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The Prehospital Burden of Disease due to Trauma in KwaZulu-Natal: The Need for Afrocentric Trauma Systems

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Abstract

Background Trauma is one of the leading prehospital disease profiles in South Africa in general and in KwaZulu-Natal (KZN) in particular. The present study was designed to review the prehospital burden of injury in KZN, identify trauma burden to ambulance ratios, analyze system deficiencies, and propose a prehospital trauma system that is Afrocentric in nature.

Methods Approval from the relevant ethics authorities was obtained. Using a convenience data set all Emergency Medical Service (EMS) call data for the months of March and September 2010 were reviewed for the three main EMS providers in KZN. Data were extrapolated to annual data and placed in the context of population, ambulance service, and facility. The data were then mapped for area distribution and prehospital workload relative to the entire province. Questionnaire-based assessments of knowledge and deficiencies of the current system were completed by senior officers of the provincial system as part of the analysis of the current system.

Results The total annual call burden for trauma ranges between 94,840 and 101,420, or around 11.6 trauma calls per thousand of the population per year. Almost 70 % of calls were either for interpersonal intentional violence or vehicular collisions. Only 0.25 % of calls involved aeromedical resources. Some 80 % of patients were considered to be moderately to seriously injured, yet only 41 % of the patients were transported to a suitable level of care immediately, with many going to inappropriate lower level care facilities. Many rural calls are not attended within the time norms accepted nationally. Deficiencies noted by the questionnaire survey are the general lack of a bypass mechanism and the feeling among staff that most EMS bases do not have a bypass option or feel part of a system of care, despite large numbers of staff having been recently trained in triage and major trauma care.

Conclusions The prehospital trauma burden in KZN is significant and consumes vital resources and gridlocks facilities. A prehospital trauma system that is financially sustainable and meets the needs of the trauma burden is proposed to enable Afrocentric emergency care planning for low and middle income regions.

This article forms part of a series of studies toward a PhD in Trauma Systems for the lead author.

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Introduction

Trauma is the second most frequent cause of mortality in KwaZulu-Natal province (KZN), the largest and most populous province of South Africa [1]. Trauma affects the young and productive population subgroup, and in this respect is similar to HIV/AIDS, the leading killer in the province. KwaZulu-Natal lies on the East coast of South Africa and has a population of almost 11 million [2], with approximately 50 % of the population living in the rural areas outside the two major cities of eThekwini (Durban) and uMsinduzi (Pietermaritzburg). Healthcare provision is divided into eleven health districts (Table 1; Fig. 1—population distribution)

South Africa is one of the few countries in Africa to have a formalized emergency medical service (EMS)[3–5], divided into private and public services, the latter being free-access. There is, at present, no formalized single emergency call center, and each of the services independently dispatches vehicles and personnel to reported incidents (this places South Africa somewhere between World Health Organisation prehospital trauma system grading level 2 and level 3) [6]. In KZN the majority of the emergency service vehicles in the public sector are staffed by basic or intermediate life support paramedics, whereas advanced life support (ALS) paramedics work from rapid response vehicles, mostly situated in the larger towns and the urban areas, many of these being aligned to private services. The majority of the population (87.5 %) is uninsured and relies on public ambulance services. Much has been published in the past about the fatal disease burden of trauma in South Africa[7–9]; however, little is known about either the prehospital or hospital overall burden of trauma in the country.

The purpose of the present study was to determine the trauma prehospital burden to this province suffering from resource constraints and the "devil of distance" for many rural patients living in a province with undulating terrain. From available data, the ratio of trauma to ambulance availability was reviewed. System deficiencies were identified and a proposal for a prehospital trauma system was developed.

Table 1 Population by district: KwaZulu-Natal (2010)

DC21: Ugu District Municipality	729,052
DC22: UMgungundlovu District Municipality	960,819
DC23: Uthukela District Municipality	680,333
DC24: Umzinyathi District Municipality	472,682
DC25: Amajuba District Municipality	484,673
DC26: Zululand District Municipality	833,037
DC27: Umkhanyakude District Municipality	593,718
DC28: Uthungulu District Municipality	917,451
DC29: iLembe District Municipality	580,307
DC43: Sisonke District Municipality	308,999
Durban: eThekwini Municipality	3,199,944
	Total 9,761,016

Methods

The study received UKZN-BREC (BE011/010) and Provincial Research Office approval, and permission for the use of de-identified call data was granted by the Netcare Ethical Committee and the Medical Director of ER24. The strategy employed a convenience data set of all EMS dispatches for a "trauma call" during the months of March and September 2010. These months were chosen to avoid "holiday bias" in December and the effect of the FIFA2010 Soccer World Cup, played in June–July of 2010.

Using extrapolation, these data were converted to a predicted annual incidence, using two methods to enable range prediction, classified by injury severity (where available) and then mapped per health district within the KZN province to reflect calls per 1,000 population. Finally, the data were placed into "facility" context by assessing trauma burden per staff and vehicle status per district and by access to major hospital (delivery destination). To illustrate the relative severity of the trauma burden, certain of the variables were geographic information system (GIS) mapped with standard mapping software [10]. From the available EMS structural data, a system was proposed for providing more efficient prehospital trauma care from an Afrocentric perspective.

The trauma causes were divided into three groups, namely vehicular related, interpersonal violence (with penetrating trauma as a separate subgroup where available), and other trauma (this includes domestic, industrial, other penetrating or blunt injury). Burn injuries were not included initially; however, these were reported for a number of the regions and the data were extrapolated to establish a regional burn incidence. The various causes of trauma were also evaluated per region to determine the spectrum of injury by region, and to determine whether rural regional variation differs from urban areas.

