Development of assessment scales for hand hygiene behavior using the health action process approach: Pre/post-COVID-19 pandemic comparison

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Abstract

This study develops scales to assess the factors contained in the Health Action Process Approach (HAPA) that relate to hand hygiene behavior as a preliminary step of investigating the suitability of HAPA as a predictive model of hand hygiene behavior. The survey was conducted among 225 university students prior to the outbreak of COVID-19 and 371 university students after the outbreak of COVID-19. The survey items were demographics, frequency of hand hygiene behavior, and original drafts of scales measuring the following factors contained in HAPA: risk perception, outcome expectancy, self-efficacy, behavioral intention, and planning. Analysis confirmed that each scale was a valid and reliable method for assessing the factors contained in HAPA. A comparison of pre- and post-COVID-19 outbreak scores for the factors contained in HAPA showed that higher, significant results were found after the outbreak of COVID-19 in all cases. Furthermore, there was no change in the frequency of hand hygiene behaviors after the outbreak of COVID-19 under some conditions.

Key words: health action process approach, hand hygiene behavior, scale development, Japanese university students

Introduction

The Corona-virus disease-2019 (COVID-19) that broke out in Wuhan, China, was reported to the World Health Organization on December 31, 2019, and was deemed to have spread worldwide by March 11, 2020, leading to a situation wherein various countries declared “lockdowns” (city-level closures) and states of emergency. In 2020, while various countries had a shortage of masks, the World Health Organization (2020) announced at a press conference that masks had a limited effect in terms of infection control and recommended hand hygiene over mask usage. According to the World Health Organization (2009), “handwashing” is defined as w*ashing hands with plain or antimicrobial soap and water*, and “hand antisepsis” is defined as r*educing or inhibiting the growth of microorganisms by the application of an antiseptic handrub or by performing an antiseptic handwash.* In this study, using these definitions as references, hand hygiene is defined as “any action that cleans the hands.” Considering the impact of COVID-19, this is an opportunity to review, from the viewpoints of health psychology and healthy behavior, hand hygiene and regular hand hygiene behavior actions taken after, for example, arriving home, before eating a meal, and after using a toilet, especially for those who are not medical practitioners or in other specific occupational fields.

Even before the outbreak of COVID-19, hand hygiene was fundamental to the control of infectious diseases (Cannon & Davis, 2005), as handwashing in running water reduces viral quantities to about 1/100th (Mori et al., 2006), and hand hygiene behavior has also been strictly observed in Japanese educational facilities to prevent infection (Japanese Society of School Health, 2018). However, accord-

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ing to a study that investigated university-based influenza preventative measures (Kudo, Kawano, Kido, Kodama, & Fujita, 2014), when asked about the implementation of hand hygiene behavior, approximately 30% of the respondents reported that they washed hands regularly, showing that hand hygiene behavior in connection to the prevention of infections is not widely habitual. Also, according to a survey by Japan's Consumer Affairs Agency (2015) of handwashing behavior in Japanese homes for the control of norovirus infection, about 40% of the people said, "I never learned handwashing," and 15.4% responded that they did not wash their hands after using the toilet, which is often the cause of norovirus infection. In this way, it has been pointed out that the implementation of hand hygiene behavior is insufficient on a global level (Freeman et al., 2014). In addition, it has been reported that the socio-psychological mechanisms of the practice of hand hygiene behavior have not been studied sufficiently (Reyes Fernández, Knoll, Hamilton, & Schwarzer, 2016). Thus, to take action to promote hand hygiene behavior, it is important to have a deeper understanding of the mechanisms of hand hygiene behavior, which the authors hypothesize can be done by establishing a foundation based on behavioral theory.

It was previously reported that the behavioral theory Health Action Process Approach (HAPA) (Schwarzer, 2008) can be used to predict hand hygiene behavior (Reyes Fernández et al., 2016). Also, it has been reported that hand hygiene behavior can be predicted by means of a behavioral model based on HAPA that combines factors from the theory of planned behavior (Zhang, Fang, Zhang, Hagger, & Hamilton, 2020). Furthermore, HAPA is a behavioral theory with a large scope of application that has also been used in studies as a model that predicts social-distancing behavior as a countermeasure to COVID-19 (Hamilton, Smith, Keech, Moyers, & Hagger, 2020). HAPA comprises five psychological factors (risk perception, outcome expectancy, self-efficacy, behavioral intention, planning) and dependent variables made of health behaviors (Schwarzer, 2016). In Japan, HAPA has been used to pioneer the development of a scale that quantifies awareness of hand hygiene behavior among new nurses (Yamamoto et al., 2019). However, in the scale by Yamamoto et al. (2019), the scope of the scale items was limited to new nurses, and it is difficult to use this as a scale to assess hand hygiene behavior in daily life.

