


SUPPLEMENT ARTICLE

Effects of the coronavirus disease 2019 pandemic and the policy response on childhood obesity risk factors: Gender and sex differences and recommendations for research

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Summary

Childhood obesity is a public health concern globally, with generally higher prevalence rates in boys compared to girls. Although biological sex is an important determinant, gender roles and norms influence the exposure and vulnerability to risk factors for noncommunicable diseases. Norms and roles might be reinforced or change due to coronavirus disease 2019 (COVID-19) related measures as well as the exposure to risk factors for childhood obesity. COVID-19 related changes, such as home confinement, influence a child's risk of obesity. Using Dahlgren and Whitehead's model of the main determinants of health, this paper aims to provide a roadmap for future research on sex, gender, and childhood obesity during the time of COVID-19. It examines how COVID-19 has led to important changes in children's general socioeconomic, cultural, and environmental conditions, social and community networks, and individual lifestyle factors and how these may affect a child's risk for obesity. It focuses on the influence of gender and sex and outlines key considerations and indicators to examine in future studies concerned with promoting health and gender equity and equality. We need to understand the differential impact of COVID-19 related measures on girls' and boys' risk for obesity to adequately react with preventive measures, policies, and programs.

KEYWORDS

children, COVID-19, gender, overweight

1 | INTRODUCTION

Childhood obesity increases the risk for having obesity later in life and for health problems such as cardiovascular diseases and diabetes.¹ According to the latest research from the WHO European Childhood Obesity Surveillance Initiative (COSI), a higher prevalence

of overweight and obesity in 6- to 9-year-old children can be observed in boys: 29% compared to 27% of girls in most of the countries.² This gap between boys' and girls' prevalence rates becomes even more profound in adolescence (11, 13, and 15 years old), with 25% of boys and 16% of girls being affected by overweight or obesity according to data from the Health Behaviour in School-aged Children study (HBSC),³ highlighting the relevance of puberty. To ensure sustained progress in reducing the burden of childhood obesity and to develop intervention and prevention

Abbreviations: COSI, Childhood Obesity Surveillance Initiative; HBSC, Health Behaviour in School-aged Children; IASC, Inter-Agency Standing Committee; NCDs, noncommunicable diseases; WHO, World Health Organization.

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efforts addressing an early life stage, it is important to fully understand the “biological and social pathways to obesity.”^{4(p. 205)} Biological differences according to one’s sex refer to genetics, body composition, hormone profile, growth patterns and the way food and nutrients interact with one’s genes. Studies suggest there is a sex-specific dietary response, metabolism, and nutrient response.^{4,5} Although it is important to acknowledge biological differences, sex-disaggregated data cannot be only analyzed from a biological perspective. Identifying the importance of the social construct of gender allows for social and political changes that can reduce inequities.⁶ In this paper, biologically determinant attributes of girls and boys are referred to using the term sex, whereas gender describes the socially constructed ones.⁷ Gender and sex are interrelated⁸: in simple terms, one is assigned a sex at birth based on external features that are understood to be male or female, but one learns to be a girl or boy who then grows into a woman or man.⁷ Gender identity and roles are shaped by this learned behavior.⁷ Gender norms and roles influence the levels of exposure and vulnerability to noncommunicable disease (NCD) risk factors among girls and boys. Norms about what constitutes masculine and feminine behavior influence, for instance, the physical activity level of girls and boys, and structural factors like the place of residence, income, and education also play a role.⁹ To understand the sex- and gender-related differences in the development of childhood obesity and overweight it is not enough to only control for children’s sex; researchers must also look at the different biological and social/cultural differences in how boys and girls interact with their physical and social environments.⁴

The energy balance, between energy intake through food and beverages and energy expenditure through activity (physical activity and sedentary behavior), is an immediate determinant of childhood obesity.⁴ The energy balance-related behaviors of physical activity, diet, sleep, and sedentary behaviors are strongly influenced by several factors, classically described in Dahlgren and Whitehead’s model of the main determinants of health. Largely fixed determinants such as age, sex and constitutional characteristics are in the center of the model. The other rainbow-like layers can be influenced by policy. The first layer describes individual lifestyle factors (e.g., physical activity, nutrition, sedentary activities), whereas the second layer portrays social and community networks including the way individuals are influenced by and interact with their community and peers. The living and working conditions are illustrated in the third layer, covering the food supply, education and access to services and goods. General socioeconomic, cultural, and environmental conditions are the last layer as a mediator for population health. Overall, this model highlights the interconnectedness between individual lifestyle factors and social norms and networks embedded in the living and working conditions and the wider socioeconomic and cultural environment. Individual, commercial, or political decisions can influence the determinants of health and can either serve as positive health factors, protective factors, or risk factors.¹⁰ Whereas some of the determinants directly affect children, others indirectly target the children’s health through their

