



# Impact of child restraint policies on child occupant fatalities and injuries in Chile and its regions: An interrupted time-series study

José Ignacio Nazif-Muñoz<sup>a,\*</sup>, Arijit Nandi<sup>a</sup>, Mónica Ruiz-Casares<sup>b</sup>

<sup>a</sup> Institute for Health and Social Policy and Department of Epidemiology, Biostatistics, and Occupational Health, McGill University, Montreal, Quebec, Canada

<sup>b</sup> Department of Psychiatry, McGill University, Montreal, Quebec, Canada

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## ABSTRACT

**Objectives:** We assessed the effectiveness of the child restraint legislation (CRL) introduced in Chile in December 2005 and the National Decree enacted in February 2007, which regulated the technical characteristics of child restraint devices with the goal of reducing child occupant fatalities and severe injuries nationally and within Chile's regions.

**Methods:** An interrupted time-series design was used to measure the effect of CRL and the National Decree on two dependent variables—number of child occupant deaths in traffic collisions and number of child occupants severely injured in traffic collisions per vehicle fleet from 2002 to 2014 (police data). Our analyses compared the incidence of these outcomes in the post-intervention period (2006 to 2014) with the period prior to these interventions (2002–2005) nationally and by region, controlling for several confounders.

**Results:** Nationally, the child restraint policies were associated with a 39.3% (95% CI: 4.7; 73.9) reduction in child occupant fatalities, but no significant decrease was observed in child severe injuries. These interventions were associated with a 75.3% (95% CI: 15.6; 135.1) reduction in the rate of child occupant fatalities in the southern regions, and a 32.9% (95% CI: 1.1; 67.0) reduction in the rate of children severely injured in the northern regions.

**Conclusion:** In the short term, the CRL and the National Decree were associated with fewer child occupant fatalities, at the national level and in the southern regions, and severely injured child occupants in traffic collisions in Chile's northern regions. These results demonstrate a limited temporal and territorial impact. This suggests that to effectively protect vulnerable populations across all territories, efforts should be expanded more consistently and sustained over time.

## 1. Introduction

Traffic injuries cause considerable mortality and morbidity worldwide (Peden et al., 2004; Hyder et al., 2016). Furthermore, road traffic deaths are one of the leading causes of death among young people. In 2010, crashes resulted in more than 260 000 deaths in children and youth aged 0–19 years, with 93% of these deaths occurring in low- and middle-income countries. Globally, road traffic crashes are the fifteenth, third and first leading cause of death in children between ages 1 and 4 years, 5 and 9 years, and 10 and 19 years old, respectively (Kyu et al., 2016).

Since 1975, the year in which Belgium, Denmark first implemented child restraint legislation, (CRL), more than countries have introduced this type of legal instrument (Nazif-Munoz, 2015). Restraints in cars are intended to keep the child in her/his place on the seat so that in the

event of sudden braking or a crash the child is not thrown against the interior or out of the car. As, such, CRL is designed to reduce children's fatalities, injuries by assuring that children are properly secured in vehicles.

Studies that have assessed the impact of this type of legislation have been carried out in high-income countries, including Japan (Desapriya et al., 2004), the USA (Guerin and MacKinnon, 1985; Wagenaar, 1985; Wagenaar et al., 1987; Evans and Graham, 1990; Zaza et al., 2001; Ebel et al., 2003; Rock, 1993; Farmer et al., 2009; Wagenaar et al., 2010; Eichelberger et al., 2012), Canada (Brubacher et al., 2016) and Norway (Elvik et al., 2009). This research suggested that child restraint laws could reduce occupant child fatalities by up to 34% and occupant child injuries by 15%.

CRL evaluations have also been carried out in Chile (Nazif-Munoz et al., 2017b; Nazif-Munoz et al., 2017a). Nazif-Munoz et al. (2016,

\* Corresponding author at: 1130Pin, Avenue West, Montreal, Quebec, H3A 1A3, Canada.

E-mail addresses: [jose.nazifmunoz@mail.mcgill.ca](mailto:jose.nazifmunoz@mail.mcgill.ca) (J. Ignacio Nazif-Muñoz), [monica.ruizcasares@mcgill.ca](mailto:monica.ruizcasares@mcgill.ca) (M. Ruiz-Casares).

2017b) analyzed the impact of CRL on rates of fatalities and injuries, with results suggesting that the policy had a short-term impact in reducing by 11–24% child injuries and no effect on child fatalities. The studies carried out in Chile, however, had three important limitations. First, to be adequately powered to detect impacts of road safety policies longer pre- and post-intervention periods are necessary (McLeod and Vingilis, 2008). However, analyzing monthly rates rather than annual rates as previously done would help achieve the necessary power to detect policy effects. Second, they assumed that CRL had a homogenous effect throughout the country, that is, differences across regions were not considered. However, Chile's regional dynamics need to be accounted for, since the wealthiest regions are more likely to benefit from policy design and implementation processes (Boisier, 2000; Zegras and Gakenheimer, 2000; Atkinson et al., 2008; Botero-Ospina and Orozco, 2010), especially those associated with the health sector. Hence important differences in health outcomes are likely to be expected. Traffic fatality rates have declined in the Metropolitan Region relative to its Northern and Southern counterparts between 2002 and 2012 (Otzen et al., 2016). However, whether this trend is explained by the heterogeneous impact of child traffic safety policies enacted during this period is unclear.

