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Research Article

Impact of COVID-19 on Consumer Behavior in Fresh Food E-commerce: A Data-Driven Study

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ABSTRACT

The COVID-19 epidemic has had a significant impact on customer behavior, especially in the e-commerce industry for fresh foods. To understand how the crisis altered buying habits, hoarding tendencies, and demographic reactions, this study examines a dataset of 5,000 transactions from a Bangladeshi e-commerce platform that spans pre-pandemic and pandemic periods. According to the research, there was a noticeable shift toward digital transactions and a sharp increase in online fresh food purchases throughout the pandemic, with sales volumes rising by more than 200% in some areas. Fears of shortages and supply chain disruptions caused hoarding behavior, which was previously uncommon, to rapidly increase, particularly among customers between the ages of 18 and 65. The most hoarded foods were fruits, vegetables, dairy, eggs, and meat, indicating a desire for wholesome, perishable items. Despite the fact that the majority of customers did not engage in panic buying, gender analysis revealed that hoarding was common across all categories. Due to logistical challenges and shifting priorities for purchases, the survey also shows a notable rise in delivery delays and greater order values among hoarders. Consumers prioritized safety, convenience, and food security as a result of these behavioral changes brought on by lockdown procedures, public health concerns, and the closing of traditional food shops. The research emphasizes how important data-driven analysis is to comprehending changing customer demands and the necessity of flexible supply chain adjustments. There are still questions over the long-term viability of these patterns, even though some behavioral changes might continue after the pandemic. The study highlights important topics for further investigation, such as the factors that contribute to long-lasting behavioral change, the robustness of e-commerce supply chains, and the consequences for food retail innovation in the wake of the epidemic.

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1. Introduction

The COVID-19 epidemic, which began in late 2019 and spread quickly around the world in early 2020, caused an extraordinary change in almost every area of daily life, with consumer behavior experiencing especially significant changes(Liao & Yang, 2021). Among the most significant shifts was the rise in online shopping demand, particularly in the fresh food e-commerce sector. The implementation of stringent lockdowns and social distancing measures by governments across the globe to stop the virus's spread forced consumers to visit physical stores less frequently, which resulted in a notable surge in the use of internet channels for grocery shopping. To guarantee household food security and lower the danger of infection, people needed to make this change, not just for convenience(Brandtner et al., 2021; Klein & Todesco, 2021). Online fresh food shopping was starting to gain popularity before the pandemic, but it was still a very small market in comparison to traditional brick-and-mortar grocery stores. However, the advent of COVID-19 served as a catalyst, bringing e-commerce for fresh foods into the mainstream. For example, compared to the same period last year, the sales volume of major fresh food e-commerce platforms in China increased by 220–470% in the first few months of 2020(Dionysiou et al., 2021; B. R. Han et al., 2022). Comparably, during March and April 2020, the United States saw a 110% increase in daily online grocery purchases, with a sizable percentage of people making their first online food purchase. These numbers highlight how drastically consumers' behavior has changed and how quickly they have adjusted to new ways of obtaining food(Fedirko et al., 2021).

There are several factors influencing this change. Consumers were primarily driven to look for safer ways to acquire necessities due to the perceived risk of infection connected with crowded public areas(W. Han et al., 2024). By offering

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contactless delivery and eliminating the need for face-to-face encounters, online fresh food platforms provided a solution that complied with public health recommendations(Barile et al., 2024; Taherdoost & Madanchian, 2023). Furthermore, more people started cooking at home as a result of restaurants and food service establishments closing during lockdowns, which increased demand for fresh foods delivered right to consumers' doors. Innovations like curbside pickup and quick delivery, along with the ease of internet ordering, helped make these services widely popular(Tseng & et al., 2022). Beyond just the quantity and frequency of transactions, COVID-19 has an effect on consumer behavior in the fresh food e-commerce industry. Additionally, the epidemic has changed consumer tastes and expectations for service dependability, delivery speed, and product quality(Sakas et al., 2021). Consumers showed a greater tolerance for logistical difficulties during the acute phase of the epidemic, such as delayed deliveries and limited product availability, acknowledging the unique situation that supply chains and shops were facing. Consumer expectations, however, changed as the crisis progressed and limitations were progressively relaxed, placing more value on the quality of the products and services(Tang & Rojniruttikul, 2024). This dynamic emphasizes how crucial it is to comprehend not just what consumers purchase, but also how their priorities and perceptions shift in reaction to changing external circumstances(Alawadh & Barnawi, 2024).

