



Factors associated with changes in movement behaviors in toddlers and preschoolers during the COVID-19 pandemic: A national cross-sectional study in Mexico

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ABSTRACT

Little is known about physical activity, screen time and sleep among Mexican toddlers and preschoolers. The COVID-19 pandemic led to the closure of childcare education centers and restrictions to spend time outdoors. This study aimed to investigate the correlates of changes in movement behaviors from before to during the early stages of the COVID-19 lockdown in a national sample of toddlers and preschoolers in Mexico. A cross-sectional study was conducted using an open online survey completed by caretakers of children aged 1–5 years from April to July 2020. The questionnaire enquired about the time spent in each movement behavior during a regular week before and during lockdown, and family and household characteristics. Factors associated with changes in movement behaviors were explored using adjusted linear regression models. A total of 631 children (3.3y, 95% CI: 3.1, 3.4) were included in the study. During lockdown, physical activity decreased by 25%, screen time doubled, and sleep quality declined in 17% ($p < 0.001$). Toddlers and preschoolers of older age, attending a childcare education center before the lockdown, with a screen in their bedroom, higher access to electronic devices, and lower socioeconomic level experienced greater changes during this period. Those with limits on the use of electronic devices, who had someone available to play with them, and availability of toys experienced less pronounced changes. Pandemic restrictions have impacted movement behaviors of toddlers and preschoolers, with disproportionate effects among lower socioeconomic levels. Interventions with a multi-level equity-oriented approach are urgently needed to mitigate these effects.

1. Introduction

The COVID-19 pandemic was declared a humanitarian crisis in Latin America (Lancet, 2020) with Mexico among the countries with the highest death rates in the region (World Health Organization, 2020). In response to this global crisis, governments implemented national lockdowns (Gobierno de México, 2020; Secretaría de Salud, 2020); including social and physical distancing measures to prevent the disease transmission, including the closure of early childcare and education centres and restrictions to spend time outdoors (World Health Organization, 2020). These measures, might have undesirable effects on children's

movement patterns, putting their health at risk.

Physical activity, sedentary time and sleep, known as movement behaviors, are influential in determining the health and development of toddlers and preschoolers (Kuzik et al., 2017; Chaput et al., 2017; LeBlanc et al., 2012). Recently, the World Health Organization released the first global guidelines for movement behaviors for children under five (World Health Organization, 2019). Physical activity among preschoolers and toddlers is positively correlated with outdoor opportunities (Gray et al., 2015); access to green spaces (Benjamin-Neelon et al., 2019); and the exposure to the promotion of healthy behaviors at education centers (Brockman et al., 2016). However, with the closure of

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these places, the ability of children to meet physical activity guidelines has been compromised. Conversely, with children spending large periods of time indoors as well as parents taking care of school and home activities and work, leisure screen time (ST) (e.g., using mobile devices, watching television, etc.) is likely to increase. Sleep may have also been affected due to changes in movement behaviors, other disruptions to family lifestyles, or stress and anxiety during the pandemic (Liu et al., 2021).

The negative effects of the COVID-19 pandemic on children movement behaviors have been documented among preschool children (Liu et al., 2021; Alonso-Martínez et al., 2021; Delisle Nyström et al., 2020). However, scarce evidence exists on movement behaviors among Latin populations, and little empirical evidence has documented the effect of pandemic restrictions in this age group. A recent study among Chilean children under the age of five reported decreases in total physical activity and sleep quality, and increases in ST as a consequence of the COVID-19 lockdown, with an attenuated impact among those with space to play at home, less educated parents and living in homes compared to apartments (Aguilar-Farías et al., 2021). The effects of the lockdown could be exacerbated among those from lower socioeconomic backgrounds (López-Bueno et al., 2021), highlighting the need to explore these behaviors among unattended populations as the case of Mexican toddlers and preschoolers.

Understanding if COVID-19 has affected movement behaviors and identifying population groups and factors associated with worse or better outcomes may provide critical information to design strategies promoting healthier levels of physical activity, ST and sleep among preschoolers and toddlers. This study aimed to investigate the correlates of changes in movement behaviors from before to during the early stages of the government restrictions to prevent the COVID-19 outbreak in a national sample of toddlers and preschoolers in Mexico.