main caregivers and/or families (e.g., unemployment and socioeconomic conditions). To understand how gender influences health and health related behavior while intersecting with other social determinants of health, it is helpful to regard gender as a set of culturally and historically constructed characteristics, which are maintained through activities in everyday life and a system of social organization.¹¹ People may be exposed to or experience the same social determinants of health, such as income level, but these determinants can create different outcomes once they interact with gender. These differences can be observed between, but also within, groups of females and males.⁸ It is important to understand the interaction between gender norms, roles, and relations with other social determinants of health that might lead to an increased burden of gender inequality.⁸ Other intersecting dimensions influencing health outcomes are, for instance, ethnicity, (dis)ability, age, sexuality, social status, socioeconomic status, education, culture, migration status and religion.^{12,13} When people do not adhere to the prevailing gender norms, they can face stigma, discrimination or social exclusion, which also influence health outcomes.⁸

Coronavirus disease 2019 (COVID-19) related measures influenced and changed conditions and factors across all levels of Dahlgren and Whitehead’s model of the main determinants of health. COVID-19 related measures such as nationwide lockdowns and school closures, but also the unavailability of fresh and healthy food influence the development and progression of weight gain and complications of childhood overweight and obesity.¹⁴ Although post-confinement data are not available yet, it can be assumed that this weight gain may not be easily reversible and might lead to an increase in adiposity during adulthood.¹⁵ Several studies conducted during the first lockdown already found a decrease in physical activity levels, an increase in sedentary behavior, and changes in dietary intake, while also observing several differences between girls and boys.^{15–17} A simulation of the impact of COVID-19 on childhood obesity in a US kindergarten cohort by An shows an increase in mean BMIs and in the prevalence rate, with a modestly larger impact among boys, non-Hispanic blacks and Hispanics compared to girls and non-Hispanic Whites and Asians.¹⁸ Analyzing and considering direct and indirect gender and sex effects of the COVID-19 outbreak is therefore vital to inform an effective response that does not reproduce or perpetuate gender and health inequities.¹⁹ Because children are more vulnerable to environmental risks, close monitoring and efforts are needed to address COVID-19 related issues to prevent long-term consequences.²⁰

This literature review aims to explore how the COVID-19 pandemic has influenced childhood obesity risks, how risk factors may be associated with gender, and which indicators could be used in future research to take account of gender disparities. We have structured the review using Dahlgren and Whitehead’s model of the main determinants of health, adding gender as a cross-cutting dimension, to explore and discuss the different factors at play and how these might be investigated in future research. We hope this will provide a roadmap for future work examining childhood obesity, COVID-19, sex, and gender.

2 | THE INTERCONNECTIONS BETWEEN ENVIRONMENTAL CONDITIONS AND INDIVIDUAL LIFESTYLE FACTORS INFLUENCED BY SEX AND GENDER NORMS AND ROLES

The community and the neighborhood play an important role in the development of obesity.⁴ Recreational spaces, the availability of transit and the walkability of the neighborhood are associated with an increase in physical activity levels and higher energy expenditure. The availability of supermarkets, farmer's markets and fast-food restaurants influence the food choices on the energy intake side.^{4,21} There are still knowledge gaps regarding the ways children interact with increasingly obesogenic environments.⁴ The physical and social environment and the family influence behavioral factors at the individual level.⁴ COVID-19 related measures change the way girls and boys interact with their environment and within their neighborhood. Available evidence suggests that for children who are out of school (e.g., on weekends or during the summer holidays) physical activity levels are lower, whereas the time spent with sedentary activities such as screen time is higher. Sleep patterns tend to become irregular and the diet becomes less favorable leading to weight gain. These aspects might also come into effect when children are confined in their homes.²⁰

Table 1 provides an overview of how COVID-19 measures lead to changes across Dahlgren and Whitehead's model of the main determinants of health and how these may affect a child's risk for overweight or obesity, while considering the influence of gender and sex. Firstly, three main individual lifestyle factors that can act as risk factors for childhood obesity are presented, and the different exposure to these risk factors for boys and girls are described. Secondly, COVID-19 related measures and consequences, relevant for childhood obesity are portrayed and the hypothesized way that this exposure may affect the obesity risk are highlighted. Finally, indicators concerned with promoting health and gender equity and equality for future research are suggested.

