

Coronavirus Pandemic

Consumer's demand for Disinfectants and Protective Gear from COVID-19 infection in Al-Hofuf, Saudi

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Abstract

Introduction: The paper aims to estimate consumers' demand for personal protecting products (PPP) from COVID-19. Thus, the paper collected primary data on consumers' demand for PPP utilizing the timeframe of the COVID-19 pandemic.

Methodology: The paper uses two sample t-test and Anova test to examine mean differences in the quantity consumed of PPP. Also, the paper uses Almost Ideal Demand System (AIDS) to estimate the responsiveness of quantity demanded of PPP for changes in prices and consumers' income.

Results: The results show that there is a significant difference in the mean of quantity demanded of facemasks among men and women. Also, the results show that there is a significant difference in the mean of quantity demand for facemasks, gloves, and hand sanitizer based on respondents' level of education. In addition, the paper analyzed the effect of price and income changes on quantity demanded of PPP. The findings indicate that the quantity demanded of facemask and gloves are sensitive to changes in consumers' income. Also, soap, hand sanitizer, and gloves were recognized as complementary products. Furthermore, facemasks were identified as a complementary product with glove use. Lastly, the own-price elasticities of demand revealed that the demand for PPP is price insensitive.

Conclusions: the paper recommends that the consumer protection unit closely monitor the prices of PPP since the sellers have an opportunity to increase those products prices and maximize their revenue by exploiting the COVID-19 pandemic.

Key words: Personal Protection Products; COVID-19; coronavirus; Disinfectants.

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Introduction

The World Health Organization Regional Office in China on December 31, 2019, was informed of cases of a phenomenon that caused unknown disease. Those cases were discovered in Wuhan, China. Later, the disease was identified as a novel coronavirus disease [1]. The virus is contagious and has rapidly spread all over the world. The Saudi Ministry of Health has recommended several precautions to prevent the spread of COVID-19 [2]. These precautions include the use of tissue for sneezing or coughing and washing the hands with water and soap. Also, the ministry recommended using face masks, gloves, and hand sanitizer in work locations and public places. Given the importance of using personal protection products (PPP) to avoid or at least to reduce the likelihood of getting COVID-19 infection, the demand for PPP has sharply increased. Thus, some traders have exploited the coronavirus outbreak situation, and have started to charge prices above acceptable average prices. As a result, the Saudi Ministry of Commerce issued more than 400 pricing violations [3]. It has been reported by [4] that the cost

of N95 masks increased from \$0.38 to \$5.75 each (1,513% increase). Also, the cost of vinyl exam gloves went from \$0.02 to \$0.06, indicating a 300% increase. At a time when countries around the world are suffering from unavailability of infection protection products, Saudi Arabia has assured its citizens and residents the availability of sufficient quantities that meet local consumers' demand. The number of factories manufacturing face masks locally is 8 [5, 6]. The Food and Drug Authority confirmed that local factories produce 3 million and 500,000 face masks per week. The authority revealed an increase in the number of hand sanitizer factories to reach 35 factories in Saudi Arabia with a production capacity of more than one million and 400,000 liters per week. Furthermore, the export of PPP has been banned by the government since the beginning of the COVID-19 crisis [7]. The Kingdom of Saudi Arabia faces a high demand of disinfectants and protective gear from COVID-19 infection. Specifically, the demand for hand sanitizer, face masks, detergent, and gloves. Consequently, the purpose of this paper is to estimate the demand for PPP

in Al-Hofuf, Saudi Arabia. A great contribution to the literature, this paper rapidly responded to collecting data and estimating the demand for PPP during a timeframe when the demand for these products are at its peak. Considering the importance of the topic and according to the authors’ humble knowledge, there are no studies that have examined the demand for disinfectants or protecting gear during COVID-19 crisis. However, studies were undertaken on the infection protecting equipment in terms of uneconomic perspectives [8, 9]. The majority of researchers who addressed the coronavirus disease focused on the medical aspects and characteristics of the coronavirus disease. They overlooked the importance of infection protection from an economic point of view. However, some studies have examined demand for infection protection products from influenza and other diseases [10–12]

Zainodin *et al.* [10] analyzed consumers’ buying patterns on the demand for detergents using hierarchically multiple polynomial method. The appropriate models were reduced to several selected models using progressive removal of multicollinearity variables and elimination of insignificant variables. To enhance the understanding of the whole concept in this study, multiple polynomial regressions with eight selection criteria were explored and presented in the process of getting the best model from a set of selected models. The results show that the consumers’ buying behavior will affect the demand for detergents.

