I Z A Institute
of Labor Economics
Initiated by Deutsche Post Foundation

DISCUSSION PAPER SERIES

IZA DP No. 16971

COVID-19 Lockdown, Home Environment, Lifestyles, and Mental Health among Preschoolers in China

Yunting Zhang
Jin Zhao
Zhangsheng Yu
Guanghai Wang
Jun Zhang
Fan Jiang
Saishuang Wu
Yue Zhang
Donglan Zhang
Xi Chen

APRIL 2024

I Z A Institute
of Labor Economics

Initiated by Deutsche Post Foundation

DISCUSSION PAPER SERIES

IZA DP No. 16971

COVID-19 Lockdown, Home Environment, Lifestyles, and Mental Health among Preschoolers in China

Yunting Zhang
Child Health Advocacy Institute

Jin Zhao
Shanghai Jiao Tong University

Zhangsheng Yu
Shanghai Jiao Tong University

Guanghai Wang
Shanghai Jiao Tong University

Jun Zhang
Shanghai Jiao Tong University

Fan Jiang
Shanghai Jiao Tong University

Saishuang Wu
Shanghai Jiao Tong University

Yue Zhang
Shanghai Jiao Tong University

Donglan Zhang
New York University

Xi Chen
Yale University and IZA

APRIL 2024

Any opinions expressed in this paper are those of the author(s) and not those of IZA. Research published in this series may include views on policy, but IZA takes no institutional policy positions. The IZA research network is committed to the IZA Guiding Principles of Research Integrity.

The IZA Institute of Labor Economics is an independent economic research institute that conducts research in labor economics and offers evidence-based policy advice on labor market issues. Supported by the Deutsche Post Foundation, IZA runs the world's largest network of economists, whose research aims to provide answers to the global labor market challenges of our time. Our key objective is to build bridges between academic research, policymakers and society.

IZA Discussion Papers often represent preliminary work and are circulated to encourage discussion. Citation of such a paper should account for its provisional character. A revised version may be available directly from the author.

ISSN: 2365-9793

IZA – Institute of Labor Economics

Schaumburg-Lippe-Straße 5–9
53113 Bonn, Germany

Phone: +49-228-3894-0
Email: publications@iza.org

www.iza.org

ABSTRACT

COVID-19 Lockdown, Home Environment, Lifestyles, and Mental Health among Preschoolers in China

During the first wave of the COVID-19 pandemic, Shanghai implemented lockdown measures to stop transmission of the virus. Over 26 million residents, including 0.8 million children aged 3-6, were confined at home. This study leveraged a city-wide cohort of preschool children - the Shanghai Children's Health, Education and Lifestyle Evaluation, Preschool (SCHEDULE-P) - and used a quasi-experimental design to study the impact of lockdown on preschool children's mental health and changes in their home environment and lifestyles. Two cohorts - the pre-pandemic cohort and the pandemic cohort - were investigated and compared using the difference-in-differences approach. The Strengths and Difficulties Questionnaire was used to screen children who were at risk for mental health distress. The Index of Childcare Environment questionnaire was used to evaluate the quality and quantity of stimulation and support available to children in their family environment. Children's screen time, sleep duration, and household socioeconomic status were also queried. The results showed that having experienced lockdown and home confinement was associated with a 3.1% increase in the percentage of children at risk for mental health distress, was associated with 21.2 minutes/day longer screen time, 15.7 minutes/day longer sleep duration, and a less favorable family environment. Children of parents with lower levels of education were more likely to experience mental health challenges associated with the lockdown.

JEL Classification: I18, I12, H75, I28, C23

Keywords: lockdown, preschoolers, mental health, home environment, lifestyle, China, COVID-19

Corresponding author:
Donglan Zhang
Long Island School of Medicine
New York University
Mineola, NY
USA

E-mail: donglan.zhang@nyulangone.org

1. Introduction

The coronavirus disease 2019 (COVID-19) pandemic is the most widespread and longest outbreak in the past decade. It has caused social disruption and an acute threat to the well-being of children and families. The most direct impact lies in children being out of school and confined at home, which deprives them of peer interactions and outdoor activities. Previous studies showed that during home confinement, children are less physically active, have much longer screen time, and have irregular sleep patterns (Brazendale et al., 2017). Furthermore, caregivers' well-being can also be negatively impacted (M. Pierce et al., 2020; Prime, Wade, & Browne, 2020). As a result, children can be indirectly exposed to various risk factors, including maltreatment, changes in family relationships, and changes in social support (Cluver et al., 2020; Galea, Merchant, & Lurie, 2020). All these stressors can put children at greater risk for mental health problems (Wang et al., 2021). As mental health problems already affect 10%-20% of children and adolescents worldwide, the pandemic may push the global disease burden to an unprecedented level and result in an immense public health challenge (Golberstein, Wen, & Miller, 2020; Green, 2020; Holmes et al., 2020).

Numerous studies have investigated the negative impacts of the COVID-19 pandemic on the mental health and lifestyles of children and adolescents (Rider, Ansari, Varrin, & Sparrow, 2021). However, these impacts may differ by study population (e.g., young children, older children, adolescents), study context (e.g., country, region, hospitals, and schools), study duration, and the wave of the COVID-19 pandemic. In reviewing the current literature, we identified several knowledge gaps: *First*, most research has focused on school-age children and adolescents. However, mental health problems can begin in early childhood before children enter the school system. A young child may show no observable or reported symptoms of distress or a formal diagnosis of mental disorders such as anxiety disorders and depression, but they may show such issues at some later time (Rider et al., 2021). Adversities experienced during this period can disrupt formation of emotional regulatory patterns and affect mental health later in life (Kieling et al., 2011). Without identifying young children's mental health needs and helping them promptly during this critical period, these problems may prevent children from reaching their full potential (Golberstein et al., 2020). *Second*, studies rarely assess the influence of

pandemic-related measures on lifestyles and the nurturing environment of young children. Given the important role of nurturing care in young children's development (Black et al., 2017), the change in family environment and lifestyle may have a distinct effect on their health (de Figueiredo et al., 2021). For example, while studies show that screen time can support online learning and online social connection in older children during quarantine (Marques de Miranda, da Silva Athanasio, Sena Oliveira, & Simoes-e-Silva, 2020), high amounts of screen time in young children have been found to be negatively associated with children's cognitive development and mental health (Zhao. J., 2022). However, less is known about how young children's family environment and lifestyle were affected when strict lockdowns were in place. *Third*, social determinants are known to play an important role in the impact of COVID-19 on population health in many countries (Singu, Acharya, Challagundla, & Byrareddy, 2020). Households that experienced financial hardship, food or housing insecurity, or inadequate internet/device access for learning were disproportionately affected by the pandemic. More research is needed to understand how children from households of various socioeconomic statuses were affected by pandemic-related measures such as school closure and home confinement (Armitage & Nellums, 2020). These lines of evidence may be unique to different situations (Racine et al., 2020), but they are critically needed when policy makers implement mitigation strategies to reduce the disparate impact of pandemic-related policies. *Fourth*, the majority of the previous studies used a cross-sectional design without pre-COVID-19 data or a control group, a key limitation to the validity of the conclusions and robustness of the estimates (Racine et al., 2020). Some researchers have urged the government to fund population-based studies to collect information from representative populations. Findings from such studies may provide reliable evidence to policy makers and health service providers (Matthias Pierce et al., 2020).

The present study used data from a population-based cohort study focusing on early childhood development among preschool children in Shanghai, China, namely the Shanghai Children's Health, Education and Lifestyle Evaluation, Preschool (SCHEDULE-P) study (Wang et al., 2021). The SCHEDULE-P study collected information on children's mental health and related risk factors such as lifestyles and family environment in two consecutive cohorts, of which the second cohort experienced the COVID-19 pandemic. The present study takes advantage of this

natural experiment to examine changes in home environment, lifestyles, and mental health among preschoolers who experienced lockdown in Shanghai during the first wave of COVID-19 and aims to test if the amount of change varies across children from households of different socioeconomic status.

2. Methods

2.1. Setting, study design, and participants

In Shanghai, children enter kindergarten (including preschool, pre-kindergarten, or kindergarten classrooms) at 3 years old and graduate at 6 years old. The SCHEDULE-P study collected data at both entry to and graduation from kindergarten and investigated the influences of family environment and lifestyles on kindergarten children's health (Wang et al., 2021). A randomized stratified two-stage cluster sampling was adopted, taking into consideration the location, ownership, and level of the kindergarten facility. The original sampling frame was identified through the registration system of the Shanghai Municipal Education Commission (SMEC). The sampling unit was kindergarten. We did not include private international kindergartens for English-speaking children because the survey questionnaires were developed and validated in Chinese and were not translated into English and did not include one kindergarten for children with special needs due to privacy concerns and confidentiality requirements. Given that over 97% of children are admitted to kindergarten at age 3-5 years in Shanghai (Information Office of Shanghai Municipality, 2019), our study population is considered a population-based, randomly selected representative sample.

Children's demographic information was first obtained from the SMEC database. A unique login code was generated for each sampled child and sent to their parents. All parents who participated in the study gave an informed consent at the beginning of the online survey. A detailed description of this study has been provided previously (**eMethods 1** in the supplement). Sampling weights were computed, adjusting for nonresponse and sampling design that calculated the inverse of the combined selection probability in each sampling stage.

The 2016 cohort included 20,899 newly enrolled preschoolers aged 3-4 years in 191 randomly selected kindergartens in Shanghai. The children were surveyed at

enrollment in 2016 and then had a follow-up survey three years later before graduation in 2019. The 2017 cohort comprised 22,444 newly enrolled preschoolers in the same 187 kindergartens (four of the 191 kindergartens were closed). The children were surveyed at enrollment in 2017 and had a follow-up survey in 2020. These children happened to have experienced the COVID-19 pandemic when lockdown was implemented in the entire city, schools were closed, and they were confined at home most of the time for five months before graduation (Figure 1). The study was approved by the Institutional Review Board of the Shanghai Children's Medical Center, the Shanghai Jiao Tong University School of Medicine (SCMCIRB-K2016022-01).

2.2. Variable measurement

Baseline demographic and socioeconomic characteristics

Child age and gender were obtained from the SMEC registration basic data and re-confirmed by parents. Social economic status (SES) by family income and parental education (highest level of paternal and maternal education), parental marital status, child primary caregiver, and single-child status were self-reported by parents in the online questionnaire.

Mental health status

Child mental health status was ascertained by the parent-reported Strengths and Difficulties Questionnaire (SDQ), a brief behavioral and psychosocial well-being screening questionnaire widely used worldwide in children aged 3 to 16 years (Goodman, Ford, Simmons, Gatward, & Meltzer, 2000). Previous studies confirmed the reliability and validity of the instrument among students aged 3-17 years in China (Du, Kou, & Coghill, 2008). Items in total difficulties, prosocial behaviors, and each subdomain were scored in accordance with published scoring instructions and norms from the Chinese population, which can be categorized as normal, borderline, or abnormal (Du et al., 2008). Each subdomain was classified as healthy (normal category) or at-risk (borderline and abnormal categories) (Hinkley et al., 2014).

Family environment and child lifestyles

The Index of Child Care Environment (ICCE) was used to evaluate the quality and quantity of stimulation and support available to children in their family

environment (Anme, Tanaka, Watanabe, Tomisaki, & Tokutake, 2013). It has a correlation of 0.76 with the score of the Home Observation for Measurement of the Environment (HOME) and a high reproducibility (0.91). To better capture the unique influence of the COVID-19 pandemic on the family environment in detail, our analysis utilized responses to each item rather than the summary scores. The response to each question was dichotomized as "seldom" or "not seldom." Details of the questionnaire and scoring methods are presented in **eMethods 2** and **eTable1** in the supplement.

