The potential impact of the implementation of the Brighter Evenings Bill on road safety in the Republic of Ireland

A report for the Road Safety Authority of Ireland

The *Brighter Evenings Bill* (2012) proposes that Ireland should move to Central European Time (CET) for a three-year pilot period. Proponents of the Bill assert that such a change will have a positive impact on road traffic collisions. This report was commissioned by the Road Safety Authority (RSA). It presents a synthesis of the best evidence available as to the potential impact of the Brighter Evenings Bill, if passed, on the number of road traffic collisions, injuries and fatalities in the Republic of Ireland. The report presents an overview of factors implicated in collisions in Ireland, a synthesis of existing empirical literature on Daylight Savings Time (DST) and collisions, and the changes in collisions and casualties in Ireland across DST transitions. The report concludes with a definitive recommendation on the proposed change to CET.

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November 2015

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Executive Summary

E.1 Introduction

Daylight Savings Time (DST) in Ireland begins on the last Sunday of March (spring DST transition) and ends on the last Sunday in October (autumn DST transition). In March each year the clocks are set forward by one hour, providing an extra hour of daylight in the evenings, but resulting in darker mornings. In October, when the clocks revert back to standard time, mornings become brighter and evenings darker.

The *Brighter Evenings Bill* proposes that Ireland should move to Central European Time (CET) for a three-year pilot period. Practically, this would mean that, in Year 1 of the trial period, the clocks will move forward by two hours during the spring DST transition and then back by one hour at the autumn transition, thus fully aligning Irish time with CET. In subsequent years, the clocks would move forward and back by one hour in-line with CET.

Under CET, the sun would rise and set one hour later than at present throughout the year. Had this change been in place for 2015, for instance, our evenings would be longer than in previous years and late-evening journeys would occur under better lighting conditions. Conversely, mornings would be darker, with early-morning travel undertaken under diminished lighting conditions.

This report was commissioned by the Road Safety Authority (RSA) to consider the potential impact of a move to CET on road traffic collisions. Much of the relevant research comes from empirical papers that have investigated the impact of DST on road traffic outcomes. In this report, we present the **findings of the first systematic review of this evidence-base**. We also present **the first authoritative investigation of the association between DST and road traffic collisions in Ireland**. In order to allow for a more complete interpretation of the potential impact the *Brighter Evenings Bill* would have on road traffic collisions, **we also present an overview of the contributory factors for collision risk in the report**.

The core objective of this report has been to develop a synthesis of the best evidence that can inform the potential impact of a move to CET on road safety in Ireland.

E.2 Assumptions

In terms of the core assumptions behind the *Brighter Evenings Bill*, and the purported positive impact the move to CET would have, the following general observations are relevant:

- There is clear evidence in the scientific literature that driver behaviour (human factors) deteriorates under poorer lighting conditions.
- Collision data from Ireland indicate that the risk of RTC involvement is greater during the evening period, compared to the morning period.

To the extent that collision risk is influenced by light, shifting light from morning to evening should have a positive impact on collisions. However, this expectation must be weighed against the evidence presented in the report.

E.3 Findings

E.3.1 Systematic Review

We conducted the first systematic review of the empirical literature examining the link between DST and RTCs. The picture that emerged from this review was complex. Specifically, we found that the effects of DST are likely to be small and potentially negative or positive depending on time of year and day. The effect is also likely to vary across different road users. The extent to which we can rely on this evidence-base must also be tempered by the methodological limitations of the DST research, including statistical assumptions that researchers have made, and difficulties accounting for potentially important factors such as traffic flow. Overall, the evidence from the review was inconclusive and cannot be used to support the proposed move to CET.

E.3.2 Analysis of RSA Collision Data

We also completed the most authoritative analyses to date of RTCs in Ireland that occurred around DST transitions. We used the RSA road collision database for this purpose. However, again the results of these analyses did not fully support the hypothesised DST effects.

DST transition in spring

First we examined the frequency of RTCs around the transition to DST in spring. Here we would anticipate a reduction in RTCs due to the extended daylight hours during the evenings. Short-term effects were probed by comparing collisions and casualties occurring two weeks before the transition with the same time period after the transition. There was no change in collision incidence. There was increase in casualty numbers, however, both for during the morning period (05:00-09:00) and for the morning and evening periods (15.00-19.00) combined. Pedestrian casualties also increased during the morning periods in the short-term analyses.

In the longer-term there were increases in collisions and casualties in the 7 weeks after the Spring transition, compared to the 7 weeks prior to the transition.

These findings are contrary to expectations, and may be attributable to factors other the DST such as, for example, monthly and weekly fluctuations or trends in traffic volume. ***In summary, analyses of the transition into DST do not support the road safety benefits of DST and thus cannot be used to support the move to CET.***

Transition to ST in autumn

We next examined the transition back to Standard Time (ST) in autumn. This change results in improved lighting conditions in the morning, but a reduction in light in the evening. Thus, we would anticipate a decrease in incidents in the morning, an increase in the evening and an increase overall (both peak periods combined). In the short-term analyses, there were significant reductions in collisions and casualties in the morning period. However, there were no significant changes in evening collisions or casualties and no effects overall.

Longer-term comparisons (±7 weeks) suggested an increase in the incidence of collisions for morning and evening periods combined. However, changes for morning or evening periods were not, on their own, significant.[1] For casualties, there was a significant increase for both the morning peak and the morning and evening peaks combined. Crucially, changes for the evening period, where the most marked increase in RTCs were anticipated, were not significant.

Overall neither the short-term nor long-term analyses around the transition to ST in autumn *supports the road safety benefits of DST.*

E.3.3 Other Considerations

The expectation that a move to CET should have a positive impact on road safety should also be weighed against the following:

While light is an important indirect risk factor for road traffic collisions, it is one of many direct and indirect contributory factors. For example, the best evidence suggests that human factors are the largest contributory factor to RTCs and injuries. Focus has been on a number of 'killer driver behaviours' that include driving while fatigued, drink driving, drug driving, being distracted while driving, speeding, and not wearing a seat belt. This is not reflected in the current debate on the *Brighter Evenings Bill.*

The evidence available to us does not have a high level of predictive utility when considering a move to CET. In particular, there is an almost complete absence of research that focuses specifically on the potential impact of CET, and we are therefore forced to rely on literature related to DST. While this provides a useful evidence-base, we are working on the assumption that there can be a reliable transfer of knowledge from DST effects to the types of effects that would occur see under CET.

The most authoritative statistical modelling of the potential impact of a move to CET is based on data from the British Summer Time (BST) experiment (1968-1971), during which the clocks remained in summertime throughout the year. Studies in the UK suggest that a move to CET there would lead to an overall reduction in fatalities of 2.6-3.4% and a reduction in serious injuries of 0.7%. However, we cannot assume that the BST experiment is a valid source of evidence for the purpose of modelling the effects of a change to CET, 45 years later, in a different jurisdiction. It also assumes that statistical modelling is sufficiently sensitive to accurately estimate such a small change in the first place.

E.3 Conclusion and Recommendations

The review of empirical evidence from other jurisdictions on the impact of DST on RTCs is inconclusive, as is the evidence based on road collisions here.

[1] That the overall effect was significant, while individual peak periods were not, is due to the fact that it is easier to reach statistical significance with larger samples/case numbers.

Moreover, there are considerable challenges associated with prospectively measuring the impact of the proposed 3-year CET pilot on road safety. In particular, there will always be multiple competing explanations for any patterns that emerge (e.g. traffic flow, school holidays etc.).

As such, ***the RSA cannot support the assertion that a move to CET would have a road safety benefit, or that a 3-year pilot period would provide conclusive evidence as to the impact of CET on road safety.***

Table E1: Impact of DST on RTCs in Ireland based on the road collision database (significant findings only).

	Spring DST		Autumn ST	
Transition	Clocks move forward by 1 hour		Clocks move back by 1 hour	
Effect	Morning: -1 hour light; Evening: +1 hour light		Morning: +1 hour light; Evening: -1 hour light	
Expected outcome	Increase in morning collisions (05.00-09.00)* Decrease in evening collisions (15.00-19.00) Net Positive Effect (Peak periods combined)		Decrease in morning collisions (05.00-09.00) Increase in evening collisions (15.00-19.00) Net Negative Effect (Peak periods combined)	
	Short Term	Long Term	Short Term	Long Term
Collisions	No effects	Increased evening collisions (±5 and ±7 weeks) and increase for combined morning and evening (±7 weeks)	Decreased morning collisions (±1 and ±2 weeks)	Increase in net morning and evening collisions combined (±7 weeks)
Casualties	Increased during morning peak (±2 weeks) and net increase for combined morning and evening peaks (±2 weeks).	Increased evening casualties (±5 and ±7 weeks) and increase for combined morning and evening peaks (±7 weeks)	Decreased morning casualties (±1 week)	Increase in morning casualties (±7 weeks) and casualties for peak morning and evening periods combined (±7 weeks).
Pedestrians	Increased during morning peak (±2 weeks).	No effects	Increased evening casualties (±1 and ±2 weeks)	Increase in evening pedestrian casualties (±5 and ±7 weeks) and for peak morning and evening periods combined (±7 weeks).
Cyclists	No effects	No effects	Decreased morning casualties (±1 and ±2 weeks) and decreased net morning and evening combined (±1 and ±2 weeks)	Decreased cyclist casualties for morning periods and for peak morning and evening periods combined (±7 weeks).

*Note that the anticipated short-term effects of moving into DST may also be negative due to the detrimental impact of the transition on sleep duration and latency, caused by the 23-hour transition day on DST Sunday.
**Morning = 05:00 to 09:00 (morning peak). Evening = 15:00 and 19:00 (evening peak); Combined =Morning and Evening combined.

Section 1: Introduction

1.1 Introduction

Daylight Savings Time (DST) in Ireland begins on the last Sunday of March and ends on the last Sunday in October. In March each year the clocks are set forward by one hour, providing an extra hour of daylight in the evenings, but resulting in darker mornings. In October, when the clocks revert back to standard time, mornings become brighter and evenings darker.

The *Brighter Evenings Bill* proposes that Ireland should move to Central European Time (CET) for a three-year pilot period. Practically, this will mean that in Year 1 of the trial period the clocks will move forward by two hours during the spring DST transition and then back by one hour at the autumn transition, thus fully aligning Irish time with CET. In subsequent years, the clocks will move forward and back by one hour in-line with the CET.[2]

Under CET, the sun would rise and set one hour later than at present throughout the year. Had this change been in place for 2015, for instance, our evenings would be longer than in previous years and late-evening journeys would occur under better lighting conditions. Conversely, mornings would have been darker, with early-morning travel undertaken under diminished lighting conditions (see Figure 1).

Proponents of the *Bill* assert that this change would enhance road safety in this jurisdiction and save lives on the road every year.[3] This is primarily based on the following logic:

1) There is an effect of light on traffic safety, with darkness being a contributory factor to road traffic collisions.
2) A move to CET would mean transferring an hour of daylight from the morning, when there are fewer casualties, to the afternoon/evening, when the risk of collisions and casualties is greatest. The net effect of the change, then, would be a reduction in collisions, casualties and fatalities.

While it appears logical to anticipate that such a change would have a positive impact on road safety here, in reality the causal factors for road traffic collisions are varied and interact in complex ways. Moreover, it may be the case that a move to CET would have a different impact on different types of road users. Given such uncertainty, there is a need to synthesise the evidence available that can inform predictions about the potential impact of a move to CET on road safety here.

This report was commissioned by the Road Safety Authority (RSA) to consider the potential impact of a move to CET on road traffic collisions. Much of the relevant research comes from empirical papers that have investigated the impact of DST on road traffic outcomes. In this report, we present a systematic review of this evidence-base (Section 3). We also present the first authoritative investigation of the association between DST and road traffic collisions in Ireland (Section 4). In order to allow for a more complete interpretation of the potential impact the

Figure 1: Sunrise and sunset for 2015 (standard time and under the proposed move to CET)

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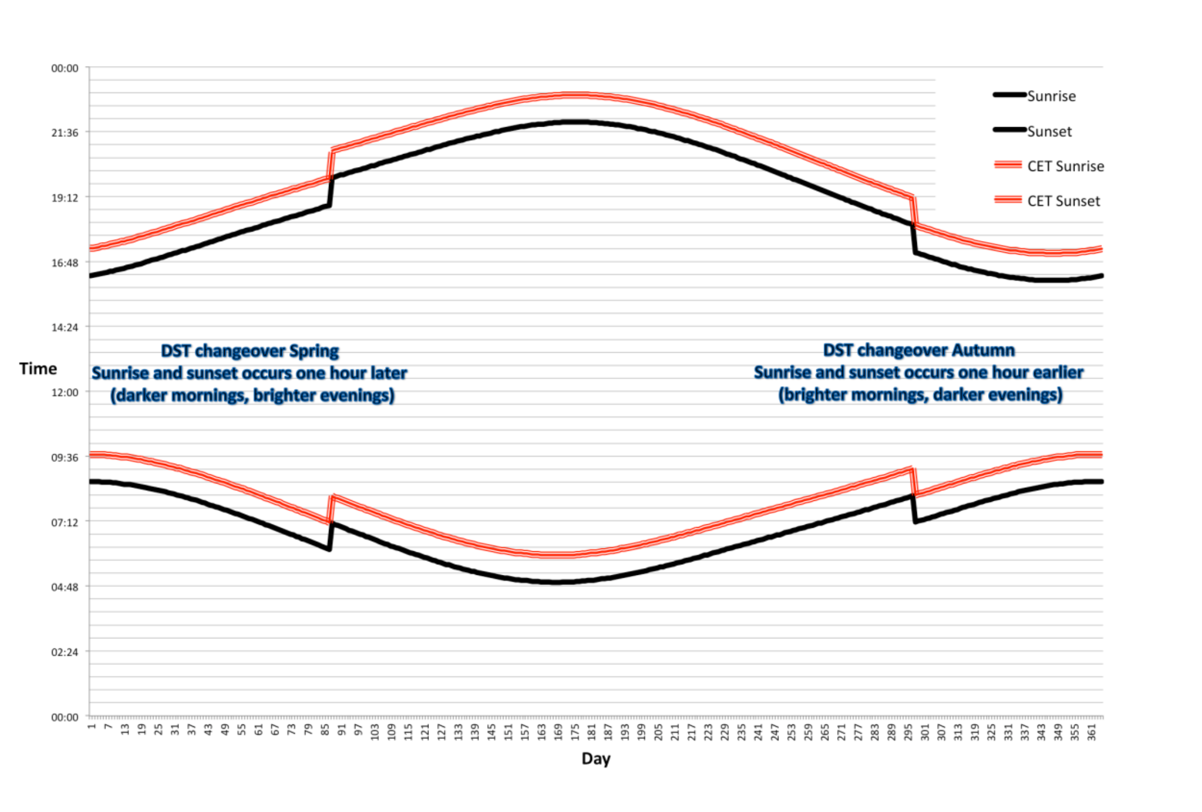
[2] A similar Private Member's Bill is being considered in the UK, where this proposed change is often referred to as Single/Double Summer Time (SDST)

[3] See for example, www.oireachtasdebates.oireachtas.ie/debates%20authoring/debateswebpack.nsf/takes/dail2013070500004?opendocument.