Therefore, this study develops scales for easy assessment of the psychological factors contained in HAPA to enable evaluation of hand hygiene behavior in daily life not limited by occupation as a preliminary step in verifying compatibility with HAPA for use as a model that predicts hand hygiene behavior. Note that the results of HAPA using the covariance structure analysis will be reported in another study.

Methods

Survey period and survey participants

This survey was performed before and after the outbreak of COVID-19. The survey prior to the outbreak of COVID-19 ("pre-COVID-19" hereafter) was implemented at the end of July 2019 among 225 university students (147 male, 77 female, 1 gender non-response; average age: 19.47 years, SD = 1.05) between the ages of 18 and 23 at two private universities in the Tokai area. The surveys after the outbreak of COVID-19 ("post-COVID-19" hereafter) were implemented at the end of July 2020 and in December 2020 among 371 university students (204 male, 167 females; average age: 18.95 years, SD = .90) between the ages of 18 and 25 at two private universities in the Tokai region, which is in central Japan. Note that there is no duplication of respondents in this survey.

Survey procedures

The pre-COVID-19 survey was performed as an anonymous in-person questionnaire-based survey while the post-COVID-19 survey was implemented using an anonymous questionnaire survey and an online survey. The questionnaires included a defini-

tion of hand hygiene behavior in line with the definition used by the World Health Organization (2009), which the participants were told to read before responding to the questions. As for the ethical considerations of this survey, the survey participants were given a written or oral explanation of the purpose of the survey and were told that cooperation in the survey was voluntary, that no disadvantage would arise from failing to respond to the survey, that any personal information would be strictly protected, that the survey results would not be used for any purpose other than that of the survey itself, and that a response to the survey would be considered consent. The participants then responded to the survey. This survey was conducted with approval from the Local Ethics Committee of Aichi University.

Survey items

Demographics: Participants were asked to state their gender and age.

Risk perception: To measure risk perception in connection to the non-performance of hand hygiene behavior, the primary author established situations where hand hygiene behavior is required (e.g., before eating, after using the toilet). Then, the primary, secondary, and tertiary authors considered the situations where handwashing is required, and, through discussion, produced a six-item draft to measure risk perception regarding the non-performance of handwashing. As for the response method, responses were sought based on a five-grade scale (1: Absolutely no risk – 5: Very high risk), with higher total scores showing greater risk perception of the non-performance of hand hygiene behavior.

Outcome expectancy: To measure outcome expectancy with regard to hand hygiene behavior, the primary author produced a draft showing the possible positive or negative outcomes from hand hygiene behavior. Then, based on consultation with the secondary and tertiary author and after inspecting the nuance of each question, a 10-item draft was prepared. As for the response method, responses were sought based on a five-grade scale (1: Completely disagree – 5: Strongly agree), with higher total scores showing greater positive or negative outcome expectancy from hand hygiene behavior.

Self-efficacy: To measure self-efficacy with regard to hand hygiene behavior, the primary author produced a draft showing self-efficacy regarding the performance of hand hygiene behavior. Then, based on consultation with the secondary and tertiary author and after inspecting the nuance of each question, an 11-item draft was prepared. As for the response method, responses were sought based on a five-grade scale (1: Completely disagree – 5: Strongly agree), with higher total scores showing greater self-efficacy regarding the performance of hand hygiene behavior.

Behavioral intention: To measure behavioral intention with regard to hand hygiene behavior, the primary author produced a draft expressing behavioral intentions for each setting of hand hygiene behavior. Then, based on consultation with the secondary and tertiary author and after inspecting the nuance of each question, a 6-item draft was prepared. As for the response method, responses were sought based on a five-grade scale (1: Completely disagree – 5: Strongly agree), with higher total scores showing stronger behavioral intentions in connection to hand hygiene behavior.

