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Daylight saving time was not associated with a change in suicide rates in Austria, Switzerland and Sweden

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Background: Some studies have reported an increase in suicides after the start of daylight saving time (DST), but the evidence is mixed and more research about proposed mechanisms (disrupted sleep, changing light exposure) is needed. **Methods:** In our preregistered study, we analyzed change in suicide rates in the 2 weeks before/after DST, based on data between 1980 and 2022 from Austria, Switzerland and Sweden, using Poisson regression models and changepoint analyses. To explore the impact of disrupted sleep, we repeated the analysis for retired people who are likely less bound to DST, and for younger people. To explore the effect of changed daylight exposure, we repeated the analysis for northern and southern regions because twilight and daylight exposure varies by latitude. **Results:** Suicide rates did not significantly increase after the start of DST (adjusted incidence rate ratio IRR = 0.98, 95% CI 0.91–1.06, $P = 0.66$, $n = 13\,362$ suicides) or after DST ended (adjusted IRR = 0.99, 95% CI 0.91–1.07, $P = 0.76$, $n = 12\,319$ suicides). There were no statistically significant findings among younger or older subgroups and also not in Sweden and Austria/Switzerland. No changepoints were detected. **Conclusions:** There were no significant changes in suicide rates associated with DST and no clear evidence to support proposed mechanisms (light exposure, disruption of sleep). Our study is one of the largest and was adequately powered. Nonetheless, even larger studies to detect smaller effects could be important to inform the debate about harms and benefits of DST.

Additional content

Additional content An author video to accompany this article is available at: https://oup.cloud.panopto.eu/Panopto/Pages/Viewer.aspx?id=3b1e3edc-f451-4f7e-89fd-b1410084b7fd.

Introduction

The impact of daylight saving time (DST) on health continues to be part of discussions about the harms and benefits of these 1-h time-shifts in spring and autumn.[1] One severe potential detrimental effect of DST reported in some studies is an increase in suicides. A German autopsy study found eight suicides in the 2 weeks preceding the start of DST and 23 suicides in the two following weeks and this difference was statistically significant.[2] A large and methodologically rigorous study reported an increase in suicides of about 6% after the start of DST.[3] One study from the US also found an increase in suicides during DST compared with the rest of the year[4] but failed to adjust for seasonal trend, which is problematic as suicides are known to peak in summer in the northern hemisphere.[5] Other studies did not find significant differences or only in subgroups, or the difference was lost after adjusting for seasonal trends.[6–9] A study from Finland did not find significant changes in suicide rates after the start of DST[7] but the chosen time-frames before/after DST were long so that an actual but small change in suicide rates may have been drowned in noise. None of the studies reported significant changes in suicides after the end of DST in autumn. Given these mixed findings, uncertainty remains if there is really any change in suicide rates associated with DST. Moreover, the literature may be affected by reporting bias, that is, the tendency that significant findings are more likely published in scientific journals.[10] Indeed, to our knowledge, none of the existing studies were preregistered, increasing the risk for false positive findings. Therefore, there is a need for preregistered studies to see if the effect of DST on suicide risk is real. This was the main goal of our study.

Another gap in the literature is the lack of research about possible mechanisms which can explain a change in suicide rates after the start of DST. Two proposed mechanisms which have been discussed are disruption of sleep rhythms and change in exposure to natural light. Sleep problems are a well-known risk factor for suicide risk and are considered as warning sign of imminent suicidality.[11] First ecological data confirmed that sleep problems precede an increase in suicide risk.[12] With regards to disruptions of sleep, the time-shift to summertime at the start of DST means that people have to interrupt their sleep-wake cycle in a way that is leading to reduced sleep (getting up 1 h earlier). This may explain the finding of some studies that there is an increase in suicides after the start of DST but not after the end of DST where people can sleep longer, and it is thus easier to adapt to the interruption of the sleep-wake cycle.[3] If the main driver for changes in suicide rates after the start of DST is the disruption of sleep, then no or

weaker associations should be seen in parts of the population which are not or less bound to time-shifts. It seems plausible to assume that retired people have more flexibility in adhering to time-shifts associated with DST, because retired people are not or less bound to work/school schedules, at least relative to people in the working/school age. In our study, we explore this hypothesis by comparing retired people (age 65 or older) to people of younger age.