Brighter Evenings Bill would have on road traffic collisions, we also present an overview of the contributory factors for collision risk here. The report concludes with a synthesis of the evidence and a set of recommendations for the Road Safety Authority based on this evidence (Section 5).

1.2 The CET argument

Proponents of the move to CET draw on two core sources of evidence on road safety. First, they stress the relationship between light and collision risk. This relationship is complex and thus very difficult to expose to scientific enquiry. However, the best evidence would suggest that light, or the absence of light, is rarely the only cause of road traffic collisions.

What darkness does, however, is compound other more direct causal factors for road traffic collisions. For example, the best evidence would suggest that driver performance deteriorates under poorer lighting conditions, due, in part, to diminished visual reaction times and impeded ability to process core information like critical stopping distances. The collision is caused by driver error, error that can occur under both ambient and dark conditions, but which is compounded under the latter. [4] Similarly, light can interact with environmental factors, like rain, frost and snow, to inflate crash risk.

[4] See for example, Plainis, S., Murray, I.J., & Pallikaris, I. G. (2006). Road traffic casualties: understanding the night-time death toll. *Injury Prevention*, 12 (2): 125-128.

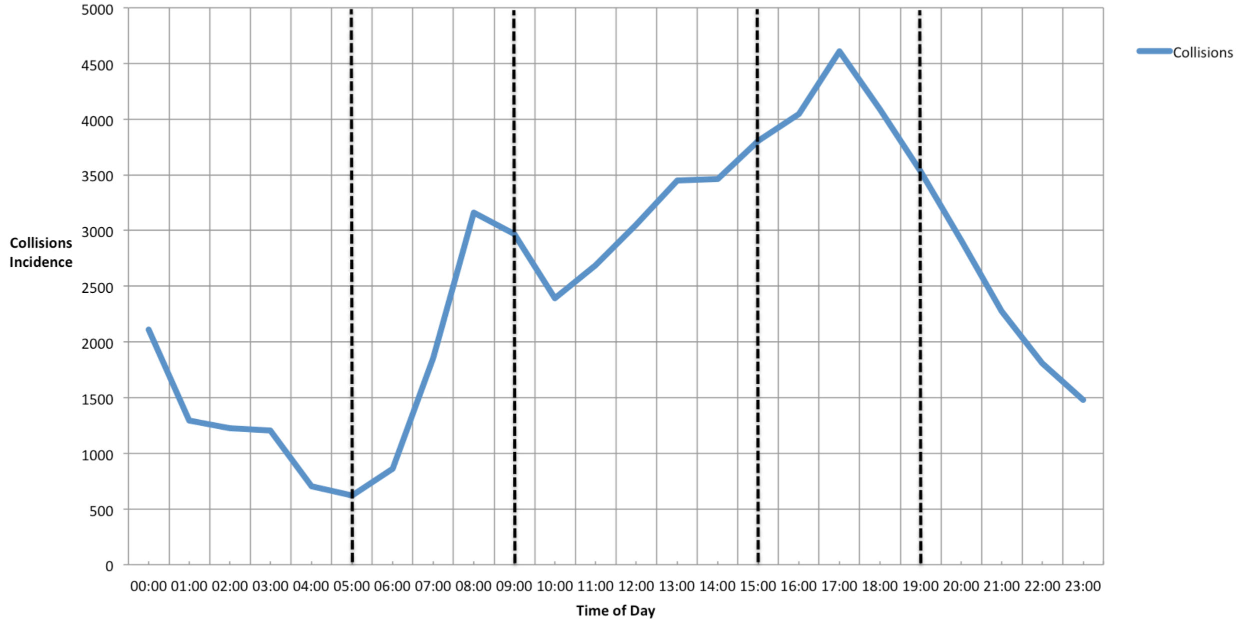


Figure 2: Road traffic collisions (fatal, serious and minor) across the day, 2003-2012

The second facet of the CET argument is that it would involve transferring an hour of daylight from the morning, when there are fewer casualties, to the afternoon/evening, when the risk of collisions and casualties is greatest. The Royal Society for the Prevention of Accidents (RoSPA), in the UK, recently concluded that this would lead to an overall net reduction in collisions, casualties and fatalities - particularly during the autumn and winter when the evenings are darker and weather conditions less favourable for road users.

RoSPA further argued that shifting risk from evening to morning could benefit drivers who tend to be 'tired after a day's work', children 'who go straight to school in the morning but often digress on their way home' and adults socialising after work. Overall, they predict that there will be 'a slight increase in the morning accident peak, but this would be more than offset by the reduction in the higher evening peak'.[5]

To some extent, there is evidence that supports the basic elements of this argument. Figure 2 illustrates the incidence of road traffic collisions across the 24 hours of the day in Ireland for the years 2003-2012. In line with patterns from the UK, collision rates peak between 08:00 and 10:00 and again between 15:00 and 17:00. Importantly, the evening incidence exceeds that of the morning. To the extent that this difference is due to light, shifting light from the morning to the evening should, theoretically, lead to a reduction in RTCs, and this effect should be more notable during the winter months when evenings are darker and weather is poorer (see Figure 3).

The overall trends relating to collisions across the day and year appear, at first glance at least, to support some of the core assumptions behind the CET argument. However, the extent to which collision risk is actually impacted by shifting light and time is unclear and very difficult to estimate. It is also relevant to note that the debate on CET has not considered, in any great depth, the

[5] RoSPA. (2014). *Single Double British Summertime Factsheet* (March), p. 1. Retrieved on-line from http://www.rospa.com/rospaweb/docs/advice-services/road-safety/british-summertime-factsheet.pdf

potential impact of such a move on vulnerable road users -– and in particular on children, the elderly, cyclists and pedestrians. There is also very little appreciation for the complex factors that contribute to the increased crash risk during evening periods, including driver fatigue, increased traffic flow, more varied travel behaviour and patterns compared to morning trips, and greater risk of drink driving.

1.3 Source of evidence on CET and road safety

Two types of evidence have been drawn upon when investigating the potential impact of a move to CET on road safety.

The first is the empirical literature on DST (dealt with in some detail later in this report). DST shifts provide a naturalistic experiment that can yield estimates as to the association between light and collisions. Particularly in the short term (typically 1-2 weeks around the transitions), these estimates can be considered to account for the influence of traffic flow and weather, which are believed not to change significantly over short periods of time. Longer term studies, between 3 and 13 weeks around the transition, may also provide insights here, provided other explanatory variables like traffic flow have been statistically controlled for.

The second type of evidence is a small number of papers that have examined traffic collisions before, during and after the British Standard Time experiment that occurred between 1968 and 1971 in the UK and Ireland. During these years, the clocks remained in summertime throughout the year. Road collision data is available for the UK during this period and this has allowed researchers to compare collision rates for these years against those during which GMT was observed. Three studies that examined the impact of the experiment on road safety concluded that a move to CET (Single/Double Summer Time) would result in fewer fatalities and injuries.[6]

Broughton and Stone, who produced the most authoritative study on the likely effects on road collisions of adopting Single/Double Summer Time (SDST, i.e. CET) year-round, concluded that a move to CET would have 'potential savings' for pedestrians and vehicle occupants, with an overall reduction in fatalities of 2.6-3.4% and reduction in serious injuries of 0.7%. However, most of the UK studies on CET are based on data derived from the 1968-1971 British Summer Time (BST) experiment. As noted by the Transport Research Laboratory, 'conditions have changed since the end of the experiment and the results cannot be applied directly to current conditions' (p. 3).

[6] Broughton, J., & Stone, M. (1998). *A new assessment of the likely effects on road accidents of adopting SDST*. TRL Report 368; Broughton, J., & Stedman. (1989). *The potential effects on road casualties of Double British Summer Time*. TRL Report RR228; TRRL. (1970). *British Standard Time and road casualties* (1970). TRRL Leaflet.

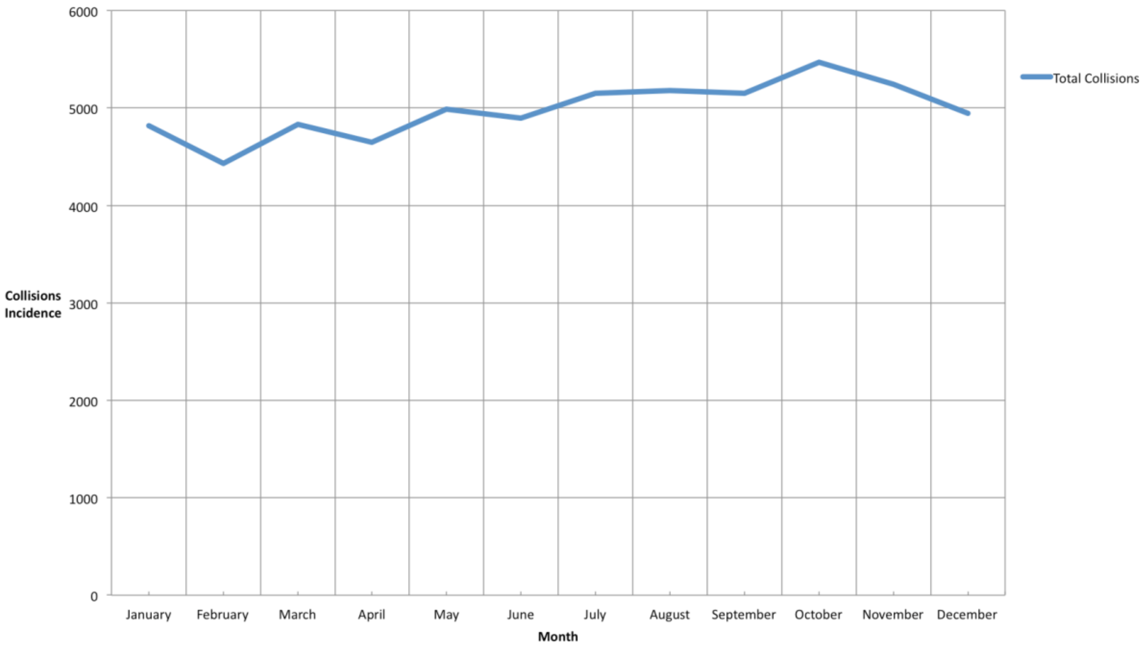


Figure 3: Incidence of collisions across the year, 2003-2012

1.4 Methodology

The objective of this report is to consider what impact the *Brighter Evenings Bill*, if passed, could have on road safety in Ireland. To this end, the current report presents the following:

1. An analysis of the factors implicated in road traffic collisions in Ireland, based on information held in the road collision database for the years 2003-2012. This will illustrate the complexity of the factors implicated in road traffic collisions, and contextualise the analyses reported later. This is reported in Section 2.

2. A systematic review of the relevant evidence from studies conducted in other jurisdictions including the UK, which is also considering a move to CET. This review covered the core empirical literature on the impact of DST on road safety. This is reported in Section 3.

3. An analysis of Irish road collision data from 2003-2012 to examine the impact of DST on road safety. The analysis presented in the report will build on, and go beyond, existing analyses that have been completed by the Road Safety Authority. This is reported in Section 4.

4. Based on the evidence presented in 1-4 above, the report will set out a definitive recommendation on the proposed change to CET - that is, whether or not the available evidence supports a change to CET from a road safety perspective. This is reported in Section 5.

1.5 A note on the Road Collision Database

The Road Safety Authority provided the road collision database for the purposes of examining contributory factors for road collisions in Ireland, and to explore the impact of DST on collisions and injuries. The database is based on CT68 forms completed by members of the Gardaí, which are returned to the RSA in hardcopy and through electronic file transfers. The CT68 is a preliminary report completed in the days after the collision and does not include findings from more in-depth investigation in the case of serious or fatal collisions.

