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Motivation for Adopting COVID Preventive Practices Among Healthcare Workers: A Cross-Sectional Analysis of Three Competing Models

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[Abstract] Background: Healthcare workers' risk perceptions towards contracting Coronavirus 2019 (COVID-19) may determine their adoption of preventive behaviors. The adoption of six-feet physical distancing and wearing face coverings reduces the spread of COVID-19 in the community setting. Three theoretical models, the Health Belief Model (HBM), the Protection Motivation Theory (PMT) and the Theory of Planned Behavior (TPB) have been used to determine the adoption of preventive practices in relation to infectious diseases. Objective: We examined the association between measures of behavioral models guiding preventive practices and using COVID-19 preventive practices (physical distancing and face coverings) among healthcare workers. Methods: A cross-sectional study using an electronic survey of healthcare workers (*N*=279) in the southeastern United States. Results: Of the HBM measures, the perceived severity and benefits subscales were associated with physical distancing. Of the PMT measures, the perceived severity and response efficacy subscales were associated with physical distancing, whereas the vulnerability, extrinsic reward, and intention subscales were associated with facial coverings. Finally, no TPB measures were directly associated with outcome measures. Conclusions: Future studies may assess how theoretically derived measures may be useful in guiding interventions to support preventive practices adoption among healthcare workers in future infectious disease public health situations.

[Key Words]　COVID-19　preventive practices　Theory of Planned Behavior　Protection Motivation Theory　Health Belief Model

醫護人員採用 COVID 預防措施動機調查：三種模型指導下的措施對比

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【摘要】背景：醫護人員對 2019 冠狀病毒感染（COVID-19）的風險認知可決定其採取預防措施。 保持六英尺的社交距離和戴口罩可減少 COVID-19 在社區中的傳播。以往採用健康信念模型（HBM）、保護動機理論（PMT）和計劃行為理論（TPB）模型來指導控制其他傳染病的預防措施。目的：研究針對以上三個理論模型指導下的預防措施的測量與 COVID-19 預防措施中的社交距離和口罩的關係。方法：本橫斷面研究對美國東南部醫療工作者（*N*=279）進行電子問卷調查。結果：在 HBM 為指導的預防措施的測量中，感知到的嚴重性和益處與保持社交距離相關；在 PMT 為指導的預防措施的測量中，感知到的嚴重性和反應效能與保持社交距離相關，而易感性、外在獎勵和意圖與戴口罩相關；在 TPB 為指導的預防措施的測量中，未發現與社交距離和戴口罩相關的因素。結論：未來研究應該評估在理論模型指導下的預防措施對控制傳染病的有效性。

【關鍵詞】　COVID-19　預防措施　計劃行為理論　保護動機理論　健康信念模型

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1 Introduction

Disruptions in healthcare delivery during the early days of the Coronavirus Disease 2019 (COVID-19) pandemic led to a focus on addressing hospital and clinic preparedness and response, rapid diagnostic testing, and public health actions to mitigate the spread of the disease (Adalja et al. , 2020). Infectious disease outbreaks in hospital settings often test the strength of and adherence to infection disease control protocols. However, with the rapid spread of COVID-19, several hospital systems adopted measures, often beyond governmental regulations, to provide protection to both patients and healthcare workers (Rhee et al., 2020). Moreover, stringent protocols were implemented to enhance better patient and staff protection, including screening of all visitors for respiratory symptoms, restricting healthcare workers from duties if they reported any upper respiratory symptoms, screening of all patients for respiratory viruses, and using contact and droplet precautions (including eye protection) when engaged in patient care (Klompas, 2020). Population level studies indicate that being a healthcare worker is a significant predictor of adherence to COVID-19 preventive behaviors (Barakat & Kasemy, 2020). However, given varying recommendations between hospital systems, along with constant regulatory updates from governing bodies (e.g., U.S.A. Centers for Disease Prevention and Control, CDC), healthcare workers may have adopted COVID-19 preventive measures to various degrees.

2 Literature Review

In the community setting, adoption of physical distancing, face covering, and eye protection can reduce the spread of COVID-19 (Chu et al., 2020). In fact, communities that adopt such preventive measures have been shown to decrease the rates of COVID-19 transmission (Lyu & Wehby, 2020; Thu et al., 2020). However, several intrinsic and extrinsic factors may influence an individual's intention to adopt COVID-19 preventive measures. Intrinsic factors include perceptions of infection risk, effectiveness of preventive measures, and attitudes towards preventive measures (Beeckman et al., 2020; Coroiu et al., 2020). Extrinsic factors include social acceptability of measures, social support, neighborhood income, and information about COVID-19 (Coroiu et al., 2020; Jay et al., 2020). Yet, such factors have not been well studied among healthcare workers. An understanding of such intentional factors may be informative in supporting the adoption of preventive practices.

Several theoretical frameworks and models have been used to determine intrinsic motivation towards adopting preventive practices. The Health Belief Model (HBM) (Champion & Skinner, 2008) is a psycho-social framework that predicts the reasons individuals act on measures to prevent, screen, or control illness conditions. The key constructs of the HBM are *perceived susceptibility* (belief regarding chances of getting a condition), *perceived severity* (belief regarding the seriousness of a condition), *perceived benefits* (beliefs about preventative actions to reduce risk of a condition), *perceived barriers* (belief about costs of taking preventative actions), cues to action (ways to get ready for the action), and *self-efficacy* (the confidence one has in the ability to take preventative action). This framework has been useful in understanding the use of preventative behaviors regarding preventing respiratory infections such as the use of face covering, handwashing, and social distancing (Ghanbari et al., 2014; Karimi et al., 2016; Okoli et al., 2022; Sim et al., 2014). Thus, this model may be a useful framework to understand healthcare workers' risk perceptions regarding COVID-19 contamination and infection.