2.1 | Physical activity influenced by confinement, safety concerns, and school closure

Through COVID-19 related measures, such as social distancing and stay-at-home orders, there are less opportunities for physical activity, especially for children living in small apartments in urban areas.¹⁴ Several studies analyzing behavioral changes in the first phase of lockdown showed a decrease in physical activity levels. Sekulic et al. found a greater decrease in physical activity levels in adolescent boys than in adolescent girls, which could be explained by primarily higher physical activity levels in boys and a participation in organized and formal sports.²² Pombo et al. found a general decrease in the physical activity time in children as well, but a different gender-related pattern. Although a difference between girls and boys was observed with girls being more involved in play without physical activity and boys in

playful screen time, no difference was found in the overall physical activity. This could be explained by boys and girls being both constrained by space, with vigorous physical activity requiring larger spaces, leading to similar behavior.¹⁶ Studies conducted before COVID-19 often show a difference between the physical activity levels of girls in comparison to boys, with girls generally being less physically active.^{23–25} Girls might be less likely to join organized sports, because boys receive a greater encouragement to join clubs and are often taught to value competition and athleticism.²⁵ Wells et al. found that the influence of factors like the socioeconomic position or having an immigrant background were more prominent for girls than for boys. Parents with a higher educational level might have a greater awareness regarding gender equality and the importance of physical activity, leading to higher participation rates and education among their daughters.²⁵ The gender-specific activity patterns of the parents may also play a role in the development of childhood obesity, whereas a higher family affluence positively influences the level of physical activity among boys and girls.^{23,24} Some studies show different obesity patterns in girls and boys regarding a rural or urban environment.^{26,27}

Urban children are probably more affected by an increase in sedentary behavior through COVID-19 related measures because they might not have access to safe, accessible outdoor spaces where social distancing can be maintained. If parks and playgrounds are open, parents might worry that they are not safe in terms of social distancing and cleanliness.¹⁴ Even without COVID-19 related measures, the perceived safety of the neighborhood among parents differs between the inner city and the suburbs, with parents living in the inner city having more concerns. At the same time children living in the suburbs are more active.²⁸ Considering the influence of gender, Esteban-Cornejo et al. found that boys had higher levels of physical activity in the neighborhood including in parks and were using more active transport (such as walking and cycling) than girls, whereas parents of adolescent boys perceived the neighborhood as safer in terms of stranger danger than the girls' parents.²⁹ When adolescents perceive their neighborhood as safe, the self-reported outdoor physical activity is higher among girls than among boys.³⁰ However, parents are more likely to prevent or discourage boys from participating in sports or physical activities, because of injury and safety concerns. This might be because boys are more likely to be engaged in high injury risk sports.³¹

Another COVID-19 related measure influencing physical activity levels is school closure, which can be part of a lockdown where people are mandated to stay in their homes in order to contain and mitigate the spread of the pandemic.¹⁵ Nearly 200 countries across the world are experiencing COVID-19 related school closures.³² School is a fundamental part of a child's environment that contributes to social development and building capacities such as health literacy, which can all contribute to achieving health equity.³³ Apart from their educational purpose, schools offer an opportunity for interaction with teachers and receiving psychosocial counseling.²⁰ School closures can lead to a gap in mental health support because it is often offered within the school context, which might not be

TABLE 1 Description of childhood obesity risk factors, how the exposures may vary for boys and girls, COVID-related disruptions, hypothesized way that the exposure may affect obesity risk, and suggested indicators for future research