Data from 2003 to 2012 were used, representing 59,755 collisions resulting in 87,660 injuries or fatalities. The penalty points system was introduced in late 2002, and selecting data after this time ensures that the collisions in our analyses better reflects the current road safety climate (i.e. enhances the validity of our analyses). Of particular importance to our analyses of contributory factors were fields relating to time (i.e. day, month, year and hour). Garda opinion on the factors that contributed to each collision was also used to inform this aspect of the report.

Our analysis of DST effects was informed by the analytic strategies used by other experts in the field, and drawing on our systematic review of the empirical literature.

Section 2: Road Traffic Collisions in Ireland

2.1. Introduction

In this section of the report, we briefly discuss risk factors for road traffic collisions (RTCs). The central aim is to illustrate that a) many collisions arise due to interactions between multiple risk factors and b) exposure to these factors is likely to explain variation in the incidence of RTCs over time (day, month and year). The discussion forms an important backdrop to CET debate, as it illustrates the complex nature of RTCs and manages expectations about the extent to which a change to CET can impact on road safety.

2.2 Contributory factors for RTCs

RTCs can occur due to a wide range of contributory factors. There have been two dominant approaches to understanding and responding to these risk factors. The first is to take a uni-factor approach, isolating each factor in turn and considering how best to mitigate its impact on collision risk.

For example, the best evidence suggests that human factors are the largest contributory factor to RTCs and injuries. Focus has been on a number of 'killer driver behaviours' that include driving while fatigued, drink driving, drug driving, being distracted while driving, speeding, and not wearing a seat belt. In the US, for example, some form of driver error is implicated in almost half (44%) of all collisions that led to fatalities.[7]

Less commonly, road design is viewed as being the primary contributory factor in collisions, with some research pointing to increased crash risk associated with inappropriate curve radius, road width, road markings, transitions from road to intersections, road-side developments and sight distances. Consequently, in recent times, traffic safety has been a central concern for planners and designers and this has led to a reduction in RTCs in some high-risk areas.[8]

Research also points to the links between broader environmental factors and RTCs. Here the focus has primarily been on weather, with studies pointing to the increased risk of collisions posed by sub-freezing road temperatures (e.g. ice) and precipitation (rain, snow and fog), which can reduce the ability of drivers to control their vehicle and obscure their visibility.[9] It has been noted that these risks become even more pronounced during winter months, when winter weather and reduced daylight combine to make driving an even more challenging task.[10]

A second approach to collision risk is more complex and holistic, and views crash risk as arising from multiple contributory factors. A popular way of conceptualising this has been within Treat *et al's* Systems Model, which views collisions as deriving from human factors, vehicle factors or

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[7] National Cooperative Highway Research Programe (2012). *Human Factors Guidelines for Road Systems*. Report 600. Retrieved from http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_600Second.pdf .

[8] See for instance, Hendricks, D. L., Fell, J. C., & Freedman, M. (2001). *The relative frequency of unsafe driving acts in serious traffic crashes*,National Highway Traffic Safety Administration. Retrieved from http://www.nhtsa.gov/people/injury/research/udashortrpt/documentation_page.html.

[9] See for instance, Koetse, M.J. and Rietveld, P. (2009). The impact of climate change and weather on transport: an overview of empirical findings. *Trasnportation Research Part D*, 14, 201-205.

[10] Edwards, J. B. (1999). Speed adjustment of motorway commuter traffic to inclement weather. *Transportation Research Part F*, 2, 1-14.

environment factors.[11] This is illustrated in Figure 4. From this perspective, a collision can be conceptualised as occurring due to unique and non-overlapping factors (as above), or to interactions between these factors (overlapping components).

This systems approach to understanding collision risk better reflects the complex aetiology of collisions. While an environmental factor such as icy roads may be viewed as a key contributory factor for collisions, for instance, the collision may occur on roads that are overshadowed and slow to thaw. The collision may only arise, however, in the presence of a judgment error by the driver where he/she selects an inappropriate speed for the road and weather conditions, misinterprets time-to-collision, or is too close to the car in front, etc. This may be further compounded when the event occurs in darkness, during heavy traffic volumes, and on unlit roads.

We examined contributory factors for RTCs based on information held in the road collisions database. Here, opinions are formed by a member of the Gardaí as to whether or not the collision was due to one or more contributory factors. The Garda can also identify which factors (driver behaviour, pedestrian behaviour, road conditions, environmental conditions and/or vehicle conditions) played a role in each collision. It should be stressed that these forms are completed during an initial assessment of a collision based on opinion and are unlikely to capture the complexity of the interactions between contributory factors.

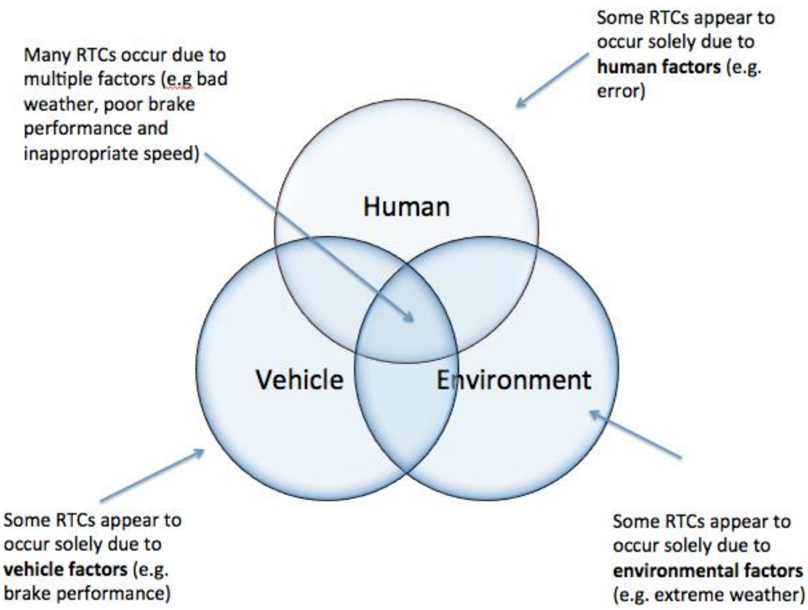

Figure 4: Unique and overlapping (interacting) factors that can contribute to RTCs

[11] Treat, J. R., Tumbas, N. S., McDonald, S. T., Shinar, D., Hume, R. D., & Mayer, R. E. (1977). *Tri-level study of the causes of traffic accidents* (Vol. Volum 1). Retrieved from: http://deepblue.lib.umich.edu/handle/2027.42/64993

In more than half (57.7%, n=33,426) of the collisions there was a 'single contributory factor' identified, with no single contributory factor identified for the remainder of the collisions.[12] When asked to report which factors were implicated in the collisions, the Gardaí provided information on 35012 collisions. Table 1 summarises the opinions of the Gardaí, with percentages based on all collisions (n=59,755) and only for collisions where the Garda formed an opinion (n=35012). Based on all collisions, 42.2% of these were attributed 'largely' to the behaviour of the drivers involved. In 10.8% of cases driver behaviour was, to some extent, implicated in the collisions (see Table 1). The next most dominant contributory factor was pedestrian behaviour, which was implicated to a large extent in 3.8% of collisions, and implicated to some extent in 1.3% of collisions. These results are in line with a report on factors that contributed to collisions on national roads, commissioned by the NRA, and based on data for the period 2007-2010.[13]

Information on the frequency with which multiple factors are responsible for collisions is also presented in Table 1. Information is only presented for collisions where the driver was largely at fault, as other combinations resulted in very low incidence. Again, it is important to stress that these findings are based on a Garda's initial assessment, and are provided here for illustrative purposes only.

Table 1: Contributory factors for RTCs in Ireland, 2003-2012 (Serious, fatal and minor collisions)

	n	% All collisions n=59,755	Opinion Formed n=35,012
"Largely to blame"			
Driver	25202	42.2	72.0
Pedestrian	2272	3.8	6.5
Environment	414	0.7	1.2
Vehicles	85	0.1	0.2
Road	778	1.3	2.2
"Somewhat to blame"			
Driver	6461	10.8	18.5
Pedestrian	769	1.3	2.2
Environment	407	0.7	1.2
Vehicles	34	0.1	0.1
Road	640	1.1	1.8
Multiple L=Large, S=Some			
Driver (L), Pedestrian (S)	62	0.1	0.2
Driver (L), Road (S)	137	0.2	0.4
Driver (L), Vehicle (S)	9	0.0	0.0
Driver (L) Environment (S)	106	0.2	0.3

[12] This is based on 57,962 collisions, with no data for 1793 collisions.
[13] Risk Solutions. (2012*). Contributory factors analsis for road traffic collisions: A report for the National Roads Authority, Ireland*. Risk solutions: Warrington UK. Retrieved from: http://www.nra.ie/safety/research/irish-collision-data-revi/Collision-Contributory-Factors.pdf

2.3 Exposure to contributory factors over time

Fluctuations in the incidence of road traffic collisions over time are reflective of fluctuations in the extent to which contributory factors for collisions are at play. As illustrated in Figure 5 (below) there has been a marked decrease in RTCs from 1996-2012. This is likely to reflect positive changes in driver and pedestrian behaviour, road safety legislation (e.g. mandatory alcohol testing), the positive impact of road safety campaigns by the RSA and improvements in vehicle safety and road design over that period – all of which can be considered contributory or protective factors in road crash risk.

Figure 6 illustrates the changes in RTCs across the months of the year, based on the data for 2003-2012. In this figure, the incidence for each month refers to the total number of collisions that occurred in that month for the full 10 years. In line with past research, there is an apparent increase in collisions during the winter months, which tends to be attributed to a combination of poorer weather, shorter days (poorer light) and poor evening driving conditions. There are also month-to-month changes. For example, there is a drop in collisions in February, and this appears to be the safest month on the roads. There are also apparent decreases in collisions in the months after the transitions (April and November). However, both transition months, and February, have less than 31 days. When statistically compensated for, the trend is less obvious – as are the broader month-to-month fluctuations.[14]

RTCs across the days of the week were also examined. The highest incidence of collisions occurred on Fridays, Saturdays and Sundays. This has implications for our analyses of DST effects later in this report, when we test the effects in weekly blocks across 10 years, having aligned the yearly data by weekday around the transition points.

We looked at the incidence and severity of collisions (fatal vs. non-fatal) across the two periods of the week (weekday vs. weekend). 5.8 percent of collisions that occurred at the weekend were fatal, in comparison to 3.8% of weekday collisions. Expressed as an odds ratio, a collision that occurred at the weekend was 1.6 times more likely to be a fatal collision than a collision at the weekend.

Figure 7 plots the incidence of RTCs across 24 hours. As illustrated in the graph, there is a notable peak in collisions in the morning, with the upward trend commencing after 05:00, and waning after 09:00. In the evening, the peak occurs after 15:00 and diminishes after 19:00. Traffic volumes from one site on the M50 motorway, based on NRA data for 112 days in 2012, are also plotted.[15] The traffic data is for average hourly volumes (both directions) on weekdays. As illustrated, from the period from 5:00 to 19:00, there is a strong association between collisions and traffic volume,[16] which supports a large body of research suggesting that a primary contributory factor to RTCs is traffic volume.[17] The association is less obvious during the early morning period, suggesting that factors other than, or at least in addition to, traffic volume are implicated. It is relevant to note that

[14] For each month with less than 31 days, we calcualted the average daily collision rate for that month based on the 2012 statistics and used this as a crude day-weighting across the 10 years. For example, there were 470 collisions in June in 2012, or approximately 16 per day. Adding 16 extra collisions to the 2012 data for June, and 160 collisions across the 10 years for the month of June, allows us to compensate for the fact that June will tend towards lower collisions simply because it has fewer days during which a collision can occur.

[15] This is from the Tymon M50-17a, year 2012, for 121 days of data. We have utilsied the 'weekdays' data here. The data is available at https://nraaudit.nra.ie/CurrentTrafficCounterData/html/M50-17a.htm

[16] We calculated this through binary logistic regression. The 95% Confidence Intervals are 1.44 and 1.69.

[17] The association between collision incidence and traffic volume for the 24 hours is 'large' (r=.82, p<.01).

the time of sunrise and sunset is not considered to be a core determinant of traffic volume – which is determined by purpose (e.g. work and school start and end times and other routine behaviours).

2.4 Conclusion

The purpose of this brief review of the contributory factors for RTCs is to illustrate the complex nature of these collisions. This has implications when considering the potential value of moving to CET, which is overly focused on light as a dominant contributor to RTCs. The World Health Organisation has noted that both academics and road safety practitioners often make the mistake of approaching crash-prevention through uni-factor risk models. The focus tends to turn to any one of the multiple factors that contribute to RTCs, often to the exclusion of other factors. In reality, RTCs are complex events, linked to a range of contributory factors that interact to determine overall crash risk.

