



# Full moon and traffic accident-related emergency ambulance transport: A nationwide case-crossover study



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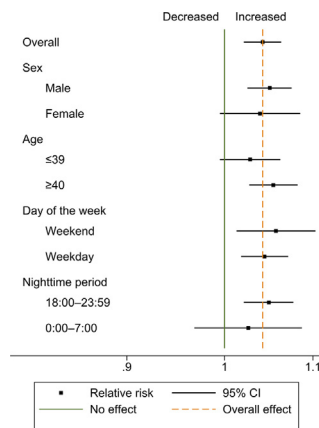
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## HIGHLIGHTS

- We estimated the association between full moon and emergency ambulance transport.
- Full moon was associated with an increase in transport due to road crashes.
- Full moon should be taken into account to decrease transport due to road accidents.

## GRAPHICAL ABSTRACT



## ARTICLE INFO

### Article history:

Received 9 May 2018

Received in revised form 4 July 2018

Accepted 4 July 2018

Available online xxxx

Editor: SCOTT SHERIDAN

### Keywords:

Full moon

Emergency ambulance transport

Epidemiology

Traffic accident

Statistical analysis

## ABSTRACT

**Background:** Several studies have examined the association between environmental factors and traffic accidents. However, the role of a full moon in triggering emergency ambulance transport due to road traffic casualties is unclear. Thus, we aimed to examine whether a full moon contributes to the incidence of emergency transport due to road traffic crashes.

**Methods:** We acquired nationwide data on daily emergency transport due to road traffic crashes from all 47 prefectures of Japan from 2010 to 2014. We conducted a time-stratified case-crossover study using conditional Poisson regression to examine the relationship between the occurrence of a full moon and emergency transport due to road traffic crashes for each prefecture. Prefecture-level results were combined using a random-effects meta-analysis to evaluate nation-level estimates.

**Results:** There were 842,554 cases of emergency transport due to road traffic crashes across 1826 nights (62 full moon nights:  $n = 29,584$ ; 1764 control nights:  $n = 812,970$ ). On days with a full moon, the pooled adjusted relative risk (RR) of emergency transport due to traffic accidents was 1.042 (95% confidence interval [CI], 1.021–1.063). Overall, 4.03% (95% CI: 2.06–5.93) of the cases (1192 cases) were attributable to full moon nights. Stratified analyses revealed a significant increase in emergency transport due to traffic accidents on full moon nights for males, people aged  $\geq 40$  years, and before midnight.

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**Conclusions:** Full moon nights are associated with an increase in the incidence of emergency transport due to road traffic crashes. These results indicate that public health strategies should account for full moon nights to decrease emergency transport due to traffic accidents.

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## 1. Introduction

Road traffic injuries have a huge impact on health, resulting in >1.2 million fatalities worldwide every year (Peden et al., 2013; WHO, 2015). Road crashes are the primary cause of death in those aged 15 to 29 years, and road traffic crashes make up 3% of a nation's gross domestic product (WHO, 2015). Although the human, social and economic cost of traffic accidents is largely preventable, there has been insufficient action to combat this global challenge. Road safety has become the focus of increasing global interest, as evidenced by its inclusion in the 2030 Agenda for Sustainable Development Goals (SDGs). In the SDGs, the United Nations established a target to reduce global road fatalities and serious injuries by 50%, compared to 2010 levels, by 2020 (WHO, 2015). Therefore, there is increasing acknowledgement of the involvement of road safety in health, development and broader environmental objectives, which is expected to improve opportunities for action.

