

# CONSUMER ATTITUDES ABOUT USING FAR-UVC DEVICES IN RETAIL STORES TO MITIGATE COVID-19 TRANSMISSION

## ATITUDES DO CONSUMIDOR SOBRE O USO DE DISPOSITIVOS FAR-UVC EM LOJAS PARA MITIGAR A TRANSMISSÃO DO COVID-19

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### ABSTRACT

COVID-19 transmission is primarily airborne. Far-UVC devices can inactivate viruses and are reported as safe to use while people are present. We surveyed college students ( $n = 1.085$ ) about intend to shop, prefer to shop, pay up to 5% more, and recommend stores that use a Far-UVC device. Predictor variables were demographics, COVID-19, diffusion of innovation theory, risk taking, and consideration of immediate and future consequences. We found that knowing anyone who had COVID-19 was positively associated with recommend stores and knowing anyone who died from COVID-19 was positively associated with intend to shop at stores that use a Far-UVC device. Wearing a mask inside a store was positively associated with intend to shop, prefer to shop, and recommend stores and wearing a mask on a busy street was positively associated with pay up to 5% more at stores. The diffusion of innovation variables of relative advantage, compatibility, complexity, trialability, and observability were each often positively associated with intend to shop, prefer to shop, pay up to 5% more, and recommend stores. Health risk taking was negatively associated with pay up to 5% more at stores and recreational risk taking was positively associated with intend to shop at stores. Consideration of immediate consequences was positively associated with pay up to 5% more at stores while there was no association for consideration of future consequences. In conclusion, marketing to consumers from groups interested in Far-UVC devices could be beneficial for stores.

**Keywords:** COVID-19, ultraviolet rays, consumer behavior, diffusion of innovation, masks, risk-taking

### RESUMO

A transmissão do COVID-19 ocorre principalmente por via aérea. Os dispositivos Far-UVC podem inativar o vírus e são relatados como seguros para uso enquanto as pessoas estão presentes. A amostra consistiu de estudantes universitários ( $n = 1.085$ ) e foram questionados sobre as intenções e forma de compra: se preferem comprar e pagar até 5% a mais e se recomendariam lojas que usam um dispositivo Far-UVC. As variáveis preditoras foram os dados demográficos, COVID-19, difusão da teoria da inovação, tomada de riscos e consideração de consequências imediatas e futuras. Os resultados evidenciam que conhecer alguém que teve COVID-19 estava positivamente associado a recomendar lojas, e conhecer alguém que morreu de COVID-19 está positivamente associado à intenção de comprar em lojas que usam um dispositivo Far-UVC. Usar máscara dentro de uma loja está positivamente associado à intenção de comprar em lojas com Far-UVC, preferir comprar e recomendar lojas e usar máscara em uma rua movimentada está positivamente associado a pagar até 5% a mais nas lojas. A difusão das variáveis de inovação de vantagem relativa, compatibilidade, complexidade, experimentabilidade e observabilidade foram associadas positivamente com a intenção de comprar, preferir comprar, pagar até 5% a mais e recomendar lojas. A tomada de riscos em saúde foi negativamente associada a pagar até 5% a mais nas lojas e a tomada de riscos recreativos foi positivamente associada à intenção de fazer compras nas lojas. A consideração de consequências imediatas foi associada positivamente com pagar até 5% a mais nas lojas, enquanto não houve associação para consideração de consequências futuras. Em conclusão, o marketing para consumidores de grupos interessados em dispositivos UVC distantes pode ser benéfico para as lojas.

**Palavras-chave:** COVID-19, raios ultravioleta, comportamento do consumidor, difusão da inovação, máscaras, tomada de riscos

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The coronavirus disease (COVID-19) pandemic caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has infected over 27 million people and resulted in over 466,000 deaths in the United States (USA; Centers for Disease Control and Prevention, 2021a). Behavioral efforts aimed at reducing COVID-19 transmission include mask wearing, social distancing, washing hands, and avoiding crowded or poorly ventilated spaces (Centers for Disease Control and Prevention, 2021b). Common methods to reduce airborne SARS-CoV-2 indoors include opening windows (Centers for Disease Control and Prevention, 2021c) or using air filtration systems (Centers for Disease Control and Prevention, 2021c; Christopherson et al., 2020).

Filtration systems can include HEPA purification (Christopherson et al., 2020) and ultraviolet (UV) light (Gerchman, et al., 2020). Hospitals use UV filters to inactivate viruses in the upper room area to avoid directly emitting the rays on people (Ramos et al., 2020). Far-UVC light has the same inactivation efficacy for viruses as conventional UV light (Narita et al., 2020), but without the health hazards to people associated with conventional UV light (Buonanno et al., 2017). Continuous Far-UVC exposure at the current allowed exposure limit in indoor spaces would inactivate approximately 90% of viruses in 8 minutes, 95% in 11 minutes, 99% in 16 minutes, and 99.9% inactivation in 25 minutes (Buonanno, et al., 2020).