Planning: To measure planning with regard to hand hygiene behavior, the primary author produced a draft expressing the planning of hand hygiene behavior. Then, based on consultation with the secondary and tertiary author and after inspecting the nuance of each question, a 5-item draft was prepared. Responses were sought (1: I do not plan at all – 5: I plan meticulously), with higher total scores showing greater planning in connection to hand hygiene behavior.

Hand hygiene behavior: To evaluate hand hygiene behavioral actions, participants were asked to state the duration of each handwashing event and the number of times per day that hand antisepsis was performed. Also, to investigate the frequency of the implementation of hand hygiene behavior in each sit-

uation, participants were asked to state the percentage (0–100%) of the frequency of implementation of hand hygiene behavior in each of the six situations (before eating; after using the toilet; after arriving at home; after performing sports, exercise, or a PE lesson; when hands are visibly unclean; when hands are invisibly unclean (viruses and bacteria, etc.)).

Method of analysis

To investigate the factor structure of the five scales (risk perception, outcome expectancy, self-efficacy, behavioral intention, planning) developed in this study, the factors were determined using a scree plot with an eigenvalue of 1 or more. Items were screened so that, in case of absolute values of skewness or kurtosis that exceed 2.0, it was deemed to be an unsuitable item for exploratory factor analysis ("EFA" hereafter) (Bandalos & Finney, 2010). Next, EFA (Maximum Likelihood; Promax Rotation) was performed for the items with absolute values of skewness or kurtosis that did not exceed 2.0. When performing the EFA, the Kaiser–Meyer–Olkin Measure of Sampling Adequacy ("KMO" hereafter) and Bartlett's Test of Sphericity were used, deeming those with a KMO value of .5 or more (Kaiser & Rise, 1974) and significance in Bartlett's Test of Sphericity as having sufficient sampling validity. Moreover, to verify the reliability of the scales, Cronbach's alpha coefficient and omega coefficient were calculated. Furthermore, to investigate the scales' construct validity, a confirmatory factor analysis ("CFA" hereafter) was conducted based on a covariance structure analysis. Maximum likelihood was used as the estimation method, and to ensure the differentiation of models, the variance of each latent variable was set as 1, and the path from error variable to observed variable was also set as 1. In this study, to investigate the suitability of the model, the Normed Fit Index (NFI), Comparative Fit Index (CFI), Bollen's incremental fit index (IFI), and Root Mean Square Error of Approximation (RMSEA) tools were used to comprehensively verify validity based on these suitability indexes. In this study, in case of NFI, CFI, or IFI being .90 or more, the model was deemed suitable, whereas RMSEA within the range of <.10 was deemed to have good model suitability (Brown, 2015).

To confirm the validity of the scales developed in this study, the correlation coefficients between the newly developed scales were calculated, and the correlation coefficients between the newly developed sense of scale and each index of hand washing behavior were obtained. Additionally, an unpaired t-test was performed for pre-/post-COVID-19. Further, to understand the change in hand hygiene behavior among the university students before and after COVID-19, hand hygiene behavior was analyzed using an unpaired t-test. In the analysis, IBM SPSS Statistics 27 and Amos 25J were used.

Results

Scale development

Risk perception: EFA resulted in the extraction of four items for the one factor with eigenvalues of 1.0 or more and factor loading greater than .6, with the cumulative contribution ratio of the first factor being 58.68% (Table 1). The measure of the KMO sampling adequacy at this time was KMO = .767, Bartlett's sphericity was χ^2 = 209.696, df = 6, and p < .001. Also, the risk perception scale alpha coefficient and omega coefficient were sufficiently high, which confirmed internal consistency (pre-COVID-19 α = .763, ω = .767, post-COVID-19 α = .809, ω = .810). As a result of CFA, sufficient values were found in the Index of Fitness (FI) before and after COVID-19, which confirmed construct validity (pre-COVID-19 NFI = .997, CFI = 1.00, IFI = 1.007, RMSEA = .00, post-COVID-19 NFI = .994, CFI = .998, IFI = .998, RMSEA = .035). The average value of the total score on the risk perception scale was 16.72 (SD = 2.85) before COVID-19 and 18.20 (SD = 2.48) after COVID-19. As a result of comparison using an unpaired t-test, it was found that the total score on the risk perception scale was significantly higher af-

ter COVID-19 (t = 6.37, df = 406.20, p < .001, d = 0.56) (Table 2).

