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A Bayesian analysis of the impact of post-crash care on road mortality in Sub-Saharan African countries

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ABSTRACT

Sub-Saharan Africa is undergoing a disproportionate road tragedy compared to its motorization rate and road network density. Most of the road traffic deaths occur in the pre-hospital phase. Yet, more than half of the African countries do not possess formal pre-hospital care system. This study assesses the potential impact of post-crash care on road mortality in 23 Sub-Saharan African countries. A panel Bayesian normal linear regression with normally distributed non-informative priors is used to fit the data set covering the time period 2001–2010. The post-crash care system is proxied by the estimated share of seriously injured transported by ambulance, and three binary variables indicating the existence of emergency access telephone services and emergency training for doctors and nurses. The findings suggest a negative correlation between the road mortality rate and the estimated share of seriously injured transported by ambulance, the emergency access telephone services and the emergency training for doctors. A positive relation is unexpectedly observed for the emergency training for nurses. Other regressors such as the Gross Domestic Product per capita and populations in the age range 15–64 years are related to higher fatality rates while the length of the road network and life expectancy are linked to decreasing fatality rates.

1. Introduction

Road accidents are a concerning issue in Africa. The continent faces a disproportionate road tragedy compared to its motorization rate and road network density [1–3]. Every day, tens of thousands of injuries and deaths occur on African roads putting a huge financial and economic burden on populations. More than 75% of the victims are in the productive age range of 16–65 years and the vulnerable road users account for over 65% of the deaths [4]. Unless suitable actions are undertaken, road traffic injuries are predicted to be ranked as the fifth cause of mortality in Africa by the year 2030 [1].

Post-crash care must be a critical component of the actions to undertake because most of the road traffic deaths in Africa occur in the pre-hospital phase [5]. However, more than half of the African countries do not possess formal pre-hospital care system [1] and they transport less than 10% of the injured in ambulances [6]. Although the primary objective is to prevent the occurrence of road traffic accidents, more can be done to curb crash-related injuries. The availability of a suitable post-crash emergency care system is a key to achieving this decrease [2,7–10]. Post-crash emergency care encompasses emergency rescue, pre-hospital medical care and victims' immediate transportation following road crashes [11,12]. Bishai et al. [13] associated the decline in traffic deaths in the developed countries to the post-injury ambulance transport and medical care. The probability of dying in motor-vehicle accidents was 10% lower in American States having organized trauma systems compared to their counterparts which did not possess such systems [14]. Van Beeck et al. [15] cited the amelioration of trauma care among the explaining factors of the decline in road mortality in some 21 industrialized countries from 1962 to 1990. Bjornstig [16] estimated a decrease of almost 20% in the Swedish traffic fatality rate among accidents victims who were not instantly killed. The author attributed this decline to the ameliorations in post-crash care.

Yet, many of the African countries are inadequately prepared in terms of emergency medicine to succor road accidents survivors [6]. Limitations appear at all the levels of the rescue chain [1,6]. Most often, crash victims wait for hours before receiving appropriate assistance because of the shortage in the number of ambulances and qualified staff, the poor communication between trauma centers and the police as well as the congestion that delays emergency cars. As a result, needless deaths occur [3].

In spite of this critical situation, road fatalities have not been appropriately considered in the design of health and development agendas in

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low and middle-income countries [2]. Consequently, rigorous empirical investigations about the effects of post-crash emergency services on road crash mortality are necessary to persuade decision-makers about the benefits of these services. To the authors' knowledge these kinds of investigations are missing in Sub-Saharan Africa (SSA). Therefore, this study is designed to examine the impact of post-crash care policies on road accidents mortality rate in this part of the African continent.

In what follows, Section 2 summarizes previous studies related to road post-crash measures and their effectiveness. The data and the estimation technique are respectively described in Sections 3 and 4. The results are presented and discussed in Section 5 while Section 6 provides the conclusions and recommendations.

2. Literature review

The prompt response of the emergency staff to crashes occurrence is an essential element to saving lives [10,17]. Accordingly, most of the studies dealing with emergency and trauma care focused either on crash notification time or on the emergency medical services (EMS) response time.