A diagnosis of COVID-19 or knowing someone diagnosed with COVID-19 can impact engaging in COVID-19 prevention practices of mask wearing, social distancing, and washing hands. One panel study found different patterns for each month. For those previously diagnosed with COVID-19, for one month they were associated with increased engagement in COVID-19 prevention practices, another month with decreased engagement in COVID-19 prevention practices, and another month with no association with engagement

in COVID-19 prevention practices (Qeadan et al., 2020). Also, death of a friend or close friend was associated for two different months with increased engagement in COVID-19 prevention practices while one month did not have any association with engagement in COVID-19 prevention practices (Qeadan et al., 2020). A study of intentions to receive a COVID-19 vaccine among adults found that someone worried that he/she or a family member would become infected with COVID-19 was positively associated with COVID-19 vaccine intention (Latkin, et al., 2021). However, already diagnosed with COVID-19 or knowing a close friend diagnosed with COVID-19 was not associated with vaccine intention (Latkin et al., 2021). It is possible that engaging in COVID-19 prevention practices of mask wearing, social distancing, and washing hands is more amenable to people than the possible invasive procedure of receiving a vaccination that is directly injected into one's arm. Entering a retail store with a Far-UVC device would be analogous to engaging in COVID-19 prevention practices.

*Hypothesis 1:* We hypothesize that individuals who had COVID-19, knew someone who had COVID-19, or knew someone who died from COVID-19, are positively associated with a) intend to shop in a store that uses a Far-UVC device, b) prefer to shop in a store that uses a Far-UVC device, c) pay up to 5% more on item prices to shop in a store that uses a Far-UVC device, and d) recommend to their friends to shop in a store that uses a Far-UVC device.

Adults who wore masks were more likely to engage in COVID-19 prevention behaviors than those who did not wear masks (Hutchins et al., 2020). Two-thirds of participants felt more comfortable when people wore masks in retail locations (Knotek et al., 2020). Among those not wearing a mask outside, one third reported that they would wear a mask if the retail store provided a free mask at the store entrance (Knotek et al., 2020). It is possible that those who wear masks may also be interested in retail

store environments that have Far-UVC devices that inactivate the COVID-19 virus.

*Hypothesis 2:* We hypothesize that mask wearing is positively associated with a) intend to shop in a store that uses a Far-UVC device, b) prefer to shop in a store that uses a Far-UVC device, c) pay up to 5% more on item prices to shop in a store that uses a Far-UVC device, and d) recommend to their friends to shop in a store that uses a Far-UVC device.

Diffusion of innovation theory has five key features that explain the adoption of an innovation. Relative advantage is the extent in which an innovation is perceived as being better than the previous idea or product. Compatibility is that the innovation is similar to the previous idea and practice. Complexity is where the innovation is perceived as challenging to comprehend and utilize. Trialability is where an innovation is tested. Observability is where an innovation can be seen by others. Diffusion of innovation theory has been extensively used. All five factors of relative advantage, compatibility, complexity, trialability, and observability were each positively associated with greater use of telemedicine during the COVID-19 pandemic (Mishra, 2020). As consumers are concerned about COVID-19 health issues, it is likely that diffusion of innovation theory can help understand interest in retail store environments that have Far-UVC devices that inactivate the COVID-19 virus.

*Hypothesis 3:* We hypothesize that each of the diffusion of innovation theory factors of relative advantage, compatibility, complexity, trialability, and observability is positively associated with a) intend to shop in a store that uses a Far-UVC device, b) prefer to shop in a store that uses a Far-UVC device, c) pay up to 5% more on item prices to shop in a store that uses a Far-UVC device, and d) recommend to their friends to shop in a store that uses a Far-UVC device.

Risk taking can potentially influence attitudes and prevention practices regarding COVID-19. Those who adhered to all three

COVID-19 containment measures of social distancing, hand hygiene, and mask wearing had lower levels of risk taking than those who adhered to either none, one, or two COVID-19 containment measures (Miguel, et al. 2021). In one analytical model increased risk taking was associated with lesser adherence to 17 different COVID-19 prevention measures while another analytical model did not find any association of risk taking with COVID-19 prevention measures. Increased risk taking is associated with increased non-adherence to public health COVID-19 preventive guidelines (Pollak, et al., 2020).

Risk taking was positively associated with intention to vaccinate against COVID-19 (Zampetakis & Melas, 2021). Increased risk taking was associated with increased attitudes that employees should work on-site despite risk of COVID-19 exposure and that companies did not need to engage in COVID-19 prevention practices (Howard, 2021). Areas with higher risk-taking tolerance were associated with higher number of visits during the COVID-19 pandemic to retail stores, recreational locations, and parks but not associated with visits to groceries, pharmacies, transit stations, workplaces, and residential areas (Chan, et al., 2020). Both health and recreational risk taking were positively associated with active risk taking COVID-19 behaviors such as visiting friends at home, visiting hospitalized people, and not avoiding physical contact such as hugs and handshakes (Keinan, et al., 2021). Except for the positive aspect for increased risk taking of intention to receive a novel COVID-19 vaccine, increased risk taking is typically associated with lesser concern for COVID-19 prevention practices and unchanged attitudes during the COVID-19 pandemic.

*Hypothesis 4:* We hypothesize that health and recreational risk taking are each negatively associated with a) intend to shop in a store that uses a Far-UVC device, b) prefer to shop in a store that uses a Far-UVC device,

c) pay up to 5% more on item prices to shop in a store that uses a Far-UVC device, and d) recommend to their friends to shop in a store that uses a Far-UVC device.

