



Association of high profile football matches in Europe with traffic accidents in Asia: archival study

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ABSTRACT OBJECTIVE

To investigate the association between popular football games played in Europe and the incidence of traffic accidents in Asia.

DESIGN

Study based on 41 538 traffic accidents involving taxis in Singapore and 1 814 320 traffic accidents in Taiwan, combined with 12 788 European club football games over a seven year period.

SETTING

Singapore and Taiwan.

PARTICIPANTS

The largest taxi company in Singapore, with fine grained traffic accident records in a three year span; all traffic accident records in Taiwan in a six year span.

EXPOSURE

Days when high profile football games were played or not played.

MAIN OUTCOME MEASURE

Number of traffic accidents.

RESULTS

Regression based and time series models suggest that days with high profile European football matches were more positively associated with traffic accidents than days with less popular European football matches. For an approximate €134.74m (£120.25m; \$159.76m) increase in average market value for matches played on a given day, approximately one extra accident would occur among Singapore taxi drivers, and for an approximate €7.99m increase in average market value of matches, approximately one extra accident would occur among all drivers in Taiwan. This association remained after control for weather conditions, time of the year, weekend versus weekday effects, driver demographics, and underlying temporal trends. It was also stronger for daytime traffic accidents than for night time traffic accidents, suggesting that the association between high profile football matches and traffic accidents cannot be attributed to night time celebration or attention

deficits while watching and driving. Annually, this increased rate of traffic accidents may translate to approximately 371 accidents among taxi drivers in Singapore and approximately 41 079 accidents among the Taiwanese public, as well as economic losses of approximately €821 448 among Singapore taxi drivers and approximately €13 994 409 among Taiwanese drivers and insurers. The total health and economic impact of this finding is likely to be much higher because GMT+8 is the most populous time zone, encompassing 24% of the world's population.

CONCLUSIONS

Days featuring high profile football matches in Europe were associated with more traffic accidents in Taiwan and Singapore than were days with lower profile football matches. A potential causal mechanism may be Asian drivers losing sleep by watching high profile European matches, which are often played in the middle of the night in Asia.

Introduction

Football (soccer) is viewed by more people worldwide than any other sport.¹ Although football enjoys global popularity, most high profile games are played in Europe. The top five most watched leagues (the English Premier League, the Spanish La Liga, the French Ligue 1, the Bundesliga, and the Italian Serie A) are all European. The Champions League—generally considered the top club competition in the world—is contested by top division European clubs, and more than half of the past 21 World Cup tournaments have been played in Europe.

This European dominance of the football market means that fans who reside outside of the European continent must watch these games at odd local times owing to differences in time zones. Asian fans are the most affected. If Manchester United, the most popular football club in 2018, is scheduled to play at 8 pm local time, fans in Beijing, Hong Kong, and Singapore will have to stay up until 4 30 am to finish the game, whereas fans in Seoul and Tokyo will have to stay up until 5 30 am. Asian fans have to stay up just as late to watch matches played in the Americas. For example, East Asian fans had to stay up from 2 am to 4 am to watch the World Cup finals held in Rio de Janeiro in 2014. Despite these hardships, football viewership in Asia has been steadily increasing over the past decade.²

Sleep deprivation is one clear outcome of staying up late to watch football games, which leads us to a novel hypothesis: on days featuring high profile football matches in Europe, more traffic accidents should occur in other continents (most notably Asia, in which the

WHAT IS ALREADY KNOWN ON THIS TOPIC

Sleep deprivation increases the risk of auto accidents

WHAT THIS STUDY ADDS

Watching popular football (soccer) games from distant time zones (eg, at 3 am local time) is positively associated with the prevalence of local auto accidents

This is especially problematic given that Asia has the most populous time zone, and many of the most popular football games are played approximately eight time zones away in Europe

time zone differences mean that the matches are played at typical sleep times). Given that sleep deprivation is associated with poor attention management, slower reaction times, and impaired decision making,³⁻⁶ we suggest that drivers are more likely to be involved in traffic accidents on days when high profile football games air early in the morning. If true, this finding would have important policy implications, as traffic accidents can result in considerable economic and medical costs.

