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COVID-19, Childcare and Women's Labor Supply

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We examine whether the impacts of COVID-19 on labor supply differ across women with different degrees of childcare burden during the initial stage of the pandemic in South Korea. To identify the effect of the outbreak, we exploit the fact that the first wave of the outbreak in South Korea was concentrated in a specific region due to a largescale religious gathering. Utilizing the Local Area Labour Force Survey, we find that the negative impact was larger for women with young children than for women without young children. Specifically, our preferred specification suggests the employment rate of women with young children decreased by 3.9 percentage points more than that of women without young children due to the COVID-19 outbreak. Women with young children also reduced weekly working hours more than their counterparts without young children. Unlike women, the impacts of COVID-19 on the labor supply among men with and without young children were not different.

JEL Classification: J13, J16, J21, J22
Keywords: COVID-19, Labor Supply, Gender, Childcare

I. Introduction

The COVID-19 pandemic caused not only a massive health crisis but also a large and immediate negative shock on labor markets. In particular, the number of employed people plummeted since March 2020—from plus 494 thousand year-to-year in February to negative 195 thousand year-to-year—when the first wave of the epidemic outbreak began to affect the labor market.

This paper contributes to the literature by examining the impact of the COVID-19 on labor market, particularly the heterogeneity of the impact on female labor

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supply in South Korea. Specifically, we examine whether the magnitude of the negative shock on labor supply due to the COVID-19 varied with caregiving burden within female workers. The negative impact of the COVID-19 on labor supply was expected to be larger for women than for men as sectors with high female employment shares such as service sector were severely affected and the increased childcare burden would disproportionally fall to women (Alon et al., 2020a; Alon et al., 2020b). Empirical evidence from the U.S. and European countries supports the expectation that the labor market shock due to the COVID-19 outbreak was harder for women than men (Adams-Prassl et al., 2020; Farré et al., 2020; Montenovo et al., 2020; Collins et al., 2020). Specifically, Sevilla and Smith (2020), Del Boca et al. (2020) and Zamarro and Prados (2020) confirm that women bear the majority of the extra burden in childcare and housework due to the COVID-19. As the result of this discrepancy in childcare burden, the impact of the COVID-19 on labor supply could also vary within gender. Using the data from the U.S., Russell and Sun (2020) and Heggeness (2020) both document that the negative impact of the COVID-19 on labor supply is larger for women with young children than for women without young children in the U.S.

As the gender norms regarding the division of labor in childcare differ across countries, the cost of childcare levied on women, in turn, leading to the reduction of labor supply, could also differ across countries. Moreover, as the aspects of the COVID-19 outbreak were substantially different across countries, the literature based on empirical settings in other countries might have yielded limited implications to the Korean contexts. Therefore, we extend our understanding on the effect of COVID-19 on labor supply by documenting the differential labor supply responses among female workers using the empirical settings of South Korea.

We examine the impact of the pandemic by exploiting the nature of the first wave of COVID-19 outbreak in South Korea. Specifically, the confirmed cases of the first wave of the outbreak were concentrated in Daegu and a neighboring province of Daegu, Gyeongsangbuk-do (Gyeongbuk, henceforth). Although there was no regional variation in the policy measures such as social distancing and closure of childcare facilities across regions during the first wave of the outbreak in Korea, the labor supply shock due to the fear of infection was disproportionately large in Daegu and Gyeongbuk (Aum et al., 2021). By utilizing the Local Area Labour Force Survey, we identify the impact of the first wave of the COVID-19 outbreak on labor supply, and explore the heterogeneity of the impact within gender using information regarding the age of the youngest child in the household. That is, we examine whether the negative impact of the COVID-19 epidemic in Daegu-Gyeongbuk area differs across females by the existence of young children in each household, that imposes caregiving burden to families. Our empirical result suggests that the COVID-19 hit harder on the labor supply of women with young children. The result from our preferred specification suggests the labor supply of

women with young children decreased by 3.9 percentage points more than that among women without young children.

We remain agnostic about the underlying reasons for the heterogeneity in the labor supply across women with and without young children. That is, neither the purpose nor the contribution of the paper is to identify the exact mechanisms behind our findings. However, further analysis employing the male workers sample suggests that burden of caregiving might have driven our result. Unlike women, we do not find that the COVID-19 had a harder impact for male workers with young children than for those without young children.[1] The observed patterns regarding the gender difference in the labor supply shock suggest that the women took a larger share of the increased childcare responsibility during the pandemic.

The rest of the paper is organized as follows; Section 2 explains the empirical setting regarding the first wave of the COVID-19 outbreak in South Korea. Section 3, summarizing the data employed in this paper, is followed by the empirical specification to identify the heterogeneous impact of COVID-19 on labor supply, in Section 4. In Section 5, we present the main empirical findings and provide the results from various robustness checks. Section 6 offers the summary and implications of this paper.

II. The First Wave of the COVID-19 in South Korea

We exploit a regional disparity in the number of confirmed cases of the COVID-19 in the spring 2020 to identify the impact of COVID-19 on labor market participation. In particular, the first wave of the COVID-19 in South Korea was mostly concentrated in the Daegu-Gyeongbuk area.