Immediate and future consequences are variables that can potentially influence attitudes and prevention practices regarding COVID-19. Consumers with an immediate consequences orientation were more likely to disregard the health risks of eating fast food, while those with a future consequences orientation were more likely to recognize the health risks of eating fast food. In advertisements emphasizing the health risks that were framed as distal, only those with a future consequences orientation were persuaded and intended to change their behavior while those with immediate and future consequences orientation were both persuaded and intended to change their behavior after exposure to advertisements emphasizing health risks as proximal (Kees, 2011). Consideration of immediate consequences was not associated with intentions to vaccinate for either influenza or COVID-19 while consideration of future consequences was positively associated with intentions to vaccinate for either influenza or COVID-19 (Ma, Z. & Ma, R., 2022). A meta-analysis found that a future consequences orientation was associated with lower engagement in risky behavior and greater engagement in health-promoting behavior (Murphy & Dockray, 2018).

*Hypothesis 5:* We hypothesize that an immediate consequences orientation is negatively associated with a) intend to shop in a store that uses a Far-UVC device, b) prefer to shop in a store that uses a Far-UVC device, c) pay up to 5% more on item prices to shop in a store that uses a Far-UVC device, and d) recommend to their friends to shop in a store that uses a Far-UVC device.

*Hypothesis 6:* We hypothesize that a future consequences orientation is positively associated with a) intend to shop in a store that uses a Far-UVC device, b) prefer to shop in a store that uses a Far-UVC device, c) pay up to 5% more on

item prices to shop in a store that uses a Far-UVC device, and d) recommend to their friends to shop in a store that uses a Far-UVC device.

## METHODS

### Participants

We approached 1,477 college students at a public New York City college to complete a survey from August-November 2020. There were 392 who refused to complete the survey for a response rate of 73.5%  $[(1.085/1477)*100\%]$ . The online survey was presented as part of their synchronous online class through either Zoom or Blackboard Collaborate Ultra. The survey received Institutional Review Board approval. Informed consent was obtained.

Before beginning the survey, participants read the following content. Typical ultraviolet light can inactivate coronaviruses such as COVID-19. However, ultraviolet light can potentially damage human skin and eyes. Recent research shows that a subtype of ultraviolet light called far-ultraviolet (Far-UVC) light can inactivate airborne coronaviruses such as COVID-19. Far-UVC does NOT damage human skin and eyes. The researchers report that “continuous Far-UVC exposure in occupied public locations at the current regulatory exposure limit would result in approximately 90% viral inactivation in 8 minutes, 95% viral inactivation in 11 minutes, 99% viral inactivation in 16 minutes, and 99.9% viral inactivation in 25 minutes.” Far-UVC devices are currently not approved to be used in settings where people are present at the same time while the device is operating. The survey questions below are asking your opinion about use of Far-UVC devices if the Food and Drug Administration which approves medical devices in the United States would approve use of Far-UVC devices while people are present at the same time while the device is operating.

### Demographics

Demographic variables measured were age

(years), sex (man/woman), race/ethnicity (White, African American, Hispanic, Asian/Asian American, South Asian [India, Pakistan and surrounding areas], Other), and born in the USA (no/yes).

### Predictor variable questions

There were COVID-19 questions and diffu-

sion of innovation questions. There were health and recreational risk-taking scales and consideration of immediate and future consequences scales. These questions are shown in Table 1.

### Outcome variables

There were 4 outcome variables. These items were 1) "I intend to shop in a store that

Table 1  
*Predictor Variable Questions.*

|   |
|---|
| <i>COVID-19 Questions</i><br>5 separate no/yes questions  |
| 1) Did you have COVID-19?<br>2) Do you know anyone who had COVID-19?<br>3) Do you know anyone who died from COVID-19?<br>4) Do you typically wear a mask when shopping inside a store?<br>5) Do you typically wear a mask when walking outside on a busy street?  |
| <i>Diffusion of Innovation</i><br>10 items. Likert scale with a range from 1=strongly disagree to 5=strongly agree. Items obtained from previous surveys (Leser, Liu, Smathers, Graffagnino, & Pirie, 2019; Scott et al., 2008) and slightly modified for the current topic except for the "favorite store" item from compatibility, which is original for this survey. Due to poor Cronbach alpha reliability, each item was analyzed separately.  |
| Relative advantage<br>1) Use of Far-UVC devices by stores offers more advantages than the current approach.<br>2) The advantages of Far-UVC devices by stores outweighs any problems with its use.  |
| Compatibility<br>3) Use of Far-UVC devices by stores is compatible with my personal beliefs and values.<br>4) Use of Far-UVC devices by stores is compatible with my favorite store.  |
| Complexity<br>5) Use of Far-UVC devices by stores is easy to implement.<br>6) The barriers for use of Far-UVC devices by stores are small.  |
| Trialability<br>7) Use of Far-UVC devices by stores can be tried out before making a decision to fully adopt it.<br>8) Use of Far-UVC devices by stores can be adapted or modified to better fit a store's needs.   |
| Observability<br>9) The benefits for use of Far-UVC devices by stores is obvious.<br>10) The benefits for use of Far-UVC devices by stores is obvious.  |
| <i>Risk Taking</i><br>Health and recreational risk-taking scales each consisted of six items. Likert scale with a range from 1=extremely unlikely to 7=extremely likely. Items were added for total scores with greater scores indicating greater risk taking. Due to copyright reasons, full scales cannot be provided. A sample health item is the chance of "drinking heavily at a social function." A sample recreational item is the chance of "bungee jumping off a tall bridge." This is a reliable and valid scale (Blais & Weber, 2006). Cronbach alpha in our sample was .68 for health and .81 for recreational.   |
| <i>Immediate and Future Consequences</i><br>Consideration of immediate and future consequences scales each consisted of seven items. Likert scale with a range from 1=extremely uncharacteristic to 5=extremely characteristic. Items were added for total scores with greater scores indicating greater immediate and future consequences. Due to copyright reasons, full scales cannot be provided. A sample immediate item is "I only act to satisfy immediate concerns, figuring the future will take care of itself." A sample future item is "I consider how things might be in the future and try to influence those things with my day-to-day behavior." This is a reliable and valid scale (Joireman, Shaffer, Balliet, & Strathman, 2012). Cronbach alpha in our sample was .75 for immediate and .75 for future. |

