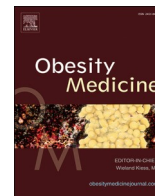




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Impact of the COVID-19 lockdown on weight status and associated factors for obesity among children in Massachusetts

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ABSTRACT

Background: This study aims to evaluate the impact of the COVID-19 lockdown on weight status, obesity and overweight among US children and identify associated factors. **Methods:** At a large safety net health system in Massachusetts, anthropometric measurements of 701 children were analyzed before and after the COVID-19 lockdown. Chi-square and paired *t*-test were computed for categorical and continuous variables, respectively. Multivariate analyses were performed to identify factors associated with obesity and overweight. **Results:** Post-lockdown, the overall mean body mass index (BMI) increased from 21.07 to 21.57 kg/m² ($p < .001$). The overall obesity (23.2%–27.4%, $p < .001$) and overweight (41.1%–44.5%, $p < .001$) burdens increased after the lockdown period. Obesity (40.5%–46.9%, $p < .001$) was highest among Spanish speakers. The youngest age group (2–5 years) had the greatest obesity rate increase by 26% (19.7%–24.8%, $p < .001$). Obesity was associated with younger age (odds ratio [OR] = 0.95, 95% confidence interval [CI] = 0.91, 1.00), higher baseline BMI (OR = 1.19, 95% CI = 1.15, 1.23) and Spanish speaking children (OR = 2.19, 95% CI = 1.10, 4.33). **Conclusions:** BMI, obesity and overweight increased among children during the COVID-19 lockdown, disproportionately affecting disadvantaged subpopulations. Strategies are needed to counteract the impact of the COVID-19 lockdown on unhealthy weight gain and childhood obesity.

1. Introduction

Since its first documented case in December 2019, the coronavirus 2019 (COVID-19) pandemic and the subsequent restrictions have had devastating impacts worldwide. As of late January 2021, there have been more than 98 million cases of COVID-19 and 2 million deaths worldwide (World Health Organization, 2021). Over 24 million of those cases and 410,000 deaths have been reported in the United States alone (World Health Organization, 2021). Concurrently, the prevalence of obesity has been steadily increasing in the United States for much longer than the COVID-19 pandemic. From 2015 to 2016, obesity was reported in 39.8% of adults and 18.5% of youths in the US. (Hales et al., 2017) Obesity has been identified as a major pre-existing condition for a more severe course of COVID-19 infection. Elevated body mass index (BMI) is associated with invasive mechanical ventilation, hospitalization, and death due to COVID-19 infection (Dietz and Santos-Burgoa, 2020; Chang

et al., 2020). There is a higher burden of obesity in the United States compared to many other countries, linked to a lack of physical activity (PA), sedentary lifestyle, and unhealthy diet. This has had disproportionate implications for the COVID-19 pandemic in populations with high rates of obesity.

To control the spread of COVID-19 infection, many restrictions have been imposed, including school closures and implementations of remote learning. Prior studies have shown unhealthy weight gain in children occurs mainly during summer months, when children are out of school (Rundle et al., 2020). At home, children tend to eat more unhealthily, which is exacerbated in food-insecure households that rely on school meals for healthier and often more expensive food choices (Rundle et al., 2020). They may also have fewer opportunities to engage in PA without school activities, particularly during periods of COVID-19 lockdown. The COVID-19 pandemic and the subsequent restrictions is expected to double out-of-school time for children in the US. (Rundle et al., 2020)

Abbreviations: COVID-19, corona virus disease 2019; EMR, electronic medical records; CHA, Cambridge Health Alliance; BMI, body mass index; PA, physical activity; M, meter squared; Kg, kilogram; ICD, International Statistical Classification of Diseases and Related Health Problems; CI, confidence intervals; AOR, adjusted odds ratio.

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These factors likely contribute to increase in weight gain during periods when students are out of school.

There is a paucity of research about the impact of the pandemic on weight status. A study based on an online questionnaire in China reported a significant increase in body mass index (BMI), obesity, and overweight during the COVID-19 lockdown among Chinese youth (Jia et al., 2020a). However, the impact of the COVID-19 lockdown on weight status among children in the US is not known. The study aims to evaluate the impact of the COVID-19 lockdown on body mass index, obesity, and overweight among US children and identify factors associated with obesity and overweight.

2. Subjects, materials and methods

Electronic medical records (EMR) data was used at Cambridge Health Alliance (CHA) in Massachusetts, USA. CHA is a large safety net health system serving more than 140,000 patients in Cambridge and Boston's metro-north region, including large minority and underserved communities. The state of emergency was declared in Massachusetts on March 10th, 2020 and most business, parks, recreational facilities were not allowed to reopen, until May 25th, 2020 (State of Massachusetts, O, 2020). The lockdown period was approximated to be between March 1st, 2020 and May 31st, 2020 for ease of data collection and analysis. Data were analyzed within three months before and after the first COVID-19 lockdown period in the state of Massachusetts.

