Executive Summary: Health Impact Review of HB 1196

Allowing for the year round observation of daylight saving time
(2019 Legislative Session)

Evidence indicates that HB 1196 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 daylight saving time on health inequities is not well researched.

BILL INFORMATION

Sponsors: Riccelli, Steele, Stonier, Fitzgibbon, Ortiz-Self, Tarleton, Doglio, Schmick, Eslick, Lovick, Fey, Shea, Tharinger, Goodman

Summary of Bill:

- If authorized by the United States Congress, the time of the State of Washington is Pacific daylight saving time throughout the calendar year, as determined by reference to coordinated universal time.
- States no code city shall adopt any provision for the observance of daylight saving time other than as authorized by section 2 of this act.
- Repeals RCW 1.20.050 (Standard time—Daylight saving time), RCW 1.20.051 (Daylight saving time), and RCW 1.20.--- (section 1 of this act).
- Requires the Governor to provide written notice of the effective date to affected parties, the chief clerk of the House of Representatives, the secretary of the Senate, the Office of the Code Reviser, and others as deemed appropriate by the Governor.
- Requires the Secretary of State to submit this act to the people for their adoption and ratification, or rejection, at the next general election to be held in Washington State.

HEALTH IMPACT REVIEW

Summary of Findings:

This Health Impact Review found the following evidence regarding the provisions in SB 1196:

- Strong evidence that implementing year-round daylight saving 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 daylight saving time on health inequities is not well researched.

For more information:
Phone: (360) 628-7342
Email: hir@sboh.wa.gov
sboh.wa.gov/hir

Health Impact Review of SB 1196

Allowing for the year round observation of daylight saving time (2019 Legislative Session)

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Staff contact:
Caitlin Lang-Perez
Phone: (360) 628-7342
Email: caitlin.lang@sboh.wa.gov

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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 House Bill 1196 (HB 1196).

Staff analyzed the content of SB 1196 and created a logic model depicting possible pathways leading from the provisions of the bill to health outcomes. We consulted with experts and contacted key informants about the provisions and potential impacts of the bill. We conducted an objective review of published literature for each pathway using databases including PubMed, Google Scholar, and University of Washington Libraries. More information about key informants and detailed methods are available upon request.

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-evidence for each relationship. The strength-of-evidence has been defined using the following criteria:

- **Not well researched:** the review of literature 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 review of literature 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 percentage 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 review of literature 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 review of literature 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 are referenced multiple times.

Analysis of SB 1196 and the Scientific Evidence

Summary of relevant background information

- It is U.S. policy (U.S. Code, Title 15 §260) to "promote the adoption and observance of uniform time within standard time zones […] the [U.S.] Secretary of Transportation is authorized and directed to foster and promote widespread and uniform adoption and observance of the same standard of time within and throughout each such standard time zone."[1]
- Federal law requires states to observe daylight saving time (DST) from early March to early November and standard time the remainder of the year.[1] However, states are permitted to implement standard time year-round, without federal approval, as Hawaii and Arizona have done. Adopting DST year-round requires Congressional and Presidential approval.
- In 2018, H.R.6202 was introduced to the 115th U.S. Congress. The legislation would allow states to elect to observe year-round DST.[2] The proposal was referred to the House Committee on Energy and Commerce.
- Currently, three other states have proposals to implement DST year-round.
    - In March 2018, Florida passed the "Sunshine Protection Act" (Florida Statute 1.025), making it the only state to adopt DST year-round.[3] While legislation to authorize Florida's act has been introduced in the U.S. Congress (S.2537 and H.R. 5279), neither chamber has voted on the proposals.[4]
    - In 2018, California voters passed Proposition 7, which encourages the legislature to consider instituting year-round DST.[5] The proposition also requires a two-thirds vote of the Legislature to change the period of DST. In December 2018, Assembly members introduced Assembly Bill 7 to establish California's standard time to year-round DST.[6]
    - In January 2019, Oregon legislators introduced legislation (House Bill 2297) to abolish the annual one-hour change in time from standard time to DST and to maintain Oregon on DST all year.[7]

Summary of HB 1196

- If authorized by the United States Congress, the time of the State of Washington is Pacific daylight saving time throughout the calendar year, as determined by reference to coordinated universal time.
- States no code city shall adopt any provision for the observance of daylight saving time other than as authorized by section 2 of this act.
- Repeals RCW 1.20.050 (Standard time—Daylight saving time), RCW 1.20.051 (Daylight saving time), and RCW 1.20.--- (section 1 of this act).
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- Requires the Secretary of State to submit this act to the people for their adoption and ratification, or rejection, at the next general election to be held in Washington State.