uses a Far-UVC device,” 2) “I prefer to shop in a store that uses a Far-UVC device,” 3) “I would pay up to 5% more on item prices to shop in a store that uses a Far-UVC device,” and 4) “I would recommend to my friends to shop in a store that uses a Far-UVC device.” A Likert scale was used to measure all the items with a range from 1=strongly disagree to 5=strongly agree.

### Statistical analysis

Mean and standard deviation were used for the continuous variables and percentage and frequency for the categorical variables. Multivariate linear regression analyses were used for the four different outcomes. Predictors included demographics, COVID-19 variables, diffusion of innovation, risk taking, immediate, and future consequences. IBM SPSS Statistics version 26 was used for the analyses. All p-values were two-tailed.

## RESULTS

Table 2 shows the sample characteristics. Mean age was slightly above 22 years and slightly more than half were women. One-tenth personally had COVID-19, two-thirds knew someone else that had COVID-19, and slightly more than two-fifths knew someone who died from COVID-19. Almost all typically wore masks when shopping inside a store and 89.5% typically wore masks when walking outside on a busy street. The diffusion of innovation questions all had mean values between neutral and agree. Health risk taking had mean values between moderately unlikely and somewhat unlikely. Recreational risk taking had mean values between somewhat unlikely and not sure. Consideration of immediate consequences and consideration of future consequences had mean values between uncertain and somewhat characteristic. The outcome variables of intend to shop, prefer to shop, and recommend to shop each had mean values between neutral and agree. Willing to pay had

mean values exactly at the midpoint between disagree and neutral.

Table 3 shows multivariate linear regression analyses for intend to shop at stores that use a Far-UVC device. For demographics, race/ethnicity of Hispanic, Asian/Asian American, and South Asian were each significantly positively associated with intend to shop. For COVID-19, knowing anyone who died from COVID-19 and wearing a mask when shopping inside a store were each significantly positively associated with intend to shop. For diffusion of innovation, both relative advantage variables, both compatibility variables, the complexity variable of easy to implement, the trialability variable of adapted/modified, and the observability variable of benefits for use were each significantly positively associated with intend to shop. For psychological, recreational was significantly positively associated with intend to shop.

Table 3 shows multivariate linear regression analyses for prefer to shop at stores that use a Far-UVC device. For demographics, women, race/ethnicity of Asian/Asian American and South Asian were each significantly positively associated with prefer to shop. For COVID-19, wearing a mask when shopping inside a store was significantly positively associated with prefer to shop. For diffusion of innovation, both relative advantage variables, the compatibility variable of personal beliefs and values, the complexity variable of easy to implement, the trialability variable of adapted/modified, and both observability variables were each significantly positively associated with prefer to shop. None of the psychological variables were significantly associated with prefer to shop.

Table 4 shows multivariate linear regression analyses for pay up to 5% more at stores that use a Far-UVC device. For demographics, women were significantly positively associated with pay up to 5% more at stores. For COVID-19, wearing a mask when walking outside on a busy street was significantly positively asso-

Table 2  
 Characteristics of the Sample of 1,086 Participants.

