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Childhood Handwashing Habit Formation and Later COVID-19 Preventive Practices: A Cohort Study

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Abstract

Objective: This study identified developmental patterns of handwashing habit formation during childhood and examined their associations with later COVID-19 preventive practices.

Methods: We used data from the Taiwan Birth Cohort Study, which included 11,254 adolescents with complete data on childhood handwashing behavior and age-15 COVID-19 survey items. Bias-adjusted 3-step latent class analysis was used to test study hypotheses.

Results: The rates of handwashing and mask-wearing during the pandemic were 63.8% and 93.8%, respectively. Five distinct patterns of handwashing habit formation were identified: early formation (14.89%), delayed formation (17.73%), gradual formation (42.98%), inconsistent formation (9.78%), and nonformation (14.62%). Compared with adolescents with an early formation pattern of handwashing habits, those with other patterns exhibited lower odds ratios (ORs) of handwashing during COVID-19; these ORs were 0.67 (95% confidence interval [CI], 0.49−0.85), 0.60 (95% CI, 0.44−0.77), 0.29 (95% CI, 0.08−0.49), and 0.21 (95% CI, 0.01−0.40) for those with delayed formation, gradual formation, inconsistent formation, and nonformation patterns, respectively. Moreover, relative to that of adolescents with the early formation pattern, mask-wearing was less common among adolescents with gradual formation, inconsistent formation, and nonformation patterns, with ORs of 0.54 (95% CI, 0.16−0.92), 0.50 (95% CI, 0.03−0.96), and 0.26 (95% CI, 0.00−0.65), respectively.

Conclusions: The early formation of hygienic habits is associated with higher adherence to pandemic preventive practices among adolescents. Our findings suggest that interventions to promote hygienic behaviors can start as early as age 3 through the introduction of healthy habits such as handwashing.

Keywords: cohort study; COVID-19; handwashing; latent class analysis; mask-wearing

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What's New

Through bias-adjusted 3-step latent class analysis, this study identified 5 patterns of handwashing habit formation during childhood and discovered that the early formation of handwashing habits is associated with higher adherence to COVID-19 preventive practices among adolescents.

In response to the COVID-19 pandemic,[1] nonpharmaceutical interventions such as mask-wearing, handwashing, and social distancing have been used to reduce viral transmission.[2,1] The adherence to these recommendations, however, varies among individuals depending on their background and characteristics.[3] In particular, low adherence is common among adolescents.[4,5] Understanding the process of habit formation can promote adherence to preventive strategies among this population for future pandemic outbreaks.

Studies evaluating factors affecting preventive practices among adolescents have reported that adherence is primarily related to gender,[6−8] socioeconomic status,[6,8] health literacy,[8] and perceived severity of the virus.[4] Most of these studies, however, have been constrained by the use of cross-sectional study designs, thus preventing further investigation on whether early-life factors could influence the health behavior of later hygiene and preventive practices. Specifically, the cascading effects of preventive practices from childhood to adolescence have never been examined despite recognition that behaviors are linked across different life stages according to life course perspectives.[9] The establishment of good hygiene habits, such as handwashing, during early and middle childhood likely affects an individual's adherence to COVID-19 preventive practices. Research has also indicated that individuals may be prompted by environmental factors (eg, the COVID-19 pandemic) to practice habitual behaviors with greater intensity.[10]

This study contributes to the literature by distinguishing patterns of handwashing habit formation during early and middle childhood and examined their associations with later COVID-19 preventive practices (specifically, handwashing and mask-wearing) in adolescence. Because brain development and cognitive maturation emerge

during childhood,[11] we hypothesized that handwashing habits could be established during childhood, with heterogeneities in patterns of habit formation. We also hypothesized that adolescents with early handwashing habit formation would be more likely to practice handwashing and mask-wearing during the COVID-19 pandemic than would adolescents with other patterns of habit formation.

