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A quasi-experimental study of the impact of school start time changes on adolescents' mood, self-regulation, safety, and health

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ABSTRACT

Objective: To determine whether school start time changes impact adolescents' mood, self-regulation, safety, and health.
Methods: In September 2015, two school start time changes were implemented in Fairfax County (VA) Public Schools: a 50-minute delay (to 8:10 AM) for high schools and secondary schools and a 30-minute advance (to 7:30 AM) for middle schools. We conducted cross-sectional surveys of students' sleep, mood, self-regulation, health, and safety before (2017 students) and after (1180 students) these changes.
Results: Adjusted for confounders, a 50-minute delay was associated with a decreased prevalence of low mood (−4.7%; 95% confidence interval [CI]: −8.2%, −1.2%), drowsy driving, (−8.4%; 95% CI: −15.9%, −0.9%), and skipping breakfast (−4.2%; 95% CI: −8.1%, −0.2%) but no other significant changes. There were no significant changes associated with a 30-minute advance.
Conclusions: A 50-minute delay in school start time in high schools and secondary schools was associated with a decreased prevalence of low mood, drowsy driving, and skipping breakfast. A 30-minute advance in start time in middle schools was not associated with any appreciable changes.

Introduction

Numerous studies have evaluated the impacts on adolescents of delaying school start times (SSTs),[1–5] but most studies have focused on sleep and academic performance. Few have involved large public school districts with adequate comparison conditions or groups. Both mood and self-regulation might mediate the relationship between sleep duration and academic performance, social relationships, and risk-taking behaviors. Some studies have shown beneficial impacts of SST delays on mood,[6–9] and others have not.[5,10] However, no studies to our knowledge have evaluated impacts on self-regulation. With regard to safety, there is indirect evidence that SST delays may reduce teen car crashes,[11,12] but no studies have evaluated the impact of SST on other injuries or drowsy driving.

Few studies of SST change have assessed any sleep-related health outcomes. Skipping breakfast may impair academic performance[13] and occur more often with earlier school start times, but it has not been evaluated in relation to SST. Many studies in children and youth have shown a relationship between obesity and short sleep,[14–16] but only a single study examined the impact of SST delay on body mass index (BMI) and found no impact.[17] In addition, although a single item to assess self-rated health was shown to be associated with shorter sleep duration and poorer sleep quality in adults,[18] this item was not related to sleep duration in teens[19] and has not been studied in relation to SST.

We previously reported the impacts on adolescents' sleep of a 50-minute *delay* in high school start times and a 30-minute *advance* in middle school start times in one of the largest US school districts. We found an increase in school-night sleep duration of approximately 30 minutes after the SST delay and a decrease of approximately 15 minutes after the SST advance.[20] This report describes the impacts of these same SST changes on adolescents' mood, self-regulation, safety, and health.

Participants and methods

We used a quasi-experimental design with repeated cross-sectional school surveys to evaluate the impacts of SST changes in

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Fairfax County (VA) Public Schools, the 10th largest US school district.[21] The study protocol was approved by the school district's Research Screening Committee and the Institutional Review Boards at the Children's National Medical Center and Temple University.

In September 2015, two district-wide changes were implemented: (1) a 50-minute delay, from 7:20 AM to 8:10 AM, in the 24 high schools (grades 9-12) and 3 secondary schools (grades 7-12) and (2) a 30-minute advance, from 8 AM to 7:30 AM, in the 23 middle schools (grades 7-8). In the spring of 2015, before SST changes, we conducted an online survey of students and their parents in a subset of 19 schools (8 middle, 8 high, and all 3 secondary schools). These 19 schools were selected to be representative of the entire district in terms of student race/ethnicity and family income. In the spring of 2016, after the SST changes, another online survey was conducted in the same 19 schools using the same survey protocol and instrument.

In both surveys, parents received an email from the school district asking them to complete an online survey and grant consent for their child to complete a survey. Students with parental consent were emailed a link to an online survey and received a $5 gift card after completing it. Of the students enrolled in the 19 schools, 3197 students (age ≥12.0 and <19.0 years) completed surveys: 2017 students before the SST changes (6% of ~34,900) and 1180 students after the SST changes (3% of ~35,300). Compared with the overall population of students in grades 7-12 in the district, those who completed surveys were more often non-Hispanic White (before changes, 60.7% vs 42.1%; after changes, 52.0% vs 41.0%) and less often received free or reduced-price school meals (before changes, 8.1% vs 27.4%; after changes, 14.0% vs 27.6%).