Li et al. [18] suggested the implementation of an automatic crash notification (ACN) system in Taiwan given the high rate of pre-hospital deaths especially in rural areas where victims are transported over long distances to care centers. Using Finnish data over the period 2001–2003, Virtanen et al. [19] revealed the ability of the ACN system to annually preclude between 5 and 10% of the fatalities. Using simulations, Taute [20] reported a decrease of 32% and 42% in the EMS response time respectively in the city and outskirts of Pretoria, South Africa, if an ACN policy is implemented in the entire city. Based on a data set of 1997, Clark and Cushing [21] reported an annual decline from 1.5% to 6% in traffic mortality in the United States due to the implementation of an ACN system. Lahausse et al. [22] found that the Australian road mortality would annually decrease by 10.8% were all vehicles equipped with the ACN system.

Noland [23] assessed road crash fatalities in some OECD countries over the period 1970–1996. The evaluation revealed a reduction of fatalities in the range of 5 to 25% as a result of the progress in medical care and technology such as the EMS. Likewise, Gonzalez et al. [24] used a 2-year, data set for the entire State of Alabama in the United States. They found that a prompt reaction of the EMS after motor vehicles crash notifications was highly associated with mortality reduction, especially in rural areas which previously witnessed greater traffic fatalities. In a similar study from the State of Utah, Wilde [25] evaluated the EMS response time on mortality of all patients including road crash victims. The analysis concluded that an additional minute in the reaction time triggered an increase of the mortality in the range of 8 to 17%. Sánchez-Mangas et al. [26] used a probit model to study the link between the probability of dying from road traffic accidents and the EMS response time in Spain. The study considered 1400 accidents in May 2004. It showed that a decrease by 10 min in the response time induced a reduction of 33% and 32% respectively in motorway and conventional road accidents deaths. Arroyo et al. [27] conducted a similar study in Spain with a data set of May 2004. Using a Bayesian probit and logit, they found that a decrease by 5 min in the response time lowered the probability of dying by 24% and 30% respectively for roads and motorways accidents.

In a nutshell, previous studies reported that post-crash care is an effective tool to curb traffic-related death toll.

3. Data description

The road safety data in the African Region are still of poor quality [1,6,8,28]. As a result, 23 SSA countries, as shown in Table 1, are considered in the study because the remaining ones do not provide measurements for as many variables and years as these 23.

Table 1
List of the 23 countries included in the study.

Countries
Benin
Botswana
Cameroon
Cape Verde
Côte d'Ivoire
Democratic Republic of Congo
Ethiopia
The Gambia
Ghana
Kenya
Lesotho
Mauritania
Mozambique
Namibia
Niger
Nigeria
Rwanda
Sao Tome and Principe
Senegal
South Africa
Sudan
Swaziland
Tanzania

The sample includes Ethiopia, Nigeria, South Africa, and Sudan which together account for half of the road injury death toll in SSA [28]. The data set covers the time period 2001–2010. Table 2 provides detailed descriptions of the variables used in the analysis. The variables of interest, the emergency-related variables, as identified by the World Health Organization [2] are the estimated share of seriously injured carried by ambulance and three indicator variables (emergency phones, emergency doctors and emergency nurses). All these variables are expected to be linked to lower mortality rates.

Based on the data availability, other variables deemed to have an impact on traffic-related fatalities and injuries are included in the analysis. The Gross Domestic Product per capita (GDPPC), population-related variables and the life expectancy have been collected from the World Development Indicators database of the World Bank while the length of the road network is from the African development Indicators 2010 of the World Bank [29]. Nevertheless, the length of road network is invariant in each country over the study period because it is not consistently collected due to situations such as conflicts. It should consequently be considered as indicating trends [29]. The remaining variables are obtained from the Global status report on road safety of the World Health Organization [2]. The dependent variable is the road mortality rate (ROADM) which is defined in the study as the number of deaths per 100,000 population. Different definitions of the concept of mortality rate are used by countries ranging from “died on the scene” to “unlimited” [2]. Therefore, data about the fatalities are adjusted to 30 days in order to mitigate the effects of these differences and compensate for underreporting in some countries [2].

The data were scrutinized through an ordinary least squares regression to detect outliers. The detected outliers were found to have no impact on the estimation results. The correlation between the variables was also inspected through the correlation matrix shown in Table 3.

ROADM is highly correlated with GDPPC and POP64. The two latter variables also show high correlation. These high correlations are likely to cause multicollinearity which may misrepresent the statistical significance of the estimates. However, the analysis revealed no multicollinearity as attested in Table 4 by the highest value of the variance inflator factor (VIF) which is 3.96; a highest VIF less than 10 suggesting the absence of multicollinearity [30].

Three of the four variables of interest are binary variables which could have been continuous if data were available. When data are limited, it is appropriate to use a modeling technique that incorporates prior