We suggest that sleep deprivation is a major reason why high profile football matches are positively associated with traffic accidents, but other plausible mechanisms may explain this relation. High profile football matches may, for example, lead to more night time celebration or more people watching games while driving, which could lead to more traffic accidents. High profile football matches and traffic accidents could also be rising over time owing to other causes, which could account for a correlation between the variables. However, our sleep deprivation account suggests that the association between high profile football matches and traffic accidents should hold after we controlled for general trends over time and that the association may actually be stronger for daytime (rather than night time) accidents, as people watch games at night or early in the morning and feel tired the next day.

We tested these hypotheses in two contexts: traffic accidents across Taiwan and traffic accidents among taxis in Singapore. These datasets offer us unique strengths. In Taiwan, we were able to test the association between football games and traffic accidents at high scale, analysing data on all recorded traffic accidents from 2013 to 2018 (1 814 320 accidents) across both rural and urban regions in Taiwan. However, these data do not include information about weather at the time or location of the accident and driver demographics. Data from Singapore, although smaller in scale (41 538 accidents in 2012-14), contain fine grained data on driver demographics as well as weather conditions at the time and location of each accident. Moreover, Singapore has a climate characterised by relative uniformity in terms of rainfall, temperature, and daylight hours (1.5° north of the equator) and generally good roadside conditions, making it a perfect test case for predictors of traffic accidents. In both datasets, we hypothesised that high profile football games are associated with a higher rate of traffic accidents and that this relation transcends weather conditions, driver demographics, and day and month information.

Methods

Traffic data

We retrieved separate datasets for daily accidents in Taiwan and accidents in Singapore. We retrieved Singapore data from the largest taxi company in Singapore, with a fleet size of more than 13 000 taxis. This organisation accounts for more than 60% market share of the taxi transport industry in Singapore. The resulting dataset contained all daily accident records from January 2012 to December 2014 (41 538

accidents). The dataset also included data on detailed characteristics of the accident, including characteristics of the taxi driver involved in the accident (gender, age, educational level, driving experience via number of years driving, and colour of car) and weather at the time and location of the accident (wet versus dry).

We retrieved Taiwanese data from the Taiwanese National Police Agency. This dataset contained all documented traffic accidents—not solely those involving taxis—in Taiwan between January 2013 and December 2018 (1 814 320 accidents). These data did not include detailed characteristics of the accidents and the drivers.

Football data

We coded all football games in the top five European football leagues: English Premier League, Spanish La Liga, German Bundesliga, Italian Serie A, and French Ligue 1. We also coded games in the knockout stage of the annual European Champion League and Europa League. We gathered all data about these teams from worldfootball.net. This source contains data on the names of football clubs, matching time, and matching date in either Greenwich Mean Time (GMT+0) or British Summer Time (GMT+1) time zone. We then converted these time zones and dates to Taiwan's and Singapore's time zone (both GMT+8).

The most direct measure of the popularity of football matches is viewership ratings. However, viewership ratings in Singapore and Taiwan were not available for most of these matches. We therefore coded the combined team salary cap as a proxy for the game's popularity. For example, FC Barcelona had a salary cap of €1280m (£1142; \$1518) in 2018, whereas Seville FC had a salary cap of €295m, reflecting their respective popularity. We obtained all year specific market value data from Transfer Markt (<https://www.transfermarkt.com/>) for 2012-18. This source provides all football players' salaries (in Euros), as well as teams' combined salary cap in every year. We then used these statistics to calculate the combined market value of a match between any two clubs.

We included all the matches from 2012-18 among the top five most watched leagues (the English Premier League, the Spanish La Liga, the French Ligue 1, the German Bundesliga, and the Italian Serie A). We also included matches from the round of 16 or more advanced matches in both the Champions League and the Europa League. We excluded the group stage games in the Champions League and the Europa League because they are often contested by at least one (and often two) low profile team not belonging to one of these top five football leagues. As such, group stage games are likely to be unpopular in Asia.

Analytical plan

In total, there were 1379 game days from 2012 to 2018 (total coverage of our datasets; we excluded non-game days). Each of these game days featured at least one football match, but not all matches were equally high profile. For example, 27 December 2013

featured several high profile games, including a match between Manchester City and Liverpool FC, with games representing teams with an average market value of €742m. By contrast, 4 May 2012 featured lesser viewed games, including a match between Dijon FCO and AJ Auxerre, with games representing teams with an average market value of €62.7m.