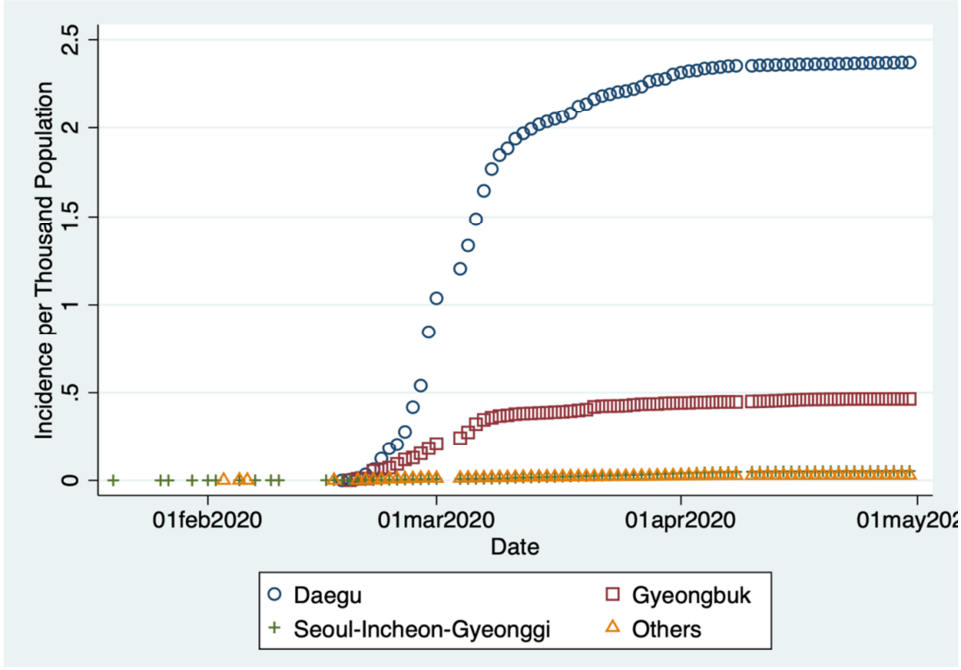
The first confirmed case of COVID-19 in South Korea was a 35-year-old Chinese woman reported on January 20th. For the following month, the number confirmed cases increased gradually. Only 30 confirmed cases were reported until February 18, 2020, approximately one daily confirmed case since the first case was reported. The situation changed rapidly on February 18 when the 31st case was confirmed in Daegu, a member of a religious organization called "Shincheonji". It turned out that some people infected with the COVID-19 including the 31st case attended a largescale religious gathering of "Shincheonji" in Daegu, and that led to the disproportional degrees of the exposure to the COVID-19 across regions.

After the contacts of the 31st case was traced, the number of cases drastically increased in the following week, marking the beginning of the first wave of COVID-19 outbreak in South Korea. The characteristics of the first wave could be

[1] It is worth noting that in the U.S. fathers with children reduced working hours more compared to men without children in response to the COVID-19 outbreak (Kalenkoski and Pabilonia, 2020).

mostly summarized as being concentrated in specific regions—Daegu and Gyeongbuk—originated from a single religious group. Figure 1 provides the trend in the number of the confirmed cases per thousand population in Daegu, Gyeongbuk, Seoul metropolitan area (Seoul, Incheon and Gyeonggi-do) and the rest of the cities and provinces during the first wave of the COVID-19 outbreak. One can verify that most of the confirmed cases were contained in Daegu-Gyeongbuk area where the first wave of outbreak was originated. Therefore, the negative impact of COVID-19 on labor market outcomes in the spring was expected to be much severe in Daegu-Gyeongbuk region although the COVID-19 spread throughout the country and has affected the entire economy.

[Figure 1] COVID-19 Infections per Thousand Population

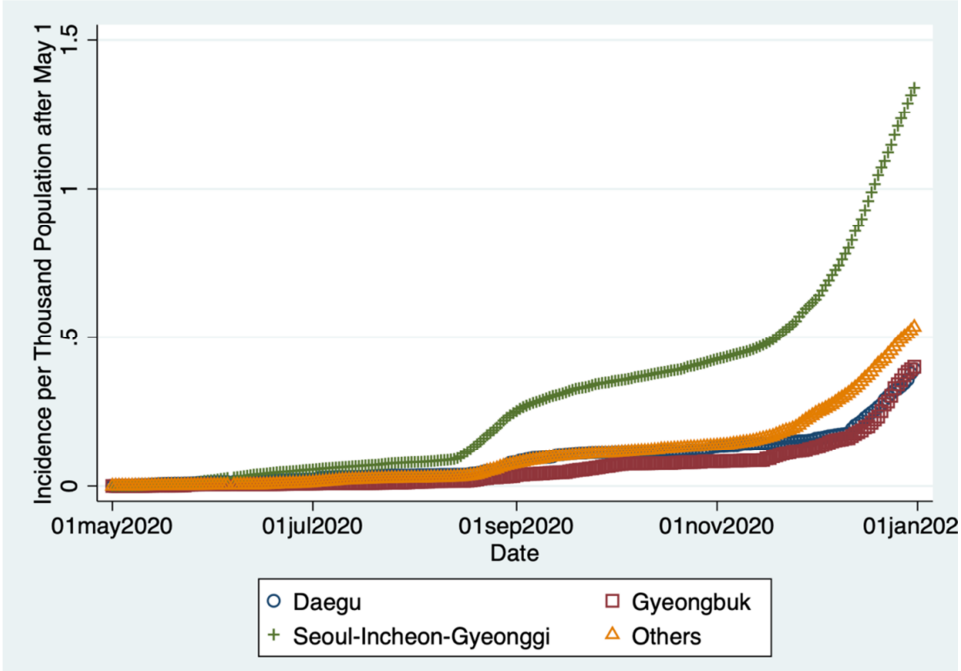


Note: Each curve is the cumulative confirmed cases per thousand population in Daegu, Gyeongsangbuk-do (Gyeongbuk), Seoul-Incheon-Gyeonggi-do (Seoul Metropolitan area), and all other regions, respectively, in the spring 2020 in South Korea.

We believe that this disproportional degrees of exposure to the COVID-19 are arguably exogenous. Prior to the first outbreak, Daegu and Gyeongbuk did not exhibit particularly different trends in the number of confirmed cases compared to other regions. Moreover, other economic activities such as the share of national GDP and employment have been stable in recent years (Aum et al., 2021). That is, except for the fact that the religious gathering was held in Daegu, there were no time-varying region-specific characteristics of Daegu and Gyeongbuk that made the

regions particularly vulnerable to the COVID-19. In particular, from Figure 2, one can verify that after the first wave of the outbreak have ended, the incidence of COVID-19 in Daegu-Gyeongbuk was not higher than that in other regions. These pieces of evidence support that the concentration of the confirmed cases in Daegu-Gyeongbuk during the first wave of the pandemic was an idiosyncratic event.

