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# School and Family Connectedness in Relation to 24-Hour Movement Behaviour among High School Students

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## Abstract

# Objective

To examine the associations of school connectedness and parental monitoring with 24-hour movement behaviour patterns among U.S. high school students.

# Methods

This cross-sectional study analysed data from the 2021 National Youth Risk Behavior Survey (YRBS), a nationally representative sample of students in grades 9–12 (N = 17,232). School connectedness and parental monitoring were self-reported and combined into a four-level school-family context variable. Outcomes included meeting individual and combined recommendations for physical activity (≥ 60 min/day, 7 days/week), recreational screen time (≤ 2 hours/day), and sleep duration (8–10 hours/night). Weighted multinomial logistic regression estimated adjusted relative risk ratios (aRRRs) for eight movement behaviour patterns, controlling for age, sex, grade, race/ethnicity, sexual identity, and COVID-related household job loss.

# Results

Only 2.2% of students met all three guidelines simultaneously. Students in the high school + high family group (high connectedness in both settings) had significantly higher odds of being in patterns that included physical activity—PA only (aRRR = 1.869, 95% CI: 1.320–2.647), PA + screen (aRRR = 1.660, 95% CI: 1.223–2.253), and PA + sleep (aRRR = 2.769, 95% CI: 1.309–5.854)—compared with the low school + low family group. They also showed lower odds of the screen-only pattern (aRRR = 0.689, 95% CI: 0.496–0.958). The adjusted predicted probability of meeting all three guidelines was 3.52% (95% CI: 2.59–4.77) in the high school + high family group versus 2.28% (95% CI: 0.98–5.22) in the low school + low family group.

# Conclusion

School connectedness and parental monitoring, particularly when both are high, are associated with healthier 24-hour movement behaviour patterns among U.S. high school students. These findings support targeting both school and family environments in interventions to promote physical activity and reduce excessive screen time during adolescence.

## 1 Introduction

Movement behaviours across a 24-hour day are increasingly recognised as integrated and interdependent components of adolescent health. The 24-hour movement behaviour paradigm proposes

that physical activity, sedentary behaviour, particularly recreational screen time, and sleep should not be examined separately because time spent in one behaviour inevitably influences time available for others [1]. Based on this framework, the Canadian 24-Hour Movement Guidelines for Children and Youth recommend that young people accumulate at least 60 minutes of moderate-to-vigorous physical activity daily, limit recreational screen time to no more than 2 hours per day, and obtain sufficient sleep each night [1]. Meeting these recommendations simultaneously has been associated with multiple health benefits, including healthier body composition, improved cardiometabolic health, better cognitive performance, lower depressive symptoms, and enhanced psychosocial well-being [2, 3]. However, evidence consistently indicates that relatively few adolescents achieve all three recommendations concurrently, particularly in the United States and other high-income countries [4, 5]. Given the important role of movement behaviours in adolescent development, identifying modifiable social and environmental factors associated with healthier 24-hour movement behaviour patterns has become an important public health priority.

The socio-ecological model provides a useful framework for understanding adolescent movement behaviours because these behaviours are shaped not only by individual characteristics but also by interpersonal and environmental contexts [6]. Among these contextual influences, schools and families represent two of the most important social settings during adolescence. School connectedness, commonly defined as students' perceptions of feeling close to, accepted by, and supported within their school environment, has been consistently associated with lower health-risk behaviours, improved emotional well-being, and better academic outcomes among adolescents [7, 8]. Previous studies have shown that adolescents with stronger school connectedness are less likely to engage in substance use, violence, and psychological distress [9, 10]. Emerging evidence also suggests that supportive school climates may encourage healthier daily routines, including greater participation in physical activity and improved sleep behaviours [11, 12]. At the family level, parental monitoring and family connectedness may provide structure, supervision, and emotional support that facilitate healthy movement behaviours. Research has demonstrated that parental support and monitoring are positively associated with adolescent physical activity participation and negatively associated with excessive recreational screen time [13, 14]. In addition, family routines and parental regulation of media use and sleep schedules have been linked to longer sleep duration and healthier sleep quality among adolescents[15, 16]. Studies examining broader family functioning have further shown that adolescents from supportive and low-conflict family environments are more likely to meet multiple 24-hour movement behaviour recommendations simultaneously [16]. Collectively, these findings suggest that social connectedness, supervision, and supportive relationships across both school and family contexts may play important protective roles in shaping adolescent movement behaviour patterns.

Despite growing research interest in 24-hour movement behaviours, several important gaps remain in the literature. First, many previous studies have examined physical activity, screen time, or sleep separately rather than considering integrated movement behaviour patterns across the entire 24-hour period [1, 17]. Because these behaviours are codependent and compete for time within a finite day, studying them independently may overlook important behavioural combinations and time-use trade-offs [18]. Increasing

evidence indicates that meeting a greater number of 24-hour movement behaviour recommendations is associated with progressively better physical and mental health outcomes among youth [3, 19]. Second, much of the existing literature has focused on younger children, while evidence among adolescents, particularly U.S. high school students, remains limited [16]. Adolescence is characterised by substantial biological, social, and behavioural changes, including declining physical activity, increasing screen exposure, and insufficient sleep, which may uniquely influence movement behaviour patterns [20, 21]. Third, although school and family environments have each been independently associated with adolescent health outcomes, relatively few studies have simultaneously examined school connectedness and parental monitoring in relation to combined 24-hour movement behaviour patterns. Existing research has also rarely explored whether supportive school and family environments may exert cumulative or interactive protective effects on adolescents' movement behaviours. A more comprehensive understanding of these social-contextual influences may help inform multi-setting interventions designed to promote healthier movement behaviour patterns among adolescents.

Therefore, the present study aimed to examine the associations of school connectedness and family connectedness, operationalised through parental monitoring, with 24-hour movement behaviour patterns among U.S. high school students using data from the 2021 National Youth Risk Behavior Survey (YRBS). Guided by the 24-hour movement behaviour framework and the socio-ecological model, this study investigated whether higher levels of school connectedness and parental monitoring were associated with healthier combinations of physical activity, recreational screen time, and sleep behaviours. In addition, this study explored whether adolescents simultaneously reporting high school connectedness and high parental monitoring were more likely to meet all three movement behaviour recommendations compared with their peers experiencing lower levels of social connectedness and supervision. The findings may help identify modifiable social-contextual factors that can inform school- and family-based interventions aimed at promoting healthier 24-hour movement behaviour patterns among adolescents.

