Dual Mediating Effects of Information and Communication Technology Resources and Family Satisfaction on COVID-19 Knowledge Among Middle School Students

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Abstract
Little is known about underlying pathways regarding how middle school students can improve their COVID-19 knowledge. This study investigates the relationship between subjective poverty and COVID-19 knowledge by considering a dual mediation model. A total of 328 middle school students were included. We used a multiple mediator model developed by Preacher and Hayes, using bootstrapping approach to include a first and sequence mediators. We employed the PROCESS macro 3.4 for SPSS to test the dual mediating effects. Both Information and Communication Technology (ICT) resources and family satisfaction mediated the association between subjective poverty and knowledge about COVID-19. Further, an indirect effect of subjective poverty via the dual mediators of ICT resources and family satisfaction was found. Further, middle school students who more satisfied with their family dynamics and who had more ICT resources were more likely to have greater levels of knowledge about COVID-19. This study contributes to further understanding of pathways between subjective poverty and COVID-19 knowledge in the context of dual mediators. It is imperative to help households in poverty before and since COVID-19; specific financial supports that focus on ICT resources should be provided to increase middle school students’ quality of online learning, which then helps to improve family satisfaction. The pathways influence COVID-19 knowledge.

Keywords
COVID-19 knowledge, poverty, middle school student, dual mediating effect

Introduction
Since the emergence of the SARS-COV-2 virus in Wuhan, China, in December 2019, at least 120 million people worldwide have been infected by the virus that causes COVID-19 disease (World Health Organization, 2021). In South Korea, there have been nearly 97,000 confirmed cases and 1,700 confirmed deaths from COVID-19 since the country’s first reported case in January 2020 (Centers for Disease Control and Prevention, 2021). Social distancing measures to prevent the spread of the virus have greatly affected everyone, but adolescents are particularly affected by prevention measures such as the transition to online schooling (Lee et al., 2021). Research has shown that knowledge regarding the risk of COVID-19 is associated with increased engagement in protective behaviors among middle school students (Lee et al., 2021). Thus, it is of interest to examine what factors may influence middle school students’ knowledge of COVID-19, including their access to Information and Communication Technology (ICT) resources, such as broadband internet, computers, or tablets, as well as their relationship with family members, as COVID-19 preventive social distancing measures have caused people to spend more time at home with family, as well as to rely on ICT resources to attend school or work or to safely communicate with people outside their immediate household (Fegert et al., 2020; Wiederhold, 2020).

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2020). It is also of interest to determine whether these factors differ based on socioeconomic status.

**Literature Review**

**Poverty and Family Satisfaction**

Research has shown that levels of income or poverty are associated with family dynamics, measured as parental involvement, conflict in the parent-child relationship and between parents, family cohesion, time spent together as a family, and the ability to cope with daily demands and solve problems (DeCarlo Santiago & Wadsworth, 2009; Mullan Harris & Marmer, 1996; Orthner et al., 2005; Ridge, 2009; Zhang, 2012). In a secondary analysis of the National Survey of Children, children in poverty had fathers who were less involved than families with higher incomes (Mullan Harris & Marmer, 1996). Moreover, researchers in China, Great Britain, and the United States found that families in poverty had more conflict between members than families not in poverty (DeCarlo Santiago & Wadsworth, 2009; Ridge, 2009; Zhang, 2012). Findings on the direction of the relationship between poverty and time spent together as a family were mixed, however. In one study, members of a family with at least one working parent reported spending more time together than members of a family without a working parent (Orthner et al., 2005), while in another study, children of parents not currently working were interviewed and they reported spending more time with their parents because they were at home more often (Ridge, 2009). Further, an inverse relationship between household poverty and a family’s ability to cope with demands and solve problems was found in two studies (Orthner et al., 2005; Ridge, 2009). These findings show that although families in poverty may often spend time together, they experience more conflict and difficulties working together to solve problems and cope with the demands of daily life (DeCarlo Santiago & Wadsworth, 2009; Orthner et al., 2005; Ridge, 2009; Zhang, 2012).