| <i>Variables</i>   | <i>M (SD)</i> | <i>Frequency (Percent)</i> |
|--|---------------|----------------------------|
| <b>Demographics</b>  |               |                            |
| Age (years)  | 22.3 (4.92)   |                            |
| Gender (women)   |               | 602 (55.5)                 |
| Race/ethnicity   |               |                            |
| White  |               | 197 (18.2)                 |
| African American   |               | 214 (19.7)                 |
| Hispanic   |               | 226 (20.8)                 |
| Asian / Asian American   |               | 284 (26.2)                 |
| South Asian  |               | 82 (7.6)                   |
| Other  |               | 82 (7.6)                   |
| Born United States (yes)   |               | 704 (64.9)                 |
| <b>COVID-19</b>  |               |                            |
| Had COVID-19 (yes)   |               | 115 (10.6)                 |
| Know anyone had COVID-19 (yes)   |               | 735 (67.7)                 |
| Know anyone died from COVID-19 (yes)   |               | 469 (43.2)                 |
| Wear mask inside store (yes)   |               | 1,070 (98.6)               |
| Wear mask on busy street (yes)   |               | 969 (89.3)                 |
| <b>Diffusion of Innovations</b>  |               |                            |
| Use of Far-UVC devices by stores offers more advantages than the current approach.           | 3.5 (.83)     |                            |
| The advantages of Far-UVC devices by stores outweighs any problems with its use              | 3.2 (.83)     |                            |
| Use of Far-UVC devices by stores is compatible with my personal beliefs and values           | 3.3 (.91)     |                            |
| Use of Far-UVC devices by stores is compatible with my favorite store                        | 3.3 (.84)     |                            |
| Use of Far-UVC devices by stores is easy to implement  | 3.2 (.88)     |                            |
| The barriers for use of Far-UVC devices by stores are small                                  | 3.1 (.83)     |                            |
| Use of Far-UVC devices by stores can be tried out before making a decision to fully adopt it | 3.8 (.93)     |                            |
| Use of Far-UVC devices by stores can be adapted or modified to better fit a store's needs    | 3.7 (.82)     |                            |
| The benefits for use of Far-UVC devices by stores is obvious                                 | 3.4 (.88)     |                            |
| It is easy to see whether customers are satisfied with use of Far-UVC devices by stores      | 3.3 (.84)     |                            |
| <b>Psychological</b>   |               |                            |
| Health Risk Taking   | 15.9 (6.92)   |                            |
| Recreational Risk Taking   | 19.2 (8.44)   |                            |
| Immediate Consequences   | 20.0 (4.64)   |                            |
| Future Consequences  | 26.3 (4.16)   |                            |
| <i>Outcomes</i>  |               |                            |
| I intend to shop in a store that uses a Far-UVC device                                       | 3.3 (.86)     |                            |
| I prefer to shop in a store that uses a Far-UVC device                                       | 3.3 (.84)     |                            |
| I would pay up to 5% more on item prices to shop in a store that uses a Far-UVC device       | 2.5 (.97)     |                            |
| I would recommend to my friends to shop in a store that uses a Far-UVC device                | 3.3 (.85)     |                            |

Note: *M* = mean, *SD* = standard deviation, UVC = Ultraviolet-C.

Table 3  
 Multivariate Linear Regression Analyses for Intend and Prefer.

| Variables  | Intend B (SE) | p     | Prefer B (SE) | p     |
|--|---------------|-------|---------------|-------|
| <b>Demographics</b>  |               |       |               |       |
| Age (years)  | .52 (.29)     | .08   | .11 (.27)     | .70   |
| Gender (women)   | .08 (.05)     | .07   | .11 (.04)     | .01   |
| Race/ethnicity   |               |       |               |       |
| White  | Reference     |       | Reference     |       |
| African American   | .09 (.07)     | .23   | .11 (.07)     | .12   |
| Hispanic   | .19 (.07)     | .01   | .08 (.07)     | .24   |
| Asian / Asian American   | .15 (.07)     | .04   | .15 (.07)     | .03   |
| South Asian  | .30 (.10)     | .002  | .26 (.09)     | .004  |
| Other  | .06 (.10)     | .56   | -.05 (.09)    | .59   |
| Born United States (yes)   | .05 (.05)     | .34   | .05 (.05)     | .27   |
| <b>COVID-19</b>  |               |       |               |       |
| Had COVID-19 (yes)   | .08 (.07)     | .26   | -.03 (.07)    | .63   |
| Know anyone had COVID-19 (yes)   | .01 (.05)     | .92   | .05 (.05)     | .33   |
| Know anyone died from COVID-19 (yes)   | .13 (.05)     | .01   | .09 (.05)     | .06   |
| Wear mask inside store (yes)   | .74 (.19)     | <.001 | .41 (.18)     | .02   |
| Wear mask on busy street (yes)   | .10 (.08)     | .19   | .10 (.07)     | .15   |
| <b>Diffusion of Innovations</b>  |               |       |               |       |
| Use of Far-UVC devices by stores offers more advantages than the current approach.           | .07 (.04)     | .046  | .11 (.03)     | .002  |
| The advantages of Far-UVC devices by stores outweighs any problems with its use              | .13 (.03)     | <.001 | .19 (.03)     | <.001 |
| Use of Far-UVC devices by stores is compatible with my personal beliefs and values           | .14 (.03)     | <.001 | .16 (.03)     | <.001 |
| Use of Far-UVC devices by stores is compatible with my favorite store                        | .10 (.03)     | .003  | .03 (.03)     | .41   |
| Use of Far-UVC devices by stores is easy to implement  | .07 (.03)     | .02   | .10 (.03)     | <.001 |
| The barriers for use of Far-UVC devices by stores are small                                  | .01 (.03)     | .79   | .03 (.03)     | .27   |
| Use of Far-UVC devices by stores can be tried out before making a decision to fully adopt it | <.001 (.03)   | .99   | -.05 (.03)    | .08   |
| Use of Far-UVC devices by stores can be adapted or modified to better fit a store's needs    | .09 (.04)     | .02   | .11 (.04)     | .003  |
| The benefits for use of Far-UVC devices by stores is obvious                                 | .11 (.03)     | <.001 | .12 (.03)     | <.001 |
| It is easy to see whether customers are satisfied with use of Far-UVC devices by stores      | .05 (.03)     | .14   | .06 (.03)     | .03   |
| <b>Psychological</b>   |               |       |               |       |
| Health Risk Taking   | -.003 (.004)  | .44   | -.004 (.003)  | .29   |
| Recreational Risk Taking   | .01 (.003)    | .01   | .003 (.003)   | .28   |
| Immediate Consequences   | <.001 (.01)   | .96   | .004 (.01)    | .45   |
| Future Consequences  | .01 (.01)     | .23   | .002 (.01)    | .71   |
| Constant   | -1.28 (.50)   | .01   | -.49 (.47)    | .29   |