Results

For the 2 months under review, the total trauma-related call volume for the three EMS services was 16,903 calls from the data provided, which was incomplete for two districts. This would equate to an annual minimum trauma call volume for the KZN province between 94,840 and 101,420 calls, using a predictive system of either monthly

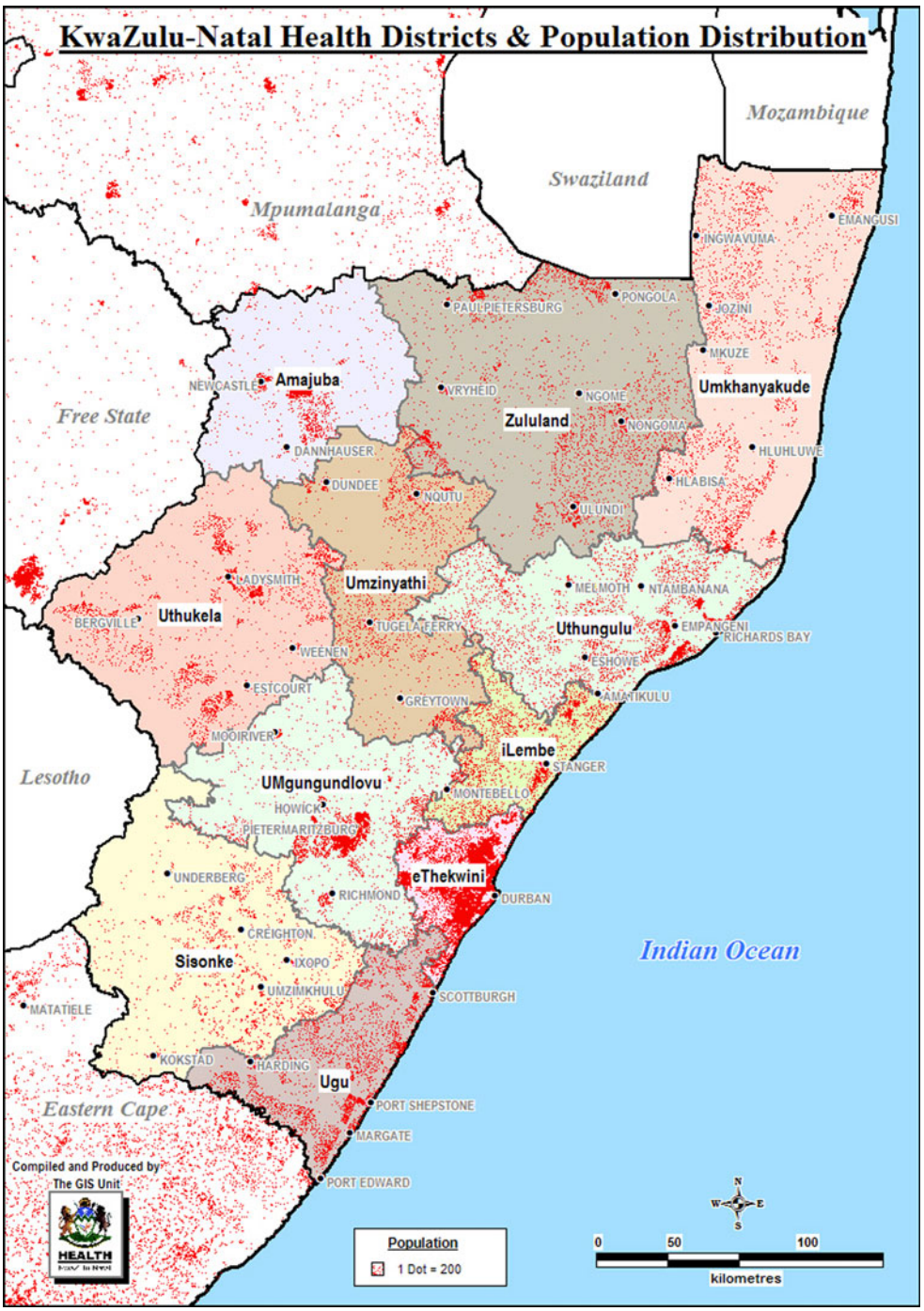

Fig. 1 Map showing the health districts and population density in KwaZulu-Natal (KZN)

averages totalled for one year or the total of the two months multiplied by six, respectively. Using the two systems resulted in a 6.5 % variance between the two possible systems to calculate the annual trauma volume. Put into population context, this equates to 11.6 trauma events requiring emergency ambulance activation per 1,000 population in the province per annum, with certain of these events presenting multiple patients. The distribution of these ambulance calls across the province is GIS-mapped in Fig. 2. In terms of ambulances per district, the distribution is mapped in Figs. 3 and 4.

During the study period, there were 2,042 operational EMS staff across the province; however, most were only basic life support (BLS) qualified, with only around 70 ALS providers for the entire patient cohort. Assuming all worked an equal number of shifts and saw a similar spectrum of disease, then each EMS provider would be exposed to between 46 and 50 trauma calls per operational

