

# Executive Summary: Health Impact Review of SB 5329

Exempting the State of Washington from Daylight Saving Time and Implementing Year-Round Pacific Standard Time (2017-2018 Legislative Session)

Evidence indicates that SB 5329 has the potential to improve health outcomes, particularly on days that would immediately follow a transition to or from daylight saving time. The evidence for the impact of implementing year-round Pacific Standard Time on health disparities is not well researched.

## BILL INFORMATION

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**Sponsors:** Honeyford, Becker, Bailey, Angel, Rivers, Warnick, Rossi

### Summary of Bill:

- Implements year-round Pacific Standard Time and exempts Washington State from daylight saving time.

## HEALTH IMPACT REVIEW

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### Summary of Findings:

This Health Impact Review found the following evidence regarding the provisions in SB 5329:

- Strong evidence that implementing year-round Pacific Standard Time would likely improve health outcomes, particularly on days that would immediately follow a transition to or from daylight saving time.
- The evidence for the impact of implementing year-round Pacific Standard Time on health disparities is not well researched.

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# **Health Impact Review of SB 5329**

**Exempting the State of Washington from Daylight Saving Time and Implementing Year-Round Pacific Standard Time (2017-2018 Legislative Session)**

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## Introduction and Methods

A Health Impact Review is an analysis of how a proposed legislative or budgetary change will likely impact health and health disparities in Washington state ([RCW 43.20.285](#)). For the purpose of this review ‘health disparities’ have been defined as the differences in disease, death, and other adverse health conditions that exist between populations ([RCW 43.20.270](#)). This document provides summaries of the evidence analyzed by State Board of Health staff during the Health Impact Review of Senate Bill 5329 ([SB 5329](#)) from the 2017-2018 legislative session.

Staff analyzed the content of SB 5329 and created a logic model depicting possible pathways leading from the provisions of the bill to health outcomes. We consulted with experts and contacted stakeholders with diverse perspectives on the bill. State Board of Health staff can be contacted for more information on which stakeholders were consulted on this review. We conducted objective reviews of the literature for each pathway using databases including PubMed and Google Scholar.

The following pages provide a detailed analysis of the bill including the logic model, summaries of evidence, and annotated references. The logic model is presented both in text and through a flowchart (Figure 1). The logic model includes information on the strength of the evidence for each relationship. The strength-of-evidence has been defined using the following criteria:

- **Not well researched:** the literature review yielded few if any studies or only yielded studies that were poorly designed or executed or had high risk of bias.
- **A fair amount of evidence:** the literature review yielded several studies supporting the association, but a large body of evidence was not established; or the review yielded a large body of evidence but findings were inconsistent with only a slightly larger percent of the studies supporting the association; or the research did not incorporate the most robust study designs or execution or had a higher than average risk of bias.
- **Strong evidence:** the literature review yielded a large body of evidence on the relationship (a vast majority of which supported the association) but the body of evidence did contain some contradictory findings or studies that did not incorporate the most robust study designs or execution or had a higher than average risk of bias; or there were too few studies to reach the rigor of ‘very strong evidence’; or some combination of these.
- **Very strong evidence:** the literature review yielded a very large body of robust evidence supporting the association with few if any contradictory findings. The evidence indicates that the scientific community largely accepts the existence of the association.

This review was subject to time constraints, which influenced the scope of work for this review. The annotated references are only a representation of the evidence and provide examples of current research. In some cases only a few review articles or meta-analyses are referenced. One article may cite or provide analysis of dozens of other articles. Therefore the number of references included in the bibliography does not necessarily reflect the strength-of-evidence. In addition, some articles provide evidence for more than one research question so they are referenced multiple times.

## Analysis of SB 5329 and the Scientific Evidence

### *Summary of SB 5329*

- Implements year-round Pacific Standard Time (PST) and exempts Washington State from daylight saving time (DST).

### *Health impact of SB 5329*

Evidence indicates that SB 5329 has the potential to improve health outcomes, particularly on days that would immediately follow a transition to or from daylight saving time. The evidence for the impact of implementing year-round PST on health disparities is not well researched.

