewalks, installing crossing controls, or even building roads at different levels from where people walk. Pedestrians are not likely to climb up or down to avoid traffic, so pedestrian bridges and underpasses tend not to be used. Rather, creative designs such as the raised roads and traffic circles near the Durban stadium built for the world cup (see figure) give pedestrians free movement and take the cars out of their way. Such extensive designs do not apply in most urban areas and far more commonly the solutions involve a combination of sidewalks, raised pedestrian crosswalks, and intersections which favour pedestrians. Sensible urban road networks may have some high speed controlled access freeways completely free of pedestrians. There are no randomized trials of traffic engineering to prevent pedestrian fatalities, but a systematic review of observational studies with before – after designs and control locations estimated that pedestrian deaths might be reduced by 37% by changing the road environment (7). Importantly, none of these studies were done in low and middle income countries and it is possible that the gains in pedestrian safety may be even greater.

Visibility

In many parts of Africa pedestrians are on their way to work or school before sunrise, and almost everywhere pedestrian activity continues well into the hours of evening darkness. Drivers can only avoid pedestrians they can see. Light colored clothing is a simple measure improving nighttime conspicuity of pedestrians. Retroreflective materials built into clothing or shoes, or added as an arm band or to a school backpack, can also greatly increase the drivers ability to see pedestrians. There are 39 randomized controlled trials showing that lamps or retroreflective materials increase drivers ability to detect pedestrians and cyclists, but as yet none have been performed to evaluate the injury outcomes of these interventions (3).

Training

Teaching children to cross the road safely is a widely practiced, if insufficient, step in preventing pedestrian injuries. There is randomized controlled trial evidence that children’s road crossing behaviour can be changed by pedestrian training programs, both immediately and at six month followup (9). No trial of child pedestrian training has actually shown a reduction in injury rates, and none has been done in a low income country. Although it is reasonable to teach children how to be safer in traffic environments, it is also necessary to make the traffic environment safer for the children as well.
Cyclists

Separation from Traffic

Many European countries have extensive networks of bicycle paths and lanes running along the regular roadways or separated from them. Recent development in China has moved from masses of people on bicycles to the more familiar urban snarl of near stationary car based traffic. American cities are desperately attempting to reinsert bicycle friendly features into cities that grew and sprawled around the needs of the automobile – and it is difficult to engineer bikes back in. Africa includes very rural areas, big urban centres, and an ongoing shift of population and development from rural to urban. Providing separate infrastructure for cycling promotes a form of transportation which is cheap, healthy, nonpolluting, and compact. There is a paucity of research regarding whether designing the traffic environment around cycling contributes to health or safety outcomes.

Helmets

Bicycle helmets reduce the risk of a head injury by 85% in the event of a crash (10). This risk reduction applies equally to crashes involving motor vehicles, and to high speed crashes. A bicycle helmet is made of stiff but lightweight polystyrene foam which crushes during an impact and absorbs energy which would otherwise be transmitted to the skull. It is effective because it is at the precise point of kinetic energy interchange during the crash. Bicycle helmets are single use helmets and should be discarded and replaced once they have been involved in a crash. Bicycle helmets are mandatory by law in many, but not all jurisdictions. Helmet laws increase the number of cyclists wearing helmets, and helmet laws do not limit the popularity of cycling or reduce the numbers of cyclists (11).

Visibility

Bicycles will be on the roadway at night and must be made maximally visible to cars. Cheap LED headlamps and tail lamps have made this much easier in recent years, they cost little to install and use minimal power to run. Moving reflectors on wheels and pedals are very effective at catching the motorists eye and clearly identifying a bicycle (8).

Motorcycles

A motorcycle is the most dangerous way, per passenger mile, of getting a person from one place to another. This is because motorcycles are almost all engine. Motorcycles are pervasive because they provide cheap, practical, and versatile transportation. In North America they may be primarily used for recreation and sport, but in Asia and Africa they form the backbone of a practical transportation system and will be around in increasing numbers for a very long time.

Helmets

A helmet is the most important part of a motorcycle, from a safety perspective. Motorcycle helmets are 72% effective at reducing the incidence of head injuries given a crash (12). Motorcycle helmet laws have come into effect over the past decade in many, but not all, African countries. A law is not enough by itself – use rates vary depending on how helmets are promoted and how the laws are written and enforced. Helmet wearing can vary considerably within a country and is usually substantially lower in rural than in urban areas. Passengers are equally at risk so also need to wear helmets. Practical problems, including the acceptability and fit of shared helmets for passengers on motorcycle taxis, still exist and demand creative solutions. Cultural acceptance is important in maintaining the helmet use rate near 100%, so identifying and addressing the concerns of helmet non-users may occasionally be a local or regional problem.