Like the HBM, the Protection Motivation Theory (PMT) proposes that behavioral intention tends to be motivated by two main related pathways which include *threat appraisal* (an assessment of threat perceptions towards behaviors or diseases) and *coping appraisal* (an

assessment of the ability to cope with a threatening situation, behavior, or disease) (Milne et al., 2000; Rogers, 1975). Threat appraisal can be measured by perceived severity of the threat, vulnerability to the threat, intrinsic rewards and extrinsic rewards, and fear arousal; whereas coping appraisal is determined by response efficacy, self-efficacy, and response cost. The PMT has been used to examine the behaviors related to the prevention of pandemic influenza among high school students, social distancing behavior, and the use of face covering to prevent Severe Acute Respiratory Syndrome (SARS) (Sharifirad et al., 2014; Tang & Wong, 2004; Williams et al., 2015). Furthermore, this model has been proposed as a potential framework that could be used to understand the protective measures used to prevent the current COVID-19 pandemic (Khosravi, 2020). Hence, the PMT may be used to understand preventive measure adoption among healthcare workers.

A final salient model that examines health behavior is the Theory of Planned Behavior (TPB) (Ajzen, 1991). This is a psycho-social theory that examines the predictive ability of *attitudes* towards a behavior, *subjective norms*, and *perceived behavioral control* in the intentions towards a behavior and the actual behavior. The attitudes towards a behavior include an individual's degree of favorable judgements towards it; the subjective norms include the perception of social pressure to execute the behavior (or not); and perceived behavioral control comprises the degree to which a person considers the behavior challenging to accomplish (Ajzen, 1991). The TPB has been used to explain healthcare workers hand hygiene and other protective behaviors (e.g., using face covering to avoid air pollution) (Hansstein & Echegaray, 2018; Srigley et al., 2015). Given the utility of the TPB in addressing health behavior protective measure adoption, it may be a useful theory to understand COVID-19 behavioral intentions among healthcare workers.

2.1 Purpose

Given the novelty of the COVID-19 pandemic, at the early stages in the U.S., and lack of evidence-based information, it was unclear how to guide the understanding of the adoption of preventive practices among healthcare workers. Indeed, with the challenge of misinformation regarding preventive practices (such as wearing facemasks), even promoted by some healthcare providers, there was a need to understand factors which influenced healthcare workers motivations to adopt preventive practices (Ayers et al., 2021; Sule et al., 2023). Therefore, given the significant health risk associated with contracting COVID-19 among healthcare workers, the purpose of this study was to examine the extent to which theoretically based models predicted preventive practice adoption by healthcare workers during the early stages of the COVID-19 pandemic in the U.S. The research questions guiding this study were: 1) How does the HBM explain the adoption of preventive practices by healthcare providers? 2) How does the PMT explain the adoption of preventive practices by healthcare providers? 3) How does the TPB explain the adoption of preventive practices by healthcare providers? To answer these questions, the specific aims of the study were to examine:

1. The associations between the HBM model measures and frequency of reported adoption of preventive practices (i.e., physical distancing and face coverings) while accounting for demographic and work-related variables
2. The associations between the PMT model measures and frequency of reported adoption of preventive practices while accounting for demographic and work-related variables
3. The associations between the TPB model measures and frequency of reported adoption of preventive practices while accounting for demographic and work-related variables

3 Methodology

3.1 Design

This cross-sectional study used an electronic survey to determine the associations between theoretically derived behavioral risk perceptions for contracting COVID-19 and the adoption of preventive measures from a sample of healthcare workers. We used the STROBE checklist for cross-sectional studies to ascertain that our research procedures were reported adequately (von Elm et al., 2007).

3.2 Sample

Our study sample was obtained from a convenience sample of healthcare workers in an academic-medical center in the south-eastern U.S. To be included in the study, participants had to be: 1) currently employed (part-time or full-time staff) at the academic-medical center, and 2) 18 years of age or older. Exclusion criteria were: 1) provisional staff or travelers, and 2) those who did not work at the academic-medical center during the study period.

3.3 Procedures

The 10-minute survey was developed using Qualtrics, a web-based survey administration software that can be used to ensure anonymity. The survey was sent to the e-mail listservs of staff in the academic medical center for a 3-month period, from May 1st, 2020 to July 31st, 2020. A cover sheet accompanied the email with an explanation of the study goals and procedures. Interested participants indicated their willingness to take part in the study by clicking on a link that directed them to the electronic survey. To minimize response bias, the anonymous survey was developed in such a way that participants could skip questions which made them uncomfortable. As an incentive to participate, those who completed the survey were entered into a drawing for one of four $50 visa gift cards. Ethical approval for the study procedures was obtained from the University of Kentucky Institutional Review Board Exemption certificate # 58974.

3.4 Measures

Demographics: The survey collected demographic information on gender (i.e., male vs. female), sexual orientation (i.e., heterosexual vs. non-heterosexual), age in categories (i.e., 18-25 yrs vs. 26-35 yrs vs. 36-50 yrs vs. 51 yrs and older) marital status (i.e., single, never married vs. cohabiting vs. divorced/separated vs. married/widowed), ethnicity (i.e., non-white vs. white, non-Hispanic), and educational attainment (i.e., some college vs. college graduate vs. postgraduate). For analysis, we dichotomized marital status into ‘single’ or ‘other’.

Professional role and work-related variables: We obtained responses on the respondent’s professional role, work tenure in year categories (i.e., 6 months or less vs. 7 months to 1 yr vs. 1-3 yrs vs. 3-5 yrs vs. 5-10 yrs vs. 10 yrs or greater), and type of shift work (i.e., days vs. nights vs. other). For analysis we categorized professional role into ‘clinical nurse’ and ‘other’ and shift work was categorized into ‘days’ and ‘other’.