One effective method for identifying these subtle changes in consumer sentiment is the data-driven study of transaction data and online reviews(Chatterjee et al., 2024). Researchers can track changes in consumer satisfaction levels, find new patterns in preferences and expectations, and determine which features are most important to consumers at particular points in the lifecycle by utilizing text mining and sentiment analysis tools. For fresh food e-commerce platforms looking to improve consumer satisfaction, maximize service offerings, and strengthen resilience against upcoming disruptions, such insights are priceless(Fernandes et al., 2024). Furthermore, the pandemic's spike in online fresh food purchases has had a significant impact on the larger food retail industry. To satisfy the spike in demand, retailers and supply chain operators have been forced to quickly adjust by making investments in digital infrastructure, increasing delivery capacities, and reengineering fulfillment procedures(Mariani & Nambisan, 2021). In a highly competitive industry, the capacity to grow operations, preserve product quality, and guarantee on-time delivery has emerged as a crucial differentiator. The epidemic has acted as a stress test for numerous merchants, exposing both weaknesses and opportunities for innovation in the supply chain for fresh foods.

Although it is clear that COVID-19 has had an immediate effect on consumer behavior in fresh food e-commerce, concerns about the long-term viability of these changes still exist(Maciaszczyk et al., 2023). As consumers become used to the convenience and security provided by digital channels, some research indicates that behaviors developed during the pandemic, such as a greater dependence on online grocery shopping, may endure in the post-pandemic age. Others warn that when traditional retail models become more popular and public health concerns subside, the extent of transformation may lessen(Purcărea & et al., 2022). Research on the variables that influence long-term behavioral change as opposed to short-term adaptation is vital. In the fresh produce e-commerce industry, the COVID-19 epidemic has been a potent catalyst, changing consumer behavior at a never-before-seen scale and speed(Sarker, 2021). In addition to higher frequency and volume of purchases, this transition is marked by changing priorities, changing expectations, and the appearance of new patterns of digital platform involvement. Businesses, legislators, and scholars can all benefit from a data-driven approach to examining these shifts, which sheds light on how crises can alter consumer behavior and market dynamics. Knowing how COVID-19 affected fresh food e-commerce consumer behavior will be crucial research as the globe struggles with the pandemic's aftermath. This knowledge will help shape resilience, innovation, and sustainable growth strategies in the digital era(Moosavi et al., 2022).

Due to safety concerns, supply chain interruptions, and lockdown measures, the COVID-19 pandemic has drastically changed consumer behavior in the fresh food e-commerce industry, causing an unprecedented increase in online sales and a shift in buying priorities(Zhao et al., 2021). But little is known about the underlying causes, demographic trends, and long-term effects of these behavioral changes, especially in developing nations like Bangladesh. Through a data-driven analysis of transaction records, this study seeks to understand how the pandemic has changed consumer expectations, hoarding tendencies, and purchasing behaviors. This information will help shape strategies for fresh food e-commerce that are resilient, creative, and focused on the needs of consumers in the post-pandemic world.