A full moon occurs every 29.53 days, or 12.37 times per year (Taylor, 2016). A full moon can draw a person's attention, and looking at a full moon can divert attention away from activities critical for safe driving (Klauer et al., 2014; Redelmeier and Shafir, 2017; Sarton, 1939). A full moon may additionally cause changes in traffic behaviors, including distracting drivers or pedestrians such that they do not notice oncoming motor vehicles (Smith, 2016), and therefore constitute a potential distraction for road users. Although several studies have examined the association between the phases of the moon and emergency visits and traffic accidents (Alves et al., 2003; Stomp et al., 2009; Thompson and Adams, 1996), the findings have been inconsistent and the studies were limited by several methodological problems, such as small sample size, study design, and insufficient control for covariates. A recent study showed a potential association between full moon nights and motorcycle-related mortality, suggesting that full moons may be a key risk factor for fatal motorcycle crashes (Redelmeier and Shafir, 2017). However, few quantitative studies have investigated the impact of a full moon on the incidence of emergency transport due to traffic accidents while also accounting for concurrent confounding by prevailing weather conditions and cloud cover, and possible confounding by factors that change according to season. Because a full moon can lead to distracted driving, we hypothesized that it might contribute to increased emergency ambulance transport due to traffic accidents (Schweizer et al., 2013).

Here, we investigated the potential association between a full moon and traffic accident-related emergency ambulance transport using national registry data between 2010 and 2014 in Japan.

## 2. Methods

### 2.1. Study design

To examine the link between a full moon and the incidence of emergency transport due to traffic accidents, we conducted a quasi-experimental study with time-stratified case-crossover analysis using data obtained from all 47 Japanese prefectures from January 1, 2010, to December 31, 2014. We used data from [timeanddate.com](http://timeanddate.com), a commonly referenced resource by the scientific community and mainstream media outlets, to identify the dates on which a full moon occurred (Time and Date AS). A full moon night was defined as one night every month during the study period when the whole surface of the moon observable from Earth was illuminated. When two full

moons were observed in a single month, which occurred in a few cases (e.g. January 1 and 30, 2010; March 1 and 30, 2010; August 2 and 31, 2012), we included both appearances. Nighttime was defined as the hours between 18:00 and 7:00 (13 h) to include all potential hours during which a full moon may be observed from Japan (including relevant hours of dusk and dawn). The remaining hours from 7:00 to 18:00 (11 h) were defined as daytime and were not examined. We analyzed data from a total of 1826 nights (62 full moon nights and 1764 control nights). Within this framework, we assessed whether there was an increase in the risk of emergency transport due to traffic accidents on full moon nights.

### 2.2. Ethical approval

The study was approved by the ethics committee of Kyushu University Graduate School of Medical Sciences. Written informed consent was not required due to the population-based study design using national registry data and the de-identification of enrolled individuals.

### 2.3. Data sources

We obtained data on all emergency ambulance transport due to traffic accidents for all 47 prefectures of Japan between 2010 and 2014 from the Fire and Disaster Management Agency (FDMA) of the Ministry of Internal Affairs and Communications of Japan. We extracted data such as the date of the emergency transport, and established the main cause of diseases using the *International Classification of Diseases*, 10th revision (ICD-10). According to the Fire Service Act in Japan, about 800 fire stations with dispatch centers are managed by municipal governments and perform emergency medical services. The Tokyo metropolitan area was excluded from our analyses due to a lack of data on emergency ambulance dispatches and data being unavailable. According to the Fire Service Act in Japan, all emergency transport data must be registered and this data is therefore considered to be complete nationwide. The data were checked for consistency by a computer system, and were validated by the FDMA.

Confounding variables were collected from appointed weather stations and the Japan Meteorological Agency, and included data on local weather variables, such as ambient temperature, relative humidity, rainfall, and cloud cover. A single weather station positioned in an urban region of each prefectural capital city was appointed as a representative for data collection for each prefecture because these were synoptic climatological stations and intended to capture macro-scale weather for each prefecture. The daily mean temperature, relative humidity, rainfall, and cloud cover levels were calculated based on hourly measurements. There was no missing data for these variables. An indicator variable for public holidays was also included in the model.

### 2.4. Outcome measures

We extracted a daily time-series of emergency transport due to traffic accidents (ICD-10: V00-V89) for the nighttime period.

### 2.5. Statistical analysis

We first examined associations between full moon nights and the incidence of emergency transport due to traffic accidents using a time-stratified case-crossover design with a conditional Poisson regression

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