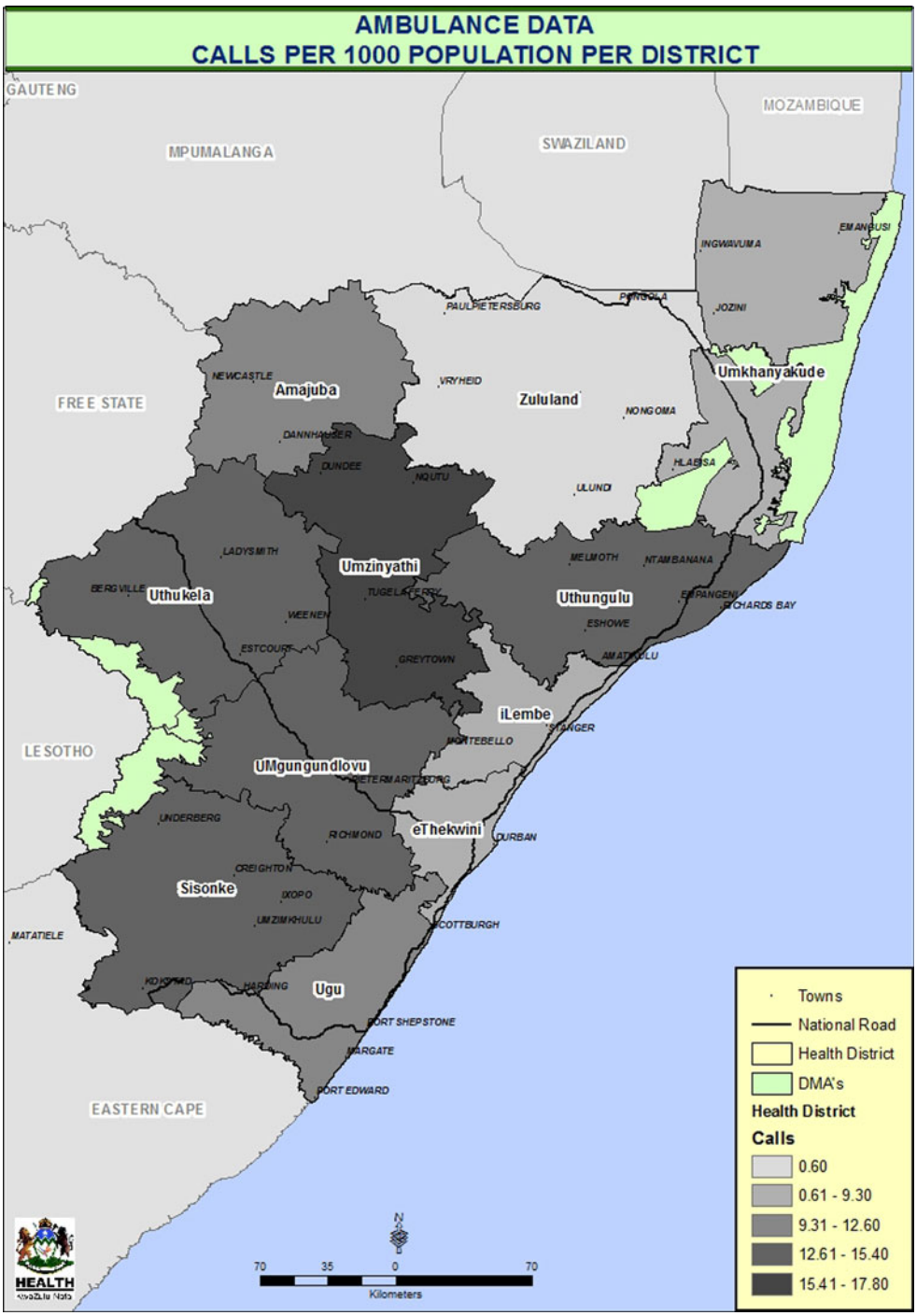

Fig. 2 Map outlining the distribution of trauma ambulance calls per 1,000 population per health district, KZN (Color figure online)

staff member. There are, however, only between six and ten ambulances per 100,000 population (including private services) operating on a daily basis, thus increasing the risk of delays and increased morbidity. Of these ambulances, 66 % of the public EMS vehicles have over 150,000 km completed service mileage. They are based at 70 public and 12 private EMS bases, with 80 % of the bases having fewer than six ambulances each. There are two rotor wing aeromedical aircraft, one private rotor wing aeromedical aircraft, and one fixed wing aeromedical aircraft, which combined to undertake fewer than 300 flights for trauma during 2010.

Regarding relative trauma volume by cause, overall violence-related trauma occupies 39.7 % of the workload (Fig. 5), while vehicular collisions are second, with 31.9 % of the trauma burden (Fig. 6). Other trauma, which includes burns, was the third cause overall at 28.4 % (Fig. 7). The predicted number of burn cases for the

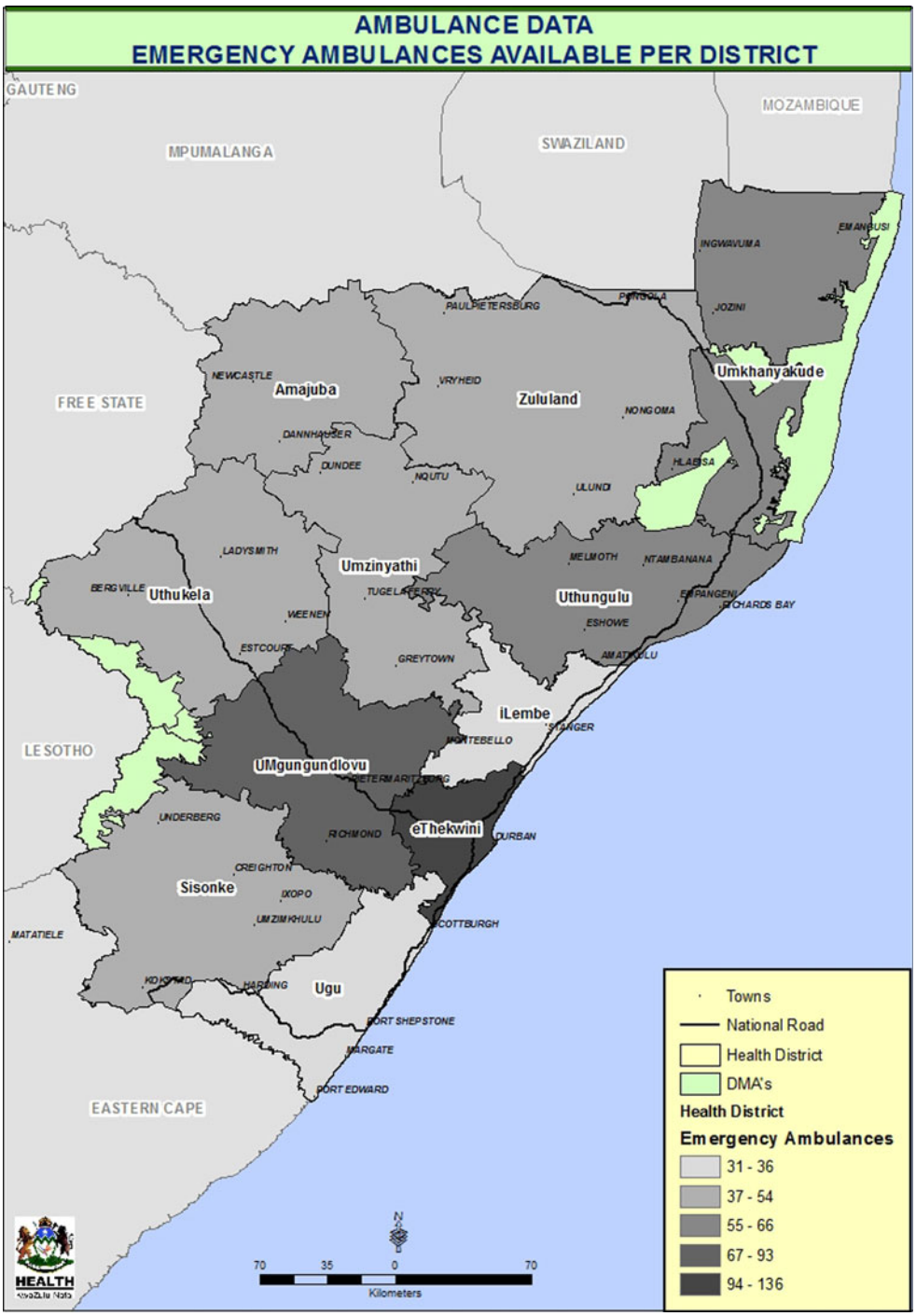

Fig. 3 Map showing the relative distribution of available ambulances per health district, KZN (Color figure online)