### *Pathways to health impacts*

The potential pathways leading from the provisions of SB 5329 are depicted in Figure 1. There is strong evidence that implementing year-round PST would likely improve health outcomes such as heart attack and stroke, particularly on the days that would have immediately followed a transition to or from daylight saving time.<sup>1-11</sup> The likely impact of implementing year-round PST on health disparities is not well researched.

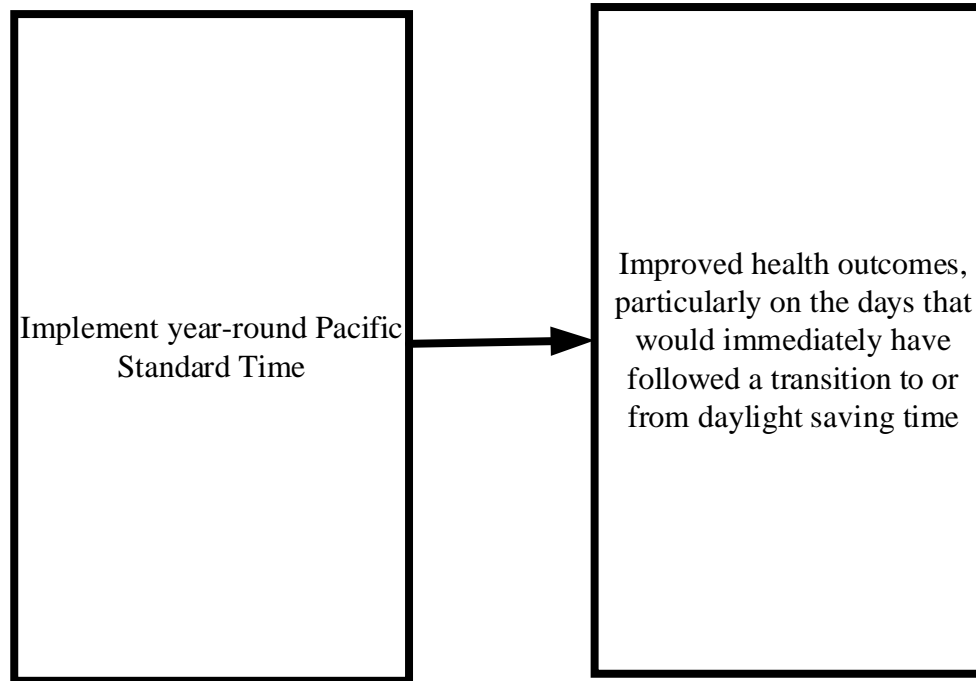
Due to time limitations we only researched the most direct connections between the provisions of the bill, health, and health disparities and did not explore the evidence for all possible pathways. For example, potential pathways that were not researched include:

- Evidence of how changing to and from daylight saving time impacts economic growth, energy use, agriculture, or crime.

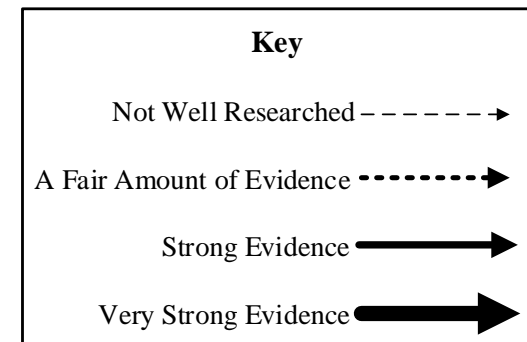
### *Magnitude of impact*

Because this bill would implement year-round PST for Washington State, the population that is likely to be impacted would be all Washington residents. Evidence from the literature does highlight a few populations that appear to have higher risk for adverse health events around the time of the transition to DST such as those taking cardiac medications,<sup>5</sup> those with low cholesterol and triglycerides,<sup>5</sup> individuals under the age of 65,<sup>6</sup> and those with other comorbidities (hypertension, diabetes, etc.).<sup>10</sup> Further, the evidence also suggests that individuals who already have trouble sleeping, children, and the elderly may have more trouble adjusting following the transition to DST in the spring.<sup>4,9</sup>

## Logic Model



**Figure 1**  
**Exempting the state of Washington from daylight saving time and implementing year-round Pacific Standard Time**  
**SB 5329**