METHODS

DATA AND SAMPLE

The study data were obtained from the Taiwan Birth Cohort Study (TBCS), the first nationwide representative study of children in Taiwan that aimed to document the health trajectories of Taiwanese children in the 21st century and to investigate the effects of the social environment on pediatric health. A two-stage stratified random sampling strategy was used to select live births in 2005 from the National Birth Report database, with a sampling rate of 11.7%. A total of 21,248 participants completed the baseline data collection at the age of 6 months and were subsequently recruited as cohort members. By 2020, ten waves of surveys were completed when participants were aged 6 months, 18 months, 3 years, 5.5 years, 7 years, 8 years, 9 years, 12 years, 13 years, and 15 years; the response rates of each wave ranged from 87.8% to 94.9%. Informed consent was obtained from the mothers or the primary caregivers for each survey. The ethics approvals and the methodology of the TBCS is detailed in a previous report.[12]

The current study mainly used data from 3-, 5.5-, 8-, and 15-year surveys because data regarding handwashing habits were only collected at these time points. Data on some demographic variables were retrieved from the 6-month survey. For the outcome variables, we only included data on COVID-19 preventive practices collected from June 2020 to August 2020, during which most of the domestic COVID-19 cases in Taiwan were reported and pandemic prevention practices were encouraged by health officials. The final analyzed sample comprised 11,254 individuals who had complete data on handwashing behavior during early and middle childhood and had no missing data on COVID-19 preventive practices.

In Taiwan, approximately 90% of the population had access to a piped water supply when the 3-year survey was conducted, and this percentage increased to 94% by the time the 15-year survey was conducted in 2020.[13] In addition, the preschool enrollment rate at 3 years of the current sample was about 21%, which was similar to the data from the Ministry of Education in Taiwan[14] during the study period (23%).

MEASURES

HANDWASHING HABITS

At the 3-, 5.5-, and 8-year surveys, the mother or the primary caregiver was asked to indicate whether the child "washed their hands after using the toilet" and "washed their hands before eating." Each item on the survey was rated on a 5-point Likert-type scale ranging from 1 ("always") to 5 ("never"). A total of 6 survey items (2 from each wave) were used as indicators of childhood handwashing habits.

COVID-19 PREVENTIVE PRACTICES

At the 15-year TBCS survey, 2 COVID-19 preventive practices—handwashing and mask-wearing—were assessed.

Handwashing practices were assessed by asking mothers or primary caregivers whether their child regularly washed their hands immediately after coming home from being outside. The response was rated on a 5-point Likert-type scale ranging from 1 ("always") to 5 ("never"); a response of "always" or "often" was recoded as 1, whereas the other responses were recoded as 0.

Mask-wearing practices were evaluated by asking mothers or primary caregivers whether their child regularly wore masks when leaving their home during COVID-19 pandemic. The possible responses were 1 ("always"), 2 ("occasionally"), and 3 ("rarely"); a response of "always" was recoded as 1, whereas the other responses were recoded as 0.

COVARIATES

All models were adjusted for the following variables: sex of the adolescent, mother's age at the birth of the child, the mother's original nationality (some were born outside of Taiwan), parental education, monthly family income, family structure, residential area, the child's general health, family functioning, maternal emotional support, and punitive parenting. The baseline demographic data, including sex of the adolescent (1: male and 2: female), mother's age at the birth of the child (<25 years, 25−34 years, or ≥35 years), and the mother's original nationality (0: Taiwanese, 1: other), were collected at the 6-month survey.

