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The impact of alcohol and road traffic policies on crash rates in Botswana, 2004–2011: A time-series analysis☆

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ABSTRACT

In Botswana, increased development and motorization have brought increased road traffic-related death rates. Between 1981 and 2001, the road traffic-related death rate in Botswana more than tripled. The country has taken several steps over the last several years to address the growing burden of road traffic crashes and particularly to address the burden of alcohol-related crashes. This study examines the impact of the implementation of alcohol and road safety-related policies on crash rates, including overall crash rates, fatal crash rates, and single-vehicle nighttime fatal (SVNF) crash rates, in Botswana from 2004 to 2011. The overall crash rate declined significantly in June 2009 and June 2010, such that the overall crash rate from June 2010 to December 2011 was 22% lower than the overall crash rate from January 2004 to May 2009. Additionally, there were significant declines in average fatal crash and SVNF crash rates in early 2010. Botswana's recent crash rate reductions occurred during a time when aggressive policies and other activities (e.g., education, enforcement) were implemented to reduce alcohol consumption and improve road safety. While it is unclear which of the policies or activities contributed to these declines and to what extent, these reductions are likely the result of several, combined efforts.

1. Introduction

More than 1.24 million people are killed on the world's roads each year with low and middle-income countries (LMICs) bearing a disproportionate burden (WHO, 2013). While 94% of road traffic-related deaths occur in LMICs, these countries represent 84% of the world's population and have just over half of the world's registered vehicles (WHO, 2013). The disproportionate road traffic injury burden of LMICs is further evident in regional death rates. The average road traffic-related death rate among the World Health Organization's (WHO) African Region is 24.1 deaths per 100,000 population, compared to 10.3 deaths per 100,000 population for countries in the WHO's European Region (WHO, 2013). Increased death rates in LMICs are driven, at least in part, by rapid motorization with a lack of concomitant road safety strategy implementation and safe road infrastructure development (Borowy, 2013; WHO, 2013). In Botswana, the situation is similar.

Botswana is a middle income country with approximately 2 million people (WHO, 2013). Between 1981 and 2001, the road traffic-related death rate in Botswana more than tripled from 9.9 to 32.4 deaths per 100,000 population (Botswana Police Service, 2013). The majority of road traffic deaths (55%) are occupants of 4-wheeled cars and light trucks (WHO, 2013). Over the last several years, the Government of Botswana has taken several steps to address both the overall growing burden of road traffic crashes and more specifically the problem of alcohol-related crashes, as part of a larger national effort to reduce alcohol use and abuse.

In October 2008, the Levy on Alcohol Beverages Fund Order was passed in Botswana, creating a 30% levy on alcohol products (Pitso

☆ *Disclaimer: The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.*

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and Obot, 2011). The purpose of the levy was to reduce alcohol consumption and related harms, including alcohol-impaired driving. Funds from the levy were designated to support programs targeting alcohol abuse and related harms. Two years later, in November 2010, the alcohol levy was further increased to 40% under the Levy on Alcohol Beverages Fund (Amendment) Order, 2010. The Amendment again called for funds raised by the levy to be used to prevent and reduce alcohol-related harms, including supporting police efforts to curb alcohol-impaired driving.

Legislation specifically aimed at improving overall road safety was also adopted during this time period. In April 2009, the Road Traffic Act of 2008 went into effect, increasing penalties and fines for several road traffic offenses, including driving without a license, speeding, alcohol-impaired driving, and failure to obey traffic signs and signals, among others. Under this new law, fines increased, nearly doubling for some offenses. For example, the fine for alcohol-impaired driving increased from 1000 to 3000 Botswana pula (bwp) (or about $115–350 USD) or imprisonment of 1.5–2 years to 2000–5000 bwp (or about $250–620 USD) or imprisonment of 2–5 years.

Findings from studies examining the effects of similar alcohol and road traffic policies on road traffic-related injuries and deaths have been mixed. Studies examining the effects of increased alcohol taxes have generally found reductions in fatal and alcohol-impaired road traffic crash rates (Chaloupka et al., 2002; Elder et al., 2010; Wagenaar et al., 2010). However, research on the effects of increased traffic offense penalties and fines has been inconsistent. Some studies indicate that certain penalties and fines may change behavior and reduce crash-related injuries and deaths, while other studies have shown no effect (Bjornskau and Elvik, 1992; Elvik and Christensen, 2007; Novoa et al., 2011; Wagenaar et al., 2007; Zambon et al., 2007). Furthermore, most of the research examining the effects of alcohol and road traffic policy implementation on crashes and injuries comes from high-income nations, and to our knowledge, there is no published research from sub-Saharan Africa on this subject. The purpose of the present study was to examine the impact of the implementation of these policies on road traffic crash rates, including overall crash rates, fatal crash rates, and single-vehicle nighttime fatal (SVNF) crash rates (a commonly used surrogate for alcohol-impaired crash rates), in Botswana from 2004 to 2011.