**Poverty and ICT Resources**

In some urban school districts in the United States, up to one-third of students have not attended classes virtually since the COVID-19 pandemic (Dooley et al., 2020). Multiple studies published since the COVID-19 pandemic have demonstrated that having a low income or being in poverty is often associated with decreased access to ICT resources, including access to broadband internet; hardware such as laptops or tablets; or a quiet, uncrowded place to study or work (Blagg et al., 2020; Drane et al., 2020; Kim & Padilla, 2020; Masonbrink & Hurley, 2020; Van Lancker & Parolin, 2020). Using data from the American Community Survey from 2014 to 2018, researchers found that children who are unable to complete schoolwork from home due to lack of a reliable broadband internet connection are more likely to come from low-income households (Blagg et al., 2020). Nearly 7% of children in Europe, 13% of households in Australia, and approximately 14% of students in the United States have no internet access at home, and this latter statistic doubles for students in low-income communities (Drane et al., 2020; Masonbrink & Hurley, 2020; Van Lancker & Parolin, 2020).

Moreover, in a case study of low-income Latino students residing in a high-income community, a significantly lower number of the students examined had access to broadband internet at home (76.4%) or access to a computer or tablet to complete schoolwork (63.6%), compared to citywide averages for internet access (92.3%) and hardware access (96.4%; Kim & Padilla, 2020). Moreover, data from the Australia Bureau of Statistics indicates that while more than 90% of households in high-income communities had internet access at home, this number drops to fewer than 40% of households in low-income communities (Drane et al., 2020).

However, even if a student in a low-income household has access to the internet and/or a computer or tablet, many students in such households do not have a quiet, uncrowded place to study or work at home. In Europe, about 5% of students have encountered this difficulty since the switch to online schooling caused by the COVID-19 pandemic (Van Lancker & Parolin, 2020). Additionally, researchers found a moderate correlation between being in poverty and living in crowded conditions, defined as having more than one person per livable room in a residence, which would make it difficult for students to have a quiet, uncrowded place to complete their work (Blagg et al., 2020). Thus, students in poverty and low-income households are at a disadvantage compared to their higher-income peers since schools switched to online learning because of the COVID-19 pandemic, due to inequitable access to internet, hardware, and a quiet place to work.

**Poverty and COVID-19 Knowledge**

There is some evidence to suggest a direct relationship between family poverty and level of knowledge one has about COVID-19 (Gudi et al., 2020; Pinchoff et al., 2020). In a sample of low-income households in the Philippines, compared to other groups where social media or the internet were used often for receiving knowledge about COVID-19 (Abdelhafiz et al., 2020; Dardas et al., 2020), these low-income families were more likely to receive knowledge about COVID-19 from the television or the radio (Lau et al., 2020). Moreover, among Indian adolescents and young adults, those in higher economic classes/castes reported higher knowledge of COVID-19 symptoms and COVID-19-related safety precautions than those in lower economic classes/castes (Gudi et al., 2020; Pinchoff et al., 2020). In this study, we examined the possible mediating factors affecting the relationship between poverty and COVID-19 knowledge.
ICT Resources, Family Satisfaction, and COVID-19 Knowledge

Digital or technological sources, such as social media or other websites, are common for receiving knowledge or information about COVID-19, including among adolescents (Abdelhafiz et al., 2020; Beaunoyer et al., 2020; Dardas et al., 2020). In one article, the authors discuss the concept of eHealth literacy as it relates to the COVID-19 pandemic; the internet has been widely used to spread information about COVID-19 and being able to access and understand such information requires a certain level of eHealth literacy that people with lower access to the internet and other technology may not have (Beaunoyer et al., 2020). Additionally, in a cross-sectional survey of adults in Egypt, COVID-19 knowledge was significantly lower among people who were older, had less education, had a lower income, and lived in a rural area, all of which are factors that can influence one’s ability to access the internet (Abdelhafiz et al., 2020).

Other than social media or internet sources, adolescents in particular also commonly receive information or knowledge about COVID-19 from their family or parents (Dardas et al., 2020; Riiser et al., 2020; Souli & Dilucca, 2020), which emphasizes the importance of positive family dynamics on COVID-19 knowledge acquisition. Parents or other family members were a primary source of COVID-19 knowledge and information from anywhere between 10% and 81% of adolescents in three samples (Dardas et al., 2020; Riiser et al., 2020; Souli & Dilucca, 2020). In these samples, adolescents received information about COVID-19 from their parents or other family members as or more often as they received such information from electronic or digital sources, such as Facebook, Instagram, or other websites (Dardas et al., 2020; Riiser et al., 2020; Souli & Dilucca, 2020). Therefore, both family satisfaction and ICT resources are mediating factors of interest on the relationship between poverty and COVID-19 knowledge among adolescents.