The data on the other sociodemographic characteristics were collected at the 3-year survey, when the first handwashing question was introduced. The participants' average monthly family income was coded into 5 categories (<NT$30,000, NT$30,000−NT$49,999, NT$50,000−NT$69,999, NT$70,000−NT$99,999, and ≥NT$100,000); US$1 was equivalent to NT$31 at the time of the study, and the families were considered to be living below the poverty threshold if their monthly income was less than NT$30,000.[15] Family structure was categorized as a single-parent or two-parent household (coded as 1 and 0, respectively) according to the marital status of the parents at the 3-year survey. Residential area was classified as provincial city and district, county-administered city and urban township, and rural township. The classification of residential area was based on the Local Government Act of Taiwan, which subdivides the local governments into provinces and special municipalities. Provinces are further subdivided into provincial cities and counties, including county-administered cities, urban townships, and rural townships; special municipalities are subdivided into districts. Child's general health was categorized as good or

fair/poor (coded as 0 and 1, respectively) according to mother's report. The education of fathers and mothers were assessed at the 5.5-year survey because the data were not available at the 3-year survey and were coded as 0 for junior high school or below, 1 for senior high school, and 2 for college or above. Family functioning was assessed using the Family Adaptation, Partnership, Growth, Affection, and Resolve scale[16] at the 3-year survey (Cronbach's α = 0.89). Maternal emotional support was assessed using an adaptation of the Home Observation for the Measurement of Environment (HOME)−Short Form[17] at the 3-year (Cronbach's α = 0.85). At the 8-year survey, 4 items adapted from the HOME−Middle Childhood Version[18] were used to assess punitive parenting (Cronbach's α = 0.63).

Statistical Analysis

Bias-adjusted three-step latent class analysis (LCA) was conducted using Latent GOLD 6.0 software to investigate the research questions. In the first step, LCA of the 6 indicators was conducted to estimate the measurement model parameters, including the number of latent classes and the relationships between the local independence of certain pairs of indicators.

In the second step, each participant was assigned into one of the classes based on their posterior probabilities of class membership. In the final step, we conducted logistic regression to examine the relationship between the classes and the distal outcomes (ie, COVID-19 preventive practices) while accounting for classification errors introduced in the second step.

LCA enables the characterization of subgroups in a population and accounts for measurement errors in group memberships, with a key assumption of local independence (ie, indicators within a latent class are independent of each other).[19] Bias-adjusted three-step LCA requires the assumption of no direct effect between covariates and indicators.[20] In the current study, the violation of local independence assumption was examined and accounted for according to the model-building approach proposed by Vermunt and Magidson.[21]

Results

Sample Characteristics

Table 1 presents the sample characteristics. Approximately half of the adolescents were male (52.7%). Most of the adolescents' mothers were 25 to 34 years old at the time of delivery (68.8%) and were native Taiwanese (88.1%). Approximately half of the parents were college-educated (48.3% and 48.7% of the mothers and fathers, respectively). Only 11.3% of the participants came from families with an average monthly family income <NT $30,000. In addition, most of the adolescents lived in a two-parent household (95.1%), and county-administered cities and urban townships were the most common type of area of residence (45.7%). Finally, 76.4% of the mothers reported that the general health of their child was good. Regarding COVID-19 preventive practices, over half of the adolescents practiced regular handwashing (63.8%), and almost all of them practiced mask-wearing during the pandemic (93.8%).

Patterns of Handwashing Habit Formation During Childhood

A 5-class model provided the best fit according to the interpretability and fit criteria (Supplementary Table 1). The item-response probabilities for each response category are presented in Supplementary Table 2, and Figure displays the probabilities of endorsing an "always" response to the handwashing questions for each latent class, which facilitated the assignment of interpretational labels to the latent classes. The five patterns of handwashing habits formation identified are described as follows:

1. Early formation (14.89%): The probabilities of always washing hands after using the toilet and before eating at the age of 3 years were 0.95 and 0.99, respectively, and remained relatively stable across ages.
2. Delayed formation (17.73%): The probabilities of always washing hands after using the toilet and before eating for adolescents in this class were both approximately 0.20 at the age of 3 years but increased to 0.99 at the age of 5 years.
3. Gradual formation (42.98%): The probabilities of always washing hands after using the toilet and before eating at the age of 3 years for adolescents in this class were 0.13 and 0.24, respectively. Nonetheless, these probabilities gradually increased at later ages.
4. Inconsistent formation (9.78%): Adolescents in this class had probabilities of having handwashing habits after using the toilet and before eating at the age of 3 years similar to that of the adolescents in the early formation group (approximately 0.99). The probabilities then sharply decreased at the age of 5 years but increased thereafter.
5. Non-formation (14.62%): Adolescents in this class had the lowest probability of having handwashing habits during childhood, with their probabilities of always washing hands after using the toilet and before eating being lower than 0.40 and 0.10, respectively.