[Figure 2] COVID-19 Infections per Thousand Population Excluding cases before May 2020



Note: Each curve is the cumulative confirmed cases excluding earlier cases before May 2020 per thousand population in Daegu, Gyeongsangbuk-do (Gyeongbuk), Seoul-Incheon-Gyeonggi-do (Seoul Metropolitan area), and all other regions, respectively.

III. Data

We use the Local Area Labour Force Survey (LALFS hereafter) to explore the heterogeneous impact of COVID-19 on labor supply among female workers with different degrees of caregiving burden. The LALFS is collected in every April and October by the Statistics Korea, and each wave of the survey is based on household members aged 15 or over from approximately 200,000 representative sample of households. The number of respondents in each wave is approximately 400,000. The survey mainly focuses on the economic activity of respondents, and reports variables related to their economic activities including their employment status and weekly working hours. It also contains respondents' socio-demographic information

such as age, sex, education level, marital status and location of residency.

There are several advantages in using the LALFS to analyze the labor market activity among female. First, it includes female sample regardless of their status of economic activity, so we can examine the characteristics of women who withdraw from the work force. Another important piece of information that we utilize from this survey is the age of the youngest child. We believe that the effect of the outbreak on female's labor market supply may differ across their childcare burden, which could be reflected in the age of the youngest child. This information with the location of their residency is available in the LALFS since October 2015, thus our analysis will employ the LALFS from October 2015 until April 2020, which was two months after the first major COVID-19 outbreak in Daegu-Gyeongbuk region.[2]

In this study, we employ three dependent variables, a dummy variable indicating whether a respondent is employed, a dummy variable indicating whether a respondent is economically inactive, and hours of working in a week. Note that the survey regards a respondent being employed if he or she works at least one hour to seek earnings in the week of survey. Even if he or she is not paid, one is regarded as being employed if working for at least 18 hours a week at one's family businesses. In addition, people who have jobs or have own businesses but did not work temporarily at the time of survey because of accident, illness, training, vacation and/or labor-management dispute, are also regarded as being employed. Hours of working in a week include hours of working for the secondary jobs (if exists) as well as for the main job.

Our hypothesis is that women who have more childcare burden would have reduced their labor supply more during the pandemic because the access to caregiving facilities was limited. Although we cannot directly measure the childcare responsibility of each female respondent, we use information on whether a respondent has young children who need substantial care in the absence of caregiving facilities. To be specific, we construct an indicator variable taking one if a respondent has a child with age seven or less in order to reflect the childcare burden of the respondent using the information about the age of the youngest child.[3] The indicator variable about the presence of young child allows us to compare the effect of COVID-19 on the labor supply among women with a young child and that among women without a young child. Women without a young child include married and unmarried women without any child, and women whose youngest

[2] As the reference week for the LALFS in April 2020 was the week containing April 15, that is, April 12 to April 18, the last wave of the survey employed in this paper would capture the employment shock from the first wave of the COVID-19 outbreak which was concentrated in Daegu-Gyeongbuk area.

[3] We adopt seven years old as a cutoff for the age of the youngest child based on the mandatory schooling start age in Korea. A child aged six usually enter an elementary school and start formal schooling. Although we adopt seven years old for the cutoff in the main analysis, we adopt other age cutoffs for the robustness checks, and our results are robust to small changes in the age cutoff.

child is older than the age cutoff.[4] In addition, we utilize various control variables, age, education level, marital status, number of children under 18 and the location of residency which could potentially affect their labor market activities.

Table 1 summarizes the LALFS data from October 2015 until April 2020. Panel A of Table 1 summarizes the female sample used for our main analysis, which is composed of approximately two million females. Columns (1) and (2) report the mean and standard deviation of variable indicted in the row heading. Panel B describes the male sample in the LALFS. The last row of the table shows the number of observations in each sample.

[Table 1] Summary Statistics

Variable	Mean (1)	SD (2)	Mean (3)	SD (4)
	Panel A: Female		**Panel B: Male**	
Daegu-Gyeongbuk (DG)	0.100	0.301	0.100	0.300
Employed	0.506	0.500	0.709	0.454
Economically Inactive	0.474	0.499	0.262	0.44
Hours of working	19.809	21.748	31.414	22.476
Age	47.185	18.318	45.436	17.137
Have underage children	0.226	0.418	0.233	0.423
The youngest child is 7 years old or younger. (AY7)	0.109	0.311	0.118	0.323
Education				
Less than high school graduate	0.296	0.457	0.194	0.395
High school graduate	0.361	0.480	0.397	0.489
More than some college education	0.342	0.474	0.409	0.492
Marital Status				
Single	0.246	0.431	0.324	0.468
Married	0.576	0.494	0.608	0.488
Widowed	0.126	0.331	0.022	0.146
Divorced	0.053	0.224	0.046	0.210
Number of Underage Children				
0	0.774	0.418	0.767	0.423
1	0.105	0.306	0.107	0.309
2	0.102	0.303	0.106	0.308
3+	0.019	0.136	0.020	0.139
	N=2,043,351		N=1,803,755	

Note: Panels A and B describe female and male samples, respectively. The numbers in columns (1) and (3) show the mean of continuous, discrete and indicator variables, and the relative frequency of each categorical variables in the sample indicated in each panel. The numbers in column (2) and (4) show the standard deviation of each variable. The last row reports the number of observations of the sample in each panel.

[4] We also adopt alternative samples that are restricted based on respondent' age, marital status and the presence of underage children for robustness checks.