2. Methods

2.1. Data sources

Road traffic crash data from January 2004 through December 2011 were obtained from Botswana's Police Service, Traffic Branch Database. The Traffic Branch Database contains data on road traffic crashes that occur on public roadways in Botswana. Crash reports are filed by police in every jurisdiction and centrally compiled at the Police Traffic Branch Headquarters in the capital, Gaborone. A crash is defined as any collision between one or more vehicles (i.e., any structure which is designed to be propelled or drawn on land) and includes single or multiple vehicle collisions of passenger vehicles (e.g., personal car, van, or light truck), motorcycles, or commercial vehicles, as well as crashes between a vehicle and a bicycle or pedestrian.

To observe whether the implementation of alcohol levies and increased traffic offense penalties and fines had an impact on different types and severities of crashes, we conducted an interrupted time-series analysis of monthly crash rates for all crashes, fatal crashes, and SVNF crashes. Because it can be difficult to obtain blood alcohol concentration (BAC) readings from drivers involved in crashes in most countries, including Botswana, proxy variables for alcohol-impaired crashes are frequently used (Shults et al., 2001). Commonly used proxy variables include both fatal crashes and SVNF crashes, among others (Shults et al., 2001).

As the number of crashes was expected to increase during this time period, in part because of increased ownership and use of motor vehicles, rates were calculated using a denominator that attempted to capture this increased road use. Rates calculated as crashes per vehicle miles traveled (VMT) are frequently used in traffic safety studies. However, reliable VMT estimates are not currently available for Botswana. As a surrogate for VMT, we used fuel volume sales for the rate denominator, which has been used in numerous other international traffic studies (Novoa et al., 2011; Sukhai et al., 2011; Zambon et al., 2007).

We obtained fuel volume sales data from the Botswana Department of Energy (DoE) and from the Motor Vehicle Accident Fund (MVAF). The DoE and the MVAF data both included tabulations of fuel volume sales but each data source captured sales for different reporting intervals during different time frames. Fuel volume sales data from the DoE were available for the entire time period (i.e., January 2004 through December 2011) but volume was tabulated on an annual basis. Fuel volume sales data from the MVAF were tabulated on a monthly basis but were only available for January 2008 through December 2010. To obtain monthly estimates for the entire time period, monthly fuel volume sales were interpolated from the DoE data using the Expand procedure in SAS (v9.2, SAS Institute Inc., Cary, NC). This procedure fits cubic spline curves to the annual estimates and then generates monthly values from the spline approximations. These monthly estimates were used for the periods of January 2004 through December 2007 and for January 2011 through December 2011. MVAF fuel volume sales data were used for the period of January 2008 through December 2010.

2.2. Statistical analysis

Crash rates were calculated by dividing the number of monthly crashes by the monthly fuel volume sales. Overall crash, fatal crash, and SVNF crash rates were calculated as crashes per 10 million liters (ML) of fuel volume sales.

We used interrupted time-series analyses to determine whether and when changes in crash rates occurred. To examine potential changes in crash rates, each of the three time series were first evaluated for autocorrelation using the ARIMA procedure in SAS (v9.2, SAS Institute Inc., Cary, NC). Autocorrelation was present only in the overall crash time series, so we examined this series using Box–Jenkins time series intervention analysis (Bowerman et al., 2005; Box and Tiao, 1975). Since there was no autocorrelation present in the fatal and SVNF crash time series, Poisson regression was used to model the rates.

The Box–Jenkins intervention analysis was conducted as part of an exploratory approach to deduce from the data whether and when reductions in overall crash rates occurred (Helfenstein, 1990). A two-stage process was used to conduct the time series intervention analysis. We first determined a Box–Jenkins model describing the monthly crash rates from January 2004 through October 2008 (i.e., the months preceding policy implementation). Using the sample autocorrelation function and the sample partial autocorrelation function, we identified this stationary portion of the time series as a non-seasonal autoregressive model of order 1 (AR(1)). Because of heterogeneity of variance in the series, we modeled the natural log of the rates instead of the rates. A constant term was included in the model since the mean of the series was nonzero. Overall fit of the model and model diagnostics were assessed by examining the model standard error, Ljung–Box statistic, autocorrelation plots of the residuals, and by conducting outlier analysis. Calendar effects (i.e., variation in rates from differing numbers of higher crash days in a month, such as Fridays, Saturday, and holidays) were not