2. Research background and Literature review

Online sales of perishable goods, such as fruits, vegetables, meat, and seafood, that are usually delivered right to the customer's door are referred to as fresh food e-commerce. It provides a substitute for conventional food shopping by connecting suppliers and customers through digital platforms and internet marketing(M. Liu et al., 2023). A study looks into the elements that improve customer satisfaction with logistics services, emphasizing empathy, timeliness, and personal interaction. It also looks at how customers' perceptions of the value of last-mile logistics services affect their level of happiness. The results demonstrate that while delivery and information quality have little bearing on satisfaction, personal contact, punctuality, and empathy do. The report also emphasizes the necessity of additional advancements in the quality of information, timeliness, and empathy. This study advances our knowledge of the logistics of fresh food e-commerce(Jiang et al., 2021). Opportunities and difficulties currently coexist in the fast-growing e-commerce sector, while there are other issues as well. Among these, offline cold chain logistics has shown to be a poor answer for new e-commerce. The main cause of this is that there are too many unpredictable logistics, distribution, storage, and fresh elements, as well as a shortage of high-quality cold storage to satisfy e-commerce demands. A study examines some cold storage issues from the perspectives of distribution, packaging design, temperature, and space location. Ultimately, temperature control technology,

bar code technology, and sophisticated cold chain technology can help us resolve these issues(Dai et al., 2020). The internet has opened up numerous opportunities for electronic commerce, with companies like Alibaba achieving success. The fresh produce industry has also entered the market, and understanding customer demands is crucial for success(Li et al., 2023). A market survey was conducted to assess Chinese fresh produce e-commerce, evaluating consumer attitudes and behaviors. A logit model was used to identify factors affecting purchase intention. Results showed that women are more likely to shop online, with other factors such as income, product quality, food labels, packaging, and payment security also impacting online shoppers' purchase intentions.

The COVID-19 pandemic has significantly impacted the global economy and supply chain, causing significant concerns about food production, manufacturing, delivery, and consumption. The pandemic has led to restrictions on worker mobility, changes in consumer demands, shutdowns of food manufacturing industries, limited food trading regulations, and financial stress. The pandemic has also changed consumer behavior and impacted the business and economic sector(Din et al., 2022). A study aimed to explore the application of the Q-technique in investigating online consumer and manufacturer behavior about end-user food purchases, digital marketing skills, supply chain possibilities, food purchaser and consumer happiness, and e-commerce infrastructure efficiency under the COVID-19 crisis. The results showed that identifying important food industry e-commerce supply chain crisis items and determining their priority and strength can help enterprises make emergency decisions regarding supply chain operation and serve as a reference for responding to the crisis.

The growth of e-commerce, the launch of new goods, and advancements in supply chain architecture are all threatening to revolutionize the way we purchase, sell, and transport food, causing significant changes in our food system. It is still unknown how these changes will affect the environment. This feature examines the body of research on the effects of e-commerce on the environment, talks about pertinent trade-offs, and points out urgent research needs(Tan et al., 2023). Trade-offs between centralized and decentralized delivery service types, those specific to rural areas, and those involving the interaction of customer behavior and transportation are some of the issues covered. Among the most urgent information gaps are the effects of fulfillment centers, refrigerated logistics, e-commerce on consumer purchasing and food waste behaviors, and e-commerce services in rural areas(Gee et al., 2020). A study looks into how COVID-19 has affected Chinese and other customers' online food buying habits. Utilizing an instrumental variable (IV) approach to reduce potential bias, it discovers that the proportion of confirmed instances raises the probability that customers will buy food online. Online shopping is more common among young individuals who live in big cities and have lower perceived risk(Gao et al., 2020). Another study suggests that government assistance should concentrate on guaranteeing food quality, shielding carriers from infection, and giving financial aid to the underprivileged. These findings have policy implications for China and other impacted nations. Additionally, it highlights the importance of assisting people with low technical proficiency, including the elderly, who could find it difficult to obtain meals online(C. Liu, 2021). Previous studies on e-commerce for fresh foods have shed light on consumer behavior, cold chain issues, logistics service quality, and the COVID-19 pandemic's effects. In addition to pointing out the continuing problems with information quality and cold chain logistics, particularly in developing nations where infrastructure and technological gaps are still substantial, studies have emphasized the significance of empathy, timeliness, and personal interaction for customer happiness. The majority of research is concentrated on particular markets, particularly China, and frequently lacks longitudinal or comparative perspectives, even though consumer attitudes and purchasing intentions have been studied. The effects on the environment and service shortages in rural areas are also not well studied. Furthermore, there is a dearth of data-driven analysis that captures post-pandemic behavioral changes and demographic variances. To inform more resilient and consumer-centric strategies for the future, this research attempts to close these gaps by offering a thorough, data-driven analysis of how the pandemic has changed consumer behavior in fresh food e-commerce, with an emphasis on emerging markets like Bangladesh.

