The Impact of Children's School Format on Women Professionals in STEM

Final Report

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16. Abstract
With many school closures during the pandemic resulting in long-term changes (more than just a month) to child education format (e.g., online or hybrid), many women took on increasingly greater home and childcare responsibilities. Even prior to the pandemic, the retention of women in science, technology, engineering, and mathematics (STEM) faced many challenges. The research project described herein tried to capture the experiences of women in STEM with children, as (rather than in retrospect) they navigated various school formats during the coronavirus pandemic (COVID-19). The authors anticipate that the results of this research will highlight the challenges facing women in STEM with children when it comes to the education of their children. Three surveys were administered to women in STEM: one in October of 2020, one in March of 2021, and one in May of 2021. Forty-six, ten and three survey respondents replied to each survey. The results suggest that while overall survey respondents remained concerned about impacts that COVID-19 may have on them and their families, the level of concern seemed to dissipate over the successive surveys. Overall, women in STEM reported very limited options for additional support (e.g., a nanny). The hybrid school format was reported as requiring some of the most significant levels of support followed by online and then in-person. As a whole, women in STEM whose children were attending school in-person reported little to no impacts, often instead remarking on impacts felt during the initial lockdowns. Women in STEM with elementary school-aged children seemed to report the most significant impact. The inability to work uninterrupted was one of the most significant challenges suggested, as there are implications that the work that women in STEM are conducting requires periods of meta focus. Therefore, while the flexibility of allowing women in STEM to work at home can bring some benefits, ultimately, when her children are also at home, the benefits are significantly mitigated. Finally, while the three surveys were expected to be able to capture the oscillation between school formats, at least one survey respondent described many changes between subsequent surveys.

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The Western Transportation Institute (WTI) was founded in 1994 by the Montana and California Departments of Transportation, in cooperation with Montana State University. WTI concentrates on rural transportation research; as stewards and champions of rural America, WTI also has a strong interest in sustainability. WTI research groups create solutions that work for clients, sponsors, and rural transportation research partners. WTI Research Centers include the Montana Local Technical Assistance Program, the National Center for Rural Road Safety, the Small Urban, Rural and Tribal Center on Mobility, the Federal-Public Lands Transportation Institute, and the West Region Transportation Workforce Center.

About the Small Urban, Rural and Tribal Center on Mobility

The mission of the Small Urban, Rural and Tribal Center on Mobility (SURTCOM) is to conduct research and provide leadership, education, workforce development and technology transfer in all transportation-related aspects of mobility for people and goods, focusing specifically on small urban, rural, and tribal areas. Member institutions include the Western Transportation Institute at Montana State University, the Upper Great Plains Transportation Institute at North Dakota State University, and the Urban and Regional Planning program at Eastern Washington University.

Disclaimer

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1 Introduction

The coronavirus pandemic (COVID-19) impacted the professional careers of many women including those in science, technology, engineering, and mathematics (STEM). With many school closures during the pandemic resulting in long-term changes (more than just a month) to child education format (e.g., online or hybrid), many women had to take on increasingly greater home and childcare responsibilities. Even prior to the pandemic, the retention of women in STEM faced many challenges ((Conrad, Abdallah, & Ross, 2021), (Meyer, 2013)). The retention of women in STEM matters, as research has linked gender diversity on teams to more innovation and better fiscal performance (Weber & Fuhrmans, 2020). Until COVID-19, it is likely that many women in STEM did not fully recognize how the ability to send their children to school enabled them to fulfill their roles as STEM professionals. In particular, *"'…in a society that still embraces a gendered division of domestic labor, women with children may have been affected disproportionately by school closures and limited access to childcare'"* (University of Michigan, 2020). It is important to research the impacts of school format on women in STEM because, as discussed by the University of Michigan in August of 2020, *"If school and childcare facilities remain closed in the coming months,"* the careers of women in science *"could be derailed"* (University of Michigan, 2020). The research project described herein tries to capture the experiences of women in STEM with children, as they navigated various school formats during (not retrospectively) the Federal COVID-19 Public Health Emergency Declaration. The authors anticipate that the results of this research can highlight the challenges facing this particular demographic when it comes to the education of their children, offering suggestions on how improvements to federal polices or programs in the United States could better support women in STEM with children.

The intent of this research effort was to shine additional light on the need to understand the correlation between school format and its influence on the success of women in STEM. The authors hypothesized that women in STEM whose children have an in-person school format would be less impacted than those with a remote learning format. Furthermore, from a productivity perspective, the authors expected those with younger children (elementary age) to report a greater impact. The literature also suggested that while women with children in daycare were affected early on during the pandemic, the impacts were short term since many daycares opened long before schools returned to in-person. For those with older children, there was an expectation that social-emotional impacts may be reported more frequently. Furthermore, as this study was a collection of successive surveys, there was potential for the impacts of school formats on the ability of women in STEM to retain their roles to increase and the consequences to become more dire.

2 Literature Review

As a result of the novelty of COVID-19, periodical articles that discussed the impacts of school models on women were reviewed. Then after, as peer reviewed journal articles have begun to be published, these were reviewed as well. However, many of these articles were not available when the surveys were being designed for this study.

2.1 Periodical Articles

A May 2020 article by Guynn (Guynn, 2020) focused on the effects of COVID-19 on childcare, with some examples extending into school-aged children. The article reported that while they were not required to close, nearly half of childcare facilities shut down as a result of the expense associated with state health protocols (e.g., additional staffing, personal protective equipment, hand sanitizer, and cleaning supplies). Guynn described the difficulty this placed on essential workers, who consequently had to rely on family members for the care of their children. Grandparents, categorized as one of the populations most vulnerable to COVID-19, were often the family members filling the role of caretaker. COVID-19 also impacted summer programming and, consequently, many parents reported working at night after their children were tucked in for bed. The article also suggested that wealthier families had more options, such as one parent staying home. The Families First Coronavirus Response Act was identified as providing sick leave or expanded family and medical leave to care for children. Frequently citing a medial concern (e.g., their children have asthma), some families expressed concerns about sending their children back to childcare even if it was available.

A July 2020 article by Boorstin and Taylor (Boorstin & Taylor, 2020) discussed the impact of COVID-19 on women's careers, with a focus on black women. The lack of childcare was identified by women as the primary reason why they could not work. The article noted the increased health risk to black workers and their families, particularly because black workers comprise a higher percentage of front-line workers. Another important point made by the article was that *"many women who decide to leave the workforce, temporarily or permanently, for child-care reasons are mid-career at the point where they should be moving into leadership roles."* Boorstin and Taylor then described how the exodus of mid-career women would impact leadership pipelines.

In July of 2020, the Society of Women Engineers (SWE) released a report based on a survey that they had conducted of their membership from June 3, 2020, through June 15, 2020, that described the impact of COVID-19 on women in engineering and technology (Rincon & Nguyen, 2020). All survey respondents were over eighteen years old. Survey respondents were grouped into three age bins, 18-24 (youngest), 25-34, and 35-44 years-old (oldest). The greatest percentage of responses were received by 25-34 years-old, followed by the youngest and oldest cohort. Using the Qualtrics interface, SWE invited its members around the globe to participate via email. Mechanical, aerospace, and electrical engineering were the most represented disciplines. A quote within indicated that where a woman had previously worked with

several other women, (which she described as the greatest percentage of women in any of her company's engineering departments) she was now the only one left. The report suggested that a "program subscription" (which was not well-described) would help working parents engage their children. Fifty-eight percent of the survey respondents reported being categorized as essential workers. The results of the survey suggested that those employed by smaller organizations reported higher levels of dissatisfaction with employer responses to COVID-19. The age groups of youngest and oldest age cohorts reported the greatest levels of dissatisfaction with work-family balance: 44% and 42%, respectively. It is unclear if this level of dissatisfaction was considered in relationship to sample proportion. In addition, those serving in academic roles reported high levels of dissatisfaction (52%). SWE survey respondents reported that they, not their partners, were primarily responsible for administering educational support to their children.

A September 2020 article by Weber and Fuhrmans (Weber & Fuhrmans, 2020) noted that support systems disappeared for working parents during COVID-19. It then delved into impacts on employed women. Weber and Fuhrmans suggested that women's advances in: 1) pay, 2) professional ranks, and 3) leadership positions would all be impacted. Of the initial 54% of COVID-19-related job losses, women still made up 49% of those unemployed. Weber and Fuhrmans then, more specifically, considered mothers: 1) one in five considered dropping out, 2) fifteen percent reported reducing hours or taking on a less demanding role, and 3) almost twenty-five percent reported considering a leave of absence or quitting. Weber and Fuhrmans suggested that white-collar women may benefit from COVID-19 impacts with flexible schedules and being able to work from home. However, they also noted that while employers have allowed their workers parenting or home-schooling benefits, the productivity expectations of employees had not changed – half of major companies did not change their performance reviews. Weber and Fuhrmans theorized that companies may recruit more remote employees after seeing that they can work productively and suggested that this was a silver lining.

In an April 2021 article, Mandavilli (Mandavilli, 2021) discussed the realities of being a woman in science during COVID-19. A particular point emphasized, but which is often overlooked in discussions associated with women in science with children, is that the *"technical and detail-orientated nature of her work requires long uninterrupted stretches of thought…",* which could not be attained with young children at home. The same scientist who was being referenced shared that while her infant was able to return to childcare, the schools did not reopen. The scientist's nanny was unable to come to the scientist's house, which ultimately led to the scientist adjusting *"expectations of herself."* Mandavilli's article described concerns over children's mental health and the impact on children's education as well as the impacts to early career women in STEM. The article also discussed the festering, misguided belief that women in STEM are not as smart as men in STEM. Furthermore, if a woman is successful in the field, they must have received a handout. The article then detailed additional concerns for Black and

Latino communities in contracting COVID-19 and discussed what universities should do when the "pandemic ends." Finally, the article noted that *"outdated notions about how to help women in science"* persist, yet it did not detail what these are.

An October 2020 article by Hayden (Hayden, 2020) discussed the issues faced by rural schools as they sought to return to in-person learning after closures for COVID-19. The particular focus was on how COVID-19 impacted school transportation, which, for many rural students, was a key to accessing education. Rural schools had been consolidating as enrollment declined, resulting in some children being bussed long distances to their school. Reducing the number of students riding a bus, implementing bus sanitization practices, seating siblings together, wearing masks, sitting every other seat (social distancing), assigning seats, contact tracing, and restricting children from sitting behind the bus driver or the opposite seat were all protocols implemented to try to reduce the likelihood of COVID-19 transmission. However, they presented obstacles in busing children to school. Because of health concerns and the need for more drivers to maintain social distancing, schools struggled to attract and retain new drivers. One solution implemented by some rural school districts was to require those serving as custodians, maintenance staff, and mechanics to obtain a license to drive a bus; however, this policy resulted in additional overtime charges.

2.2 Peer Reviewed Articles

Shockley et al. (Shockley, Clark, Dodd, & King, 2021) investigated the work-family strategies of dual-earner couples with young children during COVID-19. To recruit couples, they used snowball sampling. Initial contacts were obtained through the researchers' social networks and personal contacts; they also paid for Facebook ads to recruit participants. In addition, they offered financial incentives for participation (Amazon gift cards or a donation to the World Health Organization (WHO)). Potential participants had to live in the United States, and they had to have at least one child younger than six. While they started out with 334 couples, they used several filtering criteria to collect data from 274 couples during Time 1 (March 18-23, 2020) and 188 couples during Time 2 (May 7-18, 2020). They noted traditional assumptions that dual-earner couples were able to "outsource childcare during normal work hours" and there was an expectation that work does not occur within one's home. Another particularly telling aspect of this article was the following footnote: *"Kristen M. Shockley would also like to thank her mother, Michelle Shockley, for driving two hours every week throughout the pandemic to provide childcare. Without that 'partially outsourcing' strategy, this data collection and manuscript writing would have been impossible."* The authors highlighted that the *"sudden substantial increase in childcare responsibilities for dual-earner couples was not necessarily balanced by a reduction in work responsibilities."* Shockley et al. suggested that there was a "dearth" of research on the topic of the well-being of an individual and their job performance and that a "woman's family devotion" resulted in the trend towards women cutting back on work responsibilities to care for children. Overall, the authors reported that their data suggested *"couples were engaging in highly gendered strategies,"* supporting *"…anecdotal reports of the*

persistent gendered division of labor during COVID-19." One example described by Schockley et al. was that when women's careers were prioritized, or they earned more than men, they found poorer health outcomes for both genders. Another example dubbed "Wife Remote and Does It All," had the poorest outcomes for women. They suggested that this may be because *"doing all of the childcare equates to many more childcare hours overall than when childcare was outsourced during work hours."* They also suggested that both people in a couple felt the impact of a lack of flexibility for just one of them, even if it was not the spouse employed at the company/entity in question. Shockley et al. suggested that the *"results raise serious concerns about potential setbacks in women's career advancement."* Another finding suggested that gender may be less important than separating work and family when considering the success of the couple. They also noted that some examples of shared childcaring labor may not be possible, as they may result in a loss of income that cannot be sustained. A prime conclusion of the study was that the "*data presented here suggests that the burden of intensive, unexpected, and ongoing childcare responsibilities is disproportionately falling on mothers."*

Collins et al. (Collins, Ruppanner, Landivar, & Scarborough, 2021) reviewed data from the Elementary School Operating Status (ESOS) database to analyze instruction models (in-person, remote, hybrid) for elementary schools from September 2020 against labor force participation rates. They sought to answer the question, *"How is the country's patchwork approach to school reopening associated with mother's employment?"* Data were drawn from twenty-six of the fifty states. The article highlighted that while schools were intended for education, they also provided an expansive infrastructure of care, particularly for children in elementary school. Collins et al. pointed out that the length of closures was unlike any prior events in living memory. It discussed three reasons why schools opted for remote or hybrid learning plans: 1) a lack of resources to open schools safely, 2) opposition to in-person learning by teachers' unions and some families, and 3) consistently high levels of virus transmission in some locations. One important point made was, *"The longer these conditions remain in place, the more difficult it may be for mothers to fully recover from prolonged spells of nonemployment, resulting in reduced occupational opportunities and lifetime earnings."* It also highlighted that schools were expansive care infrastructures in the United States and their impact was far more pronounced on mothers than fathers. The importance of mothers being employed was highlighted in the following: *"Maternal employment matters because it is vital for women's psychological well-being, economic independence, and lifetime occupational attainment and earnings."* There was a concern that the economic gains seen by women over an extended period of time would be wiped out by the implications of COVID-19. *"One in three U.S. women who left employment cite childcare demands as a primary reason for their departure."* Even when both parents had the option to telecommute, Collins et al. found that mothers were the ones to reduce their work time and, if required, exit the labor force. The gap of mothers in the workforce was greater in states that offered primarily remote instruction

when compared with states that offered other options. Parents reported keeping their children home even when school districts reopened for instruction. Collins et al. pointed out that for dual earning households and single parent households, childcare and public-school systems functioned as a vital source of daily care. The authors also noted that even with the varying experiences of instruction methods, comprehensively, maternal employment suffered as a result of COVID-19 and mothers reported greater instances of anxiety, depression, and disturbed sleep when compared with fathers. They also suggested it was more acute for those in states not offering in-person learning.