Our primary models analysed the relation between this market value statistic (the average market value, in millions) for football games played on day *k* and the number of traffic accidents on day *k*. As games aired early in the morning, we predicted that the number of accidents that same day would be higher because people would be more sleep deprived during the rest of the day. Our analyses excluded traffic accidents that occurred before the first European football match that day, to avoid conflating traffic accidents that occurred after games and traffic accidents that occurred before games. This procedure excluded 960 accidents from the Singapore dataset and 51 131 accidents in Taiwan.

We did three sets of analyses to test for the association between high profile football matches and traffic accidents. The first set of analyses used Poisson regression models to predict the total number of accidents in a day. Using a dataset in which cases represented days, we regressed the number of traffic accidents per day on the average market value of football games from that day. We used Poisson modelling because our traffic accident variables represented count data, but results were similar when we used more traditional ordinary least squares modelling (supplementary tables S3 and S4). The primary effect size from Poisson models are incidence rate ratios, which we denote here as Δ incidence. This coefficient is the exponent of the Poisson regression fixed effect estimate, and it translates to the ratio of the dependent variable at value *x* of the fixed effect to the dependent variable at value *x*+1 of the fixed effect. In the context of our models, a Δ incidence of 2.00 would indicate that traffic accidents are expected to double for every one unit increase in average market value.

We first did this regression while controlling for factors that could plausibly influence the rate of traffic accidents: weekday versus weekend (0=weekend; 1=weekday) and month of year (11 dummy coded variables contrasted against December, the month with the most rainfall in Singapore). For the Singapore dataset, we next added weather and demographic controls: weather (0=dry; 1=precipitation), the percentage of male versus female drivers, the average age of drivers, the average educational level of drivers, the average driving experience of drivers (number of years of driving), and the percentage of yellow cars involved in accidents, because past research suggests that the colour of a vehicle is associated with accident rates.⁷ These models did not contain days when no football matches were played, but no other data were missing.

The second set of analyses replicated our initial models but separated “daytime” and “night time” accidents. One possibility is that high profile football matches are associated with traffic accidents because

people celebrate during or immediately after football games or watch and check football games while they are driving, resulting in higher rates of night time accidents. By contrast, our sleep deprivation hypothesis predicts that high profile football games are associated with traffic accidents because people are tired from staying awake to watch football games early in the morning, which may result in more daytime accidents as people drive to work on the same day. Analysing daytime and night time accidents separately allowed us to adjudicate between these two hypotheses.

Sunrise and sunset times in Singapore do not vary substantially across months. For example, the average sunrise time is 7 07 am in January and 7 03 am in July. For accidents in Singapore, we therefore classified “daytime accidents” as those falling between 7 am and 7 pm throughout the entire year. Taiwan daylight hours vary across season. For example, the average sunrise time in Taiwan is 6 40 am in January but 5 08 am in July. For accidents in Taiwan, we therefore classified “daytime accidents” differently depending on sunrise and sunset times throughout the year.

The third and final set of analyses used time series models that allowed us to rule out the possibility that average market value and number of traffic accidents were related because of an underlying temporal trend (for example, both factors increasing linearly over time). These time series models could also isolate whether an association between average market value and number of accidents was contemporaneous (as we hypothesised) or was defined by a more complex lagged dynamic. For example, a linear trend in market value existed in the 2013-18 Taiwan dataset, such that market value correlated with time ($r=0.40$; $P<0.001$), whereas no linear trend existed in the 2012-14 Singapore dataset ($r=0.009$; $P=0.87$). To account for this trend, we pre-whitened the Taiwanese cross correlation function before estimating coefficients, a statistical procedure that removes autocorrelation in the data. We also confirmed that all time series were stationary by using augmented Dickey-Fuller root tests ($P<0.001$) before fitting our cross correlation functions, which indicates that the data were not characterised by any systematic non-linear trends that could have biased our cross correlation function.

We also fitted Granger causality models, which evaluate whether two variables are related contemporaneously or via a time lag. We note that stationary time series still have autoregressive (AR) and moving average (MA) processes that can affect bivariate associations between time series. To ensure that our results were not driven by these processes, our supplemental materials replicate key associations using ARIMA residualised time series that are entirely stripped of autoregressive and moving average processes.