Health impact of HB 1196

Evidence indicates that SB 1196 has the potential to improve health outcomes, particularly on days that would immediately follow a transition to or from DST. The evidence for the impact of implementing year-round DST on health disparities is not well researched.

Pathway to health impacts

The potential pathways leading from the provisions of SB 1196 are depicted in Figure 1. There is strong evidence that implementing year-round DST 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 DST.[8-21] The likely impact of implementing year-round DST 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. We specifically looked at the provisions in the bill that would make daylight saving time the permanent time of Washington State. For example, potential pathways that were not researched include:

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

Magnitude of impact

Because this bill would implement year-round DST for Washington State, the population likely to be impacted includes 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,[12] those with low cholesterol and triglycerides,[12] individuals under the age of 65 years,[13] and those with other comorbidities (hypertension, diabetes, etc.).[17] 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.[11,16]

Logic Model

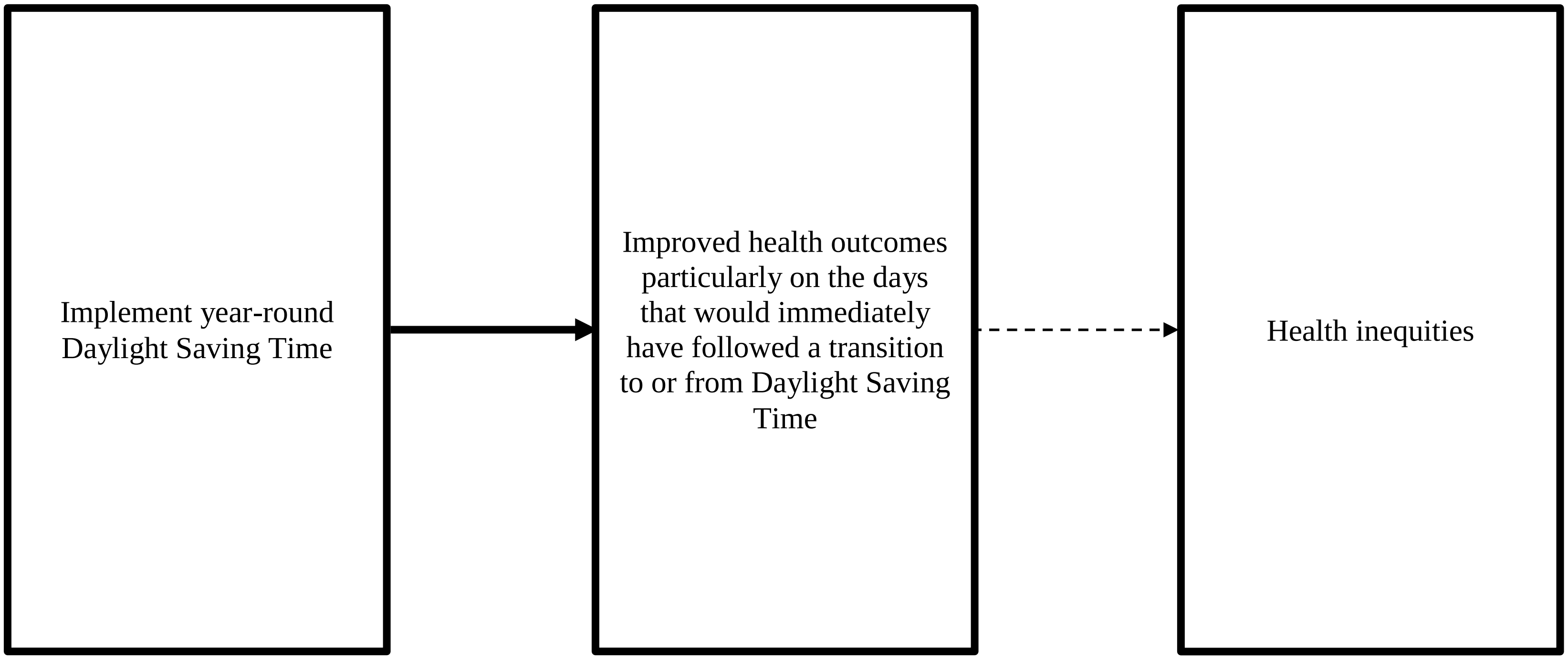
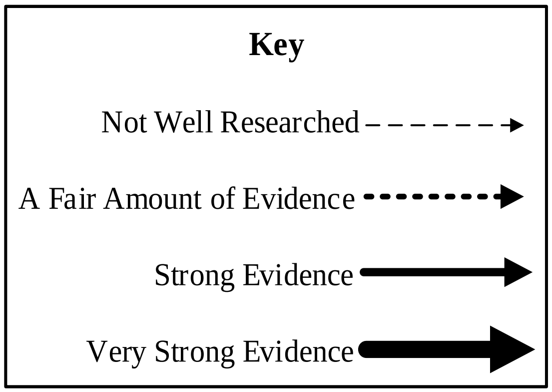