2. Methods

2.1. Study design

This is a cross-sectional study using an 80-item open online survey. Items were integrated into the author's institutional approved survey system (RedCap^{MR}), which complies with data protection standard regulations. Data was collected from April 30th (one month after the beginning of COVID-19 restrictions) to July 27th, 2020. During this period, the first wave of the COVID-19 outbreak in Mexico was still increasing and had not reached its plateau yet. The study was reviewed and approved by the research ethics committee of the National Institute of Public Health (INSP-Spanish acronym).

2.2. Participants and selection process

A convenience sample of caretakers and parents who were living in Mexico during the COVID-19 lockdown responsible for children aged 1-5y was recruited. Participants were recruited through the webpage and social media of INSP, the Latin American Congress for Physical Activity and Health Research and personal twitter accounts of the research team. Informed consent was obtained from the caretakers before completing the survey and a copy was sent to their email account to also prevent duplications or several submissions from the same respondent. Participants were informed about the length of the survey, the name and email account of the principal investigator and the INSP president of the ethics committee if any concerns arose.

2.3. Movement behaviors

An adapted version of the SUNRISE study questionnaire was used to measure movement behaviors (Okely, 2021). The child's primary caretaker reported the time per day spent in physical activity (total physical activity [TPA] and moderate to vigorous intensity physical

activity [MVPA]), ST, and sleep during a regular week both, before the COVID-19 restrictions and during this period. The questionnaire has been piloted and adjusted in 22 countries (Okely, 2021) demonstrating good validity for the measurement of TPA ($r = 0.14$; $P = 0.003$) and MVPA ($r = 0.16$; $P = 0.002$) (Okely, 2021). Minutes per day dedicated to each of these behaviors were estimated in both periods and the changes from before to during the COVID-19 pandemic were calculated. The World Health Organization guidelines for children under 5 years (World Health Organization, 2019) was used to identify whether the child met the movement recommendations in each period. Age 4 recommendations were used for 5-year old children because of a lack of specific age 5 recommendations, and the fact that in Mexico children aged 5 years attend preschool and share similar daily routines with those aged 4 years.

Sleep quality during a regular week before and during the COVID-19 restrictions was assessed by asking the question "How would you assess the child's sleep quality?", with Likert scale response options in which "1" indicated difficulty to sleep (wakes up several times during the night for long periods and is restless), while "7" indicated no trouble sleeping (falls asleep quickly, sleeps well during the whole night, breathes well, and has deep sleep).

2.4. Covariates

Demographic information was collected on the caretaker (age, sex, education level) and on the child (age, sex, attending an early childcare education center or other childcare facility, having someone to play with, having access to electronic devices, electronic devices in the room where the child sleeps, or rules to limit the use of electronic devices). The socioeconomic level of the household was measured with a validated questionnaire and participants were categorized as with high, middle and low socioeconomic level (Comité de Nivel Socioeconómico, 2017). In addition, the type of home was measured (house, apartment, or other), the presence of another child under 5 years of age in the household, availability of space to play at home, availability of toys in the household and the state and municipality where the home was located. The country regions were classified as North, Center, South, and Mexico City or surrounding municipalities (Instituto Nacional de Salud Pública, 2016). Some variables related to lockdown were explored, including home confinement, changes in the caregiver's or head of household's work during the pandemic, and the number of days they allowed their child to use electronic devices as an education means, to entertain or to calm them before and during COVID-19 lockdown.

3. Data analysis

Means for continuous variables and proportions for categorical variables were estimated to describe the data. The proportion of children that met all movement recommendations before and during the lockdown was calculated and the differences were measured using proportion tests. Differences in movement behaviors between the two periods were estimated using paired T tests.

The factors associated with differences (from before to during COVID-19) in TPA, MVPA, ST, or sleep quality were explored using separate linear regression models:

$$\Delta MB_{f-b} = \beta_0 + \beta_1 MB_b + \beta_2 factors_b + \beta_3 \Delta covariables_{f-b} + E$$

This model estimated the association of factors with the differences of the behavior in question (ΔMB = differences in TPA, MVPA, ST, or sleep quality), controlling for baseline values and changes in the other two behaviors (e.g. the model of the difference in TPA was adjusted by the differences in ST and sleep time). Baseline values of ST were introduced using a logarithmic transformation to improve model fit. The models were adjusted for characteristics of the child (sex, age category, availability of screens at home, limits in the use of electronic devices,

presence of electronic devices in the bedroom of the child); of the caretaker (age, sex, and education level); of the home (space to play, home type, availability of toys, socio-economic level); and by country region. Covariates were included altogether in the models. Statistically significant differences were considered when $p < 0.05$. The analyses were conducted using STATA version 14.1.