Obesity risk factor	Different exposure for boys and girls to risk factor	COVID-19 related measures and consequences	Hypothesized way that the exposure to COVID-related measures may affect obesity risk	Suggested indicators for future research measuring the impact of COVID-19, disaggregated by sex
Individual lifestyle factor	Cultural conditions, social and community networks	Environmental conditions, living and working conditions, and social and community networks		
Physical activity	<ul style="list-style-type: none"> Physical activity levels Parental perception of safety Encouragement for staying active Gender-specific activity patterns of the parents Influence of the socioeconomic position or having an immigrant background Impact of biological changes during puberty 	<ul style="list-style-type: none"> Confinement and lockdown Reduced access to outdoor spaces due to closure Safety concerns when spaces are reopened School closure 	<ul style="list-style-type: none"> Fewer opportunities for physical activity Urban children might not have access to safe, accessible outdoor spaces Parents might worry that parks and playgrounds are not safe in terms of social distancing and cleanliness Decreased opportunity for school-based physical activity Reduced access to school curriculum for health-conscious behaviors 	<ul style="list-style-type: none"> Physical activity level Urban or rural area and access to green spaces Parental perception of safety, education level and socioeconomic position Being part of an organized sport club or athletic group Immigrant background, age, and (dis)ability Caring for family members
Nutrition	<ul style="list-style-type: none"> Gender norms and roles regarding the preparation of food and food choices and consumption Media and parental influences, role modeling, and societal ideals influence gender-related eating behaviors Gender differences in parental attitudes and feeding practices 	<ul style="list-style-type: none"> Disruptions to food systems Increased food insecurity School closure Children's eating behaviors are only influenced by their home environment 	<ul style="list-style-type: none"> Higher energy intake, lower access to healthy food which is expensive Increase in consumption of ultra-processed and calorie-dense foods Less access to nutrition education Social isolation and/or lower exposure to peers at school or other role models leading to a change in dietary practices Cooking together leading to healthier options 	<ul style="list-style-type: none"> Dietary intake/behavior (Household) food insecurity Parental employment and socioeconomic status Influence of peers on diet Gender norms and roles around food preparation and food consumption Parental attitudes and feeding practices Body image: self-perception of weight
Sedentary activities	<ul style="list-style-type: none"> Sedentary behavior influenced by group norms Emerging sleep problems with an inconsistent bedtime routine on non-school days 	<ul style="list-style-type: none"> School closure Sedentary group norms mainly shaped by home environment Changes in schedule and daily routine 	<ul style="list-style-type: none"> Increase in sedentary activities and screen time Reduced access to mental health support Higher levels of sedentary activities Increased sleep time and disrupted sleep patterns Increased video game and social media exposure 	<ul style="list-style-type: none"> Sedentary activity levels Sleep Screen time Group norms at home and with friends Video game and social media usage

available during school closure.³⁴ Home confinement and quarantining can lead to lifestyle changes and higher psychosocial stress in children, whereas the interaction of these could further aggravate the detrimental effects on children's physical and mental health, which in itself could cause a "vicious circle".^{20(p. 946)} This possible impact on childhood obesity levels should be analyzed in future studies.

The school environment can influence the occurrence of childhood obesity through mandatory and extracurricular activities, and access to food and beverages at school.³⁵ Teachers and policymakers

can also integrate health promotion aspects into the curriculum and promote a health-conscious schedule, including topics such as good personal hygiene, good sleeping habits, physical education, and understanding what constitutes a healthy diet and level of physical activity.²⁰ For children who are already experiencing overweight or obesity, previous research showed that school closure might have negative effects on weight control lifestyle programs while at home compared to being involved in the regular school curriculum.¹⁵ The current situation exacerbates risk factors for weight gain associated with summer recess beyond school closings, which can lead to a

general increase in obesity and overweight prevalence rates. This weight gained during the summer months is often maintained throughout the school year and accrues summer to summer. Risk factors that also appear during summer breaks are perpetuated such as less physical activity and food insecurity.¹⁴

Schools are also a place where gender norms and roles are constructed and reinforced during play in school breaks. Most of the 9- to 10-year-old children who participated in a study by Boyle et al. chose to play within groups of children having the same gender and do “typical activities”: Whereas boys are physically active, girls “walk-and-talk”.^{36(p. 1344)} Reimers et al. found that on a playground the number of active children had a positive influence on the physical activity of the observed children. A negative association was found in girls between the number of boys present and physical activity.³⁷ During school closure children are primarily influenced by their families and exposed to the gender norms and roles at home. The consequences of this on childhood obesity levels in different social contexts could be assessed in future research. Confinement and school closure may influence not only energy expenditure, but also energy intake, as we will now discuss.