Carias *et al.* [11] examined potential demand for respirators and surgical masks during a hypothetical influenza pandemic in the United States. In order to match the required quantity of respirators and face masks, health care officials must develop strategic plans to insure appropriate actions in case of future pandemics with different scenario.

Watanabe *et al.* [8] examined the determinants of child health care service demand in Ghana, Kenya and Zambia using cross-sectional data. The results of the logistic regression showed that the likelihood of demanding child health care services increased with wealth, living close to a health care facility, and when the mother is employed. Chughtai *et al.* [12] addressed the use of PPE in health care facilities in Pakistan. The results showed that face masks and gloves were the highest used PPE to protect from viruses.

From the mentioned studies, it is obvious that the academic literature lacks a study that examines the effect of a price change on quantity demand of disinfectant and protective gears. Thus, this study aims to fill the gap in the literature by examining the response

of quantity demand of disinfectants and protective gears to changes in prices utilizing the current situation of COVID-19 pandemic.

Methodology

The data for this paper is primary data and was collected randomly from respondents living in Al-Hofuf city, located in the eastern province of Saudi Arabia by an online questionnaire. Thus, the data is cross-sectional data and no response was excluded because survey questions were mandatory (the survey cannot be submitted if it contains a missing item). The sample of this study was determined by Herbert Arken equation [13] based on the population of Al-Hofuf city, which is 293,179 [14].

$$n = \frac{p(1-p)}{(E+t)+[p(1-p)+N]} \tag{1}$$

Where: N = sample size; N = the population size; T = a standardized score equals 1.96 for 95% confidence level; E = allowed percentage error (equal 0.05); P = probability value ranging from 0 to 1, and usually takes the value of 0.50.

Thus, the sample size should not be less than 384 individuals. Therefore, the total number of collected observations are 396.

The Almost Ideal Demand System (AIDS) proposed by [15] is probably the most popular demand system in empirical demand analysis. The AIDS model is specified as follows:

$$w_i = a_i + \sum_j \gamma_{ij} + \ln p_j + \beta_i \ln \left(\frac{x}{P}\right) + u_i \tag{2}$$

Where w_i is the budget share of soap, face masks, hand sanitizer, and gloves. p_j is price of those PPP, x is total expenditures on PPP, and P is a prices index. The original AIDS price index is a trans log price index defined as:

$$\ln P = a_0 + \sum_i a_i \ln p_i + \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln p_i \ln p_j \tag{3}$$

The above price index is a non-linear price index. The AIDS model is usually approximated by a linear price index and expressed as LA-AIDS model. The LA-AIDS model with Stone’s price index is defined as follows:

$$\ln P = \sum w_i \ln p_i \tag{4}$$

The LA-AIDS model has to satisfy certain properties of demand function. These properties are adding up, homogeneity and symmetry. These properties represent parametric restrictions and are imposed in the estimation [16]:

$$\text{Engel aggregation } \sum_{i=1}^N \beta_i = 0 \tag{5}$$

$$\text{Cournot aggregation } \sum_{i=1}^N \gamma_{ij} = 0 \tag{6}$$

$$\text{Symmetry } \gamma_{ij} = \gamma_{ji} \tag{7}$$

$$\text{Homogeneity} \quad \sum_{j=1}^N \gamma_{ij} = 0 \quad (8)$$

The parameter estimates of the LA-AIDS model are later used to calculate price elasticities of demand and income elasticities of demand. Price elasticity of demand shows the responsiveness of quantity demanded of PPP to changes in their prices. Also, the income elasticity of demand shows the responsiveness of quantity demanded to changes in consumers' income. Then Marshallian price elasticities (which incorporates both income and substitution effect) for infection prevention products are computed below [17]:

$$e_{ii} = -1 + \frac{\gamma_{ii}}{s_i} - \beta_i \quad (9)$$

$$e_{ij} = \frac{\gamma_{ij}}{s_i} - \beta_i \left(\frac{s_j}{s_i}\right) \quad \text{for } i \neq j \quad (10)$$

Income elasticities of demand for PPP are calculated below:

$$\eta_i = \frac{\beta_i}{w_i} + 1 \quad (11)$$

Ethical Approval

The survey in this article has been approved by Research Ethics Committee at King Faisal University, and it has been given approval # KFU-REC/2020-08-04.