Associations Between Handwashing Habit Formation Patterns and Later COVID-19 Preventive Practices

Table 2 presents the associations between handwashing habit formation patterns during early and middle childhood and COVID-19 handwashing practices in adolescence. Compared with adolescents with early handwashing habit formation patterns, those with delayed formation, gradual formation, inconsistent formation, or nonformation patterns had lower odds ratios (ORs) of handwashing during the COVID-19 pandemic (0.67 [95% CI, 0.49−0.85], 0.60 [95% CI, 0.44−0.77], 0.29 [95% CI, 0.08−0.49], and 0.21 [95% CI, 0.01−0.40], respectively). Handwashing was also more common among female adolescents (OR = 1.32; 95% CI, 1.24−1.40), those whose

Table 1. Sample Characteristics

	n	%	Mean	SD
Child sex				
Male	5931	52.70		
Female	5323	47.30		
Mother's age at birth of child				
< 25 years	2067	18.37		
25–34 years	7740	68.78		
≥ 35 years	1447	12.86		
Mother's original nationality				
Taiwan	9909	88.05		
Other	1345	11.95		
Mother's education level				
Junior high school or below	1362	12.45		
Senior high school	4295	39.25		
College	5286	48.30		
Father's education level				
Junior high school or below	1365	12.43		
Senior high school	4275	38.93		
College	5342	48.74		
Monthly family income				
< NT$30,000	1267	11.32		
NT$ 30,000–49,999	2801	25.02		
NT$ 50,000–69,999	2981	26.62		
NT$ 70,000–99,999	2534	22.73		
≥ NT$100,000	1614	14.41		
Family structure				
Single-parent household	556	4.94		
Two-parent household	10697	95.06		
Residential area				
Provincial city and district	3018	26.82		
County-administered city and urban township	5142	45.69		
Rural township	3094	27.49		
General health				
Fair/Poor	2662	23.65		
Good	8592	76.35		
Family functioning	10950		7.41	2.63
Maternal emotional support	11250		25.19	3.38
Punitive parenting	11253		10.54	3.10
COVID-19 preventive practices				
Handwashing				
Yes	7176	63.76		
No	4078	36.24		
Mask-wearing				
Yes	10551	93.75		
No	703	6.25		

mothers had received a college education (OR = 1.20; 95% CI, 1.03, 1.38), those with a monthly family income ≥NT$100,000 (OR = 1.21; 95% CI, 1.02–1.40), and those with high levels of family functioning (OR = 1.05; 95% CI, 1.04–1.07) and maternal emotional support (OR = 1.02; 95% CI, 1.01–1.04). Handwashing was less common among those living in single-parent households (OR = 0.78; 95% CI, 0.59–0.97), those living in rural townships (OR = 0.81; 95% CI, 0.70–0.93), and those subjected to a high degree of punitive parenting (OR = 0.96; 95% CI, 0.95–0.98).

The multivariate analysis yielded similar results related to the adolescents' mask-wearing practices during the COVID-19 pandemic (Table 3). Specifically, the adolescents with non-early-formation patterns were less likely to wear masks when going outside (OR 0.54 [95% CI, 0.16–0.92], 0.50 [95% CI, 0.03–0.96], and 0.26 [95% CI, 0.00–0.65] for those in the gradual formation, inconsistent formation, and nonformation groups, respectively, compared with the adolescents in the early formation group [reference group]). Mask-wearing was also more common among female adolescents (OR 1.93; 95% CI, 1.77–2.10) and less common among adolescents living in county-administered areas (OR 0.72; 95% CI, 0.52–0.93) or rural townships (OR 0.59; 95% CI, 0.36–0.81), and those subjected to a higher degree of punitive parenting (OR 0.96; 95% CI, 0.94–0.99; Table 3).