## Summaries of Findings

### **Will implementing year-round Pacific Standard Time in Washington improve health outcomes?**

There is strong evidence that implementing year-round Pacific Standard Time (PST) would improve health outcomes, particularly on days that would immediately follow a transition to or from DST. While the strength of evidence for the relationship between implementing year-round PST and any one particular health outcome varies, the body of evidence between implementing year-round PST and health outcomes as a whole is strong. Additionally, some health outcomes had conflicting findings in the literature and were therefore not included in the strength of evidence analysis. The strength of evidence for this research question focuses only on the literature for heart attacks and stroke. A summary of the research not included regarding DST and traffic accidents, work-related accidents, depressive episodes, and suicide is summarized at the end of this section beginning on page 5.

#### *Heart Attack*

A number of studies have examined the relationship between daylight saving time transitions and the incidence of heart attacks. One study found a 29% increase the incidence of non-fatal acute myocardial infarctions (AMI) during the first four workdays after the transition to DST in the spring and a 44% increase during the first four workdays following the transition out of DST in the fall.<sup>2</sup> In the spring, the effect was greatest on the Monday following the transition and was also more pronounced among men. In the fall, the effect was more delayed with peaks on Tuesday and Thursday. There was also a more pronounced effect for women, and individuals who were employed, not taking a beta-blocker and who were not engaging in physical activity (a known trigger for AMI) in the fall.<sup>2</sup> Other studies have found a more pronounced risk for AMI following the transition to DST in the spring that occurs within the first week, with the most significant peaks occurring on the first day or first three days after DST.<sup>5-7</sup> A number of studies found no association between heart attacks and the transition back to standard time in the fall, but a few studies noted a decrease in the incidence of heart attacks during this time. For example, one study found that the Tuesday following a DST shift in the fall was significant for decreasing AMI count by 21%, and another found that the incidence of AMI significantly decreased the Monday following the transition.<sup>8,10</sup> It is worth noting that some studies found that while there were peaks in the number of cases in the days following a transition to or from DST, overall there were not increases in the number of total cases within the year.<sup>7,8,10</sup>

#### *Stroke*

One study identified a relationship between shifting to DST and the risk of stroke. In this study, after a DST transition, the incidence of ischemic stroke (IS) increased in the first two days. Overall, the incidence did not change compared to control weeks but the timing of events was impacted by a DST transition. When compared with men, women were more susceptible to temporal changes after DST transitions and older patients also had a significant increased risk of IS following a DST transition.<sup>11</sup>

For both heart attacks and strokes, one of the underlying factors that most studies discuss is the impact that DST has on sleep and circadian rhythm, and how these factors impact health outcomes. One literature review examined studies that looked at the impacts of DST on sleep.

Summarizing the findings from 13 studies, the author concludes that, "[t]he start of daylight saving time in the spring is thought to lead to the relatively inconsequential loss of 1 hour of sleep on the night of the transition, but data suggests that increased sleep fragmentation and sleep latency present a cumulative effect of sleep loss, at least across the following week, perhaps longer. The autumn transition is often popularized as a gain of 1 hour of sleep but there is little evidence of extra sleep on that night. The cumulative effect of five consecutive days of earlier rise times following the autumn change again suggests a net loss of sleep across the week."<sup>4</sup> These impacts on sleep, and the closely synchronized circadian system, may increase the incidence of outcomes such as stroke and heart attack, particularly among those already at risk.

### *Traffic accidents*

The literature regarding traffic accidents and DST has mixed conclusions. One study found that the transition to DST in the spring increased the amount of traffic on the roads due to more people taking advantage of afternoon daylight hours, however the impact of DST on traffic accidents is not statistically significant in the spring or in the fall.<sup>12</sup> However, another study found following the spring DST transition, fatal accidents increased on the Monday following the transition, with no significant changes on the Saturday or Sunday of the shift.<sup>13</sup> For the fall DST change, the authors found that fatal accidents increased the Sunday prior to the shift, possibly due to the perceived benefit of being able to stay out for an extra hour the night before.<sup>13</sup> Finally, a third study found that there was an increase in pedestrian fatal crashes after the transition back to standard time in the fall.<sup>14</sup> They suggest that this was due to more darkness during afternoon commute times. Overall, the authors found that shifting an hour of daylight to the evening hours decreased the number of fatal crashes that occurred. They also estimated that 901 fewer fatal crashes would have occurred, including 727 involving pedestrians and 174 involving vehicle occupants, if daylight saving time had been in place all year during the study years (1987-1991).<sup>14</sup> A literature review looked at 7 other studies in addition to the ones mentioned above and of these, 2 found mixed results for spring versus fall, 3 found a significant increase in traffic accidents, and 2 found no significant increase in accidents.<sup>4</sup>