King and Frederickson (King & Frederickson, 2021) examined the gender composition of more than 450,000 scholarly pre-print STEM papers in arXiv and bioRxiv from before and during the pandemic to analyze the impacts of social forces on workplace productivity and gender composition. King and Frederickson emphasized the impacts of social structures on professional women. They found that while there have been gains in the representation of women in STEM, they were significantly underrepresented in faculty positions, particularly those in tenured positions, and the STEM field. They expressed concern about the impact on mothers in academia, citing that eighty percent of women with doctorate or professional degrees who are forty or older now have children. King and Frederickson reported that women in STEM were more likely than men to leave a full-time STEM position after the birth of their first child. It discussed the presumption that academics and those in "white-collar" positions possessed a smooth-running care system and support at home. King and Frederickson reported that women scientists were more likely to be in dual-academic relationships, whereas men often had partners who did not work full-time for pay. Women scientists were also reported as being responsible for the majority of the childcare responsibilities in the home, even for younger dual-academic couples. In addition, the researchers found an increase in the underrepresentation of women scientists in the last authorship position of a publication, which is considered one of the most prestigious. *"The extraordinary childcare burden brought on by the COVID-19 pandemic, disproportionately shouldered by women, is consistent with our finding that gender gaps are growing fastest among last authors. Women academics are more likely to reduce their work hours and deprioritize their careers when family needs arise. Our society has long depended upon invisible and undervalued care and domestic work."* Simply extending the tenure clock does not benefit women in academia, as it in turn delays the increase in pay that is often coupled with a promotion. A vague correlation between the chosen COVID-19 policies and the implications for women in STEM was suggested by *"Women currently make up fewer than one quarter of COVID-19 experts in the media and national task forces." "…high-quality, on-campus childcare"* for infants, preschoolers, and school-aged children while schools remained closed and flexible spending accounts were recommended as a way to enable mothers to hire caretakers for children or elderly parents.

Krukowski et al. (Krukowski, Jagsi, & Cardel) evaluated academic productivity differences (submitting grants and articles) of faculty in science, technology, engineering, mathematics, and medicine (STEMM) by gender and by whether or not the survey respondent had children. Krukowski et al. compared the following two times periods: 1) mid-January to mid-March 2020, and 2) mid-March to mid-May 2020. A total of 284 surveys were received. Women represented 67.6% of the sample. 57.0% had children younger than eighteen living at home. (Krukowski et al. did not say what portion of those who identified as women also had children.) Faculty in STEMM were invited to participate via snowball sampling, with invites from emails and personal Facebook and Twitter pages of Krukowski et al. The majority of the survey respondents were white (79.9%) and were in health science fields (43.7%). Krukowski et al. found that the youngest children (ages zero to six) most significantly impacted the number of hours worked. They attributed this difference to the *"heightened needs of young children for constant physical supervision and attention."* Men reported no changes in productivity metrics between the two time periods while women reported a significant decrease in both first/corresponding author's submissions and in coauthor's article submissions. Krukowski et al. suggested that women's ability to be productive academically may have been negatively impacted. As a result of their findings, Krukowski et al. recommended that academic institutions and funding agencies consider reducing productivity thresholds for women when making funding, hiring, promotion and tenure decisions.

An August 2020 article by the University of Michigan (University of Michigan, 2020) summarized the impacts to women scientists. The article emphasized the challenge of children interrupting a working mother, described as *"workflow interruptions."* The article also noted that, *"Experts are concerned that if institutions and employers in science do not recognize the often uneven burden the pandemic and its consequences have on women, the effects could outlast the public health crisis."* The article called out Florida State University's policy of providing no allowance for employees to work from home while caring for their children. The article also suggested that employers may take work that a woman was unable to complete as a result of childcare responsibilities and give it to an employee who either does not have children or has a stay-at-home spouse.

Kasymova et al. (Kasymova, Place, Billings, & Aldape, 2021) sought to understand how mothers in academia have handled work and childcare during COVID-19 using a mixed-methods approach with online surveying and interviews. One hundred and thirty-one online surveys were collected during a two-week period in June 2020; they were recruited via a Facebook group (Academic Mamas) and took survey respondents about ten to fifteen minutes to complete. Survey questions included those asking about childcare and schooling responsibilities. Twenty of the online survey respondents agreed to be interviewed in August of 2020. The majority of survey participants were White (92%) and ranged in age from twenty-seven to fifty years of age. Survey respondents were restricted to those with children under ten years of age

and the majority indicated that they had two children. Most survey respondents indicated that they were academics in the social sciences (applied science, natural sciences, and humanities). About half of the survey respondents (50%) indicated that they were responsible for schooling, while very few (5%) indicated that their partner was responsible. The authors suggested that COVID-19 exacerbated already existing gender disparities in cisgender couples. Kasymova et al. identified the need for *"more peer-reviewed publications"* to better understand the impact of school format on women with children. Survey respondents reported technological limitations, unreliable internet service, and the lack of a dedicated and quiet workspace as challenges. Two quotes within the article described the issues with the lack of a quiet workspace: *"'no longer having a quiet place to work where I will not be interrupted'"* and *"'difficult to work among domestic noise.'"* Quotes expressing frustration with implicit messages of continuing at a pre-COVID-19 work pace all while taking care of one's children were also included. A particularly interesting quote, when one considers the suggestion that women academics are privileged was *"'We were supposed to teach without our kids present. I have three kids and live in a…house with two bedrooms…Where were the kids supposed to go?"* Another very elucidating quote was, *"'we have less time to work than we have probably ever had in our careers.'"*

The Kaiser Family Foundation conducted a survey of 3661 women and 1114 men from November to December 2020 to understand their experiences during COVID-19 (Ranji, Frederiksen, Salganicoff, & Long, 2021). The findings showed that nearly half of the women who had quit their job due to COVID-19 did so because of their child's school or daycare closing. Mothers were more likely to miss work due to school or childcare closures and nearly half of the women had to take unpaid sick leave when their child's school or childcare closed due to COVID-19.

2.3 Discussion of Literature Review

A key takeaway from many of these articles is that, in large part, it was the women who filled in the role of the support staff when schools went remote or to a hybrid structure ((Boorstin & Taylor, 2020), (Kasymova, Place, Billings, & Aldape, 2021)).

Articles like Guynn (Guynn, 2020) really show the misogyny that still exists in American culture: the expectation of the well-employed husband with a stay-at-home wife. King and Frederickson (King & Frederickson, 2021) noted that women scientists were often in a dual-career household, whereas male scientists often have a stay-at-home spouse. Therefore, the expectation of a stay-at-home spouse leaves little room for women professionals in STEM.

Guynn (Guynn, 2020) also suggested that wealthier families had more options. Yet, Mandavilli (Mandavilli, 2021) described a woman scientist with a nanny who had to adjust her expectations of herself because the nanny was unable to come. It suggests that money does not always buy options.

The idea that women in STEM are privileged in terms of earning potential has been both implied and overtly stated. Yet, Kasymova et al. (Kasymova, Place, Billings, & Aldape, 2021) shared a quote from one survey respondent who reported their living situation consisted of three children in a house with only two bedrooms. The quote implied that the expectation from their employer was to deliver virtual learning without students being aware that children were present in the household. Even so, the physical limitations of this individual's household would make such an expectation very difficult. First, these assertions also seem to overlook the disparately low salaries paid to women in comparison to their male peers (about seventy-four percent of the average male salary (National Science Foundation (NSF), 2021)), especially for those early in their career. Furthermore, to achieve the education level often required of women in STEM, many women may have taken on significant debt, especially if the woman in STEM is a first-generation college graduate or Black, Indigenous, or a Person of Color (BIPOC). Early and mid-career women in STEM may be digging themselves out of debt and into financial security – this takes time. Furthermore, there is the expectation that women in STEM remain in the field yet retention of women in STEM remains poor, particularly once they have a child. Consequently, a woman in STEM may be considered privileged from the earning potential that they can achieve, but there are many well-documented barriers that could inhibit their ability to attain it.

Weber and Fuhrmans (Weber & Fuhrmans, 2020) suggested that flexible schedules and the ability to work from home were the solution to work and childcare during COVID-19. However, this resulted in women in STEM with children working in the evening after their children were tucked into bed. While such an option was likely welcome and can be sustained in the short-term, mentally and physically, it can be exhausting in the long term.

Many of the articles described, in varying terms, the impact of interruptions (e.g., domestic noise, finding a quiet place to work) on work and concentration ((University of Michigan, 2020), (Mandavilli, 2021), (Shockley, Clark, Dodd, & King, 2021), (Krukowski, Jagsi, & Cardel), (Kasymova, Place, Billings, & Aldape, 2021)). How does one quantify the need for uninterrupted work? Similarly, how does one quantify the impacts on a mother hearing her children call for her?

While the work by Shockley et al. (Shockley, Clark, Dodd, & King, 2021), Krukowski et al. (Krukowski, Jagsi, & Cardel), and Kasymova et al. (Kasymova, Place, Billings, & Aldape, 2021) was novel in that they collected data as the pandemic was occurring, much like the research project described herein, the data for all three studies were collected early on. Therefore, it likely did not capture the fatigue which may have significant impacted work-family strategies used early on by dual-earner couples with young children. In addition, while many childcare facilities opened within a few months of the initial shutdowns, school formats varied throughout the United States for extended periods thereafter and, as time progressed, the impact to parents may have changed from parents with children too young for school (or children in childcare) to

parents with young school-aged children. Even in February of 2023, the researchers were aware of schools requiring students to isolate at home when they tested positive for COVID-19, often without a virtual option (they must miss school).

Throughout many of the articles, the value of schools was often emphasized in terms of their ability to serve as childcare. While schools do function as a vital care system, many women in STEM, which typically requires an extensive level of education, are unlikely to "settle" for substandard education for their children. There seems to be a need to shift the American perception that schools are childcare to schools are a vital piece of ensuring that America is well positioned to lead technology and innovation in the future. The literature suggests that a robust education system will benefit women the most, including women in STEM, since they were reported as the primary support for their child's schooling (Kasymova, Place, Billings, & Aldape, 2021).

A "program subscription," which seemed to imply digital engagement of children, was offered by at least one article (Rincon & Nguyen, 2020) as a means of engaging children while their parent works. However, while this may be viable as a short-term solution, parking a child in front of digital media is likely not recommended as a positive social-emotional development solution for children long term.

3 Methodology

The surveys used for the study were approved as exempt by Montana State University's Institutional Review Board (#NV-W091720-EX). Three surveys were administered over the course of the study: 1) October 2020, 2) March 2021, and 3) May 2021. The surveys were targeted towards women in STEM with children seventeen years of age or younger.

While the quantity of data collected over successive surveys decreased, and should be acknowledged, the results of the research were unique. They reported the real-time experiences of women in STEM as they traversed the pandemic as parents, rather than collect data for a retrospective. It also collected data further into the pandemic than several other studies, which only looked at time periods early on.

The first survey, in a series of three, was distributed via the SWE, American Planning Association (APA), Facebook, LinkedIn and personal emails from the researchers between Wednesday, October 14, 2020, and Thursday, October 29, 2020. Like Shockley et al. (Shockley, Clark, Dodd, & King, 2021) and Krukowski et al. (Krukowski, Jagsi, & Cardel), the researchers employed snowball sampling and social media (also used by Kasymova et al. (Kasymova, Place, Billings, & Aldape, 2021)) to distribute the survey. Unlike Shockley et al. (Shockley, Clark, Dodd, & King, 2021), however, no financial incentives were offered for participation. To some degree, the researchers relied on the altruism of the survey respondents. The goal of this survey was to invite as many women in STEM with children as possible to participate. The first survey was intended to obtain a broader level of information, with subsequent surveys having significantly reduced questions since much of the information from the first survey could be attached to the subsequent responses. However, the length of the first survey may have dissuaded some from participating. Both male and female survey respondents were captured; only survey respondents identifying as female were retained. A total of eighty-eight impressions were collected. After filtering out incomplete surveys (those with responses to very few questions), surveys that suggested insincere responses, and survey respondents with children too young to attend school, a total of forty-six responses to the October 2020 survey were available for analysis. To ensure that each respondent was a unique person, the researchers reviewed the internet protocols (IP) of survey respondents. While not definitive in ensuring a unique individual, seeing that all were unique suggested this to be the case.

The second survey was shared with the forty-six survey respondents who reported a willingness to participate in the March 2021 survey. Ten responses were available for analysis; however, of these ten, one of the survey respondents did not provide information after identifying their level of concern. Therefore, only nine responses provided complete information.

The third survey was shared with those from the second survey who reported a willingness to participate in the third and final May 2021 survey. Three responses were available for analysis.

Figure 1 shows a timeline of how the surveys were deployed in comparison to vaccination availability and rates.