DISCUSSION

The current study captured developmental changes in handwashing behavior during childhood, shedding light on distinct patterns of handwashing habits in terms of distribution, timing, and developmental course. Adolescents

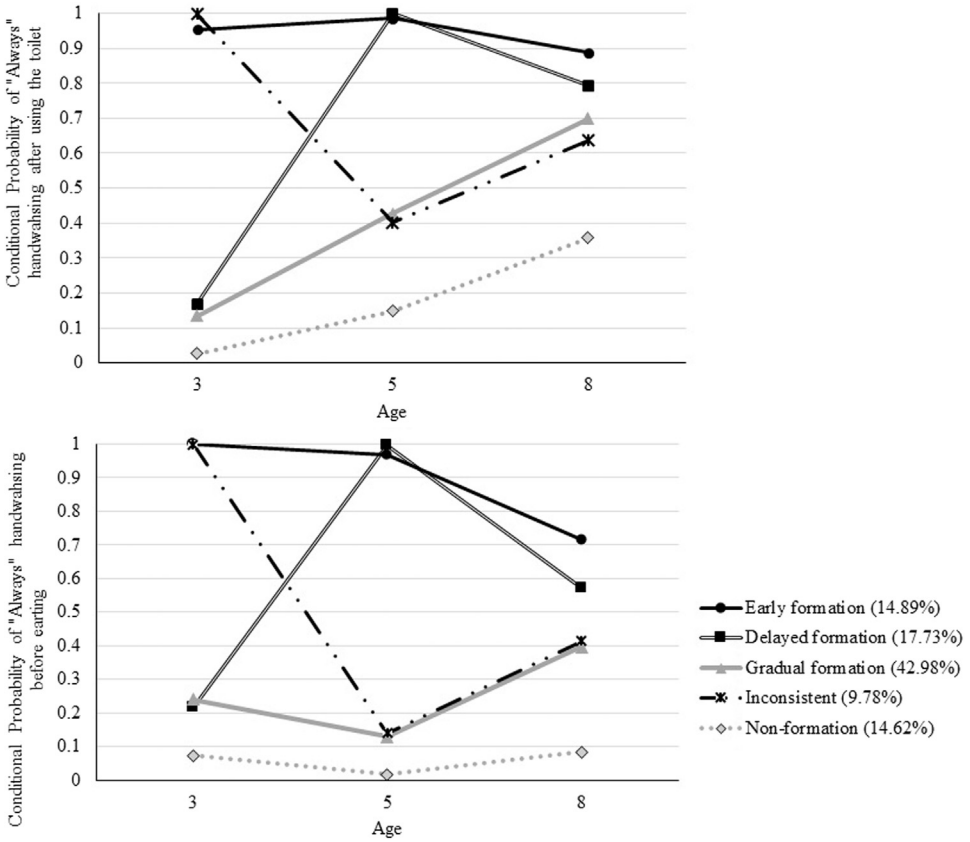

Figure. *Probability of endorsing the "always" response for each latent class.*

Table 2. Associations Between Handwashing Habit Formation Patterns and Handwashing During the COVID-19 Pandemic