Visibility

Motorcycles are small, rapid, and maneuverable which makes them less visible to drivers of cars and other vehicles. A common type of highway motorcycle crash involves a car turning across the path of an unnoticed oncoming motorcycle. Usually the motorcycle rider is most badly injured in this crash, even if not at fault. Motorcycle headlights which are linked to the ignition and are on whenever the engine is running will increase both the daytime and nighttime visibility of the vehicles.

Driver Training

Training and licensing requirements for motorcycle drivers vary considerably from country to country. Experienced drivers are in fewer crashes, but are by no means immune. Whether driver training shortens the time to proficiency or increases the safety of drivers is unknown (13).

Occupants

Motor vehicle occupant protection has improved very substantially over the past several decades. One of the main reasons that traffic death rates have fallen in North America is that cars themselves have become much safer for drivers and passengers. Systems that increase safety include those that decrease the probability of a crash, as well as passive (seat belt, vehicle interior) and active (air bags) systems which decrease the risk of injury if a crash occurs. Features such as vehicle stability control systems and antilock braking systems make new cars more forgiving of driver error than the previous generation of cars.

Seat Belts

Seat belts are the most important and the most effective components of an occupant protection system for cars. A seat belt reduces crash fatality risk by at least 40% (14-16). The best way to survive a crash is to strap oneself to the biggest mass possible, and ‘ride down’ the momentum of the crash in a more gradual way. In practical terms this means being belted to the car. Seatbelts protect drivers and passengers from being ejected from the vehicle during a crash, and ejection confers at least an eight fold increased risk of death compared with remaining in the vehicle, for a constant crash energy (17). Seat belts spread the load across the pelvis, chest and shoulders and minimize the injury from steering column to chest or from windscreen to
head by keeping occupants in the correct position during the crash. Seat belt use is required by law in most jurisdictions and the presence of a seat belt law saves lives (18).

Lap and shoulder belts together are superior to lap belts alone. Most doctors are familiar with the ‘lap belt’ injury complex which can include a transverse bruise of the anterior abdominal wall, an intrabdominal injury especially a hollow viscous perforation, a lumbar spine flexion-distraction fracture, and a spinal cord injury. This injury is the result of a large crash force and a poorly positioned lap seat belt (19-21). The lap seat belt needs to be positioned across the iliac crest rather than too high across the soft part of the abdomen. A shoulder belt helps to prevent the forward flexion of the upper body that contributes to this injury complex. It should be emphasized that any seat belt, even a lap belt alone, is much safer than travelling without a belt.

Air Bags

Air bags are not a substitute for seat belts and are not as effective if used without seat belts. A driver’s air bag deploys from the steering wheel and prevents head and chest injuries by rapidly filling the small space and minimizing injurious contact with the steering column. A passenger airbag has a much larger space to fill between the passenger and the dashboard, and a belted front seat passenger would be much less likely to contact the dash in the first place. Accordingly, the safety benefits of passenger airbags are substantially lower than those of driver airbags (22,23).

Airbags deploy with a vigorous chemical explosion (A grenade in a paper bag) which can produce head accelerations of up to 300 G forces for occupants whose head is in the zone of deployment of the airbag while it is going off. Out of position child occupants and elderly people close to the dashboard can have severe injuries from airbag deployment and should not be seated in driver or passenger positions (24).

Child Safety Seats

Children need to be properly restrained in cars even more than adults do, as children are more vulnerable to injury with their relatively large heads and weak necks and trunks. Yet, no car when purchased actually includes restraints which are safe for babies or children. Aftermarket child safety seats are required.

Child safety seats should not be installed in the front seats of a car. The rear seats are safer for all ages of children in all vehicles (25). An airbag in the front passenger seat can cause severe or fatal head injury to a child passenger whose head is in the zone of deployment of the airbag during inflation. Among the rear seats, the safest one is the centre seat as it is best protected from intrusion in the event of a side impact crash. There is no substantial difference in the crash safety between the rear outboard positions, but children are safer getting in and out through the passenger side especially if the car is parked on the side of a road.

Babies should be positioned in a rear facing infant seat. The baby is strapped in to the seat with a five point harness, and the seat is attached to the car using either the vehicle seat belts, or special clips called LATCH. The rear facing position means that in the event of a frontal crash the entire seat is cradling the head, neck, and torso of the baby and spreading the load of deceleration equally. Most severe crashes have a frontal component as the car slows rapidly (even if struck directly from the side). A forward facing baby in a frontal crash would be at risk of a devastating head and neck injury because of the relatively large mass of the head, the weak spinal extensor muscles, and the horizontal orientation and poor development of the cervical facet joints. A rear facing infant seat is safe and effective up to 10kg in size at least.