Sleep was measured by the Children's Sleep Habits Questionnaire (CSHQ), a retrospective, 33-item parent questionnaire that has been used in multiple studies to examine sleep behavior in preschool and school-aged children. The CSHQ includes items related to eight key sleep domains that encompass the major presenting clinical sleep complaints. A higher CSHQ score indicates worse sleep quality. Night sleep duration (NSD) was calculated with sleep onset and wake-up time on weekdays and weekends separately. Daily average NSD was calculated as follows: ([weekday NSD × 5] + [weekend NSD × 2])/7. CSHQ was validated in a Chinese population (Liu, Wang, Tang, Wen, & Li, 2014; Owens, Anthony, & Melissa, 2000).

Time spent on watching programs and playing electronic games via screen (including television, computer, cellphone, iPad, etc.) on weekdays and weekends in the latest month was reported by parents. Daily average screen time for each type was calculated as: ([weekday screen time × 5] + [weekend screen time × 2])/7.

2.3. Statistical analysis

We estimated the prevalence of adverse outcomes and compared the prevalence at the Entry and Graduation Surveys. Changes in each outcome in both cohorts were calculated by subtracting the indicator value at the graduation survey from the value at the entry survey. The crude difference of the change was then calculated between the non-exposed and exposed cohorts. To obtain the adjusted difference, we used generalized-estimating-equations (GEE) models with probability of being "at-risk" for mental health and other outcomes at entry and graduation as the response variable, and cohort (pre-pandemic vs. pandemic) and time period (entry vs. graduation) and their interaction as primary factors, adjusting for other covariates. A logit link was used for binary outcomes, and a working exchangeable covariance matrix was applied

to account for the clustering effect of children within kindergartens. The adjusted odds ratio (aOR with 95% CI) was calculated. The adjusted risk difference at the mean level was calculated for comparison.

We assessed differential influences of exposure on SDQ total difficulties score in different subgroups from the GEE model with the interaction term included. We conducted four subgroup analyses: (1) by parental education (middle school or below as low vs. high school or above as high); (2) by annual family income (<150k vs. ≥150k RMB); (3) by parental marital status (divorced vs. married); and (4) by gender (boy vs. girl).

We performed a sensitivity analysis for missing data with multiple imputations five times with a chained approach for the loss-to-follow-up children (15% in the non-exposed cohort and 13% in the exposed cohort) and for children with missing values (missing from 0.01% to 1.8%) (**eMethods 3** in the supplement).

All analyses were adjusted for potential risk factors associated with children's mental health, including all baseline demographic and SES characteristics. Two-tailed *p*-values less than 0.05 were considered as statistically significant.

Parents or the public WERE NOT involved in the design, conduct, reporting, or dissemination plans of our research.

3. Results

A total of 20,899 children were approached and 20,324 completed the Entry Survey in the pre-pandemic cohort (a response rate of 97%), among whom 16,590 children (82%) also finished the Graduation Survey. In the pandemic cohort, 22,444 children were approached and 22,136 participated in the Entry Survey (a response rate of 99%), among whom 18,049 children (83%) filled out the Graduation Survey (Figure 1).

We included children who participated in both the Entry and Graduation Surveys with complete data in all included variables. **Table 1** shows the demographic and SES factors of children in the two cohorts at the entry survey. Compared to the pre-pandemic cohort, children in the pandemic cohort were slightly younger (44.8 vs. 44.0 months), lived in a more favorable family environment with a higher level of parental

education (middle school or below: 5.4% vs. 4.6%), higher family income (annual family income <150kRMB: 35.0% vs. 30.0%), a higher percentage of having siblings (25.3% vs. 26.8%), and more parents being primary caregivers (61.1% vs. 62.8%). The population estimation with sampling weight yielded similar results (**Table 2**).

The pandemic cohort had slightly worse mental health status than the pre-pandemic cohort at entry. The mental health status substantially improved at graduation in both cohorts (**Table 3**). The decrease in percentage of children classified as "at-risk" with age in the pre-pandemic cohort was greater than that in the pandemic cohort (total difficulties 11.7% vs. 8.5%). After adjusting for potential confounders, the reduction in the pandemic cohort was significantly smaller as compared to the pre-pandemic cohort, with an aOR of 1.18 (95% CI, 1.10 to 1.25; $p<0.001$), and an adjusted absolute risk difference of 3.1% (95% CI, 1.9% to 4.4%) at mean covariate levels for total difficulties. Statistically significant risk differences were found in all domains except for emotional symptoms (**Table 4**). The sensitivity analysis using multiple imputation method for missing values produced similar results (**eTable2** in the supplement). Subgroup analyses suggest that the adverse impact was greater in children with lower parental education level. There was no meaningful difference in SDQ total difficulties score by gender, family income, or parental marital status (Figure 2).

We also found that the pandemic cohort had a larger increase in the percentage having an unfavorable family environment, reflected in the majority of ICCE items. The largest difference was found in the percentage of parents who seldom went shopping with the child (**Table 5**).

Overall sleep quality improved in both cohorts, and there was a larger decrease of CSHQ score in the pandemic cohort than the pre-pandemic cohort (adjusted coefficient/absolute mean difference, -0.79, 95% CI, -0.96 to -0.62). In subscale analysis by binary outcomes, the pandemic cohort has improved significantly in daytime sleepiness, sleep duration, and sleep disorder breathing, but worsened in bedtime resistance, sleep onset delay, and sleep anxiety (**eTable3** in the supplement). The sleep duration at graduation decreased in comparison to that at entry in the pre-pandemic cohort but increased in the pandemic cohort, resulting in a relative increase in sleep duration for the pandemic group (adjusted coefficient/absolute mean

difference, 18-minutes in weekday, 95% CI, 16 to 20 minutes). As to media viewing, time spent on watching programs decreased in the pre-pandemic cohort from entry to graduation but increased in the pandemic cohort (adjusted coefficient/absolute mean difference, 33 minutes, 95% CI, 30 to 35) (**Table 3**).

4. Discussion

This study provides evidence regarding the impact of lockdown during the first wave of the COVID-19 pandemic on children's mental health based on a natural experiment design in a large representative sample. We found that children who experienced lockdown and home confinement for five months had a 3.1% increase in the probability of being "at-risk" for total difficulties as measured by the SDQ. The association of home confinement with mental health was greater in children of parents with lower levels of education. The pandemic cohort also had a less favorable family environment, longer screen time, and longer sleep duration.

While a 3.1% increase in the prevalence of being "at-risk" for total difficulties seems a small number, the impact could be significant at a population level. As 20% of children were classified as "at-risk" for mental health problems at graduation in our population, a 3% absolute increase equals a 15% relative increase. Furthermore, since Shanghai had a very low COVID-19 infection rate during the first wave of the pandemic (China CDC, 2020), school closure lasted for five months while the strict lockdown lasted for two months. The survey was conducted right after the lockdown, and thus the longer-term impact was yet to be seen. In addition, children from lower SES households were more likely to be lost in the follow-up, though the attrition rates were similar in the two cohorts (**eTable4** and **eTable5** in the supplement). Taking all factors into account, the observed association was likely to be underestimated. The magnitude of the negative impact on children's mental health may be much larger and represents a significant public health problem.

The pandemic has hit all aspects of society around the world. The subsequent implementation of social distancing and lockdowns turned the family into the most important and closest environment for children. Social support from family members and friends can moderate caregivers' distress and its subsequent impact on parenting behaviors (Mcconnell, Breitkreuz, & Savage, 2011). However, our study showed that

support was less accessible for parents during the pandemic. Social distancing also prevented many families from getting extra family support. We further found that despite the fact that children spent substantially more time at home and had reduced interaction with their friends during the lockdown, they did not increase their interaction with parents. It is speculated that under a stressful situation, parents may have neglected the importance of parent-child communication, which could have a negative impact on children. Though our study did not focus on child abuse and neglect due to the short study timeline (Griffith, 2020), corporal punishment by parents was found slightly higher in the pandemic cohort with borderline significance. Furthermore, parents' mental health problems such as anxiety and depression may affect child mental health, especially in families experiencing financial hardship during the lockdown (Adegboye et al., 2021). Our findings further suggest that mental health challenges among young children from low-SES families may have been exacerbated during the pandemic, even though their mental health status was already worse than their counterparts prior to the pandemic.

The pandemic changed family lifestyle dramatically (Moore et al., 2020). The percentage of children who seldom went shopping or went to parks increased by 14.5% and 3.5%, respectively. The reduction of these activities could lead to decreased physical activity and social stimulation, both known risk factors for poor mental health (Biddle, Ciaccioni, Thomas, & Vergeer, 2019; Golberstein et al., 2020). In addition, children spent more time in media viewing, far exceeding the one-hour screen time recommended by the World Health Organization (World Health Organization, 2019). While such behavior is considered unhealthy in usual circumstances, studies have found that the entertainment media can become a tool for coping with distress, boredom, and lack of social interaction caused by the pandemic (Jiao et al., 2020). Thus, the benefits and risks of prolonged media time under such a special circumstance warrant careful assessment, which may have important implications.

The perils and promise for child sleep during the pandemic have been widely discussed (Becker & Gregory, 2020). Our study found an overall positive impact on child sleep, resulting mainly from significant improvement in daytime sleepiness and sleep duration subscales, not from other factors that are more closely related to parenting skills, such as bedtime resistance, sleep onset delay, and sleep anxiety.

Although there is more opportunity for children to obtain sufficient sleep during home confinement, behavioral sleep problems may persist or worsen and, therefore, should not be ignored.

There is nothing new to the conclusion that the COVID-19 lockdown measures have had a negative impact on children's mental health, but what is not emphasized enough is that the magnitude and duration of the impact may be specific to the study context, how strict the lockdown was, and other factors that influence the vulnerability of children, such as parental education, financial stress, mental health status prior to the pandemic, and whether quarantined due to COVID-19 infection (Singh et al., 2020). Although the present study was conducted in Shanghai during the first wave of the pandemic, the findings have implications for future policy considerations. The measures were very successful initially in controlling the spread of the disease; however, side effects and consequences of these measures must be taken into consideration. With the latest outbreak of Omicron, strict public health measures were taken in Shanghai, such as quarantine of infected cases and close contacts in shelter hospitals and hotels, and lockdown of districts with severe outbreaks. There were strict lockdowns between April 1, 2022, and June 1, 2022, during the fourth wave of the pandemic (Zhang, Zhang, & Chen, 2022), which may have had a larger impact on vulnerable children and families who had already suffered from mental health difficulties during the earlier period of the pandemic. With the increased knowledge about the coronavirus by the scientific community and the public, it is crucial to systematically weigh risks and benefits of lockdown policies to population health while containing the transmission of the disease. While longitudinal and developmental studies are needed to improve the mental health status of children and families who are affected most by the pandemic, population-based interventions such as economic policies (e.g., child tax credit) and health education and tele-mental health services are critical to mitigate risks for poor psychosocial well-being (Prime et al., 2020).

The most important strength of our study is that we include pre-pandemic measures of mental health, lifestyle, and family environments among preschoolers, which reduced the noise due to a lack of a pre-pandemic comparison group (Ford, John, & Gunnell, 2021). Administering the questionnaire in an identical approach in the two cohorts decreased potential information bias.