Daegu-Gyeongbuk (DG hereafter) is an indicator variable taking one if respondent's location of residency is Daegu or Gyeongsangbuk-do. Approximately 10% of respondents reside in this region. Approximately 50.6% of females in the sample are employed, and they work for 20 hours a week on average. Approximately 23% of females raise children under 18 years old, and 11% have children whose age is seven or younger. The male sample, which is summarized in Panel B of Table 1, is comprised of 1.8 million respondents, and 10% of them reside in Daegu-Gyeongbuk region. The employment rate for male is approximately 71%, and they work for 31 hours a week on average.

IV. Empirical Strategy

We employ an empirical framework that captures heterogeneity in the impact of COVID-19 during the first wave, which disproportionally affected Daegu-Gyeongbuk, across women with different degrees of caregiving burden. In other words, we examine whether the negative labor market shock in Daegu-Gyeongbuk due to impact of the COVID-19, was larger for women with young children, who are likely to bear childcare burden, than female workers without young children.

To be specific, we estimate the following equation using the ordinary least squares (OLS),[5]

$$Y_{idt} = \beta Post_t \cdot DG_d \cdot AY7_{it} + \gamma Post_t \cdot DG_d + \delta Post_t \cdot AY7_{it} + \eta DG_d \cdot AY7_{it} + X'_{idt}\Theta + \lambda_d + \mu_t + \varepsilon_{idt} \quad (1)$$

where Y_{idt} is a labor market outcome such as employment status and working hours for an individual i residing in a province d at the time of survey t. $Post_t$ is an indicator variable which take a value equal to one if the survey was conducted after the COVID-19 outbreak in the early 2020.

DG_d is an indicator variable taking one if the location of residence d is Daegu or Gyeongbuk, in which a disproportionately large number of cases of COVID-19 was confirmed as of April 15, 2020 when the last wave of the survey used in this paper was conducted. $AY7_{it}$ indicates whether a respondent has children aged seven or younger. In particular, the variable reflects whether a family has caregiving burden. The coefficients of the interest are β and γ; γ captures the impact of COVID-19 on labor supply among female without young children, and β summarizes the difference in the impact between females with and without young

[5] Although two of our main dependent variables are binary, we adopt a linear probability model instead of logit or probit for the convenience in the interpretation. In particular, whether to use a linear or a nonlinear model matters little for the marginal effects according to Angrist and Pischke (2009).

children. We also include various covariates in the estimating equation. X_{idt} represents various individual characteristics including $AY7_{it}$ and characteristics such as age, age squared, marital status and education level which could be associated with both having a young child and labor market outcomes of female workers. λ_d and μ_t indicate province-fixed and time-fixed effects, respectively. The error term ε_{idt} is clustered at the region level, where the impact of the first wave of COVID-19 varies.

It is important to note that the total effect of the COVID-19 outbreak on labor force from both the nationwide negative shocks and the stagnated local economic activities could be different from our estimate. Our estimate is based on the comparison between Daegu-Gyeongbuk region with other regions in Korea, before and during the COVID-19 outbreak in the spring 2020. Therefore, our estimate does not capture the negative impact of COVID-19 on labor market stemming from the social distancing or other policy measures to slow the spread of disease which were applied nationwide.

V. Results

In this section, we present our estimation results using the dataset and the methodology described in Sections 3 and 4, respectively. First, we present our main finding on the impact of the COVID-19 on labor supply, and then present the results from various robustness checks.

We examine the impacts of the COVID-19 outbreak, that imposes substantial caregiving burden on families, on labor force among women and how the impacts differ across people with and without young children. Because the access to most childcare facilities including kindergartens and schools was restricted in March and April 2020, the burden of childcare sharply increased in the spring 2020. In addition, the fear of infection at those facilities deterred families from utilizing caregiving facilities, which in turn increased the caregiving burden to families especially in Daegu-Gyeongbuk. The increased caregiving burden along with the limited access to safe childcare facilities would have affected the labor supply decision, especially among females, who usually take more of the related burden.

In Table 2, we report the estimation result of equation (1) using an indicator for being employed, an indicator for being economically inactive and weekly working hours in the natural logarithm as outcome variables. All the regressions control for age, age squared, education level, marital status, number of children under 18 and variables indicating the age of the youngest child. We also include time of survey fixed effects and region fixed effects.[6]

[6] Table 2 reports the coefficients of interest, those on $Post \cdot DG \cdot AY7$ and $Post \cdot DG$, only. The

[Table 2] The Effect of the COVID-19 Outbreak in the Spring 2020 on Labor Supply among People with and without Young Children

Dependent Variable	(1) Employed	(2) Inactive	(3) Working Hours, in log
Panel A: Female			
Post*DG*AY7	-0.0385***	0.0342***	-0.138***
	(.0074)	(.0087)	(.0281)
Post*DG	-0.0300**	0.0341**	-0.105**
	(.0121)	(.0149)	(.0481)
Adjusted R^2	0.164	0.176	0.178
N	2,043,351	2,043,351	2,043,351
Panel B: Male			
Post*DG*AY7	0.00672	-0.00647	0.0163
	(.004)	(.0041)	(.0257)
Post*DG	-0.0188***	0.0175***	-0.0651***
	(.0032)	(.0048)	(.0148)
Mean of dependent variable	0.699	0.282	2.622
Adjusted R^2	0.357	0.375	0.378
N	1,803,755	1,803,755	1,803,755

Note: 1. DG is an indicator variable taking a value of one if a respondent resides in Daegu city or Gyeongsangbuk-do (Gyeongbuk), where the COVID-19 outbreak in the spring 2020 was the most severe in Korea. Post is an indicator variable taking a value of one for periods after the COVID-19 outbreak. AY7 is an indicator variable taking a value of one if the youngest child of a respondent is seven years old or younger.
2. The sample in Panels A and B are comprised of females and males, respectively.
3. For all the regressions, we include Post, DG, AY7 and their interaction terms. We also include a set of characteristics of respondent such as age, age squared, marital status, education level, number of children under 18, a set of dummy variables for time of survey (year-by-month) and a set of dummy variables for respondent's region of residence.
4. Standard errors in parentheses are clustered at the region level. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$.