The second proposed mechanism that may explain changes in suicide rates associated with DST is a change in exposure to natural light after the start of DST which may affect biopsychological mechanisms associated with sleep and mental health. The evidence seems mixed, however. Whereas one recent monitoring study reported that increased exposure to daylight was associated with lower risk,[13] suicides peak during summer in the northern hemisphere,[5] and sunlight hours correlated positively with suicides on a national level, independent of seasonality.[14] A recent study found that suicide rates are higher at the boundaries of time-zones where exposure to daylight is shifted towards the evening,[15] in line with an explanation of effects of daylight exposure to circadian rhythms. Notably, this effect was more pronounced in the northern US-states than in southern states. Similarly, a study from southern Brazil found that after time-shift to summertime, only those regions closer to the southern-pole had an increase in suicides.[9] It was discussed that circadian misalignment caused by time-shifts potentiate seasonal changes in the photoperiod, which are larger in regions closer to the poles.[15] Based on these findings, it can be assumed that the association of DST with changes in suicide rates should be more pronounced in areas in the northern hemisphere with higher latitude. Before, while setting up our protocol and before we became aware of these studies, we hypothesized in the opposite direction: because in the northern hemisphere, twilight is longer in northern countries than countries closer to the equator, and a time-shift of 1 h should lead to 'softer' changes in light exposure. Thus, we explore the hypothesis of the effect of DST with the latitude of the investigated regions in our study without specifying an expected direction. To sum up, in our study we explored these following pre-registered hypotheses:

Hypothesis 1: Is there a change in suicide rates associated with DST?
Hypothesis 1a. Is there an increase in suicides ($\geq$ 6%, based on Osborne-Christenson 2022[3]) after the time-shift to summertime?
Hypothesis 1b. Is there a zero or near-zero change in suicides (area of null defined as less than ±3%) after the time-shift to wintertime?

Hypothesis 2: Are the associations of DST with changes in suicide rates smaller or zero among the retired population (65+ years old), compared with the population which is more bound to time-shifts (those in employment or school, that is, people younger than 65 years old).

Hypothesis 3: Do the associations of DST and suicides differ in regions with higher latitude (more northern) compared with regions with lower latitude (more southern)?

Methods

Measures

Outcome

We obtained national suicide data for the years 1970–2022 from Austria (Statistik Austria) and Switzerland (Bundesamt für Statistik). Suicide data from Sweden were available for the years 1980–2022 (Socialstyrelsen). For each suicide, we had information about the date and the age and gender of the deceased person.

Exposure

We indexed each day in the time-frame of 60 days before and after the time-shift, with the day of the time-shift at the beginning/end of DST as reference date (Day 0). Thus, we created two variables, one for the beginning and one for the end of DST. For estimating the size of the impact of DST on suicide rates, we compared the 2 weeks before the time-shift with the 2 weeks afterwards. We chose 2 weeks because this fits the findings of Osborne-Christenson.[3] We used the years 1981–2022, because DST was on exactly the same dates in the three countries in this period. In Europe, from 1980 to 1995, DST started on the last Sunday (01:00 UTC) in March until the last Sunday (01:00 UTC) in September; from 1996 onward DST ended on the last Sunday in October.[16] In Austria, DST was reintroduced in 1980 beginning Sunday April 6th and ending Saturday September 27th, and from 1981 onward in accordance with other European countries.[17] In Switzerland, DST was reintroduced in 1981 following the European scheme.[17] In Sweden, DST was reintroduced in 1980 starting Sunday April 6th, and ending Sunday 28th of September, and following the European scheme afterwards.[16]

Statistical analyses

Main analysis

Based on theoretical assumptions and data from existing studies[3] it can be assumed that, if there is an increase in suicides after time-shift to summertime (start of DST), the expected change will be temporary until people readapt to disrupted sleep-rhythms. This should correspond with a jump in the suicide rates which then returns to the normal underlying longer-term trend. Alternatively, if increased exposure to daylight is the mechanism, then there should be a jump in the suicide rates which remains elevated. For both proposed mechanisms, the change should be seen as increase in suicide rates after the start of DST, lasting about 1–3 weeks according to the findings by Osborne-Christenson.[3]