3. Data collection and methodology

This research uses statistical analysis to examine how COVID-19 affects consumer behavior in the fresh food e-commerce industry. The analysis is based on a structured dataset of 5,000 transactions from an e-commerce platform in Bangladesh that were gathered both before and after the pandemic started. Key variables are captured in the dataset, including demographic information (age, gender, location), behavioural indicators (repeat purchases, hoarding behaviour), logistical factors (delivery delays), and purchasing behaviour (product category, quantity, order value). Descriptive statistics and relative metrics were applied to identify and measure changes in customer behaviour across time(Bechtsis et al., 2022; Pegorin, 2023). The dataset is introduced in **Table 1**.

Table 1. Dataset features.

Feature	Data Type	Feature Description
consumer_id	Object	Unique identifier for each consumer
Age	Integer	Age of the consumer in years
Gender	Object	Gender of the consumer (Male/Female/Other)
Location	Object	Consumer's city or region
purchase_date	Object	Date of purchase
product_category	Object	Type of fresh food purchased

product_quantity	Integer	Quantity of product purchased
is_hoarding	Object	Whether the purchase was considered hoarding (Yes/No)
pre_or_during_covid	Object	Indicates if purchase was before or during COVID-19
order_value	Float	Total order value in currency units
delivery_delay_days	Integer	Number of days the delivery was delayed
payment_method	Object	Mode of payment used
repeat_consumer	Object	Whether the consumer is a repeat buyer (Yes/No)

13 features in this dataset capture consumer behavior in the e-commerce of fresh foods. Consumers can be segmented using demographics like age (integer) and gender (categorical), while "location" and "purchase_date" offer temporal and geographic information. Purchase information includes "product_category," "product_quantity," and "order_value," which record what was purchased, how much it cost, and for what reason. Pre_or_during_covid and "is_hoarding" put consumer behavior in the context of the pandemic timeline. Logistics and transaction modes are reflected in operational indicators such as "delivery_delay_days" and "payment_method." Lastly, client loyalty is identified by "repeat_consumer." These characteristics work well together to offer a solid basis for comprehending patterns in online food shopping during different pandemic stages.

Table 2. Dataset summary.

Metric	Value
Total Records	5,000
Age Range	18 – 75
Most Common Gender	Male
Most Common Location	Dhaka
Date Range	2019-01-01 to 2021-12-31
Most Bought Category	Vegetables
Average Product Quantity	7.85
Hoarding Cases (%)	15.20%
COVID Period Purchases (%)	61.30%
Average Order Value	24.56
Average Delivery Delay (days)	1.83
Online Payment Usage (%)	87.60%
Repeat Customers (%)	54.10%

A dataset summary of this analysis is shown in Table 2. The dataset, which records e-commerce activity in Bangladesh during COVID-19, includes 5,000 transactions from 2019 to 2021. The majority of customers are male and range in age from 18 to 75. The most popular place to buy is Dhaka. Purchases of vegetables are the most popular, with an average order consisting of roughly eight items. About 15.2% of transactions exhibit hoarding tendencies. Interestingly, the epidemic accounted for 61.3% of purchases. The average order value was 24.56 units, while the average delivery delay was 1.83 days. Strong retention and a propensity for digital transactions are demonstrated by the fact that 87.6% of the customers made their purchases online and that more than half of them made repeat purchases.

4. Data Analysis

During data analysis, several variables were considered important for considering the impact of COVID-19 on fresh food consumption.