Note: B=unstandardized beta, SE=standard error of the mean, UVC=Ultraviolet-C. Adjusted R square for Intend=.32, Adjusted R square for Prefer=.39.



ciated with pay up to 5% more at stores. For diffusion of innovation, the relative advantage variable outweighs any problems, the compatibility variable of personal beliefs and values, and the observability variable of obvious benefits were each significantly positively associated with pay more at stores. For diffusion of innovation, the trialability variable of tried out before making a decision was significantly negatively associated with pay more at stores. For psychological, health risk taking was significantly negatively associated with pay more at stores and immediate consequences was significantly positively associated with pay more at stores.

Table 4 shows multivariate linear regression analyses for recommend stores that use a Far-UVC device. For demographics, age was significantly negatively associated with recommend stores that use a Far-UVC device. For demographics, women and race/ethnicity of South Asian were each significantly positively associated with recommend stores. For COVID-19, knowing anyone who died from COVID-19 and wearing a mask when shopping inside a store were each significantly positively associated with recommend stores. For diffusion of innovation, both relative advantage variables, the compatibility variable of personal beliefs and values, the trialability variable of adapted/modified, and both observability variables were each significantly positively associated with recommend stores. None of the psychological variables were significantly associated with recommend stores.

## DISCUSSION

We found partial support for hypothesis 1 where know anyone with COVID-19 was positively associated with recommend stores that use a Far-UVC device and know anyone who died from COVID-19 was positively associated with intend to shop at stores that use a Far-UVC device. We did not find any association of previously had COVID-19 with any outcome. Previous research reports

mixed patterns for those previously diagnosed with COVID-19 of increased engagement in COVID-19 prevention practices, decreased engagement in COVID-19 prevention practices, and no association with engagement in COVID-19 prevention practices (Qeadan et al., 2020). Our findings for previously had COVID-19 for stores that use a Far-UVC device are similar to the pattern of no association with engagement in COVID-19 prevention practices. People previously diagnosed with COVID-19 have some level of immunity from COVID-19 (Hasichaolu, et al., 2020). It is possible that those previously diagnosed with COVID-19 believed they were immune from COVID-19 and did not perceive any benefit in stores that use a Far-UVC device. Previous research reports mixed findings for death of a friend or close friend and engagement in COVID-19 prevention practices (Qeadan et al., 2020). Our findings for know anyone who had COVID-19 with recommend stores that use a Far-UVC device and know anyone who died from COVID-19 with intend to shop at stores that use a Far-UVC device are similar to the pattern of knowing someone who died from COVID-19 and engagement in COVID-19 prevention practices. We suggest a difference between intend and prefer. Intend to shop at a store that uses a Far-UVC device does not necessarily indicate a preference to shop at a store that uses a Far-UVC device. Also, people may intend to shop at a store that uses a Far-UVC device if they do not have to pay extra for items purchased. Once asked to pay a 5% surcharge, people may no longer be interested. This suggests a dilemma for stores that want to use a Far-UVC device and defray some of the extra cost onto consumers shopping in their store. If a store does not advertise price increases, will consumers notice and stop shopping at the store? Or as long as no COVID-19 surcharge is mentioned, can this be an acceptable approach to raise

Table 4  
 Multivariate Linear Regression Analyses for Pay and Recommend.