province is 7,099 per annum. The high rates of assault and gunshot injury relative to the overall trauma burden is of particular significance, along with the vehicle-related trauma, as these are potentially preventable injuries. This is especially concerning in light of the United Nations WHO Decade of Action 2011–2020 [11]. This was true for nine districts; however, two districts showed a different trauma spectrum, with the Amajuba and uThukela districts (both rural) having "other trauma" as the leading cause of injury, while the two private services had a much higher vehicular collision rate and much lower interpersonal violence rates (Table 2). This is expected because most of the private services are based in urban areas with higher ALS staff availability. The private services responded to 3.5 % of the overall number of calls reviewed, mostly in the eThekwini, uMgungundlovu and Ilembe districts.

Three districts had large numbers of "exempt" calls, those where the EMS response was made and the call was

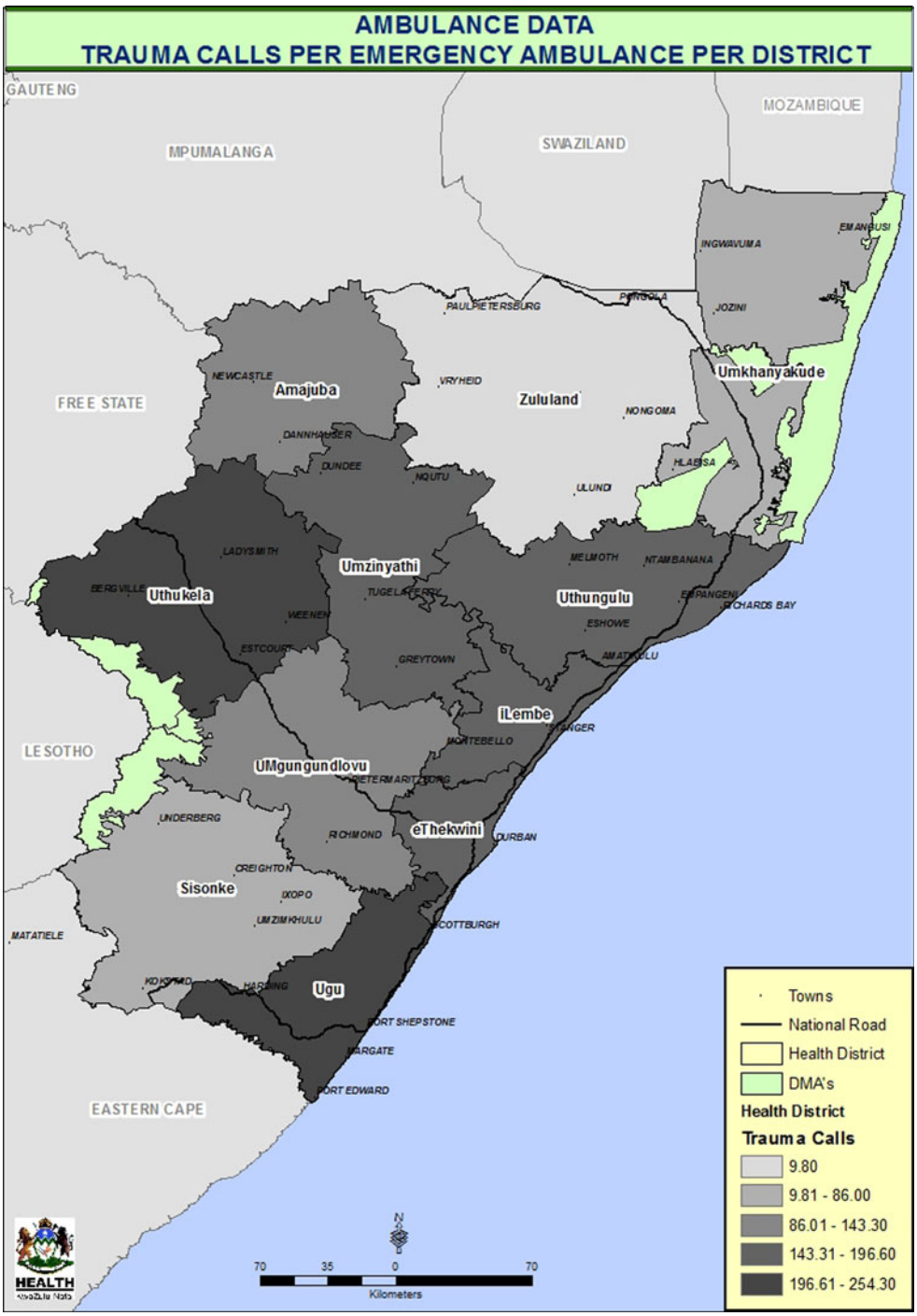

Fig. 4 GIS plot showing the trauma calls per ambulance per health district, KZN (Color figure online)

either a hoax or the patient had left the scene prior to EMS arrival. All three of those districts were largely rural in nature, and control center records show that less than 35 % of all calls in these rural regions were attended to in under 40 min (the national norm for rural responses) [12]. Overall, 6,609 unnecessary responses were recorded, where no patient was found or transported.