Outcome measures

Using the self-report survey data, we examined the impact of 2 SST changes. This report focuses on 9 outcome measures in the areas of mood, self-regulation, safety (3 separate measures), and health (4 separate measures).

Mood

Mood was measured with a single item from the Youth Risk Behavior Surveillance System.[22] Students were classified as having low mood if they answered "yes" to the following question: "During the past 12 months, did you ever feel so sad or hopeless almost every day for two weeks or more in a row that you stopped doing some usual activities?"

Self-regulation

Self-regulation was measured with the 12-item Behavior Rating Inventory of Executive Function, second edition, Screening Self-Report Form.[23,24] Students were asked whether they "had problems over the last 6 months" with each of 12 behaviors and were given the response options of "never" (1), "sometimes" (2), or "often" (3). We reverse-coded items so that higher scores reflected greater self-regulation, and calculated the self-regulation score (Executive Function Screening score, possible range 1-3) as an average of the 12 items. In the study sample, the self-regulation scores had a statistically normal distribution, with an internal consistency (Cronbach α) of .85.

Safety

For the first of 3 safety measures, students reported on whether (yes/no) they were injured "during a team sport, athletic activity, or exercise" during the past 6 months. A second safety measure was based on report of being injured (yes/no) during the past 6 months in any of the following ways: "being in a physical fight with someone," "being hit by a moving vehicle while walking," "while working at a job," or "another way." A third safety measure, evaluated only in those of driving age (≥15.5 years) who reported ever driving, was the prevalence of drowsy driving, defined as having ever "driven a car or motor vehicle while feeling drowsy" in the past year.[25]

Health

Four separate health outcomes were evaluated. Students were classified as having fair or poor self-reported health based on responses to the question, "Compared to other people your age, would you say your health is poor, fair, good, very good, or excellent?"[22] A second measure, the prevalence of skipping breakfast, was based on a "no" response to the question, "On most school days, do you eat breakfast before your first class begins? (yes/no)." The third measure, physically active days per week (0-7), was based on the student response to the question, "During the past 7 days, on how many days were you physically active for a total of at least 60 minutes per day?"[22] Self-reported height and weight were used to establish BMI ≥85th percentile for age and sex, the fourth measure.[26]

Covariates

Data on 10 potentially confounding variables were obtained from the student and parent surveys and the school district's electronic administrative records, as previously described.[20] These variables included school, 7 sociodemographic characteristics (Table 1), having attention-deficit/hyperactivity disorder, and chronotype score.[27]

Data analysis

Our analyses involved 3197 surveys of students. There were 2146 surveys of secondary and high school students (1416 before and 730 after SST delay) and 1051 surveys of middle school students (601 before and 450 after SST advance). For our 9 outcome measures,

Table 1
Student characteristics in samples with SST delay and advance

Characteristic	SST delay[a] (N = 2146)	SST advance[b] (N = 1051)
Age, y, mean (±SD)	15.7 (±1.5)	13.5 (±0.6)
Female sex, n (%)	1202 (56.0)	574 (54.6)
Race/ethnicity, n (%)		
Non-Hispanic White	1251 (58.3)	587 (55.9)
Non-Hispanic Black	150 (7.0)	47 (4.5)
Hispanic, any race	214 (10.0)	77 (7.3)
Non-Hispanic Asian	297 (13.8)	207 (19.7)
Non-Hispanic other race	234 (10.9)	133 (12.6)
Highest parental education, n (%)		
Higher than master's	342 (17.7)	183 (19.2)
Master's or some graduate school	915 (47.3)	478 (50.0)
College graduate	408 (21.1)	210 (22.0)
Some college or technical degree	171 (8.9)	67 (7.0)
High school diploma or less	97 (5.0)	17 (1.8)
Children <19 y in the household, n (%)		
1 child	549 (28.1)	185 (19.1)
2 children	891 (45.6)	517 (53.5)
3 children	348 (17.8)	191 (19.8)
4 or more children	167 (8.5)	73 (7.6)
Single-parent household, n (%)	201 (10.2)	75 (7.8)
Receives free or reduced-price meals, n (%)	265 (12.3)	64 (6.1)
Attention-deficit/hyperactivity disorder, n (%)	209 (10.0)	101 (9.8)
Chronotype score, mean (SD)	26.4 (±5.1)	27.3 (±5.2)

[a] Participants were missing data on characteristics as follows: parental education (213), children <19 years in the household (191), single-parent household (179), attention-deficit/hyperactivity disorder (48), and chronotype (145). Column percentages for race/ethnicity, parental education, and children <19 years in the household may not add to 100.0% because of rounding.