The results presented in Panel A of Table 2 document the impact of COVID-19 on female labor supply. They show that the employment rate among females without children under seven reduced by approximately three percentage point in Daegu-Gyeongbuk relative to other regions due to the COVID-19 outbreak, which is captured by the coefficient on $Post \cdot DG$ in Equation (1). Females with children younger than seven years old experienced even larger decrease in the employment rate. Specifically, the employment rate among those females decreased by approximately 6.9 (3 plus 3.9) percentage point. The difference in the impact between females with and without young children, summarized by the coefficient on $Post \cdot DG \cdot AY7$, is large and statistically significant. As the sample in this

full regression results including other covariates are reported in Tables A1-A2 in Appendix A.

analysis consists of all females without restrictions regarding age or marital status, the coefficient on $Post \cdot DG \cdot AY7$ is estimated by comparing women with a young child and women without a young child, including unmarried women, married women without a child and married women with a child older than seven years old.[7]

The analysis using an indicator for being economically inactive as a dependent variable, shows that the decrease in the employment rate is mostly due to the increase in economically inactive population, which is consistent with Aum et al., (2021). In addition, we employ the log of weekly working hours as a dependent variable, and find the similar pattern. While females without children under seven years old reduced their weekly working hours by 11% after the COVID-19 outbreak, women with children younger than seven reduced their working hours more substantially by approximately 24%.

Unlike females, we do not find evidence that male workers with young children reduced labor supply more than those without young children. Panel B in Table 2 presents the results from the equation (1) using the male sample. The employment rate among males without young children reduced their labor supply due to the COVID-19 outbreak by 1.9 percentage point, and the males with young children reduced the labor supply by similar magnitude. The average weekly working hours among males decreased by 6.5% regardless of whether they have young children or not.

As relatively older children such as teenagers impose much less caregiving burden on families, we expect to find the effect of COVID-19 among females with relatively older children is similar to that among females without children under 18 if the patterns that we find in the main analysis were attributed to childcare burden. To test our hypothesis, we adopt a categorical variable indicating the range of the age of the youngest child instead of $AY7$, and we examine whether the effect of the COVID-19 outbreak differs across women without any underage children, women with children aged seven or younger, women with children older than seven and younger than 13, and women with children aged between 13 and 18. Table 3 summarizes the results of the regression adopting this categorical variable instead of $AY7$ otherwise as same as in the main analysis. Column (1) shows that the employment rate among females without any minor children decreased by 3.1 percentage points due to the COVID-19 outbreak. While women with children aged between 8∼12 and 13∼18 experienced the decrease in the employment rate similar to that among females without any children under 18, women with children younger than seven experienced much severe decrease like in our main analysis. For

[7] As robustness checks, we perform identical analyses using alternative samples with restrictions such as regarding their ages, marital status and the presence of underage children. The results from these additional analyses are presented in Table 6.

other outcome variables, we observe the same pattern. This set of results implies that the decrease in the labor supply among women with young children during the pandemic is likely to owe to the increased childcare burden.

[Table 3] The Differential Effect of the COVID-19 Outbreak in the Spring 2020 on Labor Supply among Females with Children with Different Ages

Dependent Variable	(1) Employed	(2) Inactive	(3) Working Hours, in log
Post*DG	-0.0313***	0.0353**	-0.109**
	(.01)	(.0126)	(.0407)
Post*DG* 1(0 ≤ AY ≤ 7)	-0.0371***	0.0330***	-0.134***
	(.0076)	(.0071)	(.0273)
Post*DG* 1(8 ≤ AY ≤ 12)	0.0111	-0.00722	0.0390
	(.0275)	(.0251)	(.0952)
Post*DG* 1(13 ≤ AY ≤ 18)	0.0132	-0.0150	0.0368
	(.0138)	(.0159)	(.0436)
Adjusted R^2	0.164	0.176	0.178
N	2,043,351	2,043,351	2,043,351

Note: 1. DG is an indicator variable taking a value of one if a respondent resides in Daegu city or Gyeongsangbuk-do (Gyeongbuk), where the COVID-19 outbreak in the spring 2020 was the most severe in Korea. Post is an indicator variable taking a value of one for periods after the COVID-19 outbreak. $1(a_1 \leq AY \leq a_2)$ is an indicator variable taking a value of one if the age of the youngest child of a respondent (AY) belongs to the range of $(a_1 \leq AY \leq a_2)$.

2. For all the regressions, we include Post, DG, Post*DG as well as their interaction terms with each of $1(a_1 \leq AY \leq a_2)$. We also include a set of characteristics of respondent such as age, age squared, marital status, education level, number of children under 18, a set of dummy variables for time of survey (year-by-month) and a set of dummy variables for respondent's region of residence.

3. Standard errors in parentheses are clustered at the region level. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$.

We find that the impact of COVID-19 on labor supply varies within females. Specifically, there is a gap in the impact between females with and without young children while there is no discernible gap between male workers with and without young children. Although we cannot identify the mechanisms behind our findings, this discrepancy suggests that the increased childcare burden during the pandemic disproportionally fell to women, which could have led to the decreased in their labor supply. This disproportional share of caregiving burden might have happened because gender norms let the burden fall on women or because a person with a lower income, usually female, are more likely to drop out the work force when families need a caregiver.

In addition to our main analysis, we perform three different sets of robustness

checks, and the regressions results from those robustness checks are reported in Tables 4 through 6. First, we employ various specifications. In particular, we examine whether the effect of the COVID-19 outbreak we find in the main analysis is simply driven by the different trends of outcome variables across regions. Because we compare the changes in Daegu-Gyeongbuk region with the changes in other regions in Korea, our estimates might be biased if the trend in the employment in Daegu-Gyeongbuk is different from that in other regions. To explicitly control for this possibility, we include region-specific linear trends, in addition to all the regressors included in the main analysis, to allow heterogeneous trends in the outcome variable across regions. The results including region-specific linear trends in the regressions are reported in Panel A of Table 4. For all the outcome variables, the results are similar to our main results not only qualitatively but also quantitatively.