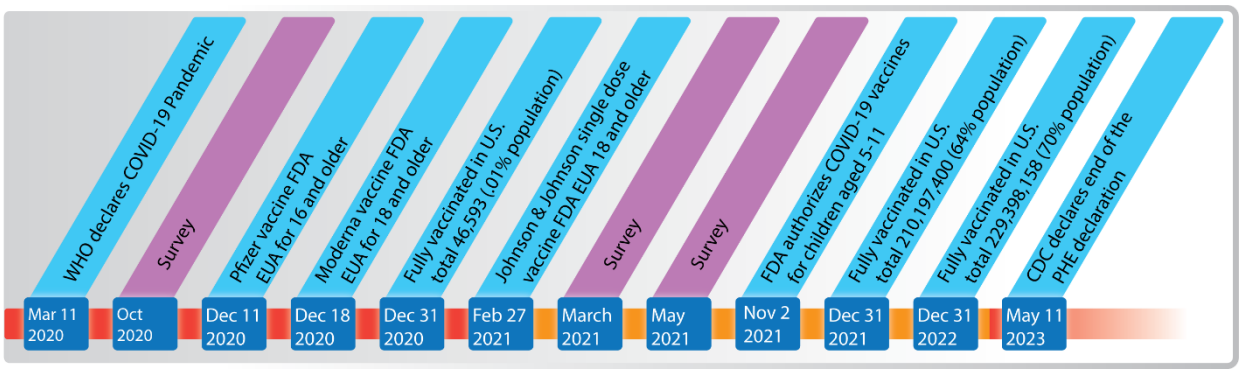

Figure 1: Timeline of Survey Deployment with COVID-19 Milestones ((Centers for Disease Control and Prevention (CDC), 2023) and (Centers for Disease Control and Prevention (CDC), 2023)).

4 Surveying Results

Forty-six, ten, and three surveys were received for the October 2020, March 2021, and May 2021 surveys, respectively. The same two questions were asked in every survey, and as a result, the changes over time associated with responses to these questions are presented first:

> 1) How would you describe your current level of concern for your immediate family if they contract COVID-19 (very concerned, concerned, neutral, not concerned, not at all concerned)?
>
> 2) What influences your level of concern (please type in your response)?

These questions were asked, as it was anticipated that the level of one's concern would have a direct influence regarding how they viewed school format. Overall, it would appear that the level of concern of survey respondents decreased as the pandemic progressed (Figure 2). However, caution should be exhibited when considering these results, as the number of respondents rapidly decreased as the survey progressed (n = 46 for the first survey, n = 10 for the second, and n = 3 for the third).

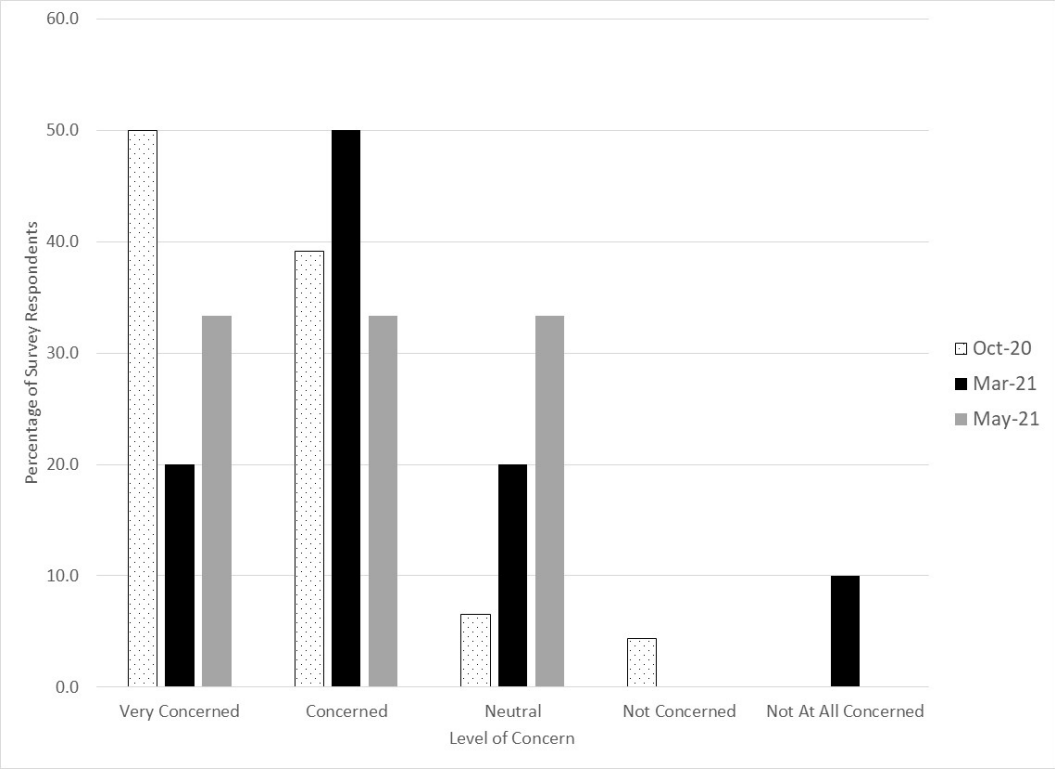

Figure 2: Level of Concern: Oct 2020, March 2021, May 2021.

The "why" one was concerned seemed to reflect what was known about COVID-19 at the time. Furthermore, it seemed that survey respondents reflected on the identified risk factors as they related to their experience. All the comments can be found in Appendix A.

In October of 2020, none of the survey respondents indicated that they were "Not at all concerned." For the other four categories, the following select quotes describe the sentiment behind why a survey respondent reported choosing the category.

(Very concerned): *"My parents and in laws are older with weakened immune systems (cancer, diabetes). And I plan to conceive in the next year, and don't want to run the risk of complications in the future."*

(Concerned): *"I've got small children (1 year old and 3.5 year old) and it feels like my work policy is constantly changing so I'm not sure how it would be handled."*

(Neutral): *"We are able to distance from most people due to remote work and school opportunities, so my worry is less than it would be, if we were forced into contact with others."*

(Not Concerned): *"My family is generally healthy and we have no underlying health issues."*

In March of 2021, none of the survey respondents indicated that they were "Not Concerned." For the other four categories, the following quotes describe the sentiment for why they reported selecting the category.

(Very concerned): *"friends who have had sick family members"*

(Concerned): *"We are not fully vaccinated yet (only shot 1) and my daughter cannot get vaccinated since she's too young. However, we still send her to daycare."*

(Neutral): *"All family over 16 are vaccinated or in the process of being vaccinated"*

(Not At All Concerned): *"Previously had it, family unaffected though exposed."*

In May of 2021, none of the survey respondents indicated that they were "Not Concerned or "Not at all concerned." However, as noted previously, the sample size is small. For the other three categories, the following quotes describe the sentiment for why a survey respondent reported selecting the category.

(Very concerned): *"co-morbidities"*

(Concerned): *"This is a novel virus and different people react differently. All of my immediate family are fully vaccinated, with the exception of my children, who are yet to be eligible. My concern has dropped a little since children are at a lower risk and the case numbers in our area have drastically reduced, but it is still not something I want to mess with as we do not understand the long term implications."*

(Neutral): *"Long term health impacts if infected by the virus."*

The following sections discuss the three surveys. The questions associated with each survey can be found in Appendix B.

4.1 October 2020 Survey

The first survey asked for the following general information from participants: with which letter in the acronym STEM did they view themselves as affiliated (science, technology, engineering, mathematics); their level of concern about COVID-19; if they were currently working (and number of hours); job title; years in position (proxy for early, mid-, or late-career); essential worker status; additional leave provisions (if given, if paid, amount used); number of children; zip code, relationship status (title of partner if one was reported); demographics (age, income, race, ethnicity) and level of education. The survey was designed so that, for each child, the following information was requested: child's grade; school type (public, private, charter, homeschool); educational format (in-person, virtual, hybrid); class size; if the survey respondent received assistance with caring for their child(ren); the amount of time they spent supporting their child(ren)'s education; and if school transportation was provided.

Of the survey respondents willing to provide information about their zip codes (n=32), the majority reported living in Missouri (7 of 32) (Figure 3). Twenty-seven of the zip codes were associated with urban areas (defined as micropolitan or metropolitan) and only five were associated with a rural area (Stephens, et al.).

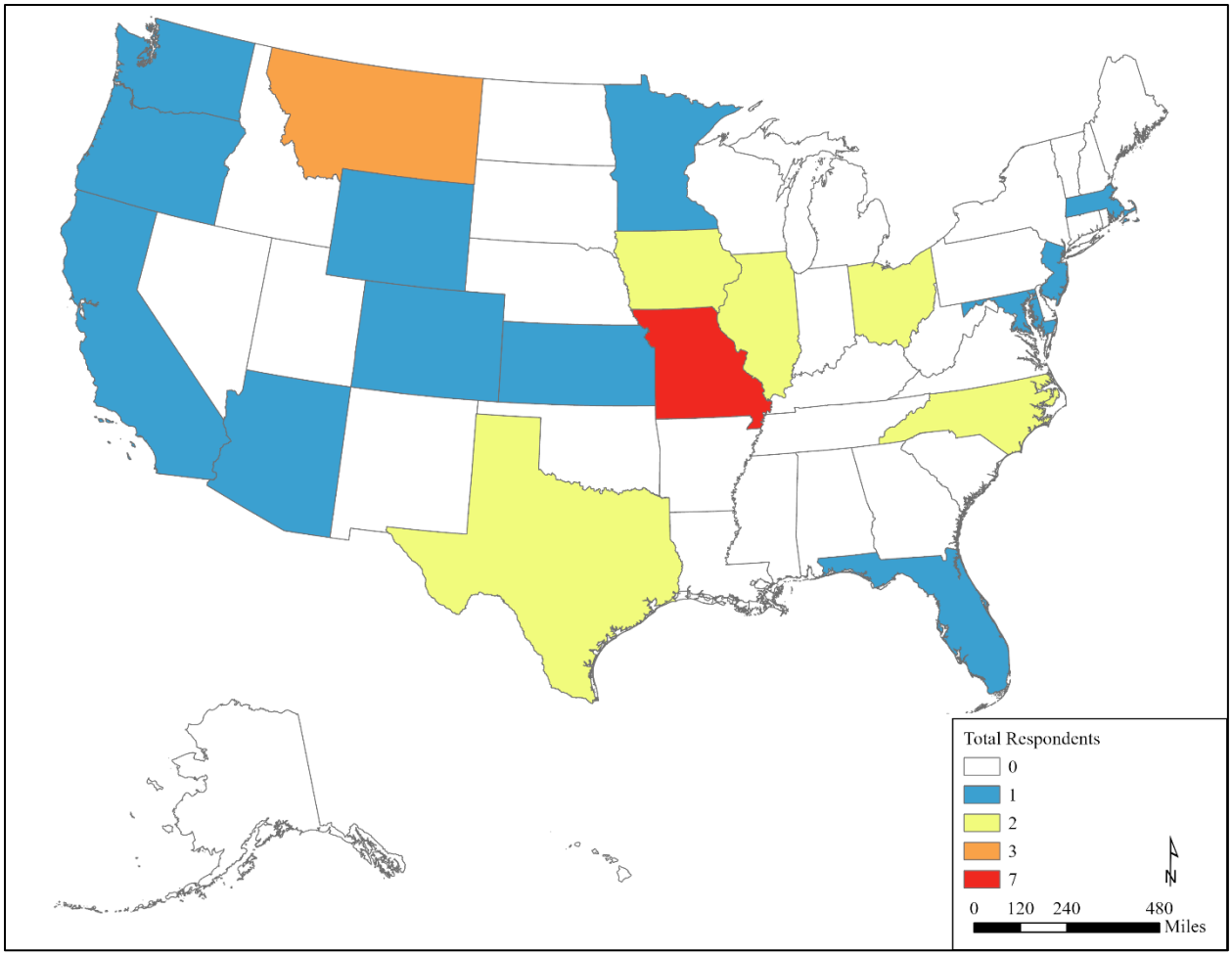

Figure 3: Number of Survey Respondents by State, Based on Provided Zip Codes.

The majority of survey respondents reported identifying most closely with engineering (Table 1).

Table 1: Affiliation Letter in STEM.

STEM	Total Respondents	% of Total Respondents
Science-Based	15	33%
Technology-Based	6	13%
Engineering-Based	21	46%
Mathematics-Based	2	4%
No Response	2	4%
TOTAL	46	100%

The majority of survey respondents (forty-three of the forty-six (93%)) reported that they were currently working. Of those who identified at what capacity they were working (full-time, part-time, other), most reported that they were working full-time (full-time = 34; part-time = 8; and other = 1). The "other" survey respondent reported working part-time while pursuing their Ph.D. For those who were working part-time, they reported working thirty-two hours (two survey respondents), thirty hours (three), twenty-five hours (two), and twenty-hours (one) weekly.

The titles identified by survey respondents can be generally categorized as: 1) academic, 2) graduate student/research assistant, 3) engineer, 4) planner, and 5) other. Academic titles include department chair, professor (full, associate, and assistant), and research faculty. Only two titles had engineering in them: transportation engineering and senior electrical engineer. Planner titles included senior planner, transportation planner, assistant director of community development, deputy director community development department, director of planning and community development, city planner, discipline leader – planning services, community development director/planner, planning director, and village planner. Many planning-related titles identified as being categorized within the engineering category. Titles described within the other category include science teacher, strategic planning and policy manager, associate principal, Lean Six Sigma Coach, functional architect, project manager, and geographic information system/asset system administrator.

The majority of survey respondents were people starting out in their current positions (Table 2). The sample was mostly composed of early to mid-career professionals. These were likely the women in STEM mostly impacted by school format choices, as their children were still in the phase of life that require the most day-to-day care.

Table 2: State in One's Career.