Young children beyond 10 kg should be restrained in a child safety seat. Many of these seats are convertible and can be installed facing either the front or the rear of the vehicle. The rear facing position is safest during a crash, for the same reasons it is safest for babies. Rear facing is actually safer for all crashes at all ages. (Next time you are on an aircraft you will probably notice that the cabin crew have rear facing seats with four point seat belts, while passengers have forward facing seats with lap belts.) Properly restrained infants in forward facing child safety seats have suffered devastating neck injuries in otherwise survivable crashes.

School aged children, from about ages 4 to 9, need a booster seat until they can fit properly into an adult seat belt. Children at this age are particularly vulnerable to both lap belt injuries (see above) and to ejection from the vehicle, because the child’s skeleton is too small to be securely held by a seatbelt designed to accommodate adults. A booster seat lifts the pelvis up and forward to improve the fit of the lap belt, and also lifts the body up to improve the fit of the shoulder belt.

Overall the effectiveness of correctly restraining a child in a child safety seat is a 70% reduction in the risk of crash injury (26-29).

Vehicle Crashworthiness

The crash protection a vehicle provides to restrained occupants relies on the integrity of the vehicle frame during a crash. A safe modern vehicle has crumple zones at the front and rear which absorb crash energy but protect the vehicle occupant compartment from intrusion. Side impact crashes are a challenge to vehicle designers. Vehicle mass confers an overwhelming advantage in protecting occupants because of conservation of momentum in a crash, yet more massive vehicles are less efficient, and more dangerous to other road users.

Vehicle Crash Avoidance

Brakes and steering systems need to be reliable and properly maintained in order to allow drivers to safely make evasive manoeuvres and avoid crashes. Antilock braking systems were an early (1980s) system which rapidly release and reapply brake pressure to prevent skidding and allow steering during maximal braking. There is good evidence that antilock brakes do not actually reduce the numbers of injury crashes (30). By contrast, the more recent electronic stability control systems (known by various tradenames) have proven highly effective, preventing the occurrence of an estimate 49% of single vehicle crashes. These systems work by detecting abnormal vehicle movements and accelerations and making automatic adjustments to brakes and throttle to prevent the onset of a skid (31).

Common Risk Factors

Speed, alcohol, and road design can increase the risk of crashes and injuries for all road user and vehicle types so they should be addressed as common
risk factors.

**Speed**

The formula for kinetic energy, $k=\frac{1}{2}mv^2$, emphasizes the role of speed in generating the injury force. Doubling the speed of a vehicle quadruples the injurious kinetic energy it carries. A pedestrian struck by a car travelling at 30 km/h has about a ten percent risk of death, compared with almost a ninety percent risk of death faced by a pedestrian struck by a car travelling at 60 km/h. Vehicle speed is also very strongly correlated with the risk of injury or death for car occupants and motorcycle riders.

![Pedestrian fatality risk as a function of the impact speed of a car](image)

Figure Source: Page 29, World Report on Road Traffic Injury Prevention, WHO 2004

**Alcohol**

Depending on the jurisdiction and the time of day, either a majority or a substantial minority of drivers and pedestrians killed in traffic are intoxicated, usually with alcohol. Interventions to limit consumption at drinking places have had some success at reducing single vehicle crashes by 15% to 23% (32). The effectiveness of increased police patrol programs to combat impaired driving has been difficult to evaluate, due to poor study designs and modest measured effects of the intervention (33).

**Road Design**

Road systems are used by human beings who may be in a hurry, distracted, or impaired. Good design of roads and road systems makes them safe for pedestrians, cyclists, motorcyclists, drivers, and vehicle occupants. Many roads in Africa are far from optimally designed. A common pattern is a linear arrangement with shops and dwellings extending for long distances on either side of a main road, the sides of which are crowded with pedestrians and are used for many activities as cars speed past and pedestrians attempt to cross. Raised pedestrian crosswalks may slow the cars and partially compensate for the bad overall design, but the solution is to move to a different arrangement of space. High speed transportation does not need to mix with the daily activities and interactions of human life, any more than does any other dangerous industrial process. Proper design of the built environment has the potential to improve safety and quality of life together, by separating people from traffic (34).

**Conclusion**

1.2 million people die on the roads each year, and millions more suffer disabling injuries. All these injuries and deaths are ultimately from a manmade cause. Proven interventions could prevent the majority of the human and economic cost entailed. Surgeons play a role in treatment, in the design of trauma systems, and in advocating for and implementing prevention programs on behalf of our patients. Development, in Africa, will bring wealth, vehicles, fuel, and kinetic energy. The road traffic injury epidemic will get worse, until we work together to make it better.

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