2.2 | Nutrition influenced by food insecurity, school closure, and disrupted breastfeeding support

COVID-19 and pandemic response measures can have an impact on food security and dietary quality.¹⁴ The access to and the availability of high-quality nutritious food is generally more difficult due to COVID-19 for many people worldwide. Major food systems disruptions appeared because of increasing poverty, decreasing cross-border trade, internal and external labor migration and employment.³⁸ The World Food Programme estimates that 346 million school children are currently missing school meals due to school closures.³² At the same time, people in many regions stockpiled ultra-processed and calorie-dense shelf-stable foods at home.¹⁴ Pietrobelli et al. already noticed an increase in the number of meals eaten per day (including a higher consumption of fruits, red meat, sugary drink intakes and potato chips) among children with obesity during the lockdown.¹⁵ Ruiz-Roso et al. also found dietary changes in adolescents due to confinement. Although the overall diet quality was not increased, families had more time to cook together and increased their consumption of legume, fruit, and vegetable intake. However, adolescents had a greater sweet food consumption, which might be induced by boredom or stress.¹⁷ Differences between girls and boys were found, with girls significantly increasing their vegetable and fruit intake, whereas boys increased their vegetable and processed meat consumption, with no change in average fruit consumption.¹⁷ From these studies there is some suggestion that the food intake changes due to COVID-19 related measures may vary between boys and girls, as well as by geographic location, culture, and socioeconomic status. The changes and differences between population groups should be further researched.

The described alterations could lead to the assumption that the school normally helps to ensure some minimum food standards for at least part of the day for children. Generally, children's eating behaviors are influenced by their peers and their parents because they rarely eat alone but in the presence of parents, caretakers, siblings, or peers at school.^{1,39} Peers can set a norm and influence the food intake and amount eaten, probably even more so when eating together on a daily basis.¹ However, during COVID-19 related school closures, children's eating behaviors are mainly influenced by family members at home.

Gender differences in parental attitudes and feeding practices are influenced by cultural ideals, such as a greater emphasis on being thin in girls. This can lead to greater concern from parents about girls' weight status compared to boys'. There is some suggestion that parents may be more active in encouraging girls to redirect desired eating behaviors, whereas boys are encouraged to eat more.⁴⁰ Mothers, who are still the main caregivers in many settings, influence their child's body image by consciously and subconsciously imparting their own beliefs.⁴¹ The mother's perception can influence treatment adherence, as well as possible body image disorders; it is therefore important to consider this when planning health promotion efforts.⁴² In a study using qualitative interviews with boys (5 to 6 years old) norms around food preparation and food consumption were analyzed. Gendered constructed roles regarding the preparation of food and food choices became evident, for example with fathers only playing a supporting role when preparing the food; for instance making the salad or cooking smaller meals.⁴³ Spending more time in the home therefore might lead to different norms being reinforced between boys and girls, depending on the gendered division of labor in their household.

Apart from parental influences, societal ideals influence gender-related eating behaviors in children via expectations on what and how girls and boys should eat. Whereas being female is associated with preferring healthier options, consuming less meat, and eating smaller portions, a masculine identity is described by focusing on physical performance and feeling full.³⁹ The perception of a healthy body image differs between ethnic groups and is connected to the cultural context.⁴¹ There is a different perception of overweight between boys and girls, which increases in adolescence.⁴⁴ More than one in four adolescents perceive themselves as too fat, a phenomenon that is more pronounced in girls and in children with a lower socioeconomic background, intensifying with increasing age. Negative body image is influenced by various factors, with use of social media being one example.⁴⁵ Meanwhile, analysis of the representation of men and diet in newspaper articles shows the influence of hegemonic masculinities. Diet is still constructed around women and therefore seen as not masculine. These traditional gendered roles in media might also play a role in explaining different dietary behavior.⁴⁶

Another COVID-19 related change in risk factors for childhood obesity on the energy intake side can be observed in breastfeeding. There is some evidence to suggest that COVID-19 related lockdowns have disrupted services such as face to face breastfeeding support for women with COVID-19, which may reduce the number of women who are able to successfully breastfeed their babies.⁴⁷ Furthermore,

when evidence about the transmission of COVID-19 to infants from infected mothers was still emerging, some countries took a cautious approach of separating mothers from babies, which negatively affected breastfeeding. Breastfeeding is thought to promote better appetite regulation later in life, whereas the timing and choice of additional food may influence dietary preference in the long term.^{4,41} Analysis of data from the Childhood Obesity Surveillance Initiative (COSI) found a lower prevalence of obesity in children who were breastfed more than 6 months in comparison to those who had never been breastfed and/or had been breastfed less than 6 months in most of the participating countries.⁴⁸