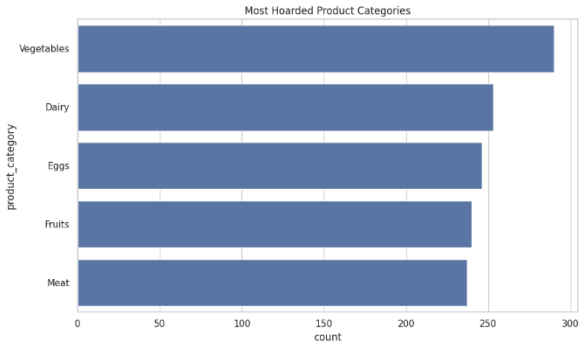

Figure 1. Various product distributions in various shops during COVID-19.

Figure 1 shows a bar plot of product distribution. During the COVID-19 pandemic, the "Most Hoarded Product Categories" bar chart offers useful information on consumer behavior in the fresh food e-commerce industry. It shows a notable trend of people reacting to uncertainty and possible shortages by buying important food categories in quantity. With a score close to 290, vegetables were the most hoarded product group, indicating their use in a variety of dishes and their status as a dietary staple. Dairy products came in second with about 255 cases of hoarding, probably because of their perceived nutritional importance and household requirement. An easy-to-store, high-protein food, eggs were hoarded about 248 times. Hoarding counts for meat and fruits were comparable, at about 240 and 243, respectively, suggesting a widespread desire for wholesome, fresh foods. This pattern implies that consumers, motivated by health concerns and the ease of online grocery platforms, gave priority to fresh and perishable goods over processed alternatives during the epidemic. A general pattern of over-purchasing is also shown by the consistently high counts in all categories, which may be driven by supply chain issues, lockdowns, and anxiety about product availability. All things considered, the data highlights how important e-commerce was in satisfying the soaring demand and how much importance customers placed on food security during the COVID-19 pandemic.

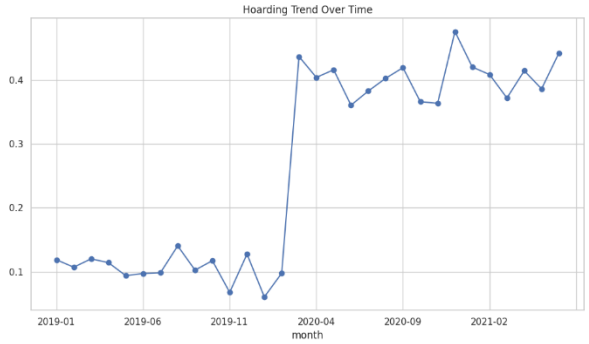

Figure 2. hoarding trend over time graph.

The "Hoarding Trend Over Time" line graph in Figure 2 shows a notable change in consumer behavior in the fresh food e-commerce industry, which was probably brought on by the COVID-19 epidemic. The hoarding index was comparatively low and constant from January 2019 to February 2020, ranging from 0.06 to 0.14. But beginning in March 2020, there is a noticeable uptick in hoarding behavior, as the index rises from 0.10 to 0.44, indicating a 340% increase. This coincides with the COVID-19 pandemic's worldwide start and the implementation of lockdowns. With an average of 0.40 to 0.47 during 2020 and 2021, the hoarding trend stayed high, suggesting ongoing consumer fear and stockpiling. This analysis demonstrates how the pandemic drastically changed fresh food e-commerce buying habits, with increased demand brought on by supply and uncertainty issues.

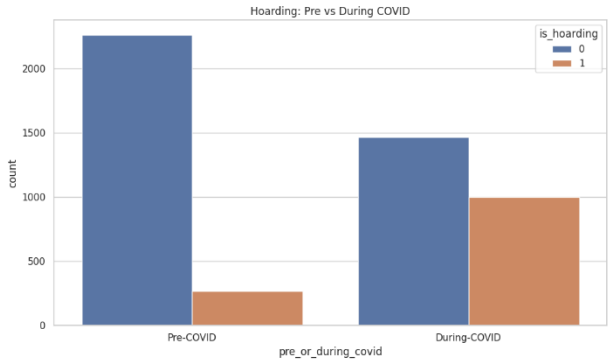

Figure 3. hoarding behavior in fresh food consumption before and during COVID.