2.1. Study population

All CHA patients who had complete anthropometric information before the lockdown period of March 1st, 2020 and after May 31st, 2020 were included. Out of the 1368 children identified between the ages of 2 and 18 years, 667 were excluded as their initial or follow-up measurements were outside of the three months of the COVID-19 lockdown period in Massachusetts, leaving a total of 701 children in the final analyses. The study was exempted by the Institutional Review Board (IRB) of the CHA.

2.2. Key measurement variables

Anthropometric data obtained during medical visits at CHA were used within three months before and after the lockdown period in the state of Massachusetts. Obesity (BMI percentile ≥ 95 th) and overweight (BMI percentile ≥ 85 th) were defined in accordance with the 2000 Centers for Disease Control and Prevention (CDC) age-sex-specific child growth standards in the USA. (Kuczmarski et al., 2000).

Demographic information of age, sex and patients' primary languages were obtained through the EMR. Patients' preferred languages are regularly collected more accurately and completely during routine registration, and were used as a proxy for race/ethnicity categories. The main categories were: English, Spanish, Brazilian Portuguese, Haitian Creole and others. Housing and food insecurity information were collected and documented in the EMR based on routine screenings for social determinants of health during patient encounters. Mental illness and COVID-19 status were defined based on carrying the corresponding International Statistical Classification of Diseases and Related Health Problems (ICD) code 10 diagnoses in the EMR.

2.3. Statistical analysis

Obesity and overweight burdens were compared by sex, age and language subgroups. Chi-square test was used for categorical variables. Paired *t*-test was computed to assess significant changes in BMI before and after the lockdown period by the outlined subgroups.

Multivariate logistic regression analyses were computed with the most recent obesity and overweight as outcome variables after adjusting for confounding factors and other covariates. Potential confounders

were identified based on priori and our conceptual framework. Confounders included in the final models were age, initial BMI, and duration of follow-up. Two-tailed statistical significance was assessed at $\alpha < 0.05$. Data analyses were conducted in December 2020 using SAS 9.4 (SAS Institute Inc., Cary, NC).

3. Results

Table 1 shows basic characteristics of study participants. The majority (55.8%) of the participants were female. Age categories of 2–5, 6–11, and 12–18 years of age included 33.4%, 22.7%, and 43.9% of the study participants, respectively. Nearly half (49.8%) of the children spoke English, followed by 15.8% of Spanish, 25.4% of Brazilian Portuguese and 3.3% of Haitian Creole. More than a quarter (28.3%) of the participants had mental illness and 6.0% were diagnosed with COVID-19 during the study period. Housing or food insecurity has been reported by 9.7% of the participants.

Changes in BMI, obesity and overweight three months before and after the COVID-19 lockdown period is shown in Table 2. Post-lockdown, the mean body mass index (BMI) increased among all participants from 21.07 kg/m² to 21.57 kg/m² ($p < .001$). The overall obesity (23.2%–27.4%, $p < .001$) and overweight (41.1%–44.5%, $p < .001$) burdens significantly increased after the lockdown period. Obesity (40.5%–46.9%, $p < .001$) was highest among Spanish speakers. The youngest age group (2–5 years) had the greatest obesity rate increase by 26% after the lockdown period (19.7%–24.8%, $p < .001$), compared to those aged 6–11 (9.4%) and 12–18 (11.9%) years.

Table 3 shows factors associated with most recent obesity and overweight during the COVID-19 lockdown period. After adjusting for confounders, obesity was associated with younger age (OR = 0.95, 95% CI = 0.91, 1.00) and higher baseline BMI (OR = 1.19, 95% CI = 1.15, 1.23). Compared to English speakers, Spanish speaking children had 219% (OR = 2.19, 95% CI = 1.10, 4.33) greater odds of having obesity. Overweight status at the follow-up was also associated with younger age (OR = 0.92, 95% CI = 0.88, 0.96) and higher baseline BMI (OR = 1.10, 95% CI = 1.08, 1.11).

4. Discussion

Understanding the impact of the COVID-19 lockdown on childhood obesity is of utmost importance due to the high burden of obesity in the US and severe complications of COVID-19 linked to obesity. Following the first COVID-19 pandemic lockdown, the mean BMI, and overall obesity and overweight burdens all increased significantly among children ages 18 and under. Overall obesity increased most in children ages 2–5 compared to other age groups, and this prevalence was highest in Spanish speaking populations. Post-lockdown, obesity and overweight

Table 1
Basic characteristics of participants during the COVID-19 pandemic lockdown at a safety-net health system in Massachusetts.