Figure 1

Allowing for the year round observation of daylight saving time

HB 1196



Summaries of Findings

Will implementing year-round Daylight saving time in Washington improve health outcomes?

There is strong evidence that implementing year-round daylight saving time (DST) 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 DST and any one particular health outcome varies, the body of evidence between implementing year-round DST 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.[9,12-15,17-21] A summary of the research not included regarding DST and traffic accidents, work-related accidents,[22-24] depressive episodes,[10] and suicide[8] is summarized at the end of this section beginning on page 6.

Heart Attack

A number of studies have examined the relationship between DST 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.[9] 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.[9] 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.[12-14] 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.[15,17] 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.[14,15,17]

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.[18]

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 [DST] 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."[11] 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, yet the impact of DST on traffic accidents is not statistically significant in the spring or in the fall.[25] 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.[26] 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.[26] A third study found that there was an increase in pedestrian fatal crashes after the transition back to standard time in the fall.[27] Authors 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 DST had been in place all year during the study years (1987-1991).[27] A New Zealand study used 12.6 million accidents claims (2005-2016) to model accident rates as a function of various date-based predictions, including days before/after the start and end of DST.[28] Results show that the start of DST was associated with significantly higher rates of road accidents (first day +16% and second day +12%).[28] A study in Spain used road traffic accident data (1990-2014) to modeled fatalities following DST changes in Spain's 52 provincial capital cities. Authors estimate 40 deaths during the study period can be attributed to DST changes: "23.4 (95% CI [2.7; 39.9]) and 14.7 (95% CI [-7.8; 32.8]) for the summer and fall changes, respectively."[29] Authors estimate, on average, "DST changes are associated with a cost of 1.5 lives every year due to road traffic accidents in Spain's capital cities." However, as 78% of fatal collisions occur on roads outside of cities, they estimate that "this could have an additional cost of another 5 lives every year."[29]

A 2013 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.[11] A 2017 systematic review of literature examined the impact of DST on collision risk.[30] The primary outcomes of interest were road traffic collisions, injuries and fatalities. Of the articles reviewed that examined short-term outcomes, five met HIR inclusion criteria. Findings were inconsistent; three of the five articles found no statistically significant short-term effects of DST.[30] Overall, authors found "[t]he long-term findings suggested a positive effect of DST. However, this cannot be attributed solely to DST, as a range of road collision risk factors vary over time."[30] They concluded that the "evidence from this review cannot support or refute the assertion that a permanent shift in light from morning to evening will have a road safety benefit."[30]

Work-related accidents

The literature regarding work-related accidents and DST is also conflicting. Looking first at work-related accidents and occupational injury, three articles found no significant difference in workplace accident frequency between the week before and the week after the shift in the spring and fall.[23,24,28] 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.[23] Alternatively, an analysis of national mining injury data from the National Institute for Occupational Safety and Health from 1983-2006 found that there are, on average, 3.6 more mining injuries on the Monday following a transition, which translates to 2,649 more days of work lost due to injury than on non-transition days.[22] This suggests that the injuries that occur on these days are more severe. Authors also analyzed a second data set from the American Time Use Survey of the Bureau of Labor Statistics 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 [DST], 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."[22] The authors conclude that the transition between DST 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.[22]

Depressive Episodes and Suicide

Two additional studies examine the association between DST, depressive episodes, and suicides.[8,10] 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.[10] 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.[10] 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.[8] 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.[8]

Will improving health outcomes for residents of Washington impact health inequities?