Given that this was a purposive sample of participants with internet access, inferences cannot be drawn for the entire Mexican population. Data and estimates were weighted using post-stratification sample weights to improve the representativeness of our sample for those in Mexico with similar characteristics. Sample weights were constructed using estimates from the (INEGI, 2018) National Income and Expenses Survey, considering only those with similar characteristics as our sample (e.g., internet access at home where the head of the household had an education level of at least part-complete high school), and based on region and household socioeconomic level.

4. Results

In total, 1024 caretakers accessed the link and consented to participate, out of which 726 accessed the survey and 640 completed it. After eliminating participants with duplicate information ($n = 2$) or missing data for any of the analytical variables ($n = 7$) a sample of 631 caretakers and their children from the 32 states in Mexico was included (data not shown). In comparison to national estimates, participants had higher socioeconomic status and education level than the national mean (Instituto Nacional de Estadística y Geografía, 2013). This sample represents 4,641,958 households in Mexico with internet access at home where the head of the household has an education level of at least part-complete high school.

In total, 47.4% of the children were girls, with a mean age of 3.3y (95% CI: 3.1, 3.4) (Table 1). Around 70% of children attended school or childcare before the lockdown and three out of four had someone to play with. Most children (62.2%) had access to 1 or 2 electronic devices at home and had time restrictions to use them (71.2%), while less than half (46.1%) had an electronic device in their room. Caretakers were mostly women (92.4%) of 32.9y (95% CI: 32.4, 33.3); 75.3% had a college degree or higher. In total, 76.3% lived in a house, most had enough space to play (94.8%) or toys (99.3%), and more than half had a middle socio-economic level. Further, 85.3% of caretakers reported being in home confinement (29.4 days in average, 95% CI: 29.2, 29.7), in 16.5% of the households the caretaker or the head of the family had lost their job or earned less. Caretakers allowed children to use more electronic devices to calm them down (46.9%), entertain them (65.7%) or for educational purposes (68.7%) during lockdown.

Overall, during COVID-19 lockdown physical activity decreased in about 25%, ST doubled, sleep time decreased by 2% and sleep quality declined by 17% (p values < 0.05) (Table 2). The percentage of children who met the recommendations of TPA (61.1% vs 36.2%), ST (15.7% vs 3.6%), and the three recommendations altogether (5.7% vs 1.3%) also decreased ($p < 0.05$), however the percentage of children meeting sleep time recommendations increased, mainly in children aged 5 years (Fig. 1).

Changes in movement behaviors were related to each other (Table 3). Increases in ST were associated with decreases in TPA ($\beta = -0.34$ min/d, 95% CI: $-0.45, -0.23$), MVPA ($\beta = -0.17$ min/d, 95% CI: $-0.24, -0.10$) and sleep quality ($\beta = -0.002$, 95% CI: $-0.004, -0.001$), as well as increases in sleep time ($\beta = 0.003$ hr/d, 95% CI: $0.001, 0.005$). Conversely, increases in TPA were associated with decreases in ST ($\beta = -0.18$ min/d, 95% CI: $-0.25, -0.11$) and sleep time ($\beta = -0.001$ hr/d, 95% CI: $-0.002, -0.000$) and increases in sleep quality ($\beta = 0.002$, 95% CI: $0.000, 0.003$).

Several demographic factors were associated to these changes (Table 3). Greater decreases in physical activity were associated with older age (MVPA: 3–4 y: $\beta = -25.22$ min/d, 95% CI: $-41.56, -8.88$, 5y: $\beta = -19.31$, 95% CI: $-36.27, -2.33$), higher access to electronic devices

Table 1
Characteristics of the child, caregiver, and household (n = 631).