Variables, n (%)	All	Males	Females
All participants	701 (100.0)	310 (44.2)	391 (55.8)
Age:	–	–	–
2-5 y	234 (33.4)	107 (34.5)	127 (32.5)
6-11 y	159 (22.7)	91 (29.4)	68 (17.4)
12-18 y	308 (43.9)	112 (36.1)	196 (50.1)
Language:	–	–	–
English	349 (49.8)	143 (46.1)	206 (52.7)
Spanish	111 (15.8)	47 (15.2)	64 (16.4)
Brazilian Portuguese	178 (25.4)	88 (28.4)	90 (23.0)
Haitian Creole	23 (3.3)	11 (3.6)	12 (3.1)
Others	40 (5.7)	21 (6.8)	19 (4.9)
Mental illness	198 (28.3)	98 (31.6)	100 (25.6)
COVID-19	42 (6.0)	19 (6.1)	23 (5.9)
Housing or food insecurity	68 (9.7)	32 (10.3)	63 (9.2)

COVID-19: coronavirus disease 2019; y - years of age.

Table 2

Changes in BMI, obesity and overweight before and after the COVID-19 pandemic lockdown among participants at a Safety-net Health System in Massachusetts.

Variables	Obesity, n (%)		Overweight, n (%)		Mean BMI (SD) in kg/m ²	
	Before	After	Before	After	Before	After
All	167 (23.2)	192 (27.4)	288 (41.1)	312 (44.5)	21.07 (6.25)	21.57 (6.36)
Sex:						
Males	85 (27.4)	91 (29.4)	136 (43.8)	147 (47.4)	20.65 (6.01)	21.25 (6.13)
Females	82 (20.9)	101 (25.8)	152 (38.9)	165 (42.2)	21.39 (6.43)	21.83 (6.54)
Age:						
2-5 y	46 (19.7)	58 (24.8)	85 (36.3)	103 (44.0)	16.76 (2.54)	17.19 (2.90)
6-11 y	54 (33.9)	59 (37.1)	76 (47.8)	84 (52.8)	19.84 (4.88)	20.95 (5.23)
12-18 y	67 (21.8)	75 (24.4)	127 (41.2)	125 (40.6)	24.97 (6.46)	25.23 (6.60)
Language:						
English	83 (23.8)	89 (25.5)	137 (39.3)	149 (42.7)	21.18 (6.54)	21.68 (6.71)
Spanish	45 (40.5)	52 (46.9)	64 (57.7)	66 (59.5)	22.17 (6.66)	22.91 (6.88)
Brazilian Portuguese	28 (15.7)	38 (21.4)	67 (37.6)	70 (39.3)	20.42 (5.54)	20.89 (5.51)
Haitian Creole	5 (21.7)	5 (21.7)	8 (34.8)	11 (47.8)	22.57 (5.94)	22.85 (5.83)
Others	6 (15.0)	8 (20.0)	12 (30.0)	16 (40.0)	18.96 (4.86)	19.23 (4.49)

BMI: body mass index; m: meter; SD: standard deviation; kg: kilogram.

Table 3

Factors associated with obesity and overweight during the COVID-19 pandemic lockdown at a Safety-net Health System in Massachusetts.

Variable	Adjusted Odds Ratio (95% CI)	
	Obesity	Overweight
Age, years	0.95 (0.91, 1.00)	0.92 (0.88, 0.96)
BMI percentile	1.19 (1.15, 1.23)	1.10 (1.08, 1.11)
Female sex	1.16 (0.71, 1.92)	0.84 (0.53, 1.32)
Language		
English	1.00 (ref)	1.00 (ref)
Spanish	2.19 (1.10, 4.33)	1.23 (0.64, 2.34)
Brazilian Portuguese	0.96 (0.52, 1.75)	0.89 (0.52, 1.55)
Haitian Creole	0.74 (0.19, 2.87)	0.97 (0.31, 3.02)
Others	1.18 (0.38, 3.66)	0.87 (0.34, 2.23)
Mental illness	1.26 (0.71, 2.21)	1.46 (0.86, 2.49)
COVID-19	0.88 (0.30, 2.57)	0.65 (0.25, 1.70)
Housing or food insecurity	1.12 (0.50, 2.51)	0.73 (0.35, 1.51)

COVID-19: coronavirus disease 2019; BMI: body mass index. Using logistic regressions. Ref: reference. Adjusting for the duration of follow up. AOR: adjusted odds ratio. CI: confidence interval.

burdens were also associated with higher baseline BMI. These findings suggest the COVID-19 pandemic lockdown is significantly associated with increase in unhealthy weight, overweight and childhood obesity.