## 2 Methods

# 2.1 Study Design and Data Source

This study was a cross-sectional secondary analysis of data obtained from the 2021 National Youth Risk Behavior Survey (YRBS). The YRBS is a nationally representative school-based survey conducted by the Centers for Disease Control and Prevention (CDC) to monitor priority health-risk behaviours among U.S. adolescents in grades 9–12 [22]. The survey collects information on multiple behavioural and psychosocial health indicators, including physical activity, sedentary behaviour, sleep, mental health, and social connectedness. The 2021 YRBS used a three-stage cluster sampling design to generate a nationally representative sample of students attending public and private high schools across the United States. In the first stage, counties or groups of counties were selected as primary sampling units (PSUs). In the second stage, schools were selected with probability proportional to school enrollment size. In the final stage, classes within selected schools were randomly sampled, and all students in selected classes were eligible to participate. Sampling weights were applied to account for nonresponse and the complex

survey design, allowing national population estimates to be generated. The 2021 survey cycle was particularly important because it included measures related to school connectedness during the period following major educational and social disruptions associated with the COVID-19 pandemic. These contextual factors may have influenced adolescents' movement behaviours, emotional well-being, and social relationships. The YRBS protocol was approved by the CDC institutional review board, and local school districts followed established parental permission and student assent procedures before data collection [22]. The present study used publicly available de-identified data and was therefore exempt from additional institutional ethical review.

## 2.2 Measures

### 2.2.1 24-Hour Movement Behaviour

The outcome variables were based on three movement behaviour components included in the 24-Hour Movement Guidelines for Children and Adolescents: physical activity, recreational screen time, and sleep duration [1]. Physical activity was assessed using the YRBS item asking students on how many of the past 7 days they had been physically active for at least 60 minutes per day. Students reporting physical activity on all 7 days were classified as meeting the moderate-to-vigorous physical activity (MVPA) recommendation. Recreational screen time was measured using items assessing the average number of hours per day students spent watching television and using computers, smartphones, or other electronic devices for non-school purposes during a typical school day. Total recreational screen time was derived by combining these measures. Consistent with the 24-Hour Movement Guidelines, students reporting ≤ 2 hours of recreational screen exposure per day were categorized as meeting the screen time recommendation [1]. Sleep duration was assessed using the item asking participants how many hours of sleep they usually obtained on an average school night. Based on current adolescent sleep recommendations, students reporting 8–10 hours of sleep per night were classified as meeting the sleep guideline [23]. Following previous 24-hour movement behaviour studies, combined movement behaviour variables were created according to the number of recommendations met simultaneously [5]. Participants were categorized into four groups: meeting none, one, two, or all three recommendations. The primary outcome variable was the number of movement behaviour recommendations achieved.

### 2.2.2 School Connectedness

School connectedness was assessed using the 2021 YRBS item asking students whether they agreed with the statement: "I feel close to people at my school." Response options included "strongly agree," "agree," "not sure," "disagree," and "strongly disagree." Consistent with previous adolescent health research, responses were dichotomised into high school connectedness ("strongly agree" or "agree") and low school connectedness ("not sure," "disagree," or "strongly disagree") [7]. School connectedness has been widely identified as a protective social factor associated with improved emotional health, lower engagement in health-risk behaviours, and greater psychosocial well-being among adolescents. Therefore, it was included as a key exposure variable in the present study.

### 2.2.3 Family Connectedness / Parental Monitoring

The YRBS does not directly assess family connectedness. Therefore, parental monitoring was used as a proxy indicator of supportive family functioning. Parental monitoring was measured using the survey item asking students how often their parents or other adults in their family knew where they were going or with whom they would be spending time. Response categories included “never,” “rarely,” “sometimes,” “most of the time,” and “always.” In line with previous studies examining adolescent health behaviours, responses were categorized into high parental monitoring (“most of the time” or “always”) and low parental monitoring (“never,” “rarely,” or “sometimes”) [16]. Parental monitoring reflects parental supervision, awareness, and involvement in adolescents’ daily lives and has been associated with healthier behavioural outcomes, including greater physical activity participation, lower screen time, and healthier sleep patterns among youth [16]. Accordingly, parental monitoring was considered an indicator of family-level social support in this study.

### 2.2.4 Covariates

Several demographic and health-related covariates were included in the analyses based on previous evidence linking these variables with movement behaviours and social connectedness. Covariates included age, sex, school grade, race/ethnicity, and sexual identity. Race/ethnicity categories followed standard YRBS classifications. Body mass index (BMI) status was calculated using self-reported height and weight data and categorized according to CDC age- and sex-specific growth references. Mental health status was assessed using the YRBS item asking whether students had experienced persistent feelings of sadness or hopelessness during the past 12 months. These covariates were included to reduce potential confounding because demographic characteristics and mental health factors may influence both social connectedness and movement behaviour patterns among adolescents.

## 2.3 Statistical analyses

All analyses accounted for the complex survey design and weighting procedures of the YRBS. Survey weights, stratification variables, and primary sampling units were incorporated into all statistical analyses to produce nationally representative estimates. Descriptive analyses were first conducted to summarize sample characteristics and estimate the weighted prevalence of meeting individual and combined 24-hour movement behaviour recommendations. Categorical variables were reported as weighted percentages with corresponding standard errors. Survey-adjusted chi-square tests were used to examine differences in movement behaviour patterns according to levels of school connectedness and parental monitoring. These analyses evaluated whether adolescents with stronger social connectedness demonstrated healthier movement behaviour profiles. Multinomial logistic regression analyses were then performed to examine associations between school connectedness, parental monitoring, and the number of movement behaviour recommendations met. Participants meeting none of the recommendations served as the reference category. Unadjusted models were initially estimated to examine crude associations between the primary exposure variables and movement behaviour outcomes. Adjusted models subsequently controlled for age, sex, grade, race/ethnicity, sexual identity, BMI status, and depressive symptoms. To investigate whether school and family social environments jointly influenced movement behaviour patterns, interaction analyses between school connectedness

and parental monitoring were also conducted. Additional subgroup analyses stratified by sex, race/ethnicity, and sexual identity were performed to examine potential differences across demographic groups. Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) were reported for all regression analyses. Statistical significance was defined as a two-sided p-value < 0.05. All analyses were conducted using Stata version 18.0 (StataCorp LLC, College Station, TX, USA), with survey commands used to account for weighting, clustering, and stratification.

# 3 Results

## 3.1 Sample Characteristics and Prevalence of 24-Hour Movement Behaviours

The weighted characteristics of the analytic sample are shown in Table 1. Among U.S. high school students, the largest age groups were 15-year-olds (25.3%) and 16-year-olds (24.7%). The sample was relatively balanced by sex, with 51.6% male students and 48.4% female students. In terms of race and ethnicity, 50.7% identified as White, 25.3% as Hispanic/Latino, 12.1% as Black or African American, and 11.8% as other racial or ethnic groups. Overall, 61.1% of students reported high school connectedness, whereas 85.9% reported high parental monitoring. More than half of the participants (53.9%) were classified into the “high school + high family” group, while only 6.8% belonged to the “low school + low family” group.