4.1. Limitations

Our study has several limitations. *First*, although we used a comparison group and a difference-in-differences estimation, we only had one pre-observation; thus, we were not able to test the parallel trend assumption, a key assumption to draw any causal implication of the identified effect. This limitation attenuates the study's validity to make causal conclusions. *Second*, all the measurements in our study were reported by parents, whereas both parents and children were substantially affected by the COVID-19 lockdowns. In a prior study, mothers of young children were found to be mostly affected by depression and anxiety (Racine et al., 2022). Our study did not measure the mental health status of parents, which limited our ability to distinguish between parents and children about the pandemic's impact. Further, parent-related measures may lead to reporting bias. Nevertheless, the distribution of our main outcome did not differ substantially between the pandemic and pre-pandemic cohorts (**eTable6** in the supplement). Studies from different countries have reported a good inter-rater agreement between parent and teacher versions of the SDQ, suggesting that parental mental health does not have a large influence on SDQ score (Du et al., 2008; Katikireddi, Niedzwiedz, & Popham, 2016). *Third*, SDQ is one of the most commonly used measurement tools in studies on child and adolescent mental health globally. Although it can predict the broad type of disorder (Goodman et al., 2000), the increased percentage of children classified as "at-risk" should be interpreted with caution and does not necessarily mean that they require treatment for mental illness. *Lastly*, the pandemic situation during the first wave in Shanghai differed substantially from the later period of the pandemic. The economic impact may not be large enough to substantially increase serious outcomes such as maltreatment behavior, limiting the generalizability of our findings to other study contexts and the second, third, or fourth waves of the pandemic. However, the confinement policy was strictly implemented in Shanghai, which allowed us to estimate the possible impact of home confinement alone.

5. Conclusion

Our study found that lockdown and home confinement was significantly associated with poor family environment, lifestyles, and mental health in young children. It is therefore incumbent to strengthen mental health services with the aim of

establishing a healthier family environment and daily routines, as well as building resilience during challenging times (Cluver et al., 2020; Klass & Navsaria, 2021). In addition, further follow-up studies are warranted to explore long-term impacts of pandemic-related lockdown measures and home confinement on child mental health.

Highlights

- A cohort study was conducted among a representative sample of preschool children who experienced lockdown and home confinement in Shanghai during the first wave of the COVID-19 pandemic.
- Compared with a pre-pandemic cohort of preschoolers, experiencing a two-month strict lockdown was associated with a 3.1% increase in the prevalence of being at risk for mental health disorders among preschool children.
- Children of parents with lower levels of education were more likely to be at risk for mental health problems associated with the lockdown.
- Preschool children had longer screen time and daytime sleep duration and experienced a worse family environment during the lockdown.

Author statement

Contributors: YZ and JZhao make equal contribution. JZhang and FJ are corresponding authors. YZ contributed to survey design, implementation, analysis plan, and wrote the first draft of the manuscript; JZhao conducted the surveys, and analyzed the data; ZY mentored and supervised data analysis process; DZ designed the analytical plan; SW and YZ participated in data analysis and examined the results; XC critically reviewed and revised the manuscript; GW contributed to survey design and revised the manuscript; JZhang conceptualized the study and revised the manuscript critically for important intellectual content; FJ conceptualized the study, was the PI of the survey design and implementation, and revised the manuscript. All authors made contributions to data interpretation and manuscript writing and approved the manuscript for submission.

Conflict of Interest Disclosures:
None reported.

Acknowledgments
We are grateful to the excellent work and commitment by the study team of the Shanghai Children's Health, Education and Lifestyle Evaluation, Preschool (SCHEDULE-P) study, which includes education experts Ms. Youhua He, Ms. Hongmei Mao and Mr. Jiajie Qu, all kindergarten teachers and field work team from the Shanghai Children's Medical Center. The SCHEDULE-P was funded by the Shanghai Education Committee. We are also thankful for Prof. Myron Belfer at Boston Children's Hospital, Prof. Lincoln Chen at China Medical Board, Prof. Barbara Stoll at China Medical Board, Prof. Yuning Zhang at University of Southampton and Prof. Xinyue Li at City University of Hong Kong for their valuable comments and suggestions. Fan Jiang had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. The IZA Discussion Paper Series serves as a preprint server to deposit latest research for feedback.

Funding statement
The study was supported by the Shanghai Municipal Education Commission, and the U.S. National Institute on Aging (R01AG077529 and P30AG021342). Xi Chen also acknowledges financial support from the Drazen scholarship and the Aden scholarship dedicated to research on Chinese healthcare systems. The funding sources had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

References

Adegboye, D., Williams, F., Collishaw, S., Shelton, K., Langley, K., Hobson, C., . . . van Goozen, S. (2021). Understanding why the COVID-19 pandemic-related lockdown increases mental health difficulties in vulnerable young children. *JCPP Adv, 1*(1), e12005. doi:10.1111/jcv2.12005

Anme, T., Tanaka, E., Watanabe, T., Tomisaki, E., & Tokutake, K. (2013). Validity and Reliability of the Index of Child Care Environment (ICCE). *Journal of Public Health Frontier*.

Armitage, R., & Nellums, L. B. (2020). Considering inequalities in the school closure response to COVID-19. *Lancet Glob Health, 8*(5), e644. doi:10.1016/s2214-109x(20)30116-9

Arora, S., Grover, V., Saluja, P., Algarni, Y. A., Saquib, S. A., Asif, S. M., . . . Ohri, A. (2022). Literature Review of Omicron: A Grim Reality Amidst COVID-19. *Microorganisms, 10*(2). doi:10.3390/microorganisms10020451

Becker, S. P., & Gregory, A. M. (2020). Editorial Perspective: Perils and promise for child and adolescent sleep and associated psychopathology during the COVID-19 pandemic. *J Child Psychol Psychiatry, 61*(7), 757-759. doi:10.1111/jcpp.13278

Biddle, S. J. H., Ciaccioni, S., Thomas, G., & Vergeer, I. (2019). Physical activity and mental health in children and adolescents: An updated review of reviews and an analysis of causality. *Psychology of Sport and Exercise, 42*, 146-155.

Black, M. M., Walker, S. P., Fernald, L. C. H., Andersen, C. T., DiGirolamo, A. M., Lu, C., . . . Grantham-McGregor, S. (2017). Early childhood development coming of age: science through the life course. *The Lancet, 389*(10064), 77-90. doi:10.1016/s0140-6736(16)31389-7

Brazendale, K., Beets, M. W., Weaver, R. G., Pate, R. R., Turner-McGrievy, G. M., Kaczynski, A. T., . . . von Hippel, P. T. (2017). Understanding differences between summer vs. school obesogenic behaviors of children: the structured days hypothesis. *Int J Behav Nutr Phys Act, 14*(1), 100. doi:10.1186/s12966-017-0555-2

China CDC. (2020). Distribution of COVID-19 outbreaks. *2020.* Retrieved from http://2019ncov.chinacdc.cn/2019-nCoV/

Cluver, L., Lachman, J. M., Sherr, L., Wessels, I., Krug, E., Rakotomalala, S., . . . McDonald, K. (2020). Parenting in a time of COVID-19. *The Lancet, 395*, e64. doi:10.1016/S0140-6736(20)30736-4

de Figueiredo, C. S., Sandre, P. C., Portugal, L. C. L., Mázala-de-Oliveira, T., da Silva Chagas, L., Raony, Í., . . . Bomfim, P. O. (2021). COVID-19 pandemic impact on children and adolescents' mental health: Biological, environmental, and social factors. *Prog Neuropsychopharmacol Biol Psychiatry, 106*, 110171. doi:10.1016/j.pnpbp.2020.110171

Du, Y., Kou, J., & Coghill, D. (2008). The validity, reliability and normative scores of the parent, teacher and self report versions of the Strengths and Difficulties Questionnaire in China. *Child and Adolescent Psychiatry and Mental Health,*

2(1), 8.
Ford, T., John, A., & Gunnell, D. (2021). Mental health of children and young people during pandemic. *BMJ, 372*, n614. doi:10.1136/bmj.n614
Galea, S., Merchant, R. M., & Lurie, N. (2020). The Mental Health Consequences of COVID-19 and Physical Distancing: The Need for Prevention and Early Intervention. *JAMA Intern Med, 180*(6), 817-818. doi:10.1001/jamainternmed.2020.1562
Golberstein, E., Wen, H., & Miller, B. F. (2020). Coronavirus Disease 2019 (COVID-19) and Mental Health for Children and Adolescents. *JAMA Pediatr*. doi:10.1001/jamapediatrics.2020.1456
Goodman, R., Ford, T., Simmons, H., Gatward, R., & Meltzer, H. (2000). Using the Strengths and Difficulties Questionnaire (SDQ) to screen for child psychiatric disorders in a community sample. *Br J Psychiatry, 177*, 534-539. doi:10.1192/bjp.177.6.534
Green, P. (2020). Risks to children and young people during covid-19 pandemic. *BMJ, 369*, m1669. doi:10.1136/bmj.m1669
Griffith, A. K. (2020). Parental Burnout and Child Maltreatment During the COVID-19 Pandemic. *J Fam Violence*(4).
Hinkley, T., Verbestel, V., Ahrens, W., Lissner, L., Molnár, D., Moreno, L. A., . . . De Bourdeaudhuij, I. (2014). Early childhood electronic media use as a predictor of poorer well-being: a prospective cohort study. *JAMA Pediatr, 168*(5), 485-492. doi:10.1001/jamapediatrics.2014.94
Holmes, E. A., O'Connor, R. C., Perry, V. H., Tracey, I., Wessely, S., Arseneault, L., . . . Bullmore, E. (2020). Multidisciplinary research priorities for the COVID-19 pandemic: a call for action for mental health science. *The Lancet Psychiatry, 7*(6), 547-560. doi:10.1016/s2215-0366(20)30168-1
Information office of Shanghai Municipality. (2019). Press Release for September 20, 2019 Media Briefing by the Shanghai Municipal People's Government. Retrieved from http://en.shio.gov.cn/government-news/municipal/5154.shtml
Jiao, W. Y., Wang, L. N., Liu, J., Fang, S. F., Jiao, F. Y., Pettoello-Mantovani, M., & Somekh, E. (2020). Behavioral and Emotional Disorders in Children during the COVID-19 Epidemic. *J Pediatr, 221*, 264-266.e261. doi:10.1016/j.jpeds.2020.03.013
Katikireddi, S. V., Niedzwiedz, C. L., & Popham, F. (2016). Employment status and income as potential mediators of educational inequalities in population mental health. *Eur J Public Health, 26*(5), 814-816. doi:10.1093/eurpub/ckw126
Kieling, C., Baker-Henningham, H., Belfer, M., Conti, G., Ertem, I., Omigbodun, O., . . . Rahman, A. (2011). Child and adolescent mental health worldwide: evidence for action. *Lancet, 378*(9801), 1515-1525. doi:10.1016/s0140-6736(11)60827-1
Klass, P., & Navsaria, D. (2021). Creating Practical Primary Care Supports for Parent-Child Relationships-Language, Literacy, and Love. *JAMA Pediatr*. doi:10.1001/jamapediatrics.2020.5706
Liu, Z., Wang, G., Tang, H., Wen, F., & Li, N. (2014). Reliability and validity of the

Children's Sleep Habits Questionnaire in preschool-aged Chinese children. *Sleep and Biological Rhythms, 12*(3), 187-193.

Marques de Miranda, D., da Silva Athanasio, B., Sena Oliveira, A. C., & Simoes-e-Silva, A. C. (2020). How is COVID-19 pandemic impacting mental health of children and adolescents? *International Journal of Disaster Risk Reduction, 51*, 101845. doi:https://doi.org/10.1016/j.ijdrr.2020.101845

Mcconnell, D., Breitkreuz, R., & Savage, A. (2011). From financial hardship to child difficulties: main and moderating effects of perceived social support. *Child Care Health & Development, 37*(5), 679-691.