HBM measure: This HBM measure was based on adaptations of prior studies using the HBM to assess risk behaviors (Aldohaian et al., 2019; Othman et al., 2019). The measure included 17 questions categorized into subscales of perceived susceptibility (3 questions), perceived severity (2 questions), perceived benefits (3 questions), perceived barriers (3 questions), cues to action (2 questions), perceived self-efficacy (2 questions), and intention (2 questions) (see supplementary materials Appendix A). Each question was based on a response choice of 0=completely disagree to 10=completely agree. Cronbach’s alpha coefficients for the subscales fell between 0.47 to 0.89. Mean scores for the responses to the questions in each subscale were calculated.

PMT measure: The PMT measure was adapted from others using the PMT to examine health behaviors (Camerini et al., 2019; Ling et al., 2019). The measure included 19 questions grouped into subscales of

perceived severity (2 questions), perceived vulnerability (2 questions), intrinsic reward (2 questions), extrinsic reward (2 questions), fear arousal (3 questions), response efficacy (2 questions), perceived self-efficacy (2 questions), response cost (2 questions), and intention (2 questions) (see supplementary materials Appendix B). Each question was based on a response choice of 0=completely disagree to 10=completely agree, except for the intention questions which were on a scale of 1=completely disagree and 7=completely agree. Cronbach's alpha coefficients for the subscales fell between 0.66 to 0.89. Mean scores for the responses to the questions in each subscale were calculated.

TPB measure: The TPB measure was developed based on an instruction manual provided by the original TPB developers (Ajzen, 2019). The measure included 11 questions sorted into subscales of intentions (2 questions), attitudes (3 questions), subjective norms (3 questions), and perceived behavioral control (3 questions) (see supplementary materials Appendix C). Each question was based on a response choice of 1=completely disagree to 7=completely agree, except for intention which was based on a scale of 1=completely disagree and 7=completely agree. Cronbach's alpha coefficients for the subscales fell between 0.62 to 0.89, with a total coefficient of 0.88. Mean scores for the responses to the questions in each subscale were calculated.

Preventive practices: We asked participants about their frequency of engaging in two preventive practices related to COVID-19. Specifically, participants were asked to rate how often at work in the past month they: 1) kept six feet social distance from people, and 2) wore a face covering. Response choices for each question was on a scale of 0=never, 1=seldom, 2=occasionally, and 3=very often.

3.5 Data Analysis

Because this study was based on a convenience sample, no pre-determined study size was calculated. A total of 487 participants initially responded to the survey of which 279 (57.3%) provided complete responses to the main outcome variables. Of these responses, less than 10% had missing values on any one variable, thus mean (for continuous variables) or modal (for categorical variables) replacements were made. To examine the associations between the HBM, PMT, and TPB measures and preventive practices, we conducted a series of separate hierarchical regression analyses. In the first step of each model, we included the variables associated with the subscales of the specific theoretical framework to assess the association with preventive measures. In the next step of the analyses for both the PMT and TPB, we included the intention to perform the behavior as a potential mediator of the relationship between the behavior and the subscales, based on theoretical considerations for these models. In the next step, we included demographic variables, and in the final step, we included work related variables. Adjusted R^2s and associated F-statistics were used to determine the model fit for each step of the analysis. For all analyses, an alpha level of $p \leq 0.05$ was used to indicate significant findings.

4 Result

4.1 Sample Characteristics

Participants were mostly female (79.9%), 36 years of age or older (54.8%), and identified as white Non-Hispanic (93.9%) and heterosexual (90.3%). The majority were married or widowed (58.1%), college graduates or postgraduates (90.7%), clinical nurses (52.3%), working on the day shift (80.3%), and had 5 years or greater of work experience (63.0%) (Table 1).

4.2 Associations between HBM Model Measures and Preventive Practices

In the first step of the hierarchical regression analysis examining the associations between HBM measures and frequency of physical distancing, a well-fitting model was obtained ($F[df=6,272]=3.6$, $p=0.002$) that explained 5% in the variance of the model.

Table 1　Demographic characteristics of sample (*N* = 279)

Demographic characteristics	*N*	%	Demographic characteristics	*N*	%
Gender			**Grade in School**		
Female	223	79.9	Some College*	26	9.3
Male	56	20.1	College Graduate	159	57.0
Sexual Orientation			Postgraduate	94	33.7
Non-heterosexual	27	9.7	**Professional Role**		
Heterosexual	252	90.3	Advance Practice/Pharmacy	11	3.9
Age			Clinical Nurse	146	52.3
18 to 25 years	41	14.7	Counselors (Psychology/Social Work)	10	3.6
26 to 35 years	85	30.5	Nursing Assistant/Paramedics	41	14.7
36 to 50 years	100	25.8	Therapists (e.g., Occupational, Respiratory, Physical, Diagnostics, Dietetics)	18	6.5
51 or older	53	19.0	Other (e.g., Administrative Staff, Information Technology)	53	19.0
Ethnicity			**Disciplinary Tenure**		
Non-white	17	6.1	1 year or less	25	8.9
White	262	93.9	> 1 to 5 years	78	28.0
Marital Status			> 5 to 10 years	52	18.6
Married/Widowed	162	58.1	> 10 years	124	44.4
Unmarried but Cohabiting	30	10.8	**Shift Work**		
Divorced/Separated	15	5.4	Days	224	80.3
Single, Never Married	72	25.8	Nights	43	15.4
			Other	12	4.3

*Note 1 individual had a Highschool degree and was included with some college category

In this step, only cues to action was associated with physical distancing. The addition of demographic variables in the second step improved the model fit ($F[df=15,263]=4.0$, $p<0.0001$), explaining 14% of the variance in the model. In this step, among demographic variables, older age was associated with physical distancing. In the final step, by including work-related variables, there was a further improvement in the model fit (adjusted $R^2=0.24$, $F[df=18,260]=4.5$, $p<0.0001$) and perceived severity, perceived benefits, older age, and not being a clinical nurse were significantly associated with a higher frequency of adhering to physical distancing (Table 2).