[b] Participants were missing data on characteristics as follows: parental education (96), children <19 years in the household (85), single-parent household (84), attention-deficit/hyperactivity disorder (20), and chronotype (55). Column percentages for race/ethnicity, parental education, and children <19 years in the household may not add to 100.0% because of rounding.

Table 2
Impact of a 50-minute delay and a 30-minute advance in SST on sleep-related health outcomes

	SST delay			SST advance		
	Before (N = 1416)[a]	After (N = 730)[a]	Adjusted difference (95% CI)[b]	Before (N = 601)[c]	After (N = 450)[c]	Adjusted difference (95% CI)[b]
Low mood, n (%)	266 (20.4)	109 (16.6)	−4.72 (−8.20, −1.24)*	66 (11.7)	56 (14.1)	2.16 (−1.99, 6.31)
Self-regulation score, mean (SD)	2.26 (0.41)	2.29 (0.42)	0.02 (−0.02, 0.06)	2.37 (0.41)	2.38 (0.40)	0.01 (−0.04, 0.06)
Sport or exercise injury in past 6 mo, n (%)	609 (46.6)	285 (43.0)	−2.69 (−7.35, 1.97)	293 (51.7)	194 (48.6)	−2.04 (−8.33, 4.26)
Other injuries in past 6 mo, n (%)	349 (26.7)	160 (24.2)	−2.05 (−6.14, 2.04)	167 (29.5)	120 (30.0)	1.51 (−4.29, 7.31)
Drowsy driving in past year, n (%)[d]	205 (47.6)	90 (40.0)	−8.38 (−15.89, −0.87)**	–	–	–
Fair or poor self-reported health, n (%)	203 (14.6)	100 (14.0)	−1.65 (−4.73, 1.43)	49 (8.2)	44 (10.1)	1.85 (−1.68, 5.37)
Skipping breakfast, n (%)	404 (29.9)	190 (27.3)	−4.16 (−8.12, −0.20)**	109 (18.3)	77 (18.1)	−0.67 (−5.29, 3.95)
Physically active days per week, mean (SD)	3.70 (2.31)	3.61 (2.35)	0.05 (−0.16, 0.27)	4.04 (2.20)	4.05 (2.13)	0.07 (−0.20, 0.34)
BMI ≥85th percentile, n (%)	263 (19.5)	110 (16.0)	−3.37 (−6.83, 0.10)	103 (18.1)	61 (14.9)	−3.18 (−7.80, 1.44)

* $P < .01$.
** $P < .05$.
a For SST delay, participants were missing data on outcomes as follows (before SST delay; after SST delay): low mood (110; 72), self-regulation (134; 87), sport or exercise injury (110; 67), other injuries (109; 68), self-reported health (27; 18), skipping breakfast (66; 33), physically active days (106; 66), and overweight and obesity (70; 42).
b Difference adjusted for 10 covariates: age, sex, race/ethnicity, highest parental education, children <19 years in the household, single-parent household, free or reduced-price meals, attention-deficit/hyperactivity disorder, chronotype, and school. Missing data were imputed for all covariates (not outcomes). Sequential regression imputation was used to create 20 imputed data sets for each outcome.
c For SST advance, participants were missing data on outcomes as follows (before SST advance; after SST advance): low mood (38; 53), self-regulation (49; 60), sport or exercise injury (34; 51), other injuries (35; 50), self-reported health (3; 15), skipping breakfast (6; 24), physically active days (30; 50), and overweight and obesity (33; 41).
d Sample sizes for drowsy driving are 431 (before SST delay) and 225 (after SST delay). Among those in the SST delay samples, this outcome was only assessed in those ≥15 years of age (legal age for obtaining a learner's permit in VA) who also reported ever driving. This outcome did not apply to those in middle schools with an SST advance because all were <15.5 years of age.