	n	% (95% CI) ^a
Child characteristics		
Girl	295	47.2 (43.0, 51.4)
Age		
1–2 y	215	34.0 (30.1, 38.1)
3–4 y	258	39.4 (35.4, 43.5)
5 y	158	26.7 (23.1, 30.6)
Attending an early childhood education center ^a	459	72.3 (68.3, 75.89)
Having someone to play with		
No	160	25.6 (22.1, 29.5)
Yes	471	74.4 (70.5, 77.9)
Access to electronic devices		
None	13	1.6 (0.0, 2.9)
1–2	390	62.3 (58.1, 66.2)
≥3	228	36.0 (32.2, 40.2)
Screens in the bedroom	288	46.1 (41.9, 50.3)
Rules that limit screen time at home	456	71.3 (67.3, 74.9)
Caregiver characteristics		
Woman	583	92.3 (89.7, 94.3)
Age		
≤30 years	199	34.7 (30.7, 38.9)
31–40 years	371	56.9 (52.6, 60.9)
≥41 years	61	8.5 (6.5, 11.0)
Education level		
Secondary or less	20	2.6 (1.6, 4.4)
High school or undergraduate (part-complete)	131	21.9 (18.5, 25.7)
Undergraduate or postgraduate degree	480	75.5 (71.6, 79.0)
Household characteristics		
Living with other children under 5 years of age	135	22.2 (19.0, 26.1)
Household type		
House	479	76.4 (72.6, 79.8)
Apartment or Flat	147	22.9 (19.6, 26.6)
Other (Shack or ranch)	5	0.8 (0.3, 1.9)
Availability of space to play	600	94.8 (92.5, 96.4)
Availability of toys	625	99.3 (98.2, 99.7)
Socioeconomic status		
Low	14	0.3 (0.2, 0.6)
Medium	325	64.1 (60.3, 67.9)
High	292	35.6 (31.8, 39.4)
Country region		
North	107	24.0 (20.3, 28.1)
Center	216	28.7 (25.3, 32.6)
South	127	20.6 (17.3, 24.1)
Mexico City ^b	181	26.6 (23.2, 30.5)
COVID-19 related factors		
Home confinement	535	85.4 (82.1, 88.0)

(continued on next page)

Table 1 (continued)

Child characteristics	n	% (95% CI) ^a
Changes in the caregiver's or head of household's job ^b		
No changes or doing home-office	460	83.5 (79.8, 86.6)
Reduced income or lost job	89	16.6 (13.4, 20.2)
Reasons for allowing the child to use electronic devices more frequently than before COVID-19 lockdown		
Calm him/her	289	46.9 (42.8, 51.1)
Entertaining him/her	418	65.6 (30.4, 38.4)
Educate him/her	434	68.7 (64.7, 72.4)

95% CI, 95% Confidence intervals.

^a Percentages and 95% CI were weighted using survey weights.

^b n = 549 due to missing information.

Table 2

Movement behaviors before and during COVID-19 lockdown among preschoolers and toddlers in Mexico (n = 631).

	Before lockdown	During lockdown	Difference ^a
	Mean (95% CI)	Mean (95% CI)	Mean (95% CI)
Total physical activity (min/d)	234.3 (222.1, 246.8)	174.0 (161.9, 186.1)	-60.4 (-71.2, -49.6)
Moderate to vigorous physical activity (min/d)	116.2 (107.7, 124.8)	81.7 (73.4, 90.0)	-34.9 (-42.3, -27.5)
Screen time (min/d)	97.5 (91.7, 103.3)	192.8 (183.6, 202.1)	95.4 (87.0, 103.7)
Sleep time (hr/d)	13.8 (13.8, 13.9)	13.6 (13.5, 13.7)	-0.2 (-0.4, -0.1)
Sleep quality ^b	5.9 (5.8, 6.0)	4.9 (4.7, 5.0)	-1.0 (-1.2, -0.9)

95% CI, 95% Confidence intervals.

Data were weighted using survey weights.

Bolds indicate significant differences between before and during lockdown.

^a Differences estimated with mp.

^b Measured with a Likert scale where "1" indicates difficulty to fall asleep, waking up several times throughout the night for long period and being restless (coughing and turning, moving and kicking the bedclothes off), whereas "7" indicates falling asleep easily and within few minutes, sleeping well through the night, breathing normally and sleeping deeply.