Behavioural study

Our analysis plan was designed to rigorously test the hypothesis that high profile football matches are positively associated with traffic accidents in

Asia. However, our analysis still relied on two key assumptions. The first assumption was that taxi drivers are a representative sample of Singaporeans, in terms of football viewing habits. On the one hand, taxi drivers demographically skew male and less educated, which may make them more likely to watch football matches than the average Singaporean. On the other hand, taxi drivers often work long shifts, and their schedule may make them less likely to watch football matches than the average Singaporean. Our second assumption was that the market value of football teams is a valid indicator of viewership. Asian fans may be more likely to watch games involving low budget teams if they are evenly matched, or may only watch their favourite teams regardless of market value. Although the first assumption does not apply to our Taiwan data because we included all accidents that occurred, the second assumption could affect analyses in both contexts.

To confirm that our assumptions were correct, we did a supplemental behavioural study involving 100 taxi drivers (99 men; mean age 53.07 (SD 11.71) years) who we surveyed as they were waiting for customers at taxi stands, and 100 non-taxi drivers (49 men; mean age 34.78 (14.33) years) who we surveyed at two local malls as a comparison group (see supplementary materials for details).

Survey respondents all answered two key items. Firstly, participants responded to the item: “how many nights have you stayed up late to watch a European football game in the last month,” using a scale from 0 (“zero nights”) to 4 (“four or more nights”). This item allowed us to test whether taxi drivers actually stay up late to watch football games and whether they are vastly more or less likely to do so than a sample of non-taxi drivers in Singapore. Secondly, participants used a 1 (“very unlikely”) to 7 (“very likely”) scale to indicate how likely they would be to watch several types of football games: a football game between a top team and a bottom team, a bottom team and a similarly ranked bottom team, a top team and a top team, their favourite team and a bottom team, their favourite team and a top team, and their favourite team and any team. This item allowed us to confirm that people would be more likely to watch games if they involved top teams, even if these games involved unequal match-ups.

Patient and public involvement

We did not involve patients and the public in this research.

Results

Evaluation of assumptions

Before testing our central hypothesis, we used data from our behavioural study to evaluate our key assumptions: that taxi drivers in Singapore watch football matches at the same rate as other Singaporeans and that people are more likely to watch games involving high market value teams than games with low market value teams.

Of the 100 taxi drivers surveyed, 37 self-reported having stayed up to watch football at least once in the previous month. This was similar to the general

population, of whom 35 (out of 100) stayed up late at least once. We found no significant difference between the average number of nights in the previous month that taxi drivers (mean 0.98 (SE 0.15)) and the general public (0.70 (0.12)) stayed up late to watch games (mean difference 0.28, 95% confidence interval -0.10 to 0.66; $P=0.144$). The lack of difference was even more apparent when we controlled for gender (mean difference 0.03, -0.35 to 0.41; $P=0.991$). In sum, this suggests that many taxi drivers lose sleep to watch football games and that this tendency is at least somewhat representative of the general population in Singapore.

We next examined whether people would be more interested in watching games involving teams with higher (versus lower) market values. We examined this question across two repeated measures analyses of variance. The first analysis investigated participants' interest in games involving their favourite team. This showed a significant effect ($F_{1,199}=11.88$; $P<0.001$), with group means suggesting that participants were more interested in watching their favourite team against a top team (mean 3.68 (SE 0.17)), compared with a bottom team (3.05 (0.16); mean difference 0.63, 0.45 to 0.82) or any team (3.24 (0.16); 0.44, 0.30 to 0.58). The next analysis investigated participants' interest in games not involving their favourite team. This analysis also showed a significant effect ($F_{1,199}=97.14$; $P<0.001$), with group means suggesting that participants were more interested in watching two top teams (mean 3.30 (0.09)), compared with a top team against bottom team (2.09 (0.11); mean difference 1.21, 0.96 to 1.46) or two bottom teams (1.75 (0.09); 1.55, 1.27 to 1.83). Each of these analyses suggested that participants were more interested in watching games involving teams with high market values, rather than watching equally matched bottom teams.

In sum, our behavioural study supported our key assumptions. Singaporean taxi drivers do watch football games late at night, and their viewing habits do not differ from those of typical Singaporeans. In addition, games involving teams with large market values attract more interest than games involving teams with lower market value.