Adherence to individual 24-hour movement behaviour guidelines was generally low. Specifically, 23.9% of students met the physical activity guideline, 24.2% met the recreational screen time guideline, and 22.9% met the sleep duration guideline. When the three behaviours were considered together, nearly half of the students (47.6%) did not meet any recommendations, 36.1% met one recommendation, 14.1% met two recommendations, and only 2.2% met all three recommendations simultaneously. Across the eight movement behaviour patterns, “none met” was the most common category (47.6%), followed by “screen only” (12.6%) and “physical activity + screen time” (12.0%). Meeting all three guidelines simultaneously was the least common pattern (2.2%).

Missing data for the key study variables are summarized in Table S1. Missingness was low for age (0.6%), sex (1.5%), and grade (0.8%), but higher for sleep duration (21.0%), school connectedness (45.6%), and parental monitoring (47.2%). To reduce potential bias related to missing data, multiple imputation procedures were conducted before the main analyses.

Table 1
Sample Characteristics and Prevalence of 24-Hour Movement Behaviour Indicators and Patterns

| Variable | Category | Unweighted n | Weighted % (95% CI) |
|---|---|---|---|
| Age | | | |
| | 12 years old or younger | 40 | 0.2 (0.1–0.3) |
| | 13 years old | 63 | 0.4 (0.2–0.6) |
| | 14 years old | 3422 | 20.0 (18.4–21.5) |
| | 15 years old | 4458 | 25.3 (24.0–26.6) |
| | 16 years old | 4298 | 24.7 (23.9–25.5) |
| | 17 years old | 3921 | 23.6 (22.4–24.9) |
| | 18 years old or older | 1030 | 5.8 (5.1–6.6) |
| Sex | | | |
| | Female | 8324 | 48.4 (46.8–50.1) |
| | Male | 8908 | 51.6 (49.9–53.2) |
| Grade | | | |
| | 9th grade | 4687 | 26.7 (25.2–28.2) |
| | 10th grade | 4513 | 25.4 (23.8–27.1) |
| | 11th grade | 4144 | 24.2 (23.1–25.4) |
| | 12th grade | 3864 | 23.5 (22.0–24.9) |
| | Ungraded or other grade | 24 | 0.2 (0.1–0.2) |
| Race/ethnicity | | | |
| | White | 9357 | 50.7 (47.1–54.3) |
| | Black or African American | 2403 | 12.1 (9.5–14.7) |
| | Hispanic/Latino | 3338 | 25.3 (22.5–28.1) |
| | Other race/ethnicity | 2134 | 11.8 (9.2–14.5) |
| Sexual identity | | | |
| | Heterosexual (straight) | 12875 | 74.3 (72.6–76.0) |
| | Gay or lesbian | 550 | 3.2 (2.7–3.6) |
| | Bisexual | 1921 | 11.8 (10.9–12.7) |

**Note**: PA = Physical activity.

| Variable | Category | Unweighted n | Weighted % (95% CI) |
|---|---|---|---|
| | Some other way | 683 | 3.8 (3.3–4.3) |
| | Not sure | 856 | 5.1 (4.4–5.7) |
| | Don't know what this means | 347 | 1.9 (1.5–2.3) |
| Household job loss | | | |
| | No jobs before pandemic | 741 | 4.1 (3.7–4.5) |
| | Yes | 3903 | 24.3 (22.8–25.8) |
| | No | 12588 | 71.6 (70.0–73.2) |
| School connectedness | | | |
| | High | 10414 | 61.1 (59.1–63.1) |
| | Not high | 6818 | 38.9 (36.9–40.9) |
| Parental monitoring | | | |
| | High | 14747 | 85.9 (84.7–87.1) |
| | Not high | 2485 | 14.1 (12.9–15.3) |
| School-family context | | | |
| | Low school + low family | 1227 | 6.8 (6.0–7.7) |
| | High school only | 1258 | 7.3 (6.6–7.9) |
| | High family only | 5591 | 32.0 (30.3–33.8) |
| | High school + high family | 9156 | 53.9 (51.9–55.8) |
| Physical activity | | | |
| | Met | 4,275 | 23.9 (22.8–24.9) |
| | Not met | 12,957 | 76.1(75.1–77.2) |
| Screen time | | | |
| | Met | 4,270 | 24.2 (22.8–25.6) |
| | Not met | 12,962 | 75.8 (74.4–77.2) |
| Sleep | | | |
| | Met | 4,085 | 22.9 (21.7–24.0) |
| | Not met | 13,147 | 77.1 (76.0–78.3) |
| **Note**: PA = Physical activity. | | | |

| Variable | Category | Unweighted n | Weighted % (95% CI) |
|---|---|---|---|
| Movement count | | | |
| | None met | 7,954 | 47.6 (46.2–49.0) |
| | One met | 6,341 | 36.1 (35.1–37.1) |
| | Two met | 2,522 | 14.1 (13.2–15.0) |
| | All three met | 415 | 2.2 (1.9–2.6) |
| Movement pattern | | | |
| | None met | 7,954 | 47.6 (46.2–49.0) |
| | PA only | 2,004 | 11.5 (10.9–12.1) |
| | Screen only | 2,171 | 12.6 (12.0–13.3) |
| | Sleep only | 828 | 4.4 (3.8–5.0) |
| | PA + screen | 2,166 | 12.0 (11.1–12.8) |
| | PA + sleep | 838 | 4.7 (4.1–5.4) |
| | Screen + sleep | 856 | 4.9 (4.3–5.6) |
| | All three met | 415 | 2.2 (1.9–2.6) |

**Note**: PA = Physical activity.

# 3.2 24-Hour Movement Behaviour Patterns by School-Family Context

The weighted prevalence of the eight 24-hour movement behaviour patterns across the four school–family context groups is shown in Table 2. A significant overall association was observed between school–family context and movement behaviour patterns (Rao–Scott $\chi^2$, $p < 0.001$). Among students in the “low school + low family” group, 52.9% did not meet any movement behaviour recommendations, and only 1.6% met all three recommendations simultaneously. In contrast, students in the “high school + high family” group showed a lower prevalence of meeting none of the recommendations (44.6%) and a higher prevalence of meeting all three recommendations (2.6%). Patterns involving physical activity were more common among students reporting high parental monitoring. For example, the prevalence of the “physical activity only” pattern was 11.0% in the “high family only” group and 12.8% in the “high school + high family” group, compared with 8.2% in the “low school + low family” group and 8.3% in the “high school only” group. A similar trend was observed for the “physical activity + screen time” pattern, which was more prevalent among students with both high school connectedness and high parental monitoring (13.2%) than among those with low support in both contexts (8.6%). By comparison, the “screen time only” pattern was more common in groups with lower parental monitoring. The highest prevalence was observed in the “high school only” group (20.8%), whereas the lowest prevalence was found in the “high

school + high family" group (10.9%). Figure 1 further illustrates that "none met" remained the largest category across all school–family groups, while the proportion meeting all three recommendations remained low in every group.