we determined the adjusted differences between the samples before and after SST changes. For each outcome, separate regression models were used for those experiencing SST delay (9 total models) and those experiencing SST advance (8 total models [excludes drowsy driving]). Each model included the outcome of interest, all 10 covariates, and a binary variable for before or after SST change. For adjusted mean differences in self-regulation score and physically active days, we used linear regression models. For the other 7 outcomes (all binary), we computed standardized prevalence differences before and after the SST change using logistic regression models.[28] For those outcomes that were significantly different after SST changes, we added school-night sleep duration to regression models to explore possible mediation of these outcomes by changes in sleep duration.

Results

Table 1 shows the characteristics of the 3197 students in the samples used to evaluate the 2 SST changes (50-minute delay and 30-minute advance), and Table 2 shows the estimated impacts of these changes on the 9 outcomes. The adjusted prevalence of low mood was significantly lower after the SST delay, as was the adjusted prevalence of drowsy driving and skipping breakfast. However, there were no significant changes in self-regulation or other measures of safety or health after the SST delay. None of the outcomes significantly changed after the SST advance.

After further adjusting regression models for school-night sleep duration, the estimated decreases (95% confidence interval [CI]) in the prevalence of low mood, drowsy driving, and skipping breakfast following the SST delay were −2.55% (−6.19%, 1.08%), −6.30% (−14.03%, 1.43%), and −2.09% (−6.19%, 2.00%), respectively, and was no longer statistically significant ($P > .05$).

Discussion

Following a 50-minute SST delay in the high schools and secondary schools of a large US public school district, there were statistically significant reductions in the prevalence of adolescents' reports of low mood, drowsy driving, and skipping breakfast. Self-regulation and other health and safety outcomes were not appreciably impacted by SST changes. For the middle school students, following a 30-minute SST advance, there were no statistically significant impacts on mood, self-regulation, safety, or health-related variables. It is likely that the 15-minute decrease in sleep associated with this start time advance[20] in middle schools was insufficient to have any of the hypothesized adverse impacts. In addition, some younger middle school students may not have experienced the effects of the adolescent circadian phase delay as strongly as older high school students, and this could have partially explained the lack of significant impacts of the 30-minute advance in middle school start time.

The positive impacts on mood were consistent with some evaluations of SST delay[6–9] but not others.[5,10] In contrast to the other SST evaluations, we measured mood with a single item. Using cross-sectional data collected from 2009 on this same item in Fairfax County Public Schools, Winsler and colleagues showed that the prevalence of low mood was significantly associated with sleep duration among 27,937 middle and high school students.[29] Low mood decreased from approximately 32% among those who slept 6 hours per night to approximately 20% among those who slept 8 hours per night. These data are consistent with the possibility that the changes we found in the prevalence of low mood after changes in SST (a 4.7% decrease in low mood with a 30-minute increase in sleep duration and a 2.2% increase in low mood with a 15-minute decrease in duration) were caused by changes in school start time.

To our knowledge, impacts of SST changes on self-regulation and drowsy driving have never been evaluated. Our findings for these 2 outcomes are consistent with our reports from cross-sectional analyses of the baseline surveys examining the relationships between school-night sleep duration and the self-regulation score (no significant association[24]) and the prevalence of drowsy driving (significant inverse association[25]). Consistent with other studies, we found no impact of SST delay on BMI[17] or self-reported health,[10] and we know of no SST impact evaluations that assessed injuries or breakfast skipping.

This design had the limitations of low response rate, self-report measures, and lack of random assignment, as previously reported.[20] The external validity of our findings may be limited by the fact that those who responded to the surveys did not represent the full diversity of the students in the entire school district. We studied a representative subset of schools in the district. However, as previously noted,[20] the low response rate was likely due to the school district's restriction on administering the survey during class time, which was the method used to obtain data in other SST studies. Despite this limitation, the study may have still provided a valid estimate of the impact of SSTs on the outcomes examined.[30] The statistically significant impacts on 3 measures should be taken as preliminary because we examined several outcomes. Because the addition of school-night sleep duration to our regression models attenuated the magnitude of the association between SST delay and the 3 statistically significant outcomes, it is possible that these impacts were partially mediated by increased school-night sleep duration. However, the study design did not allow us to formally test mediation.[31,32]

This report provides evidence that a 50-minute delay in start time in high schools and secondary schools, which was associated with an increased school-night sleep duration of 30 minutes, may have also had beneficial effects on mood, drowsy driving, and eating breakfast. Impacts of greater magnitude and in other areas of health and safety may require later start times and additional educational interventions about sleep health.