There is a need to account for potentially confounding variables. First, there is an underlying seasonal trend of an increase in suicides during spring and a decrease during autumn.[5] Second, suicides are varying during the week, with an increase on Mondays and Tuesdays and a decrease on weekends.[5] Finally, suicide rates around the start of the DST may also be influenced by the effects of the Easter holidays which are temporarily located close to start of DST and sometimes coincide with DST, with a known reported increase in suicides after these holidays.[18] We used the following two statistical methods we already used in previous publications.[5,18,19]

1. *Poisson regression analysis*
   We compared the 2 weeks before the time-shift to the 2 weeks afterwards. The models were adjusted for the confounding variables mentioned above. To do so, the underlying longer-term seasonal trend was modelled with a simple linear term. Weekdays were modelled as ordinal variable with Mondays as baseline (suicides are known to peak here with lower rates until Sundays). Easter holidays were adjusted for by categorizing days in three categories: day is Easter–Monday or one of the preceding 6 days, day is one of the 7 days after Easter–Monday, or day is in other time period.
2. *Changepoint analysis*
   First, we used R's 'strucchange' package with a model that allowed for change of slopes and intercepts (regression lines do not need to be joint). Second, we applied Bayesian changepoint analysis similar as in a previous analysis,[19] with 60 days before and after the time-shift. To account for the confounding effect of Easter holidays, the same changepoint analysis was repeated for the 4 subsets of years where Easter was preceding the time-shift, when Easter coincided with the time-shift, when Easter was in the week following the time-shift, and when Easter was 14+ days after the time-shift (this is a slight deviation from the protocol where we specified the four subsets less precise).

For Austria and Switzerland, we also had data for the time-period before the introduction of daylight saving (1970–79) so that this may serve as a control period, keeping power-issues in mind.

Sensitivity analyses

(1) Because the first day of start/end of DST is always a Sunday and most people do not need to change their sleep-rhythm on Sundays, we ran a sensitivity analysis for Hypothesis 1, where the index-date was the day after the time-switch (Monday instead of Sunday).
(2) Adaption to the time-shifts may be longer or shorter than the 2-week period we use as time-frame in our analyses. According to the protocol, we planned to graphically inspect the distribution of suicides and to run an analysis for Hypothesis 1 using a time-span that reflect the observed change in suicide rates in the visual inspection of the time-series. Because of the null-findings in the main analysis, we deviated from the protocol by simply using three different time-spans: (a) using a 3-day period consisting of Sundays/Mondays/Tuesdays in the week before/after DST, (b) the week (7 days) before/after DST and (c) 3 weeks (21 days) before/after DST.
(3) End of summertime changed in the study period from last Sunday in September 1980–95 to last Sunday in October from 1996 onward. If the seasonal trend of suicides differs at the end of September and October, than this could bias the results. We thus ran a sensitivity analysis where the two time-periods were analyzed separately for the time-shift to wintertime.

Ethical considerations

This study is based on suicide data from national registers to which access is restricted. The statistical departments mentioned in the methods section can provide the raw data for research purposes upon request. The data we provide online are aggregated so that anonymity is guaranteed.

Results

Descriptives

There were 166 093 suicides in the time between 1981 and 2022 in all three countries (Austria: 65 240, Sweden: 47 950; Switzerland: 52 903). There were 13 362 suicides within 2 weeks pre/post start of DST and 12 319 suicides within 2 weeks pre/post end of DST. The mean daily suicides in the 2 weeks before and after DST are provided in table 1.

Hypothesis 1—Is there a change in suicide rates associated with DST?
Hypothesis 1a—Is there an increase in suicides (≥ 6%) after the time-shift to summertime?

As can be seen in table 2, the Poisson regression revealed there was no significant increase in suicides in the 2 weeks after the start of DST compared with the 2 preceding weeks, neither in the unadjusted model (incidence rate ratio IRR = 1.00, CI 0.97–1.04, $P = 0.95$), nor in the model adjusted for seasonal trend, Easter, and day of week (IRR = 0.98, CI 0.91–1.06, $P = 0.66$). Suicides were significantly lower during Easter and on days other than Mondays and Tuesdays (with a minimum at Saturdays and Sundays). Changepoint analyses could not detect significant changepoints. The results for the Bayesian changepoint analysis are given in figure 1, details for the frequentist analysis are available online.

Hypothesis *1 b*. Is there a zero or near-zero change in suicides after the time-shift to wintertime?