	OR	95% CI
Early handwashing habits (ref. Early formation)		
Delayed formation	0.67	**0.49, 0.85**
Gradual formation	0.60	**0.44, 0.77**
Inconsistent formation	0.29	**0.08, 0.49**
Nonformation	0.21	**0.01, 0.40**
Child sex (ref. male)		
Female	1.32	**1.24, 1.40**
Mother's age at birth of child (ref. < 25 years)		
25−34 years	0.99	0.87, 1.10
≥ 35 years	0.97	0.81, 1.12
Mother's original nationality (ref. Taiwan)		
Other	1.13	0.98, 1.29
Mother's education level (ref. Junior high school or below)		
Senior high school	1.09	0.94, 1.25
College	1.20	**1.03, 1.38**
Father's education level (ref. Junior high school or below)		
Senior high school	0.94	0.80, 1.08
College	1.07	0.91, 1.23
Monthly family income (ref. < NT$30,000)		
NT$ 30,000−49,999	1.10	0.96, 1.25
NT$ 50,000−69,999	1.07	0.91, 1.22
NT$ 70,000−99,999	0.98	0.81, 1.15
≥ NT$100,000	1.21	**1.02, 1.40**
Family structure (ref. two-parent household)		
Single-parent household	0.78	**0.59, 0.97**
Residential area (ref. provincial city and district)		
County-administered city and urban township	0.91	0.81, 1.01
Rural township	0.81	**0.70, 0.93**
General health (ref. fair/poor)		
Good	1.07	0.97, 1.16
Family functioning	1.05	**1.04, 1.07**
Maternal emotional support	1.02	**1.01, 1.04**
Punitive parenting	0.96	**0.95, 0.98**

Boldface indicates statistical significance ($P < .05$).
Ref. indicates reference.

Table 3. Associations Between Handwashing Habit Formation Patterns and Mask-Wearing During the COVID-19 Pandemic

	OR	95% CI
Early handwashing habits (ref. Early formation)		
Delayed formation	0.63	0.21, 1.06
Gradual formation	0.54	**0.16, 0.92**
Inconsistent formation	0.50	**0.03, 0.96**
Nonformation	0.26	**0.00, 0.65**
Child sex (ref. male)		
Female	1.93	**1.77, 2.10**
Mother's age at birth of child (ref. <25 years)		
25−34 years	0.97	0.75, 1.18
≥ 35 years	1.10	0.80, 1.41
Mother's original nationality (ref. Taiwan)		
Other	1.13	0.83, 1.42
Mother's education level (ref. Junior high school or below)		
Senior high school	1.12	0.84, 1.41
College	1.09	0.76, 1.41
Father's education level (ref. Junior high school or below)		
Senior high school	0.88	0.62, 1.14
College	0.87	0.56, 1.17
Family monthly income (ref. < NT$30,000)		
NT$ 30,000−49,999	1.16	0.90, 1.42
NT$ 50,000−69,999	1.16	0.88, 1.43
NT$ 70,000−99,999	1.33	1.02, 1.65
≥ NT$100,000	1.23	0.88, 1.58
Family structure (ref. two-parent household)		
Single-parent household	0.84	0.51, 1.18
Residential area (ref. provincial city and district)		
County-administered city and urban township	0.72	**0.52, 0.93**
Rural township	0.59	**0.36, 0.81**
General health (ref. fair/poor)		
Good	1.17	0.99, 1.34
Family functioning	1.02	0.99, 1.34
Maternal emotional support	1.02	0.99, 1.04
Punitive parenting	0.96	**0.94, 0.99**

Boldface indicates statistical significance ($P < .05$).
Ref. indicates reference.

in the early formation group exhibited a consistently high probability of handwashing beginning at age 3. The high rate of compliance with handwashing practices may be partly attributed to the emphasis on hand hygiene in Taiwanese health education since the 1950s,[22] which has endowed Taiwanese children over the decades with the knowledge and self-efficacy necessary to practice regular handwashing. The 2003 outbreak of severe acute respiratory syndrome (SARS) may also have increased parents' perceived benefits of handwashing in preventing respiratory infections[23] and encouraged them to promote hand hygiene compliance in children.