(TPA: ≥ 3 devices: 98.02 min/d, 95% CI: -187.89, -7.15), and belonging to a lower socioeconomic level (TPA: Medium $\beta = -18.59$ min/d, 95% CI: -36.48, -0.70, Low: -51.90 min/d, 95% CI: -102.86, -0.94). In contrast, having someone to play with (TPA: $\beta = 22.52$ min/d, 95% CI: 2.17, 42.89; MVPA: $\beta = 17.78$ min/d, 95% CI: 5.38, 30.17) and availability of toys at home (TPA: $\beta = 45.52$, 95% CI: 5.75, 85.29) were associated with smaller decreases in TPA. Greater increments in ST were associated with older age (3.4 y: $\beta = 23.76$ min/d, 95% CI: 6.47, 41.04), attending an early childcare education center before the COVID-19 lockdown ($\beta = 28.22$ min/d, 95% CI: 11.34, 45.10), having access to more electronic devices (1-2 devices: $\beta = 78.14$ min/d, 95% CI: 34.94, 105.34; ≥ 3 devices: $\beta = 84.28$ min/d, 95% CI: 45.15, 123.40), and a screen in the bedroom where the child sleeps ($\beta = 16.34$ min/d, 95% CI: 1.46, 31.22). Conversely, smaller increases in ST were associated with having someone to play with ($\beta = -40.38$ min/d, 95% CI: -58.52, -25.17), rules limiting the use of electronic devices ($\beta = -41.42$ min/d, IC 95%: -57.69, -25.17) and living in the south region of the country ($\beta = -24.95$, 95% CI: -48.10, 1.81) or Mexico City ($\beta = -32.40$ min/d, IC 95%: -55.65, -9.17) compared to the North region of

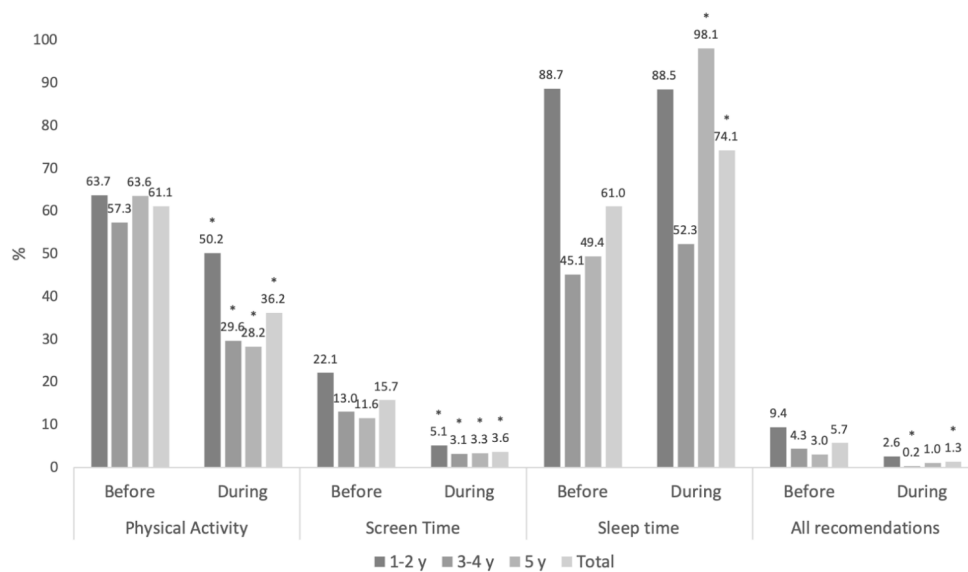
the country. Being a male was associated with higher increases in sleep time compared to being a female ($\beta = 0.28$ hr/d, 95% CI: 0.05, 0.51). Greater decreases in sleep quality were associated with belonging to a lower socioeconomic level (Medium: $\beta = -0.32$, IC 95%: -0.59, -0.04) and living in Mexico City compared to the North region of the country ($\beta = -0.55$, 95% CI: -0.97, -0.14), whereas having toys available at home was associated with smaller decreases in sleep quality ($\beta = 2.08$, IC 95%: 1.25, 2.90).

5. Discussion

Results showed that during the COVID-19 lockdown, toddlers and preschoolers in Mexico performed less physical activity, more ST, and had lower sleep quality. These changes were strongly related to each other. Toddlers and preschoolers of older age, attending a childcare education center before the COVID-19 lockdown, with higher access to electronic devices, a screen in their bedroom, and lower socioeconomic level experienced greater changes during this period. In contrast, those who had someone available to play with them, rules limiting ST, and availability of toys in the household experienced less pronounced changes.

The compliance with movement behaviors recommendations during the pandemic has decreased in school-aged children and preschoolers worldwide (Liu et al., 2021; Alonso-Martínez et al., 2021; Delisle Nyström et al., 2020; Pietrobelli et al., 2020; Xiang et al., 2020; Moore et al., 2020). In line with this, results of our study indicated that during lockdown only 1 out of 3 preschoolers and toddlers met physical activity recommendations and <4% met ST guidelines. Data showed that only 1.3% of this study children met the movement recommendations in this period. Results indicated that a high percentage of caretakers allowed more frequent use of electronic devices for educational reasons. This may be explained by children migrating to home-based online and television education, as part of the Mexican strategy to prevent the COVID-19 outbreak (Secretaría de Educación Pública, 2020). Thus, home-based learning may be a decisive factor in the increase of ST and declines in the compliance with movement behavior guidelines altogether (Secretaría de Educación Pública, 2020). Mexican preschool children will continue school remotely or in a hybrid format (e.g., where students receive some days of classroom instruction per week) until the health emergency for COVID-19 attenuates, which represents an important influence on physical, cognitive and well-being development of preschoolers in Mexico (Kuzik et al., 2017; Chaput et al., 2017; LeBlanc et al., 2012). Thus, a prompt attention of parents, caretakers and decision makers of this condition is imperative.