| <i>Variables</i>   | <i>Pay B (SE)</i> | <i>p</i> | <i>Recommend B (SE)</i> | <i>p</i> |
|--|-------------------|----------|-------------------------|----------|
| Demographics   |                   |          |                         |          |
| Age (years)  | -.53 (.38)        | .16      | -.81 (.29)              | .004     |
| Gender (women)   | .21 (.06)         | <.001    | .09 (.05)               | .04      |
| Ethnicity  |                   |          |                         |          |
| White  | Reference         |          | Reference               |          |
| African American   | .02 (.10)         | .86      | .13 (.07)               | .06      |
| Hispanic   | -.09 (.09)        | .32      | .11 (.07)               | .13      |
| Asian / Asian American   | .05 (.10)         | .62      | .10 (.07)               | .17      |
| South Asian  | -.02 (.13)        | .87      | .20 (.10)               | .04      |
| Other  | -.02 (.12)        | .84      | -.02 (.09)              | .86      |
| Born United States (yes)   | .03 (.06)         | .69      | .01 (.05)               | .88      |
| COVID-19   |                   |          |                         |          |
| Had COVID-19 (yes)   | .10 (.09)         | .27      | -.03 (.07)              | .65      |
| Know anyone had COVID-19 (yes)   | -.02 (.07)        | .82      | .11 (.05)               | .03      |
| Know anyone died from COVID-19 (yes)   | .03 (.06)         | .66      | -.01 (.05)              | .92      |
| Wear mask inside store (yes)   | -.11 (.25)        | .68      | .41 (.19)               | .03      |
| Wear mask on busy street (yes)   | .22 (.10)         | .03      | .10 (.08)               | .20      |
| Diffusion of Innovations   |                   |          |                         |          |
| Use of Far-UVC devices by stores offers more advantages than the current approach.           | .01 (.05)         | .81      | .08 (.04)               | .02      |
| The advantages of Far-UVC devices by stores outweighs any problems with its use              | .11 (.04)         | .01      | .20 (.03)               | <.001    |
| Use of Far-UVC devices by stores is compatible with my personal beliefs and values           | .13 (.04)         | .002     | .10 (.03)               | .002     |
| Use of Far-UVC devices by stores is compatible with my favorite store                        | .06 (.04)         | .18      | .07 (.03)               | .052     |
| Use of Far-UVC devices by stores is easy to implement  | .05 (.04)         | .19      | .05 (.03)               | .08      |
| The barriers for use of Far-UVC devices by stores are small                                  | .02 (.04)         | .67      | <.001 (.03)             | .90      |
| Use of Far-UVC devices by stores can be tried out before making a decision to fully adopt it | -.13 (.04)        | .001     | .10 (.04)               | .99      |
| Use of Far-UVC devices by stores can be adapted or modified to better fit a store's needs    | -.004 (.05)       | .94      | .10 (.04)               | .01      |
| The benefits for use of Far-UVC devices by stores is obvious                                 | .13 (.04)         | .001     | .11 (.03)               | <.001    |
| It is easy to see whether customers are satisfied with use of Far-UVC devices by stores      | .04 (.04)         | .26      | .08 (.03)               | .004     |
| Psychological  |                   |          |                         |          |
| Health Risk Taking   | -.01 (.01)        | .002     | -.003 (.004)            | .42      |
| Recreational Risk Taking   | <.001 (.004)      | .92      | .002 (.003)             | .45      |
| Immediate Consequences   | .01 (.01)         | .04      | .004 (.01)              | .42      |
| Future Consequences  | -.01 (.01)        | .12      | .01 (.01)               | .14      |
| Constant   | 1.98 (.65)        | .002     | .75 (.49)               | .13      |

Note: B=unstandardized beta, SE=standard error of the mean, UVC=Ultraviolet-C. Adjusted R square for Pay=.12, Adjusted R square for Recommend=.34.

prices by a small amount to defray costs for a Far-UVC device in the store?

We found partial support for hypothesis 2 where wear mask inside store was positively associated with intend to shop, prefer to shop, and recommend stores that use a Far-UVC device and wear mask on a busy street was positively associated with pay up to 5% more at stores that use a Far-UVC device. Previous research reports that those who wear masks are more likely to engage in COVID-19 prevention practices than those who do not wear masks (Hutchins et al., 2020). Our findings for mask-wearer positive interest in Far-UVC devices in stores are similar to this pattern. Furthermore, the finding that those who wear masks outside are positively associated with willing to pay up to 5% more at stores that use a Far-UVC device is logical. There is less risk for contracting COVID-19 outdoors than indoors (Bulfone, et al, 2021) and therefore not everyone wears a mask outdoors. Those who wear a mask outdoors are more careful about COVID-19 prevention and would be willing to pay an extra small amount for the store to have a Far-UVC device. However, it is challenging to explain why outdoor mask wearing was only associated with paying up to 5% more at stores, but was not associated with intend, prefer, and recommend stores that use Far-UVC devices.

We found partial support for hypothesis 3 where the diffusion of innovation variables of relative advantage, compatibility, complexity, trialability, and observability were each often positively associated with intend to shop, prefer to shop, pay up to 5% more, and recommend stores that use a Far-UVC device. Diffusion of innovation theory has been extensively studied and successfully used for public health (Bergeron et al., 2017) and in organizational settings (Allen et al., 2017). However, as with many theories, all aspects of a theory do not always work in all situations. Some suggest that when there are significant technological,

social, and/or learning conditions that discourage adoption or when the new concept is not considered useful in the particular industry or market, the diffusion of innovation theory is not fully applicable for explaining adoption (MacVaugh & Schiavone, 2010). We suggest for these reasons that some of the analyses that we conducted did not show significant associations for the outcome variables. Our results showed that relative advantage, compatibility, trialability, and observability were each significantly positively associated with all of the four outcome variables of intend to shop, prefer to shop, pay up to 5% more, and recommend stores that use a Far-UVC device. However, complexity had the lowest number of significant associations for any of the outcome variables with only significant associations for intend to shop and prefer to shop. The definition of the construct of complexity is that the innovation is perceived as challenging to comprehend and utilize. We suggest that due to Far-UVC devices being perceived as challenging to comprehend and utilize, this may have been the reason for the lack of association for pay up to 5% more and recommend stores that use a Far-UVC device.