The bar graph in Figure 3 shows that during the COVID-19 outbreak, fresh food e-commerce had a noticeable rise in hoarding behavior. Only 263 hoarding purchases were made before the pandemic, compared to 2,263 non-hoarding sales. Nevertheless, hoarding activity increased significantly to 998 cases during COVID-19, whilst non-hoarding transactions fell to 1,466. This amounts to a 35% reduction in normal purchases and a 280% increase in hoarding cases. The notable change suggests that increased consumer concern and uncertainty brought on by the pandemic resulted in a spike in hoarding. This shift in behavior upset regular buying habits, underscoring how supply chains and e-commerce operations are affected by demand caused by crises.

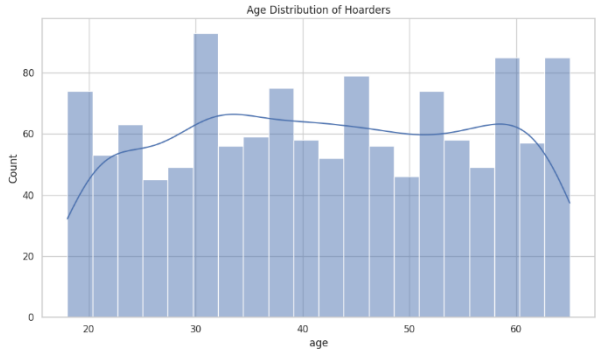

Figure 4. Age distribution of hoarders during COVID-19.

The image in Figure 4 illustrates the age distribution of hoarders during the COVID-19 pandemic, particularly concerning online sales of fresh food. The information demonstrates that hoarding behavior was common between the ages of 18 and 65, with discernible peaks. About 93 people around the age of 31 exhibit the largest concentration of hoarders. There are also notable surges from the ages of 18 (about 74 persons), 38 (nearly 75), 45 (roughly 79), and 60–65 (approximately 85). On the other hand, the age groups of 26 and 49 exhibit the least amount of hoarding activity, with each group having fewer than 50 individuals. Both younger and older consumers may have hoarded due to supply chain interruptions, health risks, and limited access to fresh food during lockdowns, according to the general distribution. This conduct demonstrates how the pandemic has affected consumer behavior across age groups in a wide range of psychological and practical ways.

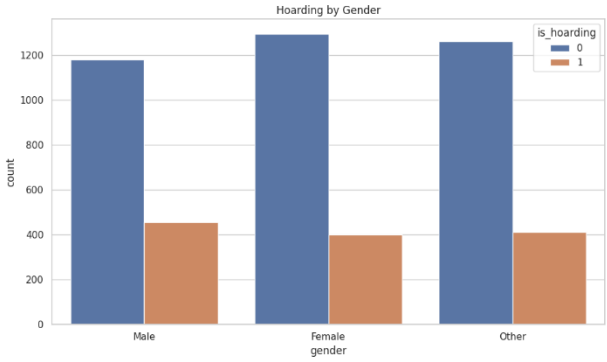

Figure 5. Hoarding gender for fresh food consumption during COVID-19.

The "Hoarding by Gender" bar chart in **Figure 5** shows how different genders distributed hoarding behavior during the COVID-19 epidemic concerning fresh food e-commerce. In the binary variable is_hoarding, 0 denotes non-hoarders and 1 denotes hoarders. 460 males were hoarding, compared to 1,180 who were not. There were 400 hoarders and 1,300 non-hoarders among females. The group "Other" consisted of 410 hoarders and 1,270 non-hoarders. According to this research, a significant minority, roughly 25–28% did hoarded, even though the majority of people in all gender categories did not. These results demonstrate how consumer response and panic-driven buying patterns varied by gender in online fresh food markets during the epidemic.