In the analysis of the associations between the HBM measures and frequency of face covering, poor fitting models were obtained. In the final step (adjusted $R^2=0.00$, $F[df=18,260]=1.0$, $p=0.444$), being a clinical nurse was associated with the outcome (Table 2). In this model, none of the HBM measures were associated with the frequency of face covering.

4.3　Associations between PMT Model Measures and Preventive Practices

In the first step of the analysis examining the associations between PMT model measures and frequency of physical distancing, a well-fitting model was obtained ($F[df=8,270]=5.4$, $p<0.0001$) that explained 11% in the variance of the model. In this step, perceived severity, perceived vulnerability, and response efficacy were significantly associated with physical distancing. The addition of intention in the second step did not significantly contribute to the model. However, adding demographic variables in the third step improved the model fit (adjusted $R^2=0.16$, $F[df=18,260]=4.0$, $p<0.0001$), and older age was associated with physical distancing. In the final step, by including work-related variables, there was a further improvement in the model fit (adjusted $R^2=0.19$, $F[df=21,257]=4.2$, $p<0.0001$) in which perceived severity, response efficacy, older age, and not being a clinical nurse were significantly associated with a higher frequency of adhering to physical distancing (Table 3).

In the analysis examining the associations between the PMT model measures and frequency of face covering, a well-fitting model was obtained in the first step (adjusted $R^2=0.03$, $F[df=8,270]=2.2$, $p=0.027$) in

Table 2　Hierarchical linear regression assessing the association between the HBM model measures, demographic, and work-related variables and preventive practices

Variables in hierarchical linear regression analysis	Physical Distancing[a]				Face Covering[a]			
	Beta	*Estimate*	*S.E.*	*p*	*Beta*	*Estimate*	*S.E.*	*p*
Step 1: HBM	**Step 1: Adjusted R^2=0.07, F=3.60, p=0.002**				**Step 1: Adjusted R^2=-0.01, F=0.66, p=0.684**			
Perceived Susceptibility	-0.04	-0.02	0.03	0.619	0.02	0.01	0.02	0.728
Perceived Severity	0.14	0.06	0.03	0.028	0.04	0.01	0.02	0.608
Perceived Benefits	0.13	0.08	0.04	0.035	0.06	0.02	0.02	0.396
Perceived Barriers	-0.03	-0.02	0.03	0.596	0.00	0.00	0.02	0.951
Cues to action	0.07	0.04	0.04	0.229	0.05	0.02	0.02	0.430
Perceived Self-Efficacy	0.04	0.02	0.04	0.544	0.03	0.01	0.02	0.660
Step 2: Demographics	**Step 2: Adjusted R^2=0.19, F=4.03, p=<0.0001**				**Step 2: Adjusted R^2=-0.01, F=0.81, p=0.672**			
Female (ref. Male)	-0.06	-0.15	0.15	0.336	-0.06	-0.09	0.09	0.357
Non-heterosexual (ref. Heterosexual)	-0.08	-0.27	0.19	0.165	-0.03	-0.06	0.12	0.641
26 to 35 years (ref. 18-25)	0.08	0.18	0.20	0.351	0.01	0.01	0.12	0.948
36 to 50 years (ref. 18-25)	0.23	0.49	0.23	0.037	0.02	0.02	0.14	0.859
51 or older (ref. 18-25)	0.26	0.69	0.26	0.008	-0.03	-0.03	0.16	0.774
White (ref. Non-white)	-0.01	-0.05	0.25	0.842	-0.00	-0.00	0.15	0.978
Single, Never Married (ref. other)	0.04	0.10	0.15	0.842	0.09	0.09	0.09	0.215
College Graduate (ref. some college)	0.13	0.27	0.22	0.224	0.01	0.01	0.14	0.945
Postgraduate (ref. some college)	0.11	0.25	0.23	0.283	0.00	0.00	0.14	0.980
Step 3: Work-related variables	**Step 3: Adjusted R^2=0.24, F=4.51, p=<0.0001**				**Step 3: Adjusted R^2=0.00, F=1.01, p=0.444**			
Clinical Nurse (ref. other)	-0.23	-0.46	0.14	<0.0001	0.18	0.18	0.08	0.015
Work tenure in years	0.12	0.08	0.05	0.108	0.00	0.00	0.03	0.970
Day shift (ref. other)	0.08	0.21	0.15	0.150	0.02	0.02	0.09	0.797

HBM = Health Belief Model

[a] The analysis results represents the final analysis results after the third step of the hierarchical regression analysis.

Table 3　Hierarchical linear regression assessing the association between the PMT model measures, demographic, and work-related variables and preventive practices