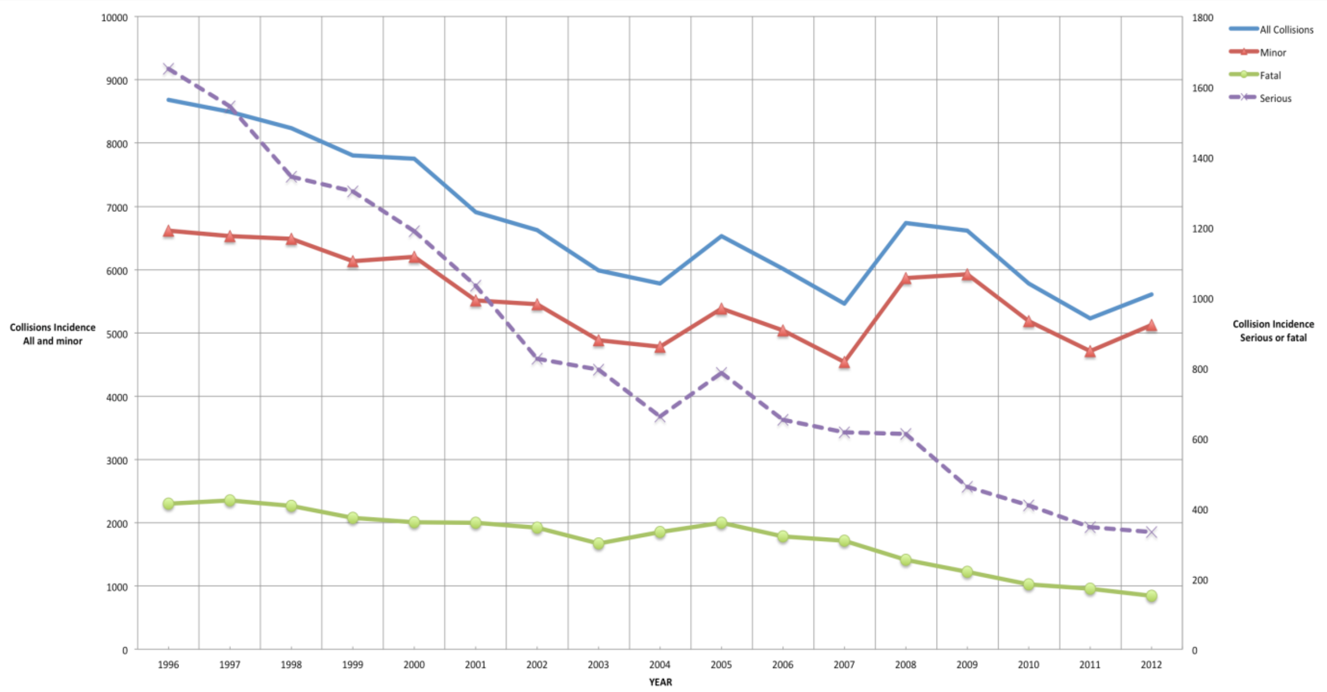

Figure 5: Incidence of collisions (and for minor, fatal and serious collisions) by year, 1996-2012

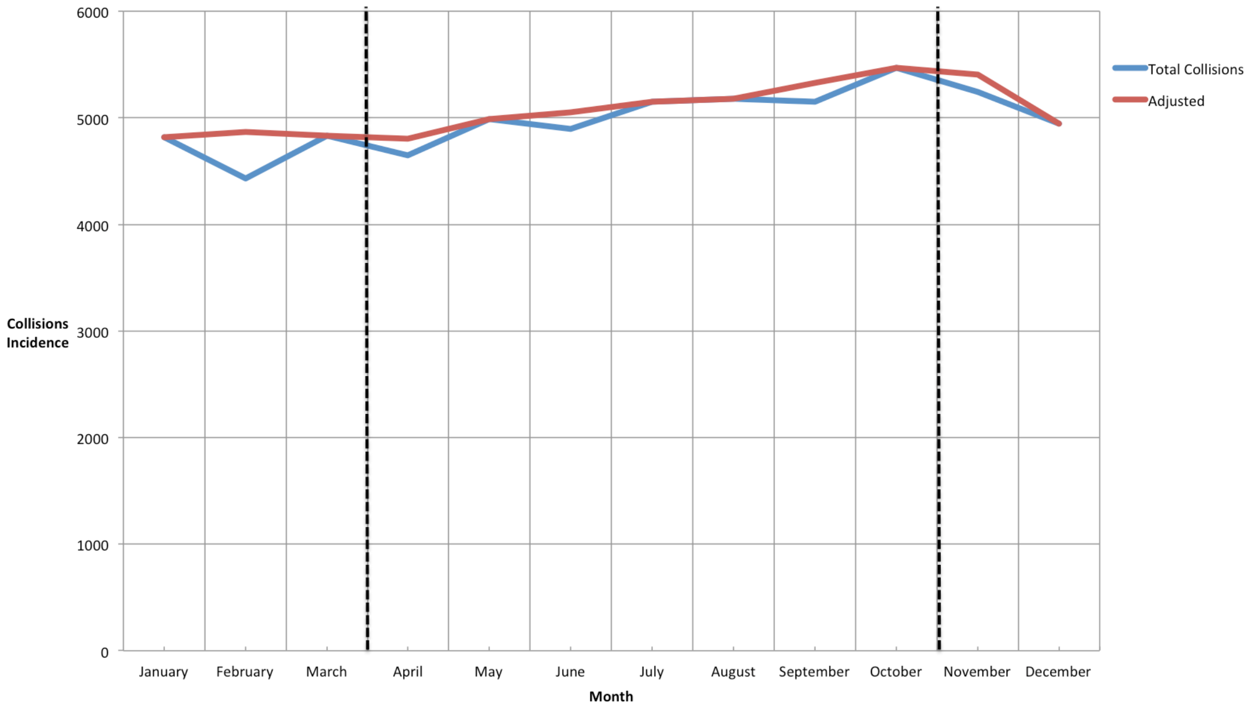

Figure 6: Incidence of collisions by month, 2003-2012, with DST transition days indicated

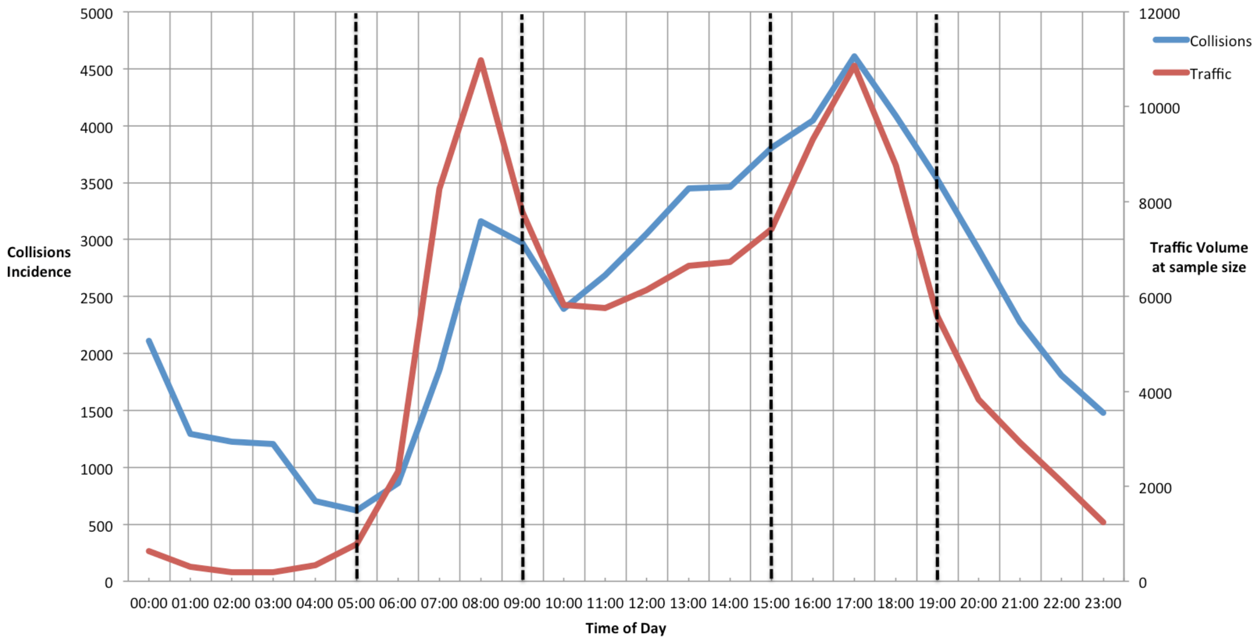

Figure 7: Incidence of collisions across day, 2003-2012, with traffic counter data from NRA sample site and peak collision periods indicated.

Section 3: A systematic review of impact of DST on road safety

3.1 Introduction and Overview

Several studies have empirically investigated the impact of DST on road safety. However, these studies have taken place in different jurisdictions, focused on short and/or long-term effects and used a variety of statistical and methodological approaches. Attempting to extrapolate key lessons from this literature base, then, can be difficult.[18] This section of the report summarises the findings of the first systematic review of the literature relating to the impact of DST on road safety.

In executing the systematic review, we followed recommendations from the Cochrane Collaboration.[19] Studies were included in the review if they provided a quantitative analysis, using primary data, of the effect of DST on road safety-related outcomes. Papers were identified through an electronic search of ten online databases. A number of road safety organisations were also contacted, via the Irish Road Safety Authority, and asked to forward information on papers relating to DST.

Full details of our methodology, including search strategy and data extraction form, are available in Technical Appendix 1. In summary, the database search and information from national and international stakeholders in the road safety arena led to the identification of 1120 papers, 1049 of which were excluded based on title/abstract screening. Full text reviews were conducted on 71 papers, 23 of which met the study inclusion criteria. This review is based on these 23 empirical papers on DST and road traffic collisions (RTCs).

3.2 Review Questions

The review addressed the following research questions:

a) What is the impact of DST on road traffic collisions, injuries and fatalities?
b) What is the impact of DST on road traffic collisions, injuries and fatalities for different types of road users (e.g. vehicle occupants vs. pedestrians)?
c) What is the impact of DST on morning and evening risk?
d) What is the magnitude of the change in risk (if any) resulting from the onset and ending of DST?

[18] More problematic than the variation in findings, however, is that many of the empirical studies have had significant methodological weaknesses and limitations in statistical approaches and inappropriate extrapolation of short term effects to long term benefits/harm. For more on this, see Stevens, C. R., & Lord, D. (2006). Evaluating safety effects of daylight savings time on fatal and nonfatal injury crashes in texas. *Transportation Research,* 147-155. doi: 10.3141/1953-17

[19] Higgins JPT, Green S, eds. *Cochrane handbook for systematic reviews of interventions*. Version 5.1.0. 2011. www.cochrane-handbook.org.

3.3 Findings

Study Characteristics

Tables 2 and 3 provide summary information on the studies included in the review. Data for a majority of studies (74%) were from the USA, with 9% of studies based on DST in the UK. The included DST studies also examined road safety in Canada, Finland, Israel, and Sweden. Years captured in the analyses ranged from 1973 to 2011. As noted earlier in this report, there have been changes in driver behaviour, road design, vehicle innovation and traffic volume over time and findings based on earlier data will have less predictive validity when generalising to current risks.

Sixteen of the included studies (70%) investigated the short-term effects of DST by examining the period immediately (two weeks or less) before and after the shift. Of these papers, 50% focused on the effects of sleep disruptions caused by the DST shift, 25% focused on light levels and 25% looked at both sleep and light.

Eleven of the studies (48%) examined the overall or long-term effects of DST,[20] focusing on changes in light levels that result from DST. Their timeframes ranged from 3 to 13 weeks around the DST transition.

A minority (31%) of the short-term analyses distinguished between morning and evening risk, while a majority (55%) of the long-term analyses did so. Conversely, almost all (94%) of the short-term analyses separated spring from autumn transitions, while less than half (45%) of the long-term studies made this distinction. Nine of the 23 studies provided analyses by road user (e.g. pedestrian vs. motor vehicle user). Overall outcomes included road traffic collisions, injuries and fatalities.

What is the impact of DST on road traffic collisions, injuries and fatalities?

Short-term Impact: Of the studies that examined the short-term (0-2 weeks) impact of DST transitions, the picture emerging is complex, with inconsistent findings across studies and depending on season (spring vs. autumn). An overall increase in collision risk, irrespective of season, was observed among 31% of short-term studies. These effects tended to be short, with one study reporting a return to baseline two weeks after the transition.[21] A further 31% of short-term studies reported no measurable/significant effects.[22]

In some of the studies the impact of transitioning *into* DST (i.e. the spring shift) was found to have a negative impact on road safety. During the spring transition, a 23-hour day occurs, creating a 'missing' hour and leading to sleep loss. This may have a negative impact on sleep quality for up to two weeks after the transition. However, again the findings did not hold across all studies, with 38% of short-term analyses revealing no impact, and a further 19% reporting *reductions* in collisions

[20] Note that 4 studies examined both short- and long-term effects, and these analyses were treated separately in the synthesis.
[21] Hicks, R. A., Lindseth, K., & Hawkins, J. (1983). Daylight saving-time changes increase traffic accidents. *Perceptual & Motor Skills, 56*, 64-66.
[22] For example, Lahti, T., Nysten, E., Haukka, J., Sulander, P., & Partonen, T. (2010). Daylight saving time transitions and road traffic accidents. *Journal of environmental and public health, 2010*, 657167-657167. doi: 10.1155/2010/657167; Lambe, M., & Cummings, P. (2000). The shift to and from daylight savings time and motor vehicle crashes. *Accident Analysis and Prevention, 32*(4), 609-611. doi: 10.1016/s0001-4575(99)00088-3

during the spring transition. For the autumn transition back to standard time (ST), the impact was more likely to be either negative or result in no change.