The Current Study

The novel coronavirus (COVID-19) has had a great impact on lives around the world for more than a year and it still may not be overcome for a while. Until enough people are vaccinated, and we can move into the post-COVID-19 era, it is important for people to obtain knowledge about COVID-19 to protect themselves from the disease. As middle school students are not as mature as adults and have been exposed to negative effects of COVID-19 not only on their health, but also on social and other developmental processes, it is imperative to examine how middle school students can attain knowledge about COVID-19 to protect their health. Generally, poverty may be related to certain COVID-19 knowledge, because poverty may negatively influence the ability to access some knowledge and information. Since COVID-19, households’ economic status, including poverty, greatly influences how easily children can access ICT resources for their online learning and for communication with classmates, and those who meet their needs in ICT resources may be more satisfied with their family relationships and obtain more COVID-19 knowledge through mutual communication with family members. That is, there are complicated pathways to acquiring knowledge about COVID-19 to protect themselves from the unprecedented spread of the virus. Thus, this study aims to identify such pathways among middle school students. However, little is known about underlying pathways regarding how middle school students can improve their COVID-19 knowledge. Therefore, the current study investigates the relationship between poverty and COVID-19 knowledge by considering a dual mediation model. The specific research questions are as follows: (1) Does subjective poverty influence COVID-19 knowledge among middle school students?; (2) Does subjective poverty influence Information & Communication Technology (ICT) resources and family satisfaction?; (3) Do ICT resources and family satisfaction mediate the relationship between subjective poverty and COVID-19 knowledge?; and (4) Is there a dual mediating effect of ICT resources and family satisfaction on the relationship between subjective poverty and COVID-19 knowledge?

Methods

Participants and Sampling

Participants in this study were limited to middle school students in South Korea. They were registered in a public school in Gyeonggi province, which is the most populous province in South Korea. To recruit the middle school students, the research team utilized an official online communication tool, approved by the government, used by both teachers and middle school students. Data collection occurred from September to October 2020. We used Google Forms to generate the questionnaire and a link was posted to the official online communication tool to access the online survey. In the process of creating the questionnaires, we modified the questions based upon experts’ feedback and comments to keep students’ rights protected. Further, we distributed a consent form to both students and parents as the students were not old enough to consent themselves. Once participants finished the survey, which took about 20 minutes, a $2 gift card was delivered to them as a reward. A total of 354 middle school students engaged in this survey. However, we did not include respondents whose parents refused their participation or if they refused to participate themselves. About 328 respondents were included in the final sample. Although this study did not collect any private information such as name, address, and the like, the Institutional Review Board approved this research (#200810-1A).
Measures

COVID-19 knowledge. The COVID-19 knowledge variable measured levels of one’s knowledge regarding how to protect oneself from COVID-19 and how to behave if one experiences some symptom related to COVID-19. Middle school students were asked to respond to the following five questions: “Social distancing is important”; “Wearing a face mask is mandatory”; “Self-quarantine and monitoring symptoms are needed for a period of 14 days if you think you might have been exposed to COVID-19”; “Social gatherings are not recommended”; and “You should follow governmental guidance if COVID positive”. Respondents chose one of the following response options for each question: Strongly disagree, disagree, neutral, agree, or strongly agree. The average score of the five items was computed, with higher scores indicating greater levels of knowledge about COVID-19 ($M = 4.61; SD = 0.48$). The Cronbach’s $\alpha$ of the five-point Likert-type scale was .77.

Subjective poverty. Subjective poverty indicates to what extent middle school students think that their household is in poverty. This scale originated from the Leyden Poverty Line (Kapteyn et al., 1988). The specific question was as follows: “In your circumstances, do you consider your household’s economic status to be good or bad?” Six response options were provided to participants: Very bad, bad, insufficient, sufficient, good, and very good. The six-point Likert-type scale was used to measure subjective poverty. Lower scores indicated high poverty, while higher scores indicated lower poverty ($M = 4.00; SD = 0.90$).