Regarding the severity of injury, the EMS use a four-part triage system with red implying life-threatening injury, yellow a stable stretcher case, and green walking wounded. Code blue indicates that the patient was dead on arrival. Injury classification had been recorded by the control centers for 13,133 cases (77.7 % of all calls received). The spread of injury severity across the province was as follows: 80.3 % of cases were coded "yellow"; 15.6 % were cases of severe trauma and were coded "red," whereas only 3.7 % of the cases were coded "green" and a minority of 0.4 % were dead on arrival. This implies that 80 % of

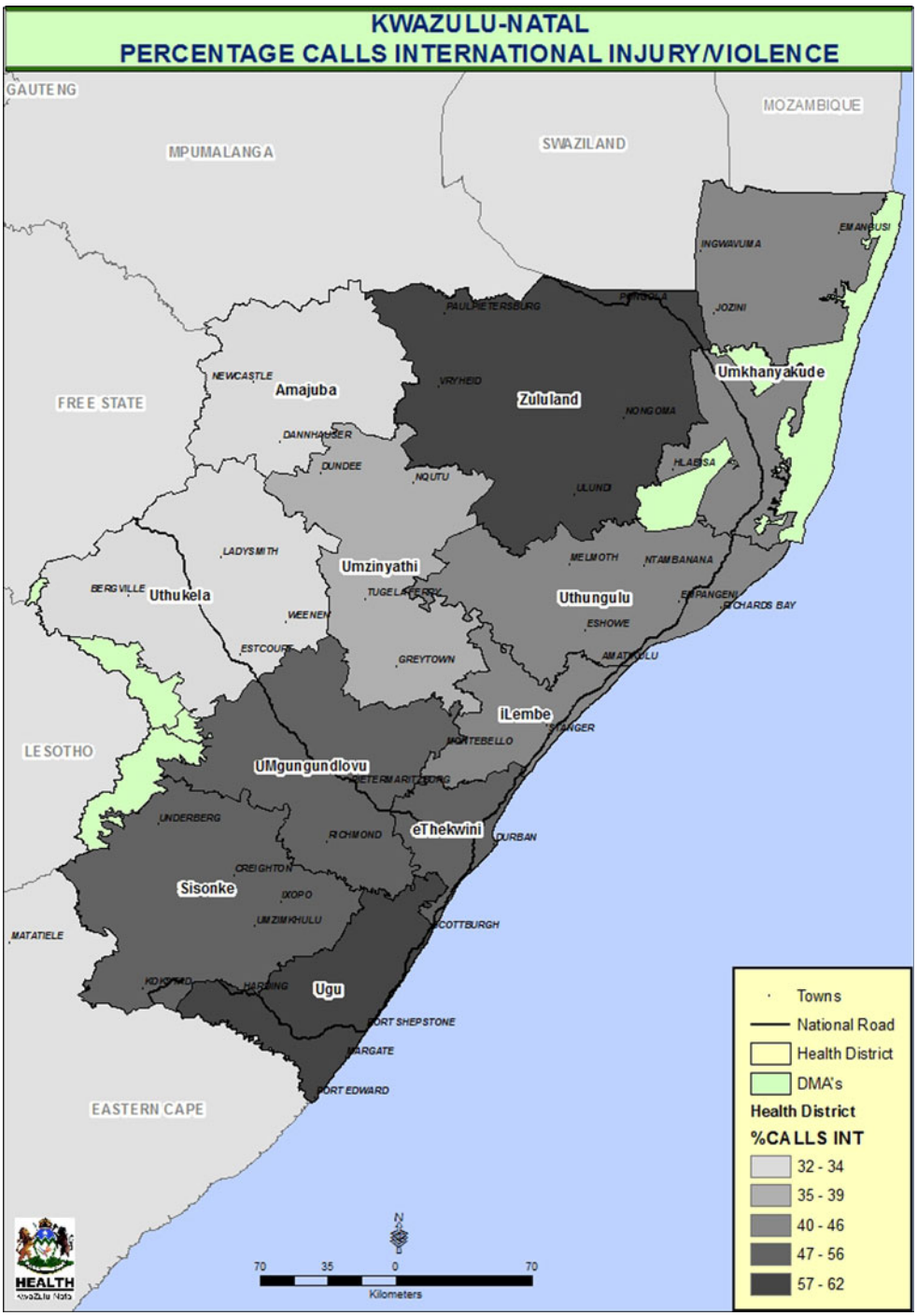

Fig. 5 GIS plot showing the relative distribution of violence-related trauma calls to the ambulance service per health district, KZN (Color figure online)

the patients should be treatable in appropriately equipped and staffed regional hospitals and that the majority of trauma victims should bypass small clinics and district hospitals. Only 15 % of cases will require care in a fully equipped level 1 trauma center, and there is only one such center in the province.

When examining definitive care destination, however, it was noted that almost 57 % of trauma cases were transferred to district hospitals, which have limited imaging and surgical facilities, whereas 40 % were taken to regional hospitals and 1 % to tertiary or quaternary hospitals, whereas only 0.42 % were taken to the private hospital sector facilities. A further 1.6 % of cases were inappropriately taken to community (nurse-run) clinics. Around 2.7 % of transfers required transfer out of the district, thus further reducing the limited numbers of ambulances available for emergency cases in these districts (Fig. 6). All code blue patients were transported to state forensic