	Full-Time	**Part-Time**
Early Career (0 to 5 years)	22	4
Mid-Early-Career (6 to 10 years)	9	2
Mid-Career (10 to 15 years)	5	0
Late Career (More than 15 years)	0	3
TOTAL	36	9

For survey respondents who reported being full-time or part-time, about half for each category reported being deemed "essential" (Table 3). Overall, about forty-five percent of those answering the question identified as being essential, which was a little less than the percentage of survey respondents who reported being essential in the SWE survey (58%) (Rincon & Nguyen, 2020).

Table 3: Status as "Essential" Employee.

Full or Part-Time	Essential?	Total Respondents	% of Total Respondents
Full-Time	Yes	16	38%
	No	18	43%
Part-Time	Yes	3	7%
	No	5	12%
	TOTAL	42	100%

Some of the literature suggested that providing additional leave could help those caring for children. Survey respondents were asked if additional leave (sick, annual, or other) was provided as a result of the pandemic and the majority (27 or 64%) indicated that no additional leave was provided. The responses were broken down by those who had been deemed "essential" and those who were full-time and part-time employed, and no differences were apparent (Table 4). A positive, however, was that those who reported receiving additional leave indicated it was paid.

Table 4: Additional Leave Provided?

Full or Part-Time	Essential?	Sick Leave?	Total Respondents	% of Total Respondents
Full-Time	Yes	Yes	5	12%
		No	11	26%
	No	Yes	7	17%
		No	11	26%
Part-Time	Yes	Yes	1	2%
		No	2	5%
	No	Yes	2	5%
		No	3	7%
		TOTAL	42	100%

For those survey respondents who reported annual household income, all reported that it was $50,000 or more (Table 5).

Table 5: Reported Annual Household Income.

Reported Annual Household Income	Total Respondents
Less than $20,000	0
$20,000 to $49,999	0
$50,000 to $74,999	2
$75,000 to $99,999	3
$100,000 to $149,999	11
$150,000 or more	16
Prefer not to answer	5
No response	9
TOTAL	46

With a national median household income of $70,784 in 2021 (Semega & Kollar, 2022), most survey respondents who reported a household income earned above this threshold, which suggests a level of financial stability. However, a unique aspect of COVID-19, as suggested by the example from Mandavilli (Mandavilli, 2021), was that having a good income did not necessarily equate to finding a schooling solution for one's child(ren).

The majority of survey respondents identified as White/Caucasian (Table 6). Of the thirty-six survey respondents who provided information about their ethnicity, five (11%) reported identifying as Hispanic/Latino.

Table 6: Reported Racial Identity.

Reported Racial Identity	Total Respondents
American Indian/Alaska Native	1
Asian	2
Black/African American	0
Native Hawaiian or Other Pacific Islander	0
White/Caucasian	33
Decline to answer	1
Other	1
No Response	9
TOTAL	47*

*One survey respondent identified with more than one racial group.

The survey sample had high education levels, with most holding at least a master's degree (Table 7).

Table 7: Level of Educational Attainment Reported.

Reported Level of Educational Attainment	Total Respondents
8th Grade	0
Some High School	0
High School Diploma/GED	0
Some College	0
Associate's Degree	0
Bachelor's Degree	5
Master's Degree	19
Doctoral Degree	9
Post-Doctoral Degree	4
No Response	9
TOTAL	46

4.1.1 Children

The previous section detailed responses specific to the women in STEM. This section describes the parenting experiences of these women based on their children. It looks at the number of children in the women's care; their ages; whether they received public, private, charter, or homeschooling; whether or not they were attending school in-person, online, or in a hybrid format; the child(ren)'s class size; if the women received any help in caring for their child(ren); the women's opinion on the quality of their child(ren)'s education before and at the time of the survey; how many hours the women were providing to assist their child(ren)'s education; the impacts to the women's job function and performance; and if any impacts were felt as a result of new rules regarding a child's transportation needs to and from school.

The majority of survey respondents (n=46) reported having two children (Table 8) though some survey respondents only identified the number of children they had, without providing further details. These surveys were not initially filtered out, as they provided a wealth of information about the women in STEM, but information was not provided by four women who each reported having one child, four women who each reported having two children, and one woman who reported having four children. One woman who reported having four children only provided information about two of her four children. Therefore, this remaining section will provide summaries of the information shared for sixty-six children provided by the thirty-seven respondents.

Table 8: Number of Children.

Number of Children	Total Survey Respondents	% of Total Respondents
1	17	37%
2	22	48%
3	5	11%
4	2	4%
TOTAL	46	100%

Some elementary schools include first through eighth grade and some include only first through fifth. For the purposes of the analysis, the researchers divided the children into six groups:

1) childcare,

2) kindergarten (4K and 5K),

3) elementary school (1st through 5th grade),

4) middle school (6th grade through 8th grade),

5) high school (9th grade through 12th grade) and

6) post-secondary education (university).

(Note: There was not a separate category for preschool.) The majority of children (twenty-four (36%)) were in elementary school; however, this is not completely surprising because elementary school also covers the widest range of grades (Figure 4).

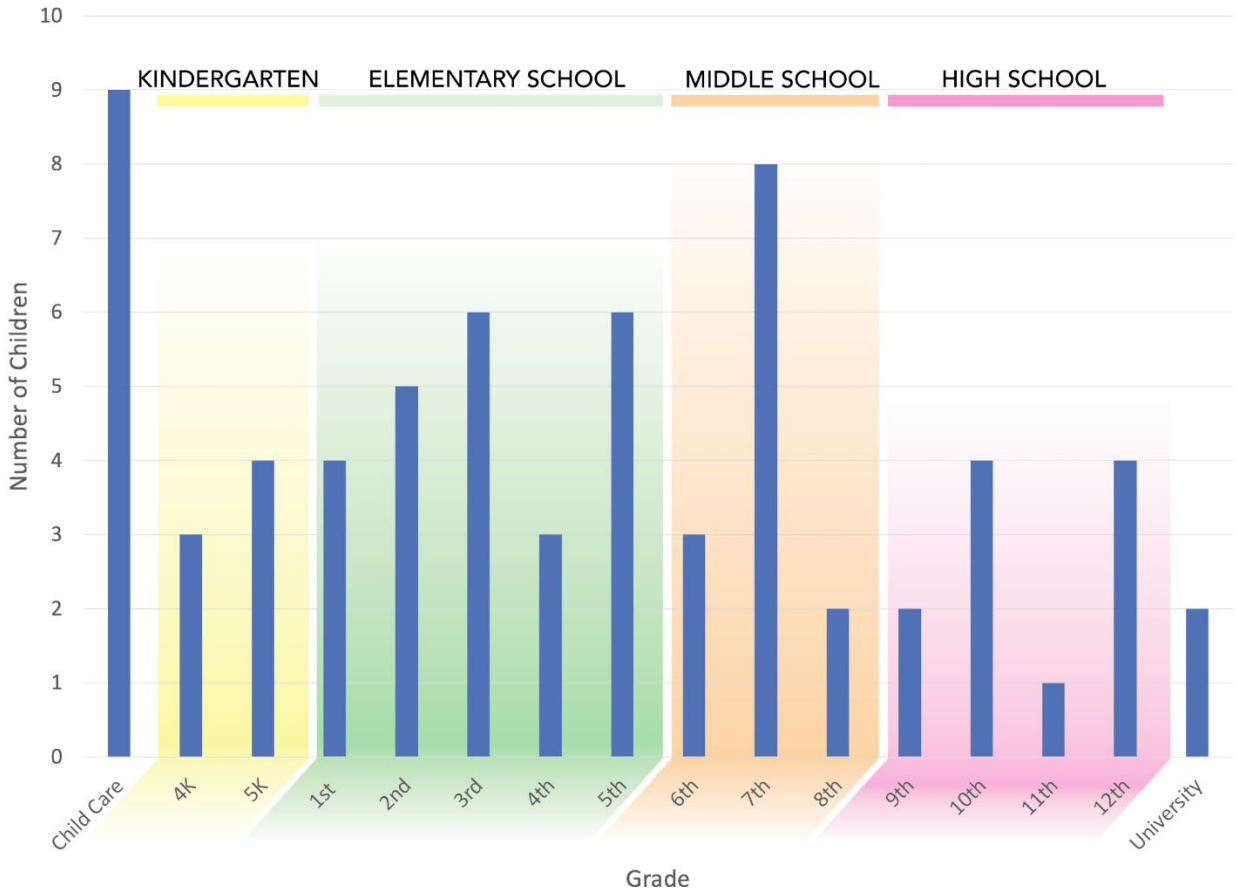

Figure 4: Number of Children in Each Grade (or Childcare).

For those children in the sample who were going to school (e.g., not in childcare), most were in public school (Figure 5).

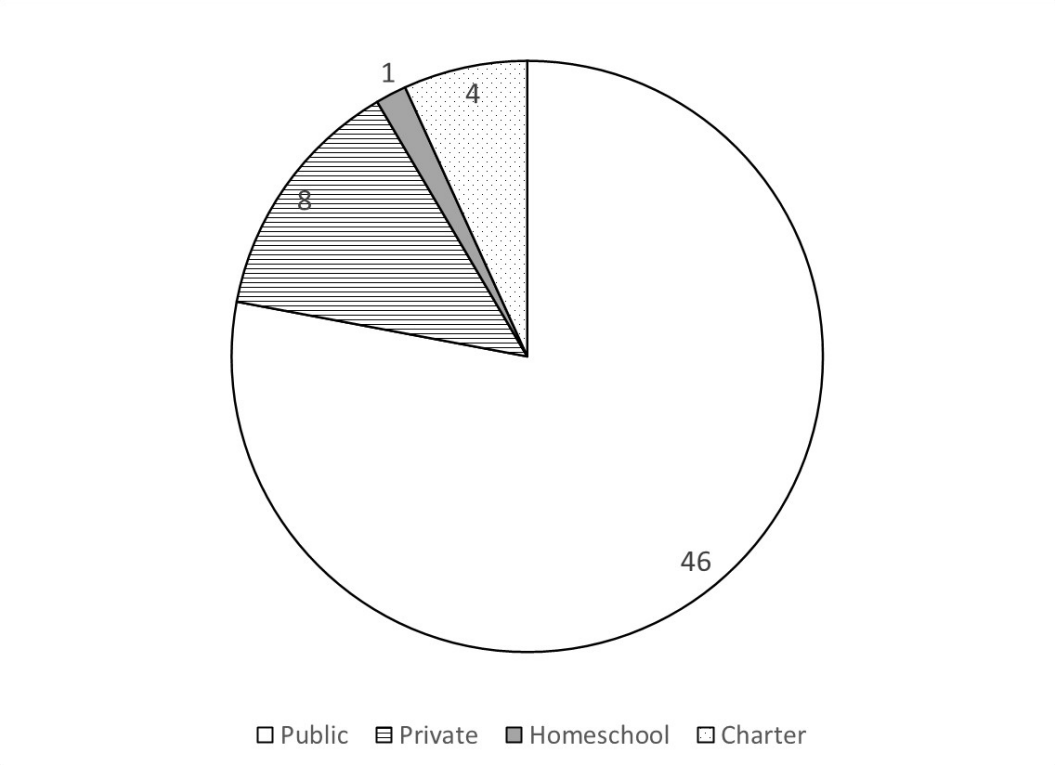

Figure 5: School Types: Public, Private, Homeschool, Charter.

The sample was distributed approximately evenly with respect to school format, except for the category homeschool (Figure 6).

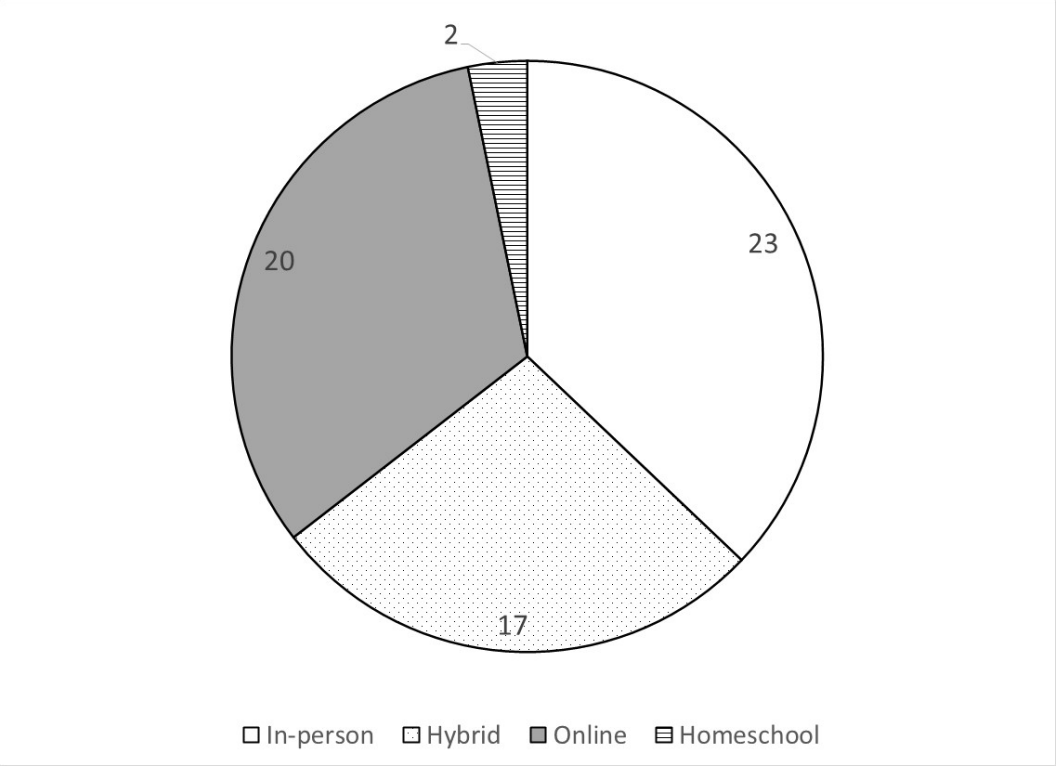

Figure 6: School Format: In-person, Hybrid, Online, Homeschool.