As expected, there was no significant change in suicide rates after the end of DST in autumn (see table 3), neither in the unadjusted model (IRR = 1.03, CI 1.00–1.07, $P = 0.07$) nor in the adjusted model (IRR = 0.99, CI 0.91–1.07, $P = 0.76$) and no changepoints were detected. Detailed results are available online.

Hypothesis 2: Are the associations of DST with changes in suicide rates smaller or zero among the retired population (65+ years old), compared with the population which is more bound to time-shifts (those in employment or school, that is, people younger than 65 years)?

As the results for the regression analysis show (table 3), the point-estimates hint at reduced suicide rates after the start of DST among older people (adjusted IRR = 0.93, CI 0.81–1.07, $P = 0.32$), whereas the point estimate among younger people is closer to the null (adjusted IRR = 1.01, CI 0.92–1.10, $P = 0.90$). However, the confidence intervals overlap substantially and the findings were not statistically significant, thus no firm conclusions can be drawn. No changepoints could be detected among the younger group. There was one changepoint for people 65+ years of age but this was 28 days before start of DST. No significant findings were found for the end of DST (detailed results online).

Hypothesis 3: Do the associations of DST and suicides differ in regions with higher latitude (more Northern, Sweden) compared with regions with lower latitude (more Southern, Austria/Switzerland)?

As the results for the regression analysis show (table 3), the point-estimates hint at increased suicide rates after the start of DST in higher latitude (Sweden) (adjusted IRR = 1.05, CI 0.91–1.21, $P = 0.53$), whereas the point estimate of lower latitudes (Austria/Switzerland) hinted at reduced suicide rates (adjusted IRR = 0.96, CI 0.88–1.05, $P = 0.36$). However, the confidence intervals overlap substantially and the findings were not statistically significant, thus no firm conclusions can be drawn. No changepoints could be detected. No significant findings were found for the end of DST (detailed results online).

Sensitivity analyses

Results were essentially unchanged in all sensitivity analysis (table 3). A description can be found online.

Table 1 Mean number of daily suicides (SD) in the 2 weeks before/after DST

	Start DST		End DST	
Country	pre	post	pre	post
All	11.36 (3.89)	11.37 (4.21)	10.3 (3.84)	10.65 (3.89)
Sweden	3.11 (1.81)	3.26 (1.95)	3.00 (1.76)	3.11 (1.79)
Austria/Switzerland	8.24 (3.34)	8.11 (3.51)	7.3 (3.22)	7.53 (3.30)

Table 2 Poisson regression results for start of DST and suicide rates

	Unadjusted model			Adjusted model		
Predictors	IRR	95% CI	*P*	IRR	95% CI	*P*
DST—post (vs. pre)	1.00	0.97–1.04	0.945	0.98	0.91–1.06	0.661
Seasonal trend				1.00	1.00–1.01	0.656
Easter				Reference: day is in Easter-week		
In week afterwards				1.25	1.16–1.34	<0.001
In other days				1.13	1.07–1.19	<0.001
Weekday				Reference: day is Monday		
Tuesdays				0.95	0.89–1.01	0.073
Wednesdays				0.90	0.84–0.95	<0.001
Thursdays				0.87	0.82–0.93	<0.001
Fridays				0.80	0.75–0.85	<0.001
Saturdays				0.79	0.74–0.85	<0.001
Sundays				0.79	0.74–0.84	<0.001
Observations	1176			1176		
R^2 Nagelkerke	0.000			0.146		