Studies have shown that movement behaviors are intrinsically related and that combinations of behaviors may impact health in a different way that may not be explained by the impact of individual behaviors alone (Kuzik et al., 2017). This premise was supported by this study data, and reinforces evidence suggesting that changing one movement behavior may affect or improve others (Chaput et al., 2014). Taken together, evidence underlines the need of a comprehensive strategy to encourage compliance with the recommendations of the three behaviors altogether. Indeed, interventions that combine the three movement behaviors (e.g., increasing physical activity, limiting ST and promoting adequate sleep time) have shown more beneficial effects compared with interventions targeting behaviors separately (Kuzik et al., 2017). Parallel to previous studies (Hinkley et al., 2015; Robinson and Borzekowski, 2006), this study's findings support that limiting the access to and time using electronic devices might limit increases in ST and decreases in physical activity and sleep quality. In line with other studies (Hinkley et al., 2008; Hinkley et al., 2012), this study's results also suggested that providing the child with opportunities to play with others could also encourage physical activity. There is evidence that family outdoor time that follows preventive actions for COVID-19 transmission could help encourage healthy movement behaviors in this age group (Cerin et al., 2016). Thus, an effective strategy to increase



* Indicates significant differences with before COVID-19 restrictions

Fig. 1. Percentage of children meeting movement behaviors guidelines before and during COVID-19 restrictions. * Indicates significant differences with before COVID-19 restrictions.

physical activity in this age group during lockdown may consist on promoting family activities involving movement (Guan et al., 2020).

There is an urgent need to provide effective solutions that do not increase the burden on parents and caretakers. Hence, while it is essential to raise awareness among parents and caretakers of the importance of movement behaviors and provide them with tools to foster environments that favor energetic play instead of screen use in their leisure time, other efforts at the community or political level are also needed. At the policy level, offering massive long distance physical education classes has been effective to help school children maintain their physical activity levels during the pandemic (Guerrero et al., 2020). This strategy could be considered as a possible solution for all preschool children. In Mexico, the Ministry of Education's Learn at Home strategy provides Physical Education classes by television or other online resources (Secretaría de Educación Pública, 2020). These strategies should be widely offered and adapted for the preschool population, acknowledging the challenge of keeping them connected without adult supervision.

In line with studies suggesting exacerbated effects of the COVID-19 pandemic and restrictions among vulnerable populations (López-Bueno et al., 2021; Tso et al., 2020); this study's findings indicated that toddlers and preschoolers from the lower socioeconomic level experienced greater impacts in movement behaviors during COVID-19 lockdown. Low-income families may face greater difficulties in designating specific play spaces in their homes for their child to be active due to overcrowding. This lack of home space may be mitigated using public spaces or outdoors. Hence, restrictions in the use of parks, recreation, and education centers, may have had a disproportionate impact among people with low income, who may rely on outdoor space for leisure. Further studies are needed to better understand these relations. Despite the limited representativeness of these findings for lower socioeconomic level, this study uncovered possible disproportionate impacts of COVID-19 restrictions among preschoolers and toddlers with lower socioeconomic backgrounds. Results also underscore the need to maximize existing strategies to promote movement behaviors among toddlers and preschoolers, especially among those from lower socioeconomic backgrounds, to mitigate the impact of COVID-19 restrictions.

The results of this study should be interpreted with consideration of its limitations. First, although data on movement behaviors before and

during COVID-19 lockdown were collected, the cross-sectional nature of the study does not allow inferring causality. The study used self-reported measures, which tend to overestimate physical activity behaviors and to be less precise than device-based measures (e.g., accelerometers) (Sarker et al., 2015; Loney et al., 2011). Another limitation is the possible social-desirability bias that could have influenced caretakers' responses (Adams et al., 2005). Due to the nature of the survey (online), study participants were mostly from a middle and high socioeconomic level, thereby limiting the representativeness of the findings for lower socioeconomic levels. Finally, the survey did not track participants' IP addresses limiting our ability to identify duplicate reports. However, e-mail addresses provided by participants were used to eliminate duplicate responses.