Moore, S. A., Faulkner, G., Rhodes, R. E., Brussoni, M., Chulak-Bozzer, T., Ferguson, L. J., . . . Tremblay, M. S. (2020). Impact of the COVID-19 virus outbreak on movement and play behaviours of Canadian children and youth: a national survey. *International Journal of Behavioral Nutrition and Physical Activity, 17*(1), 85. doi:10.1186/s12966-020-00987-8

Owens, J. A., Anthony, S., & Melissa, M. G. (2000). The Children's Sleep Habits Questionnaire (CSHQ): psychometric properties of a survey instrument for school-aged children. *Sleep, 23*(8), 1043-1051.

Pierce, M., Hope, H., Ford, T., Hatch, S., Hotopf, M., John, A., . . . Abel, K. M. (2020). Mental health before and during the COVID-19 pandemic: a longitudinal probability sample survey of the UK population. *Lancet Psychiatry, 7*(10), 883-892. doi:10.1016/s2215-0366(20)30308-4

Pierce, M., McManus, S., Jessop, C., John, A., Hotopf, M., Ford, T., . . . Abel, K. M. (2020). Says who? The significance of sampling in mental health surveys during COVID-19. *Lancet Psychiatry, 7*(7), 567-568. doi:10.1016/S2215-0366(20)30237-6

Prime, H., Wade, M., & Browne, D. T. (2020). Risk and resilience in family well-being during the COVID-19 pandemic. *Am Psychol, 75*(5), 631-643. doi:10.1037/amp0000660

Racine, N., Cooke, J. E., Eirich, R., Korczak, D. J., McArthur, B., & Madigan, S. (2020). Child and adolescent mental illness during COVID-19: A rapid review. *Psychiatry Res, 292*, 113307. doi:10.1016/j.psychres.2020.113307

Racine, N., Eirich, R., Cooke, J., Zhu, J., Pador, P., Dunnewold, N., & Madigan, S. (2022). When the Bough Breaks: A systematic review and meta-analysis of mental health symptoms in mothers of young children during the COVID-19 pandemic. *Infant Ment Health J, 43*(1), 36-54. doi:10.1002/imhj.21959

Rider, E. A., Ansari, E., Varrin, P. H., & Sparrow, J. (2021). Mental health and wellbeing of children and adolescents during the covid-19 pandemic. *BMJ, 374*, n1730. doi:10.1136/bmj.n1730

Singh, S., Roy, D., Sinha, K., Parveen, S., Sharma, G., & Joshi, G. (2020). Impact of COVID-19 and lockdown on mental health of children and adolescents: A narrative review with recommendations. *Psychiatry Res, 293*, 113429. doi:10.1016/j.psychres.2020.113429

Singu, S., Acharya, A., Challagundla, K., & Byrareddy, S. N. (2020). Impact of Social Determinants of Health on the Emerging COVID-19 Pandemic in the United

States. *Front Public Health, 8*, 406. doi:10.3389/fpubh.2020.00406

Wang, X., Zhang, Y., Zhao, J., Shan, W., Zhang, Z., Wang, G., . . . Jiang, F. (2021). Cohort Profile: The Shanghai Children's Health, Education and Lifestyle Evaluation, Preschool (SCHEDULE-P) Study. *Int J Epidemiol*. doi:10.1093/ije/dyaa279

World Health Organization. (2019). Guidelines on physical activity, sedentary behaviour and sleep for children under 5 years of age. 2019.

Zhang, X., Zhang, W., & Chen, S. (2022). Shanghai's life-saving efforts against the current omicron wave of the COVID-19 pandemic. *Lancet, 399*(10340), 2011-2012. doi:10.1016/s0140-6736(22)00838-8

Zhao. J., Y. Z., Sun. X., Wu. S., Zhang. J., Zhang. D, Zhang. Y, Jiang, F,. (2022). Association Between Screen Time Trajectory and Early Childhood Development in Children in China. *Jama Pediatrics, accepted*.

Table 1. Characteristics of analytical sample in pre-pandemic and pandemic cohorts at entry survey

	Pre-pandemic Cohort (n=16590)	Pandemic Cohort (n=18409)
Age, mean (SD), months	44.8 (3.5)	44.0 (3.5)
Gender, No. (%)		
Male	8606 (51.9)	9534 (51.8)
Female	7984 (48.1)	8875 (48.2)
Parental education, No. (%)		
Middle school or below	904 (5.4)	853 (4.6)
High school	1836 (11.1)	1780 (9.7)
Some college	3983 (24.0)	4257 (23.1)
Graduate study or above	9825 (59.2)	11458 (62.2)
Don't know	1 (0.0)	2 (0.0)
Refuse to answer	41 (0.3)	59 (0.3)
Family income, No. (%)		
<150k RMB	5809 (35.0)	5518 (30.0)
150-300k RMB	5682 (34.3)	6519 (35.4)
>300k RMB	4095 (24.7)	5429 (29.5)
Don't know	181 (1.1)	170 (0.9)
Refuse to answer	823 (5.0)	773 (4.2)
Siblings, No. (%)		
None	12398 (74.7)	13475 (73.2)
One or more	4192 (25.3)	4934 (26.8)
Marital status, No. (%)		
Married	15853 (95.6)	17619 (95.7)
Divorced	450 (2.7)	498 (2.7)
Refuse to answer	287 (1.7)	292 (1.6)
Primary caregiver, No. (%)		
Parents	10134 (61.1)	11558 (62.8)
Grandparents or others	6456 (38.9)	6851 (37.2)

Table 2. Demographic characteristics population represented by pre-pandemic and pandemic cohort (weighted)

	Pre-pandemic cohort at entry (n=20324)	Pandemic cohort at entry (n=22136)
Age, mean (95%CI), months	44.8 (44.7, 44.8)	43.9（43.8, 44.0)
Gender, No. (%)		
Male	10573 (52.5)	11460 (52.0)
Female	9751 (47.5)	10676 (48.0)
Parental education, No. (%)		
Middle school or below	968 (6.4)	829 (5.2)
High school	2121 (13.2)	1875 (10.7)
Some college	3732 (18.8)	3797 (19.0)
Graduate study or above	13452 (61.3)	15566 (64.6)
Don't know	1 (0.0)	0 (0.0)
Refuse to answer	49 (0.3)	64 (0.4)
Family income, No. (%)		
<150k RMB	7610 (41.9)	6992 (36.0)
150-300k RMB	6595 (31.9)	7494 (33.9)
>300k RMB	4825 (19.7)	6468 (24.9)
Don't know	233 (1.1)	223 (0.9)
Refuse to answer	1059 (5.3)	959 (4.3)
Siblings, No. (%)		
None	14700 (71.1)	15720 (69.3)
One or more	5620 (28.9)	6408 (30.7)
Marital status, No. (%)		
Married	19269 (94.8)	21114 (95.2)
Divorced	629 (3.0)	646 (3.0)
Refuse to answer	417 (2.1)	366 (1.8)
Primary caregiver, No. (%)		
Parents	12807 (63.6)	14288 (65.1)
Grandparents or others	7514 (36.4)	7839 (34.9)

Mean, 95%CI, and proportion were estimated by sampling weight.

Table 3. Significance testing of difference on mental health between pre-pandemic and pandemic cohort

	Entry in analysis sample			**Graduation in analysis sample**		
	Pre-pandemic cohort (n=16590)	**Pandemic cohort** (n=18409)	**P value**	**Pre-pandemic cohort** (n=16590)	**Pandemic cohort** (n=18409)	**P value**
Mental health, high-risk No. (%)						
Total difficulties	5741(34.6)	5976(32.5)	<0.001	3802(22.9)	4418(24.0)	<0.05
Emotional symptoms	3760(22.7)	4041(22.0)	0.11	3110(18.7)	3428(18.6)	0.76
Conduct problems	5529(33.3)	5816(31.6)	<0.01	3785(22.8)	4564(24.8)	<0.001
Hyperactivity/inattention	5364(32.3)	5734(31.1)	<0.05	4045(24.4)	4588(24.9)	0.24
Peer relationship problems	8834(53.2)	9685(52.6)	0.23	6467(39.0)	7754(42.1)	<0.001
Poor prosocial behavior	5574(33.6)	6212(33.7)	0.77	3308(19.9)	4040(21.9)	<0.001

Table 4. Association of home confinement with percentage of children classified as at-risk for mental health

	Pre-pandemic Cohort (n=16590)			Pandemic Cohort (n=18409)			Crude Difference [a]	Adjusted Difference		
	Survey at Entry	Survey at Graduation	Difference	Survey at Entry	Survey at Graduation	Difference	Rate Change (95% CI)	Adjusted Absolute Risk Difference [b] (95% CI)	Adjusted Odds Ratio [c] (95% CI)	p-value
	No. (%)		*%*	*No. (%)*		*%*				
Mental Health by SDQ										
Total difficulties	5741 (34.6)	3802 (22.9)	-11.7	5976 (32.5)	4418 (24.0)	-8.5	3.2*** (1.9, 4.6)	3.1 (1.9, 4.4)	1.18 (1.10, 1.25)	<0.001
Emotional symptoms	3760 (22.7)	3110 (18.7)	-3.9	4041 (22.0)	3428 (18.6)	-3.3	0.6 (-0.6, 1.8)	0.5 (-0.7, 1.7)	1.03 (0.96, 1.11)	0.38
Conduct problems	5529 (33.3)	3785 (22.8)	-10.5	5816 (31.6)	4564 (24.8)	-6.8	3.7*** (2.4, 5.0)	3.7 (2.3, 5.0)	1.21 (1.13, 1.30)	<0.001
Hyperactivity/inattention	5364 (32.3)	4045 (24.4)	-8.0	5734 (31.1)	4588 (24.9)	-6.2	1.7* (0.4, 3.1)	1.7 (0.4, 2.9)	1.09 (1.02, 1.16)	<0.01
Peer relationship problems	8834 (53.2)	6467 (39.0)	-14.3	9685 (52.6)	7754 (42.1)	-10.5	3.8*** (2.3, 5.2)	3.8 (2.3, 5.3)	1.17 (1.10, 1.25)	<0.001
Poor prosocial behavior	5574 (33.6)	3308 (19.9)	-13.7	6212 (33.7)	4040 (21.9)	-11.8	1.9** (0.6, 3.2)	1.9 (0.8, 3.0)	1.12 (1.06, 1.19)	<0.001

Abbreviations: SDQ, Strengths and Difficulties Questionnaire.

a. The unadjusted crude difference in rate change was calculated as follows: (follow-up rate − baseline rate in pandemic group) – (follow-up rate − baseline rate in pre-pandemic group).

b. The adjusted absolute risk difference represents adjusted differences between group-specific changes over time and was estimated with the use of the generalized-estimating-equations (GEE) model. The GEE model adjusted for child age, gender, parental education, family income, siblings, marital status, and primary caregiver, with kindergarten as cluster factor.

c. The adjusted odds ratios for the interaction between groups (non-exposed vs. exposed) and timing (entry vs. graduation) were estimated with the use of the GEE model.