Table 2
Weighted Prevalence of 24-Hour Movement Behaviour Patterns Across School-Family Context Groups

| Movement pattern | Low school + low family | High school only | High family only | High school + high family |
|---|---|---|---|---|
| None met | 52.9 (48.4–57.5) | 41.9 (38.9–44.8) | 52.6 (50.5–54.6) | 44.6 (42.1–47.1) |
| PA only | 8.2 (6.3–10.1) | 8.3 (6.3–10.3) | 11.0 (9.9–12.1) | 12.8 (11.5–14.1) |
| Screen only | 17.3 (13.4–21.2) | 20.8 (18.5–23.1) | 12.8 (11.8–13.8) | 10.9 (9.0–12.8) |
| Sleep only | 4.2 (2.7–5.7) | 6.1 (4.2–8.0) | 3.7 (2.8–4.6) | 4.5 (3.5–5.5) |
| PA + screen | 8.6 (6.8–10.4) | 11.1 (9.0–13.2) | 10.9 (10.1–11.8) | 13.2 (11.8–14.6) |
| PA + sleep | 1.9 (0.8–3.0) | 4.3 (2.5–6.1) | 3.6 (3.0–4.2) | 5.7 (4.3–7.1) |
| Screen + sleep | 5.3 (3.8–6.7) | 5.8 (3.8–7.7) | 3.7 (2.9–4.6) | 5.6 (4.4–6.8) |
| All three met | 1.6 (0.7–2.5) | 1.8 (0.5–3.1) | 1.7 (1.0–2.3) | 2.6 (2.0–3.3) |
| **p-value (Rao-Scott chi-square)**: 1.08e-10 | | | | |

**Note**

PA = Physical activity.

# 3.3 Multivariable Associations Between School-Family Context and Movement Behaviour Patterns

Adjusted relative risk ratios (aRRRs) for the associations between school–family context and the eight 24-hour movement behaviour patterns are shown in Table 3, with the "low school + low family" group used as the reference category. After adjustment for demographic and health-related covariates, students in the "high school + high family" group were more likely to belong to movement behaviour patterns that included physical activity. Specifically, they showed higher likelihood of being in the "physical activity only" pattern (aRRR = 1.869, 95% CI: 1.320–2.647, $p < 0.001$), the "physical activity + screen time" pattern (aRRR = 1.660, 95% CI: 1.223–2.253, $p = 0.001$), and the "physical activity + sleep" pattern (aRRR = 2.769, 95% CI: 1.309–5.854, $p = 0.008$), compared with the reference group. In contrast, students in the "high school + high family" group were less likely to belong to the "screen time only" pattern (aRRR = 0.689, 95% CI: 0.496–0.958, $p = 0.026$). No significant association was observed

between the “high school + high family” group and meeting all three recommendations simultaneously relative to meeting none (aRRR = 1.677, 95% CI: 0.783–3.592, p = 0.183).

Adjusted predicted probabilities are provided in Table 4 and Fig. 2. The probability of meeting all three recommendations was highest in the “high school + high family” group (3.52%, 95% CI: 2.59–4.77) and lowest in the “high family only” group (2.27%, 95% CI: 1.20–4.22). Conversely, the probability of meeting no recommendations was lowest in the “high school + high family” group (96.48%) and highest in the “high family only” group (97.73%). Additional analyses in Supplementary Table S2a indicated that students in both the “high school only” group and the “high school + high family” group had significantly greater likelihood of meeting two recommendations rather than none (aRRR = 1.52 and 1.44, respectively). However, Supplementary Table S2b, which compared meeting all three recommendations with meeting 0–2 recommendations, did not identify any statistically significant associations.

Table 3
Association Between School-Family Context and 24-Hour Movement Behaviour Patterns

| Outcome category | School-family context | aRRR | 95% CI | p |
|---|---|---|---|---|
| PA only vs none met | High school only | 1.307 | 0.852–2.006 | 0.220 |
| PA only vs none met | High family only | 1.362 | 0.971–1.910 | 0.073 |
| PA only vs none met | High school + high family | 1.869 | 1.320–2.647 | 0.000 |
| Screen only vs none met | High school only | 1.285 | 0.836–1.977 | 0.253 |
| Screen only vs none met | High family only | 0.659 | 0.485–0.896 | 0.008 |
| Screen only vs none met | High school + high family | 0.689 | 0.496–0.958 | 0.026 |
| Sleep only vs none met | High school only | 1.424 | 0.853–2.375 | 0.176 |
| Sleep only vs none met | High family only | 0.763 | 0.438–1.328 | 0.338 |
| Sleep only vs none met | High school + high family | 1.160 | 0.738–1.823 | 0.519 |
| PA+screen vs none met | High school only | 1.548 | 1.076–2.227 | 0.019 |
| PA+screen vs none met | High family only | 1.202 | 0.857–1.686 | 0.286 |
| PA+screen vs none met | High school + high family | 1.660 | 1.223–2.253 | 0.001 |
| PA+sleep vs none met | High school only | 2.190 | 0.988–4.855 | 0.054 |
| PA+sleep vs none met | High family only | 1.525 | 0.727–3.200 | 0.265 |
| PA+sleep vs none met | High school + high family | 2.769 | 1.309–5.854 | 0.008 |
| Screen+sleep vs none met | High school only | 1.317 | 0.754–2.300 | 0.333 |
| Screen+sleep vs none met | High family only | 0.708 | 0.465–1.076 | 0.106 |
| Screen+sleep vs none met | High school + high family | 1.127 | 0.765–1.660 | 0.546 |
| All three met vs none met | High school only | 1.218 | 0.366–4.047 | 0.748 |
| All three met vs none met | High family only | 1.061 | 0.555–2.028 | 0.859 |
| All three met vs none met | High school + high family | 1.677 | 0.783–3.592 | 0.183 |

**Note**: PA = Physical activity, aRRR = adjusted relative risk ratio comparing each category vs. ‘None met’.

Table 4
Adjusted Predicted Probabilities of Selected Movement Behaviour Patterns

| School-family context | Predicted probability of none met (95% CI) | Predicted probability of all three met (95% CI) |
|---|---|---|
| Low school + low family | 97.72 (94.78–99.02) | 2.28 (0.98–5.22) |
| High school only | 97.14 (93.92–98.67) | 2.86 (1.33–6.08) |
| High family only | 97.73 (95.78–98.80) | 2.27 (1.20–4.22) |
| High school + high family | 96.48 (95.23–97.41) | 3.52 (2.59–4.77) |