### *Work-related accidents*

The literature regarding work-related accidents and DST is also conflicting. Looking first at work-related accidents and occupational injury, two articles found no significant difference in workplace accident frequency between the week before and the week after the shift in the spring and fall.<sup>15,16</sup> The authors of one study did notice a trend in annual and seasonal variation of workplace accidents, which they attribute to seasonal changes in weather conditions.<sup>15</sup> Alternatively, Barnes et al. examined national mining injury data from the National Institute for Occupational Safety and Health from 1983-2006 and found that on the Monday following a transition, there are, on average, 3.6 more mining injuries and this translates to 2,649 more days of work lost due to injury than on non-transition days.<sup>17</sup> This suggests that the injuries that occur on these days are more severe. The second data set this group used was from the American Time Use Survey of the Bureau of Labor Statistics and they aimed to understand the link between phase changes (i.e. DST transitions) and sleep quantity. Results from this study indicate that, "...on Mondays directly following the switch to Daylight Saving Time, workers sleep on average 40 min less than on other days. On Mondays directly following the switch to Standard Time—in which 1 hour is gained—there are no significant differences in sleep, injury quantity, or injury severity."<sup>17</sup> The authors conclude that the transition between daylight saving time and standard

time put employees in danger and that as a practical application, employers should be mindful of scheduling dangerous work activities around a phase shift.<sup>17</sup>

### *Depressive Episodes and Suicide*

Two additional studies examine the association between DST, depressive episodes, and suicides.<sup>1,3</sup> The first article found that the transition from DST to standard time in the fall was associated with an 11% increase in unipolar depressive episodes that dissipated over a 10 week period.<sup>3</sup> There were no differences following the transition to DST in the spring. The authors hypothesize that these findings have less to do with the changes in circadian rhythm patterns due to the time change but are perhaps a result of the distress caused by a shortening of daylight hours in the fall.<sup>3</sup> In the second study, the authors found that there were no differences in rates of suicide in Australia around DST compared to the rest of the year for females.<sup>1</sup> However, for men, there was a significant increase in incidence at 2 and 4 weeks following the change to DST in the spring compared to the weeks after DST finished in the fall and the rest of the year. After adjusting for season, which is a significant predictor of suicide, the relationship was greatly weakened. There was also no significant relationship in suicides for men in the 2 weeks or 4 weeks after the start of DST and the rest of the spring season. Prior to 1986, there was a significant increase in suicides in the weeks following the transition out of DST in the fall but the relationship was no longer significant after this time.<sup>1</sup>



## Annotated References

1. **Berk Michael, Dodd Seetal, Hallam Karen, et al. Small shifts in diurnal rhythms are associated with an increase in suicide: The effect of daylight saving. *Sleep and Biological Rhythms*. 2008;6(1):22-25.**

In this study, the authors utilized a list of registered suicide deaths from the Australian Bureau of Statistics to see whether the small shift in time associated with transitioning to and from daylight saving time (DST) has a measurable impact on suicide rates. Using data from 1971-2001, the authors analyzed 47,215 male and 14,383 female suicide deaths from across Australia and compared death rates at 2 and 4 week time periods after the start of DST and at the return to "normal time". The authors found that there were no differences in rates of suicide around DST compared to the rest of the year for the female data set. However, for men, there was a significant increase in incidence at 2 and 4 weeks following the change to DST in the spring compared to the weeks after DST finished in the fall and the rest of the year. However, after adjusting for season, which is a significant predictor of suicide, the relationship was greatly weakened. There was also no significant relationship in suicides for men in the 2 weeks or 4 weeks after the start of DST and the rest of the spring season. Prior to 1986, there was a significant increase in suicides in the weeks following the transition out of DST in the fall but the relationship was no longer significant after this time. The authors did note that in general, suicides among men are three times greater than those in women so this finding may be reflecting this difference.