* P<0.05 ** P<0.01 *** P<0.001

Table 5. Association of home confinement with family environment and lifestyle

	Pre-pandemic Cohort (n=16590)			Pandemic Cohort (n=18409)			Crude Difference [a]	Adjusted Difference		
	Survey at Entry	Survey at Graduation	Difference	Survey at Entry	Survey at Graduation	Difference	Rate Change (95% CI)	Adjusted Absolute Risk Difference [b] (95% CI)	Adjusted Odds Ratio [c] (95% CI)	p-value
	No. (%)		*%*	*No. (%)*		*%*				
Family environment by ICCE										
Human stimulation										
Seldom play with child	835 (5.0)	980 (5.9)	0.9	858 (4.7)	1200 (6.5)	1.9	1.0** (0.3, 1.7)	1.1 (0.4, 1.7)	1.21 (1.07, 1.37)	<0.01†
Seldom read to child	3426 (20.7)	3316 (20.0)	-0.7	3679 (20.0)	4023 (21.9)	1.9	2.5*** (1.3, 3.7)	2.6 (1.4, 3.8)	1.18 (1.09, 1.27)	<0.001†
Seldom sing songs with child	3973 (23.9)	7371 (44.4)	20.5	4419 (24.0)	8954 (48.6)	24.6	4.2*** (2.8, 5.5)	4.4 (3.1, 5.7)	1.19 (1.11, 1.27)	<0.001†
Seldom have other caregivers help with the child	1928 (11.6)	2147 (12.9)	1.3	1975 (10.7)	2492 (13.5)	2.8	1.5** (0.5, 2.5)	1.5 (0.7, 2.4)	1.16 (1.07, 1.25)	<0.001†
Seldom eat meals together with parents (children)	1452 (8.8)	1352 (8.1)	-0.6	1465 (8.0)	1537 (8.3)	0.4	1.0* (0.2, 1.8)	1.0 (0.3, 1.7)	1.14 (1.04, 1.25)	<0.01†
Social stimulation										
Seldom go shopping with child	5717 (34.5)	6598 (39.8)	5.3	6165 (33.5)	9807 (53.3)	19.8	14.5*** (13.0, 15.9)	14.5 (13.3, 15.7)	1.81 (1.72, 1.91)	<0.001†
Seldom go to park with child	4125 (24.9)	5974 (36.0)	11.1	4447 (24.2)	7111 (38.6)	14.5	3.3*** (2.0, 4.7)	3.5 (2.1, 4.9)	1.16 (1.09, 1.24)	<0.001†
Seldom meet with children of a similar age (children)	10968 (66.1)	11613 (70.0)	3.9	12289 (66.8)	13421 (72.9)	6.1	2.3** (0.9, 3.6)	2.3 (0.7, 3.8)	1.12 (1.04, 1.21)	<0.01†
Avoidance of restriction										
Use corporal punishment if he/she spills milk on purpose	163 (1.0)	105 (0.6)	-0.3	161 (0.9)	139 (0.8)	-0.1	0.2 (0.0, 0.5)	0.2 (0.0, 0.5)	1.34 (0.95, 1.89)	0.09
Hit or kick child within a week	3153 (19.0)	2255 (13.6)	-5.4	3493 (19.0)	2664 (14.5)	-4.5	0.9 (-0.2, 2.0)	0.9 (-0.2, 2.0)	1.08 (1.00, 1.17)	0.06
Social support										
Seldom talk with partner about	3076 (18.5)	3411 (20.6)	2.0	3154 (17.1)	4249 (23.1)	5.9	3.9*** (2.7, 5.1)	4.1 (3.0, 5.1)	1.29 (1.21, 1.39)	<0.001†

child										
Nobody help to take care of child	2108 (12.7)	2516 (15.2)	2.5	2132 (11.6)	2766 (15.0)	3.4	1.0 (0.0, 2.0)	1.0 (0.2, 1.8)	1.10 (1.02, 1.19)	<0.01
Nobody to consult with about childcare	5278 (31.8)	5442 (32.8)	1.0	6021 (32.7)	7238 (39.3)	6.6	5.6*** (4.2, 7.0)	5.6 (4.2, 7.0)	1.28 (1.20, 1.36)	<0.001†

(continued) Association of home confinement with family environment and lifestyle

	Pre-pandemic Cohort (n=16590)			**Pandemic Cohort (n=18409)**			**Crude Difference [a]**	**Adjusted Difference**	
	Survey at Entry	**Survey at Graduation**	**Difference**	**Survey at Entry**	**Survey at Graduation**	**Difference**	**Mean Change (95% CI)**	**Adjusted Mean Change [d] (95% CI)**	**p-value**
	Mean (SE)		*Mean*	*Mean (SE)*		*Mean*			
Sleep disturbance by CSHQ scores[e]	47.7 (0.0)	45.9 (0.1)	-1.8	47.8 (0.0)	45.2 (0.0)	-2.5	-0.8*** (-1.0, -0.6)	-0.79 (-0.96, -0.62)	<0.001
Night sleep duration, minutes/day									
Weekday	566.2 (0.3)	558.9 (0.3)	-7.3	564.0 (0.3)	574.7 (0.3)	10.7	18.0*** (16.9, 19.1)	18.00 (15.96, 20.03)	<0.001
Weekend	582.1 (0.3)	581.1 (0.3)	-1.0	578.9 (0.3)	587.9 (0.3)	8.9	9.9*** (8.6, 11.2)	9.92 (8.59, 11.24)	<0.001
Average	570.8 (0.3)	565.2 (0.2)	-5.5	568.3 (0.3)	578.5 (0.3)	10.2	15.7*** (14.6, 16.7)	15.69 (13.96, 17.42)	<0.001
Media time[f], minutes/day									
Weekday	140.1 (1.0)	120.2 (1.1)	-19.9	124.8 (0.8)	134.0 (1.2)	9.2	29.0*** (25.1, 33.0)	29.04 (25.30, 32.79)	<0.001
Weekend	172.9 (1.2)	161.1 (1.2)	-11.8	151.5 (0.9)	141.2 (1.0)	-10.3	1.5 (-2.7, 5.7)	1.51 (-2.34, 5.36)	0.44
Average	149.5 (1.0)	131.9 (1.0)	-17.6	132.5 (0.7)	136.1 (1.1)	3.6	21.2*** (17.4, 24.9)	21.18 (17.79, 24.57)	<0.001

Abbreviations: ICCE, Index of Child Care Environment; CSHQ, Children's Sleep Habits Questionnaire.

a. The unadjusted crude difference in rate/mean change was calculated as follows: (follow-up rate/mean − baseline rate/mean in exposed group) – (follow-up rate/mean − baseline rate/mean in non-exposed group).

b. The adjusted absolute risk difference represents adjusted differences between group-specific changes over time and was estimated with the use of the generalized-estimating-equations (GEE) model. The GEE model adjusted for child age, gender, parental education, family income, siblings, marital status, and primary caregiver, with kindergarten

as cluster factor.

c. The adjusted odds ratios for the interaction between groups (pre-pandemic vs. pandemic) and timing (entry vs. graduation) were estimated with the use of the GEE model.

d. The adjusted mean difference (equal to the adjusted coefficient) was estimated with the use of the GEE model.

e. The higher score in CSHQ score indicates greater sleep problems.

f. The media time was summed by the time of watching programs and playing video games.

* P<0.05 ** P<0.01 *** P<0.001

† indicates adjusted difference is significant at alpha level corrected by Bonferroni adjustment.

Figure 1: Study profile for pre-pandemic cohort and pandemic cohort

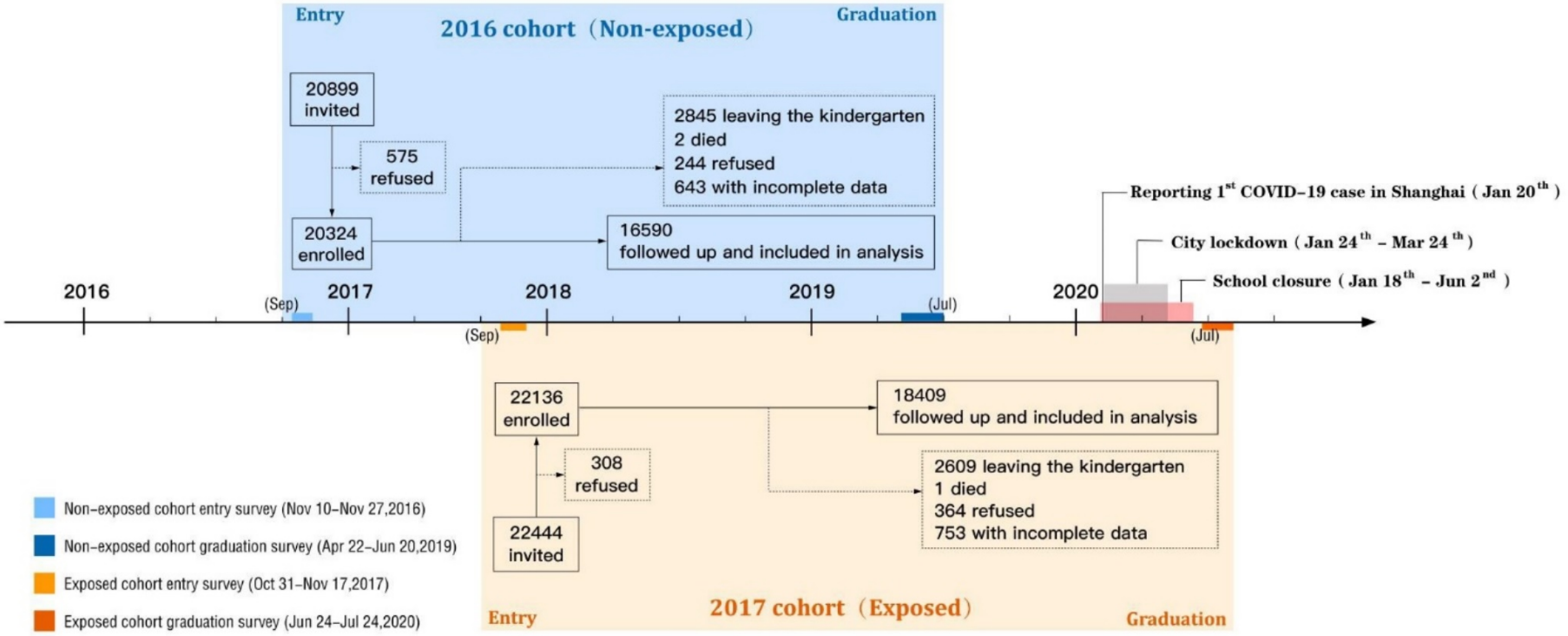
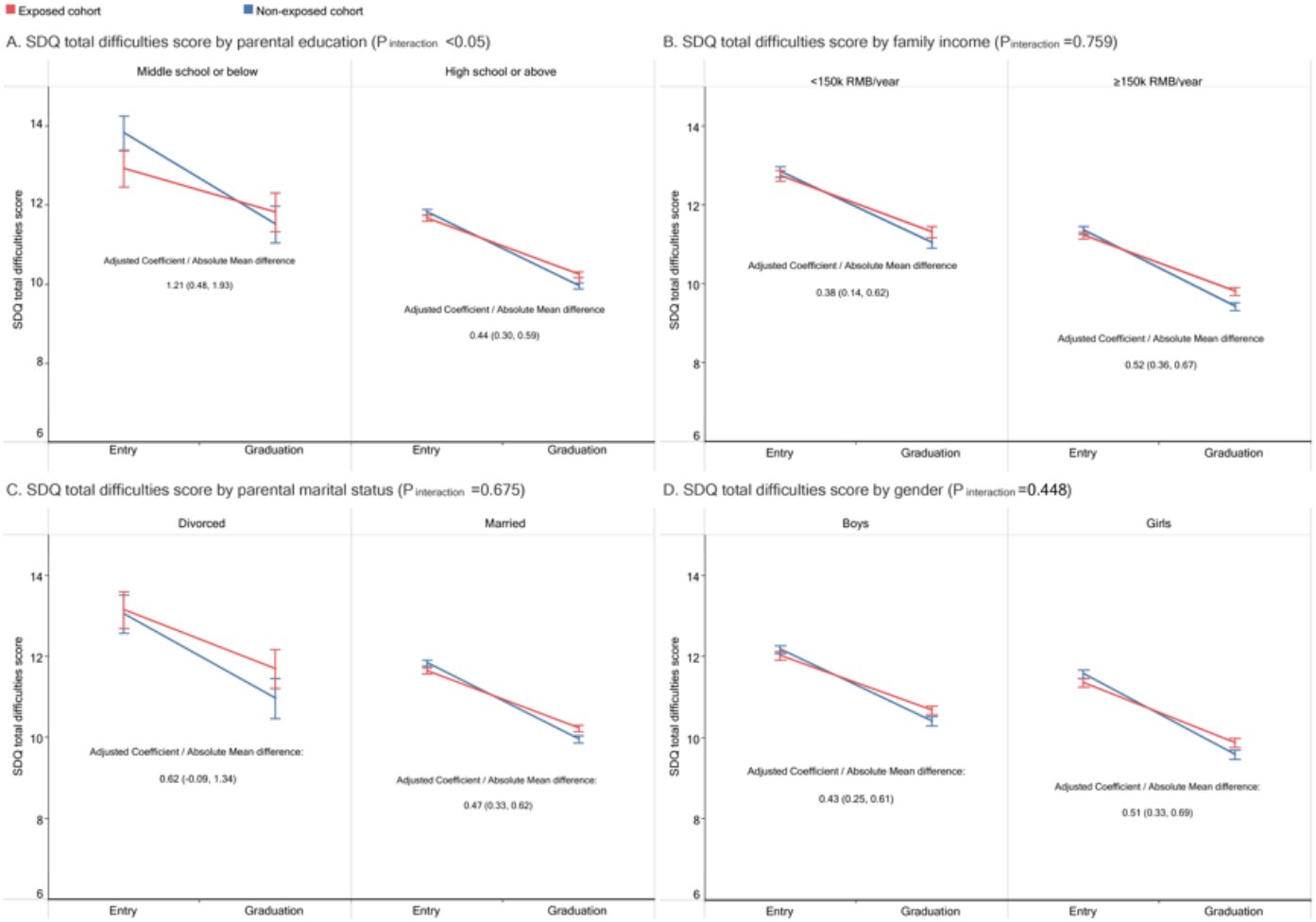