Additionally, early handwashing habit formation was found to promote adherence to COVID-19 handwashing practice. This finding is consistent with life course perspectives[9] that emphasize the effect of early life experiences on health and behaviors in later life. Our results are also consistent with the habit formation theory[24] that suggests that habits can prompt frequent performance of the associated behavior when individuals encounter contextual cues. The COVID-19 pandemic may serve as a contextual cue that triggers the impulse of the adolescents who had formed handwashing habits during early and middle childhood to adhere to COVID-19 handwashing guidelines with minimal cognitive effort.

Notably, we observed that the timing and patterns of handwashing habit formation are influential. Compared with the adolescents in the early formation group, those who exhibited inconsistent handwashing habits (the inconsistent formation group), or who infrequently washed their hands (the nonformation group) were less likely to adhere to COVID-19 handwashing practices. Although no other study has evaluated the benefits of the early formation of handwashing habits, other research[25] has investigated the effect of the early formation of other hygiene habits (eg, tooth brushing). In addition, the risk of nonadherence to COVID-19 handwashing practices was highest for the adolescents in the nonformation group, which suggests that healthy habits may be more influential than behavioral intention in regulating action in the presence of contextual cues.[24]

Furthermore, the likelihood of practicing handwashing during the COVID-19 pandemic was also lower among the adolescents who formed handwashing habits at later ages (the delayed and gradual formation groups). The varying patterns of habit formation observed in the current study likely reflect adolescents at different stages in the habit formation process that consists of 4 stages,[10] wherein the final stage is distinguished by the strengthening of cue-behavior association (in contrast to the

penultimate stage, which involves behavior repetition alone). The adolescents in the later formation or gradual formation groups may have still been in the penultimate stage of habit formation and may have, therefore, performed behaviors repeatedly without a strong cue−behavior association. Alternatively, given that research has shown that individuals with stronger self-control tend to engage in healthy behaviors more frequently,[26] the adolescents who developed handwashing habits early may have had higher levels of self-control than did those with other patterns of handwashing habit development and were therefore better able to maintain their habits over time.

The present study contributes to the literature on the connection between handwashing and mask-wearing behavior by demonstrating that patterns of handwashing habit formation during childhood are associated with later mask-wearing practices during the COVID-19 pandemic. Because handwashing has been considered as one of the healthy living practices,[27] children with early handwashing habit formation patterns are likely to live healthy lifestyles that help promote mask-wearing practices later in life. Moreover, hygiene practices often cluster together,[28] which suggests that these behaviors may be affected by similar factors. Studies have reported that factors promoting COVID-19 handwashing practices also promote mask-wearing practices. For example, handwashing and mask-wearing during the COVID-19 pandemic were associated with action control.[29] Therefore, early handwashing habit formation can likely help shape not only handwashing practices but also other health-related preventive behaviors (eg, mask-wearing) later in life.

Overall, the associations between habit formation and COVID-19 preventive practices identified in the current study are consistent with the capability−opportunity−motivation−behavior (COM-B) model[30] and have implications for COVID-19 prevention. The COM-B model proposes that for any behavior to occur, people must have the motivation, which comprises habit-related automatic processes, to perform that behavior. Of the 3 COM-B components, motivation affects behavior most strongly.[31] Therefore, the promotion of pandemic prevention−related behaviors necessitates promoting the public's motivation to develop habits that protect oneself and others. Strategies targeting habit formation to increase adherence to COVID-19 preventive behavior have been suggested,[32] and our findings further demonstrate the importance of promoting early handwashing habit formation for ensuring adherence to future preventive practices. In addition, the distinct habit formation patterns observed in this longitudinal cohort study suggest that interventions encouraging the development of hygiene habits may be effectively introduced at an age of approximately 3 years, with additional reinforcements and prompts introduced at regular intervals throughout childhood.