Variables in hierarchical linear regression analysis	Physical Distancing[a]				Face Covering[a]			
	Beta	*Estimate*	*S.E.*	*p*	*Beta*	*Estimate*	*S.E.*	*p*
Step 1: PMT	**Step 1: Adjusted R^2=0.11, F=5.44, p=<0.0001**				**Step 1: Adjusted R^2=-0.03, F=2.21, p=0.027**			
Perceived Severity	0.17	0.07	0.03	0.021	-0.06	-0.01	0.02	0.467
Perceived Vulnerability	-0.13	-0.05	0.03	0.095	0.17	0.04	0.02	0.032
Fear Arousal	0.10	0.04	0.03	0.209	0.06	0.01	0.02	0.452
Intrinsic Reward	-0.01	-0.00	0.03	0.925	0.07	0.02	0.02	0.345
Extrinsic Reward	0.06	0.03	0.03	0.344	0.14	0.03	0.02	0.046
Response Efficacy	0.17	0.08	0.03	0.010	0.02	0.01	0.02	0.737
Perceived Self-Efficacy	0.05	0.03	0.04	0.371	0.02	0.01	0.02	0.702
Response Cost	0.02	0.01	0.03	0.782	-0.03	-0.01	0.02	0.652
Step 2: Intention	**Step 2: Adjusted R^2=0.11, F=4.91, p=<0.0001**				**Step 2: Adjusted R^2=-0.05, F=2.72, p=0.005**			
Intention	-0.01	-0.01	0.06	0.935	0.17	0.10	0.04	0.009
Step 3: Demographics	**Step 3: Adjusted R^2=0.16, F=3.97, p=<0.0001**				**Step 3: Adjusted R^2=-0.05, F=1.81, p=0.025**			
Female (ref. Male)	-0.03	-0.07	0.15	0.650	-0.04	-0.05	0.09	0.557
White (ref. Non-white)	-0.01	-0.04	0.25	0.867	-0.03	-0.06	0.15	0.665
Non-heterosexual (ref. Heterosexual)	-0.08	-0.28	0.19	0.153	0.01	0.02	0.11	0.892
Single, Never Married (ref. other)	0.04	0.10	0.15	0.505	0.11	0.15	0.09	0.094
26 to 35 years (ref. 18-25)	0.13	0.30	0.20	0.140	-0.02	-0.02	0.12	0.862
36 to 50 years (ref. 18-25)	0.22	0.48	0.24	0.048	0.00	0.00	0.14	0.996
51 or older (ref. 18-25)	0.24	0.63	0.27	0.018	-0.03	-0.05	0.16	0.766
College Graduate (ref. some college)	0.12	0.25	0.22	0.262	0.00	0.00	0.13	0.987
Postgraduate (ref. some college)	0.14	0.29	0.23	0.200	-0.01	-0.01	0.14	0.919
Step 4: Work-related variables	**Step 4: Adjusted R^2=0.19, F=4.164, p=<0.0001**				**Step 4: Adjusted R^2=0.08, F=2.09, p=0.004**			
Clinical Nurse (ref. other)	-0.20	-0.41	0.14	0.003	0.23	0.26	0.08	0.001
Work tenure in years	0.09	0.06	0.05	0.246	0.01	0.01	0.03	0.881
Day shift (ref. other)	0.08	0.19	0.15	0.192	0.03	0.04	0.09	0.641

PMT = Protection Motivation Theory

[a] The analysis results represents the final analysis results after the third step of the hierarchical regression analysis.

which perceived vulnerability was significantly associated with the outcome. Adding intention in the second step slightly improved the model fit (adjusted R^2=0.05, F[df=9,269]=2.7, p=0.005) and perceived vulnerability and intention remained significantly associated with a higher frequency of face covering. In the third step, the addition of demographic variables did not significantly improve the model, with no demographic variables associated with the outcome. In the final step, by adding work-related variables, a well-fitting model was obtained (adjusted R^2=0.08, F[df=21,257]=2.1, p=0.004), in which perceived vulnerability, extrinsic reward, intention, and being a clinical nurse were significantly associated with higher frequency of face covering.

4.4 Associations between TPB Model Measures and Preventive Practices

In the first step of the hierarchical regression analysis examining the associations between TPB model measures and frequency of physical distancing, a well-fitting model was obtained (adjusted R^2=0.07, F[df=3,275]=8.1, p<0.0001) in which both attitudes and perceived behavioral control were associated with the outcome. The addition of intention in the second step did not significantly contribute to the model. Adding demographic variables in the third step improved the model fit (adjusted R^2=0.14, F[df=13,265]=4.5, p<0.0001), in which older age was associated with physical distancing. Including work-related variables in the final step resulted in a well-fitting model (adjusted R^2=0.17, F[df=16,262]=4.5, p<0 .0001) in which only older age and not being a clinical nurse were significantly associated with a higher frequency of adhering to physical distancing (Table 4).

In the analysis of the association between the TPB model measures and frequency of face covering, subjective norms were associated with the outcome in the first step. The additions of intention in the second step and demographics in the third step did not significantly improve the model. In the final step, the addition of work-related variables produced a well-fitting model (adjusted R^2=0.05, F[df=16,262]=1.9, p=0.019), in which being a clinical nurse was the only variable significantly associated with higher frequency of face covering.

Table 4 Hierarchical linear regression assessing the association between the TPB model measures, demographic, and work-related variables and preventive practices

Variables in hierarchical linear regression analysis	Physical Distancing[a]				Face Covering[a]			
	Beta	***Estimate***	***S.E.***	***p***	***Beta***	***Estimate***	***S.E.***	***p***
Step 1: TPB	**Step 1: Adjusted R^2=0.07, F=8.07, p=<0.0001**				**Step 1: Adjusted R^2=0.03, F=3.59, p=0.014**			
Attitude	0.12	0.12	0.07	0.088	0.10	0.05	0.04	0.215
Subjective Norms	0.13	0.11	0.08	0.157	0.05	0.02	0.05	0.642
Perceived Behavioral Control	0.05	0.03	0.04	0.471	-0.05	-0.02	0.02	0.442
Step 2: Intention	**Step 2: Adjusted R^2=0.07, F=6.09, p=<0.0001**				**Step 2: Adjusted R^2=0.094, F=3.59, p=0.007**			
Intention	-0.09	-0.09	0.08	0.272	0.15	0.09	0.05	0.080
Step 3: Demographics	**Step 3: Adjusted R^2=0.14, F=4.50, p=<0.0001**				**Step 3: Adjusted R^2=0.03, F=1.66, p=0.071**			
Female (ref. Male)	-0.05	-0.12	0.15	0.415	-0.04	-0.06	0.09	0.492
White (ref. Non-white)	0.01	0.06	0.25	0.825	-0.00	-0.00	0.15	0.982
Non-heterosexual (ref. Heterosexual)	-0.06	-0.21	0.20	0.286	-0.01	-0.02	0.12	0.866
Single, Never Married (ref. other)	0.04	0.10	0.15	0.509	0.09	0.11	0.09	0.210
26 to 35 years (ref. 18-25)	0.09	0.20	0.20	0.328	-0.02	-0.02	0.12	0.840
36 to 50 years (ref. 18-25)	0.22	0.48	0.24	0.046	-0.01	-0.01	0.14	0.927
51 or older (ref. 18-25)	0.24	0.63	0.26	0.017	-0.06	-0.09	0.16	0.584
College Graduate (ref. some college)	0.07	0.15	0.22	0.500	-0.03	-0.04	0.13	0.766
Postgraduate (ref. some college)	0.10	0.22	0.23	0.336	-0.03	-0.03	0.14	0.807
Step 4: Work-related variables	**Step 4: Adjusted R^2=0.17, F=4.51, p=<0.0001**				**Step 4: Adjusted R^2=0.05, F=1.91, p=0.019**			
Clinical Nurse (ref. other)	-0.17	-0.35	0.14	0.010	0.21	0.24	0.08	0.004
Work tenure in years	0.11	0.08	0.05	0.144	-0.01	-0.00	0.03	0.924
Day shift (ref. other)	0.08	0.21	0.15	0.171	0.02	0.02	0.09	0.784