The evidence for the impact of implementing year-round daylight saving time on health inequities is not well researched. One study which identified a relationship between shifting to DST and the risk of stroke found that, 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.[18] A study of DST transitions and AMI found significant increased risk for men in the first 3 days after spring DST transition (RR 1.155, 95% CI 1.000-1.334) as well as for individuals who took angiotensin.[21] However, results of a literature review found that while there was evidence to support the presence of an association between DST and a modest increase of AMI occurrence, there were no definite sex specific differences.[20] Further study is necessary to determine whether specific subpopulations experience health inequities related to DST.

Annotated References

Uncategorized References

1. **Standard Time, 15 U.S.C. §260 United States Code, 2011 Edition.**
Title 15 (Commerce and Trade), Chapter 6 (Weights and Measures and Standard Time), Subchapter IX - Standard Time of the U.S. Code discusses Congressional adoption and observance of uniform standard time, advancement of time or changeover dates, commerce, and designated time zones.

2. **H.R.6202 - To allow States to elect to observe year-round daylight saving time, and for other purposes. Washington, D.C. : Library of Congress; 2018.**
In June 2018, Representative Mike D. Rogers of Alabama introduced H.R.6202, which would allow States to elect to observe year-round daylight saving time.

3. **Sunshine Protection Act, 1.025 Florida Statutes(2018).**
Florida State House Bill 1013, signed by Governor Rick Scott on March 23, 2018, amended Title 1 - Construction of Statutes, Chapter 1 - Definitions to include the Sunshine Protection Act (1.025). The statute states, "if the [U.S.] Congress amends 15 U.S.C. s. 260a to authorize states to observe daylight saving time year-round, it is the intent of the Legislature that daylight saving time shall be the year-round standard time of the entire state and all of its political subdivisions."

4. **Sunshine Protection Act of 2018. Washington, DC: Library of Congress; 2018.**
Florida-specific legislation was introduced during the 115th U.S. Congress (2018-2018) to implement the "Sunshine Proection Act of 2018." In March 2018, Florida Senator Marco Rubio introduced S.2537 on and Florida Representative Vern Buchanan introduced H.R.5279 to make daylight saving time permanent in the state. Both have been referred to committees.

5. **Proposition 7, Conforms California Daylight Saving Time to Federal Law. Allows Legislature to Change Daylight Saving Time Period. Legislative Statute. Sacramento, California2018.**
The law proposed by Assembly Bill 807 2017-2018 Regular Session (Chapter 60, Statutes of 2018) was submitted to the people in accordance with Section 10 of Article II of the California Constitution. The proposition passed.

6. **Chu Kansen, Gonzalez Lorena, Obernolte Jay. Assembly Bill 7, An act to amdend Section 6808 of the Government Code, relating to computation of time, and declaring the urgency thereof, to take effect immediately. . Sacramento, California2018.**
Assembly Bill 7 would set California's standard time to year-round daylight saving time afte the U.S. Congress authorizes the state to do so, as specified. The bill requires a two-thirds majority to pass.

7. **Post Bill, Lively John. House Bill 2297, Relating to standards of time; providing that this Act shall be referred to the people for their approval or rejection. The proposal abolishes the one-hour change in time from standard time to daylight saving time and maintains Oregon on daylight saving time year-round. . 2019.**
If the U.S. Congress authorizes year-round daylight saving time, this bill would maintain Oregon on daylight saving time all year.

8. **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.

9. **Culic V. Daylight saving time transitions and acute myocardial infarction. *Chronobiology international.* 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 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.

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

11. **Harrison Y. The impact of daylight saving time on sleep and related behaviours. *Sleep medicine reviews.* 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.

12. **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.* 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.

13. **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 involves 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.

14. **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.*** **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.

15. **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.

16. **Schneider A. M., Randler C. Daytime sleepiness during transition into daylight saving time in adolescents: Are owls higher at risk? *Sleep medicine.* 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.