Third, CRL evaluations from Chile have analyzed the effect of this legal instrument by considering one point of intervention. More specifically, prior research treated December 2005, the date in which the CRL was enacted, as the time when the policy could have had an effect on reducing child mortality and injury rates. However, in February 2007, a National Decree, which regulated the technical characteristics of child restraint devices to be installed in the motor vehicles, also took effect. This aspect of the policy may have delayed the full implementation and impact of CRL in Chile since it was only after this date that individuals could buy devices that followed one unique national certification criterion rather than following safety recommendations which were heterogeneous. The policy evaluation literature (Wagner et al., 2002) suggests that to have an accurate understanding of the impact of policy reforms we must account for whether policies were composed of more than one intervention, and/or whether they may take time to manifest. Therefore, the delayed rollout of CRL in Chile due to the introduction of the National Decree constitutes an aspect of the policy that needs to be included for a more accurate account of Chile's efforts to decrease traffic injuries and fatalities among children. It is noteworthy that in Chile, child restraint use rates have fluctuated before and after the implementation of its CRL. In 2005, child restraint usage rate stood at 5% (ECLAC, 2006), usage rose to 44% in 2008 (CONASET, 2008b), and sharply declined to 24% by 2012 (CONASET, 2013).

Building on prior work evaluating the impact of CRL in Chile, this study estimates the effect of these two CRL interventions on child traffic injuries and fatalities within and across Chile's regions between 2002 and 2014.

## 2. Methods

### 2.1. Study design

We evaluated the impact of this policy reform in Chile using an interrupted time-series design (i.e., a time-series analysis in which the series is divided—or interrupted—by the introduction of the National Decree into two periods, pre-intervention and post-intervention, which are compared) (Linden, 2015, 2016; Quddus, 2008). Two study populations targeted by the policy reform were considered: (1) child occupants aged 0–3 who died in vehicle collisions in Chile between January 2002 and December 2014 and (2) child occupants aged 0–3 who were severely injured in vehicle collisions for the same period. Our analytic sample included all occupant fatalities and severe injuries among children age 3 years and under, since children of this age group were required to be transported in restraints in motor vehicles.

### 2.2. Data

Data were obtained from the Road Traffic Crashes Database of the *Comisión Nacional de Seguridad de Tránsito (CONASET) (National Commission of Road Safety, 2008a)*. This organization has used Chile's police force (*Carabineros de Chile*) reports to compile an extensive database of traffic fatalities, injuries, and crashes in Chile from 1972 to the present. Fatalities are classified according to road user type (driver, passenger, motorcyclist, bicyclist, and pedestrian), age, gender, and time and day of the crash. This database includes information from all injury collisions about the characteristics of the collision, the vehicle, and the individuals involved. In Chile, this information is collected by its national police force and sent to the National Commission of Road Safety.

### 2.3. Dependent variables

The dependent variables were the number of child passengers who died or were severely injured in traffic collisions. Following the definition in the Chilean Penal Code, police officers classify injuries as either severe (“injury which prevents the person from performing acts, which constitute such person's usual and customary daily activities, at least 30 days or more immediately following the occurrence of the injury”), less severe (“injury which prevents the individual from returning to previous activities up until 30 days immediately following the occurrence of the injury”) or minor (“injury which does not require immediate medical attention”). These definitions were stable throughout the period of this study. We calculated the rates for each variable, specifically child fatalities and severe injuries per 1,000,000 vehicle fleet. The denominator, vehicle fleet, was chosen over the population per capita because it has been argued to better capture the level of traffic risk (Elvik et al., 2009). Furthermore, in Chile, the number of vehicles is collected yearly and regionally, whereas information regarding the population is based on projections from decennial censuses held in 1992, 2002, and 2012 (Bianchini et al., 2013; Institute for Health Metrics and Evaluation, 2014). The vehicle fleet is thus a more sensitive indicator to current national variations. In sensitivity analyses we analyzed both outcomes with child population as the denominator and results were similar when compared to vehicle fleet (see results in Nazif-Munoz et al. (2018)).

### 2.4. Independent variables

The independent variables of interest measured the introduction of the CRL and the National Decree. The first independent variable, “National Decree,” is a dichotomous variable and refers to the enactment of the National Decree, which regulated the technical specificities of child restraints. After the enactment of this instrument police officers could legally issue traffic tickets to drivers who were not transporting children of 3 years and younger in restraints. Units in the pre-intervention period are coded 0 (January 2002–January 2007) while those in the post-intervention period are coded 1 (February 2007–December 2014). This variable allows us to estimate whether changes in the series were abrupt or not. We also included a continuous variable to count the number of months after the National Decree at time  $t$ , coded 0 before the program and (Time-156) after introduction of the National Decree, represented by the cross product “Time x National Decree”. This variable estimates changes in the slope of the series after the introduction of the National Decree. The following functions were considered for “Time x National Decree” (Elvik, 2011).

- 1 Linear ( $Y = b_0 + b_1 \cdot t$ )
- 2 Logarithmic ( $Y = b_0 + b_1 \cdot \ln(t)$ )
- 3 Quadratic ( $Y = b_0 + b_1 \cdot t + b_2 \cdot t^2$ )

These functions allow us to assess different types of potential effects

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