TPB = Theory of Planned Behavior

[a] The analysis results represents the final analysis results after the third step of the hierarchical regression analysis.

5 Discussion

Our study of the responses of clinical hospital staff found that not all measures based on theoretically derived models of behavior change were associated with the use of preventive practices in the early stages of the COVID-19 pandemic in the U.S. Our results indicated that although no full model measures were associated with specific preventive practices, some model measures had stronger correlations than others. These findings may provide a basis for future research and may support the adoption of preventive practices in healthcare settings.

Our first aim was to assess whether the HBM model measures would be associated with the frequency of preventive practices. We found that both perceived severity and perceived benefits were associated with physical distancing, but no measure was associated with face covering. Other population-level studies investigating the HBM in relation to COVID-19 preventive behaviors have found that perceived susceptibility, benefits, barriers, cues to action, and self-efficacy are associated with preventive practices (Adesina et al., 2021; Bechard et al., 2021; Karimy et al., 2021; Shitu et al., 2022). However, in each investigation, preventive behaviors are measured quite differently. It is possible that the poor associations between the HBM measures and preventive behaviors in our present study is an indication of the novelty of healthcare workers response to the COVID-19 pandemic. Another reason may be that healthcare workers may have had reasons other than the measures of the HBM in adopting the preventive practices. In other words, the HBM may not be the best model predicting individual preventive practice adoption (i.e., social distancing vs. hand washing vs. face covering) as has been noted by others (Guidry et al., 2021). However, the fact that perceived severity and benefits were associated with physical distancing suggests that providing information on the severity of disease outcomes and the benefits of prevention may increase healthcare workers' adoption of some preventive practices. Future mixed-methods studies may be needed to further understand the salience of HBM measures among healthcare workers.

Our second aim was to examine how measures derived from the PMT were associated with preventive practices. When controlling for demographic and work-related variables, we found that perceived severity and response efficacy were directly associated with physical distancing, whereas perceived vulnerability, extrinsic reward, and intentions to engage in preventive practices were associated with face covering. Few studies have examined the PMT in relation to COVID-19 preventive practices among healthcare workers. A recent survey among healthcare workers in Iran found that the threat appraisal components (i.e., perceived severity and vulnerability) of the PMT had a higher predictive ability than the coping appraisal (i.e., response efficacy and self-efficacy) in association with behavioral intention (Bashirian et al., 2020). Contrary to our findings, another recent survey among healthcare workers in Saudi Arabia found that self-efficacy was the highest predictor of preventive practices (Mortada et al., 2021). Future studies are needed to examine why the PMT model measures vary in their predictive ability in relation to healthcare workers' adoption of different preventive practices.

Our third aim was to examine the association between TPB model measures and preventive practices. In the initial steps of the hierarchical regression analysis, both attitudes and perceived behavioral control were associated with the frequency of adopting physical distancing, however, this relationship was completely mediated by adding demographic and work-related variables to the analysis. No measure was associated with face covering. A recent study of the TPB model in relation to COVID-19 preventive practices found that the measures of the model were predictive of both behavioral intention and actual social distancing

behavior (Gibson et al., 2021). Another population-based study in the U.S. found that each of the TPB measures were associated with both physical distancing and face coverings (Aschwanden et al., 2021); however, for physical distancing, the strongest predictor was attitudes and for face covering, the strongest predictor was perceived behavioral control. Given these divergent findings in the literature, future studies of healthcare workers are needed to fully understand the potential contribution of the TPB in understanding preventive practices.

Finally, irrespective of theoretically derived model measures, there were salient demographic and work-related variables associated with the frequency of preventive practices. Specifically, older age was associated with a greater frequency of physical distancing in each model. Compared to other discipline groups, being a clinical nurse was associated with greater frequency of face covering but lower frequency of physical distancing. Older age among healthcare workers has been found to be a consistent factor in adopting COVID-19 preventive practices (Olum et al., 2020; Tien et al., 2021; Walle et al., 2021). Our findings that clinical nurses were more likely to use face covering but less likely to maintain physical distancing compared to other healthcare workers may reflect the specific duty of nurses in the hospital. Because clinical nurses are more involved in direct patient care, they may be unable to maintain physical distancing but more likely to face cover. This finding demonstrates that in some instances, preventive measures cannot be maintained because of the nature of job duties for clinical nurses. On the other hand, this finding also provides some evidence for the increased risk and vulnerability that nurses may face during infectious disease outbreaks. Regardless of internal motivations to avoid infection, the nature of a nurse's job may prevent them from adhering to some preventive practices.

5.1 Implications for Nursing Research and Practice

Since 52.3% of our sample were clinical nurses, the study findings may have specific implications for nursing practice and research. First, we found that the HBM factors associated with preventive practices (i.e., physical distancing) were perceived severity and benefits. In relation to nurses, this finding suggests that it is important to provide information on the severity of disease outcomes and the benefits of adopting preventive measures to reduce risk of exposure and infection. However, nursing research, employing mixed-methods, may further examine nurses perceptions of severity and benefits to better understand how the HBM measures may be used to support preventive practices in nurses.