Outcome expectancy: EFA resulted in the extraction of four items for the one factor with eigenvalues

Table 1
Results of Exploratory Factor Analysis (Risk Perception Scale)

Item	Factor 1	Communalities
After returning home	.807	.652
After sports, exercise, or PE classes	.638	.407
When hands are invisibly unclean (viruses, bacteria, etc.)	.625	.390
Before eating	.612	.374

Instructional text: In each situation, how much risk do you think there is to your health if you do not perform hand hygiene behavior?
Note: If you need the Japanese version of the scale items, please contact the first author.

Table 2
T-test Results

	Time	*N*	Mean	*SD*	*t*	*df*	*p*	Cohen's *d*
Risk perception	Before	218	16.72	2.85	6.37	406.20	.00	0.56
	After	370	18.20	2.48				
Outcome expectancy	Before	216	16.48	3.13	4.09	400.62	.00	0.36
	After	368	17.52	2.72				
Behavioral intention	Before	217	16.57	3.40	4.74	374.68	.00	0.43
	After	371	17.85	2.69				
Action self-efficacy	Before	218	15.65	3.38	8.45	389.63	.00	0.76
	After	370	17.94	2.79				
Coping self-efficacy	Before	217	12.65	4.02	7.65	586.00	.00	0.65
	After	371	15.16	3.73				
Planning	Before	218	9.20	4.13	4.19	586.00	.00	0.36
	After	370	10.78	4.58				
Handwashing time per wash	Before	225	20.11	18.15	3.05	594.00	.00	0.26
	After	371	24.31	15.02				
Hand antisepsis per day	Before	224	.920	1.71	12.56	485.86	.00	0.87
	After	371	4.64	5.26				
Frequency of hand hygiene before meals	Before	150	61.11	32.22	2.82	519.00	.01	0.27
	After	371	69.29	29.07				
Frequency of hand hygiene after toilet use	Before	150	90.74	21.18	2.70	203.17	.01	0.31
	After	371	95.81	13.93				
Frequency of hand hygiene after returning home	Before	151	76.73	31.26	6.63	178.35	.00	0.84
	After	371	94.35	14.89				
Frequency of hand hygiene after playing sports	Before	151	71.33	30.20	1.14	250.88	.26	0.12
	After	371	74.54	26.77				
Frequency of hand hygiene when visible dirt is attached	Before	151	92.29	20.03	3.52	167.03	.00	0.47
	After	371	98.19	7.42				
Frequency of hand hygiene when invisible dirt is attached	Before	150	61.04	33.13	1.18	236.65	.24	0.12
	After	371	64.66	27.57				

Note. For the indication of the time, "Before" is used for the time before COVID-19 was reported to WHO, and "After" is used for the time after COVID-19 was reported.

of 1.0 or more and factor loading greater than .6, with the cumulative contribution ratio of the first factor being 64.16% (Table 3). The measure of the KMO sampling adequacy at this time was KMO = .762, Bartlett's sphericity was $\chi^2 = 291.684$, $df = 6$, and $p < .001$. Also, the outcome expectancy scale alpha coefficient and omega coefficient were sufficiently high, which confirmed internal consistency (pre-COVID-19 $\alpha = .805$, $\omega = .803$, post-COVID-19 $\alpha = .761$, $\omega = .761$). As a result of CFA, sufficient values were found in the FI before and after COVID-19, which confirmed construct validity (pre-COVID-19 NFI = .963, CFI = .968, IFI = .969, RMSEA = .141, post-COVID-19 NFI= .996, CFI = .999, IFI = .999, RMSEA = .020). The average value of the total score on the outcome expectancy scale was 16.48 ($SD = 3.13$) before COVID-19 and 17.52 ($SD = 2.72$) after COVID-19. As a result of comparison using an unpaired t-test, it was found that the total score on the outcome expectancy scale was significantly higher after COVID-19 ($t = 4.09$, $df = 400.62$, $p < .001$, $d = 0.36$) (Table 2).