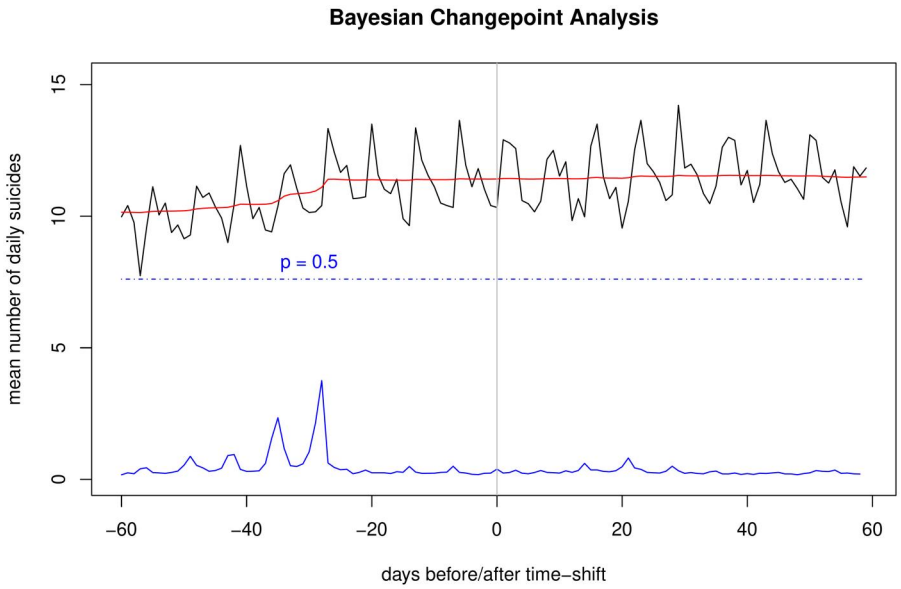

Figure 1 Bayesian changepoint analysis. Black line: number of suicides per day. Red line: posterior distribution. Blue solid line: probability of changepoint. Blue dashed line: threshold probability changepoint of 0.5

Table 3 Main results from Poisson regression models

		Start of DST		End of DST	
Analysis	**Adjusted**	**IRR (95% CI)**	***P***	**IRR (95% CI)**	***P***
H1—Main analysis	No	1.00 (0.97–1.04)	0.945	1.03 (1.00–1.07)	0.067
	Yes	0.98 (0.91–1.06)	0.661	0.99 (0.91–1.07)	0.763
Control 1970–79	No	0.95 (0.88–1.03)	0.246		
	Yes	0.87 (0.73–1.04)	0.123		
H2—Age					
Age <65	No	1.03 (0.99–1.07)	0.142	1.04 (1.00–1.08)	0.071
	Yes	1.01 (0.92–1.10)	0.898	1.03 (0.94–1.13)	0.507
Age 65+	No	0.93 (0.88–0.99)	0.029	1.02 (0.95–1.09)	0.556
	Yes	0.93 (0.81–1.07)	0.317	0.89 (0.77–1.03)	0.112
H3—Region					
Sweden	No	1.05 (0.98–1.12)	0.146	1.04 (0.97–1.11)	0.278
	Yes	1.05 (0.91–1.21)	0.526	0.97 (0.84–1.12)	0.649
AT-CH	No	0.98 (0.94–1.02)	0.409	1.03 (0.99–1.08)	0.140
	Yes	0.96 (0.88–1.05)	0.362	1.00 (0.91–1.09)	0.947
Sensitivity analyses					
Day 0 is Monday	No	0.99 (0.96–1.03)	0.756	1.01 (0.98–1.05)	0.482
	Yes	0.99 (0.92–1.07)	0.786	0.94 (0.87–1.02)	0.154
±Sunday/Monday/Tuesday	No	1.00 (0.93–1.08)	0.942	1.02 (0.95–1.10)	0.535
±7 days[a]	No	0.99 (0.95–1.04)	0.817	1.01 (0.96–1.06)	0.684
±21 days	No	1.00 (0.97–1.04)	0.945	1.03 (1.00–1.07)	0.067
	Yes	0.99 (0.92–1.07)	0.745	0.99 (0.91–1.07)	0.763
End DST September	No			1.03 (0.98–1.09)	0.220
	Yes			0.93 (0.83–1.05)	0.257
End DST October	No			1.03 (0.99–1.08)	0.175
	Yes			1.03 (0.93–1.15)	0.551

Discussion

In our preregistered study, we could not find significant changes in suicide rates associated with DST, based on 166 093 suicides occurring between 1981 and 2022 in Austria, Switzerland, and Sweden. There was no or inconclusive evidence to support proposed mechanisms which were discussed to explain an increase in suicides after the start of DST in some studies. The first mechanism are negative consequences from interrupted sleep after the start of DST. However, there was no or inconclusive evidence for a differential effect of age, where we hypothesized that the increase in suicides is more pronounced among people up to 64 years who are more bound to the time-shifts than compared with retired people 65+ years of age. The second mechanism was a change in exposure to natural light, where we hypothesized that the results may vary by latitude (Sweden vs. Austria/Switzerland) due to different effects of length of day and twilight. We found no or inconclusive evidence supporting a difference by latitude. The results from the sensitivity analysis where we used different time-frames before/after DST were comparable.