Exclusive breastfeeding is recommended by WHO during the first 6 months and should be combined with solid food for the next 6 additional months up to 2 years and beyond.⁴⁹ COVID-19-affected or COVID-19-suspected mothers should be informed that keeping close contact with their newborn and (continuing) breastfeeding is still recommended by WHO, although taking some precautions, such as respiratory and hand hygiene.^{49,50} Breastmilk could even protect the infant from an infection with COVID-19 due to its anti-infective and anti-inflammatory factors and potential antibodies, even when the mother is infected.⁵¹ We also note that epigenetic factors may play a role in the development of childhood obesity, for example through the maternal diet and lifestyle in the pre- and perinatal periods, but further research is needed.^{21,41}

To summarize, there are gendered constructed norms and roles around food preparation, consumption and choices.^{43,46} Future research should continue to analyze how these norms and roles might change during lockdowns and school closures. Having more possibilities for shared preparation of food at home may cause families to reflect on their own norms and roles regarding food preparation and consumption.

2.3 | Sedentary activities, screen time, and sleep influenced by confinement and school closure

Besides the decrease in physical activity levels and changes in nutrition, levels of sedentary behavior and screen time are expected to increase while practicing social distancing.¹⁴ It was observed that sleep and screen time increased in Italian children during the lockdown.¹⁵ Uebergang et al. found that boys with an inconsistent bedtime routine on non-school days had a higher risk of sleep problems than girls.⁵² Whether this is also true for boys during lockdowns or school closures would need to be analyzed. Pombo et al. found a general increase in sedentary time during confinement in comparison to school days. Screen time increased not only for study, but also for leisure purposes, which include social networking to keep in contact, watching TV or playing video games. Screen time, sleep and family activities have increased showing a change in the organization of time during confinement.¹⁶ Whether these changes and the way the sedentary time is used differs between boys and girls needs further research. Additionally, it should be analyzed how family norms influence these behaviors. Hoyos Cillero et al. conducted a study prior to

the COVID-19 pandemic which found that boys were more likely to spend more time on playing console games if there was a sedentary group norm. They had social reasons for engaging in this activity, thus it can be at least partially explained through shared normative values.⁵³

3 | GENDER-SENSITIVE RECOMMENDATIONS FOR FUTURE ACTION

The effects of the COVID-19 pandemic and particularly the control measures implemented exceed those of other viral infections. This has collateral effects leading to children and adolescents in general, and in particular children affected by obesity being in an unfavorable environment for maintaining healthy lifestyle behaviors through isolation and other measures affecting social contact and usual behaviors. Recognizing these effects is the first step in prevention efforts,¹⁵ which should involve six relevant levels: the family, schools, health professionals, government, industry and media.⁵⁴ When raising awareness and developing interventions, it is important to recognize that the influence of COVID-19 measures and their impact on risk factors for childhood obesity varies between countries and regions. The influence of gender and sex in combination with other intersecting factors, such as culture, ethnicity, age, socioeconomic status, education, and religion should be recognized when conducting scientific studies and when planning prevention efforts. In particular, awareness should be raised among parents, the school, community, and the government about the negative consequences of home confinement in order to address these adequately. Experiences from previous outbreaks could be useful.²⁰

3.1 | Governments

To achieve gender equality and avoid perpetuating inequality, gender mainstreaming should be part of the planning, design, implementation, monitoring and evaluation of policies, programs and measures across sectors. Gender mainstreaming describes a process in which a gender perspective is systematically applied in any planned political or societal act in order to assess their different effects for women and men.⁸ Additionally, gender analysis methods should be used, to understand how gender norms, roles and relations influence the health and well-being of girls and boys across the life course, and in order to have an evidence base as a foundation for decision making.⁸ Governments can facilitate and support collecting and analyzing sex-disaggregated data on obesity levels in children, as well as the impacts of COVID-19 related measures and prevalence rates of COVID-19, to identify whether boys and girls are differently affected. Timely use of data to modify interventions quickly and to manage COVID-19⁵⁵ is also relevant for the long-term effects such as childhood obesity.