Results and Discussion

Table 1 shows that 61% of the sampled consumers' age in range of 20-30 years old and 70% of the respondents were female while 30% were male. In addition, 81% hold university degree (bachelor's degree). Regarding the income distribution of respondents, 73% earn less than 10,000 Saudi Riyal (SAR) a month, 23% earn between 10,000-20,000 Saudi Riyal (SAR) and 3% earn more than 20,000 Saudi Riyal (SAR) a month. Furthermore, 70% of sampled respondents use one hand sanitizer per week, 21% of respondents use 2 per week, and 8 percent of respondents use 3 per week. Furthermore, almost 50 percent of respondents pay a price for hand sanitizer in the range of 10-20 Saudi Riyal (SAR). Also, the majority of respondents (88%) use less than 20 gloves per week, and 79% of respondents pay a price between 10 to 20 SAR for gloves per week. Almost half of respondents use one soap per week and, 73% of them pay less than 10 SAR for one soap. In addition, the number of reported face masks used per week by most respondents is less than 10, and most of respondents pay less than 20 SAR for face masks per week.

The data were analyzed using R software and the study relied on several tests, including t-test, Levene's test, Cohen's D test, ANOVA test, and Tukey's HSD test using five percent significance level. Moreover, the

Table 1. Summary of Questionnaire Results.

Variable	Percentage
Age	
20 – 30 years old	61.11%
31 – 40 years old	21.46%
41 – 50 years old	12.63%
51 – 60 years old	4.04%
Above 60 years old	0.76%
Gender	
Male	29.55%
Female	70.45%
Education	
Primary school	0.25%
Middle school	2.78%
Secondary school	15.40%
University	81.57%
The income	
< 10,000 R.S	73.23%
10,000 – 20,000 R.S	23.49%
> 20,000 R.S	3.28%
Do you care to use precautions products to avoid getting COVID-19?	
Yes	80.05%
No	2.27%
Sometimes	17.68%
The number of hand sanitizer to use per week	
1	70.45%
2	21.21%
3	8.33%
The price of hand sanitizer	
< 10 SAR	13.13%
10 – 20 SAR	49.75%
20 – 30 SAR	22.47%
30 – 40 SAR	14.65%
The number of gloves to use per week	
< 20	87.88%
20 - 40	12.12%
The price of gloves	
10 – 20 R.S	79.29%
20 – 30 R.S	17.43%
30 – 40 R.S	3.28%
The number of soap items to use per week	
1	42.68%
2	29.04%
3	16.41%
4	5.56%
5	6.31%
The price of soap	
< 10 R.S	25.51%
10 – 20 R.S	53.78%
20 - 30 R.S	17.43%
30 - 40 R.S	3.28%
The number of face masks to use per week	
< 10	91.92%
> 10	8.08%
The price of face masks	
< 20 R.S	81.06%
> 20 R.S	18.94%

LA-AIDS model was used and their results were reported with at least 10% significance level.

We start our analysis by exploring the mean difference between quantity used of PPP among consumers based on their gender, education level, and age group. We conducted Levene's test of homogeneity of variance in order to select the appropriate t-test. The results in Table 2 show that we fail to reject the null hypothesis of equal variance for all PPP, except face masks. Thus, we conducted a t-test assuming equal variance for quantity demanded of hand sanitizer, gloves, and soap.

Table 2 shows that women consume more hand sanitizer and soap than men. Conversely, men consume more gloves and face masks than women. However, the results of the t-test show that there is no significant difference in the mean quantity consumed of hand sanitizer, gloves, and soap between male and female.

Because the results of Levene's test showed that we reject the null hypothesis of homogeneity of variance for the quantity consumed of face masks between male and female, we conducted a t-test assuming unequal variance (Welch's t-test) to examine if there is a significant difference in the mean of quantity demanded of face masks between male and female. The results of the Welch's t-test shows that there is a significant difference at the one percent level in the mean quantity demanded of face masks between male and female. This is attributed to the fact that the weekly mean quantity of face masks used by female and male reached 4.07 and 6.09, respectively. Also, Cohen's D test shows that the effect is a medium size effect.

Table 3 shows that respondents whose education level is middle school demand more hand sanitizer, soap, and face masks compared to other respondents with different educational levels. Also, respondents whose education level is high school demand more gloves than other respondents with different educational level. In addition, we examine if there is a significant difference in the mean of quantity demanded of PPP based on respondents' educational level using the Anova test. The results of the Anova test in Table 3 show that there is a significant difference in the mean of quantity demanded based on respondents' level of education for hand sanitizer, gloves, and face masks. However, we fail to reject the null hypothesis that the mean of quantity demanded of soap is equal for respondents based on their level of education.