Are high profile matches associated with total traffic accident rates?

Our hypothesis was that days with higher profile football matches (via team market value) would also feature more traffic accidents. Market value and traffic accidents had a significant association in Taiwan (estimate=0.00015, 95% confidence interval 0.0001 to 0.0002; Δ incidence=1.00015; $z=19.40$; $P<0.001$) (table 1; Taiwan model 1) and Singapore (estimate=0.0002, 0.0001 to 0.0003; Δ incidence=1.00021; $z=3.75$; $P<0.001$) (table 1; Singapore model 1). The Singapore association replicated with a similar effect size when we controlled for demographic covariates (estimate=0.0002, 0.0001 to 0.0003; Δ incidence=1.00020; $z=3.43$; $P<0.001$) (table 1; Singapore model 2).

Table 1 | Poisson regression predictors of accident incidence rates in Taiwan and Singapore

Variable	Estimate (SE)	ΔIncidence	P value	95% CI of estimate
Taiwan model (df=1066)				
Intercept	6.74 (0.004)	841.98	<0.001	6.73 to 6.74
Average market value	0.00015 (0.000008)	1.00015	<0.001	0.0001 to 0.0002
Weekday	-0.003 (0.003)	0.99	0.20	-0.008 to 0.002
Singapore model 1 (df=590)				
Intercept	3.56 (0.03)	35.29	<0.001	3.51 to 3.62
Average market value	0.0002 (0.00006)	1.00021	<0.001	0.0001 to 0.0003
Weather	0.29 (0.05)	1.34	<0.001	0.19 to 0.39
Weekday	-0.10 (0.02)	0.91	<0.001	-0.13 to -0.07
Singapore model 2 (df=582)				
Intercept	3.32 (0.03)	27.71	<0.001	2.83 to 3.81
Average market value	0.0002 (0.00006)	1.00020	<0.001	0.0001 to 0.0003
Weather	0.27 (0.05)	1.31	<0.001	0.17 to 0.37
Weekday	-0.09 (0.02)	0.91	<0.001	-0.13 to -0.06
Per cent male	0.29 (0.23)	1.33	0.20	-0.15 to 0.73
Average age	0.0006 (0.003)	1.00058	0.83	-0.005 to 0.006
Per cent yellow	-0.06 (0.09)	0.94	0.47	-0.23 to 0.11
Average education	-0.01 (0.02)	0.99	0.55	-0.06 to 0.03
Average experience	-0.008 (0.005)	0.99	0.07	-0.02 to 0.007

Market value is in millions of Euros. Incidence change is expected change in predicted accident incidence for every unit increase in predictor. Taiwan incidence rate of 1.0001487 translates to 1 additional accident for every €7.99m (£7.13; \$9.47) in average market value; Singapore incidence rate of 1.0002103 translates to 1 additional accident for every €134.74m in average market value for football matches (average market value per game day is €297.25m). Month of year effects are reported in supplementary tables S1 and S2.

In Taiwan, incidence rates predicted that an additional accident would occur for every €7.99m increase in market value for matches played on a given day. In the Singapore dataset, which was considerably smaller, models predicted an additional accident for every €134.74m (Singapore model 1) to €145.68m (Singapore model 2) increase in average market value. In the Singapore data, we also tested for all possible interaction effects between average market value and demographic, weekday, and weather data. In the Taiwan data, we tested for the interaction effect between average market value and weekday. None was statistically significant (see supplementary tables S5-S12). The supplementary materials also contain more information about the functional form of these models, examining linear as well as quadratic effects. The overall linear trends remained significant in both the Taiwan and Singapore data when we controlled for quadratic effects (supplementary tables S17 and S18; see also tables S19 and S20).