Figure 2. Strengths and Difficulties Questionnaire total difficulties score[a] in pre-pandemic and pandemic cohort by parental education (A); family income (B); marital status (C); gender (D)



Supplementary Online Content

eMethods 1. Sampling strategy

The Shanghai Children's Health, Education, and Lifestyle Evaluation, Preschool (SCHEDULE-P) study

The SCHEDULE-P study was designed and implemented by the Child Health Advocacy Institute, Shanghai Children's Medical Center, Shanghai Jiao Tong University School of Medicine. It aimed to investigate the effects of nurturing care on Early Child Development status of children aged 3-6 years old from kindergartens in Shanghai and explore the scientific evidence for policy-making and implementation on nurturing care.

Sampling

Non-exposed cohort

All three-year-old children living in Shanghai are required to enter kindergarten and be enrolled in the registration system of the Shanghai Municipal Education Commission (SMEC). According to this database, a total of 167,597 enrolled children entered 1,584 kindergartens in 2016, excluding international kindergartens. We selected a representative sample from newly enrolled children by a stratified cluster random sampling design. First, all 16 districts in Shanghai were set as Primary Sampling Units (PSUs). We then defined Secondary Sampling Units (SSUs) based on the kindergarten's ownership and level. In Shanghai, the kindergartens are categorized as public and private, and are rated into different levels depending on the teaching quality, child development, health care, facility and equipment, kindergarten management, and others. There were a total of nine categories of SSUs (Figure 1). In each SSU, one or two kindergartens were randomly selected, and all the enrolled children in the junior grade were invited to this survey. Finally, 20,899 children aged 3-4 years old from 191 kindergartens were randomly selected as subjects.

Exposed cohort

In 2017, a total of 176193 enrolled children entered 1473 kindergartens, excluding international kindergartens. All kindergartens selected in 2016 survey were invited to participate in the 2017 survey. However, of all 191 kindergartens, 4 kindergartens were closed. Finally, 22444 children aged 3-4 years old from 187 kindergartens were invited as subjects.

Survey Procedure

At the beginning of each survey, we worked with SMEC to host an orientation meeting and contacted each District Education Committee and kindergarten representatives for participation. At the meeting, we firstly introduced the purpose and significance of the SCHEDULE-P study, lesson learned and study findings from previous investigations, technical procedures and timelines of the survey study. Secondly, we provided a standard training for kindergarten representatives to carry out this survey following the proper protocol. The kindergarten representatives were responsible for making sure the completeness and accuracy of the survey information and guiding parents to complete a parent-reported survey online within a given time window.

Children's personal information was first obtained from the SMEC database, and then after the kindergarten teachers double-checked the information, a unique login code was generated for each child and sent to the parents. An exclusive login code linking personal information retrieved from the SMEC Database including name, birthdate, sex, and attending kindergartens was generated for each sample child. An online questionnaire along with a login code was distributed by head teachers to the parent of each participant. Before the survey started, the parent needed to check the checkbox to consent their participation. If they refused, they could check "I refuse to participate in this survey", which would also be recorded in the system.

eMethods 2. Introduction of Index of Child Care Environment (ICCE)

The Index of Child Care Environment (ICCE) was developed as a questionnaire version of the Home Observation for Measurement of the Environment (HOME). It evaluates child care environment by using self-report questions or reports by caregivers for children under the age of 6. The ICCE measures child care environment through 13 questions in four domains: human stimulation, social stimulation, avoidance of restriction, and social support.[1] Each item is assessed using a multiple-choice format, and the answer is given a binary score (1=No/seldom, 0=Yes/often) according to the eTable 1.

eMethods 3. Sensitivity analysis

In this study, multiple imputation (MI) was applied in handling missing values. In contrast to single imputation, MI creates a number of datasets by imputing missing values. These values take imputation uncertainty into consideration. While single imputation has been criticized for its bias and ignorance of uncertainty about estimation of missing values, MI, if performed properly can give an accurate estimate of real result. Since missing values occurred in several variables in the dataset, we applied the multivariate imputation by chained equation (MICE) package with the statistical software R to perform multiple imputation. Here, we outline the MICE algorithm for a set of variables, x1, . . . , xk, some or all of which have missing values. [2] Initially, all missing values are filled in at random. The first variable with at least one missing value, x1 say, is then regressed on the other variables, x2, . . . , xk. The estimation is restricted to individuals with observed x1. Missing values in x1 are replaced by simulated draws from the posterior predictive distribution of x1, an important step known as proper imputation. The next variable with missing values, say x2, is regressed on all the other variables, x1, x3, . . . , xk. Estimation is restricted to individuals with observed x2 and uses the imputed values of x1. Again, missing values in x2 are replaced by draws from the posterior predictive distribution of x2. The process is repeated for all other variables with missing values in turn: one such round is called a cycle. To stabilize the results, the procedure (similar to a Gibbs sampler) is usually repeated for about ten cycles to produce a single imputed dataset. van Buuren et al. (1999) suggest 20 cycles but say that 10 or even 5 may be adequate. [3] We used the default set of 5 cycles of MICE in this anlysis. The entire procedure is repeated independently 5 times, yielding 5 imputed datasets.

eTable 1. The items and scoring rules of the Index of Child Care Environment

	Options	1=No/seldom	0=Yes/often
Human stimulation			
1. How often do you play with your child per week?	① Rarely; ② 1–3 times/month; ③ 1-2 times/week; ④ 3-4 times/week; ⑤ almost every day	① ②	③ ④ ⑤
3. How often do you read to your child?	① Rarely; ② 1–3 times/month; ③ 1-2 times/week; ④ 3-4 times/week; ⑤ almost every day	① ②	③ ④ ⑤
4. How often do you sing songs with your child?	① Rarely; ② 1–3 times/month; ③ 1-2 times/week; ④ 3-4 times/week; ⑤ almost every day	① ②	③ ④ ⑤
7. How often does your spouse, partner, or other caregiver help you with the child?	① Rarely; ② 1–3 times/month; ③ 1-2 times/week; ④ 3-4 times/week; ⑤ almost every day	① ②	③ ④ ⑤
8. How often does your child eat meals together with both parents?	① Rarely; ② 1–3 times/month; ③ 1-2 times/week; ④ 3-4 times/week; ⑤ almost every day	① ②	③ ④ ⑤
Social stimulation			
2. How often do you go shopping with your child?	① Rarely; ② 1–3 times/month; ③ 1-2 times/week; ④ 3-4 times/week; ⑤ almost every day	① ②	③ ④ ⑤
5. How often do you go to the park with your child?	① Rarely; ② 1–3 times/month; ③ 1-2 times/week; ④ 3-4 times/week; ⑤ almost every day	① ②	③ ④ ⑤
6. How often do you and your child meet with friends or relatives with children of a similar age?	① Rarely; ② 1–3 times/month; ③ 1-2 times/week; ④ 3-4 times/week; ⑤ almost every day	① ②	③ ④ ⑤
Avoidance of restriction			
9. What do you do if your child spills milk on purpose?	① Hit the child; ② Scold the child; ③ discipline in another way; ④ Determine how to prevent it in the future; ⑤ Other	①	② ③ ④ ⑤
10. How many times did you hit or kick your child last week?	① Never; ② 1–2 times; ③ 3-4 times; ④ 5-6 times; ⑤ almost every day	①	② ③ ④ ⑤
Social support			
11. How many times do you have a chance to talk with your partner about your child?	① Rarely; ② 1–3 times/month; ③ 1-2 times/week; ④ 3-4 times/week; ⑤ almost every day	① ②	③ ④ ⑤
12. Does someone help you take care of your child?	① No; ② Yes	①	②
13. Do you have someone to consult with about childcare?	① No; ② Yes	①	②

eTable 2. Demographic characteristics population represented by non-exposed and exposed cohort (weighted)

	Non-exposed cohort at entry (n=20324)	Exposed cohort at entry (n=22136)
Age, mean (95%CI), months	44.8 (44.7, 44.8)	43.9（43.8, 44.0)
Gender, No. (%)		
Male	10573 (52.5)	11460 (52.0)
Female	9751 (47.5)	10676 (48.0)
Parental education, No. (%)		
Middle school or below	968 (6.4)	829 (5.2)
High school	2121 (13.2)	1875 (10.7)
Some college	3732 (18.8)	3797 (19.0)
Graduate study or above	13452 (61.3)	15566 (64.6)
Don’t know	1 (0.0)	0 (0.0)
Refuse to answer	49 (0.3)	64 (0.4)
Family income, No. (%)		
<150k RMB	7610 (41.9)	6992 (36.0)
150-300k RMB	6595 (31.9)	7494 (33.9)
>300k RMB	4825 (19.7)	6468 (24.9)
Don’t know	233 (1.1)	223 (0.9)
Refuse to answer	1059 (5.3)	959 (4.3)
Siblings, No. (%)		
None	14700 (71.1)	15720 (69.3)
One or more	5620 (28.9)	6408 (30.7)
Marital status, No. (%)		
Married	19269 (94.8)	21114 (95.2)
Divorced	629 (3.0)	646 (3.0)
Refuse to answer	417 (2.1)	366 (1.8)
Primary caregiver, No. (%)		
Parents	12807 (63.6)	14288 (65.1)
Grandparents or others	7514 (36.4)	7839 (34.9)

Mean, 95%CI, and proportion were estimated by sampling weight.

eTable 3. Significance testing of difference on mental health between non-exposed and exposed cohort