To the authors' knowledge, this is the first study to report movement behaviors in preschoolers and toddlers in Mexico during the COVID-19 lockdown. We used internationally comparable methods to collect movement behaviors and achieved a robust sample size from all the states in Mexico. Our results provide important information for parents, educators, and policy makers to help guide strategies aimed at mitigating the impact of the COVID-19 in Mexico and other Latin American countries with similar conditions.

6. Conclusion

This study presents evidence about the side effects of the COVID-19 pandemic, suggesting that toddlers and preschoolers from middle and high socioeconomic level in Mexico decreased their physical activity, increased their time spent in ST and reduced their sleep time and quality. Findings also suggest a disproportionate impact among those living in lower socioeconomic conditions. Concerted efforts to mitigate the effects of COVID-19 lockdown considering an equity-driven approach should represent a priority during the lockdown and afterwards. Results of this study may prove important for guiding policy decision-making and educating parents, caretakers and educators.

CRedit authorship contribution statement

Alejandra Jáuregui: Conceptualization, Formal analysis, Investigation, Data curation, Writing – original draft. **Gabriela Argumedo:**

Table 3
Factors associated to the changes in movement behaviors during COVID-19 lockdown (n = 631).

	Δ TPA ^a	Δ MVPA ^a	Δ ST ^a	Δ Sleep Time ^a	Δ Sleep Quality ^{a,b}
	β 95% CI	β (min/d) 95% CI	β (min/d) 95% CI	β (hr/d) 95% CI	β 95% CI
Changes in other behaviors					
Total physical activity (min/d)	–	–	–0.18 (–0.25, –0.11)	–0.001 (–0.002, –0.000)	0.002 (0.000, 0.003)
Screen time (min/d)	–0.34 (–0.45, –0.23)	–0.17 (–0.24, –0.10)	–	0.003 (0.001, 0.005)	–0.002 (–0.004, –0.001)
Sleep time (hr/d)	–4.67 (–9.65, 0.32)	–6.11 (–10.17, –2.04)	6.35 (1.68, 11.03)	–	–
Child characteristics					
Sex					
Female	Reference	Reference	Reference	Reference	Reference
Male	11.37 (–6.27, 29.03)	10.74 (–1.57, 23.04)	13.08 (–1.14, 27.30)	0.28 (0.05, 0.51)	0.18 (–0.09, 0.45)
Age group					
1–2 y	Reference	Reference	Reference	Reference	Reference
3–4 y	–17.00 (–40.50, 6.51)	–25.22 (–41.56, –8.88)	23.76 (6.47, 41.04)	–0.07 (–0.35, 0.22)	0.34 (–0.02, 0.65)
5 y	–21.75 (–46.77, 2.28)	–19.31 (–36.27, –2.33)	17.91 (–0.98, 36.81)	–0.22 (–0.65, 0.21)	0.04 (–0.35, 0.44)
Attending an early childhood education center					
Yes	Reference	Reference	Reference	Reference	Reference
No	–5.44 (–26.29, 15.42)	–5.52 (–20.37, 9.33)	28.22 (11.34, 45.10)	0.01 (–0.38, 0.37)	–0.12 (–0.45, 0.22)
Having someone to play with					
No	Reference	Reference	Reference	Reference	Reference
Yes	22.52 (2.17, 42.89)	17.78 (5.38, 30.17)	–40.38 (–58.52, –25.17)	–0.03 (–0.34, 0.29)	–0.01 (–0.32, 0.32)
Access to electronic devices					
None	Reference	Reference	Reference	Reference	Reference
1–2	–85.25 (–175.14, 4.63)	4.24 (–45.24, 53.73)	78.14 (34.94, 105.34)	1.03 (–0.52, 2.58)	0.41 (–0.90, 1.71)
≥3	–98.02 (–187.89, –7.15)	–0.76 (–51.00, 49.47)	84.28 (45.15, 123.40)	1.08 (–0.53, 2.68)	0.28 (–1.05, 1.61)
Screen in the bedroom					
No	Reference	Reference	Reference	Reference	Reference