Daytime versus night time accidents

We hypothesised that the association between average market value and traffic accident rate would be stronger for daytime than night time accidents. Consistent with this sleep deprivation account, the Taiwanese dataset showed a stronger association between market value and daytime accidents (estimate=0.0002 (SE 0.000009), 95% confidence interval 0.00016 to 0.00019; Δincidence=1.00017; $z=20.17$; $P<0.001$) than night time accidents (estimate=0.00005 (0.00002), 0.00002 to 0.00009; Δincidence=1.000054; $z=3.16$; $P=0.002$). Moreover, the non-overlapping 95% confidence intervals of the estimates showed that the daytime effect (0.00016 to 0.00019) was significantly stronger than the night time effect (0.00002 to 0.00009). The Singapore

dataset showed an even stronger pattern. The average market value was positively associated with daytime accidents (estimate=0.0004 (0.00007), 0.0002 to 0.0004; Δincidence=1.00035; $z=4.92$; $P<0.001$) but not night time accidents (estimate=-0.0001 (0.0001), -0.0003 to 0.00008; Δincidence=0.99; $z=-1.12$; $P=0.26$). These associations, shown in figure 1 and supplementary tables S13-S16, suggest that high profile football matches are positively associated with accidents because of sleep deprivation rather than night time celebration or viewing games while driving.

Time series analysis of football matches and traffic accidents

Figure 2 shows the output from our cross correlation function. The contemporaneous relation between market value and traffic accident rate was significant and positive in both Taiwan ($r=0.10$) and Singapore ($r=0.11$), with no other correlations reaching the same magnitude in either sample ($r<0.10$; see supplementary tables S21 and S22). This suggests that our effects were not driven by increases in traffic volume the day before high profile football games.

Results using vectorial autoregression and Granger causality tests mirrored these cross correlation results. In the Taiwanese data, a Granger test of causality extracted from a vectorial autoregression model with a lagged threshold of 5—recommended by Akaike information criterion fit statistics—estimated that average market value had a significant contemporaneous association with number of traffic accidents ($\chi^2=11.61$; $P<0.001$), with a smaller lagged association ($F_{5,2102}=3.18$; $P=0.01$).

In the Singapore data, a Granger test of causality extracted from a vectorial autoregression model with a lagged threshold of 4—again recommended