	Entry in analysis sample			Graduation in analysis sample		
	Non-exposed cohort (n=16590)	**Exposed cohort** (n=18409)	**P value**	**Non-exposed cohort** (n=16590)	**Exposed cohort** (n=18409)	**P value**
Mental health, high-risk No. (%)						
Total difficulties	5741(34.6)	5976(32.5)	<0.001	3802(22.9)	4418(24.0)	<0.05
Emotional symptoms	3760(22.7)	4041(22.0)	0.11	3110(18.7)	3428(18.6)	0.76
Conduct problems	5529(33.3)	5816(31.6)	<0.01	3785(22.8)	4564(24.8)	<0.001
Hyperactivity/inattention	5364(32.3)	5734(31.1)	<0.05	4045(24.4)	4588(24.9)	0.24
Peer relationship problems	8834(53.2)	9685(52.6)	0.23	6467(39.0)	7754(42.1)	<0.001
Poor prosocial behavior	5574(33.6)	6212(33.7)	0.77	3308(19.9)	4040(21.9)	<0.001

eTable 4. The adjusted odds ratios of generalized-estimating-equations model using imputation data

Mental health by SDQ	Adjusted Odds Ratio [a] (95% CI)	P value
Total difficulties	1.20 (1.13, 1.27)	<0.001
Emotional symptoms	1.06 (0.99, 1.14)	0.09
Conduct problems	1.25 (1.17, 1.33)	<0.001
Hyperactivity/inattention	1.10 (1.04, 1.17)	<0.01
Peer relationship problems	1.18 (1.12, 1.25)	<0.001
Poor prosocial behavior	1.13 (1.07, 1.20)	<0.001

Abbreviations: SDQ, Strengths and Difficulties Questionnaire; GEE, generalized-estimating-equations

a. The adjusted odds ratios for the interaction between groups (non-exposed vs. exposed) and time (entry vs. graduation) were estimated with the use of the GEE model. The GEE model adjusted for age, gender, parental education, family income, siblings, marital status, and primary caregiver, with kindergarten as cluster factor.

eTable 5. Association of home confinement with sleep disturbance by Children's Sleep Habits Questionnaire

	Non-exposed Cohort (n=16590)			Exposed Cohort (n=18409)			Crude Difference [a]	Adjusted Difference	
	Survey at Entry	Survey at Graduation	Difference	Survey at Entry	Survey at Graduation	Difference	Mean Change (95% CI)	Adjusted Mean difference [b] (95% CI)	p-value
Sleep disturbance by CSHQ scores									
Total	47.7 (0.0)	45.9 (0.1)	-1.8	47.8 (0.0)	45.2 (0.0)	-2.5	-0.8*** (-1.0, -0.6)	-0.79 (-0.96, -0.62)	<0.001
Bedtime resistance	11.5 (0.0)	10.3 (0.0)	-1.3	11.6 (0.0)	10.5 (0.0)	-1.1	0.1*** (0.1, 0.2)	0.15 (0.09, 0.20)	<0.001
Sleep onset delay	1.8 (0.0)	1.5 (0.0)	-0.2	1.7 (0.0)	1.6 (0.0)	-0.2	0.0*** (0.0, 0.1)	0.04 (0.02, 0.06)	<0.001
Sleep duration	4.6 (0.0)	4.8 (0.0)	0.2	4.6 (0.0)	4.8 (0.0)	0.1	0.0 (-0.1, 0.0)	-0.03 (-0.07, 0.01)	0.099
Sleep anxiety	7.4 (0.0)	6.8 (0.0)	-0.7	7.4 (0.0)	7.0 (0.0)	-0.5	0.2*** (0.1, 0.2)	0.18 (0.13, 0.23)	<0.001
Night wakings	3.5 (0.0)	3.3 (0.0)	-0.2	3.5 (0.0)	3.3 (0.0)	-0.2	0.0 (0.0, 0.0)	-0.02 (-0.05, 0.00)	<0.05
Parasomnia	8.5 (0.0)	8.1 (0.0)	-0.4	8.6 (0.0)	8.1 (0.0)	-0.5	-0.1*** (-0.1, 0.0)	-0.10 (-0.15, -0.05)	<0.001
Sleep disorder breathing	3.3 (0.0)	3.3 (0.0)	0.0	3.3 (0.0)	3.3 (0.0)	-0.1	-0.1*** (-0.1, 0.0)	-0.06 (-0.08, -0.04)	<0.001
Daytime sleepiness	11.9 (0.0)	12.0 (0.0)	0.1	11.8 (0.0)	11.0 (0.0)	-0.7	-0.9*** (-0.9, -0.8)	-0.86 (-0.94, -0.77)	<0.001

(to be continued)

(continiued) Association of home confinement with sleep disturbance by Children's Sleep Habits Questionnaire

	Non-exposed Cohort (n=16590)			Exposed Cohort (n=18409)			Crude Difference [a]	Adjusted Difference		
	Survey at Entry	Survey at Graduation	Difference	Survey at Entry	Survey at Graduation	Difference	Rate Change (95% CI)	Adjusted Absolute Risk Difference [c] (95% CI)	Adjusted Odds Ratio [d] (95% CI)	p-value
	No. (%)		*%*	*No. (%)*		*%*				
Sleep disturbance by CSHQ[e]										
Total	13955 (84.1)	12243 (73.8)	-10.3	15699 (85.3)	12996 (70.6)	-14.7	-4.4*** (-5.6, -3.2)	-4.4 (-5.6, -3.2)	0.78 (0.72, 0.84)	<0.001
Bedtime resistance	11011 (66.4)	7844 (47.3)	-19.1	12266 (66.6)	9124 (49.6)	-17.1	2.0** (0.6, 3.5)	2.0 (0.8, 3.2)	1.08 (1.03, 1.14)	<0.01
Sleep onset delay	2965 (17.9)	1787 (10.8)	-7.1	3062 (16.6)	2264 (12.3)	-4.3	2.8*** (1.7, 3.8)	2.8 (1.7, 3.8)	1.27 (1.16, 1.38)	<0.001
Sleep duration	4778 (28.8)	5553 (33.5)	4.7	5541 (30.1)	6090 (33.1)	3.0	-1.7* (-3.1, -0.3)	-1.7 (-3.0, -0.4)	0.92 (0.87, 0.98)	<0.01
Sleep anxiety	8820 (53.2)	6247 (37.7)	-15.5	10012 (54.4)	7786 (42.3)	-12.1	3.4*** (2.0, 4.9)	3.4 (2.3, 4.6)	1.16 (1.11, 1.21)	<0.001
Night wakings	652 (3.9)	382 (2.3)	-1.6	836 (4.5)	534 (2.9)	-1.6	0.0 (-0.6, 0.5)	0.0 (-0.5, 0.5)	1.09 (0.92, 1.29)	0.31
Parasomnia	1893 (11.4)	1096 (6.6)	-4.8	2208 (12.0)	1188 (6.5)	-5.5	-0.7 (-1.6, 0.1)	-0.7 (-1.5, 0.2)	0.92 (0.82, 1.03)	0.15
Sleep disorder breathing	701 (4.2)	715 (4.3)	0.1	797 (4.3)	643 (3.5)	-0.8	-0.9** (-1.5, -0.3)	-0.9 (-1.5, -0.3)	0.78 (0.67, 0.91)	<0.01
Daytime sleepiness	1830 (11.0)	1968 (11.9)	0.8	1832 (10.0)	1113 (6.0)	-3.9	-4.7*** (-5.6, -3.9)	-4.7 (-5.5, -3.9)	0.54 (0.49, 0.59)	<0.001

Abbreviations: CSHQ, Children's Sleep Habits Questionnaire.

a. The unadjusted crude difference in rate/mean change was calculated as follows: (follow-up rate/mean − baseline rate/mean in exposed group) – (follow-up rate/mean − baseline rate/mean in non-exposed group).

b. The adjusted absolute mean difference (equal to the adjusted coefficient) represents adjusted differences between group-specific changes over time and was estimated with the use of the generalized-estimating-equations (GEE) model. The GEE model adjusted for child age, gender, parental education, family income, siblings, marital status, and primary caregiver, with kindergarten as cluster factor.

c. The adjusted absolute risk difference was estimated with the use of the GEE model.

d. The adjusted odds ratios for the interaction between groups (non-exposed vs. exposed) and timing (entry vs. graduation) were estimated with the use of the GEE model.

e. The instrument includes 33 items that are grouped into 8 subscales, and the cutoff scores of each subscale were defined as follow: bedtime resistance 10.84, sleep onset delay 2.31, sleep duration 5.27, sleep anxiety 7.79, night wakings 5.29, parasomnias 10.61, sleep disordered breathing 4.50, and daytime sleepiness 15.24. A CSHQ total score > 41 has been shown to be the most sensitive and specific clinical cutoff for identifying global sleep disturbance in children.[4]

* P<0.05 ** P<0.01 *** P<0.001

eTable 6. Comparison of demographic characteristics between the samples enrolled at entry and missed at graduation survey

	Non-exposed cohort			Exposed cohort		
	Sample at entry (n=20324)	Missed at graduation (n=3734)	P value	Sample at entry (n=22136)	Missed at graduation (n=3727)	P value
Age, mean (SD), months	44.7 (3.6)	44.7 (3.8)	<0.05	44.0（3.5)	43.9 (3.7)	<0.001
Gender, No. (%)						
Male	10573 (52.0)	1967 (52.7)	0.46	11460 (51.8)	1926 (51.7)	0.91
Female	9751 (48.0)	1767 (47.3)		10676 (48.2)	1801 (48.3)	
Parental education, No. (%)						
Middle school or below	968 (4.8)	471 (12.6)	<0.001	829 (3.7)	370 (9.9)	<0.001
High school	2121 (10.4)	776 (20.8)		1875 (8.5)	599 (16.1)	
Some college	3732 (18.4)	706 (18.9)		3797 (17.2)	688 (18.5)	
Graduate study or above	13452 (66.2)	1766 (47.3)		15566 (70.3)	2053 (55.1)	
Don’t know	1 (0.0)	1 (0.0)		0 (0.0)	0 (0.0)	
Refuse to answer	49 (0.2)	13 (0.4)		64 (0.3)	12 (0.3)	
Missing	1 (0.0)	1 (0.0)		5 (0.0)	5 (0.1)	
Family income, No. (%)						
<150k RMB	7610 (37.4)	1801 (48.2)	<0.001	6992 (31.6)	1474 (39.5)	<0.001
150-300k RMB	6595 (32.5)	913 (24.5)		7494 (33.9)	975 (26.2)	
>300k RMB	4825 (23.7)	730 (19.6)		6468 (29.2)	1039 (27.9)	
Don’t know	233 (1.1)	52 (1.4)		223 (1.0)	53 (1.4)	
Refuse to answer	1059 (5.2)	236 (6.3)		959 (4.3)	186 (5.0)	
Missing	2 (0.0)	2 (0.0)		0 (0.0)	0 (0.0)	
Siblings, No. (%)						
None	14700 (72.3)	2302 (61.6)	<0.001	15720 (71.0)	2245 (60.2)	<0.001
One or more	5620 (27.7)	1428 (38.2)		6408 (29.0)	1474 (39.5)	
Missing	4 (0.0)	4 (0.1)		8 (0.0)	8 (0.2)	
Marital status, No. (%)						
Married	19269 (94.8)	3416 (91.5)	<0.001	21114 (95.4)	3495 (93.8)	<0.001
Divorced	629 (3.1)	179 (4.8)		646 (2.9)	148 (4.0)	
Refuse to answer	417 (2.1)	130 (3.5)		366 (1.7)	74 (2.0)	
Missing	9 (0.0)	9 (0.2)		10 (0.0)	10 (0.3)	
Primary caregiver, No. (%)						
Parents	12807 (63.0)	2673 (71.6)	<0.001	14288 (64.6)	2730 (73.2)	<0.001
Grandparents or others	7514 (37.0)	1058 (28.3)		7839 (35.4)	988 (26.5)	
Missing	3 (0.0)	3 (0.1)		9 (0.0)	9 (0.2)	

eTable 7. Comparison of demographic characteristics between samples missing in non-exposed and exposed cohort