It is vital to implement prevention measures during periods of lockdown, especially when the duration is uncertain.¹⁵ Policy makers, educators, and administrators should make sure that disruptions to

academic development are minimized, while at the same time considering other consequences of school closure such as food insecurity and a lack of mental health services.³⁴ Government could further facilitate tele (mental)health services and make sure that families as well as school-based clinicians have the resources and knowledge to access them.³⁴

Children's outdoor play was substantially reduced during the COVID-19 pandemic, which may lead to lasting negative health impacts.⁵⁶ Playing outdoors is important for a healthy development and preventing obesity. It can help maintaining a robust immune system, while also supporting processing emotions, such as stress. Regional differences in COVID-19 cases and measures are leading to regional differences in time spent outdoors. It should be a high public health priority to promote and preserve the access to green spaces and outdoor play.⁵⁶ Before implementing restrictions on spending time outdoors, (local) governments should always consider ways to mitigate the negative health consequences, especially for children.

Although children's outdoor play was reduced, active commuting with cycling and walking increased during the pandemic, across genders, age groups and social classes.⁵⁷ Local governments should support (e.g., financially) changes in infrastructure such as pop-up bike lanes, wider pavements and more cycle tracks, as well as free cycle training courses or free bicycle use. Changes need to be implemented across sectors in order to address local barriers, and communities should be involved in decision making.⁵⁷ Local community organizations as well as city governments play an essential role in responding to the pandemic. They give and put into place guidance on COVID-19 related measures, but can also support and give guidance to mitigate long-term social or economic effects of social distancing measures. Municipalities can act as an additional channel for reaching and engaging people within communities.⁵⁸

3.2 | Communities and schools

Communities are a valuable resource for supporting families.²⁰ A social safety net comprising social workers, psychologists and parents' committees can be especially helpful for disadvantaged or single-parent families. This can help connect the needs of students with the school requirements, advocate for children's right to a healthy lifestyle, provide mental health services online and help parents cope with family issues arising from the pandemic.²⁰

Due to school closures, classes shifted to distance-learning models in some instances.³⁴ Physical education could be incorporated in remote teachings. Existing exercise plans could be adapted into home lesson plans or classes could be streamed online.¹⁴ Although the content of the online school courses should ideally meet educational requirements, some allowance must be made for the exceptional circumstances, and students should not be overloaded. The education authorities could use this as an opportunity to gather the best online education courses regarding psychosocial support and healthy lifestyles. This could help motivate children to

have a healthy lifestyle at home through a good personal hygiene, regular sleep patterns, a balanced diet, and sufficient physical activities. Such resources need to be age-appropriate and attractive, therefore require expertise.²⁰ These programs should be tailored around the needs of the regional and community environment and must therefore involve local professionals that can culturally adapt the interventions, as well as adapting them to the administrative system. The context of the online courses must be relevant for children and adolescents to be sustainable.²⁰ Schools should make sure that their online courses are age-, gender-, ethnicity-, and disability-responsive. They could additionally integrate disease prevention and control in daily activities and lessons within existing subjects.⁵⁹ Remote teaching, especially regarding physical activity, could be shared within a region, a country or even across borders. This could be an opportunity to offer gender responsive classes or plans for girls and boys.

Pediatric practitioners could also play a role in supporting families to maintain healthy lifestyle choices.¹⁵ Guidelines for clinicians on how to treat childhood obesity and other NCDs that were induced by COVID-19 following a gender responsive approach would also be beneficial. In order to treat childhood obesity multidisciplinary programs are needed, adjusted to different age groups. Psychological, genetic and biological factors need to be considered when planning an approach,⁵⁴ including the differences in body composition, hormone biology and susceptibility to particular environmental aspects between boys and girls.²³

Meanwhile, schools should work with social service systems to ensure that critical services are still provided and observe whether there are specific implication for girls increasing their risk, such as taking care of sick people at home or being exploited outside of school.⁵⁹ Girls and adolescent girls tend to spend more hours on chores compared to their male counterparts, and are at a higher risk of dropping out of school or not returning to school after the crisis is over.⁶⁰ This should be closely monitored by communities and schools. Improving the health literacy of children by sharing experiences and resources through networks (e.g., SHE network)⁶¹ could support a successful response.