One of the most effective means of promoting handwashing in young children is through school-based education and activities[33] because schools often implement rigid daily routines that help students develop good hygiene habits. Incorporating hygiene education into preschool curricula is a promising approach to promoting handwashing, especially because preschool enrollment has increased worldwide in recent years.[34] For example, the preschool enrollment rate in Taiwan increased from 23% to 71% from 2008 to 2020.[14] Several studies have demonstrated the effectiveness of school-based hygiene interventions in increasing handwashing practices among toilet-trained preschoolers.[33,35] Research has further suggested that extending hygiene education from schools to homes can increase its effectiveness.[35] A cost-benefit analysis of early childhood hygiene programs similarly demonstrated that interventions can be more effective when accompanied by the education of teachers, parents, and children.[36]

Finally, consistent with previous research on the relationships between demographic factors and COVID-19 preventive practices,[7] we discovered that the female adolescents were more likely to practice preventive measures than were the male adolescents. The observed sex differences may be due to sex differences in adolescents' levels of disease-related knowledge, with female adolescents having more relevant knowledge than their male counterparts.[7] Compared with males, females may also be more likely to perceive COVID-19 as a serious health concern and to comply with recommended preventive measures.[37] Moreover, we found that the probabilities of handwashing and mask-wearing among the adolescents living in rural townships were lower than those living in provincial cities and districts. This may be because adolescents living in rural areas have lower health literacy concerning disease prevention and control.[38] Adolescents living in rural areas may also have had lower COVID-19 awareness,[38] particularly because most of the COVID-19 cases in Taiwan during the study period were recorded in urban areas (eg, provincial cities and districts). Therefore, disease prevention programs targeting preventive behaviors should be developed and implemented with consideration given to the effects of sex and location.

This study has several strengths, including its use of a representative sample and longitudinal data that contains several waves of survey data collection. By employing repeated measures and advanced statistical analyses, we contributed to the literature by outlining distinct developmental patterns of handwashing habit formation during childhood. The long duration of the follow-up period further enabled us to identify the longitudinal relationships between handwashing habits during childhood and later COVID-19 preventive practices. Our results were further strengthened through adjustment for important covariates (eg, family socioeconomic status, family functioning, and parenting) in the model.

LIMITATIONS

Our findings should be interpreted within the context of this study's limitations. First, this study used self-reported data from the participants' mothers or caregivers, which may have resulted in reporting bias. Individuals may have different perceptions about or awareness of hygiene

behavior at different ages. Second, when assessing the participants' mask-wearing practices, we only included 3 potential responses, which may have restricted the respondents' ability to express the exact frequency of mask-wearing. Third, because our study outcomes were restricted to only 2 behaviors during the COVID-19 pandemic, caution should be exercised when generalizing our results to other preventive practices. Moreover, the study sample was from Taiwan, which has a relatively high rate of mask-wearing; therefore, the generalizability of the current findings to other locations or populations with different social and cultural characteristics must be further evaluated.

Finally, our findings may have been confounded by other factors that were not included in the model. For example, personality traits are associated with both health behaviors[39] and COVID-19 preventive measures.[40] Adolescents who are more conscientious and agreeable are more organized, responsible, and respectful; therefore, they may be more likely to develop handwashing habits during childhood and to comply with COVID-19 preventive behaviors. Similarly, adolescents who have greater self-efficacy in health behaviors may be more likely to practice handwashing during childhood[41] and COVID-19.[29] In addition, other family factors, such as parent −child bonding, family cohesion, and family conflict, are associate with both handwashing and COVID-19 preventive behaviors[42,43] and may therefore have confounded our findings. Nonetheless, our results remained significant when we controlled for similar family factors, namely maternal support and family functioning. Future research should continue to test the robustness of these findings by controlling for other potential confounders.

CONCLUSIONS

Our findings demonstrate that differential patterns of handwashing habit formation during early and middle childhood affect COVID-19 preventive practices in adolescence. The results suggest that the development of effective intervention programs targeting preventive behaviors can start as early as age 3 through the introduction of healthy habits such as handwashing, to enable the encouragement, cultivation, and retention of such habits over time.

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SUPPLEMENTARY DATA

Supplementary data related to this article can be found online at https://doi.org/10.1016/j.acap.2022.05.014.

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