	Non-exposed (n=3091)	Exposed (n=2974)	P value
Age, mean (SD), months	44.7 (3.8)	43.9 (3.7)	<0.001
Gender, No. (%)			
Male	1967 (52.7)	1926 (51.7)	0.39
Female	1767 (47.3)	1801 (48.3)	
Parental education, No. (%)			
Middle school or below	471 (12.6)	370 (9.9)	<0.001
High school	776 (20.8)	599 (16.1)	
Some college	706 (18.9)	688 (18.5)	
Graduate study or above	1766 (47.3)	2053 (55.1)	
Don’t know	1 (0.0)	0 (0.0)	
Refuse to answer	13 (0.4)	12 (0.3)	
Missing	1 (0.0)	5 (0.1)	
Family income, No. (%)			
<150k RMB	1801 (48.2)	1474 (39.5)	<0.001
150-300k RMB	913 (24.5)	975 (26.2)	
>300k RMB	730 (19.6)	1039 (27.9)	
Don’t know	52 (1.4)	53 (1.4)	
Refuse to answer	236 (6.3)	186 (5.0)	
Missing	2 (0.0)	0 (0.0)	
Siblings, No. (%)			
None	2302 (61.6)	2245 (60.2)	0.25
One or more	1428 (38.2)	1474 (39.5)	
Missing	4 (0.1)	8 (0.2)	
Marital status, No. (%)			
Married	3416 (91.5)	3495 (93.8)	<0.001
Divorced	179 (4.8)	148 (4.0)	
Refuse to answer	130 (3.5)	74 (2.0)	
Missing	9 (0.2)	10 (0.3)	
Primary caregiver, No. (%)			
Parents	2673 (71.6)	2730 (73.2)	0.05
Grandparents or others	1058 (28.3)	988 (26.5)	
Missing	3 (0.1)	9 (0.2)	

eTable 8. Distribution of items of Strengths and Difficulties Questionnaire in non-exposed and exposed cohort

	Survey at entry, No. (%)		Survey at graduation, No. (%)	
Items	**Non-exposed cohort**	**Exposed cohort**	**Non-exposed cohort**	**Exposed cohort**
Emotional symptoms				
3. Often complains of headaches, stomach-aches or sickness				
Not true	13721 (82.7)	15495 (84.2)	13625 (82.1)	15461 (84.0)
Somewhat true	2275 (13.7)	2256 (12.3)	2386 (14.4)	2388 (13.0)
Certainly true	593 (3.6)	658 (3.6)	579 (3.5)	560 (3.0)
8. Many worries, often seems worried				
Not true	12750 (76.9)	14271 (77.5)	12080 (72.8)	13598 (73.9)
Somewhat true	3296 (19.9)	3549 (19.3)	3867 (23.3)	4205 (22.8)
Certainly true	543 (3.3)	589 (3.2)	643 (3.9)	606 (3.3)
13. Often unhappy, down-hearted or tearful				
Not true	11871 (71.6)	13485 (73.3)	12888 (77.7)	14234 (77.3)
Somewhat true	4062 (24.5)	4236 (23.0)	3159 (19.0)	3564 (19.4)
Certainly true	655 (3.9)	688 (3.7)	543 (3.3)	611 (3.3)
16. Nervous or clingy in new situations, easily loses confidence				
Not true	3545 (21.4)	4063 (22.1)	5623 (33.9)	5913 (32.1)
Somewhat true	9491 (57.2)	10290 (55.9)	8828 (53.2)	9979 (54.2)
Certainly true	3554 (21.4)	4056 (22.0)	2139 (12.9)	2517 (13.7)
24. Many fears, easily scared				
Not true	8977 (54.1)	10051 (54.6)	10827 (65.3)	11813 (64.2)
Somewhat true	6617 (39.9)	7129 (38.7)	5010 (30.2)	5738 (31.2)
Certainly true	996 (6.0)	1229 (6.7)	753 (4.5)	858 (4.7)
Conduct problems				
5. Often has temper tantrums or hot tempers				
Not true	5677 (34.2)	6819 (37.0)	8628 (52.0)	9152 (49.7)
Somewhat true	9118 (55.0)	9714 (52.8)	6928 (41.8)	7974 (43.3)

Certainly true	1795 (10.8)	1876 (10.2)	1034 (6.2)	1283 (7.0)
7. Generally obedient, usually does what adults request				
Not true	3182 (19.2)	3671 (19.9)	2495 (15.0)	3150 (17.1)
Somewhat true	10374 (62.5)	11307 (61.4)	9195 (55.4)	10368 (56.3)
Certainly true	3034 (18.3)	3431 (18.6)	4900 (29.5)	4891 (26.6)
12. Often fights with other children or bullies them				
Not true	14423 (86.9)	16179 (87.9)	14577 (87.9)	16097 (87.4)
Somewhat true	1838 (11.1)	1843 (10.0)	1720 (10.4)	2007 (10.9)
Certainly true	329 (2.0)	387 (2.1)	293 (1.8)	305 (1.7)
18. Often lies or cheats				
Not true	13675 (82.4)	15487 (84.1)	14495 (87.4)	15948 (86.6)
Somewhat true	2630 (15.9)	2559 (13.9)	1835 (11.1)	2198 (11.9)
Certainly true	285 (1.7)	363 (2.0)	260 (1.6)	263 (1.4)
22. Steals from home, school or elsewhere				
Not true	15804 (95.3)	17531 (95.2)	15387 (92.8)	16920 (91.9)
Somewhat true	543 (3.3)	563 (3.1)	937 (5.7)	1207 (6.6)
Certainly true	243 (1.5)	315 (1.7)	266 (1.6)	282 (1.5)
Hyperactivity/inattention				
2. Restless, overactive, cannot stay still for long				
Not true	4425 (26.7)	5186 (28.2)	6224 (37.5)	6636 (36.1)
Somewhat true	8840 (53.3)	9632 (52.3)	7676 (46.3)	8562 (46.5)
Certainly true	3324 (20.0)	3591 (19.5)	2690 (16.2)	3211 (17.4)
10. Constantly fidgeting or squirming				
Not true	6503 (39.2)	7879 (42.8)	6366 (38.4)	7352 (39.9)
Somewhat true	7490 (45.2)	7817 (42.5)	7355 (44.3)	8085 (43.9)
Certainly true	2596 (15.6)	2713 (14.7)	2869 (17.3)	2972 (16.1)
15. Easily distracted, concentration wanders				
Not true	4452 (26.8)	5179 (28.1)	5170 (31.2)	5638 (30.6)
Somewhat true	9655 (58.2)	10486 (57.0)	9008 (54.3)	10144 (55.1)
Certainly true	2483 (15.0)	2744 (14.9)	2412 (14.5)	2627 (14.3)
21. Thinks things out before acting				

Not true	2740 (16.5)	2973 (16.1)	1425 (8.6)	1739 (9.5)
Somewhat true	10511 (63.4)	11741 (63.8)	9325 (56.2)	10501 (57.0)
Certainly true	3339 (20.1)	3695 (20.1)	5840 (35.2)	6169 (33.5)
25. Sees tasks through to the end, good attention span				
Not true	3924 (23.7)	4381 (23.8)	2508 (15.1)	3008 (16.3)
Somewhat true	10135 (61.1)	11223 (61.0)	9889 (59.6)	11047 (60.0)
Certainly true	2531 (15.3)	2805 (15.2)	4193 (25.3)	4354 (23.7)
Peer relationship				
6. Rather solitary, tends to play alone				
Not true	8832 (53.2)	9811 (53.3)	11230 (67.7)	11997 (65.2)
Somewhat true	6312 (38.1)	6965 (37.8)	4319 (26.0)	5092 (27.7)
Certainly true	1446 (8.7)	1633 (8.9)	1041 (6.3)	1320 (7.2)
11. Has at least one good friend				
Not true	1113 (6.7)	1299 (7.1)	547 (3.3)	678 (3.7)
Somewhat true	5269 (31.8)	5980 (32.5)	3127 (18.8)	4272 (23.2)
Certainly true	10208 (61.5)	11130 (60.5)	12916 (77.9)	13459 (73.1)
14. Generally liked by other children				
Not true	928 (5.6)	1147 (6.2)	836 (5.0)	1201 (6.5)
Somewhat true	9462 (57.0)	10644 (57.8)	7023 (42.3)	8352 (45.4)
Certainly true	6200 (37.4)	6618 (36.0)	8731 (52.6)	8856 (48.1)
19. Picked on or bullied by other children				
Not true	12662 (76.3)	14470 (78.6)	13358 (80.5)	15026 (81.6)
Somewhat true	3568 (21.5)	3522 (19.1)	2835 (17.1)	2987 (16.2)
Certainly true	359 (2.2)	417 (2.3)	397 (2.4)	396 (2.2)
23. Gets on better with adults than with other children				
Not true	6038 (36.4)	7100 (38.6)	6223 (37.5)	6911 (37.5)
Somewhat true	7458 (45.0)	8047 (43.7)	6432 (38.8)	7299 (39.7)
Certainly true	3093 (18.6)	3262 (17.7)	3935 (23.7)	4199 (22.8)
Poor prosocial behavior				
1. Considerate of other people's feelings				
Not true	1099 (6.6)	1204 (6.5)	680 (4.1)	763 (4.1)

Somewhat true	11381 (68.6)	12359 (67.1)	7343 (44.3)	8786 (47.7)
Certainly true	4119 (24.8)	4846 (26.3)	8567 (51.6)	8860 (48.1)
4. Shares readily with other children (treats, toys, pencils etc.)				
Not true	1545 (9.3)	1813 (9.8)	819 (4.9)	946 (5.1)
Somewhat true	8760 (52.8)	9954 (54.1)	5972 (36.0)	7415 (40.3)
Certainly true	6285 (37.9)	6642 (36.1)	9799 (59.1)	10048 (54.6)
9. Helpful if someone is hurt, upset or feeling ill				
Not true	1260 (7.6)	1548 (8.4)	1233 (7.4)	1441 (7.8)
Somewhat true	8372 (50.5)	9013 (49.0)	6326 (38.1)	7444 (40.4)
Certainly true	6958 (41.9)	7848 (42.6)	9031 (54.4)	9524 (51.7)
17. Kind to younger children				
Not true	1108 (6.7)	1278 (6.9)	728 (4.4)	778 (4.2)
Somewhat true	7454 (44.9)	8214 (44.6)	4904 (29.6)	5875 (31.9)
Certainly true	8028 (48.4)	8917 (48.4)	10958 (66.1)	11756 (63.9)
20. Often volunteers to help others (parents, teachers, other children)				
Not true	1338 (8.1)	1493 (8.1)	888 (5.4)	1091 (5.9)
Somewhat true	9009 (54.3)	10012 (54.4)	7239 (43.6)	8370 (45.5)
Certainly true	6243 (37.6)	6904 (37.5)	8463 (51.0)	8948 (48.6)

eReference

1. Anme T, Tanaka E, Watanabe T, Tomisaki E, Tokutake KJPHF. Validity and Reliability of the Index of Child Care Environment (ICCE). *Journal of Public Health Frontier.* 2013; **2**(3): 141-5.
2. White IR, Royston P, Wood AM. Multiple imputation using chained equations: Issues and guidance for practice. *Statistics in Medicine.* 2011; 30(4):377-399.
3. van Buuren S, Boshuizen HC, Knook DL. Multiple imputation of missing blood pressure covariates in survival analysis. *Statistics in Medicine.* 1999;18(6):681-694.
4. LIU Z, WANG G, GENG L, et al. Sleep Patterns, Sleep Disturbances, and Associated Factors Among Chinese Urban Kindergarten Children [J]. *Behav Sleep Med*. 2016; 14(1): 100-17.