Female labor supply might differ between married females and single females, and between females with a young child and without one. In order to confirm that our main results are not driven by the different trends of labor supply between groups defined based on their marital status and the presence of a young child in a household, we include group-specific linear trends in addition to all the regressors used in the main analysis. Panel B of Table 4 presenting the regression results from these analyses, confirms that our results from the main analysis are robust to the inclusion of these group-specific linear trends.

As the last specification of the robustness checks, we employ the COVID-19 infection per thousand population in each region instead of an indicator variable for Daegu-Gyeongbuk area in Equation (1). As the reference week of the survey in the spring 2020 was the week including April 15, 2020, we use the COVID-19 infection per thousand population on that day, which ranges from 0.007 in Jeollanam-do to 2.359 in Daegu.[8] The coefficient on the interaction term $Post \cdot Infection$ summarizes the effect on labor supply as the COVID-19 infection per thousand population increases by one, and the coefficient $Post \cdot Infection \cdot AY7$ captures the difference in the effect between women with and without children aged seven or younger. The regression results are presented in Panel C of Table 4, and they are consistent with the results from our main analysis. Specifically, when the COVID-19 infection per thousand population increased by one, the employment rate among women without young children decreases by 2.1 percentage point, and that among women with young children decreased even further, by 3.96 (2.07 plus 1.89) percentage point.

[8] The COVID-19 infection per thousand population in Gyeongbuk on April 15, 2020 was 0.459, which is the second highest. The third and fourth highest numbers are 0.133 in Sejong-si and 0.062 in Seoul.

[Table 4] Robustness Checks: Various Specifications

Dependent Variable	(1) Employed	(2) Inactive	(3) Working Hours, in log
Panel A: Include Region-specific Linear Trends			
Post*DG*AY7	-0.0387***	0.0346***	-0.139***
	(.0075)	(.0088)	(.0283)
Post*DG	-0.0250*	0.0295**	-0.0921
	(.0125)	(.0134)	(.0531)
Adjusted R^2	0.164	0.176	0.178
N	2,043,351	2,043,351	2,043,351
Panel B: Include Group-specific Linear Trends			
Post*DG*AY7	-0.0371***	0.0327***	-0.133***
	(.0077)	(.0085)	(.0285)
Post*DG	-0.0310**	0.0352**	-0.109**
	(.0115)	(.0143)	(.0455)
Adjusted R^2	0.159	0.171	0.173
N	2,043,351	2,043,351	2,043,351
Panel C: COVID-19 infection per thousand population instead of DG			
Post*Infection*AY7	-0.0189***	0.0140**	-0.0667***
	(.0043)	(.0049)	(.0166)
Post*Infection	-0.0207***	0.0240***	-0.0756***
	(.0014)	(.0019)	(.0057)
Adjusted R^2	0.164	0.176	0.178
N	2,043,351	2,043,351	2,043,351

Note: 1. DG is an indicator variable taking a value of one if a respondent resides in Daegu city or Gyeongsangbuk-do (Gyeongbuk), where the COVID-19 outbreak in the spring 2020 was the most severe in Korea. Post is an indicator variable taking a value of one for periods after the COVID-19 outbreak. AY7 is an indicator variable taking a value of one if the youngest child of a respondent is seven years old or younger. Infection, used instead of DG in Panel C, is the COVID-19 infection per thousand population on April 15, 2020.

2. The samples in Panels A through C are identical to the sample used in our main analysis.

3. For all regressions, we include Post, DG (Infection in Panel C), AY7 and their interaction terms. We also include a set of characteristics of respondent such as age, age squared, marital status, education level, number of children under 18, a set of dummy variables for time of survey (year-by-month) and a set of dummy variables for respondent's region (Si-do) of residence. The regressions reported in Panel A additionally include region-specific linear trends. The regressions reported in Panel B additionally include linear trends with different slopes for different groups based on their marital status and whether having a young child.

4. Standard errors in parentheses are clustered at the region (Si-do) level.

In addition to adopting various regression specifications, we also examine whether our results are robust to small changes in the age cutoffs. Instead of $AY7$ taking one if a respondent has a child aged seven or younger, we adopt $AY6$ (or $AY8$), which takes one if a respondent has a child aged six (eight) or younger. The

results using $AY6$ and $AY8$, presented in Panels A and B of Table 5, confirm that our main results do not change much despite different age cutoffs for young children adopted in the regressions.

[Table 5] Robustness Checks: Alternative Age Cutoffs for the Youngest Child

	(1)	(2)	(3)
Dependent Variable	Employed	Inactive	Working Hours, in log
Panel A: Adopt AY6 instead of AY7			
Post*DG*AY6	-0.0309***	0.0253*	-0.105***
	(.0081)	(.0128)	(.0335)
Post*DG	-0.0310**	0.0352**	-0.109**
	(.0125)	(.0152)	(.0493)
Adjusted R^2	0.164	0.177	0.179
N	2,043,351	2,043,351	2,043,351
Panel B: Adopt AY8 instead of AY7			
Post*DG*AY8	-0.0324***	0.0292***	-0.118***
	(.0056)	(.0085)	(.0229)
Post*DG	-0.0300**	0.0341**	-0.105**
	(.0123)	(.0152)	(.0488)
Adjusted R^2	0.164	0.176	0.178
N	2,043,351	2,043,351	2,043,351

Note: 1. DG is an indicator variable taking a value of one if a respondent resides in Daegu city or Gyeongsangbuk-do (Gyeongbuk), where the COVID-19 outbreak in the spring 2020 was the most severe in Korea. Post is an indicator variable taking a value of one for periods after the COVID-19 outbreak. AY6 (AY8) are indicator variables taking a value of one if the youngest child of a respondent is six (eight) years old or younger, which are adopted instead of AY7.