When considering the school format by kindergarten, elementary, middle, and high school categories, it appears that kindergarten and elementary school were offered more in-person, middle school was offered more online, and high school was either in-person or online (Figure 7).

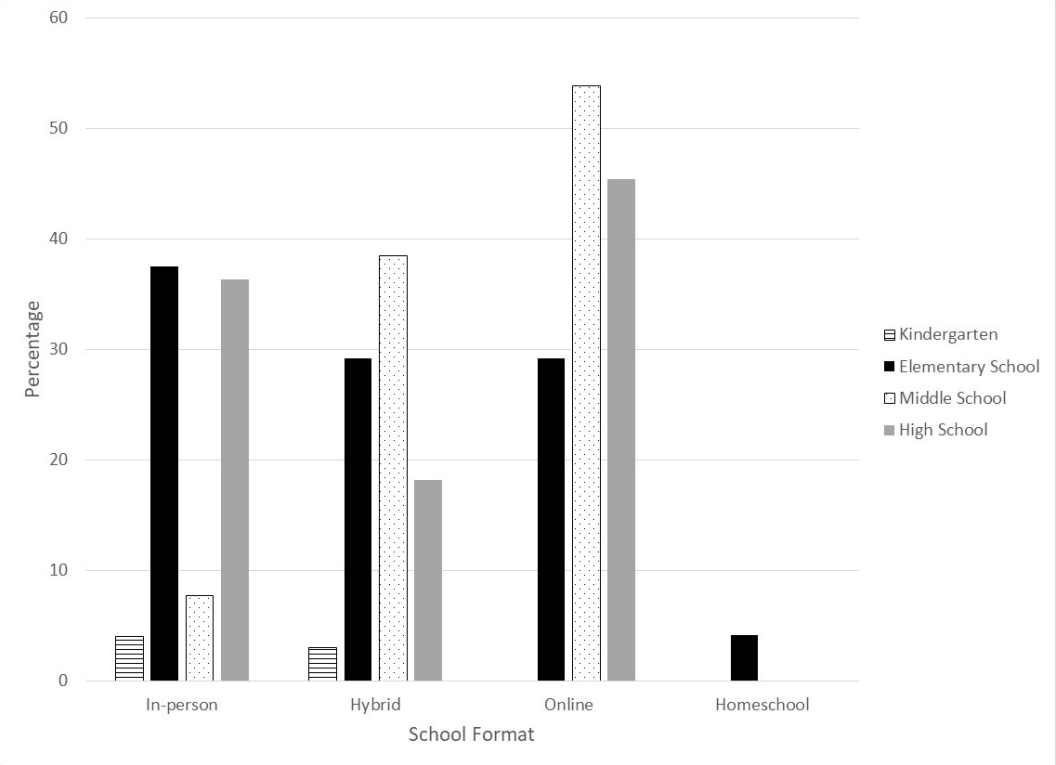

Figure 7: School Format by Level of Education.

Therefore, while the sample was small, the data as defined by school format are representative of the three main school format categories.

The researchers also considered the reported school format by the location of the survey respondent (Figure 8). Overall, with the exception of Minnesota, only survey respondents from coastal states reported online learning. Survey respondents living in states in the middle part of the country reported a variety of school formats.

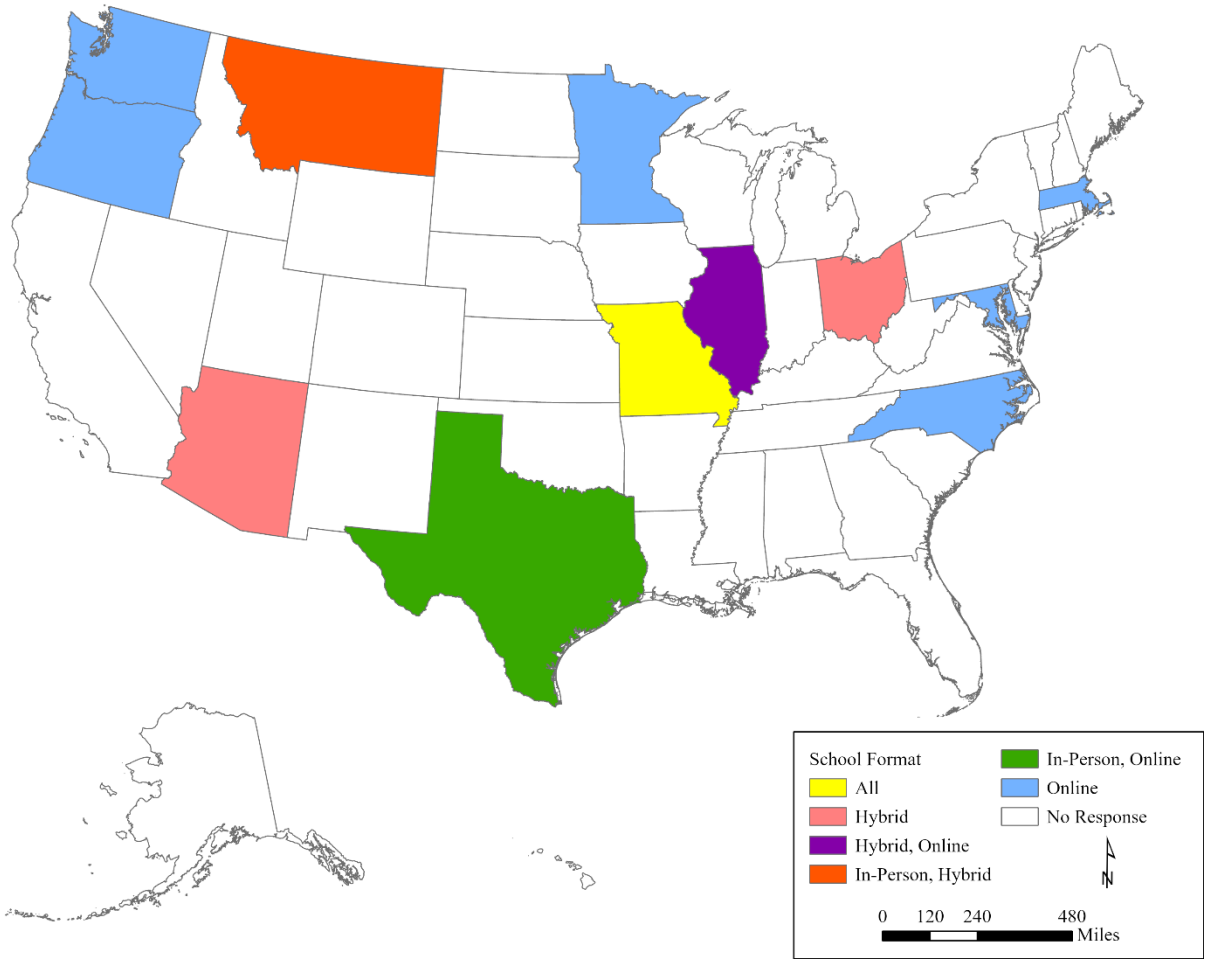

Figure 8: School Format by State.

Most survey respondents reported that their children were in classes with more than twenty students (Figure 9).

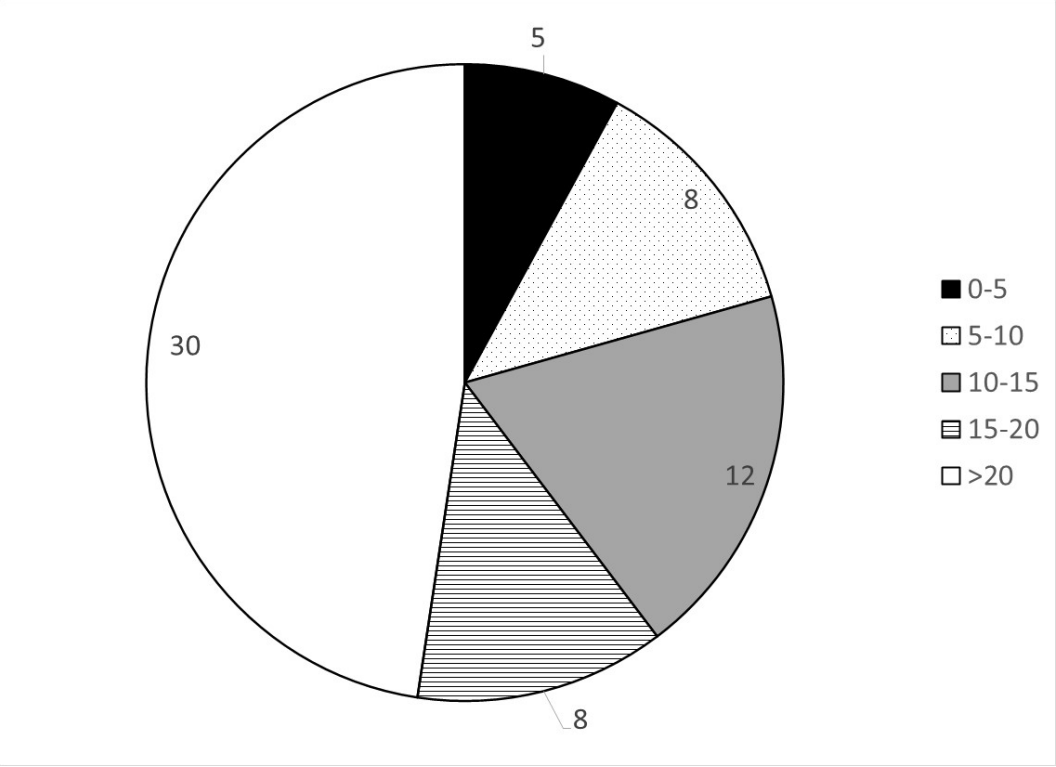

Figure 9: Class Size (n=63).

Looking at the data further, there appears to be an overrepresentation of children with class sizes greater than twenty students as correlated with online learning (Figure 10).

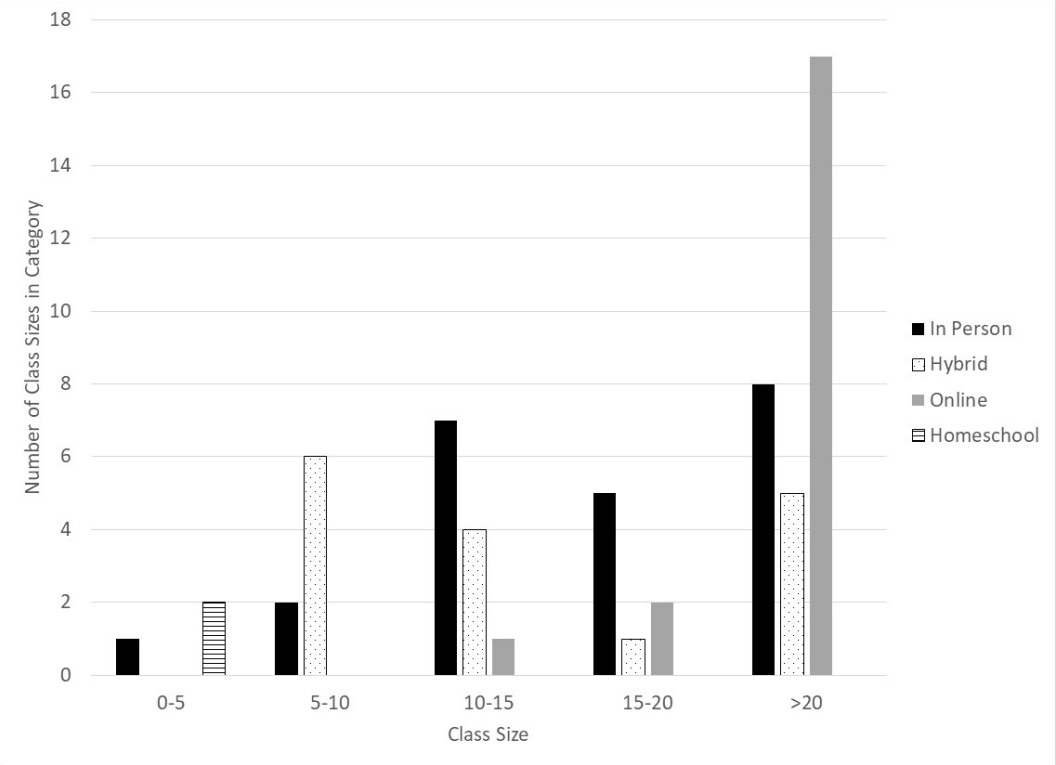

Figure 10: Class Size and School Format (n=63).

The fact that the majority of survey respondents reported that their children were in classes with more than twenty students made social distancing more challenging and had potential implications for the school format that could be offered.

Eighty-one percent of survey respondents reported receiving no assistance in caring for their children (n=54). Of the nine examples where care was leveraged, five children were cared for by their grandparents, four by a nanny, and one by a babysitter. Additional assistance identified by survey respondents included a sister-in-law, employer-provided childcare, a pocket school available one day a week, a spouse, and a video tutor. (Note: The authors believe that a pocket school may be similar to a pod school, where groups of students learn together in the home of a student(s) under the guidance of a parent(s) or hired teacher (Wenner Moyer, 2020).) A video tutor may be similar to a "program subscription," as suggested by the SWE survey (Rincon & Nguyen, 2020), although a video tutor is believed to be more interactive than a program subscription; the child sits down to watch a video subscription whereas video tutoring involves communication between the student and teacher via a video interface. It would have been interesting to learn more about the employer-provided childcare described by one survey respondent. Overall, very limited assistance seemed to be available to women in STEM with children, even when work productivity expectations did not decrease ((Weber & Fuhrmans, 2020), (Kasymova, Place, Billings, & Aldape, 2021)

and, in some instances, there seemed to be a suggestion that greater productivity should result from stay-at-home orders.

Women in STEM typically reported providing one to two hours of assistance each day for each child (Figure 11).