## 3.4 Results of Sensitivity Analyses

Sensitivity analyses examining different physical activity thresholds are shown in Supplementary Table S3. Under the strict physical activity definition (7 days/week), the association between the “high school + high family” group and meeting all three guidelines was not statistically significant (aOR = 1.68, 95% CI: 0.78–3.59, p = 0.183). However, when the alternative threshold (≥ 5 days/week) was applied, the association became statistically significant but changed direction (aOR = 0.50, 95% CI: 0.27–0.93, p = 0.028). Results using three-level measures of school connectedness and parental monitoring are reported in Tables S4a and S4b. Neither the “unsure” nor the “high” category showed statistically significant associations, and parental monitoring remained non-significant across models. Complete-case analyses excluding participants with missing data are shown in Table S5. No exposure group demonstrated a statistically significant association with meeting all three recommendations, although the direction of the estimates was generally consistent with the primary analyses. Finally, comparisons between models with and without adjustment for sexual identity are provided in Table S6. Including sexual identity did not materially change the estimates for any exposure group, supporting the robustness of the main findings.

# 4 Discussion

The present study examined associations between school and family connectedness and adherence to 24-hour movement behaviour patterns among U.S. high school students using data from the 2021 National YRBS. Overall, adherence to the 24-hour movement guidelines was low, with less than a quarter of students meeting recommendations for physical activity, screen time, or sleep, and only 2.2% meeting all three guidelines simultaneously. Students with high school and high family support were more likely to engage in patterns that included physical activity and were less likely to display exclusive screen time behaviors. However, differences in meeting all three guidelines simultaneously were minimal across the school–family context groups, reflecting the persistent challenge of achieving comprehensive movement guideline adherence among adolescents.

The observed low adherence to 24-hour movement guidelines among U.S. high school students aligns with previous studies both domestically and internationally. Tremblay et al. [1] reported that fewer than 10% of Canadian youth met the integrated movement recommendations, and similar trends were observed in multinational reviews, with prevalence ranging from 5% to 15% among adolescents [5, 24]. These findings highlight the global challenge of promoting balanced daily movement behaviors during adolescence, a critical period for establishing lifelong health patterns [3, 25]. The influence of school connectedness and parental monitoring observed in this study is consistent with existing literature linking supportive social environments to favorable adolescent health behaviors. High school connectedness has been associated with increased physical activity, reduced sedentary behaviors, and better sleep quality [7, 16]. Similarly, parental monitoring has been shown to positively affect physical activity engagement, limit recreational screen time, and support sufficient sleep duration [26–28]. While prior studies often considered school and family influences separately, our study extends this evidence by demonstrating that the combination of high school and high family support appears particularly advantageous for promoting movement patterns that include physical activity [29, 30]. Despite these consistencies, some discrepancies emerge when comparing across studies. For example, the extremely low prevalence of meeting all three guidelines in our sample is lower than some international estimates [24], which may be attributable to differences in measurement approaches, age ranges, or cultural and environmental contexts. Additionally, prior research often focuses on younger children or utilizes variable-centered methods, whereas our person-centered approach highlights the importance of examining combined social contexts for adolescents specifically [31].

The present findings suggest that school connectedness may play an important role in shaping adolescent 24-hour movement behaviour patterns. Students reporting high school connectedness were more likely to engage in movement behaviour patterns that included physical activity, particularly the “PA only” and “PA + screen” patterns, and were less likely to belong to the “screen time only” pattern. These findings are generally consistent with previous studies showing that supportive school environments are associated with higher physical activity participation, lower sedentary behaviour, and better psychological well-being among adolescents [32, 33]. School connectedness may strengthen adolescents’ engagement in organized sports, extracurricular activities, and active social participation within the school setting, thereby increasing opportunities for daily movement [34]. In addition, students who feel emotionally connected to school may demonstrate stronger motivation, better emotional adjustment, and greater adherence to structured daily routines that support healthier behaviours [7]. The observed gradient across school–family context groups further supports the importance of supportive school environments. Adolescents with both high school connectedness and high parental monitoring showed the most favourable movement behaviour profiles, whereas those in the low school + low family group showed the highest prevalence of meeting none of the recommendations. These findings align with the socio-ecological model, which emphasizes that adolescent behaviours are influenced by multiple interacting social contexts [35]. However, no statistically significant association was observed between the high school + high family group and simultaneously meeting all three movement behaviour recommendations relative to meeting none. One possible explanation is the very low prevalence of

adolescents meeting all three guidelines in the current sample (2.2%), which may have reduced statistical power to detect significant associations. Previous studies examining integrated 24-hour movement behaviours among adolescents have similarly reported that adherence to all three recommendations is uncommon, particularly during late adolescence [5, 24]. In addition, meeting all three recommendations simultaneously may require more complex behavioural regulation across multiple domains than achieving individual or dual behaviour patterns alone.

Parental monitoring was also associated with more favourable movement behaviour patterns, particularly patterns involving lower recreational screen exposure and higher physical activity participation. Adolescents reporting higher parental monitoring demonstrated lower prevalence of the “screen time only” pattern and greater likelihood of engaging in movement behaviour combinations that included physical activity. These findings are consistent with previous research indicating that parental supervision, household rules, and family support are important correlates of adolescent movement behaviours [16, 36]. Parents and caregivers may influence movement behaviours through several pathways, including regulation of recreational media use, encouragement of physical activity participation, transportation support for organized activities, and establishment of consistent sleep schedules [37, 38]. The cumulative pattern observed in the present study suggests that family support may operate most effectively when combined with positive school environments. Adolescents with high parental monitoring alone showed intermediate movement behaviour profiles, whereas the combination of high parental monitoring and strong school connectedness was associated with the most favourable outcomes. This finding supports previous evidence that multiple supportive social environments may jointly reinforce healthy behavioural habits during adolescence [3, 39]. Structured supervision from parents may help limit excessive screen time and support regular sleep routines, while supportive school environments may provide additional opportunities for physical activity participation and peer engagement. Together, these complementary influences may contribute to healthier daily movement patterns across the 24-hour period. Nevertheless, the absence of significant associations for meeting all three guidelines simultaneously suggests that broader environmental, social, and behavioural factors may also influence integrated movement behaviour adherence among adolescents. Future longitudinal studies are needed to clarify the mechanisms linking family support, school connectedness, and combined movement behaviour patterns over time.

Sensitivity analyses revealed that variations in physical activity thresholds, alternative coding of school and family connectedness, and complete-case analyses did not materially alter the primary associations [31, 33]. While the strict criterion for physical activity (7 days/week) reduced statistical significance for some outcomes, adopting a more lenient threshold (≥ 5 days/week) produced results in the expected direction, indicating robustness of observed patterns. Similarly, including additional covariates such as mental health or sexual identity did not substantially change estimates. These analyses confirm the stability of the main findings while also highlighting limitations associated with low prevalence of adolescents meeting all three guidelines, which reduces statistical power for some comparisons [24, 25].