2. **Culic V. Daylight saving time transitions and acute myocardial infarction. *Chronobiology international*. Jun 2013;30(5):662-668.**

Culic et al. present findings from a study that aimed to investigate the association between the transitions to and from daylight saving time (DST) and incidence of acute myocardial infarction (AMI) in Croatia. The data set included data for 2,412 patients from 1990-1996 in Split, Croatia. Patients were interviewed in the hospital about the time of AMI and possible triggers such as physical activity, meals eaten, surgery, sexual activity, nicotine or alcohol abuse, etc. The authors reported the incidence ratios for the week following each of the DST transitions and the incidence ratio for each day during that posttransitional week. There was a significant increase in both posttransitional weeks and a significant decrease in the 2 week period following the posttransitional week for both spring and fall. Overall, the findings suggest a 29% increase in the incidence of non-fatal AMI during the first four workdays after the transition to DST in the spring and a 44% increase during the first four workdays following the transition out of DST in the fall. In the spring, the effect was greatest on the Monday following the transition and was also more pronounced among men. In the fall, the effect was more delayed with peaks on Tuesday and Thursday. In the fall there was also a more pronounced effect for women, and individuals who were employed, not taking a beta-blocker and who were not engaging in physical activity. The authors conclude that this study provides evidence to support the possibility that DST transitions may increase the risk of AMI through the pathway of sleep disturbances, and that risk appears to vary by a number of factors.

3. **Hansen B. T., Sonderskov K. M., Hageman I., et al. Daylight savings time transitions and the incidence rate of unipolar depressive episodes. *Epidemiology*. Oct 20 2016.**

Hansen et al. aimed to investigate the impact that daylight saving time (DST) transitions have on the incidence rate of unipolar depressive episodes. The study utilized data from the Danish Psychiatric Central Research Register (DPCRR) for all primary diagnoses of unipolar depressive episodes and bipolar disorder from January 1995 through December 2012. To analyze the data the authors used a time series intervention analysis and observed trends in the weeks following the transitions to and from DST. The transition from DST to standard time in the fall was associated with an 11% increase in unipolar depressive episodes that dissipated over a 10 week period. There were no differences following the transition to DST in the spring. The authors hypothesize that these findings are not as much do to changes in circadian rhythm patterns due to the time change but perhaps a result of the distress of marking the shortening of daylight hours in the fall.

4. **Harrison Y. The impact of daylight saving time on sleep and related behaviours. *Sleep medicine reviews*. Aug 2013;17(4):285-292.**

In this review article, Harrison aimed to explore the literature to understand the immediate impact that the transition to and from daylight saving time (DST) has on sleep and to evaluate the evidence regarding the link between sleep disruption and other short-term outcomes of DST such as accidents, illness, health, and performance. Harrison examined 13 studies that presented data on the relationship between DST and sleep. Summarizing the findings from these studies, the author concludes that, "The start of daylight saving time in the spring is thought to lead to the relatively inconsequential loss of 1 h of sleep on the night of the transition, but data suggests that increased sleep fragmentation and sleep latency present a cumulative effect of sleep loss, at least across the following week, perhaps longer. The autumn transition is often popularised as a gain of 1 h of sleep but there is little evidence of extra sleep on that night. The cumulative effect of five consecutive days of earlier rise times following the autumn change again suggests a net loss of sleep across the week." Harrison also looked at traffic accidents and DST and found mixed results. of the 9 studies examined, 2 found mixed results for spring versus fall, 4 found a significant increase in traffic accidents, and 3 found no significant increase in accidents.