Second, when examining factors associated with preventive practice adoption using the PMT, we found that perceived severity and response efficacy were associated with physical distancing, and that perceived vulnerability, extrinsic reward, and intentions to engage in preventive practices were associated with face coverings. This finding suggests that there are different motivations for the adoption of different aspects of preventive practices. Perhaps it is important to consider different types of education and awareness related to the type of preventive practices being recommended for adoption. For example, when recommending physical distancing among nurses, emphasis should be placed on issues related to the severity of infection and the efficacy of responding to preventive measures. Whereas, when recommending face coverings, the educational emphasis should be on promoting awareness of vulnerability, the extrinsic rewards of adopting the behavior, and ways to increase intentions to adopt the behavior. Nonetheless, future targeted studies with nurses are needed to examine how the PMT constructs may affect their adoption of preventive practices in other infectious disease areas.

Third, because the TPB model constructs were completely mediated by demographic variables, it may

be implied that attitudinal, subjective norm, and perceived behavioral control aspects that are associated with preventive practices adoption are explained through other variables. The finding that older age was associated with a greater frequency of physical distancing suggests that younger nurses may either perceive the risk of physical contact as low or have lower risk aversion in being infected by COVID-19 as has been observed in other studies (Wolfe et al., 2021). In addition, clinical nurses, compared to other health provider groups, were more likely to adopt face covering but less likely to use physical distancing. This finding may be reflective of institutional policies regarding using face coverings and face masks which is more normative among clinical nurses, whereas the nature of their job in caring for patients prevents them from maintaining physical distancing. Future studies would be needed to better understand clinical nurses' views on preventive policies in relation to their job responsibilities to better guide infectious disease prevention practice.

5.2 Limitations

A few important limitations must be considered in interpreting the findings of this study. First, although the measures used in our study were adapted from prior studies, their reliability estimates ranged from poor to acceptable for the HBM, PMT, and TPB measures. This challenge is due to the timing of the data collection. The study was designed at the initial stages of the COVID-19 pandemic in the U.S. and at that time no reliable or valid measures of preventive practices or methods to assess COVID-19 risk had been developed. For the preventive practices measure we used a perceived frequency measure which has not been previously validated. Poor reliability can affect the internal validity of the study such that some of the findings may have been a result of challenges in measuring the theoretical model under study. Future studies should select other question formats to better determine the measures under study.

Second, since based on a cross-sectional analysis, our study findings can only be understood within the time point of the data collection. No causal inferences can be made from the data. Thus, it is possible that the responses of participants could change over time based upon the development of the COVID-19 pandemic, especially as new information on preventive practices was made available. Future studies with longitudinal designs could be used to strengthen the predictive ability of the measures under study in relation to the main outcomes.

Third, the survey respondents were derived from a convenience sample of healthcare workers in an academic-medical center. The non-random sampling method of data collection limits the generalizability of findings to all the healthcare workers in the setting. Moreover, since the study sample was based on one main setting, our findings cannot be generalized to healthcare workers beyond the study context. Future studies including healthcare workers across multiple settings can strengthen the generalizability of such findings.

Fourth the exploratory models generated by our regression analyses have low explanatory power for the relationship between variables. This means that there are other potential variables, not included in the study, which may better explain the reasons why participants adopted preventive practices. Such variables may have included internal hospital-based policies or external governmental regulations. Thus, at best, participants' responses to the theory-based survey measures may indicate their individual perspectives and motivations and may not necessarily fully capture the reasons for their actual adoption of preventive behaviors.

6 Conclusion

The main deductions from our study are that the theoretically derived measures based on the HBM and

PMT contributed some explanatory power to understand healthcare workers' perceived frequency in adopting two different preventive practices (i.e., physical distancing and face covering), but the TPB did not. These findings suggest that healthcare workers may have different risk appraisals based on specific preventive practices. For example, whereas physical distancing may be associated with perceived severity of contracting COVID-19, face covering may not be met with the same risk appraisal. Such differences in risk appraisals based on different preventive practices may need to be further explored. This is especially salient given that our study findings reflect data from healthcare providers during the height of the COVID-19 pandemic. However, our exploration of such differences may improve our ability to tailor health risk communications to nurses and other healthcare workers to support preventive practice adoptions in future public health emergencies related to infectious disease processes. However, given the limitations in the design of our study, further longitudinal and experimental studies are needed, using theoretically derived measures, to determine optimal methods to support preventive practice adoption by healthcare workers during novel infectious disease outbreaks.

Other Author Footnotes

C. Okoli conceptualized the study, worked on data analysis, drafted the results section, and reviewed sections of the paper. Z. Almogheer, S. Seng, B. Abufarsakh, and W. Xie assisted in drafting the introduction, methods, and discussion section of the manuscript. All authors hold themselves jointly to the content in the manuscript.

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Conflicts of Interest

The authors have no conflict of interest to declare. There was no funding associated with the current study.