3.3 | Families

The best and closest resource for help seeking during home confinement for children is often their families and parents.²⁰ In case of isolation, it is important that parents keep an open and close communication with their children to provide comfort and identify any psychological or physical issues. As described above, they are important role models for healthy behavior in children.²⁰ The stressful environment caused by home-schooling, additional unpaid work, loss of predictability, and concerns regarding financial stability can worsen the mental health of parents and therefore also influence the well-being of their children.⁶²⁻⁶⁴

However, home confinement can be also seen as an opportunity for family cohesion and skill development, by increasing the

TABLE 2 Key considerations and questions for future gender-sensitive research on the effects of the COVID-19 pandemic and related measures on childhood obesity risk factors**Key considerations for future quantitative and qualitative research:**

1. How exactly are COVID-19 related measures influencing the vulnerability and exposure to risk factors for childhood obesity in boys and in girls?
2. Is there a difference between girls and boys regarding weight gain/loss caused by COVID-19 related measures?
3. How did the perception of gender norms and roles change within families and societies during the pandemic regarding risk factors of childhood obesity?
4. Is the perception of safety (of parents and children) regarding COVID-19 differently affecting boys and girls?
5. How do the questions above apply differently to different age groups, socioeconomic positions, family circumstances, geographic locations, and other intersecting factors?

interaction between children and their parents, involving children in family activities, and strengthening their self-sufficiency skills.²⁰ The additional time that parents might have with their children could be used to acknowledge their gender norms, roles, and relations more broadly. Women still provide most of the informal care within families; therefore, there might be a higher strain on them, and their work and economic opportunities might be limited.^{19,64} Fathers who were not as involved in care giving before could find an opportunity to be more involved in their children's life, leading to better health and well-being of the whole family.^{11,64} In addition to observing their children's performance and behaviors, parents need to respect their identity and needs²⁰ and avoid reinforcing harmful gender norms and roles. With parents having such an essential role in ensuring the well-being of their children, they should receive special support and be taken into consideration when deciding on further COVID-19 related measures.^{62–64}

3.4 | Discussion

This literature review has explored and discussed some of the impacts of COVID-19 response measures on childhood weight status, using a gender lens to contextualize these in terms of Dahlgren and Whitehead's model of health determinants. It has therefore shed light on an emerging area of concern within child health. It should be considered a roadmap primarily aimed at health researchers, giving an outline of key considerations for future work on this topic. However, we have also made recommendations for how some of the unintended consequences of home confinement can be mitigated by different actors from government to individual families, based on the existing literature.

The main limitation is that we did not employ a systematic search strategy. However, using a thematic approach allowed us to discuss a broad range of issues within this emerging area of research. Obesity is a complex and multifactorial disease;²¹ therefore, we do not claim to provide a comprehensive review of every risk factor. Future research could include systematic reviews of the literature with quality assessment of included studies. Areas for further empirical exploration include the relationship between mental health and energy intake or expenditure and the influence of irregular meal patterns on childhood weight status during lockdowns, while also

considering the influence of gender and/or sex. Key considerations and questions for future gender-sensitive research on the effects of the COVID-19 pandemic and related measures on obesity risk factors are described in Table 2.

4 | CONCLUSION

The health and well-being of children and adolescents will be strongly affected by COVID-19, even though they currently appear to be least vulnerable to the effects of the virus itself. It is therefore necessary to act in a timely fashion to reduce potential long-term impacts.³⁴ Understanding the primary and secondary effects of disease outbreaks on the individual as well as at the community level, for girls and boys, is key to developing effective, equitable policies.²⁰ Sex and gender influence the prevalence rates, exposure, and vulnerability to risk factors for childhood obesity in general^{9,11} and are likely to also do so during the pandemic, as we have shown. Timely, sex-disaggregated data, analyzed and reported in a gender responsive way, are essential going forward. This can help incorporate a gender analysis into the response and preparedness efforts, to accelerate the effectiveness of health interventions and endorse health and gender equity goals.¹⁹

Many of our assumptions need to be tested by empirical research, both observational and through intervention studies. Although differences between boys and girls can be observed, they are not homogeneous groups and other intersecting factors (e.g., ethnicity, culture, socioeconomic status, religion, and location) must be considered too, especially when analyzing the effects of the pandemic. Although it is important to mitigate the immediate effects of COVID-19, it is also vital to recognize and address the long-term effects on children's health,¹⁴ as well as learning lessons for future pandemics or other unexpected disasters that require home confinement. A gender responsive approach on all levels is needed to reduce unintended harmful effects from COVID-19 related measures on obesity and other NCDs in children.

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STATEMENT OF ETHICS

This paper is a review article and therefore does not report new empirical research involving human subjects.

POTENTIAL CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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DISCLAIMER

JB, IR, IYA, MWW and JW are staff members of WHO. The authors alone are responsible for the views expressed in this article and they do not necessarily represent the views, decisions or policies of the institutions with which they are affiliated.

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