5. **Janszky I., Ahnve S., Ljung R., et al. Daylight saving time shifts and incidence of acute myocardial infarction--Swedish Register of Information and Knowledge About Swedish Heart Intensive Care Admissions (RIKS-HIA). *Sleep medicine*. Mar 2012;13(3):237-242.**

Using data from the Register of Information and Knowledge about Swedish Heart Intensive Care Admissions (RIKS-HIA), Janszky et al. aimed to understand risk associated with daylight saving time (DST) on acute myocardial infarctions (AMI) and the role individual factors may play on this interaction. The individual level factors examined were age, sex, history of cardiac events, diabetes, hypertension, smoking, BMI, lipids, and medication. Patients from the RIKS-HIA were included in the analysis if they were admitted to the coronary care unit of a participating hospital between 1995 and 2007. The authors found that there was a short term increase in risk for AMI for the first week after transitioning into DST in the spring (incidence ratio= 1.039, confidence interval= 1.003-1.075). There was not a statistically significant effect of transitioning out of DST

in the fall. In the spring, the risk was more pronounced among those taking cardiac medications and those with low cholesterol and triglycerides. In the fall, there was a lower incidence among patients with hyperlipidemia and those taking statins and calcium-channel blockers. The authors conclude that even small disturbances to sleep may increase the risk of AMI and that vulnerable individuals might benefit from avoiding such sudden changes in their biological rhythms.

**6. Janszky I., Ljung R. Shifts to and from daylight saving time and incidence of myocardial infarction. *New England Journal of Medicine*. 2008;359(18):1966-1968.**

In this correspondence, Janszky et al. present an overview of their study that aimed to examine the influence that transitioning to and from daylight saving time has on acute myocardial infarction (AMI). Using data from the Swedish Myocardial Infarction Register, the authors compared the incidence of AMI on each of the 7 days following the spring and autumn transitions and compared these incidences to the mean of the corresponding weekday 2 weeks before and 2 weeks after the particular day of interest. The authors provide an example indicating that, "the Tuesday after the transition, we would have divided the incidence on that Tuesday by the mean of the incidence on the Tuesday 2 weeks earlier and the incidence on the Tuesday 2 weeks later." The data analyzed was for all AMI in Sweden from 1987-2006. In the spring, the incidence of AMI was significantly higher for the first 3 weekdays following the transition to daylight saving time while only the first weekday was significantly increased during the autumn transition. The authors also noted that the spring transition was more pronounced in women while the autumn transition was more pronounced in men. Overall, the transitions were more pronounced for people under the age of 65. Potential explanations for the findings include adverse effects of sleep deprivation and circadian misalignment, mental stress of a new work week, and the impact of a later bedtime but earlier wake time at the beginning of a work week.

**7. Jiddou M. R., Pica M., Boura J., et al. Incidence of myocardial infarction with shifts to and from daylight savings time. *The American journal of cardiology*. Mar 01 2013;111(5):631-635.**

Jiddou et al. conducted a retrospective case-control study to determine the incidence ratio of acute myocardial infarction (AMI) immediately following the shift to and from daylight savings time (DST). The authors reviewed 935 electronic medical records from the Royal Oak and Troy campuses of the Beaumont Hospitals in Michigan. Cases were selected by primary diagnosis of AMI the week after the spring transition to DST and the week after the shift back to standard time in autumn. Controls were selected based on comparable diagnoses 2 weeks before and 2 weeks after the shift to and from DST. From October 2006 to April 2012, 328 cases and 607 controls were selected. After controlling for confounding factors, the authors found that overall frequency of AMI was similar in the spring and in autumn. The incidence of AMI in the week following the shift to and from DST was not significantly different in spring and in autumn, 1.17 (95% CI 1.00 to 1.36) and 0.99 (95% CI 0.85 to 1.16), respectively. While there were no significant changes from spring to autumn in AMI incidence, the large increase in AMI occurred on the first day (Sunday) after the spring shift (1.71, 95% CI 1.09 to 2.02;  $p < 0.05$ ). While incidence was lower than expected following the autumn shift, the Saturday following the shift (one week after) was significantly greater than any other day that week. The authors conclude that more research needs to be done to determine the biological causes behind this slight increase in AMI incidence following the shift to and from DST.