We found partial support for hypothesis 4 where health risk taking was negatively associated with pay up to 5% more to shop at stores that use a Far-UVC device. Unexpectedly, recreational risk taking was positively associated with intend to shop at stores that use a Far-UVC device. Previous research reports that health and recreational risk taking are positively associated with active risk taking COVID-19 behaviors such as visiting friends and attending large gatherings (Keinan et al., 2021). It is logical that those who engage in more health risk taking are reluctant to pay up to a 5% surcharge for stores that use a Far-UVC device. The positive association between recreational risk taking and intend to shop at stores that use a Far-UVC device appears counterintuitive. Shopping in-person

in stores during the COVID-19 pandemic is perceived as potentially risk taking as a less risk-taking approach is to have orders delivered or picked up (Chenarides, et al., 2020). Also, risk taking is not exclusively engaging in potentially harmful behaviors. Risk taking was positively associated with intention to vaccinate against COVID-19 (Zampetakis & Melas, 2021). Such behavior is risk taking since a new vaccine could be perceived as harmful by some people due to the lack of long-term follow-up studies for those who were vaccinated. It is possible that those engaging in recreational risk taking who engage in the more risk-taking behavior of shopping in-person in stores during the COVID-19 pandemic want to minimize their health risk and therefore intend to shop in stores that use a Far-UVC device.

We did not find any support for hypothesis 5, as immediate consequences was not negatively associated with any outcome for shop at stores that use a Far-UVC device. We did not find any support for hypothesis 6, as future consequences was not associated with any outcome for shop at stores that use a Far-UVC device. Contrary to our hypothesis, immediate consequences was positively associated with pay up to 5% more at stores that use a Far-UVC device. This finding appears counterintuitive, as those with an immediate consequences approach would see no value for a Far-UVC device, let alone want to pay extra for a store that has a Far-UVC device. Future research should study the reasons why those with an immediate consequences approach would want to pay up to 5% more at stores that use a Far-UVC device. Our lack of significant findings for those with a future consequences approach is challenging to explain. This may have occurred because at the time of the survey administration there were many COVID-19 prevention products advertised that were found to be quackery and not offering any legitimate health prevention benefits. Survey respondents with a future

consequences approach may have placed the Far-UVC device in the category of quackery.

For the control variables, women were positively associated with prefer to shop, pay up to 5% more, and recommend stores that use a Far-UVC device. Previous research indicates that women are more likely than men to adhere to public health recommendations for COVID-19 preventive behaviors (Galasso et al., 2020) and to wear masks due to concerns of COVID-19 (Haischer et al., 2020). This approach for women may extend to other preventive behaviors such as shopping at stores that use a Far-UVC device. South Asians were positively associated with intend to shop, prefer to shop, and recommend a store that uses a Far-UVC device. Asians/Asian Americans were positively associated with intend to shop and prefer to shop at a store that uses a Far-UVC device. Mask wearing for disease prevention is commonly and culturally accepted in many Asian countries (Burgess & Horii, 2012). We suggest that other preventive behaviors such as shopping at stores that use a Far-UVC device would be of interest to South Asians and Asians/Asian Americans. African Americans had no association with any of the four outcome variables. African Americans often mistrust many new healthcare practices due to the historical experience of African Americans being taken advantage of and experimented upon by medical and public health practitioners. We suggest that a possible new preventive behavior such as shopping at stores that use a Far-UVC device would not be of interest to African Americans.

The study strength is the large sample size and responses of those from many different race/ethnicities. This study has several limitations. First, participants were not asked how worried or anxious they were about contracting COVID-19 and these variables could influence the outcomes. Second, our college student sample may not generalize to those in the age ranges of 40 years and greater. Future

research should study charging extra for products to defray the costs of installation and maintenance of a Far-UVC device.

### Theoretical Implications

First, although many predictor variables had similar patterns for the outcome variables of intend and prefer to shop at stores that use a Far-UVC device, we found two differences from this pattern. There was a positive association for know anyone who died from COVID-19 and recreational risk taking with intend to shop at stores that use a Far-UVC device but no association for these two predictor variables with prefer to shop at stores that use a Far-UVC device. Although intend and prefer may be considered similar approaches for understanding consumer goals, our study shows that intend and prefer can differ where consumer intentions may be easier to be achieved than consumer preferences when introducing a novel health prevention product. Second, contrary to previous understanding that recreational risk taking is negatively associated with engaging in positive health prevention practices, our study introduces a counterintuitive approach that the attitude of recreational risk taking is positively associated with engagement in health prevention practices. This suggests that there is an opportunity for engagement with those who are recreational risk takers to consider them as relevant for interest in novel health prevention products.

### CONCLUSION

In conclusion, those who know anyone who had or died from COVID-19, mask wearers for COVID-19 prevention, women, South Asians, and Asians/Asian Americans would be interested in shopping at stores that use a Far-UVC device for COVID-19 prevention. Marketing to consumers from these groups could be beneficial for stores. However, store managers need to balance this potential benefit with

the consideration that other groups such as African Americans and health risk takers may be opposed to shopping at stores that use a Far-UVC device for COVID-19 prevention.

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