Behavioral intention: EFA was conducted on the remaining items of the draft behavioral intention scale for hand hygiene behavior after the two items of the original six with an absolute value of skewness/kurtosis greater than 2.0 were excluded. This resulted in the extraction of four items for the one factor with eigenvalues of 1.0 or more and factor loading greater than .6, with the cumulative contribution ratio of the first factor being 63.66% (Table 4). The measure of the KMO sampling adequacy at this time was KMO = .774, Bartlett's sphericity was $\chi^2 = 282.744$, $df = 6$, and $p < .001$. Also, the behavioral intention scale alpha coefficient and omega coefficient were sufficiently high, which confirmed internal consistency (pre-COVID-19 $\alpha = .808$, $\omega = .811$, post-COVID-19 $\alpha = .801$, $\omega = .801$). As a result of CFA, sufficient values were found in the FI before and after COVID-19, which confirmed construct validity (pre-COVID-19 NFI = .982, CFI = .988, IFI = .988, RMSEA = .086, post-COVID-19 NFI = .989, CFI = .994, IFI = .994,

Table 3
Results of Exploratory Factor Analysis (Outcome Expectancy Scale)

Item	Factor 1	Communalities
I think that washing my hands will help prevent illness	.824	.679
I think that washing my hands will make me clean	.759	.576
I think that washing my hands can make me healthier	.694	.481
I think that washing my hands will make me feel good	.608	.370

Instructional text: By performing hand hygiene behavior, what do you think could happen to you?
Note: If you need the Japanese version of the scale items, please contact the first author.

Table 4
Results of Exploratory Factor Analysis (Behavioral Intention Scale)

Item	Factor 1	Communalities
After returning home, I intend to wash my hands properly	.857	.735
Before eating, I intend to wash my hands properly	.686	.470
When I feel like my hands are invisibly unclean (viruses, bacteria, etc.), I intend to wash my hands properly	.681	.463
After sports, exercise, or PE classes, I intend to wash my hands properly	.648	.420

Instructional text: In each situation, to what extent do you intend to perform hand hygiene behavior?
Note: If you need the Japanese version of the scale items, please contact the first author.

RMSEA = .062). The average value of the total score on the behavioral intention scale was 16.57 (*SD* = 3.40) before COVID-19 and 17.85 (*SD* = 2.69) after COVID-19. As a result of comparison using an unpaired t-test, it was found that the total score on the behavioral intention scale was significantly higher after COVID-19 (t = 4.74, df = 374.68, $p < .001$, d = 0.43) (Table 2).

Self-efficacy: EFA resulted in the extraction of eight items for two factors with eigenvalues of 1.0 or more and factor loading greater than .4, with the cumulative contribution ratio of the first factor being 55.12%, and the cumulative contribution ratio of the second factor being 69.92% (Table 5). The measure of the KMO sampling adequacy at this time was KMO = .866, Bartlett's sphericity was χ^2 = 901.358, df = 28, and $p < .001$. The first factor comprised four items denoting the execution of hand hygiene behavior and as therefore named "Action Self-efficacy" ("Action SE" hereafter). The second factor comprised four items denoting coping strategies for when one encounters difficulties in executing hand hygiene behavior and therefore was named "Coping Self-efficacy" ("Coping SE" hereafter). Also, the self-efficacy scale alpha coefficient and omega coefficient were sufficiently high, which confirmed internal consistency ([Action SE: pre-COVID-19 α = .834, ω = .838, post-COVID-19 α = .859, ω = .860], [Coping SE" pre-COVID-19 α = .833, ω = .828, post-COVID-19 α = .788, ω = .783]). As a result of CFA, sufficient values were found in the FI before and after COVID-19, which confirmed construct validity (pre-COVID-19 NFI= .923, CFI = .941, IFI = .942, RMSEA = .111, post-COVID-19 NFI= .937, CFI = .948, IFI = .948, RMSEA = .108). The average value of the total score for Action SE was 15.65 (*SD* = 3.38) before COVID-19 and 17.94 (*SD* = 2.79) after COVID-19. As a result of comparison using an unpaired t-test, it was found that the total score for Action SE was significantly higher after COVID-19 (t = 8.45, df = 389.63, $p < .001$, d = 0.76). Also, the average value of the to-

Table 5
Results of Exploratory Factor Analysis (Self-efficacy Scale)