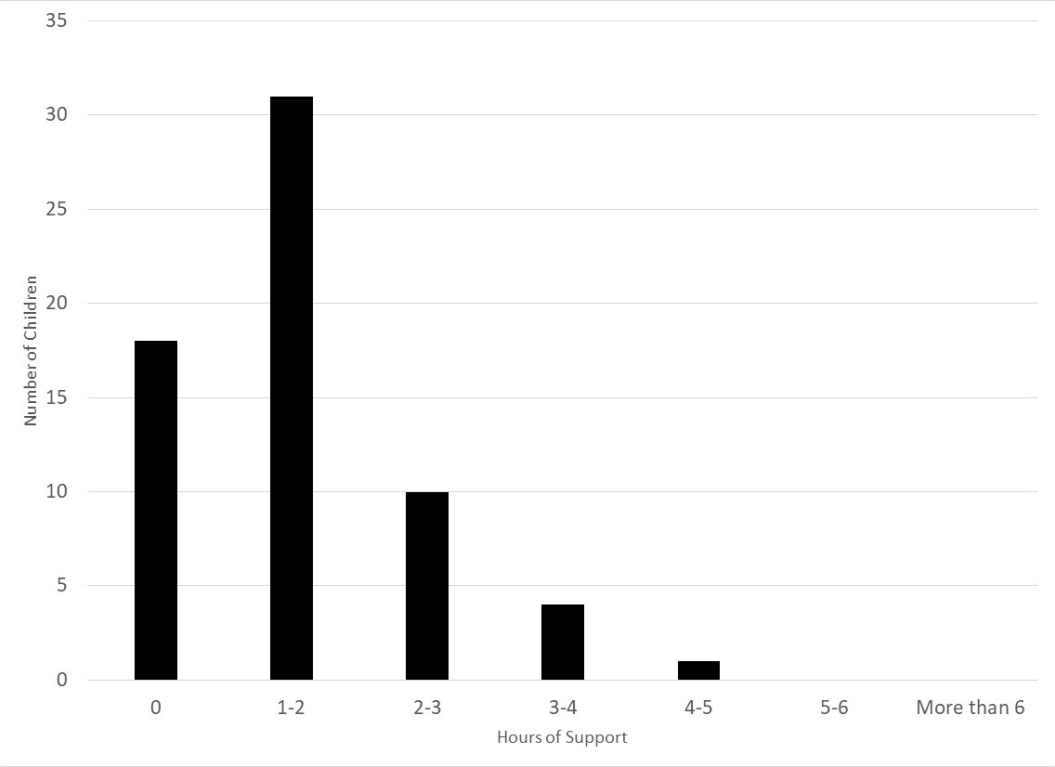

Figure 11: Hours of Support (n=64).

The researchers then considered the number of hours that a survey respondent needed to provide support based on the education level of their child (kindergarten, elementary, middle, and high school). No more than four to five hours of support was provided (Figure 12) and most children received one to two. However, because elementary-aged children were the least likely to receive zero hours of support and were the only age category represented in four to five hours of support, they were reported as requiring the greatest number of hours of support.

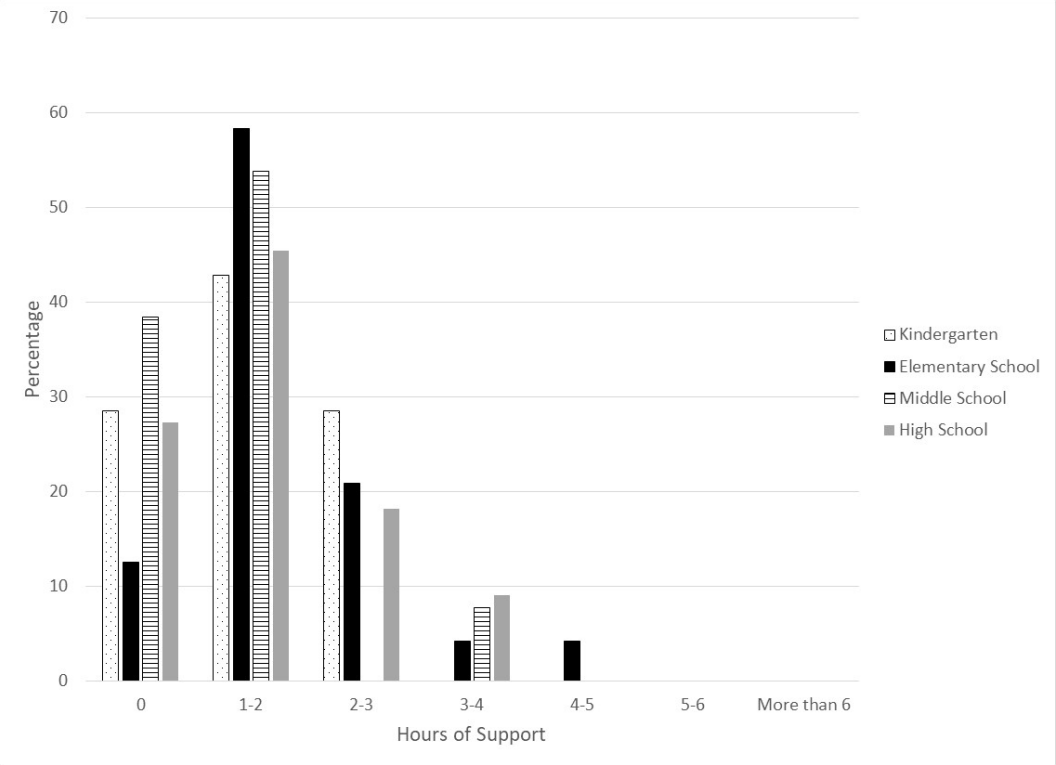

Figure 12: Hours of Support: Elementary, Middle and High School.

The researchers then considered the daily hours of support that were reported compared with the school format. Clearly, in-person schooling required the least amount of assistance, the hybrid format potentially required the greatest amount of time, and online schooling fell somewhere in between (Figure 13). The authors had expected that online schooling required the greatest level of support; however, it could be that the oscillation back and forth between in-person and online of the hybrid format was logistically challenging (e.g., parents and children need to make different preparations for in-person versus online schooling and they had to remember which day they were on).

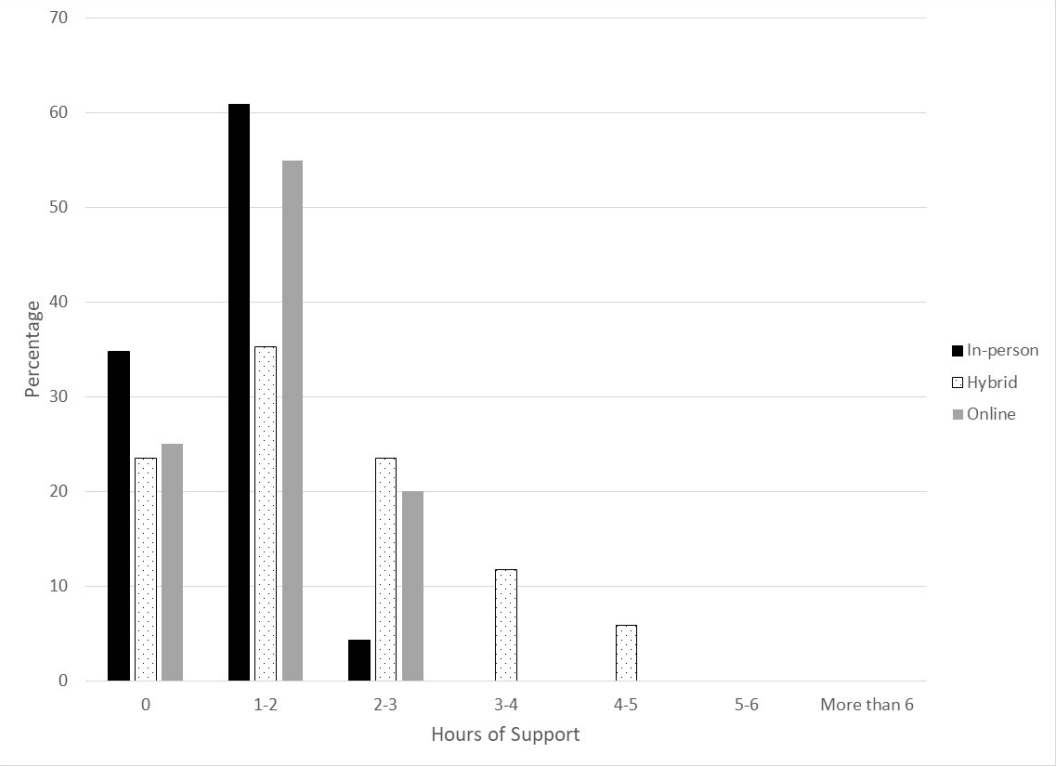

Figure 13: Daily Hours of Support, School Format.

The results of this question show that for a woman in STEM to miss at least one hour of work every day during a weekday, she would either have to reduce her hours of work per week by five or make up that time on the weekend or late in the evening. While this may be sustainable for a short period of time, the fatigue she may experience over a long period, such as the 2020-2021 school year when only online or hybrid school formats were offered, may be unsustainable.

The survey responses based on whether a student was in elementary, middle, or high school suggested that elementary school-aged children had a much greater impact on a woman in STEM's work. Only one of five high school aged children who were reported as going to school in-person was "*a constant distraction*." For middle school-aged children, the comment associated with the child attending school in-person only remarked on the impacts when their child was quarantined. For elementary school, the impacts of the lack of before and after school programming were communicated. A survey respondent also noted impacts of having their child quarantined and recalled that, from March to June of 2020, their child needed "*full support*." For women in STEM who no longer had to deal with online or hybrid learning, survey responses suggest they felt a lasting effect – they understood the burden with which they were no longer saddled.

Looking at the impacts on women based on school format for each group (elementary, middle, and high school), in-person school clearly held the fewest impacts. For high school, only online school format impacts were relayed. One survey respondent remarked on the competition between band practice and needing to be in meetings. Yet another respondent highlighted the challenge that technology presented to her child. For middle school, the only reported impact for a child attending in-person school was when the child was quarantined. In contrast, for online learning, survey respondents reported:

> "*Its hard I have to monitor his assignments online and hope he logs into class*", and
>
> "*I have to constantly check his progress online and email teachers about missing assignments and if he actually goes to class*".

For some middle school online learners, the survey respondents reported that impacts were "*Minimal due to child's age*." In contrast with the experience of survey respondents with high school-aged children and, to a lesser degree, middle school-aged children, the impacts on women in STEM with an elementary school-aged child were more apparent based on school format. For some of the students attending school in-person, the only impacts reported were those from the initial lockdowns:

> "*Currently, it does not impact my job. However, during the lockdown, when my son stayed at home for 2.5 months, it was nearly impossible to work*."

Others simply said, "*It doesn't [impact them]*" or indicated concern for the impact quarantines had on their ability to work and the need to reduce their work schedule because of the lack of before and after school care.

For the online learning, one respondent indicated that they were not home while their child attended class. Constant interruptions were also reported as an issue. Therefore, contrary to what Weber and Fuhrmans (Weber & Fuhrmans, 2020) suggested, being able to work from home was not necessarily viewed as a benefit, particularly as many survey respondents reported being interrupted while they worked. It goes back to the finding reported by Schockley et al. (Shockley, Clark, Dodd, & King, 2021): it is important to separate work from home. Another survey respondent noted:

> "*He needs help with the technology and finding the assignments; the teaching portion is very small; we (husband and I) need to go over every assignment with him and help him; teacher is very bad at technology so things don't work and we have to spend time trying to find the resources and assignments, trouble shooting with the teacher; difficult to have a meeting when he is listening to class next to me*."

Survey respondents were not asked to identify the gender of their child. However, when asked to provide how caring for their child impacted their work, survey

respondents often identified their child as he or she. It is interesting to note that most of the survey respondents who indicated their child was self-sufficient seemed to imply that the child was a girl, whereas many more survey respondents who reported having to oversee their child's schooling suggested that their child was a boy. For example, for a boy, "*He needs help with technology*…" For a girl, "*She is responsible and doesn't need much assistance*." This was not an absolute, but, particularly for high schoolers who needed additional assistance, there seemed to be a bias towards the respondent inadvertently identifying the child as a boy. However, while it seemed that most girls were described as "self-sufficient" or the like, they may be taking on the burden brought by their mother's demanding work schedules even though it may not have been in their best interest. Concerns about children's mental health were cited in Mandavilli (Mandavilli, 2021).

Survey respondents were asked to indicate their level of agreement that their child was receiving a "high-quality education" based on the school format prior to COVID-19 as compared with their present format. Survey respondents reported a decrease in their level of agreement, regularly rating hybrid and online education lower when taking the average of the post-pandemic rating minus the pre-pandemic rating (Table 9).

Table 9: Post-Pandemic Education Quality Subtracted by Pre-Pandemic Education Quality.

Reported Level of Educational Attainment	n	Minimum	Average	Maximum
In-Person	23	-1	0.13	2
Hybrid	17	0	1.47	3
Online	20	0	1.35	4

Therefore, even though a woman in STEM may have supported hybrid or online learning, the results suggest that they saw a reduction in the quality of education with these alternative formats. One silver lining should be noted: a woman in STEM reported that their child with dyslexia was able to access online tutoring that was not made available before the pandemic.

The majority of survey respondents (59%) reported they were not required to provide transportation for their children. Of those who indicated that they were, some remarked that they had already been doing so pre-pandemic. Therefore, the challenges described by Hayden (Hayden, 2020) in finding more bus drivers to drive more buses as a result of social distancing requirements did not seem to impact the women in our sample, which was likely because most of the survey respondents lived in more urbanized locations.

One survey respondent touched on the challenges of supporting the education of a child with a disability. They noted that:

> "*Identifying digital skills for the disabled is a frontier that has not been addressed yet*."

This was highlighted in the literature, in that there was a need to address STEM professionals with disabilities. However, it was not highlighted with respect to the challenges faced by STEM professionals who are supporting children with disabilities.