Disclosure

All authors have no financial relationships or other conflicts of interest relevant to the manuscript to disclose.

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Conflict of Interest Statement

All authors have no financial relationships or other conflicts of interest relevant to the manuscript to disclose.

References

1. Morgenthaler TI, Hashmi S, Croft JB, Dort L, Heald JL, Mullington J. High school start times and the impact on high school students: what we know, and what we hope to learn. *J Clin Sleep Med*. 2016;12:1681–1689. https://doi.org/10.5664/jcsm.6358.
2. Minges KE, Redeker NS. Delayed school start times and adolescent sleep: a systematic review of the experimental evidence. *Sleep Med Rev*. 2016;28:82–91. https://doi.org/10.1016/j.smrv.2015.06.002.
3. Bowers JM, Moyer A. Effects of school start time on students' sleep duration, daytime sleepiness, and attendance: a meta-analysis. *Sleep Health*. 2017;3:423–431. https://doi.org/10.1016/j.sleh.2017.08.004.
4. Wahlstrom KL, Owens JA. School start time effects on adolescent learning and academic performance, emotional health and behaviour. *Curr Opin Psychiatry*. 2017;30:485–490. https://doi.org/10.1097/YCO.0000000000000368.
5. Dunster GP, de la Iglesia L, Ben-Hamo M, et al. Sleep*more* in Seattle: later school start times are associated with more sleep and better performance in high school students. *Sci Adv*. 2018;4. https://doi.org/10.1126/sciadv.aau6200.
6. Owens JA, Belon K, Moss P. Impact of delaying school start time on adolescent sleep, mood, and behavior. *Arch Pediatr Adolesc Med*. 2010;164:608–614. https://doi.org/10.1001/archpediatrics.2010.96.
7. Boergers J, Gable CJ, Owens JA. Later school start time is associated with improved sleep and daytime functioning in adolescents. *J Dev Behav Pediatr*. 2014;35:11–17. https://doi.org/10.1097/DBP.0000000000000018.
8. Lo JC, Lee SM, Lee XK, et al. Sustained benefits of delaying school start time on adolescent sleep and well-being. *Sleep*. 2018;41. https://doi.org/10.1093/sleep/zsy052.
9. Chan NY, Zhang J, Yu MWM, et al. Impact of a modest delay in school start time in Hong Kong school adolescents. *Sleep Med*. 2017;30:164–170. https://doi.org/10.1016/j.sleep.2016.09.018.
10. Thacher PV, Onyper SV. Longitudinal outcomes of start time delay on sleep, behavior, and achievement in high school. *Sleep*. 2016;39:271–281. https://doi.org/10.5665/sleep.5426.
11. Vorona RD, Szklo-Coxe M, Lamichhane R, Ware JC, McNallen A, Leszczyszyn D. Adolescent crash rates and school start times in two central Virginia counties, 2009-2011: a follow-up study to a southeastern Virginia study, 2007-2008. *J Clin Sleep Med*. 2014;10:1169–1177. https://doi.org/10.5664/jcsm.4192.
12. Wahlstrom K, Dretzke B, Gordon M, Peterson K, Edwards K, Gdula J: *Examining the impact of later high school start times on the health and academic performance of high school students: a multi-site study*. Final report 2014. St. Paul, MN: Center for Applied Research and Educational Development. https://conservancy.umn.edu/bitstream/handle/11299/162769/Impact%20of%20Later%20Start%20Time%20Final%20Report.pdf?sequence=1&isAllowed=y.pdf. Accessed March 4, 2019.
13. Adolphus K, Lawton C, Dye L. The effects of breakfast on behavior and academic performance in children and adolescents. *Front Hum Neurosci*. 2013;7. https://doi.org/10.3389/fnhum.2013.00425.
14. Miller MA, Kruisbrink M, Wallace J, Ji C, Cappuccio FP. Sleep duration and incidence of obesity in infants, children, and adolescents: a systematic review and meta-analysis of prospective studies. *Sleep*. 2018;41. https://doi.org/10.1093/sleep/zsy018.