These findings have important implications for interventions targeting adolescent movement behaviors. Enhancing school connectedness and parental monitoring could be central components of programs aiming to improve adherence to integrated movement guidelines. Strategies may include school-based initiatives to increase student engagement and peer support, and family-oriented interventions that promote structured daily routines, set consistent sleep schedules, and regulate screen time. Given the low overall adherence observed, interventions should adopt a multi-setting approach that simultaneously leverages both school and family environments to maximize impact.

Key strengths of this study include the use of a nationally representative dataset, application of the 24-hour movement behavior framework, and the combined examination of school and family social-context measures. Nonetheless, limitations must be acknowledged. The cross-sectional design precludes causal inference, self-reported measures may introduce bias, and missing data required imputation, although sensitivity analyses support the robustness of findings. Additionally, the extremely low prevalence of adolescents meeting all three movement guidelines constrains statistical power for certain outcomes. Future research should employ longitudinal designs to examine temporal relationships, evaluate intervention effectiveness in school and family contexts, and explore additional social and environmental moderators that may influence integrated movement behaviors.

# 5 Conclusion

This study demonstrates that adherence to the 24-hour movement behaviour guidelines remains very low among U.S. high school students in the 2021 YRBS. Students with both high school connectedness and high parental monitoring showed more favorable movement behaviour patterns, particularly those including physical activity, and a lower likelihood of exclusive screen-based behaviour. However, the proportion meeting all three recommendations simultaneously remained very small across all school–family contexts, indicating a persistent gap in achieving integrated healthy behaviours during adolescence. These findings highlight the importance of strengthening both school and family environments to support healthy daily movement patterns. Interventions that promote school connectedness and enhance parental monitoring may help improve physical activity engagement and reduce sedentary behaviour. Given the cross-sectional design, causal relationships cannot be confirmed. Future studies should use longitudinal data to further examine how school and family contexts jointly influence 24-hour movement behaviours over time.

# Declarations

### Ethics approval

This study is a secondary analysis of publicly available, de-identified data from the 2021 National Youth Risk Behavior Survey (YRBS). The YRBS protocol was approved by the Centers for Disease Control and Prevention (CDC) institutional review board. Local school districts followed established parental

permission and student assent procedures before data collection. As this study used only publicly available, de-identified data, no additional ethical approval was required.

**Consent for publication**

Not applicable.

**Availability of data and material**

The datasets analysed in this study are publicly available from the Centers for Disease Control and Prevention (CDC) Youth Risk Behavior Survey (YRBS) website at https://www.cdc.gov/yrbs/results/2021-yrbs-results.html.

**Competing interests**

The authors declare that they have no competing interests.

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**Authors' contributions**

**QS**: conceptualization, methodology, formal analysis, writing – original draft, writing – review & editing. **TR**: conceptualization, supervision, writing – review & editing. All authors read and approved the final manuscript.

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**Clinical trial number**

Not applicable.

# References

1. Tremblay MS, Carson V, Chaput J-P, Connor Gorber S, Dinh T, Duggan M, Faulkner G, Gray CE, Gruber R, Janson K. Canadian 24-hour movement guidelines for children and youth: an integration of physical activity, sedentary behaviour, and sleep. Appl Physiol Nutr Metab. 2016;41(6):S311–27.
2. Carson V, Hunter S, Kuzik N, Gray CE, Poitras VJ, Chaput J-P, Saunders TJ, Katzmarzyk PT, Okely AD, Connor Gorber S. Systematic review of sedentary behaviour and health indicators in school-aged children and youth: an update. Appl Physiol Nutr Metab. 2016;41(6):S240–65.

3. Walsh JJ, Barnes JD, Cameron JD, Goldfield GS, Chaput J-P, Gunnell KE, Ledoux A-A, Zemek RL, Tremblay MS. Associations between 24 hour movement behaviours and global cognition in US children: a cross-sectional observational study. Lancet Child Adolesc Health. 2018;2(11):783–91.
4. Dugger R, Williams T, Burkart S, Zhu XX, Reesor-Oyer L, Pfledderer CD, Klinggraeff Lv, Parker H, White J III, McLain AC. Family and home environment predictors of children's 24-hour movement guideline adherence: a mixed-methods study. Child Obes. 2025;21(3):297–308.
5. Roman-Viñas B, Chaput J-P, Katzmarzyk PT, Fogelholm M, Lambert EV, Maher C, Maia J, Olds T, Onywera V, Sarmiento OL. Proportion of children meeting recommendations for 24-hour movement guidelines and associations with adiposity in a 12-country study. Int J Behav Nutr Phys activity. 2016;13(1):123.
6. Sallis JF, Cervero RB, Ascher W, Henderson KA, Kraft MK, Kerr J. An ecological approach to creating active living communities. Annu Rev Public Health. 2006;27(1):297–322.
7. Control CfD, Prevention. School connectedness: Strategies for increasing protective factors among youth. In.: Atlanta, GA: US Department of Health and Human Services; 2009.
8. Resnick MD, Bearman PS, Blum RW, Bauman KE, Harris KM, Jones J, Tabor J, Beuhring T, Sieving RE, Shew M. Protecting adolescents from harm: findings from the National Longitudinal Study on Adolescent Health. JAMA. 1997;278(10):823–32.
9. Bond L, Butler H, Thomas L, Carlin J, Glover S, Bowes G, Patton G. Social and school connectedness in early secondary school as predictors of late teenage substance use, mental health, and academic outcomes. J Adolesc Health. 2007;40(4):357. e359-357. e318.
10. Shochet IM, Dadds MR, Ham D, Montague R. School connectedness is an underemphasized parameter in adolescent mental health: Results of a community prediction study. J Clin Child Adolesc Psychol. 2006;35(2):170–9.
11. Langille DB, Asbridge M, Cragg A, Rasic D. Associations of school connectedness with adolescent suicidality: Gender differences and the role of risk of depression. Can J Psychiatry. 2015;60(6):258–67.
12. Patte KA, Qian W, Leatherdale ST. Sleep duration trends and trajectories among youth in the COMPASS study. Sleep health. 2017;3(5):309–16.
13. Gustafson SL, Rhodes RE. Parental correlates of physical activity in children and early adolescents. Sports Med. 2006;36(1):79–97.
14. Ramirez ER, Norman GJ, Rosenberg DE, Kerr J, Saelens BE, Durant N, Sallis JF. Adolescent screen time and rules to limit screen time in the home. J Adolesc Health. 2011;48(4):379–85.
15. 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(1):4.
16. Guerrero MD, Barnes JD, Tremblay MS, Pulkki-Råback L. Typologies of family functioning and 24-h movement behaviors. Int J Environ Res Public Health. 2021;18(2):699.
17. Ian J, Thompson W. Adherence to the 24-hour movement guidelines among 10-to 17-year-old Canadians. Health promotion chronic disease Prev Canada: Res policy Pract 2017, 37(11):369.