Mediators

Family satisfaction. This variable indicated to what extent respondents were satisfied with their relationships with family members. To measure family satisfaction, we used the Family Satisfaction Scale (Olson, 2011). This scale consists of ten items with a five-point Likert-type scale. Middle school students were queried, for example, how satisfied they were with “the degree of closeness between family members”; “their family’s ability to cope with stress”; “the quality of communication between their family members”; “their family’s ability to resolve conflicts”; and “the amount of time you spend together as a family”. Participants indicated their family satisfaction by selecting one of the following: Very dissatisfied, somewhat dissatisfied, generally satisfied, very satisfied, or extremely satisfied. The average of all items was computed, and higher scores imply greater levels of family satisfaction ($M = 4.25; SD = 0.79$). This scale had a Cronbach’s alpha of .72.

Information & Communication Technology (ICT) resources. In this study, ICT resources were defined as E-learning resources and tools that middle school students have been able to access since COVID-19. Respondents were asked four questions: “I have a high quality of electronic resources that I can use for E-learning (e.g., laptop, smartphone, iPad, or other tablet, etc.)”; “I have my own tools for E-learning, which other family members do not use”; “I have an adequate internet connection speed for E-learning”; and “I have a place for E-learning where I can work without any interruptions.” Respondents reported whether they strongly disagreed, disagreed, were neutral, agreed, or strongly agreed to each question. We computed an average score of all items, with higher scores indicating greater ICT resources ($M = 4.00; SD = 0.90$).

Control variables. Gender, age, and siblings were included as control variables in this study.

Analysis Strategy

To identify dual mediating effects, we used the multiple mediator model developed by Preacher and Hayes (2004, 2008). Based on the model they suggested, a bootstrapping approach was used because it makes it possible to estimate the effect size of indirect effects and to include more than one mediator in a single model. The effects of subjective poverty on COVID-19 knowledge include direct and indirect effects of subjective poverty on COVID-19 knowledge through family satisfaction and ICT resources, which are a first and sequence mediators. We employed the PROCESS macro 3.4 for SPSS to test the dual mediating effects. Research design for the current study was shown in Figures 1 and 2.

Results

Descriptive statistics are shown in Table 1. The average scores of COVID-19 knowledge and subjective poverty were 4.61 and 4.00, respectively. The mean of ICT resources was
The average age of the middle school students was 14.4 years old. About 55% of the sample were girls and 86% of the students had more than one sibling.

As shown in Table 2, subjective poverty was associated with ICT resources and family satisfaction ($\beta = .17$, $p < .001$; $\beta = .19$, $p < .001$, respectively). In other words, middle school students who regarded their households as not in poverty were more likely to have access to greater ICT resources and had higher levels of family satisfaction. ICT resources were also positively associated with family satisfaction ($\beta = .38$, $p < .001$). The dual mediation model is presented in Figures 1 and 2 to explore the association between subjective poverty and COVID-19 knowledge, considering family satisfaction and ICT resources as mediators. Figure 1 shows the total effect of subjective poverty on COVID-19 knowledge, while Figure 2 illustrates the direct and indirect effects after considering the two mediators: Family satisfaction and ICT resources. Tables 2 and 3 represent the findings in Figures 1 and 2. Model 1 in Table 3 indicates that the total effect of subjective poverty on COVID-19 knowledge was not significant. Further, the direct effect of subjective poverty on COVID-19 knowledge was not significant after including mediators (Model 2). As mediators, family satisfaction and ICT resources were significantly associated with COVID-19 knowledge ($\beta = .21$, $p < .001$; $\beta = .08$, $p < .05$). Regarding indirect effects, the indirect effect of subjective poverty via ICT resources was significant ($\beta = .01$, $p < .05$) and the indirect effect of subjective poverty via family satisfaction was also significant ($\beta = .04$, $p < .001$). That is, ICT resources and family satisfaction mediated the relationship between subjective poverty and COVID-19 knowledge. Further, the indirect effect of subjective poverty via dual mediators such as ICT resources and family satisfaction was significant ($\beta = .01$, $p < .05$). In addition, being female was positively associated with COVID-19 knowledge ($\beta = .11$, $p < .05$).