17. **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.

18. **Sipila J. O., Ruuskanen J. O., Rautava P., et al. Changes in ischemic stroke occurrence following daylight saving time transitions. *Sleep medicine.* 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.

19. **Manfredini R., Fabbian F., Cappadona R., et al. Daylight saving time, circadian rhythms, and cardiovascular health. *Intern Emerg Med.* 2018;13(5):641-646.**
Manfredini et al. review the relationship between daylight saving time (DST) and cardiovascular health. "The available evidence suggests the existence of an association between DST and a modest increase of occurrence of acute myocardial infarction, especially in the first week after the spring shift." Authors note possible mechanisms include sleep deprivation, circadian misalignment and environmental conditions. Authors recommend further study consider the role of gender and individual preference in circadian rhythms (chronotype).

20. **Manfredini R., Fabbian F., Giorgi A. De, et al. Daylight saving time and myocardial infarction: should we be worried? A review of the evidence. *European Review for Medical and Pharmacological Sciences.* 2018;2018(22):750-755.**
Authors identified and evaluated the possible association between daylight saving time (DST) and acute myocardial infarction (AMI), using electronic health database (years 2009-2016). Search terms included, ‘daylight saving time’, ‘daylight saving time’ plus ‘gender’, and ‘daylight saving time’ plus ‘acute myocardial infarction’. In total, authors identified 72, 10, and 6 studies were found, respectively. "Overall, 6 studies, including a total of 87,994 cases, resulted to satisfy the searching request, and were included in the present analysis. All studies confirmed a higher occurrence of AMI in the spring shift, ranging from 4 to 29%, whereas only 1 study showed a higher occurrence of AMI in the autumn shift." Five studies providing separate analysis found results by sex were not univocal. In regards to the spring shift, "2 studies did not show differences between men and women, 2 reported a higher frequency in men, and 1 in women." Specific to the autumn shift, "only 1 study reported a higher occurrence of AMI in women." Results support the presence of an association between DST and a modest increase of AMI occurrence, especially for the spring shift, but do not indicate definite gender specific differences.

21. **Kirchberger I., Wolf K., Heier M., et al. Are daylight saving time transitions associated with changes in myocardial infarction incidence? Results from the German MONICA/KORA Myocardial Infarction Registry. *BMC Public Health.* 2015;15:778.**
Kirchberger et al. examined the association of daylight saving time (DST) transitions with acute myocardial infarction (AMI) incidence recorded in the population-based German MONICA/KORA Myocardial Infarction Registry. The study sample consisted of 25,499 coronary deaths and non-fatal AMI cases aged 25-74 years. Authors "used Poisson regression with indicator variables for the 3 days or the week after the spring and the autumn transition and adjusted for potential confounders to model the association between DST transitions and AMI incidence." They also built an excess model by calculating observed over expected events per day. Overall, results showed "no significant changes of AMI risk during the first 3 days or 1 week after the transition to and from DST." However, "subgroup analyses on the spring transition revealed significantly increased risks for men in the first 3 days after transition (RR

1.155, 95 % CI 1.000-1.334) and for persons who took angiotensine converting enzyme (ACE) inhibitors prior to the AMI (3 days: RR 1.489, 95 % CI 1.151-1.927; 1 week: RR 1.297, 95 % CI 1.063-1.582)." Additionally, following the autumn shift, "patients with a prior infarction had an increased risk to have a re-infarction (3 days: RR 1.319, 95 % CI 1.029-1.691; 1 week: RR 1.270, 95 % CI 1.048-1.539)." Authors concluded that specific subgroups (i.e.., men and persons with a history of AMI or prior treatment with ACE inhibitors) may have a higher risk for AMI during DST. They suggested further studies that include data on chronotype and sleep duration are necessary to confirm results.

22. **Barnes C. M., Wagner D. T. Changing to daylight saving time cuts into sleep and increases workplace injuries. *The Journal of applied psychology.* 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.

23. **Lahti T., Sysi-Aho J., Haukka J., et al. Work-related accidents and daylight saving time in Finland. *Occupational Medicine (London).* 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.

24. **Morassaei S., Smith P. M. Switching to Daylight Saving Time and work injuries in Ontario, Canada: 1993-2007. *Occupational and environmental medicine.* 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.