4.2 March 2021 Survey

Ten survey responses were received for the March 2021 survey; this was a little less than twenty-two percent of the October 2020 survey sample. One of the survey respondents did not provide information after identifying their level of concern. At the time of the March 2021 survey, many states had already begun deploying vaccines to those over the age of 16. In fact, most states were heading towards vaccinating the entirety of the adult population. Furthermore, a directive from the federal government made a push for elementary and secondary schools to offer some in-person schooling. It was potentially the aforementioned changes, the fatigue that had kicked-in after more than a year of pandemic impacts, or something else, but participation in the follow-up survey significantly dropped and should be acknowledged as a limitation of the results. In fact, one survey respondent hinted at the complexities of completing the survey at this point:

> *"Your survey was not designed in a way that cover[s] all possible scenarios and responses. So[,] I could not answer all [of] the questions. For example[,] my daughter['s] school format had changed multiple times and I wasn't sure for which period I have to respond [to] the questions."*

The authors had not even anticipated this level of complexity of the school format (e.g., schools going back and forth between formats as spikes occurred). This feedback suggests how chaotic children's school format was and provides a window into how challenging it could be for women in STEM to accommodate. Since the results provide a unique insight into viewpoints at a specific point in time during COVID-19, there is still value in reviewing them. The specific questions for this survey are listed in Appendix .

Of the nine survey respondents who provided information regarding whether their child(ren)'s school format had changed, three indicated that it had changed and six indicated that it had not. One survey respondent reported that their child was back in childcare. Another indicated that they had a hybrid model and that their children had returned to in-person school. The third respondent described how chaotic some children's school formats were:

> *"My daughter (kindergartener) had the option to switch between online and in-person. So she was online for the first quarter then in-person for the second quarter then online and now in-person again."*

Survey respondents were asked if they experienced stressors as a result of their job and/or their child(ren)'s school format. Of the eight survey respondents who provided input, six (75%) reported that they experienced increased personal stress/anxiety. One survey respondent reported that they had no new stressors. Another reported that they had experienced a physical injury. Only one survey respondent reported three new stressors, including an increase in personal stress/anxiety, change in job status (new position, new company), and their family moving temporarily. Therefore, survey respondents seemed to have experienced a range of impacts, from few to no stressors to a significant stressor (e.g., physical injury).

Survey respondents were also asked about specific job impacts. Every respondent who provided an answer to the question identified at least two job impacts. The majority of survey respondents indicated that they had to extend the deadline on projects and that they had difficulty concentrating, which was similar to what was reported by Shockley et al. (Shockley, Clark, Dodd, & King, 2021) (Figure 14).

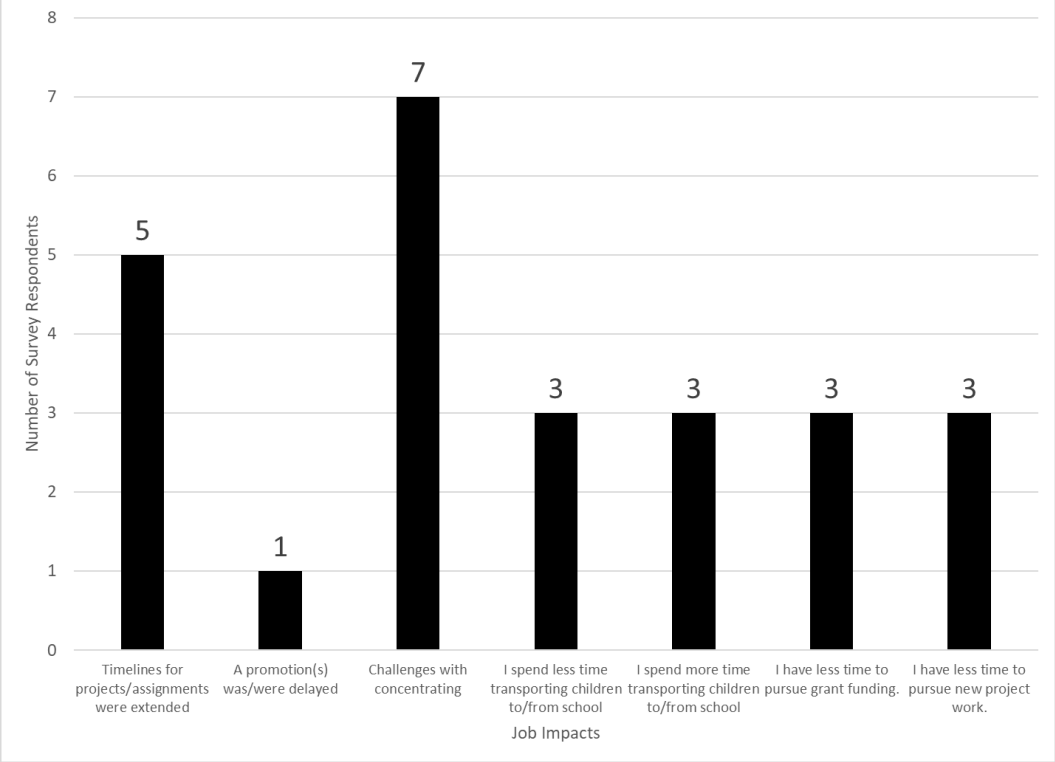

Figure 14: Reported Job Impacts.

To ensure a balanced understanding of how COVID-19 may have impacted women in STEM, survey respondents were asked if they had experienced both positive and negative impacts to their jobs as a result of their child(ren)'s school format/childcare format. Of the eight survey respondents who provided feedback, two indicated that they had a positive impact.

> *"Because there is no after school program, my employer has let me be more flexible. I have also been allowed to continue to work from home, which I like (that will not last forever though). I get a lot more time with my children now, which I love."*
>
> *"Having her go to in-person daycare has been much easier for both my husband and me"*

Of the eight survey respondents, five reported negative impacts.

> *"I get the impression that I have not been considered for new projects or included as I used to be in existing projects. Only one other person on our team has children still at home (although they are older than mine), and he has a stay at home wife. No one else has kids at home and they can be much more flexible. I quite fran[k]ly don't feel like part of the team anymore and more importantly, like I'm going backwards in my career."*
>
> *"She has been sick a few times (not COVID), which means we have to keep her home from school making it hard for me to work"*
>
> *"increased transportation needs to minimize child exposure to others"*
>
> *"No after care program is provided and so the kids are often coming home during my meetings."*
>
> *"I was the only person in my office who was also the primary caregiver to children at home during COVID."*

Survey respondents were asked if they were willing to provide any additional insight. In addition to the one highlighted early on (that their child went back and forth between school formats), the following three pieces of feedback were provided:

> *"Workplace schedule flexibility has been so important for managing the stress of working & childcare during the pandemic."*
>
> *"Although the kids are back at school full time, there is no after care which impacts my ability to work past 3pm."*
>
> *"I've been working from home for many years. Having more students/adults sharing the same work space has been challenging, but positive. I'm thinking more in 2 hour chunks than in work-day/evening/night paradigms."*

The third comment seems to coincide with the literature review (((University of Michigan, 2020), (Mandavilli, 2021), (Shockley, Clark, Dodd, & King, 2021), (Krukowski, Jagsi, & Cardel), & (Kasymova, Place, Billings, & Aldape, 2021)) suggesting the availability of shorter periods of time during which one can concentrate.

4.3 May 2021 Survey

This section discusses the results of the third survey. Eight survey respondents indicated a willingness to receive the invitation for the third and final survey. The third survey was sent to recipients on Sunday, June 27, 2021 and they were given two weeks to fill it out, with Monday, July 12, 2021, as the requested response date.

Only survey respondents with one or two children remained by the third survey. Consequently, two surveys were created, one for a survey respondent with one child and one for survey respondents with two children. This allowed questions specific to the child's school format to be varied by child. The specific questions for this survey can be found in the Appendix .

Only three of the previous nine survey respondents provided feedback (the tenth survey respondent from survey two did not provide their email address for the third survey); all three of the survey respondents had two children. However, one of the three did not provide their email address, so their responses could not be linked to previous responses. None of the survey respondents reported changing their type of school (e.g., from public to private school). All the survey respondents reported that they had a choice regarding their children's school format (e.g., their child could attend in-person, hybrid, or online based on the family's choice). The following were reported as reasons why a particular school format was chosen:

> *"Had less than one semester left in school."*
>
> *"We remained in person as the case numbers were drastically dropping, and the school year had so far been a success. She really likes attending in person."*
>
> *"in person- he is vaccinated"*

The second comment is particularly interesting because during the first survey, several survey respondents with daughters reported them to be acting autonomously. In contrast, this quote highlights a preference by at least one daughter for in-person schooling. With a small sample size, significant conclusions cannot be drawn. However, it does highlight that when considering school format, very little input, whether from parents or administrators, seems to have been queried from children regarding their preference. Therefore, while girls may be acting autonomously, the toll that online or hybrid learning may have taken on a girls' mental health was likely not fully considered. Many milestones such as school dances, graduations, and science fairs, which often make up the lore of our childhood, were missed.

Two of the three survey respondents indicated that their child's school offered after school activities in person.

Survey respondents were again asked about positive impacts to their job as a result of their child's school format. Two of the three survey respondents reported no

negative or positive impacts for either of their children. For the third survey respondent, they provided a positive and negative associated with each of their children. When referring to their oldest child, they wrote:

> (Positive): *"I have been permit[t]ed to pick her up at the end of the day and can continue to work the remainder of my day from home."*
>
> (Negative): *"It is really difficult to get a full uninter[r]upted day of work in now. It was much easier when I was just working from home, but now that I also have to be in the office I feel like I have to work a couple more hours each day, just to get in an 8 hour day."*

When referring to their youngest child, they wrote:

> (Positive): *"Yes, I have been granted more flexibility."*
>
> (Negative): *"It takes me a lot longer to get things accomplished when she is around. I also feel like I am really failing as a Mom when I have to tell my 6 year old to leave me alone so I can work."*

This suggests that working from home is welcome, at least for some time. But splitting the time across a single day in two locations is cumbersome. It also suggests that working from home is good until one cannot separate work from family, such as when a child is at home while the parent is expected to work.

5 Discussion, Recommendations, & Future Research

Overall, over time, survey respondents reported feeling continually concerned about the impacts of COVID-19 on their families and themselves. However, the reported level of concern seemed to dissipate as the pandemic progressed, likely because of the increased availability of vaccines as well as a better understanding of COVID-19.

There was the suggestion that simply having money to pay for childcare or to support online education would solve the problems faced by the women in STEM with children. However, as described by Mandavilli (Mandavilli, 2021), even a woman scientist with a nanny had to readjust her expectations of her work productivity, and the women in this study reported very limited assistance provided by others, whether it was a nanny, babysitter, or grandparent. One survey respondent reported childcare provided by their employer; this was a unique offering, and the researchers would have liked to learn more.

Overall, women in STEM seemed to report that their children attending a hybrid format school required the most assistance, followed by those in the online school format. Children in in-person schooling required little to no assistance by the women in STEM. However, the survey respondent with children learning in-person often cited the challenges of school shutdowns in the spring of 2020 or described the challenges caused by a lack of after school care activities in 2021.

One respondent in the second survey described how her child had oscillated between school formats so much that the survey could not capture the changes. The respondent seemed exasperated, which suggested the challenges that inconsistencies in school formats caused.

Overall, women in STEM with elementary school aged children seemed to report the most significant impacts. As the child grew older, reported impacts were reduced.

Strengths of this study included obtaining input from women in STEM at the time of the event rather than a retrospective assessment. In particular, the quick response of developing and deploying the surveys is a testament to the need to better describe the experiences of women in STEM, where attrition persists. Limitations of this study include the small overall sample size, particularly over time, as well as limited demographic and discipline variation.

As discussed in the literature ((University of Michigan, 2020), (Mandavilli, 2021), (Shockley, Clark, Dodd, & King, 2021), (Krukowski, Jagsi, & Cardel), (Kasymova, Place, Billings, & Aldape, 2021)) and highlighted in the survey responses received during this study, one of the reported challenges was constant presence of children, which hampered concentration and work for an undefined period of time. It did not allow for the extended periods of thought necessary for STEM jobs, nor did it aid women who need to be physically on-site to collect data or oversee projects (e.g.,

construction inspection). How does one define this impact? The lack of interruptions from children may be why the morning is the most productive part of the workday; a woman can start a task and expect not to be interrupted. They can also finish the task before their eight-hour (or more) workday has ended. At least one school that transitioned to online education scheduled time throughout each day when a child was required to check-in. This approach to online education, while well-suited for a child's education, does not support women in STEM who are trying to work productively and be successful. Therefore, the suggestion that working from home is a solve-all or a solution for women in STEM with children is misguided.

Many women who transitioned to caring for children at home during the workday had not previously experienced working from home. Therefore, while the challenges were highlighted by some of the literature, many of the questions in the surveys did not necessarily capture those challenges.

The idea of a entertaining children with a "program subscription" was short-sighted and seemed not to fully consider how long the impacts of COVID-19 on school formats would extend.

5.1 Recommendations

There was no easy or singular solution to an event like COVID-19. It was unprecedented. However, the implications of sweeping decisions made without input from all who were impacted, from teachers to parents to children, did not seem to prove effective. Some parents and teachers wanted in-person learning. Some parents and teachers wanted remote learning. Some parents and teachers wanted a hybrid approach. The authors recommend that, should an event like COVID-19 ever present itself again, our government, our administrators, our teachers, and our parents work together to find a balanced approach, enabling all of those impacted to select the option that best fits their familial situation, particularly as it relates to health-related implications.

Overall, what this experience has shown is, if the United States is serious about increasing the representation of women in STEM, it should invest in sustainable, consistent, high-quality childcare and public education. It would benefit not only women in STEM, but all women in this country.

5.2 Future Research

Similar to Krukowski et al. (Krukowski, Jagsi, & Cardel), the majority of this survey sample was drawn from women who identified as White/Caucasian. Therefore, the need to better understand the implications of childcare and school impact on BIPOC women in STEM remains.