### Discussion

It is important to increase people’s knowledge about COVID-19 to protect their health from the coronavirus and to prevent the spread of COVID-19 around the world. However, there is little evidence regarding how certain factors influence COVID-19 knowledge among middle school students. The current study identified underlying pathways between subjective poverty and knowledge about COVID-19 among middle school students by considering a dual mediation model. This study’s findings revealed that both ICT resources and family satisfaction mediated the association between subjective poverty and knowledge about COVID-19. Further, an indirect effect of subjective poverty via the dual mediators of ICT resources and family satisfaction was found. The model indicated that subjective poverty first influenced ICT resources, which then affected family satisfaction, which last influenced...
knowledge about COVID-19. Additionally, we found that middle school students who thought their family was in poverty were less likely to have ICT resources and had lower family satisfaction than those who didn’t think their family was in poverty. Additionally, middle school students with high levels of family satisfaction and ICT resources tended to have greater knowledge about COVID-19.

Findings in the current study demonstrated that middle school students who perceived their household as being in poverty were likely to have low levels of ICT resources and family satisfaction. These findings align with previous studies, indicating that poverty makes it difficult to access to information or communication technology (Blagg et al., 2020; Dooley et al., 2020; Drane et al., 2020; Kim & Padilla, 2020; Masonbrink & Hurley, 2020; Van Lancker & Parolin, 2020) and brings about family conflict and lower satisfaction with family members (Chen et al., 2018; DeCarlo Santiago & Wadsworth, 2009; East et al., 2020; Mullan Harris & Marmer, 1996; Ridge, 2009; Stock et al., 2017; Zhang, 2012). Since COVID-19, middle school students are required to have advanced tools to facilitate online learning, such as a smartphone or iPad. These items are very expensive, but not having access to such items decreases the quality of E-learning. Even though there may be governmental assistance for ICT resources, such financial supports are often not sufficient for all ICT resources, such as an adequate physical place for E-learning, having one’s own hardware for E-learning, or having a fast internet connection speed. As a result, middle school students in poverty tend to have lower levels of ICT resources.

Moreover, middle school students with high levels of ICT resources showed greater family satisfaction in our study. Students from households in poverty might have conflicts with their parents due to lack of ICT resources or having to share with other family members, leading to lower levels of family satisfaction (Kontos et al., 2007; Mesch, 2006; Rideout & Katz, 2016). As higher ICT resources are available through having a family with access to more financial resources, those with greater ICT resources are also more likely to show greater family satisfaction. Given that this study’s findings focused on the period since COVID-19, the problems that middle school students encountered may get worse, since financial challenges have increased dramatically among individuals in poverty since COVID-19 (World Bank, 2020).

This study also identified that middle school students who more satisfied with their family dynamics and who had more ICT resources were more likely to have open family communication, leading to more frequent opportunities to learn about COVID-19 based on parents’ or caregivers’ knowledge. Further, those with greater ICT resources can more easily access information and knowledge on the Internet by themselves, as well as to attend online classes and chat with teachers and friends. Thus, family satisfaction and access to ICT resources should be deeply considered in the context of COVID-19 knowledge, because they make it possible to have more frequent communication with extended family, teachers and friends, which may then result in greater levels of COVID-19 knowledge.

### Table 3. Direct and Indirect Effects of Subjective Poverty on COVID-19 Knowledge Using SPSS PROCESS.

| Variables | Model 1 | Model 2 |
|-----------|---------|---------|
| (Constant) | 4.49 (0.41) | 3.80 (0.39) |
| Subjective poverty | 0.018 (0.029) | −0.051 (0.029) |
| Age | −0.008 (0.026) | −0.024 (0.024) |
| Gender (girls) | 0.095 (0.053) | 0.111 (0.049)* |
| Siblings | 0.129 (0.076) | 0.133 (0.071) |
| Mediators | | |
| ICT resources | 0.080 (0.035)* | |
| Family satisfaction | 0.214 (0.038)*** | |
| Indirect effects | | |
| Subjective poverty → ICT resources | | 0.014 (0.007)* |
| Subjective poverty → Family satisfaction | | 0.041 (0.011)*** |
| Subjective poverty → ICT resources → Family satisfaction | | 0.014 (0.005)** |