18. Chaput J-P, Carson V, Gray CE, Tremblay MS. Importance of all movement behaviors in a 24 hour period for overall health. Int J Environ Res Public Health. 2014;11(12):12575–81.
19. Rollo S, Antsygina O, Tremblay MS. The whole day matters: understanding 24-hour movement guideline adherence and relationships with health indicators across the lifespan. J sport health Sci. 2020;9(6):493–510.
20. Dumuid D, Pedišić Ž, Stanford TE, Martín-Fernández J-A, Hron K, Maher CA, Lewis LK, Olds T. The compositional isotemporal substitution model: a method for estimating changes in a health outcome for reallocation of time between sleep, physical activity and sedentary behaviour. Stat Methods Med Res. 2019;28(3):846–57.
21. Owens J, Group ASW, Adolescence Co, Au R, Carskadon M, Millman R, Wolfson A, Braverman PK, Adelman WP, Breuner CC. Insufficient sleep in adolescents and young adults: an update on causes and consequences. Pediatrics. 2014;134(3):e921–32.
22. Mpofu JJ. Overview and methods for the youth risk behavior surveillance system—United States, 2021. *MMWR supplements* 2023, 72.
23. Paruthi S, Brooks LJ, D'Ambrosio C, Hall WA, Kotagal S, Lloyd RM, Malow BA, Maski K, Nichols C, Quan SF. Recommended amount of sleep for pediatric populations: a consensus statement of the American Academy of Sleep Medicine. J Clin Sleep Med. 2016;12(6):785–6.
24. Tapia-Serrano MA, Sevil-Serrano J, Sanchez-Miguel PA, Lopez-Gil JF, Tremblay MS, Garcia-Hermoso A. Prevalence of meeting 24-Hour Movement Guidelines from pre-school to adolescence: A systematic review and meta-analysis including 387,437 participants and 23 countries. J sport health Sci. 2022;11(4):427–37.
25. Manyanga T, Barnes JD, Chaput J-P, Katzmarzyk PT, Prista A, Tremblay MS. Prevalence and correlates of adherence to movement guidelines among urban and rural children in Mozambique: a cross-sectional study. Int J Behav Nutr Phys Activity. 2019;16(1):94.
26. Khor SP, McClure A, Aldridge G, Bei B, Yap MB. Modifiable parental factors in adolescent sleep: A systematic review and meta-analysis. Sleep Med Rev. 2021;56:101408.
27. Pyper E, Harrington D, Manson H. Do parents' support behaviours predict whether or not their children get sufficient sleep? A cross-sectional study. BMC Public Health. 2017;17(1):432.
28. Sadeh A. Consequences of sleep loss or sleep disruption in children. Sleep Med Clin. 2007;2(3):513–20.
29. Bohnert AM, Bates CR, Heard AM, Burdette KA, Ward AK, Silton RL, Dugas LR. Improving urban minority girls' health via community summer programming. J Racial Ethnic Health Disparities. 2017;4(6):1237–45.
30. Hu D, Zhou S, Crowley-McHattan ZJ, Liu Z. Factors that influence participation in physical activity in school-aged children and adolescents: a systematic review from the social ecological model perspective. Int J Environ Res Public Health. 2021;18(6):3147.
31. Weaver RG, Armstrong B, Hunt E, Beets MW, Brazendale K, Dugger R, Turner-McGrievy G, Pate RR, Maydeu-Olivares A, Saelens B. The impact of summer vacation on children's obesogenic behaviors

and body mass index: a natural experiment. Int J Behav Nutr Phys Activity. 2020;17(1):153.
32. Bonell C, Fletcher A, Jamal F, Wells H, Harden A, Murphy S, Thomas J. Theories of how the school environment impacts on student health: systematic review and synthesis. Health Place. 2013;24:242–9.
33. Friel CP, Duran AT, Shechter A, Diaz KM. US children meeting physical activity, screen time, and sleep guidelines. Am J Prev Med. 2020;59(4):513–21.
34. McNeely C, Falci C. School connectedness and the transition into and out of health-risk behavior among adolescents: A comparison of social belonging and teacher support. J Sch Health. 2004;74(7):284.
35. Sallis JF, Owen N, Fisher E. Ecological models of health behavior. Health behavior: Theory Res Pract. 2015;5:43–64.
36. Pyper E, Harrington D, Manson H. The impact of different types of parental support behaviours on child physical activity, healthy eating, and screen time: a cross-sectional study. BMC Public Health. 2016;16(1):568.
37. Bohnert A, Fredricks J, Randall E. Capturing unique dimensions of youth organized activity involvement: Theoretical and methodological considerations. Rev Educ Res. 2010;80(4):576–610.
38. Pearson N, Biddle SJ, Gorely T. Family correlates of breakfast consumption among children and adolescents. A systematic review. Appetite. 2009;52(1):1–7.
39. Baranowski T, O'Connor T, Johnston C, Hughes S, Moreno J, Chen T-A, Meltzer L, Baranowski J. School year versus summer differences in child weight gain: a narrative review. Child Obes. 2014;10(1):18–24.