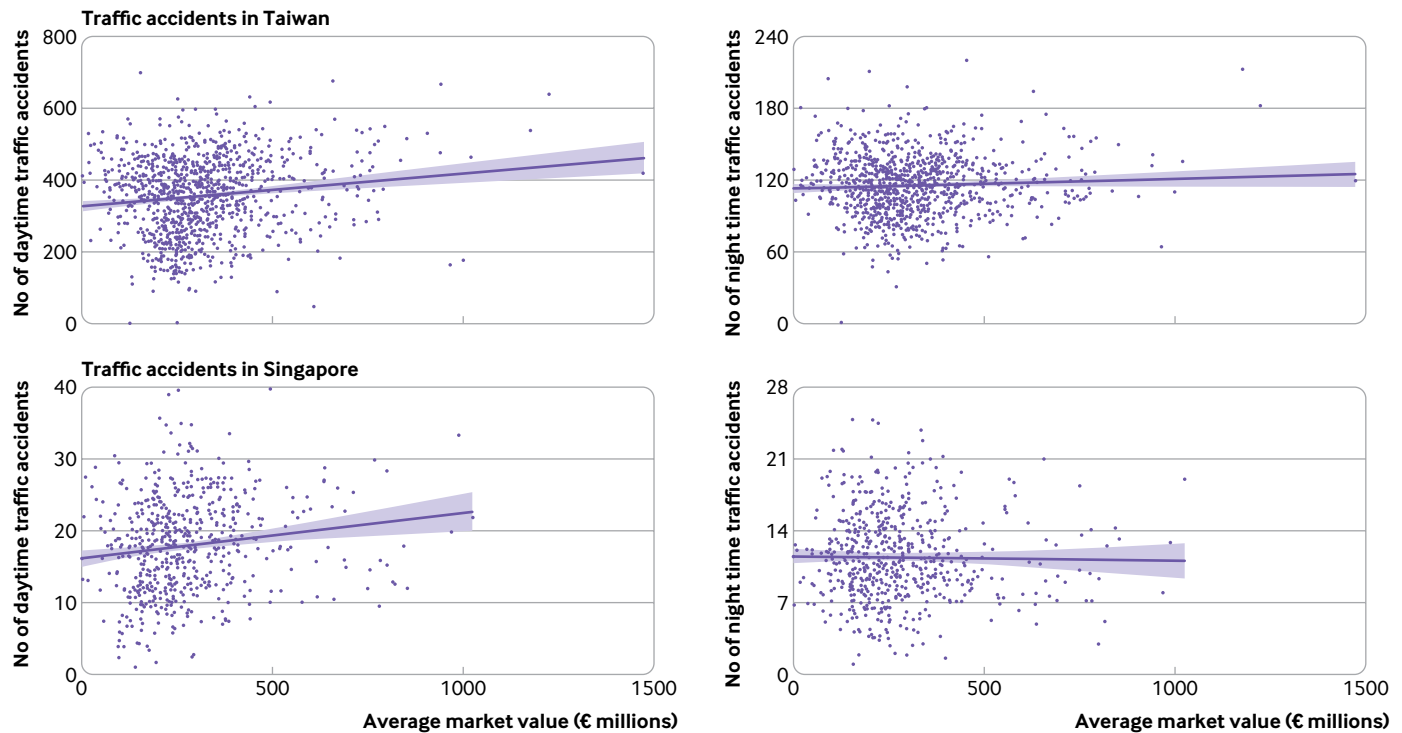


Fig 1 | Relation between average market value of football games and number of daytime and night time traffic accidents. Values have been residualised to control for covariates and then linearly transformed to be positive for display purposes

by Akaike information criterion fit statistics—estimated that average market value had a significant contemporaneous association with number of traffic accidents ($\chi^2=4.68$; $P=0.03$), with a null lagged association ($F_{4,1156}=1.81$; $P=0.12$). These tests are not as suitable as regression analysis for calculating effect sizes, but they show that the relation between high profile football matches and traffic accidents is better characterised by same day associations than by multi-day lagged associations, consistent with our hypothesis.

Discussion

Our analysis of traffic accidents in Taiwan and Singapore supports our hypothesis that days with high profile European football matches also have higher than average rates of traffic accidents in Asia. Our account of these findings is that people in East Asia stay awake until the early hours of the morning to watch high profile football games. Our data were correlational, which means that we cannot make causal claims. However, our models show that the association between high profile football matches and traffic accidents holds across two geographically and culturally diverse regions (Singapore and Taiwan) and also when we controlled for weather, weekday versus weekend effects, month of year, and driver demographics, meaning that this association is unlikely to be confounded by an unmodelled covariate or regional differences. Moreover, our time series models rule out the possibility that high profile football matches and traffic accidents are positively associated

only because of an underlying temporal trend from extraneous variables.

Strengths and limitations of study

This work has limitations, which could spark future research. Firstly, the consequences of traffic accidents can range from minor injuries to multiple deaths, but we do not have data on the severity of the accidents reported, which limits our ability to discern the total medical impact of these findings. Secondly, although our results from both datasets provide convergent support to our sleep deprivation explanation of these effects, future research could do primary survey studies and directly assess drivers who were in accidents and survey their football viewing habits and sleep hours before their accidents. Thirdly, we did not compare days when football matches were played against non-game days, and readers should interpret our findings across days when football matches were played only as a function of the games' market values. Fourthly, drivers in Singapore and Taiwan have to pay for subscriptions to watch football games, and we do not know if the drivers in our samples had these subscriptions. However, with the popularity of illegal streaming services, we suggest that people can watch games easily even without such paid subscriptions. Finally, we did not distinguish sleep disruption arising from staying up to midnight versus 3 am. Although crucial recovery, maintenance, and growth activities occur during both rapid eye movement (REM) and non-REM sleep,^{8,9} future research could explore whether disruptions to REM versus non-REM sleep, as a result