25. **Huang A., Levinson D. The effects of daylight saving time on vehicle crashes in Minnesota.** ***Journal of safety research.*** **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.

26. **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.

27. **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.

28. **Robb D., Barnes T. Accident rates and the impact of daylight saving time transitions.** ***Accid Anal Prev.*** **2018;111:193-201.**
Robb and Barnes use data from 12.6 million accident claims in New Zealand during 2005-2016 to model accident rates as a function of various date-based predictors including days before/after the start and end of DST, holidays, day of week, and month of year. According to authors, this is the first study to consider multiple accident categories (Road, Work, Falls and Home & Community), and the first in the southern hemisphere. Results show the start of DST was associated with significantly higher rates of road accidents (first day +16% and second day

+12%). The analysis also provides evidence that accident rates for Falls and Home & Community decline (increase) prior to the start (end) of DST, which indicates potential individual behavioral change in response to the anticipated time shift. Work accidents show limited impact from DST changes. "[F]indings are consistent with most of the literature, which suggests that the end of DST has less impact on accident rates than does the start of DST." Authors also note that "studies considering the impact of DST on accidents commonly compare rates after DST start to those in the preceding week, which are assumed to be unaffected by DST." However, study findings suggest that this common approach may need to be re-evaluated to consider behavior change.

29. **Prats-Uribe A., Tobias A., Prieto-Alhambra D. Excess Risk of Fatal Road Traffic Accidents on the Day of Daylight Saving Time Change. *Epidemiology.* 2018;29(5):e44-e45.**
Prats-Uribe et al. submitted a letter to the editor of *Epidemiology* detailing the estimated risk of daily fatal traffic accidents following summer and fall daylight saving time (DST) changes in Spain. Authors used data from the Spanish National Institute of Statistics to identify daily deaths caused by road traffic accidents in all 52 Spanish provincial capital cities between 1990 and 2014. An ecologic time-series study design was used and data were analyzed using quasi-Poisson regression with a distributed lay nonlinear model. They adjusted for long-term trend and seasonality as well as day of the week, and they modeled lagged effects for up to 30 days after DST changes. Overall, an average of 3.5 death per day were attributed to road traffic accidents (standard deviation [SD] = 2.8; range: 0 to 33). On the day of a DST change, the average number of deaths increased to 4.3 (SD = 3.3). "Risk of fatal road traffic accident increased by 30% on the same day as summer DST change (risk ratio [RR] = 1.30; 95% CI = [1.04; 1.62] at lag 0), to decrease in the consecutive 1–3 days [...] Fall DST change showed a similar distributed lag pattern, but with a smaller risk increase on the same day (RR = 1.16; 95% CI = [0.93; 1.45]) and almost no harvesting effect thereafter." Authors estimate that between 1990 to 2014, approximately 40 deaths can be attributed to DST changes (summer = 23.4 deaths; fall = 14.7 deaths). Authors note that 78% of fatalities due to road traffic accidents in Spain occur on roads outside of cities, which "could have an additional cost of another 5 lives every year."

30. **Carey R. N., Sarma K. M. Impact of daylight saving time on road traffic collision risk: a systematic review. *BMJ Open.* 2017;7(6):e014319.**
Carey et al. conducted a systematic review of literature to examine the impact of daylight saving time (DST) on collision risk. Authors did not limit the search to date of publication (the last search was performed in January 2017) and requested access to unpublished reports through an international expert group. "Studies that provided a quantitative analysis of the effect of DST on road safety-related outcomes were included. The primary outcomes of interest were road traffic collisions, injuries and fatalities." Of the 24 studies that met the inclusion criteria, 17 examined the short-term impact of transitions around DST and 12 examined long-term effects. Of those reviewed, 5 studies examining short-term outcomes were published after 2008 (HIR date of publication limit). Findings from the short-term studies were inconsistent. However, 3 of the 5 articles found no statistically significant short-term effects of DST. Overall, "[t]he long-term findings suggested a positive effect of DST. However, this cannot be attributed solely to DST, as a range of road collision risk factors vary over time." Authors conclude that the "evidence from this review cannot support or refute the assertion that a permanent shift in light from morning to evening will have a road safety benefit."