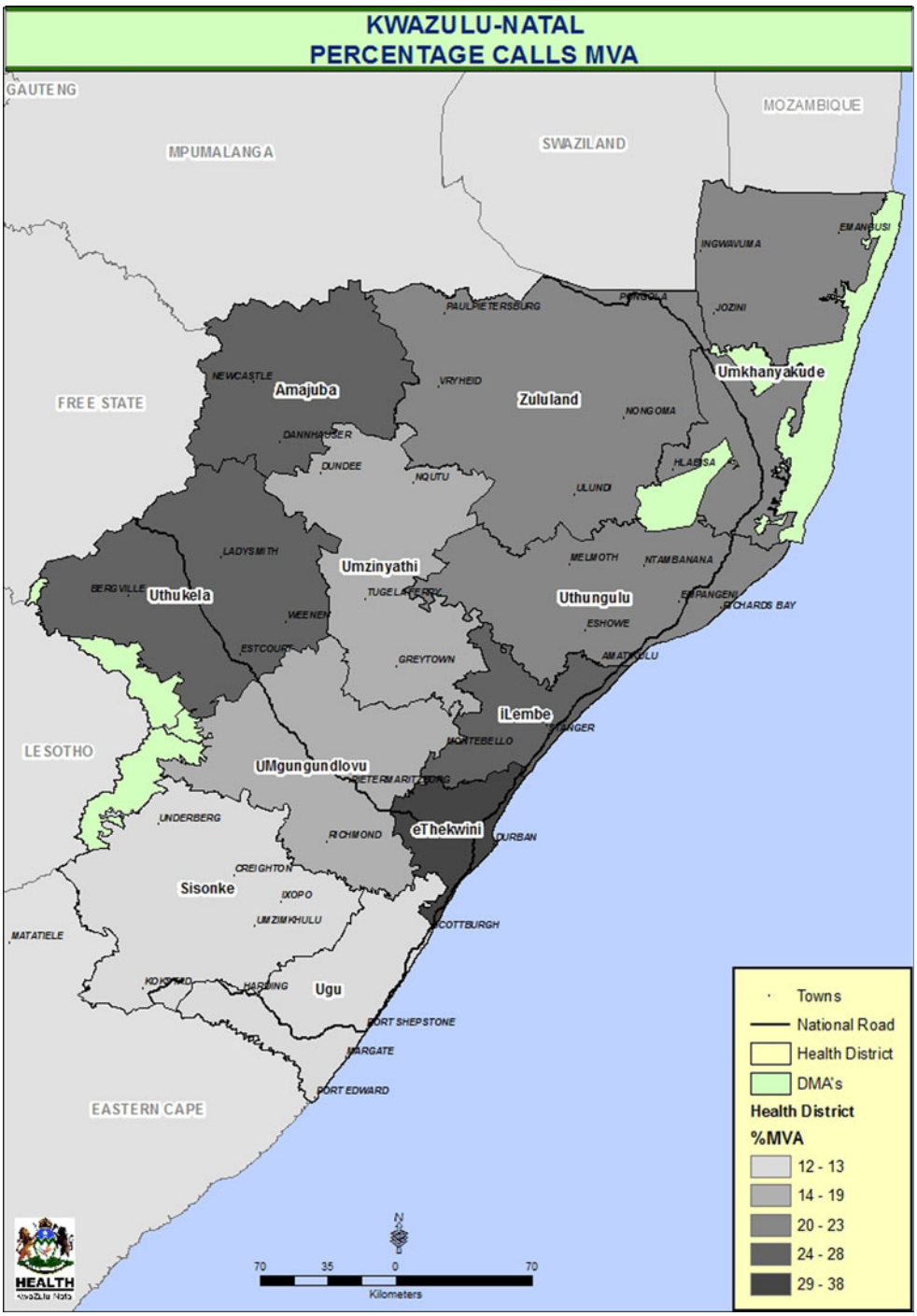

Fig. 6 GIS plot showing the relative distribution of motor vehicular trauma per district, KZN (Color figure online)

mortuaries, as SA law require a medico-legal post-mortem in these cases [13].

As part of the process of gauging the need for a trauma system in the prehospital phase of care, qualitative questionnaires were sent to 29 senior ambulance personnel ("Zonal Officers") across the province, and the following recurring themes were noted: 83 % of respondents had knowledge of the free triage and mass casualty system training in the province and they indicated that over 460 staff had been trained. Despite this, 55 % felt there was no established system to bypass district hospitals effectively when injury severity clinically justifies such bypass. When appropriate, it was often left to the individual advance life support practitioner, incident commander, or hospital medical officer to recommend such bypass maneuvers. In fact, 18 of the officers responded that all patients are initially taken to the closest hospital or clinic, even when this is not the best facility for the patient, as this is what the