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Appendix A　Health Belief Model questions and internal consistency reliability estimates

Scale	Item	Mean (SD)	Cronbach's alpha
Perceived Susceptibility	My risk for getting COVID-19 will likely get worse in the future	6.25 (2.72)	0.57
	I've heard healthcare workers should get tested for COVID-19	6.38 (3.37)	
	Caring for people who are sick increases my exposure to COVID-19	7.79 (2.75)	
Perceived Severity	Having COVID-19 could lead to severely compromised lungs	7.71 (2.65)	0.74
	Getting COVID-19 can lead to premature death	7.71 (2.82)	
Perceived Benefits	The benefits of preventing COVID-19 infection would outweigh the costs	7.49 (2.89)	0.47
	I would be healthy if I didn't get COVID-19	7.23 (2.94)	
	I can continue working if I don't get COVID-19	9.27 (1.78)	
Perceived Barriers	Practicing preventative measures (i.e., washing hands, wearing masks, social distancing, and wiping down work areas) is inconvenient	2.89 (2.97)	0.58
	Practicing preventative measures (i.e., washing hands, wearing masks, social distancing, and wiping down work areas) doesn't work well against COVID-19	1.57 (2.42)	
	Practicing preventative measures (i.e., washing hands, wearing masks, social distancing, and wiping down work areas) is not supported at work	1.44 (2.49)	
Cues to Action	I have heard good things about practicing preventative measures (i.e., washing hands, wearing masks, social distancing, and wiping down work areas) to prevent COVID-19	8.43 (2.19)	0.69
	I know what to do to prevent COVID-19 transmission	8.83 (1.70)	
Perceived Self-Efficacy	It would be difficult to practice preventative measures against COVID-19 (i.e., washing hands, wearing masks, social distancing, and wiping down work areas)	3.11 (3.12)	0.71
	Practicing preventative measures for COVID-19 (i.e., washing hands, wearing masks, social distancing, and wiping down work areas) is easy	3.96 (3.08)	
HBM Total	All questions	103.21 (16.33)	0.62

Appendix B　Protection Motivation Theory questions and internal consistency reliability estimates

Scale	Item	Mean (SD)	Cronbach's alpha
Perceived Severity	Having COVID-19 could lead to severely compromised lungs	7.71 (2.65)	0.74
	Getting COVID-19 can lead to premature death	7.71 (2.82)	
Vulnerability	It is possible that I will get COVID-19 at work	8.05 (2.56)	0.81
	Working at the hospital increases my risk for getting COVID-19	7.74 (2.66)	
Intrinsic Reward	I enjoy working in the hospital despite my risk of exposure to COVID-19	7.47 (2.68)	0.76
	I would miss my time at work if I had to stop working due to the risk of exposure to COVID-19	6.91 (2.95)	
Extrinsic Reward	In spite of the risk of exposure to COVID-19, working at the hospital is my duty to patients as a health care worker	8.22 (2.50)	0.85
	In spite of the risk of exposure to COVID-19, continuing to work at the hospital is important to support my co-workers	8.14 (2.56)	
Fear arousal	The thought of getting COVID-19 makes me very anxious	5.33 (3.23)	0.78
	If my family member was infected with COVID-19, I would be very concerned	8.42 (2.45)	
	I'm worried about the possibility of inadvertently infecting others with COVID-19	7.25 (3.08)	
Response Efficacy	I can greatly minimize my exposure to COVID-19 by using preventative measures (i.e., washing hands, wearing masks, social distancing, and wiping down work areas) at work	8.09 (2.37)	0.86
	I can prevent exposing others with COVID-19 if I practice preventative measures (i.e., washing hands, wearing masks, social distancing, and wiping down work areas) at work	8.02 (2.17)	
Perceived Self-Efficacy	It would be difficult to practice preventative measures against COVID-19 (i.e., washing hands, wearing masks, social distancing, and wiping down work areas)	3.11 (3.12)	0.71
	Practicing preventative measures for COVID-19 (i.e., washing hands, wearing masks, social distancing, and wiping down work areas) is easy	3.96 (3.08)	
Response Cost	Practicing preventative measures (i.e., washing hands, wearing masks, social distancing, and wiping down work areas) at work makes people think you are overreacting against COVID-19	2.74 (2.78)	0.66
	Practicing preventative measures (e.g., wearing masks, social distancing) at work may cause patients to be upset with us	2.80 (2.91)	
PMT intention	I expect to practice preventative measures (e.g. washing hands, wearing masks, social distancing, and wiping down work areas) at work in the next 3 months.	6.66 (0.95)	0.89
	I intend to practice preventative measures (e.g. washing hands, wearing masks, social distancing, and wiping down work areas) at work in the next 3 months.	6.48 (1.13)	
PMT total	All questions	124.83 (18.59)	0.66

Appendix C　Theory of Planned Behavior questions and internal consistency reliability estimates

Scale	Item	Mean (SD)	Cronbach's alpha
Attitudes	On a scale of 1 being 'harmful' and 7 being 'beneficial' how would you rate practicing preventative measures (e.g. washing hands, wearing masks, social distancing, and wiping down work areas) at work for the next 3 months.	6.40 (1.04)	0.88
	On a scale of 1 being 'bad' and 7 being 'good' how would you rate practicing preventative measures (e.g. washing hands, wearing masks, social distancing, and wiping down work areas) at work for the next 3 months.	6.19 (1.26)	
	On a scale of 1 being 'worthless' and 7 being 'useful' how would you rate practicing preventative measures (e.g. washing hands, wearing masks, social distancing, and wiping down work areas) at work for the next 3 months.	6.08 (1.29)	
Subjective Norms	People who are important to me want me to practice preventative measures at work for the next 3 months.	6.18 (1.47)	0.78
	It is expected of me that I practice preventative measures at work for the next 3 months.	6.44 (1.22)	
	Most of my peers think it is important to practice preventative measures at work for the next 3 months.	5.59 (1.63)	
Perceived Behavioral Control	I am confident that I can practice preventative measures at work for the next 3 months.	6.15 (1.38)	0.62
	The decision to practice preventative at work for the next 3 months is in my control	5.01 (1.71)	
	Whether I practice preventative measures at work for the next 3 months is in entirely up to me	4.25 (2.37)	
Intention	I expect to practice preventative measures (e.g. washing hands, wearing masks, social distancing, and wiping down work areas) at work in the next 3 months.	6.66 (0.95)	0.89
	I intend to practice preventative measures (e.g. washing hands, wearing masks, social distancing, and wiping down work areas) at work in the next 3 months.	6.48 (1.13)	
TPB	All items	65.43 (10.66)	0.88