*p < .05. ***p < .01. ****p < .001.
Moreover, this study confirmed that both family satisfaction and ICT resources mediated the relationship between subjective poverty and knowledge about COVID-19 among middle school students. However, subjective poverty did not directly affect knowledge about COVID-19. Thus, it is important to identify underlying mediation pathways between subjective poverty and COVID-19 knowledge among middle school students. First, middle school students who perceived themselves to be in poverty are less likely to be satisfied with their family, leading to decreased communication with their family and thus fewer opportunities to gain knowledge about COVID-19 through their family members. Further, middle school students who perceive themselves to be in poverty may not be able to receive sufficient financial support from their parents to have satisfactory ICT resources. A lack of ICT resources since COVID-19 may result in diminished communications with teachers, friends, and others outside of their immediate household. Given that family and social media sites where they connect with friends are common sources of information on COVID-19 (Dardas et al., 2020; Riiher et al., 2020; Souli & Dilucca, 2020), this corresponds with the finding that middle school students with lower ICT resources had less knowledge about COVID-19.

In this study, we also identified dual mediating effects of ICT resources and family satisfaction on the relationship between subjective poverty and knowledge about COVID-19 among middle school students. The COVID-19 pandemic has affected everyone’s lives in a myriad of ways (e.g., Singh & Singh, 2020). In particular, middle school students’ knowledge about COVID-19 can be greatly influenced by their family, as parents, and family members are primary resources to obtain information and knowledge about what they do not know (Bray et al., 2021; Ceka & Murati, 2016). In the period since COVID-19, ICT resources are also important to receive online education and obtain knowledge about COVID-19, but there is inequity in access to ICT resources based on one’s socioeconomic status (e.g., Drane et al., 2020). Further, those who have low ICT resources may complain to their parents about their lack of ICT resources, which may result in increased family conflict and decreased family satisfaction. Additionally, decreased family satisfaction may bring about less frequent communication and interactions among family members, which may discourage middle school students from accessing information and knowledge about COVID-19 from family members. In other words, subjective poverty first is associated with low levels of ICT resources, and then those individuals with low ICT resources may have more conflict and less cohesion and communication with their family members, which then results in lower levels of knowledge about COVID-19. Thus, middle school students’ COVID-19 knowledge is influenced by these complicated pathways. Based on these pathways, it is imperative to help households in poverty before and since COVID-19; specific financial supports that focus on ICT resources should also be provided to increase middle school students’ quality of online learning. This support by the community or government can improve family relationships and lead to increased satisfaction with family. That is, the associations among subjective poverty, ICT resources, and family satisfaction should be deeply considered to understand levels of COVID-19 knowledge among middle school students.

This study contributes to the understanding of knowledge about COVID-19 among middle school students by considering a dual mediation model. However, interpretations in the current study should be understood based on limitations. First, family structures and economic situations are different in other countries. However, the current study does not consider the cultural and economic differences between South Korea and other countries, so that interpretations in this study are limited. We recommend that future studies account for the pathways between subjective poverty and COVID-19 knowledge in other countries. Second, the target population in this study was middle school students, but we did not address students with disabilities. As they may have different characteristics or experiences that influence the pathways in this study, future studies should consider examining the pathways of interests among that group. Third, knowledge about COVID-19 is important for all generations, not only among youth. However, the current study only focused on middle school students. To rapidly end the coronavirus pandemic and to protect one’s health, all generations around the world should have more knowledge about COVID-19. Thus, we suggest that similar research should be conducted across other age groups. Fourth, to examine circumstances related to the novel and rapidly evolving circumstances related to COVID-19, we developed scales such as ICT resources and COVID-19 knowledge for use in this study.

Implications for Practice

It is critical to provide more economic support for households in poverty so that students in such households can access appropriate E-learning via adequate ICT resources, as well as to be more satisfied with their family dynamics. As middle school students cannot live without the support of parents or caregivers and they are not able to interact with others in person during the COVID-19 pandemic, their family, teachers, and friends have a great impact on their knowledge about the coronavirus, both in-person and online. Further, it is critical to identify mediators that influence the relationship between subjective poverty and COVID-19 knowledge among middle school students as there is little known about the pathway. In addition to the mediating effects, we identified the dual mediating effects of ICT resources and family satisfaction on the relationship between subjective poverty and knowledge about COVID-19 among middle school students. This implies that decreasing poverty, increasing access to ICT resources, and increased family satisfaction would be fundamentally helpful to increase...
COVID-19 knowledge among middle school students, which would be beneficial to prevent the spread of COVID-19 and to protect middle school students from the virus.

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