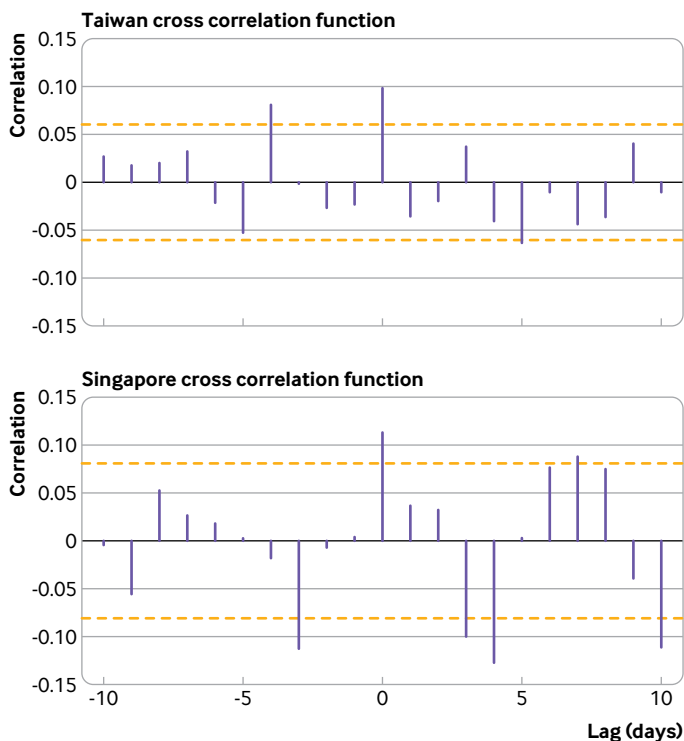


Fig 2 | Results of cross correlation analysis involving average market value of football games and number of daily traffic accidents in Taiwan (top) and Singapore (bottom). Each bar in plot represents correlation at different lag. Negative lags indicate that accidents preceded high market value football games. Positive lags indicate that accidents followed high market value games. Dashed orange line represents significance at $\alpha=0.05$

of watching football games, are more detrimental for traffic accidents.

Conclusion and policy implications

Our model estimates allow us to calculate the potential monetary impact of football matches on East Asian drivers. Based on our incidence rates, €134.74m in football games' market value translates to one extra daily automobile accident among Singapore taxi drivers in our dataset, whereas €7.99m translates to one extra daily automobile accident among all Taiwanese drivers. Given these figures, we estimate that football games may be responsible for at least 371.53 accidents a year among taxi drivers in Singapore (the figure is likely much larger across all drivers in Singapore) and approximately 41 079.50 accidents per year among the Taiwanese general public (see supplementary materials for the impact analyses). Furthermore, insurance data indicate that the average insurance claim in Singapore was €2129 and the average insurance claim in Taiwan was €2044.^{10 11} The economic impacts of our findings thus total at least €821 448 annually among Singapore taxi companies, and €13 994,409.50 for Taiwanese drivers and insurance companies.

We note, however, that these economic impacts should be interpreted with caution because other obvious economic benefits are associated with football viewership in Asia, such as revenues for restaurants and bars in extended hours. We thus encourage future

researchers to account for all potential costs and benefits associated with European football games. Nevertheless, these estimates are also probably conservative because our account suggests that cities within the GMT+8 time zone are likely to be affected similarly. To put this into perspective, Singapore and Taiwan combined represent less than 1.73% of the population in this particular time zone.

Our analysis has shown an association between high profile football matches and traffic accidents in the most populous time zone in the world, with more than 1.7 billion people (~24% of the world's population). These findings have important policy implications for traffic regulation and televised sports in Asia. One policy implication is that football's governing societies/leagues could consider scheduling high profile games more strategically. We do not recommend that they change the start time of games, but scheduling more high profile games in Saturday or Sunday early mornings (local Asia time zones) when fans can sleep in immediately after watching the games might have the potential to lower traffic accidents. That said, we acknowledge that any scheduling changes would be difficult. Another implication is that increasing roadside safety in Asia on high profile game days (for example, more traffic patrols), as well as banning all video based devices for drivers, could potentially reduce these economic impacts and injuries related to traffic accidents.

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Contributors: KCY formulated the research idea, designed the study, analysed the data, and drafted the manuscript. JCJ analysed the data and drafted the manuscript. JL coded the data and provided critical revisions to the manuscript. XQ, CB, and JKC provided critical revisions to the manuscript. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted. KCY and JCJ contributed equally to this work. KCY is the guarantor.

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Competing interests: All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: support from the National University of Singapore's Humanities and Social Sciences Faculty Research Fellowship and the National Natural Science Foundation of China; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

Ethical approval: Not needed.

Data sharing: All data and codes are available via the Open Science Framework: https://osf.io/q9jpc/?view_only=bce492b556054785b73b43aaba5cc3e5.

The lead author affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as originally planned (and, if relevant, registered) have been explained.

Dissemination to participants and related patient and public communities: We will disseminate these findings via news articles to the public communities. We have not yet prepared a summary at this point.

Provenance and peer review: Not commissioned; externally peer reviewed.

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Web appendix: Supplementary materials