**8. Sandhu A., Seth M., Gurm H. S. Daylight savings time and myocardial infarction. *Open heart*. 2014;1(1):e000019.**

Sandhu, Seth, and Gurm used data from the Blue Cross Blue Shield of Michigan Cardiovascular Consortium Percutaneous Coronary Intervention Quality Improvement Initiative (BMC2-PCI). The authors used this prospective, multicenter registry to determine associations of increased acute myocardial infarction (AMI) following the spring and autumn daylight savings time (DST) changes. Hospital admissions for AMI between January 2010 and September 2013 were recorded and entered into the BCM2-PCI registry. After controlling for potential confounding factors, the authors used regression analysis to map yearly, weekly, and seasonal trends in AMI. The Monday following the Spring DST shift was associated with a 24% increase in daily AMI count ( $p=0.011$ ). The Tuesday following the Autumn DST shift was also significant for decreasing AMI count by 21% ( $p=0.044$ ). While these findings are significant, other data suggests that the yearly incidence of AMI did not reflect a major increase in cases. The authors suggest that switching to DST in the spring could accelerate events that are likely to occur in particularly vulnerable patients.

**9. Schneider A. M., Randler C. Daytime sleepiness during transition into daylight saving time in adolescents: Are owls higher at risk? *Sleep medicine*. Oct 2009;10(9):1047-1050.**

Schneider and Randler conducted a cross-sectional cohort study to determine the effects of daylight savings time (DST) on sleepiness of adolescents in Germany schools in the spring of 2008. Children from three schools volunteered to fill out questionnaires while attending classes the week prior to, during, and after the DST switch. Four hundred and sixty-nine teenagers participated (mean age 13.5 years) during the three week sampling period. After regression, researchers found that sleepiness and being an evening person correlated with increased age. Students who were older and who tended to be night people scored significantly higher for daytime sleepiness in the week after the DST shift. The authors suggest that class and performance tests should not be scheduled in the first week after the DST shift due to increased sleepiness for older students.

**10. Sipila J. O., Rautava P., Kyto V. Association of daylight saving time transitions with incidence and in-hospital mortality of myocardial infarction in Finland. *Annals of medicine*. 2016;48(1-2):10-16.**

Sipila, Rautava, and Kyto used data from 22 Finnish hospitals to determine association between acute myocardial infarction (AMI) and the spring and autumn shifts in daylight savings time (DST) during 2001-2009. Researchers compared expected incidence and actual incidence for the two weeks prior to and the three weeks following each DST shift. Any year where spring DST occurred on Easter was excluded. After controlling for confounding factors, researchers found that incidence of AMI increased on the Wednesday following the spring transition (IR 1.16; 95% CI 1.01-1.34). After the autumn DST transition, researchers found that incidence of AMI decreased the following Monday (IR 0.85; 95% CI 0.74-0.97), but incidence increased compared to control weeks by the following Thursday (IR 1.15; 95% CI 1.02-1.3). There was no significance in gender differences, but they did find that patients who had other comorbidities

were at increased risk of AMI after the spring or autumn DST transition. Overall, there was no impact on overall incidence of AMI but rather a change in the temporal distribution.

**11. Sipila J. O., Ruuskanen J. O., Rautava P., et al. Changes in ischemic stroke occurrence following daylight saving time transitions. *Sleep medicine*. Nov - Dec 2016;27-28:20-24.**

Sipila, Ruuskanen, Rautava, and Kyto used data from 20 Finnish hospitals to determine association between acute ischemic stroke (IS) and the spring and autumn shifts in daylight savings time (DST) during 2004-2013. Expected and actual incidence of IS were compared. Over the course of the study, there were a total of 3,033 patients with acute IS in the week following either the spring or autumn DST transition. A total of 11,801 cases of IS occurred during control weeks. After a DST transition, incidence of IS increased in the first two days (RR 1.08; CI 1.01-1.15). Overall, the incidence did not change compared to control weeks but the timing of events was impacted by a DST transition. When compared with men, women were more susceptible to temporal changes after DST transitions. Older patients also had a significant increased risk of IS following a DST transition.

**12. Huang A., Levinson D. The effects of daylight saving time on vehicle crashes in Minnesota. *Journal of safety research*. Dec 2010;41(6):513-520.**

Huang and Levinson analyzed Minnesota State data between 2001 and 2007 to determine if the spring or fall daylight savings time (DST) transitions had any impact on incidence of vehicle crashes. The authors determined that transition to DST in the spring increased traffic due to more people taking advantage of afternoon daylight hours. The most relevant finding was that the short-term impact of DST on traffic accidents is not statistically significant in the spring or in the fall. The authors suggest that while increased afternoon visibility may have decreased the incidence of vehicle crashes, the increased number of cars on the road may have actually offset those numbers.