Item	Factor 1	Factor 2	Communalities
I can wash hands using soap or an antiseptic alcohol solution, etc. to maintain cleanliness.	.935	–.181	.680
I can wash hands using soap or an antiseptic alcohol solution, etc., even if no one instructs me to do so.	.882	.000	.779
I can wash hands using soap or an antiseptic alcohol solution, etc., without regard for if people see me or not	.711	–.039	.469
I can immediately wash hands if I realize that I haven't been doing so.	.442	.236	.391
Even if there is no handwashing location nearby, I can still wash my hands.	–.038	.784	.577
I can carry around soap or an antiseptic alcohol solution, etc., for washing hands	–.224	.770	.412
I can wash hands using soap or an antiseptic alcohol solution, etc., even if I'm short on time.	.281	.657	.758
I can wash hands using soap or an antiseptic alcohol solution, etc., even if I feel like doing so is bothersome.	.316	.589	.697
Factor correlation	—	.670	

Instructional text: To what extent are you confident about your hand hygiene behavior in each situation?
Note: If you need the Japanese version of the scale items, please contact the first author.

tal score for Coping SE was 12.65 (SD = 4.02) before COVID-19 and 15.16 (SD = 3.73) after COVID-19. As a result of a comparison using an unrelated t-test, it was found that the total score for Coping Self-efficacy was significantly higher after COVID-19 (t = 7.65, df = 586, p < .001, d = 0.65) (Table 2).

Planning: EFA resulted in the extraction of four items for the one factor with eigenvalues of 1.0 or more and factor loading greater than .6, with the cumulative contribution ratio of the first factor being 73.39% (Table 6). The measure of the KMO sampling adequacy at this time was KMO = .772, Bartlett's sphericity was χ^2 = 507.793, df = 6, and p < .001. Also, the planning scale alpha coefficient and omega coefficient were sufficiently high, which confirmed internal consistency (pre-COVID-19 α = .878, ω = .878, post-COVID-19 α = .875, ω = .876). As a result of CFA, sufficient values were found in the FI before and after COVID-19, which confirmed construct validity (pre-COVID-19 NFI = .956, CFI = .960, IFI = .960, RMSEA = .213, post-COVID-19 NFI = .979, CFI = .982, IFI = .982, RMSEA = .139). The average value of the total score on the planning scale was 9.20 (SD = 4.13) before COVID-19 and 10.78 (SD = 4.58) after COVID-19. As a result of comparison using an unpaired t-test, it was found that the total score on the planning scale was significantly higher after COVID-19 (t = 4.19, df = 586, p < .001, d = 0.36) (Table 2).

Hand hygiene behavior: Considering the correlation coefficients between the newly developed scales, correlation coefficients between the newly developed scales and between the newly developed scales and hand washing behavior generally showed significant weak correlation coefficients. However, no significant correlation coefficients were obtained between some of the scales or between the newly developed scales and hand washing behavior (Tables 7

Table 6
Results of Exploratory Factor Analysis (Planning Scale)

Item	Factor 1	Communalities
I plan other measures that I can take when I am unable to wash hands	.929	.863
I plan how I will wash hands in case soap or an antiseptic alcohol solution, etc., is not available	.890	.793
I plan to learn how to wash hands correctly	.697	.486
I plan the locations where I can wash hands	.667	.445

Instructional text: To what extent do you tend to plan your hand hygiene behavior?
Note: If you need the Japanese version of the scale items, please contact the first author.

Table 7
Correlation Coefficients between the Newly Developed Scales

	Outcome expectancy	Behavioral intention	Action self-efficacy	Coping self-efficacy	Planning	*Mean*	*SD*	*Skewness*	*Kurtosis*
Risk perception	.464**	.236**	.283**	0.129	0.065	16.72	2.846	–1.159	1.696
Outcome expectancy	1	.277**	.411**	.200**	.169*	16.48	3.134	–.843	.596
Behavioral intention		1	.543**	.395**	.217**	16.57	3.396	–1.419	2.047
Action self-efficacy			1	.605**	.267**	15.65	3.375	–.548	–.170
Coping self-efficacy				1	.504**	12.65	4.023	–.143	–.514
Planning					1	9.20	4.128	.317	–.811

* p < .05, ** p < .01

and 8). As a result of a comparison using an unpaired t-test for hand hygiene behavior, it was found that the time spent per handwashing event, the frequency of hand antisepsis per day, and the frequency of hand hygiene behavior implementation in each of the four settings (before eating, after using the toilet, after arriving at home, and when hands are visibly unclean) were significantly higher after COVID-19 (Table 2). However, no significant difference was found for two of the settings (after sports and when hands are invisibly unclean).