Although there is a paucity of research, similar findings were observed in other countries hit hard by the COVID-19 pandemic, such as China and Italy. A national online questionnaire for school-aged children was conducted in China before and after the COVID-19 lockdown (Jia et al., 2020a, 2020b; Yang et al., 2020). Similar to our study's findings, the youths' overall BMI significantly increased from 21.8 kg/m² to 22.6 kg/m² after the lockdown in China (Jia et al., 2020a). Following the lockdown, the overall prevalence of overweight (21.3%–25.1%, $P < .001$) and obesity (10.5%–12.9%, $P < .001$) increased in China as observed in our study, but reflecting the overall lower burdens of overweight and obesity in China compared to the US. (Jia et al.,

2020a, 2020b; Yang et al., 2020).

Increased unhealthy eating and behavior patterns during the COVID-19 lockdown period could explain our findings. In a longitudinal study among children in Italy, unhealthy eating, such as consumptions of potato chips and red meat as well as sugary drink intake increased during the lockdown (Pietrobelli et al., 2020). Whereas, time spent on sport activities decreased, and sleep time increased significantly (Pietrobelli et al., 2020). Based on a national study in China, Jia et al. also reported decreased physical activities, while sedentary activities increased during the COVID-19 lockdown (Jia et al., 2020b). Simultaneously, significant increase in screen time has been found by nearly 5 h per day since the lockdown, which is linked to childhood obesity. (Jia et al., 2020b; Pietrobelli et al., 2020).

The COVID-19 pandemic and the subsequent lockdown has increased isolation, psychological distress, anxiety and depression (Guessoum et al., 2020; Saurabh and Ranjan, 2020; Zhou et al., 2020; Mattioli et al., 2020). Zhou et al. reported a high prevalence of depression (43.7%), anxiety (37.4%) and combination of depression and anxiety (31.3%) symptoms among Chinese adolescents during the outbreak of COVID-19 (Zhou et al., 2020). Along with the high prevalence of stress, anxiety and depression, related increase in problematic eating behaviors, such as night time and stress eating could also be contributing to our findings of increased obesity during the pandemic (Almandoz et al., 2020; Pellegrini et al., 2020; Marchitelli et al., 2020). Furthermore, decreased PA due to physical distancing measures could exacerbate mental illness and negatively impacting mental health. (Caputo and Reichert, 2020).

Our study found disproportionately higher burden of obesity among Spanish speakers before and after the first pandemic lockdown in Massachusetts. This concurs with other studies showing higher prevalence of obesity among Hispanics and other minorities (Hales et al., 2017; Isong et al., 2018). School closures and loss of access to more nutritious school meals might have exacerbated the racial and ethnic disparity in childhood obesity since the pandemic (Kinsey et al., 2020). Furthermore, food insecurity, which has been linked to obesity, has dramatically increased since the pandemic, disproportionately affecting nearly 42% of Hispanic households with children. (Kinsey et al., 2020; Karnik et al., 2011; Schanzenbach and Pitts, 2020).

The study has several limitations. First, the study's generalizability can be limited since it was conducted at a large safety net health center in the state of Massachusetts, USA. Second, there is inherent challenge of using electronic medical records data as information obtained during routine clinical encounters may not have been complete. Therefore, appropriate cautions must be taken when interpreting the study findings. However, the study has several strengths. The study uses actual clinical diagnoses and measurements rather than self-reported data. This study also has large and diverse sample size, allowing for analyses of understudied subpopulations, such as Brazilian and Haitian immigrants in the US.

5. Conclusions

The study assesses the impact of the lockdown on weight status among children in the US. During the COVID-19 lockdown, BMI, obesity and overweight burdens increased, particularly in younger and Spanish speaking populations. Not only is obesity a major risk factor for severe complications of COVID-19 infections, childhood obesity is also a major predictor of adult obesity and other chronic conditions, such as cardiovascular disease. Beyond the short-term effects of the COVID-19 pandemic, forward-thinking strategies must be developed to prevent unprecedented increase in childhood obesity and unhealthy weight gain.

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Institutional Review Board statement

Ethical review and approval were waived for this study, due to a retrospective analysis of data from electronic health records.

Informed consent statement

Not applicable.

Data availability statement

The de-identified data presented in this study can be made available on request from the corresponding author. The data are not publicly available due to HIPAA concerns.

CRedit authorship contribution statement

Wudeneh Mulugeta: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing - original draft, Preparation, Writing - review & editing, Visualization, Supervision, Project administration, Funding acquisition.
Laboni Hoque: Writing - review & editing, Visualization, Supervision.

Declaration of competing interest

None.

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