It is worth noting that a majority of these short-term studies focus on the effects of sleep deprivation, particularly during the spring transition, and thus they may be of limited use in understanding the potential impact of a move to CET.

Long-term Impact: Eleven of the 23 studies examined the overall or longer-term impact (>2 weeks) of DST on road safety outcomes. All of these studies reported a reduction in collisions, injuries and fatalities associated with DST. The magnitude of this effect, though hard to estimate given the variability in study approaches and analyses, tended to be small.

Huang and Levinson, for example, report that 'a day in DST, all else equal, is associated with about 0.09% fewer crashes than a day in ST [standard time]'.[23] Meyerhoff reported a net reduction of 0.7% of fatal collisions during 2 months in DST, compared to 2 months in ST, and little overall impact of DST in winter months.[24]

Importantly, there was an observed increase in collisions during the morning hours in DST (although not in all studies; see Meyerhoff, 1978), but it was noted that the overall benefit to road safety tended to outweigh the morning risks.

Several studies extrapolated from the findings of their analyses to the impact of retaining DST year-round. The estimated effects approximated 13%[25] or 727[26] fewer pedestrian fatalities, and 3%[27] or 174[28] fewer vehicle occupant fatalities.

What is the impact of DST on road traffic collisions, injuries and fatalities for different types of road users (e.g. vehicle occupants Vs pedestrians, etc.)?

A number of studies focused on one population only, or broke their analysis down by road user type. In general, the evidence would suggest that pedestrians, in particular, benefit from DST.

Of the 9 studies that analysed DST effects on different types of road users, the beneficial effects of DST were most pronounced for pedestrians. The collision risk posed to pedestrians following the transition back to ST was found to be greater than that for motor vehicle occupants. Ferguson *et al*, for example, reported a much greater collision risk for pedestrians than for motor vehicle occupants, following the transition from DST to ST. Specifically, they found the change from daylight to twilight to be associated with a 300% increase in fatal collisions involving pedestrians. Of the 901 fewer fatal collisions they estimate would have occurred from 1987 to 1991, had DST operated year-

[23] Huang, A., & Levinson, D. (2010). The effects of daylight saving time on vehicle crashes in Minnesota. *Journal of Safety Research, 41*(6), 513-520. doi: 10.1016/j.jsr.2010.10.006
[24] Meyerhoff, N. J. (1978). The influence of daylight saving time on motor vehicle fatal traffic accidents. *Accident Analysis and Prevention, 10*(3), 207-221
[25] Coate, D., & Markowitz, S. (2004). The effects of daylight and daylight saving time on US pedestrian fatalities and motor vehicle occupant fatalities. *Accident Analysis and Prevention, 36*(3), 351-357. doi: 10.1016/s0001-4575(03)00015-0
[26] Ferguson, S. A., Preusser, D. F., Lund, A. K., Zador, P. L., & Ulmer, R. G. (1995). Daylight Saving Time and Motor Vehicle Crashes: The Reduction in Pedestrian and Vehicle Occupant Fatalities. *American Journal of Public Health, 85*(1), 92-95
[27] Coate & Markowitz, Note 23.
[28] Ferguson et al, Note 24.

round, 727 of these would have involved pedestrians, while 174 would have involved motor vehicle occupants.[29]

Further, Sullivan and Flannagan found pedestrian collision fatalities to be 3 to 6.75 times more likely in darkness (during ST), compared to in daylight (during DST), whereas this difference was only marginal for other collision types. They concluded that the risk posed by darkness, relative to light, is greater for pedestrians than for any other road user.[30]

Sood and Ghosh reported an overall long-term reduction in collisions involving both pedestrians (8 to 11%) and motor vehicle occupants (6 to 10%). They noted that the saving in collisions peaked in the third (for pedestrians) and fourth (for motor vehicle occupants) weeks after DST onset.[31]

Again, however, the impact of DST on pedestrian risk may differ from morning to evening. Coate and Markowitz estimated that year-round DST would reduce pedestrian fatalities in the evening by one-quarter, but increase those in the morning by one-third. They conclude that, since pedestrian activity is higher in the evening compared to the morning, year-round DST would reduce overall pedestrian fatalities by 13%.[32]

3.4 Limitations of the DST Literature

While all included studies provided a quantitative analysis of effect, there was large variation in terms of focus, scope and analytic strategy. More than half the included studies focused on the short-term effects of DST transitions, most of which investigated the impact of sleep deprivation on road safety. As mentioned earlier, this literature is limited in the extent to which it informs our understanding of the potential long-term impact of a move to CET.

Of those studies that examined the long-term effect of DST, a diverse range of statistical approaches were adopted and a range of assumptions were made. Consequently, we did not statistically combine findings through meta-analysis, and cannot therefore estimate the overall magnitude of the effect.

Finally, in terms of the risk posed to different groups of road users, given the small number of studies that examined this, our findings relating to increased pedestrian risk should be interpreted cautiously.

3.5 Conclusions

DST transitions were associated with a short-term increase in road traffic collisions, though this finding varied considerably from study to study, and was predominantly attributed to sleep deprivation effects associated with the spring transition. The overall impact of DST was positive (i.e. risk-reducing) in all 11 long-term studies, although the magnitude of this impact was often small. A relatively small number of studies reported that pedestrians, in particular, benefit from DST and

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[29] Ferguson et al, Note 24.

[30] Sullivan, J. M. (2001). *Characteristics of pedestrian risk in darkness*. Transportation Research Institute. Retreived from: http://deepblue.lib.umich.edu/bitstream/handle/2027.42/49450/UMTRI-2001-33.pdf?sequence=1&isAllowed=y; Sullivan, J. M., & Flannagan, M. J. (2002). The role of ambient light level in fatal crashes: Inferences from daylight saving time transitions. *Accident Analysis and Prevention, 34*(4), 487-498

[31] Sood, N., & Ghosh, A. (2007). The short and long run effects of daylight saving time on fatal automobile crashes. *The BE Journal of Economic Analysis & Policy, 7*(1)

[32] Coate & Markowitz, Note 23.

may further benefit from a move to year-round DST. There were also considerable limitations to the DST literature, as noted in Section 3.4.

The implications of these findings for this report are as follows:

1. There is a need to distinguish between the impact of the spring transition and the autumn transition.

2. Both short-term and long-term impacts need to be explored. While findings based on longer-term impacts may appear to be most relevant to the *Brighter Evenings* initiative, they are more likely to be influenced by changes in contributory factors other than light, such as traffic volume. Short-term increases in collisions after the spring transition are likely to be influenced, in part, by a detrimental impact on sleep.

3. Short-term effects after the autumn transition, which is not impacted by sleep effects, may offer a useful barometer of DST effects. Factors like climate and traffic flow will vary less in the short-term, thus providing a more sensitive test of DST effects.

4. Analyses need to be broken down by road-user type, and in particular deal with the risk to pedestrians, children, cyclists and older people.

Table 1a: Characteristics of papers included: Short-term timeframe

Author (Year)	Country	Year(s)	Focus (sleep/light)	By season	By time of day	Population/ Outcome	Timeframe (short Vs long)
Askenasey (1997)	Israel	1994-1996	Sleep	✓		All collisions	2 weeks before & 2 weeks after
Conte (2007)	USA	1987-2006	Sleep	✓		All collisions excluding pedestrians	2 weeks before & 2 weeks after
Coren (1996)	Canada	1991-1992	Sleep	✓		All collisions	1 week before, week of, & 1 week after
Crawley (2012)	USA	1976-2010	Sleep and light	✓		All collisions	Monday before and after
Green (1980)	UK	1975-1977	Light	✓	Evening Only	All collisions	5 days before & after and 10 days before and after.
Hicks (1998)	USA	1989-1992	Sleep	✓[33]		All alcohol-related fatal road traffic collisions	1 week before & 1 weeks after
Hicks (1983)	USA	1976-1978	Sleep	✓		All collisions	1 week before & 1 week after
Huang (2010)	USA	2001-2007	Sleep and light	✓	✓	All collisions & fatal collisions	First day (Sunday) of time change compared with other Sundays
Lahti (2010)	Finland	1981 - 2006	Sleep	✓		All collisions	1 week before & 1 week after
Lambe (2000)	Sweden	1984 - 1995	Sleep	✓		All collisions	Monday before & after, & one week after
Meyerhoff (1978)	USA	1973-1974	Light	✓	✓	All fatal collisions	Morning and evening on day of transitions in 1974 (DST) and 1973 (No DST)
Smith (2014)	USA	2002-2011	Sleep and light	✓	✓	All fatal collisions	Unclear
Sood (2007)	USA	1976-2003	Sleep and light	Spring only		Fatal collisions: Pedestrians and motor vehicle occupants.	Monday before, Monday of, and Monday after.
Stevens (2005)	USA	1998-2000	Light	✓	✓	Fatal & nonfatal collisions involving pedestrians and motor vehicle occupants	5 working days before & after.
Varughese (2001)	USA	1975-1995	Sleep	✓		All fatal collisions	Saturday/Sunday and Monday of the transition vs. same days for the week before and after.
Whittaker (1996)	UK	1983-1993	Light	✓	✓	Casualties: vehicle occupants, cyclists, pedestrians, children	1 week before & 1 week after

[33] Spring and autumn transition data were combined as not statistically different from one another

Table 2b: Findings: Short-term timeframe (read in conjunction with Table 2a)

Author (Year)	Finding (in narrative form)
Askenasey (1997)	Significant decrease in RTCs after change back to ST (autumn; attributed to sleep benefits). Technically a significant increase in RTCs after change to DST (spring) - however, 'within the chain of day-to-day increases the alleged effect of DST became non-significant'.
Conte (2007)	Overall (combined spring & autumn) significant differences in mean daily RTCs between DST adjusted and DST unadjusted Mondays (DST 'seems to increase the number of traffic accidents')
Coren (1996)	The spring DST shift resulted in an average increase in RTCs of approximately 8%, whereas the autumn shift resulted in a decrease in RTCs of approximately the same magnitude.
Crawley (2012)	Statistically insignificant short-term effects of DST
Green (1980)	Based on 5-day comparison, reduction of 31% in RTCs in March (spring) and increase of 64% in October (autumn). Less marked findings for 10-day data.
Hicks (1998)	Alcohol-related fatalities increased significantly in the first week after the DST transition (spring and autumn combined as not different), although this returned to baseline by the second week.
Hicks (1983)	Regardless of season of the year, DST change was associated with a significant increase in RTCs during the post-change weeks.
Huang (2010)	Short-term effect of DST on crashes on the morning of the first DST is not statistically significant.
Lahti (2010)	Transitions into and out of DST did not significantly increase the amount of traffic accidents.
Lambe (2000)	The shift to and from DST did not have measurable effects on RTC incidence.
Meyerhoff (1978)	DST reduced fatal RTCs by approximately 1% during several weeks at spring and autumn transitions. This effect was attributed to the spring transition, with little change during the autumn transition.
Smith (2014)	5.4-7% increase in fatal RTCs immediately following spring transition. No impact in autumn.
Sood (2007)	No short-term effect, having controlled for trends in collisions trends within and across years.
Stevens (2005)	The immediate impact of DST, both spring and autumn, is negative, but is particularly marked for autumn transition. An increase in daylight results in a decrease in the number of collisions involving pedestrians.
Varughese (2001)	In spring, there was a small significant increase in fatal RTCs on Monday from 78.2 to 83.5 (no impact on Saturday or Sunday). In autumn, a significant increase was found in fatalities for Sunday from 126.4 to 139.5 (no difference for Saturday or Monday).
Whittaker (1996)	Overall net reduction in casualty numbers for British Standard Time (BST) periods compared to GMT. Onset of BST in spring associated with reductions in casualty numbers of 6% in morning & 11% in evening. No rise in casualties with the darker mornings. Reductions were maximal in the pedestrian (36%), cyclist (11%), and schoolchild (24%) subgroups. The change back to GMT in autumn produced an anticipated reduction (6%) in casualties in the lighter mornings. Darker evenings associated with significant increases in casualties (4%), mainly vehicle (5%) and pedestrian (8%).