Discussion

This study develops scales to assess the psychological factors contained in HAPA in relation to hand hygiene as a preliminary step in investigating the capacity of HAPA to predict hand hygiene behavior. Although a previously existing scale in Japan is limited to the scope of a specific occupation, namely, newly employed nurses (Yamamoto et al., 2019), this scale cannot be used to assess regular hand hygiene, and therefore, it was necessary to develop a new scale. As a result of this study, a simple scale of four items was produced to assess each of the five factors contained in HAPA (risk perception, outcome expectancy, self-efficacy, behavioral intention, and planning). When using models that comprise multiple psychological factors, like HAPA, using numerous items to assess each psychological factor increases the overall number of items and the burden on survey respondents, which, in turn, can produce changes in data (Okayasu, Katayanagi, Shimada, Kubo, & Sakano, 1993). Moreover, from the perspective of model modifiability when using a CFA model (Kano, 2002) and the bias due to the number of items when making a point estimation of reliability by means of the α coefficient (Raykov, 1997), the minimum required number of items per factor is four (Takamoto & Hattori, 2015). Because Cronbach's alpha coefficient and McDonald's omega coefficient of the newly developed scale showed acceptable ranges of internal consistency (DeVellis, 2017; Taber, 2018), the reliability of the newly developed scale is deemed to be ensured. For some of the newly developed scales, RMSEA did not meet the criteria. As it is necessary to determine the goodness of a model comprehensively by combining multiple indicators (e.g., Toyoda, 2003), the validity of the newly developed scales is deemed to be ensured because the other three indicators in this study showed

Table 8
Correlation Coefficients between the Newly Developed Scale and Hand Hygiene Behavior

	Handwashing time per wash	Hand antisepsis per day	Frequency of hand hygiene before meals	Frequency of hand hygiene after toilet use	Frequency of hand hygiene after returning home	Frequency of hand hygiene after playing sports	Frequency of hand hygiene when visible dirt is attached	Frequency of hand hygiene when invisible dirt is attached
Risk perception	0.073	0.002	.201*	0.087	.266**	0.143	–0.012	.203*
Outcome expectancy	0.099	–0.093	.172*	0.160	0.082	0.089	0.038	.188*
Behavioral intention	0.063	0.076	.228**	0.047	.223**	.280**	0.007	.309**
Action self-efficacy	.141*	0.011	0.160	0.115	.263**	.260**	0.040	.298**
Coping self-efficacy	0.116	.172*	.271**	–0.054	.250**	0.109	–0.113	.191*
Planning	0.078	.186**	.194*	–0.150	.192*	0.083	–0.074	0.120

* $p < .05$, ** $p < .01$

goodness of fit. In a study using the HAPA model for hand hygiene behavior in China during the COVID-19 epidemic, the correlation coefficients among the components of HAPA (risk perception, outcome expectancy, self-efficacy, behavioral intention, and action plan) were r = .14 – .72, indicating that hand hygiene behavior can be predicted by the HAPA model (Lao, Li, Zhao, Gou, & Zhou, 2021). The item contents of the newly developed scales in this study are similar to those used in the previous study (Lao et al., 2021), and the correlation coefficients between the scales in this study are rs = .169 – .605, which are similar to those in the previous study (rs = .19 – .72). For example, in the present study, behavioral intentions were weakly correlated with risk perception and outcome expectancy, and similar trends have also been observed in previous studies. From these results, it was inferred that the scales developed in this study were guaranteed to have content validity and construct validity. Additionally, because weak but significant correlation coefficients were obtained between the newly developed scales and each variable of hand hygiene behavior, which is an external standard, and the correlation coefficient was as significant and weak as that of a previous study that examined hand hygiene behavior using HAPA (Lao et al., 2021), the validity of the newly developed scales is deemed to be guaranteed. The kurtosis of the scale scores of the behavioral intention scale was 2.047. However, because the scale was created with items whose skewness and kurtosis did not exceed 2 in absolute value when the items were selected, it was concluded that there was no extreme bias in the distribution of the scale scores. In addition, the items of the present scale were judged to be content-valid because they were similar to those of a previous study (Lao et al., 2021). Based on these perspectives, each factor in the scale developed in this study had four items, which is the number of items that minimizes the burden on survey respondents but is also statistically suitable. As this study confirmed the correlations among the variables that constitute HAPA, it is possible to examine hand hygiene behavior using covariance structure analysis.