15. Patel SR, Hu FB. Short sleep duration and weight gain: a systematic review. *Obesity*. 2008;16:643–653. https://doi.org/10.1038/oby.2007.118.
16. Fatima Y, Doi SAR, Mamun AA. Longitudinal impact of sleep on overweight and obesity in children and adolescents: a systematic review and bias-adjusted meta-analysis. *Obes Rev*. 2015;16:137–149. https://doi.org/10.1111/obr.12245.
17. Li S, Arguelles L, Jiang F, et al. Sleep, school performance, and a school-based intervention among school-aged children: a sleep series study in China. *PLoS One*. 2013;8:e67928. https://doi.org/10.1371/journal.pone.0067928.
18. Moore PJ, Adler NE, Williams DR, Jackson JS. Socioeconomic status and health: the role of sleep. *Psychosom Med*. 2002;64:337–344.
19. Adam EK, Snell EK, Pendry P. Sleep timing and quantity in ecological and family context: a nationally representative time-diary study. *J Fam Psychol*. 2007;21:4–19. https://doi.org/10.1037/0893-3200.21.1.4.
20. Owens JA, Dearth-Wesley T, Herman AN, Oakes JM, Whitaker RC. A quasi-experimental study of the impact of school start time changes on adolescent sleep. *Sleep Health*. 2017;3:437–443. https://doi.org/10.1016/j.sleh.2017.09.001.
21. Fairfax County Public Schools: about FCPS [Fairfax County Public Schools Website]. 2019. Available at: https://www.fcps.edu/about-fcps.
22. Centers for Disease Control and Prevention: *Youth Risk Behavior Surveillance System Questionnaire: YRBS questionnaire content*—1991-2015. August 2014. https://www.cdc.gov/healthyyouth/data/yrbs/pdf/crosswalk_1991-2015.pdf. Accessed March 4, 2019.
23. Gioia GA, Isquith PK, Guy SC, Kenworthy L. *Behavior Rating Inventory of Executive Function®*. Second Edition (BRIEF®2. Lutz, FL: PAR, Inc; 2015.
24. Owens JA, Dearth-Wesley T, Lewin D, Gioia G, Whitaker RC. Self-regulation and sleep duration, sleepiness, and chronotype in adolescents. *Pediatrics*. 2016;138. https://doi.org/10.1542/peds.2016-1406.
25. Owens JA, Dearth-Wesley T, Herman AN, Whitaker RC. Drowsy driving, sleep duration, and chronotype in adolescents. *J Pediatr*. 2019;205:224–229. https://doi.org/10.1016/j.jpeds.2018.09.072.
26. Kuczmarski RJ, Ogden CL, Guo SS, et al. 2000 CDC growth charts for the United States: methods and development. *Vital Health Stat*. 2002;11:1–190.
27. Carskadon MA, Vieira C, Acebo C. Association between puberty and delayed phase preference. *Sleep*. 1993;16:258–262. https://doi.org/10.1093/sleep/16.3.258.
28. Cummings P. Estimating adjusted risk ratios for matched and unmatched data: an update. *Stata Journal*. 2011;11:290–298. https://doi.org/10.1177/1536867X1101100208.
29. Winsler A, Deutsch A, Vorona RD, Payne PA, Szklo-Coxe M. Sleepless in Fairfax: the difference one more hour of sleep can make for teen hopelessness, suicidal ideation, and substance use. *J Youth Adolesc*. 2015;44:362–378. https://doi.org/10.1007/s10964-014-0170-3.
30. Rothman KJ, Gallacher JEJ, Hatch EE. Why representativeness should be avoided. *Int J Epidemiol*. 2013;42:1012–1014. https://doi.org/10.1093/ije/dys223.
31. Maxwell SE, Cole DA, Mitchell MA. Bias in cross-sectional analyses of longitudinal mediation: partial and complete mediation under an autoregressive model. *Multivariate Behav Res*. 2011;46:816–841. https://doi.org/10.1080/00273171.2011.606716.
32. Hayes AF. Beyond Baron and Kenny: statistical mediation analysis in the new millennium. *Commun Monogr*. 2009;76:408–420. https://doi.org/10.1080/03637750903310360.