Table 3a: Characteristics of papers included: Long-term timeframe

Author (Year)	Country	Year(s)	Focus (sleep/light)	By season	By time of day	Population/Outcome	Timeframe (short vs. long)
Chu (1976)	USA	1974	Light	Jan-March only	✓	All fatalities	Three months
Coate (2004)	USA	1998 and 1999	Light	✓	✓	Fatalities: Pedestrians & motor vehicle occupants	One month before & one month after
Crawley (2012)	USA	1976-2010	Both sleep and light	✓		All collisions	Thirteen weeks before & nine weeks after. Also comparison of 1987-2003 to 1976-1986
Ferguson (1995)	USA	1987 - 1991	Light	✓	✓	Fatal collisions: Pedestrians & motor vehicle occupants	Thirteen weeks before & nine weeks after
Huang (2010)	USA	2001-2007	Both sleep and light	✓	✓	All collisions and fatal collisions	8 weeks before & after
Meyerhoff (1978)	USA	1973-1974	Light	✓	✓	All fatal collisions	Jan-Feb and March-April 1974 (DST) and Jan-Feb and March-April 1973 (No DST) (long-term).
Sood (2007)	USA	1976-2003	Both sleep and light	Spring only		Fatal collisions: Pedestrians and motor vehicle occupants.	13 weeks before & 8 weeks after
Sullivan (2003 & 2004)	USA	1987-2001	Light	Autumn only	Evening only	Fatal collisions: Motor vehicle occupants only	5 weeks before & after
Sullivan (2002)	USA	1987-1997	Light	✓	✓	Fatal collisions: Pedestrians and motor vehicle occupants	9 weeks before and after
Sullivan (2001)	USA	1987-1997	Light		Evening only	Fatal collisions: Pedestrians	3 weeks before and after
Sullivan (2007)	USA	FARS=1987-2004; NCDOT=1991-1999.	Light		Evening only	Fatal & nonfatal collisions: Pedestrian (child, adult, elderly) and motor vehicle occupants	5 weeks before and after

Table 3b: Findings: Long-term timeframe (read in conjunction with Table 3a)

Author (Year)	Finding (in narrative form)
Chu (1976)	Overall estimate of 47 lives saved (8%) in the first half of 1974 that can be attributed to DST. A markedly higher fatality rate during morning rush hour and a markedly lower rate in the afternoon hour.
Coate (2004)	Full year DST would reduce pedestrian fatalities by 171 per year (13%), and motor vehicle occupant fatalities by 195 per year (3%). An hour later sunset would reduce evening pedestrian fatalities by about one-quarter and an hour later sunrise would increase morning fatalities by about one-third. No increased risk to school children from full year DST.
Crawley (2012)	Significant fatal crash-saving effects of DST in the long term, shown particularly in the autumn test (the spring test gave little evidence either way).
Ferguson (1995)	An estimated 901 fewer fatal crashes (727 involving pedestrians and 174 involving vehicle occupants) might have occurred had DST been retained year-round from 1987-1991. Benefits are smallest during the darkest winter months because the evening reduction is increasingly offset by increases during the morning. The most notable effects of changing light levels on fatal crashes were seen when light levels changed from light to twilight (crashes increased) and when twilight changed to light (crashes decreased).
Huang (2010)	DST, all else equal, is associated with fewer RTCs and fatal RTCs for most day parts (except 9am-3pm).
Meyerhoff (1978)	A net reduction of about 0.7% during the DST period, March and April 1974, compared to the non-DST period, March and April 1973, but little net DST effect on fatal accidents in winter. A marked decrease in evening fatalities is observed, but the morning increase is not seen as anticipated.
Sood (2007)	Long-term reduction of 8-11% in RTCs involving pedestrians, and 6-10% in RTCs involving vehicle occupants.
Sullivan (2003 & 2004)	Rear-end collisions change from an average count of about 13 crashes in the light (DST) to an average of 37 in the dark (ST). Impact of light on crash risk varies across rear-end collision types.
Sullivan (2002)	Overall, pedestrian fatalities 3 to 6.75 times more likely in darkness (ST) than in daylight (DST), while other crashes were only marginally more likely in darkness Spring am: Twilight shows a decline in crashes from week−8 (39 crashes) to week−1 (8 crashes); at the changeover, when the period is returned to darkness, the crash level rises again Spring pm: the crash frequency is high during the dark period just before the DST changeover, and drops to 54, the week after the changeover and declines more the following week to 32 Autumn am: 79 crashes before the transition and 29 after Autumn pm: In the week before the transition there were 65 crashes, in the following week there were 227, an increase of three and a half times.
Sullivan (2001)	Pedestrian fatalities 4.14 times more likely in darkness (DST) than in daylight (ST). Interaction between light and alcohol use.
Sullivan (2007)	Fatal crashes involving pedestrians, animals, and other motor vehicles showed the most reliable increases in risk in low light levels (ST). Children show a reliably greater risk in darkness, but this risk is much smaller than the risk observed for adult and elderly pedestrians – which is nearly 7 times greater in darkness. Even when the data are not separated by age, the apparent increase in pedestrian risk in the dark is very strong.

Section 4: Changes in RTCs and casualties associated with DST.

4.1 Introduction and Overview

As noted earlier in this report, there is an active debate in the UK as to the potential road safety benefits of a move to CET in that jurisdiction. This debate has, in part, drawn on the findings of a number of studies that have examined the impact of Daylight Savings Time (DST) on road safety in the UK. Proponents have referenced a number of studies which have reported that DST has a positive impact on collisions and casualties and that delaying sunset year-round would have an even more pronounced positive effect on road safety.

There has been no authoritative study conducted on the effects of DST on road traffic collisions (RTCs) in Ireland. This section of the report explores the trends in RTCs and casualties around the spring and autumn transitions. It tests three predictions relating to DST and collision risk.

1) The transition to DST in March should have a negative short-term effect (0-2 weeks) on road safety. During this transition, road users 'lose' one hour when the clocks move forward and this has been shown to have a detrimental impact on sleep and driver performance for up to 2 weeks.

2) The transition to DST in March should have a positive long-term effect (>2 weeks). This transition shifts light from a lower risk period (morning) to a higher risk period (evening), which should lead to an increase in morning collisions, decrease in evening collisions and overall net positive effect across the combined peak periods.

3) The transition back to Standard Time (ST) in October should have negative short-term and long-term effects. In both cases, the transition results in the shifting of light from a high-risk period to a low risk period. Collision rates should decrease in the morning, and increase in the evening, leading to an overall combined increase in collisions and casualties.

4.2 The limitations of DST data

It is important to acknowledge the difficulties associated with testing the impact of DST on RTCs, and by extension the use of this evidence in informing the *Brighter Evenings* proposal. We would draw attention to the following in particular:

Long-term analyses (>2 weeks after transitions) of the impact of DST on collisions is very problematic as there are longitudinal trends in traffic volume, weather etc. that may explain these changes. Positive or negative associations between DST and collisions, then, may actually be due to other factors, including the killer driver behaviours as noted in section 2.2.

It seems sensible to introduce statistical controls of these other explanatory variables. However, this would require access to reliable data relating to these variables for the statistical modelling.

This issue is compounded by the complex relationship between 'light' and RTCs, with light typically interacting with other factors to create the increased crash risk. That is, the additional hour of light in the evenings is not hypothesised to directly cause a reduction in collisions, but rather improves general driving conditions and visibility.

Finally, and as noted in the systematic review, the impact of DST on collisions is likely to be very small, with some researchers concluding that it is associated with a reduction in RTCs of approximately 1%. A 1% reduction in RTCs is practically meaningful given the high incidence of collisions. However, detecting such a statistically small effect is very difficult, and made even more so by the aforementioned challenges in selecting control variables and accessing reliable data.

As a solution, researchers have pointed to the value of looking at short-term effects, of up to 2 weeks, based on the assumption that there will be little variation in the other explanatory variables across the DST transitions (with any annual fluctuations negated by the use of data from multiple years). Theoretically, this approach automatically controls for the other explanatory variables (known and unknown), allowing the analyses to be sensitive to DST effects.

However, the short-term data is also problematic. As demonstrated in the last section of this report, for the spring DST transition there is a disruption to sleep patterns which may inflate crash risk for the initial two weeks. Again, this may undermine any attempts to isolate a 'pure' DST effect.

4.3 Method

In preparing the data for analyses, the transition Sundays were identified for each year and for both transition points (spring and autumn). Collisions and casualties were then arranged in weekly blocks (Sundays to Saturdays), using the transition Sunday as an anchor. Next, the data for each of the 10 years (2003-2012) were merged, ensuring that the weekly blocks aligned. This was completed for approximately 7 weeks prior to each transition and 8 (autumn) or 9 (spring) weeks after the transition.[34]

Second, data was collated for collisions and casualties occurring between 05:00 and 09:00 (morning peak), 15:00 and 19:00 (evening peak) and both peak periods combined for the years 2003-2012. DST has the greatest impact around sunset and sunrise and this approach is the most sensitive 'test' of DST effects.

The analyses we report focus on the changes in incidence of collisions and casualties around each of the transitions. Specifically, we compared the number of collisions that occurred the week after the transition with the number that occurred the week before the transition. We repeated this process for all collisions in the first two weeks after the transition, compared with the two weeks prior to the transition. For longer-term changes, we used 5 and 7 weeks either side of the transitions. For each set of analyses, we calculated the percentage change in collisions and casualties that occurred across the transition and tested statistical significance based on the raw incident data.[35]

Tables A1 and A2 (Appendix A) present summary tables for all analyses completed. In the text of the report, we only reference statistically significant associations between DST and collisions and casualties.

[34] This approach caters for the extra day in February that occurs during leap years.

[35] Chi-square tests were run comparing the observed incidence with the expected incidence if no difference in collisions and casualties occurred across the transition. Technically this tests an association between the two periods and collisions, but for ease of reporting results are reported in terms of the difference between the time periods.

4.4 Spring transition from ST to DST

The spring transition to DST occurs in the last Sunday of March every year in Ireland. During that transition, the clocks move forward by one hour, resulting in an hour less light in the morning and an extra hour of light in the evening. Spring DST findings have been mixed, however, a number of studies that examined the first two weeks after the transition have reported increases in crash risk, which was attributed to the negative impact of the transition on sleep duration and latency. Long-term, the impact could be expected to be positive, with crash risk being transferred from the evening period (decrease in collisions) to the morning period (increase in collisions) with a net positive effect.

Short-term effects of Spring DST

Short-term effects were investigated by examining the incidence of collisions and casualties one week and two weeks around the transition. Taking the ***collision data*** first, comparisons were made for morning collisions (05:00-09:00), evening collisions (15:00 to 19:00) and morning and evening collisions combined (net effect for peak traffic periods). There were no statistically significant short-term associations between the transition to DST and road collisions.

The analyses were replicated, this time working with ***casualty numbers***. There were increases in casualties in the morning period in the first two weeks, but none of the other comparisons were statistically significant and no obvious trends were evident. Combining the morning and evening casualty figures, the net effect was a significant increase (10.6%) in casualties at 2 weeks.

There was a significant increase in ***pedestrian casualties*** in the mornings in the first two weeks after the transition, compared with the two weeks prior to the transition (increase of 105.3%). There were no significant effects for the evening comparisons or the combined (morning + evening) comparisons at either 1 or 2 weeks.

No statistically significant effects emerged from the analyses of ***cyclist casualties***. However, there was a trend towards increased casualties in the morning period, evening period and for both periods combined (and for both long and short-term).

It is important to note that this short-term analysis may be ***distorted by changes in traffic volume*** caused by school mid-term breaks, which can occur over the months of March and April, or by longitudinal trends in traffic volume or the use of bicycles for commuting or recreation

Long-term effects of Spring DST

As noted in the systematic review, most of the research on the long-term effects of the spring DST transition reports a reduction in collisions and casualties. Here, we anticipate an increase in morning incidence, decrease in evening incidence and net reduction when the peak periods are combined. For this set of analyses, comparisons were made between incidence for the 5 weeks prior to and after the transition, and for the 7 weeks prior to and after the transition.

The ***collisions*** data did not support the initial predictions. There were statistically significant increases in collisions in the evening period for both the 5-(12.6%) and 7-week (13.1%) comparisons and overall there was an increase in the combined collision data (morning and evening collisions combined) (6.3%). Again, contrary to expectations, there were *decreases* in morning collisions, and these results were nearing statistically significant levels (±5 week=10.3% decrease; ±7 week=13.1% decrease).[36]

In the evening, and in line with the collision data, there were statistically significant increases in ***casualties*** in the first 5 weeks (17.6% increase) and 7 weeks (19.5%). Combining the morning and evening casualty figures, the net effect was a significant increase in casualties for the 5-week (10.5% increase) and 7-week comparison (12.7%). A similar trend is present in the data for all casualties, irrespective of time of day.

There were no significant long-term changes in ***pedestrian*** or ***cyclist casualties*** across the spring DST. However, the non-significant trends were towards decreased evening pedestrian casualties, increased morning casualties and a net decrease for the two peak periods of the day combined. There were non-significant increases in cyclist casualties in the morning period, evening period and for both periods combined.

The 5 week and 7 week increases for collisions and casualties are contrary to findings in other papers, although they are in line with recent research from the UK.[37] The shifting of an hour from morning to evening should have led to increased collisions in the morning and decreased collisions in the evening. Interestingly, the Dublin Transportation Office's *Transport Monitoring Report* for 2008 noted increases in traffic flow throughout March, April, May and June on the M50 and M4. Furthermore, on the M4 morning traffic decreased over this time, while evening traffic peaked in May.[38] As such, the trends here may reflect traffic flow patterns.

There is further evidence that this increase in RTCs is occurring independently of DST. Figure 8 plots the collisions occurring in the 7 weeks leading up to the transition to DST, and the 9 weeks that followed. In line with our findings, there is no obvious decrease in collisions evident across the transition period. Rather, collisions in general, as well as collisions during the evening peak, appear to have increased, with slight reductions in morning collisions. This appears to be part of a longitudinal trend, commencing 6 weeks prior to the transition, and continuing for the 9 weeks after the transition.

Similarly, the trend towards a net decrease in pedestrian casualties (a non-significant decrease) may be part of a longitudinal trend. As illustrated in Figure 9, and based on all pedestrian casualties in the 7 weeks leading up to the transition and 9 weeks after, there appears to be a gradual decrease in casualties occurring over this prolonged period. Any changes to pedestrian casualties evident across the DST transition may therefore not be due to DST.

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[36] As sleep may have had a detrimental impact on collisions in this analysis, we repeated it comparing weeks 3-7 either side of DST (omiting the two weeks where collisions may have been impacted by sleep loss). The findings held, with a statistically significant increase in collisions (morning and evening combined).