Next, the results of a comparison of HAPA factors and hand hygiene behavior before and after the outbreak of COVID-19 shall be discussed. It has been reported that, since COVID-19, there has been a global increase in risk perception about this unknown virus (Ding et al., 2020, Dryhurst et al., 2020). Also, while another study confirmed that young people recognize that they are at low risk of being infected by COVID-19, they are also aware that COVID-19 is dangerous to society (Franzen & Wöhner, 2021). In particular, actions to prevent infection were carried out more frequently by those whose family, cohabitants and other close people were at a higher risk of infection (Franzen & Wöhner, 2021). Also, it has been reported that risk perception is significantly related to the adoption of preventative health actions (e.g., washing hands, wearing a face mask, and physical distancing). It is assumed that risk perception in HAPA has either a correlation or causal relationship with the other factors contained in HAPA (Schwarzer, 2016). Thus, it is possible that the increase in risk perception among university students since the outbreak of COVID-19 impacts the other factors contained in HAPA, causing the other factors to increase. Also, with regard to hand hygiene behavior, it was found that the time spent per handwashing event, the frequency of hand antisepsis per day, and the frequency of hand hygiene behavior implementation in four of the settings (before eating, after using the toilet, after arriving at home, and when hands are visibly unclean) were significantly higher after COVID-19. As for the causes of the increase in hand hygiene behavior, in addition to the social background of increased risk perception with regard to COVID-19 (Ding et al., 2020, Dryhurst et al., 2020), hand hygiene behavior may have increased due to videos, etc., on the website of the Ministry of Health, Labour and Welfare, as well as on TV and social media, recommending time-taking, careful, correct hand hygiene behavior becoming widely known since the

outbreak of COVID-19 (Ministry of Health, Labour and Welfare, 2020). The high scores in the post-COVID-19 survey are also considered to be due to the fact that the environment allows for more simple and habitual use of alcohol disinfectant, with dispensers being permanently placed in the entrances of various buildings, including universities and shopping malls. Furthermore, regarding hand hygiene behavior in two of the settings (after sports and when hands are invisibly unclean), there was no significant difference in the pre- and post-COVID-19 surveys. Due to the declaration of states of emergency after COVID-19, many universities switched to online lessons, many similar measures that were taken for practical physical education classes, and people were requested to voluntarily curtail sports club activities. For these reasons, situations that require hand hygiene behavior, such as when performing sports and exercise, may have become less frequent for many university students. Also, with regard to invisible viruses such as COVID-19, because it is not possible to see if the virus is attached to the hand, it is considered possibly difficult to determine the immediate need for hand hygiene behavior. Based on the results of this study, in the post-COVID-19 survey, there was an increase in hand hygiene implementation when hands were visibly unclean, which means that hand hygiene can likely be more frequently implemented if invisible uncleanliness is visualized. For that reason, it may be possible to increase the frequency of hand hygiene behavior by having people undergo the following experience to confirm how effective their handwashing is: apply an artificial colorless and transparent liquid to the entirety of the hands, likening it to uncleanliness, perform hand hygiene behavior, and then shine a blacklight onto the hands to see any remaining unwashed parts (e.g., Fishbein, Tellez, Lin, Sullivan & Groll, 2011).

Finally, the advantage of this study is that hand hygiene behavior was surveyed prior to COVID-19, enabling a pre- and post-COVID-19 comparison. This enables changes in the psychological factors that impact hand hygiene behavior to be studied in connection to a global outbreak of an emerging infectious disease such as COVID-19. However, this study was limited to being a cross-sectional study. It became impossible to implement the study as originally planned because of the declaration of the states of emergency that led to university lessons taking place online, which meant that a longitudinal study could not be performed; test–retest reliability for newly developed scales could not be conducted, and the changes made by individuals before and after COVID-19 could not be measured. Therefore, the results of this study do not clarify the level of impact, or the level of change, on the factors comprising HAPA due to COVID-19. In the future, it is necessary to consider the potential of using HAPA to predict hand hygiene behavior among Japanese people by performing a pre- and post-COVID-19 HAPA model verification.

Self-Declaration of Conflicts of Interest

Nothing to declare.

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