The SWE (Rincon & Nguyen, 2020) survey early in the pandemic obtained input from women in engineering. Krukowski et al. (Krukowski, Jagsi, & Cardel) obtained input from women in the health sciences fields. This study contributed to the body of

knowledge regarding women in STEM, and more specifically those with children, with a more varied sample of professions, although with higher proportions of those in Science-Related and Engineering-Related fields. Therefore, a gap still exists regarding the impact of women in STEM in the Mathematics-Related and Technology-Related fields. There are great opportunities for more research in this realm to better understand the challenges and consequently uncover approaches that support the success of women in STEM with children.

Future research should specifically seek out women in STEM with children who left the workforce as a result of COVID-19 and identify the reasons why they have remained out of the workforce. Only one survey respondent within this study reported a job change. However, at least one other survey respondent reported being the only women employee who remained at her place of work. It could also investigate women who had cut back their hours and why they continued to work that number, as well as women who may have been eligible but did not receive their promotion. There is much that has yet to be understood with respect to the impacts of COVID-19 school format choices on women in STEM.

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7 Appendix A

Survey	Very Concerned	Concerned	Neutral	Not Concerned
October 2020	• "My parents and in laws are older with weakened immune systems (cancer, diabetes). And I plan to conceive in the next year, and don't want to run the risk of complications in the future." • "Their age, pre-existing conditions, their proximity to COVID-19 hotspots" • "We have no family within driving distance and so if our child gets sick my husband or I would have to take time off work to care for him." • "Long-term effect the disease on a person's health.	• "My immediate family is relatively young and healthy, so I am less concerned for them than I am for my older relatives that have various complicating health conditions." • "Cases in my state; others not wearing masks; seeing people gather together on social media; president's lies" • "The unknowns of longterm impact COVID-19. Some also have slightly elevated risk of complication from existing health factors" • "Currently health issues" • "I've got small children (1 year old and 3.5 year old) and it feels like my work policy is constantly changing so I'm not sure how it would be handled." • "potential to spread the virus and the potential to die from it"	• "We are able to distance from most people due to remote work and school opportunities, so my worry is less than it would be, if we were forced into contact with others." • "At this point, if they contract it, we have enough information to treat it successfully	• "My family is generally healthy and we have no underlying health issues."

Survey	Very Concerned	Concerned	Neutral	Not Concerned
	The cost involved in curing the disease short-term and long-term." • "the potential impact of COVID-19 to people with underlying conditions." • "Primary care giver for elderly parent with several health issues. Spouse easily gets bronchitis that often turns into pneumonia." • "Science and knowing that this virus impacts each individual differently. I'm concerned that my immediate family may be part of the group that this virus severely impacts. I also believe that unlike the flu, this virus does enduring	• "age/health/access to care" • "Number of cases rising in our State." • "Long term effects we don't yet know about the virus, chance of exposing elderly relatives" • Impacts to the medically sensitive, if exposed. • "We have overall good health and are young, but I do NOT want to have to parent while battling Covid." • "age, pre-existing conditions" • "comorbidities and at risk factors in family members." • "Pre-existing conditions."		

Survey	Very Concerned	Concerned	Neutral	Not Concerned
	damage that may affect quality of life, for a life time." • "Family members with diabetes and asthma." • "While I am not extremely concerned one of us might lose our life, I am extremely concerned about the long term impacts of covid. Will there still be side effects or other concerns in a year, 2 years, 20 years." • "the severity of COVID" • "Detected post effects in children" • "Health conditions, asthma" • "Seeing patients at the hospital who are on ventilators" • "little knowledge of the long-term			

Survey	Very Concerned	Concerned	Neutral	Not Concerned
	health implications" • ""Very concerned" would be regards to my husband, not my young children. My husband has co-morbidities and we live in a rural area with lower quality medical care." • "Unknown long term health impacts" • "The inability to stop spread and it's potential fatality and long term health impacts."			
March 2021	• "friends who have had sick family members" • "their short and long term health"	• "My kids who have not get vaccinated and my family in Iran." • "Age, I have asthma and struggle with respitory illnesses, and the new varients appear to be much works and impact kids more."	• "As levels start to spike and I see people are no longer wearing masks in public as	• "Previously had it, family unaffected though exposed."

Survey	Very Concerned	Concerned	Neutral	Not Concerned
		• "We are not fully vaccinated yet (only shot 1) and my daughter cannot get vaccinated since she's too young. However, we still send her to daycare." • "The new variants being more contagious and potentially deadly for younger people."	required by law." • "All family over 16 are vaccinated or in the process of being vaccinated"	
May 2021	"co-morbidities"	• "This is a novel virus and different people react differently. All of my immediate family are fully vaccinated, with the exception of my children, who are yet to be eligible. My concern has dropped a little since children are at a lower risk and the case numbers in our area have drastically reduced, but it is still not something I want to mess with as we do not understand the long term implications."	• "Long term health impacts if infected by the virus."	

8 Appendix B

October 2020 Survey Questions

1. How do you identify your gender? (female, male, transgender, other)
2. Which of the following best describes your training/education or current profession: 1) science-based, 2) technology-based, 3) engineering-based, and 4) mathematics-based?
3. How would you describe your level of concern for your immediate family if they contract COVID-19? (very concerned, concerned, neutral, not concerned, not at all concerned)
4. What influences your level of concern?
5. Are you currently working? (yes, no)
6. Are you currently working: 1) full-time, 2) part-time, and 3) other?
7. On average, how many hours do you work each week?
8. What is your job title?
9. How many years have you held your current position?
10. Are you considered an essential employee? (yes, no)
11. Has your employer provided additional leave (sick, annual or other) as a result of the pandemic? (yes, no)
12. Is the leave paid? (yes, no)
13. How much of the allotted leave have you used?
14. Were you previously working? (yes, no)
15. What was your job title?
16. How many years had you been working in that position?
17. Had your employer provided additional leave (sick, annual or other) as a result of the pandemic? (yes, no)
18. Was the leave paid? (yes, no)
19. If you had been provided with additional leave, would you have remained at your position? (yes, no)
20. What prompted you to leave this position?
21. Were you considered an essential employee? (yes, no)
22. How many children do you have? (it then asks the questions about each child below)
23. What is your five-digit zip code?
24. Please describe your relationship status: I am single; I am married; I am in a long-term relationship; other.
25. What's your spouse's/significant other's job title?
26. How old are you?
27. What is your annual household income? (less than $20,000; $20,000 to $49,999; $50,000 to $74,999; $75,000 to $99,999; $100,000 to $149,999; $150,000 or more; prefer not to answer).
28. With which racial group(s) do you closely identify? (Please select as many as applicable.) (American Indian/Native American; Asian; Black/African American; Native Hawaiian or other Pacific Islander; White/Caucasian; Decline to answer; other)

29. Are you of Hispanic or Latino origin or descent? (Yes, Hispanic or Latino; No, not Hispanic or Latino; Decline to answer.)
30. What is the highest level of education that you have completed? (8th grade; some high school; high school diploma/GED; some college; associate's degree; bachelor's degree; master's degree; doctoral degree)

For each child, the survey asks:

1. What is their age?
2. Which best describes the grade level that the child is in?
3. Is your child's school (public, private, homeschool, charter, other)?
4. For your child, what is the current format that their school/child care facility is currently planning for the educational format? (in-person, hybrid (in-person and online learning), online learning, homeschool, "pandemic pod", other)
5. What is the size of your child's class? (0-5 children; 5-10 children; 10-15 children; 15-20 children; more than 20 children in the class)
6. Have you been able to leverage any of the following for caring for your child or assisting with online learning? (yes, grandparents; yes, a nanny; yes, a babysitter; no; other)
7. Please rate your level of agreement with the following statement: "Prior to the pandemic, I felt that may child was receiving a high quality education." (strongly agree, agree, neutral, disagree, strongly disagree)
8. Please rate your level of agreement with the following statement: "Based on the current proposed education format, I feel that my child will be receiving a high-quality education" (strongly agree, agree, neutral, disagree, strongly disagree).
9. Please choose the category that best describes how many hours, per day, that you support your child's education: 0 hours, 1-2 hours, 2-3 hours, 3-4 hours, 4-5 hours, 5-6 hours, more than 6 hours.
10. Please describe how the current format for your child's school impacts your job function.
11. Have you been asked by your child's school to provide transportation to and/or from school this fall? (yes, no)
12. Have changes to your child's school transportation had an impact on you or your family? If yes, please describe.

March 2021 Survey Questions

1. How would you describe your current level of concern for your immediate family if they contract COVID-19? (very concerned, concerned, neutral, not concerned, not at all concerned)
2. What influences your level of concern (please type in your response)?
3. Since we sent the last survey in October of 2020, have any of your child(ren)'s school/child care facility type (e.g. public to private, private to public, public to homeschool; childcare to care at home (or with family); other) changed? (yes, no)
4. Please tell us how your child(ren)'s school/child care facility type has changed from when we last sent the survey (October of 2020) to the present time.
5. Which best describes the number of children in your family: 1, 2, 3.
6. Do you have a child in child care (at home or at a facility)? (yes, no)
7. How would you rate the quality of your child's care at the facility as compared with pre-COVID-19? (better, about the same, worse)
8. What influences your opinion (better, about the same, worse) regarding the quality of your child's care at the facility when comparing now with pre-COVID-19?
9. How would you rat ethe quality of your child's school/child care compared with pre-COVID-19? (better, about the same, worse)
10. What influences your opinion (better, about the same, worse) regarding the quality of your child's school/child care when comparing now with pre-COVID-19?
11. Has your child's school format (e.g. in-person, hybrid, online) changed since we sent the last survey (October 2020) to the present time? (yes, no)
12. Please tell us how your child's school format (e.g. in-person, hybrid, online) has changed since we last sent the survey (October 2020) to the present time.
13. Were you provided a choice regarding your child's current school format (e.g. you chose to have your child attend school online, although in-person was provided)? (yes, no)
14. What influenced your choice of school format (if it varies by child, please describe for each child (i.e., for my child in college, we chose to have online because his school is 30 miles from home; for my fourth grader, we chose in person because it's hard to work uninterrupted when she's home)?
15. Is your child's school currently offering any after school activities? (yes, no other)
16. Have any of the following stressors occurred at least in part due to your child(ren)'s school/child care format and/or job requirements throughout COVID-19? (No new stressors; change in job status (i.e., new position, new company); change in relationship status; additional family members moving into your residence; your family moving temporarily; your family moving permanently; increased personal stress/anxiety; other)
17. Please indicate if you have experienced any of the following job impacts: 1) Timeliness for projects/assignments were extended; 2) A promotion(s) was/were delayed, 3) Challenges with concentrating, 4) I spend less time transporting children to/from school, 5) I spend more time transportation children to/from school, 6) I have less time to pursue grant funding, and 7) I have less time to pursue new project work.

18. Have you experienced any additional positive impacts to your job as a result of your child(ren)'s school/child care format? (yes, no)
19. Please describe the additional positives that resulted from your child(ren)'s school/child care format on your job.
20. Have you experienced any additional negative impacts to your job as a result of your child(ren)'s school/child care format? (yes, no)
21. Please describe the additional negatives that resulted from your child(ren)'s school/child care format on your job.
22. Do you have any additional insights that you would like to share that can help describe the experiences of women in STEM who have been impacted by changes to school/child care formats?

May 2021 Survey Questions

1. How would you describe your current level of concern for your immediate family if they contract COVID-19? (very concerned, concerned, neutral, not concerned, not at all concerned)
2. What influences your level of concern (please type in your response)?
3. From the time we sent the second survey in April of 2021 to the end of the school year, did your child's school/child care facility type change (e.g. public to private; private to public; public to homeschool; childcare to care at home (or with family); other)? (yes, no)
4. Please tell us how your child's school/child care facility type changed from when we last sent the survey (April of 2021) to the end of the school year (e.g., public to private; private to public; public to homeschool).
5. Were you provided with a choice regarding your child's school/child care format between April 2021 and the end of the school year (e.g. you chose to have your child attend school online, although in-person was provided)? (yes, no)
6. What influenced your choice of school/child care format for your child (e.g., we chose to remain virtual because his school is 30 miles from home and there is no bus service)?
7. Between April 2021 and the end of the school year, did your child's school offer any after school activities? (Yes, they're in person; Yes, they're virtual; No; N/A, my child is in child care; other)
8. Have you experienced any negative impacts to your job as a result of your child's school/child care format? (yes, no)
9. Please describe the negative impacts that resulted from your child's school/child care format on your job.
10. Have you experience any positive impacts to your job as a result of your child's school/child care format? (yes, no)
11. Please describe the positive impacts that results from your child's school/child care format on your job.
12. Have you experienced, or do you continue to experience, any of the following stressors, at least in part due to your child's school/child care format and/or job requirements since the last survey in April of 2021 and the end of your child's school year? (No new stressors; change in job status (i.e., new positions, new company); change in relationship status; additional family members moving into your residence; your family moving temporarily; your family moving permanently; increased personal stress/anxiety; other)
13. Please indicate if you have experienced any of the following job impacts since the last survey in April of 2021 and he end of your child's school year: 1) Timelines for projects/assignments were extended; A promotion(s) was/were delayed; Challenges with concentrating; I spend less time transporting children

to/from school; I spend more time transporting children to/from school; I have less time to pursue grant funding; I have less time to pursue new project work; I feel less like a part of the team.

14. Over the course of the pandemic (roughly March 2020 through today), have you considered leaving your job? (often, sometimes, maybe, never)
15. Over the course of the pandemic (roughly March 2020 through today), have you put off pursuing a promotion? (yes, maybe, no)
16. Do you wish that any changes to school/child care format would have been handled differently during the COVID-19 pandemic? (yes, no)
17. What changes could your child's school/child care format could have been implemented that would have been helpful to you and your family?
18. Do you have any final comments, suggestions, or considerations that you would like to share regarding the impact of school/child care format on women in STEM?