**13. Varughese J., Allen R. Fatal accidents following changes in daylight savings time: the American experience. *Sleep medicine*. 2001.**

Varughese and Allen analyzed fatal automobile accident data from the United States National Highway Transportation Safety Administration for a 21-year period from 1975-1995 to determine if there was an association between fatal automobile accidents and the shift to and from daylight savings time (DST). They used data from the Saturday (pre-switch), the Sunday (during the switch), and the Monday (post-switch) of the spring and fall DST transitions. For the spring DST change, the authors found that fatal accidents increased on the Monday following the transition, with no significant changes on the Saturday or Sunday of the shift. For the fall DST change, the authors found that fatal accidents increased the following Sunday, possibly due to the perceived benefit of being able to stay out for an extra hour the night before. The authors suggest that the increase in fatal accidents following the spring and fall transitions to and from DST could be caused by an immediate shift in sleep cycle and behavior adaptation.

14. **Ferguson S., Preusser D., Lund A., et al. Daylight saving time and motor vehicle crashes: The reduction in pedestrian and vehicle occupant fatalities. *American Journal of Public Health*. 1995;85(1):92-95.**

Ferguson and Lund, et al. compared daylight data and fatal vehicle crash data in the United States between the years 1987-1991 during the spring and fall daylight saving time (DST) shifts. The authors found that there was an increase in pedestrian fatal crashes after the transition back to standard time in the fall. They suggest that this was due to more darkness during afternoon commute times. Overall, the authors found that shifting an hour of daylight to the evening hours decreased the number of fatal crashes that occurred. They also estimated that 901 fewer fatal crashes would have occurred, including 727 involving pedestrians and 174 involving vehicle occupants, if daylight saving time had been in place all year from 1987-1991.

15. **Lahti T., Sysi-Aho J., Haukka J., et al. Work-related accidents and daylight saving time in Finland. *Occupational Medicine (London)*. Jan 2011;61(1):26-28.**

Lahti et al. analyzed the number of occupational accidents one week before and one week after the shift to and from daylight savings time (DST) from 2002-2006. Data was gathered from the registry of Federation of Accident Insurance Institutions, which collects data on workplace accidents. The authors found no significant difference in workplace accident frequency between the week before and the week after the shift. However, the authors did notice a trend in annual and seasonal variation of workplace accidents ( $p < 0.001$ ), which they attribute to seasonal changes in weather conditions.

16. **Morassaei S., Smith P. M. Switching to Daylight Saving Time and work injuries in Ontario, Canada: 1993-2007. *Occupational and environmental medicine*. Dec 2010;67(12):878-880.**

Morassari and Smith analyzed claim reports from the Ontario Workplace Safety & Insurance Board that were filed between 1993 and 2007 to determine incidence of lost time and no lost time workplace injury claims within the weeks before and after the spring and autumn daylight saving time (DST) shifts. After accounting for the Easter holiday which often coincides with the spring DST shift, the authors found no significant changes in the incidence of workplace injury claims before and after the spring and autumn DST shift.

17. **Barnes C. M., Wagner D. T. Changing to daylight saving time cuts into sleep and increases workplace injuries. *The Journal of applied psychology*. Sep 2009;94(5):1305-1317.**

In this study by Barnes et al., the authors explored a number of different hypotheses using two different studies. The first study utilized national mining injury data from the National Institute for Occupational Safety and Health from 1983-2006 to examine the influence that time changes may have on workplace injuries. The results indicate that on the Monday following a transition, there are 3.6 more mining injuries and this translates to 2,649 more days of work lost due to injury than on non-transition days. This suggests that the injuries that occur on these days are more severe. The second study used data from the American Time Use Survey of the Bureau of Labor Statistics to understand the link between phase changes and sleep quantity. Results from the second study indicate that, "...on Mondays directly following the switch to Daylight Saving Time, workers sleep on average 40 min less than on other days. On Mondays directly following

the switch to Standard Time— in which 1 hour is gained—there are no significant differences in sleep, injury quantity, or injury severity." The authors conclude that the transition between daylight saving time and standard time put employees in danger and that as a practical application, employers should be mindful of scheduling dangerous work activities around a phase shift.