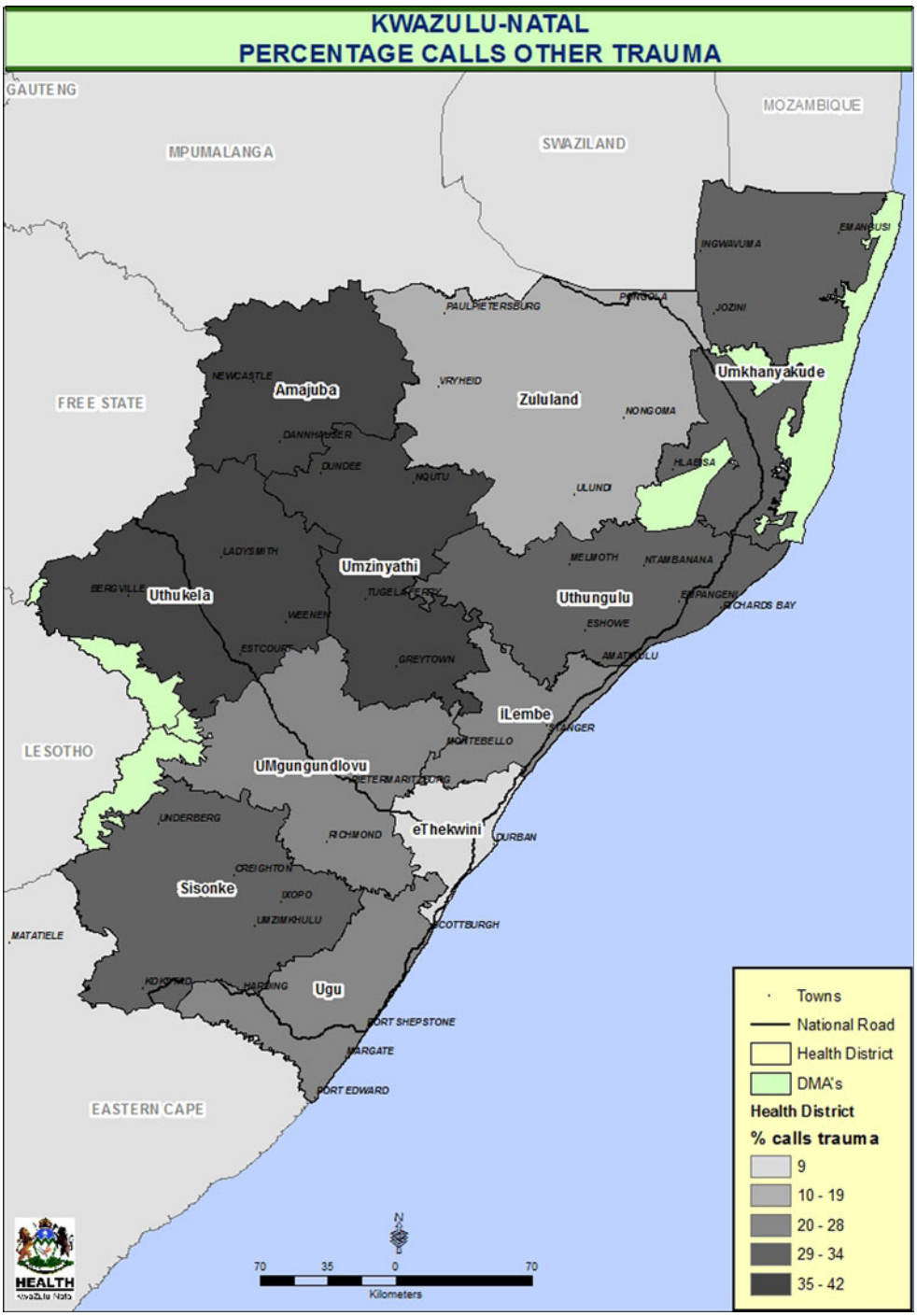

Fig. 7 GIS plot showing the distribution of "other trauma" per district, KZN (Color figure online)

current referral pathway dictated. A further five officers suggested the district hospital is appropriate only for minor and moderate injuries, and that major cases (code red) should be offered bypass to larger regional hospitals. Three officers said they never offer bypass as an option for their patients.

When asked which patients they would bypass, the responses were varied and included the following: 17 suggested only major cases, while one each stated cases of prolonged transfer distance and mass casualty situations, respectively. Four officers suggested bypass for those needing computed tomography (CT), surgery, or orthopedic intervention, as these specialties are available only at regional facilities. Only two respondents suggested that only helicopter cases qualified for service upgrade and bypass.

Finally, the officers were asked to comment on what they felt was necessary to improve the system once implemented. Seventeen suggested upgrading receiving

Table 2 Variance of call type per service and district

District	% Calls motor vehicle accident	% Calls intentional injury/ violence	% Calls other trauma
Ugu 21	12	62	26
UMgungundlovu 22	18	55	27
Uthukela 23	26	32	42
Umzinyathi 24	19	39	42
Amajuba 25	25	34	41
Zululand 26	22	58	19
Umkhanyakude 27	23	43	34
Uthungulu 28	21	46	33
iLembe 29	28	44	28
Sisonke 43	13	56	31
eThekwini Unicity	38	53	9
ER24	71	6	23
Netcare911	64	13	23

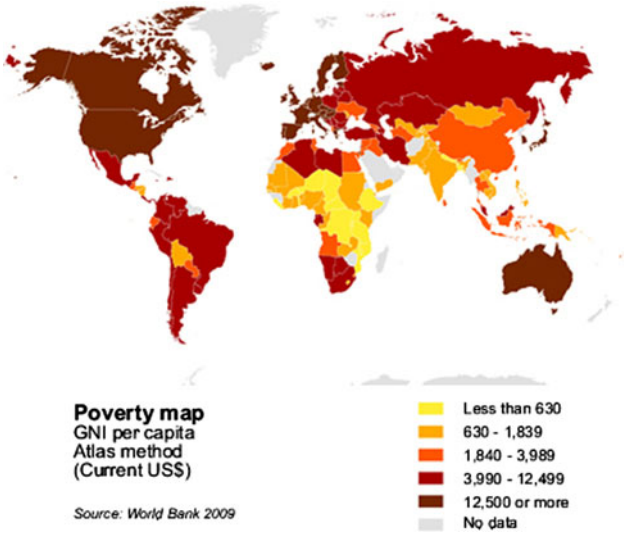

Fig. 8 World map demonstrating the economic levels of African countries (Color figure online)

hospitals at the district level. In particular they mentioned provision of adequate staff, training for the medical and nursing staff in trauma care, improvement of equipment (especially for ventilation), provision of imaging at all hospitals (CT scanner) to reduce transfers, and allowing EMS staff to directly discuss patients with regional center staff if the triage category suggested the need for a higher level of care. They also mentioned predesignation of trauma centers and increased access to aeromedical evacuation as priorities for improving outcome.

Discussion

South Africa is considered by many to be a mixed developed and developing country (Fig. 8 from World Bank data), with parts of the country comparable to well-resourced international cities and other parts comparable to very poorly resourced low to middle income countries. [14] The EMS in South Africa is far more developed and established than in most other parts of Africa, where reliance on passers-by and informally trained first-aiders is the norm and ambulances are few and far between [15, 16].

Trauma, as a relative disease-burden, has been examined both regionally [17] and nationally from various aspects, although the prehospital burden has largely been ignored, with the last large series reported in 1996 [18, 19]. Mostly these studies have focussed on mortality and not the live-patient cohort. Relative to other countries, South Africa has advanced training and fairly modern facilities for prehospital emergency care; however, much of this is located in the urban regions where the effectiveness of ALS has been questioned [20, 21]. Trauma also consumes much more of the health care budget and constitutes relatively more of the emergency workload relative to other developed countries [22]. The additional challenge to the EMS in South Africa is the high level of brain drain among the highest levels of emergency care providers [23, 24].

Despite these advantages and challenges, previous reviews have demonstrated that there is a semi-formal system of care in South Africa, which is split into a private sector and a public sector [12, 25, 26]. There is professional cooperation, with the private sector aiming to capture the insured section of the health care sector comprising <20 % of the population, with some mistrust between the two sectors evident [27]. This is coupled with a referral pathway largely based on a system relevant to primary medical healthcare conditions, such as maternal-child health, infectious or chronic disease. In addition, the system is burdened by numerous mass-casualty events [4, 28–32]. This leads to the inappropriate delivery of severely injured patients to inadequately equipped facilities, which were not designed for trauma care, necessitating subsequent transfer, often with delayed dispatch of ALS prehospital services, which are engaged in treating minor and moderate injury cases [28, 32]. These services are often already overwhelmed, as noted by the fact that only between 30 and 40 % of all emergency patients arrive at hospital in an ambulance [33]. Violence and motor vehicle incidents make up the lion's share of the work, in a similar spectrum to that recorded previously, with no apparent reduction over time [34–36]. In keeping with this study, the previous Durban study showed that only about 15–20 % of cases comprise major trauma [28].