In addition, we conducted Anova test to examine if there is a significant difference in the mean of quantity demanded of PPP based on consumers' age group. The results in Table 4 show we only reject the null

hypothesis of equal mean for quantity demanded of hand sanitizer. Moreover, the results of Tukey's HSD test (available upon request) shows that the difference in mean is among respondents whose age level is 20-30 and 51-60. This is attributed to the fact that respondents whose age is between 51 to 60 demand more hand sanitizer compared to respondents who fall in other age categories.

The second step in the empirical analysis is to explore the impact of price and income changes on quantity demanded of PPP. Thus, the LA-AIDS model was estimated using seemingly unrelated regression methods with restrictions (5)-(8) imposed in the estimation. Also, all prices were mean scaled to avoid simultaneity problem [18]. Table 5 shows the results of the estimated parameters. R^2 shows that 64% of the variation in consumers' budget share for hand sanitizer, 52% of the variation in consumers' budget share for gloves, 46% of the variation in consumers' budget share for soap, and 51% of the variation in consumers' budget share for face masks have been explained by the LA-AIDS's model independent variables.

The estimated income elasticities and Marshallian price elasticities of PPP are shown in Table 6. The results show that the demand for gloves and face masks is income elastic, indicating that a one percent increase in income increases quantity demand for gloves and face masks by more than one percent. Furthermore, since the income elasticity for gloves and facemasks is greater than unity, we classify them as luxury items. Conversely, the demand for hand sanitizer and soap are income inelastic revealing that a one percent increase in income increases quantity demanded by less than one percent. Additionally, since the income elasticities of hand sanitizer and soap are less than unity, we conclude that hand sanitizer and soap are considered as necessities.

Furthermore, all own-price elasticities are negative and comply with economic intuition that an increase in a commodity price reduces quantity demanded of that commodity. Also, all own-price elasticities are inelastic, indicating that changes in price have a small effect on quantity demand of PPP. Also, the inelastic own-price elasticity benefits PPP sellers since increases in those products' prices will have a slight effect on quantity demanded of those products, and eventually they will guarantee a maximized revenue as a result of coronavirus pandemic. Thus, this gives the sellers an opportunity to exploit their customers during the COVID-19 pandemic to generate the highest return unless the consumers' protection unit takes action.

Table 2. Hypothesis Testing Based on Respondents' Gender.

Item	Mean Value Based on gender		T-statistics	p-value	Cohen's d	Levene's test
	Male	Female				
Hand Sanitizer	1.32	1.40	1.0965	0.2735	0.124	0.2735
Gloves	9.34	7.89	- 1.9251	0.05494	0.210	0.2538
Soap	2.00	2.05	0.50818	0.6116	0.056	0.6366
Face Mask	6.09	4.07	- 4.9348	1.186e-06 ***	0.535	0.04392 **

***, ** significant at the one and five percent level, respectively.

Table 3. Hypothesis Testing Based on Respondents' Education Levels.

Item	Mean Value For Education Level				Sum sq	Mean sq	f-value	Pr(>F)
	Primary	Middle	Secondary	University				
Hand Sanitizer	1.00	1.82	1.58	1.33	4.94	1.6474	4.187	0.00619 ***
Gloves	3.00	9.18	10.79	7.79	496	165.31	3.325	0.0198 **
Soap	1.00	2.63	2.28	1.97	9.8	3.274	2.392	0.0682
Face Mask	1.00	6.36	5.72	5.42	132	43.99	3.047	0.0287 **

***, ** significant at the one and five percent level, respectively.

Table 4. Hypothesis Testing Based on Respondents' Age Groups.

Item	Mean Value Per Age Group					Sum sq	Mean sq	f-value	Pr (> F)
	20-30	31-40	41-50	51-60	> 60				
Hand Sanitizer	1.31	1.41	1.52	1.81	1.00	5.54	1.3860	3.527	0.00764 ***
Gloves	7.98	8.63	9.58	7.56	4.33	171	42.72	0.843	0.499
Soap	1.96	2.00	2.36	2.43	1.33	10.6	2.643	1.929	0.105
Face Mask	4.56	4.57	5.02	5.37	6.00	23	5.685	0.385	0.819

***, ** significant at the one and five percent level, respectively.

Table 5. Parameter Estimates for the LA-AIDS Model.