2. The samples in Panels A and B are identical to the sample used in our main analysis.

3. For all regressions, we include Post, DG, AY6 (or AY8 in Panel B) and their interaction terms. We also include a set of characteristics of respondent such as age, age squared, marital status, education level, number of children under 18, a set of dummy variables for time of survey (year-by-month) and a set of dummy variables for respondent's region (Si-do) of residence.

4. Standard errors in parentheses are clustered at the region (Si-do) level.

As the last set of robustness checks, we use alternative samples of females with some restriction. We limit our sample in three different ways, their age, marital status and the presence of underage children in a household. The differential effect that we found in the main analysis, might be attributed to the difference across ages, across marital status across the presence of a child, not to whether to have a young child to take care. Although we have explicitly addressed this possibility by including age, age squared, marital status and the number of children aged 18 or less as covariates, we check whether our main results are still valid in a restricted sample of females aged between 25 and 45, a restricted sample of females with a

spouse, and a restricted sample of females with underage children aged between 0 and 18. Panels A through C in Table 6 document the results based on the restricted samples. The result shows that the implication of our main findings is robust to the restrictions imposed the samples.

[Table 6] Robustness Checks: Various Samples

Dependent Variable	(1) Employed	(2) Inactive	(3) Working Hours, in log
Panel A: Females aged between 25 and 45			
Post*DG*AY7	-0.0241***	0.0256***	-0.0847***
	(.0063)	(.0087)	(.025)
Post*DG	-0.0429***	0.0410**	-0.152**
	(.0125)	(.0155)	(.053)
Adjusted R^2	0.090	0.112	0.096
N	481,185	481,185	481,185
Panel B: Females with a Spouse			
Post*DG*AY7	-0.0423***	0.0392***	-0.145***
	(.0093)	(.0131)	(.0349)
Post*DG	-0.0284	0.0309	-0.106
	(.0179)	(.0203)	(.0658)
Adjusted R^2	0.095	0.100	0.104
N	1,222,815	1,222,815	1,222,815
Panel C: Females with a child aged between 0 and 18			
Post*DG*AY7	-0.0508**	0.0458*	-0.179**
	(.0187)	(.0236)	(.0662)
Post*DG	-0.0174	0.0221	-0.0631
	(.0283)	(.0316)	(.101)
Adjusted R^2	0.059	0.063	0.063
N	382,349	382,349	382,349

Note: 1. DG is an indicator variable taking a value of one if a respondent resides in Daegu city or Gyeongsangbuk-do (Gyeongbuk), where the COVID-19 outbreak in the spring 2020 was the most severe in Korea. Post is an indicator variable taking a value of one for periods after the COVID-19 outbreak. AY7 is an indicator variable taking a value of one if the youngest child of a respondent is seven years old or younger.

2. The sample used in Panel A is composed of females aged between 25 and 45. The regressions in Panel B are based on females with a spouse, and those in Panel C are based on females with a child aged between 0 and 18.

3. For all regressions, we include Post, DG, AY7 and their interaction terms. We also include a set of characteristics of respondent such as age, age squared, marital status, education level, number of children under 18, a set of dummy variables for time of survey (year-by-month) and a set of dummy variables for respondent's region (Si-do) of residence.

4. Standard errors in parentheses are clustered at the region (Si-do) level.

VI. Conclusion

The COVID-19 pandemic has created a massive economic shock which spread through the labor market. Many people have lost their jobs or fail to enter the labor market as the jobs could not be maintained or not be created due to the health crisis. In this paper, we extend our understanding on the negative impact of the COVID-19 on labor market by examining the heterogeneity in the impact among female workers. Specifically, we explore whether women with young children had a larger negative impact than women without young children.

By exploiting the large discrepancy in the number of confirmed cases across regions in the first wave, we analyze the impact of the COVID-19 using the Local Area Labour Force Survey (LALFS). The empirical results suggest that the impact of COVID-19 on labor supply vary within female workers. Compared to women without young children, women with young children are less likely to be employed, and work for fewer hours during the first wave of the outbreak in South Korea. We do not, however, find the similar pattern among men. That is, the negative shock on the labor supply of male workers with young children did not differ from that of male workers without young children.

Although we remain agnostic about the underlying mechanism, the differential effects of the COVID-19 on labor supply suggest that mothers with young children decreased their labor supply as women take the lion's share of childcare responsibility. Combined with the persistence of labor force participation (Clark and Summers, 1982), our findings imply the pandemic could exacerbate the existing gender gap in labor market participation through the different childcare burden. In particular, Albanesi and Kim (2021) and Kim (2021) argue the women's employment losses could have a longer term impact as the occupations severely affected by the pandemic could become susceptible to automation. Furthermore, human capital obsolescence or skill depreciation due to the unemployment and labor market nonparticipation during the pandemic could further reduce women's probability of reentering the workforce or their wage when they decide to work again. Therefore, to mitigate the long-run impact stemming from the job loss and abrupt discontinuity in women's career, the public policies that increase access to childcare, assisting households to balance work and childcare, are highly warranted.

Appendix A

Tables A1 report the full regression results including other covariates of the main regressions, from which the coefficients on $Post \cdot DG \cdot AY7$ and $Post \cdot DG$ are reported in Panel A of Table 2. The coefficient on $Post$ from the regression adopting the employment as a dependent variable, is approximately -0.032 for females, implying that the employment rate among female without a young child in the regions other than Daegu-Gyeongbuk in the first wave of COVID-19 pandemic is lower by 3.2 percentage point compared to that in the pre-pandemic period. The employment rate among female with young children in the regions other than Daegu-Gyeongbuk in the first wave is reduced by 0.8 (-0.032+0.0238) percentage point compared to that in pre-pandemic period. The coefficient on $AY7$ from the same regression is approximately -0.16, and it suggests that women with a young child in the regions other than Daegu-Gyeongbuk tend to have a lower probability of being employed compared to women without a young child in those regions during the pre-pandemic period.