Previous local studies have shown that care at a major trauma center leads to less morbidity, mortality, and missed injury, especially for the more severely injured [37, 38]. Studies from other parts of Africa have demonstrated reduced morbidity and mortality through community participation and basic prehospital system development [39–41]. Similar studies from other parts of Africa have shown that the lack of EMS services lead to higher complication rates, longer prehospital times, and multiple transfers [41–44]. It is interesting to note from the present study that the EMS providers themselves determined this to be a challenge to optimal care and illustrates the blatant link to poorer outcomes. The need for a more formal all-encompassing trauma system is readily apparent. Most of the steps to achieve this will be fairly simple and cost-efficient, such as bypass to appropriate "first contact" facilities and upgrading the lower levels of hospital facility.

As far back as 1998, the Cape Town Summit, endorsed by the Trauma Society of South Africa, called for Emergency Medical Systems that took account of the world's economic constraints and proposed that these require change in the delivery of health care in both the developing and developed world. The proposal they offered was a step-wise evolutionary system adaptable to many different practice environments [45, 46]. South Africa is now fairly advanced on the template proposed at the summit; however, the same is not true of many other African countries. The Cape Town model proposes beginning with self-care and prevention, progressing to access and intervention by trained providers, and completion of care in a properly staffed, equipped, and regionally credentialed hospital, such as facilities that meet the recently proposed local South African standards [46, 47].

To place this in perspective, it is interesting to compare the trauma prehospital event rate of 11.6 per 1,000 population to other local or international data. Regionally, the total ambulance call rate is listed in data on hand as 72/1,000 population, implying that trauma is approximately 15 % of the total ambulance workload in KZN. No other local data have been published looking at the prehospital trauma burden, while the reported hospital burden is around 40 per 1,000 [48]. This total includes all ambulance transports in the public sector, except planned outpatient transports. Comparatively, the rates are far in excess of those reported from developed countries, with Wales reporting a rate of 19 per 100,000 and Norway 30 per 100,000, while other developing countries also report much lower rates, with Pakistan varying between 9 and 23 per 100,000, depending on the underlying injury mechanism [49–52]. This begs the question of what prehospital trauma system will work in under-resourced countries. The World Health Organisation document for essential prehospital care suggests that the components of an efficient prehospital care system must include, at a minimum, prompt communication and activation of the system, the prompt response of the system, and the assessment, treatment, and transport of injured people to formal health-care facilities, regardless of whether they are urban or rural. This system may be constituted of one or more tiers of care, but it must have a lead organisation, appropriate cost-effective staffing of at least the basic level of EMS response, and disaster planning. Funding options and the need for political and legislative considerations are highlighted, similar to points highlighted recently in a South African publication. Additionally, the WHO and TSSA documents suggest that there is a need for medical oversight of the EMS service, regular audits, and quality assurance [22, 47, 53].

In the context of the present study, the system must optimize the number of ambulances per geographical region, determine and appropriately equip predetermined receiving facilities, and establish the option of bypassing limited resourced facilities. Putting more advanced emergency care practitioners in the rural areas would potentially reduce prehospital mortality. Additionally, the WHO document highlights the need for bypass to allow prehospital providers to take patients to the appropriate level of care [53].

Can this be done cost effectively in Africa? Recent studies have shown that trauma systems are cost-effective; however, these studies also show that it takes about 10 years to realize the cost benefits [54]. To ensure success in constructing more efficient systems, health departments need to demonstrate courage in putting the structure and processes in place, knowing that the ends must justify the means in Africa. The data presented in this study also show the need to redesign the system in South Africa to make it more inclusive and cost effective, with bypass as a simple initial stage in this process.

A logical system must include a single national number, with universal access from mobile and landline telephony, integration of private and public service providers into a coordinated control structure to ensure efficient resource utilization, using regionalized control centers with rapid access to other emergency services. Using the TSSA guidelines and the WHO Trauma System Evaluation tool will enable South Africa to reach at least a level 3 rating and aspire to level 4 [6, 47]. Predesignation of trauma facilities, both private and public, will ensure that patients reach the closest appropriate care facility rapidly. The funding for all emergency cases, especially trauma, should be from the central government, with universal payment to prevent a dichotomy of service provision, such as the planned National Health Insurance scheme proposed recently by the South African health ministry [22, 47, 48, 55].

The present study has some limitations, including the fact that it was undertaken in a single province in one of the more developed countries in Africa. Thus the generalizability of the results may not be high, although trauma is recognized across the continent as a major challenge. Additional limitations include reliance on recorded data interpreted secondhand from call-center records, which may lead to the possibility of underreporting of the trauma burden. In fact, approximately 5 % of all potential calls were excluded by the researchers due to lack of clarity of the underlying cause. It was known to the researchers that two of the districts provided incomplete data, thus the total trauma burden is at best an estimate of the minimum burden. This may have led to an underestimation of up to 5 % of the true trauma burden. Third, this study only included data from the two large nationally functioning private ambulance services, while there are numerous small private services in the province, probably providing care to as much as an additional 2 % of cases. Thus the true underestimate may be as high as 7 %, meaning that there would most likely be closer to 110,000 trauma calls to EMS per annum. In addition, it has been noted that a significant proportion of trauma cases present to definitive care via their own transport [34, 35, 56].

Conclusions

The burden of prehospital trauma in South Africa is significant and higher than in most developed countries; at about 18 % of the overall emergency burden of disease, however, this consumes vital resources and reduces the availability of ambulances, already at a premium, for other non-trauma emergency cases. The optimal system will deliver the patient with appropriate severity to the correct level of care, but will bypass non-doctor primary care services and inappropriately resourced district services for moderate and major severity cases. A system must be inclusive and incorporate all services from EMS to rehabilitation, rather than focusing on one or two super-specialized major trauma centers, which should be maintained as a regional lead resource.

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