	α	P1	P2	P3	P4	β	R ²
Hand Sanitizer	0.565 *** (0.0259)	0.109 *** (0.0049)	- 0.072 *** (0.0055)	- 0.026 *** (0.0041)	- 0.011 *** (0.0025)	- 0.081 *** (0.0048)	0.64
Gloves	- 0.287 *** (0.0650)	- 0.072 *** (0.0055)	0.239 *** (0.0125)	- 0.078 *** (0.0082)	- 0.089 *** (0.0061)	0.140 *** (0.0120)	0.52
Soap	0.567 *** (0.0416)	- 0.026 *** (0.0041)	- 0.078 *** (0.0082)	0.113 *** (0.0076)	- 0.008 * (0.0039)	- 0.077 *** (0.0077)	0.46
Face Masks	0.155 ** (0.0578)	- 0.011 *** (0.0025)	- 0.089 *** (0.0061)	- 0.009 * (0.0039)	0.110 *** (0.0057)	0.016 (0.0107)	0.51

Standard errors are in parentheses. ***, **, * significant at the one, five, and ten percent level, respectively.

Table 6. Price and Income Elasticities of Infection Protection Products.

Item	Hand Sanitizer Price	Gloves Price	Soap Price	Face Mask Price	Income Elasticity
Hand Sanitizer	- 0.110 *** (0.037)	- 0.231 *** (0.041)	- 0.094 *** (0.031)	0.036 (0.018)	0.399 *** (0.035)
Gloves	- 0.181 *** (0.011)	- 0.663 *** (0.025)	- 0.200 *** (0.016)	- 0.235 *** (0.012)	1.280 *** (0.024)
Soap	- 0.096 *** (0.026)	- 0.248 *** (0.052)	- 0.217 *** (0.048)	0.041 (0.024)	0.520 *** (0.048)
Face Mask	- 0.067 *** (0.013)	- 0.484 *** (0.030)	- 0.057 *** (0.019)	- 0.473 *** (0.028)	1.082 *** (0.052)

Standard errors are in parentheses. ***, **, * significant at the one, five, and ten percent level, respectively.

Furthermore, the cross-price elasticities show that gloves, soap, and hand sanitizer are all complementary products for consumers.

We also notice that the cross-price elasticity of face masks with respect to hand sanitizer use and soap use is not significantly different from zero, indicating that face masks are independent (unrelated) from hand sanitizer and soap use. Conversely, the cross-price elasticity of face masks with respect to gloves shows that the two products are complements. This is true since during the outbreak of COVID-19, many individuals have used facemasks along with gloves to protect themselves and others from the spread of COVID-19. Furthermore, in some working places in Saudi Arabia, it is mandatory for employees to use face masks and gloves at work.

Conclusions

This paper examined the demand for infection protection products (PPP) from COVID-19 in Al-Hofuf city, located in eastern Saudi Arabia. The paper relies on primary data that was collected during the spread of COVID-19. The results of the *t*-test show that there is a significant difference in the mean of quantity demanded among men and women because men consume, on average, two more face masks per week than women. Also, the results of the Anova test show that the mean of quantity demand of hand sanitizer, face masks, and gloves differs significantly based on respondents' level of education. It is noted that respondents whose education level is middle school consumed the highest quantity of face masks and hand sanitizers, while high school graduate consumed the largest quantity of gloves compared to other respondents with different educational levels. Moreover, Tukey's HSD test revealed that the mean of quantity demanded of hand sanitizer is significantly different for respondents whose age group is in the range of 20-30 and 51-60. This is attributed to the fact that respondents aged between 51 to 60 consumed the highest quantity of hand sanitizer compared to other age groups.

In order to analyze the effect of price and income changes of quantity demand of PPP, we used the popular Almost Ideal Demand System (AIDS) model. The results of own-price elasticities of PPP are all price inelastic, indicating that changes in these products prices have a small impact on the quantity demanded. Also, income elasticity of demand revealed that face masks and gloves are income elastic while soap and hand sanitizer were income inelastic. Consequently, a one-percent increase in income increased the demand for face masks and gloves by more than one percent.

Through the income elasticity, we categorized soap and hand sanitizer as necessities, while facemasks and gloves were categorized as luxury products. The cross-price elasticities of demand showed that gloves, soap, and hand sanitizer are all complementary products. On the other hand, facemasks and gloves were identified as complementary in use. This is attributed to the fact that many firms have obligated their employees to wear gloves and face masks at work. This paper recommends that the consumer protection unit should monitor the prices of PPP during the COVID-19 crisis to prevent any price manipulation because increases in those products' prices will have a modest effect on the quantity demanded of those products. Thus, if sellers of PPP increased the selling price, they will guarantee a high revenue.

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