The coefficient of Age is positive whereas the coefficient of Age^2 is negative implying concave relationship between probability of being employed and age. Moreover, probability of being employed among female increase with educational attainment. In particular, the coefficients of both high school graduates and some college education are both positive and statistically significant. Finally, the coefficients of have a spouse, widowed, and divorced show that the females who have never married are more likely to be in the labor force.

[Table A1] The Effect of the COVID-19 Outbreak in the Spring 2020 on Labor Supply among People with and without Young Children, Full Regression Results, Female

	(1)	(2)	(3)
Dependent Variable	Employed	Inactive	Working Hours, in log
Post*DG*AY7	-0.0385***	0.0342***	-0.138***
	(.0074)	(.0087)	(.0281)
Post*DG	-0.0300**	0.0341**	-0.105**
	(.0121)	(.0149)	(.0481)
Post*AY7	0.0238***	-0.0149*	0.0994***
	(.0072)	(.008)	(.0284)
DG*AY7	-0.0383*	0.0403*	-0.132
	(.0212)	(.0193)	(.0761)
Post	-0.0320***	0.0248***	-0.178***
	(.0041)	(.0057)	(.0158)
DG	0.0785***	-0.0773***	0.302***
	(.0037)	(.0039)	(.0125)
AY7	-0.162***	0.165***	-0.632***
	(.0093)	(.0093)	(.0352)
Age	0.0432***	-0.0443***	0.164***
	(4.6e-04)	(4.6e-04)	(.0018)
Age^2	-0.000454***	0.000466***	-0.00174***
	(7.5e-06)	(8.1e-06)	(3.0e-05)
high school graduates	0.0403***	-0.0498***	0.152***
	(.011)	(.0113)	(.0381)
some college education	0.156***	-0.173***	0.571***
	(.0088)	(.009)	(.033)
have a spouse	-0.0928***	0.112***	-0.324***
	(.0072)	(.0084)	(.0247)
widowed	-0.0979***	0.112***	-0.387***
	(.0108)	(.0106)	(.04)
divorced	-0.0760***	0.0831***	-0.249***
	(.0083)	(.0086)	(.0264)
one child aged ≤18	0.00354	-0.00396	0.0190
	(.0114)	(.0107)	(.0401)
two children aged ≤18	0.00961	-0.00911	0.0295
	(.0082)	(.0076)	(.0287)
Adjusted R^2	0.164	0.176	0.178
N	2,043,351	2,043,351	2,043,351

Note: This table presents the results from the identical regressions used in Panel A of Table 2, but it presents the coefficients on covariates that are not reported in Table 2. The coefficient on the dummy variables for region (Si-do) of residence and the dummy variables for time of survey (year-by-month) are suppressed. The omitted category for education attainment is less than high school graduates, and for the marital status, the category of never married is omitted.

Appendix B

Our finding towards the differential effects of COVID-19 across females with and without a young child, might be attributed to the differences in their occupational distribution prior to the COVID-19 outbreak. To explore this possibility, we have calculated the proportion of each occupation among employed women with and young children, and that among women without young children. Table B1 describes the distribution of occupations, classified based on the Korean Standard Classification of Occupations (KSCO), among employed females with and without a young child using the 2019 Spring LALFS, which was conducted prior to the COVID-19 outbreak. As we observe the occupation only for employed females, the proportion is calculated among employed females.

According to Aum et al. (2021), sales and service workers were heavily affected in Daegu-Gyeongbuk region during the first wave of COVID-19. Table B1 shows that the proportion for sales and service workers, that were hit hard by COVID-19, tends to be larger among females without a young child than among females with young children. Although we cannot be definite, the observed difference in occupations among female workers suggests that the labor demand might not have been a major factor in explaining the relative fall in employment of females with young children compared to females without a young child.

[Table B1] Occupation Distribution among Employed Females, April 2019

Occupation	Proportion among employed women without young children	Proportion among employed women with young children
Managers	0.0028	0.0010
Professionals	0.1480	0.3556
Clerks	0.1299	0.2827
Service Workers	0.1796	0.1193
Sales Workers	0.1070	0.1025
Skilled Agricultural, Forestry, Fishery Workers	0.2181	0.0289
Craft and Related Trades Workers	0.0249	0.0154
Equipment, Machine Operating and Assembling Workers	0.0299	0.0316
Elementary Workers	0.1599	0.0630
Total	1.0000	1.0000

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여성의 자녀 양육 부담에 따른 코로나19의 고용 충격

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초 록

본 연구는 대한민국의 코로나19 유행 초기, 여성의 자녀 양육 부담에 따라 코로나19의 유행이 여성의 노동공급에 미치는 영향이 다른지를 분석하고 있다. 코로나19 확산의 효과를 파악하기 위해 본 논문에서는 대한민국에서의 코로나19 1차 유행이 대규모 종교적 모임에 의해 발생하여 특정지역에 집중되어 있었다는 점을 활용하였다. 지역별고용조사를 활용한 분석결과, 코로나19의 유행이 노동공급에 미치는 부정적인 영향은 어린 자녀가 없는 여성에 비해 어린 자녀가 있는 여성에게 더 크게 나타났다. 보다 구체적으로, 어린 자녀가 있는 여성의 고용률은 어린 자녀가 없는 여성에 비해 코로나19의 확산으로 인해 약 3.9% 더 감소하였다. 또한 어린 자녀를 둔 여성의 경우 어린 자녀가 없는 여성에 비해 근로시간의 감소 역시 더 뚜렷하게 관찰되었다. 반면, 남성의 경우에는 코로나19가 노동공급에 미치는 충격의 크기가 어린 자녀의 유무에 따라 다르지 않았다.

핵심 주제어: 코로나19, 노동공급, 여성, 자녀 양육

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