Yes	7.97 (–9.18, 25.12)	5.86 (–7.74, 19.47)	16.34 (1.46, 31.22)	–0.05 (–0.31, 0.22)	–0.09 (–0.36, 0.19)
Rules limiting screen time					
No	Reference	Reference	Reference	Reference	Reference
Yes	2.41 (–16.26, 21.07)	–0.76 (–15.34, 13.82)	–41.42 (–57.69, –25.17)	0.01 (–0.28, 0.30)	0.09 (–0.20, 0.39)
Caregiver characteristics					
Age					
≤ 30 y	Reference	Reference	Reference	Reference	Reference
31–40 y	–4.77 (–23.86, 14.32)	3.35 (–10.79, 17.49)	–0.09 (–17.31, 17.14)	0.09 (–0.18, 0.37)	0.00 (–0.31, 0.32)
≥41 y	–20.39 (–65.20, 24.41)	0.61 (–22.23, 23.47)	–8.23 (–39.14, 22.67)	0.11 (–0.35, 0.57)	–0.30 (–0.79, 0.18)
Sex					
Female	Reference	Reference	Reference	Reference	Reference
Male	7.78 (–21.35, 36.92)	–2.58 (–21.04, 15.89)	10.75 (–15.16, 36.67)	–0.07 (–0.35, 0.57)	0.20 (–0.26, 0.66)
Household characteristics					
Type of household					
House	Reference	Reference	Reference	Reference	Reference
Flat	–11.17 (–32.43, 10.10)	–1.94 (–17.19, 13.32)	16.29 (–1.80, 34.38)	–0.22 (–0.49, 0.05)	0.25 (–0.09, 0.60)
Other	–53.37 (–134.00, 27.26)	–35.89 (–66.94, –4.82)	9.23 (–42.31, 60.77)	0.50 (–0.80, 1.80)	–0.40 (–2.26, 1.46)
Availability of space to play					
No	Reference	Reference	Reference	Reference	Reference
Yes	–2.70 (–58.62, 53.22)	–13.70 (–41.67, 14.26)	–37.80 (–76.12, 0.51)	0.05 (–0.55, 0.65)	0.09 (–0.59, 0.77)
Availability of toys					
No	Reference	Reference	Reference	Reference	Reference
Yes	45.52 (5.75, 85.29)	29.90 (–16.25, 76.04)	–37.80 (–117.95, 60.77)	0.75 (–0.65, 2.16)	2.08 (1.25, 2.90)
Socioeconomic level					
High	Reference	Reference	Reference	Reference	Reference
Medium	–18.59 (–36.48, –0.70)	–11.66 (–24.13, 0.81)	–5.53 (–19.20, 8.13)	0.10 (–0.13, 0.65)	–0.32 (–0.59, –0.04)
Low	–51.90 (–102.86, –0.94)	1.85 (–57.72, 61.43)	–59.78 (–167.17, 47.62)	0.25 (–0.63, 1.13)	0.14 (–1.08, 1.36)
Region					
North	Reference	Reference	Reference	Reference	Reference
Center	–13.06 (–38.19, 12.06)	–5.51 (–24.05, 13.03)	–19.70 (–41.04, 1.64)	0.24 (0.05, 0.53)	–0.09 (–0.43, 0.24)
South	–10.69 (–37.69, 16.31)	–0.96 (–21.37, 19.45)	–24.95 (–48.10, –1.81)	0.14 (–0.29, 0.58)	–0.33 (–0.75, 0.10)
Mexico City	–9.48 (–36.03, 17.06)	–3.00 (–21.17, 15.18)	–32.40 (–55.65, –9.17)	–0.25 (–0.08, 0.58)	–0.55 (–0.97, –0.14)

TPA, Total Physical Activity; MVPA, Moderate to Vigorous Physical Activity; ST, Screen time; 95% CI, 95% Confidence intervals, Ref, Reference category.

Bolds indicate significant associations ($p < 0.05$)

^a β and 95% CI estimated using linear regression models adjusted by variables listed in the table, the baseline behavior (before the COVID-19 lockdown) of the dependent variable and post-stratification survey weights.

^b Based on a Likert scale from 1 = difficulties to sleep, waking up several times during the night or feels uncomfortable when trying to sleep (frequent caught, moving, remove the blanket), to 7 = sleep without difficulty and in short time, sleep well throughout the breath well and sleep deeply. Statistically significant differences ($p < 0.05$) in bold.

^c Significant ($p < 0.05$) trend within strata categories.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

The data presented in this study are available in FigShare at <https://doi.org/10.6084/m9.figshare.13574897.v1>.

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