Our study is one of the largest so far and was adequately powered to detect a change in suicide rate of 6% in the 2 weeks following the start/end of DST, at least in the unadjusted regression analysis. The results for the adjusted regression analyses were generally comparable to the unadjusted analysis but the confidence intervals widened, making the results more or less inconclusive. For example, after the start of DST in spring, a change in suicide rates between −3% and

4% in the unadjusted analysis, and −9% and +6% in the adjusted analysis, would be compatible with the evidence we had from all three countries. We specified our null-field as ±3%. Thus, the unadjusted results were close to being conclusive (favouring the null-finding), but the adjusted analysis produced somewhat inconclusive results. However, we considered a positive effect as an increase of ≥6% and, therefore, it can be said with high certainty that the increase in suicides in the 2 weeks after the start of DST does not exceed 6%.

Our study should be replicated with larger samples because it was underpowered to detect smaller changes in suicide rates (<6% in the first 2 weeks after DST) which may be nonetheless important to evaluate the harm/benefit ratio of DST. We invite other researchers to use our data and code, which we openly share, and to add data from European countries to which they have access to, or to provide us this data so that we can expand our analysis to achieve more precise estimations.

Besides power-issues, there may be concerns with the plausibility of the hypotheses. The degree of being bound to time-shifts for retired people vs. those in the working/school age should be empirically tested. Similarly, the association between exposure to natural light and latitude may be weak, especially when much of life is happening indoors in the colder time of year. Furthermore, as one reviewer pointed out, we did not report results by gender (72% of suicides were males). We did not plan this because we were not aware of gender-specific effects and to maximize statistical power. Results for men and women are now reported in Supplementary tables S1 and S2 and are generally in line with those for the full sample. A strength of the study is that suicide is a 'hard outcome' which is indicative of distress and mental health problems and less prone to biases than for example, self-reports of mental health.

If we consider our study as null-finding, the question remains why some published studies found an increase in suicides after the start of DST. One explanation could be selective reporting of 'positive', statistically significant results, which can easily be found when there are a lot of degrees of freedom to carry out the data-analysis.[10] This can explain why most published research findings are false[20] and why registered reports and replication studies lead to a dramatic increase in null-findings.[21] Given that none of the studies about DST and suicide were preregistered (based on information in the publications), it is thus plausible to assume that the mixed findings in the literature about suicides and DST may have been partly influenced by these known biases, too. It is also puzzling that only few studies on the topic exist. If there really is a change in suicide rates after the start of DST, then a larger number of publications could be expected, even more so as many researchers have access to national suicide databases and such research is then easy to accomplish. Another explanation could be that the effect of the Easter holidays, which often coincide with the start of DST were not accounted for. Furthermore, the research question might not have drawn sufficient attention yet. Finally, the effects of DST and suicide may be real but small and studies so far have been underpowered.

Conclusion

There was no significant increase in suicide rates after the start of DST in our study. There was no or inconclusive evidence to support proposed mechanisms which were discussed to explain previous findings of an increase in suicides after DST, that is, change in exposure to light and disruption of sleep. Our study is one of the largest so far and was adequately powered to replicate the positive findings of existing studies. Selective reporting may be one explanation of the mixed findings in the literature. Replication with larger samples to detect very small effects should be done.

Supplementary data

Supplementary data are available at *EURPUB* online.

Funding

No funding was involved in the study.

Conflicts of interest: None declared.

Data availability

The protocol and the R-code are available at the Open Science Foundation (OSF): https://osf.io/4h7tw/. We cannot provide the raw suicide data because of restrictions by the national statistics departments (see Methods Section). These departments can provide the raw data for research purposes upon request. However, we uploaded the aggregated data (sum of suicides per day in the three countries and the two age-groups) for the time-period of interest (± 60 days before/after DST) because this guarantees anonymity.

Key points

- Some evidence suggests an increase in suicides after the start of daylight saving time.
- Disrupted sleep and changed exposure to light are proposed explanatory mechanisms.
- This study attempted to replicate the findings and explored proposed mechanisms.
- The study was pre-registered and one of the largest so far.
- There was no significant increase in suicides after the start of daylight saving time.

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