# Figures

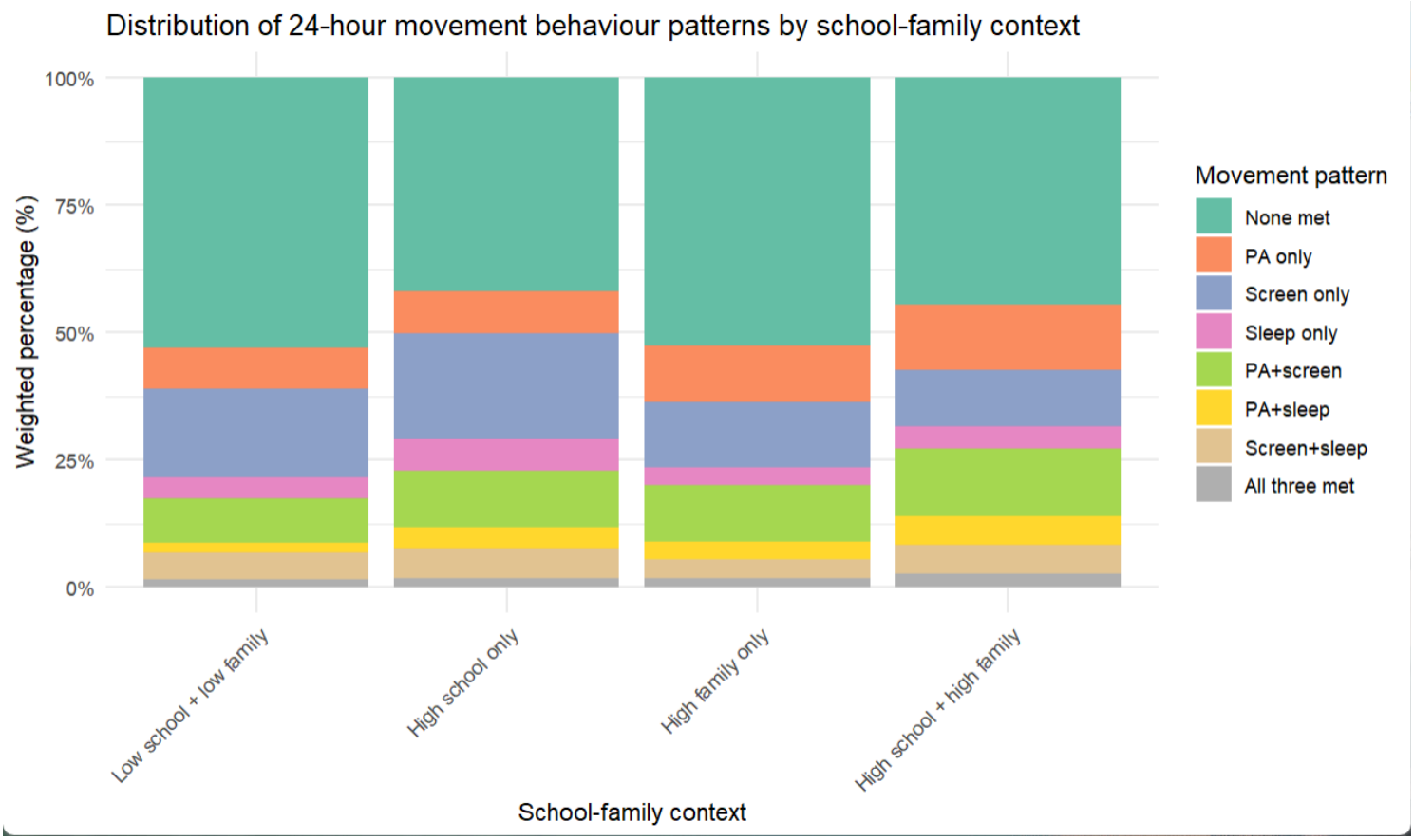



**Figure 1**

**Distribution of 24-Hour Movement Behaviour Patterns by School-Family Context**

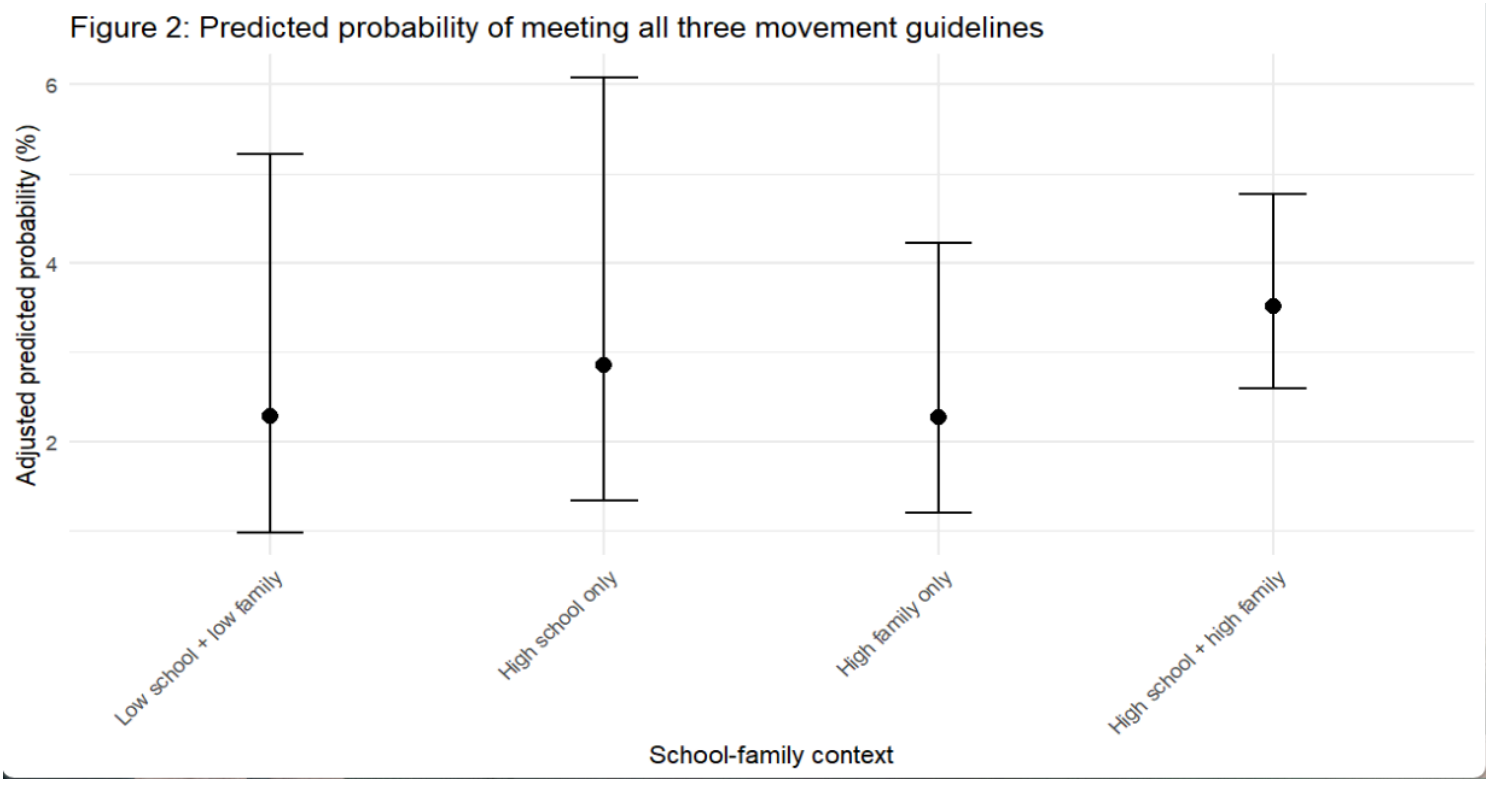


**Figure 2**

**Adjusted Predicted Probability of Meeting All Three Movement Guidelines**

# Supplementary Files

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- Supplementarymaterials.docx