[37] Parliamentary Advisory Council for Transport Safety (PACTS) (2010). *How does daylight saving time affect the safety of Britain's Roads?: An interim examination of crash and casualty trends around clock trends*. Retrieved from: http://www.roadsafetyanalysis.org/wp-content/uploads/sites/3/2010/10/DST_Interim_Oct2010.pdf. Note: In this report, the researchers reported short-term decreases in morning collisions and increases in evening collisions after the March (spring) transition to DST.

[38] Dublin Transportation Office. *Road Users Monitoring Report 2008.* Dublin Trasportation Office. Retrieved from http://www.nationaltransport.ie/wp-content/uploads/2011/12/road_user_monitoring_2008.pdf.

4.5 Autumn transition from DST to ST

The autumn transition back to Standard Time (ST) occurs towards the end of October every year. During that transition, the clocks move back by one hour, resulting in an hour less light in the evening and an hour extra of light in the morning. In contrast to the spring transition, where a 23-hour day is created on the first day after the transition, the autumn transition creates a 25-hour transition day, which would have no negative effect on sleep duration.[39] The shifting of an hour of light from the high-risk evening period to the lower-risk morning period, however, should result in an increase in collisions, both in the short-term and in the longer-term (thus evidencing the benefits of DST).

Short-term effects of the return to ST

Figure 10 plots the collisions occurring in the weeks leading up to the transition back to ST, and the weeks that followed. It is relevant to note that primary and post-primary schools in Ireland are on mid-term break towards the end of October and/or early November. That is, mid-term can fall immediately before or after the return to ST, and this is likely to have undeterminable influences on traffic volumes and reduce our ability to link changes in casualties across the transition to the transition itself.[40]

In line with predictions, there were significant reductions in ***collisions*** in the morning period for both the 1-week (down 26.9%) and 2-week (down 17.3%) comparisons (see Table A2). Collisions in the evening period did not change significantly in the short-term, nor did collisions for both peak periods combined. ***Casualties*** also decreased in the morning period, based on the comparison of 1 week prior to and after the transition (down 20.9%).

There were also short-term decreases in ***pedestrian casualties*** in the morning period and these reductions were nearing statistical significance (p=.07) for both 1-week and 2-week comparisons. Evening pedestrian casualties increased significantly, up 68.1 percent for the 1-week comparisons and 32.5% for the 2-week comparisons.

Similarly, there were significant decreases in ***cyclist casualties*** in the morning period, and there was a net positive effect for the two peak periods combined. These findings held for both the 1-week and 2-week comparisons.

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[39] See Smith, A. C. (2014). *Spring Forward at Your Own Risk: Daylight Saving Time and Fatal Vehicle Crashes*. University of Colorado Boulder. Retreived from: http://www.colorado.edu/econ/papers/WPs-14/wp14-05/wp14-05.pdf

[40] To put this in perspective, in 2014 the October mid-term ran from Monday October 27th to Friday October 31sth. In 2015, this occurred from Monday October 26th to Friday October 30th. In 2016, mid-term will be held from Monday October 31st to Friday November 4th.

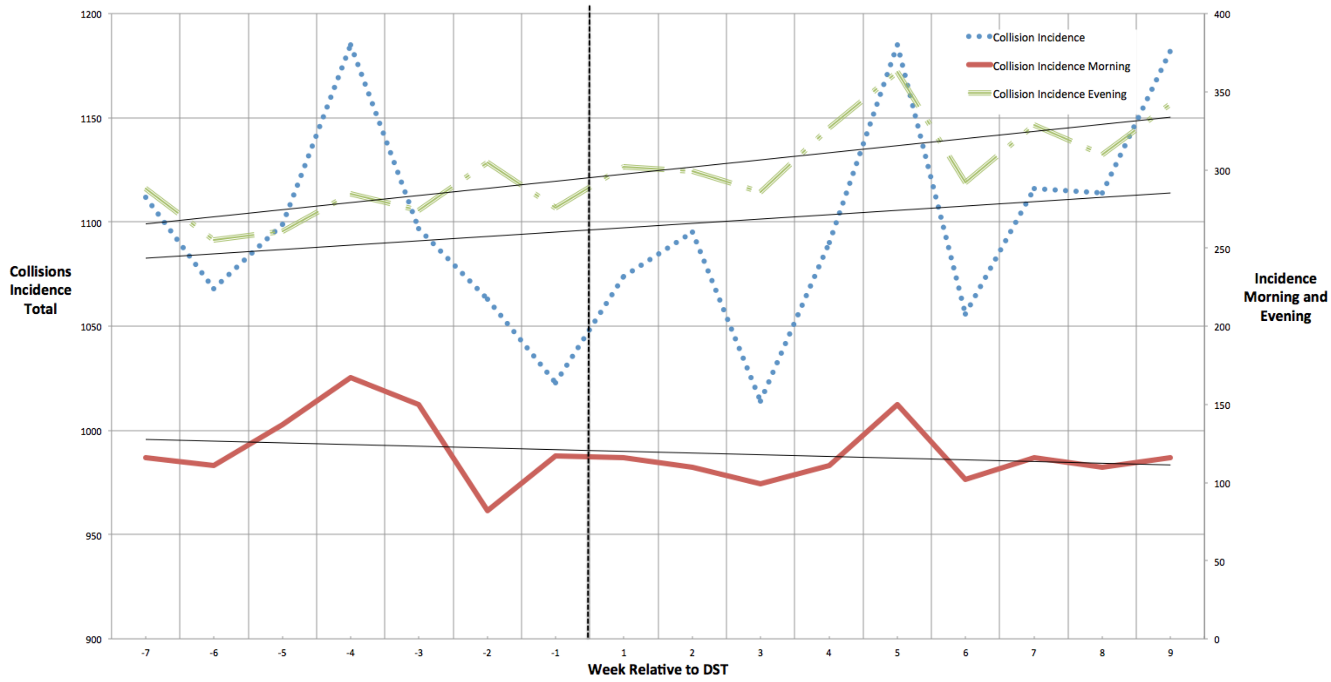

Figure 8: Collision Incidence for the period -7 weeks to +9 weeks around the Spring transition, 2003-2012
Note: Collision incidence is for all collisions occurring, not just those that occurred during peak periods.

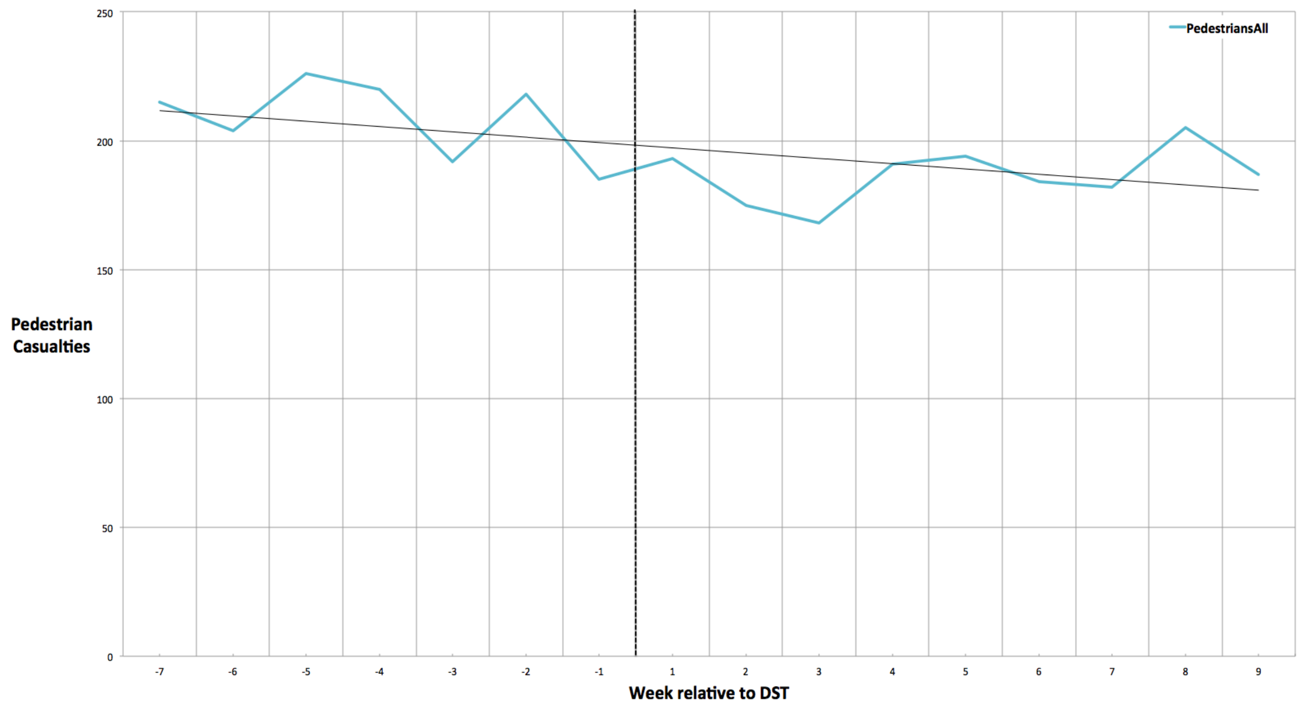

Figure 9: Incidence of pedestrian casualties for 7 weeks prior to, and 9 weeks after, the onset of Spring DST, 2003-2012.

As short-term effects of the return to ST are likely to be the best test of DST, we looked at casualties among children under the age of 17. Casualty rates increased significantly in the morning period for both 1 and 2 week comparisons. The trends towards an increase in casualties for evening periods and morning+evening periods combined were not significant. These findings are contrary to predictions. Assuming children's morning routine is not impacted by the change back to ST, there should have been either no effect or a positive effect on morning risk. Evening risk, conversely, should have increased. Again it is important to note that October mid-term break occurs around the ST transition and may have an undeterminable impact on casualties among children.

Long-term effects of the return to ST

When we compared the ***collision*** incidence for both peak times together at 7 weeks prior to and post the transition back to ST, there was a significant increase (5.5%) in collisions after the transition. This resonated with the ***casualty*** data, with longer-term, statistically significant increases for morning (7-week comparisons +12.4%) and evening (5-week comparison +7.4%) periods. When the two periods were combined, the net effect was an increase in casualties for both the 5-week (5.7%) and 7-week (5.5%) comparisons.

Pedestrian casualties increased for the evening periods for the 5-week (17.6%) and 7-week (26.3%) comparisons and the overall net effect for both peak periods combined over the first 7 weeks was a 25.6% increase in casualties. Conversely, ***cyclist casualties*** decreased significantly for both the morning periods and combined morning and evening peaks. This may, in part, represent a decrease in the use of bicycles for commuting and recreation from October to December (i.e. bicycle traffic volume). We did not compute longer-term casualty figures for children due to the presence of a) the mid-term break (short-term) and b) Christmas holidays (long-term) on casualty risk.

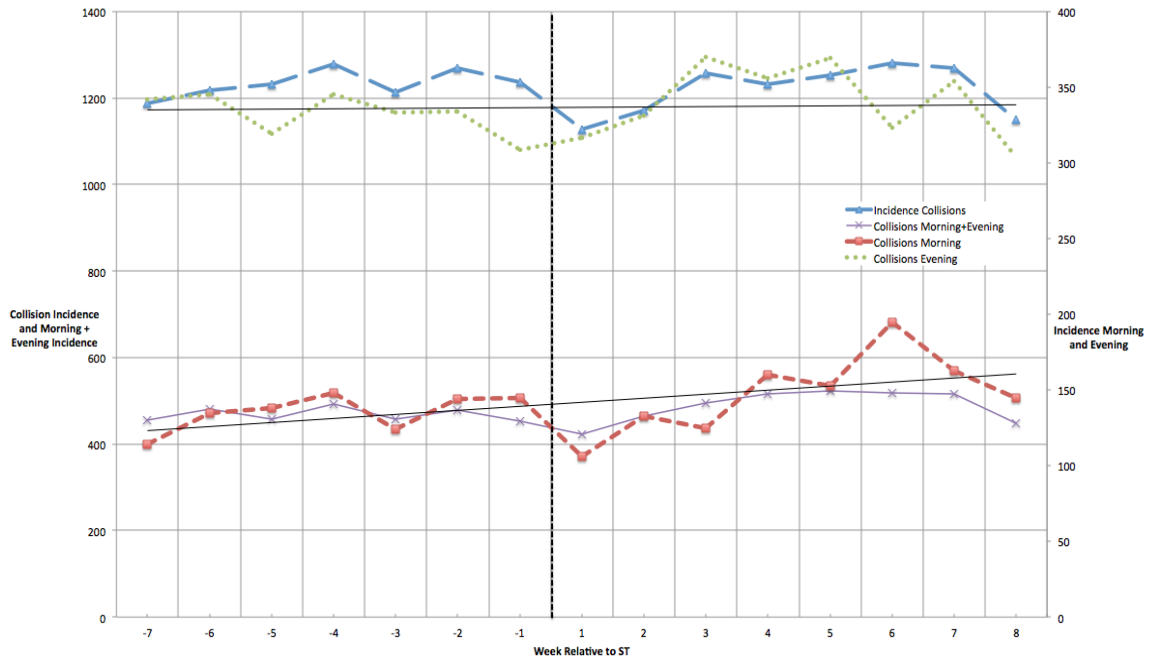

Figure 10: Collision incidence for the period -7 weeks to +8 weeks around the autumn transition, 2003-2012 (Note: Collision incidence is for all collisions occurring, not just those that occurred during peak periods).

Table 4: Impact of DST on RTCs in Ireland based on the road collision database (significant findings only).

	Spring DST		Autumn ST	
Transition	Clocks move forward by 1 hour		Clocks move back by 1 hour	
Effect	Morning: -1 hour light; Evening: +1 hour light		Morning: +1 hour light; Evening: -1 hour light	
Expected outcome	Increase in morning collisions (05.00-09.00)* Decrease in evening collisions (15.00-19.00) Net Positive Effect (Peak periods combined)		Decrease in morning collisions (05.00-09.00) Increase in evening collisions (15.00-19.00) Net Negative Effect (Peak periods combined)	
	Short Term	Long Term	Short Term	Long Term
Collisions	No effects	Increased evening collisions (±5 and ±7 weeks) and increase for combined morning and evening (±7 weeks)	Decreased morning collisions (±1 and ±2 weeks)	Increase in net morning and evening collisions combined (±7 weeks)
Casualties	Increased during morning peak (±2 weeks) and net increase for combined morning and evening peaks (±2 weeks).	Increased evening casualties (±5 and ±7 weeks) and increase for combined morning and evening peaks (±7 weeks)	Decreased morning casualties (±1 week)	Increase in morning casualties (±7 weeks) and casualties for peak morning and evening periods combined (±7 weeks).
Pedestrians	Increased during morning peak (±2 weeks).	No effects	Increased evening casualties (±1 and ±2 weeks)	Increase in evening pedestrian casualties (±5 and ±7 weeks) and for peak morning and evening periods combined (±7 weeks).
Cyclists	No effects	No effects	Decreased morning casualties (±1 and ±2 weeks) and decreased net morning and evening combined (±1 and ±2 weeks)	Decreased cyclist casualties for morning periods and for peak morning and evening periods combined (±7 weeks).

*Note that the anticipated short-term effects of moving into DST may also be negative due to the detrimental impact of the transition on sleep duration and latency, caused by the 23-hour transition day on DST Sunday. **Morning = 05:00 to 09:00 (morning peak). Evening = 15:00 and 19:00 (evening peak); Combined =Morning and Evening combined.

4.6 Conclusions

Headline findings are summarised in Table 4. There were increases in collisions and casualties in the longer-term analysis of up to 7 weeks after the spring transition. This effect is likely to be due to factors other the DST, and may reflect monthly and weekly fluctuations or trends in traffic volume, for example. ***In summary, analyses of the transition to DST do not support the road safety benefits of DST and thus cannot be used to support the move to CET.***

The transition out of DST, to ST, should have been associated with a net increase in collisions. The short-term impact of the transition back to ST is the 'purest' test of DST effects, as there should be no sleep effects, and other explanatory factors (e.g. traffic flow) are largely negated. However, the evidence here was inconclusive. While the incidence of collisions and casualties were lower in the mornings for the two weeks after the transition, in comparison to the two weeks prior to the transition, there was no clear effect for evening collisions. In the longer term, collisions and casualties increased after the change back to ST, though it may be the case that these can be attributed to factors other than the transition. ***It is concluded that while there is some evidence***

from the autumn transition data to suggest that DST may have a road safety benefit, this evidence is inconclusive.

The return to ST was associated with significant reductions in cyclist casualties. This may indicate that cyclists, in particular, benefit from brighter mornings. However, the darker evenings may have coincided with reduced use of bicycles for commuting to work, thus impacting on the total incidence of cyclist casualties for both morning and evening periods.

Overall, the evidence presented here is inconsistent. Simple comparisons of incidence of collisions and casualties does not conclusively indicate that DST offers a road safety benefit and does not offer strong evidence of a potential benefit to road safety of a move to CET.

Section 5: Conclusion and Recommendations

5.1 Conclusions

The core objective of this report has been to develop a synthesis of the best evidence that can inform the potential impact of a move to CET on road safety in Ireland.

In terms of the ***core assumptions*** behind the Brighter Evenings Bill, and the purported positive impact the move to CET would have, the following general observations are relevant:

1) While collision risk is determined by multiple factors, there is clear evidence that driver behaviour (human factors) deteriorates under poorer lighting conditions.

2) Collision data from Ireland indicated that the risk of RTC involvement is greater during the evening period, compared to the morning period.

   To the extent that collision risk is influenced by light, shifting light from morning to evening should have a positive impact on collisions.

However, this expectation, must be weighted against the evidence presented in the report.

Systematic Review

We conducted the first systematic review of the empirical literature examining the link between DST and RTCs. The picture that emerged from this review was complex. Specifically, we found that the effects of DST are likely to be small and potentially negative or positive depending on time of year and day. The effect is also likely to vary across different road users. The extent to which we can rely on this evidence-base must also be tempered by the methodological limitations of the DST research, the statistical assumptions that researchers have made, and difficulties accounting for potentially important factors such as traffic flow. Overall, the evidence from the review was inconclusive and cannot be used to support the proposed move to CET.

Analyses of RSA Collision Data

We also completed the most authoritative analyses of RTCs in Ireland that occurred around the DST transitions. However, again the results of these analyses did not fully support the anticipated DST effects.

First we examined the frequency of RCTs around the transition to DST in spring. Results did not support the road safety benefits of DST. However, during this transition the clocks go forward, leading to a 23-hour day and a short-term reduction in sleep duration and latency. Research suggests that this can have an impact on human performance for up to 2 weeks after the transition, and this may lead to short-term increases in crash risks. This would obscure any positive impact of the move to DST during the spring transition.

Thus we next examined the transition back to Standard Time (ST) in autumn. This is viewed in the empirical literature as providing the 'purest' test of DST effects. We gain an extra hour during this transition and the sleep deprivation linked to the spring transition does not apply. We further constrained the influence of other explanatory factors by looking at short-term impacts, based on the assumption that factors such as traffic flow do not vary to any meaningful extent across short intervals around the transition. Despite this, findings from our analyses of the transition back to ST were inconclusive. For example, while the incidence of collisions and casualties was lower in the mornings for the two weeks after the autumn transition, in comparison to the two weeks prior, there was no clear effect for evening collisions. In the longer term, collisions and casualties increased after the change back to ST, though it is possible that this can be attributed to factors other than the transition.

Overall, simple comparisons of incidence of collisions and casualties pre- and post-transition do not conclusively indicate that DST offers a road safety benefit. Thus, these analyses do not provide strong evidence of a potential benefit to road safety of a move to CET.

Other Considerations

The expectation that a move to CET should have a positive impact on road safety should also be weighted against the following:

While light is an important indirect risk factor for road traffic collisions, it is one of many direct and indirect contributory factors. For example, the best evidence suggests that human factors are the largest contributory factor to RTCs and injuries. Focus has been on a number of 'killer driver behaviours' that include driving while fatigued, drink driving, drug driving, being distracted while driving, speeding, and not wearing a seat belt. This is not reflected in the current debate on the *Brighter Evenings Bill.*

The evidence available to us does not have a high level of predictive utility when considering a move to CET. In particular, there is an almost complete absence of research that focuses specifically on the potential impact of CET, and we are therefore forced to rely on literature related to DST. While this provides a useful evidence-base, we are working on the assumption that there can be a reliable transfer of knowledge from DST effects to the types of effects that we will see under CET.

The most authoritative statistical modelling of the potential impact of a move to CET is based on data from the British Summer Time (BST) experiment (1968-1971), during which the clocks remained in summertime throughout the year. Studies in the UK suggest that a move to CET there would lead to an overall reduction in fatalities of 2.6-3.4% and reduction in serious injuries of 0.7%. However, this assumes that the British Summer Time (BST) experiment is a valid source of evidence for the purpose of modelling the effects of a change to CET, 45 years later, in a different jurisdiction. It also assumes that statistical modelling is sufficiently sensitive to accurately estimate such a small change in the first place.

A trial period where CET is adopted in Ireland, with road traffic outcomes measured prior to and following implementation, would provide more relevant, usable evidence. However, it is important to manage expectations here. In order to fully test the impact of an experimental trial period, we would need a) access to highly reliable data on road collisions for both the experimental period and a control/comparison period and b) access to reliable data on traffic flow and other factors that may need to be statistically controlled for. Even if such conditions were met, it may be unrealistic to expect this kind of pilot to lead to conclusive answers regarding the impact of CET on road safety.

5.2 Recommendations

The review of empirical evidence from other jurisdictions on the impact of DST on RTCs is inconclusive, as is the evidence based on road collisions here.

Moreover, there are considerable challenges associated with prospectively measuring the impact of the proposed 3-year CET pilot on road safety. In particular, there will always be multiple competing explanations for any patterns that emerge (e.g. traffic flow, school holidays etc.).

As such, ***the RSA cannot support the assertion that that a move to CET would have a road safety benefit, or that a 3-year pilot period would provide conclusive evidence as to the impact of a CET on road safety.***

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Appendix 1: Supplementary tables for DST analyses

Table A1: Incidence of collisions and casualties around the Spring DST transition.

SPRING DST	±1 Week			±2 Week			±5 Week			±7 Week		
	Before	After	% Change	Before	After	% Change	Before	After	% Change	Before	After	% Change
Peak periods												
Collisions Morning	117	116	-0.9	199	226	13.6	653	586	-10.3	880	804	-8.6
Collisions Evening	276	302	9.4	581	601	3.4	1401	1577	12.6**	1944	2198	13.1**
Collisions Morning+Evening	393	418	3.3	780	827	10.6	2054	2163	5.3	2824	3002	6.3*
Casualties Morning	158	163	3.2	266	355	33.5**	885	837	-5.4	1173	1138	-3.0
Casualties Evening	414	428	3.4	850	879	3.4	1979	2327	17.6**	2726	3258	19.5**
Casualties Morning+Evening	572	591	3.3	1116	1234	10.6*	2864	3164	10.5**	3899	4396	12.7**
Pedestrians Morning	10	17	70	19	39	105.3**	75	85	13.3	90	107	18.9
Pedestrians Evening	57	49	-14.0	121	101	-16.5	299	271	-9.4	422	398	-5.7
Pedestrians Morning+Evening	67	66	-1.5	140	140	0.0	374	356	-4.8	512	505	-1.4
Cyclists Morning	8	5	-37.5	11	16	45.5	38	47	23.7	52	67	28.8
Cyclists Evening	15	23	53.3	35	44	25.7	93	110	18.3	143	156	9.1
Cyclists Morning+Evening	23	28	21.7	46	60	30.4	131	157	19.8	195	223	14.4
All day												
All Collisions all day	1023	1074	5.0	2086	2169	4.0	5467	5458	-0.2	7647	7630	-0.2
All Casualties all day	1491	1574	5.6	3057	3257	6.5**	7890	8129	3.0	10971	11389	3.8**
Pedestrians all day	185	193	4.3	403	368	-8.7	1041	921	-11.5**	1460	1287	-11.8**
Cyclist all day	52	55	5.8	102	118	15.7	274	271	-1.1	402	441	9.7

Note: *=p<.05, **=p<.01.

Table A2: Incidence of collisions and casualties around the Autumn DST-ST transition.

AUTUMN DST	±1 Week			±2 Week			±5 Week			±7 Week		
	Before	After	% Change	Before	After	% Change	Before	After	% Change	Before	After	% Change
Peak periods												
Collisions Morning	145	106	-26.9*	289	239	-17.3*	699	677	-3.1	948	1035	9.2
Collisions Evening	309	317	2.6	643	648	0.8	1640	1743	6.3	2327	2420	4.0
Collisions Morning+Evening	454	423	-6.8	932	887.0	-5.0	2339.0	2420	3.5	3275	3455	5.5*
Casualties Morning	182	144	-20.9*	375	327	-12.8	883	894	1.2	1220	1371	12.4**
Casualties Evening	450	471	4.7	922	945	2.5	2361	2535	7.4*	3374	3476	3.0
Casualties Morning+Evening	632	615	-2.7	1297	1272	-1.9	3244	3429	5.7*	4594	4847	5.5*
Casualties <17 Morning	22	40	81.8	40	64	60.0	-	-	-	-	-	-
Casualties <17 Evening	94	103	9.6	191	207	8.4	-	-	-	-	-	-
Casualties <17 M+E	116	143	23.3	231	271	17.3	-	-	-	-	-	-
Pedestrians Morning	21	10	-52.4	42	26	-38.1	103	99	-3.9	122	150	23.0
Pedestrians Evening	47	79	68.1**	117	155	32.5*	340	400	17.6*	471	595	26.3**
Pedestrians Morning+Evening	68	89	30.9	159	181	13.8	443	499	12.6	593	745	25.6**
Cyclists Morning	21	9	-57.1*	34	16	-52.9*	78	54	-30.8*	104	75	-27.9*
Cyclists Evening	22	16	-27.3	41	34	-17.1	120	101	-15.8	171	140	-18.1
Cyclists Morning+Evening	43	25	-41.9*	75	50	-33.3*	198	155	-21.7*	275	215	-21.8**
All day												
All Collisions all day	1236	1128	-8.7*	2505	2299	-8.2**	6228	6041	-3.0	8634	8592	-0.5
All Casualties all day	1818	1685	-7.3*	3616	3412	-5.6*	8985	8778	-2.3	12587	12361	-1.8
Pedestrians all day	225	224	-0.4	467	439	-6.0	1207	1185	-1.8	1617	1764	9.1*

Note: *=p<.05, **=p<.01.