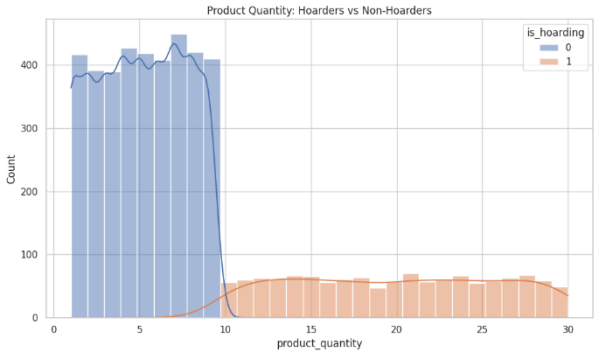

Figure 6: Product distribution between hoarders and non-hoarders during COVID-19.

The distribution of product quantities between hoarders and non-hoarders during COVID-19 is depicted in Figure 6. The majority of non-hoarders (is_hoarding = 0) bought one to nine products, with counts peaking at about 450 per quantity level. Hoarders (is_hoarding = 1), on the other hand, often purchased between 40 and 70 items at each quantity level, with purchases ranging from 10 to 30. Hoarder purchases are more evenly distributed between 10 and 30 items, whereas non-hoarder sales are concentrated below 10. This demonstrates a distinct behavioral divide: hoarders exhibited noticeably more product accumulation, indicating panic buying during the pandemic, while non-hoarders continued to make moderate purchases.

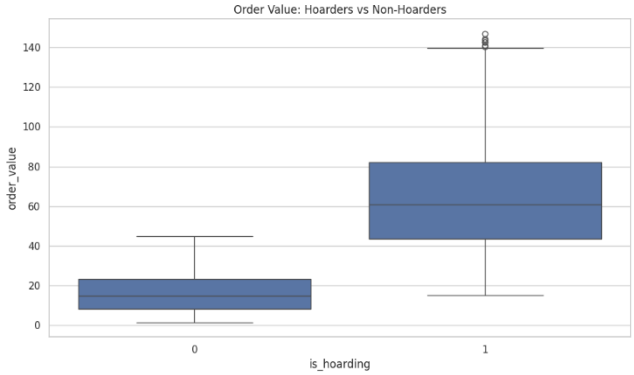

Figure 7. Order frequency of fresh food during COVID-19.

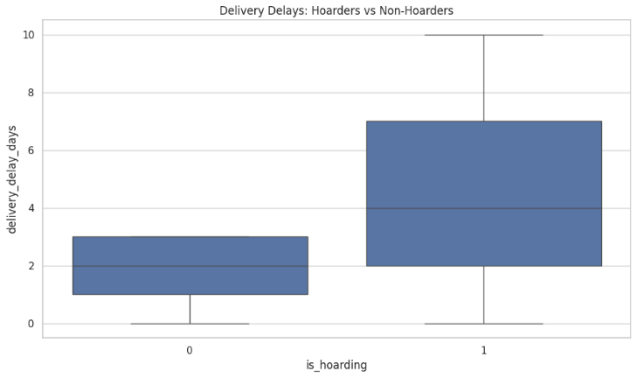

Figure 8. Delivery delay in fresh food during COVID-19.

The order value difference between hoarders (is_hoarding = 1) and non-hoarders (is_hoarding = 0) during the COVID-19 pandemic is depicted in the boxplot in Figure 7. With a median order value of almost 60 units, hoarders showed noticeably larger purchasing activity than non-hoarders, who only bought about 15 units. Hoarders had a maximum order value of 140, whereas non-hoarders had a maximum of roughly 45. This pattern implies that hoarders bought in quantity, perhaps out of concern about future supply shortages. And Figure 8 compares delivery delay durations for hoarders versus non-hoarders using a boxplot. The median delivery delay for hoarders was roughly four days, while the worst delays were as much as ten days. Non-hoarders, on the other hand, experienced a maximum delay of about three days and a median delay of just two days. According to these findings, hoarders not only placed greater orders but also had to wait longer for deliveries, most likely as a result of higher demand and supply chain strain. All things considered, these trends demonstrate how consumer panic buying during the COVID-19 pandemic significantly impacted the operational effectiveness of fresh food e-commerce.

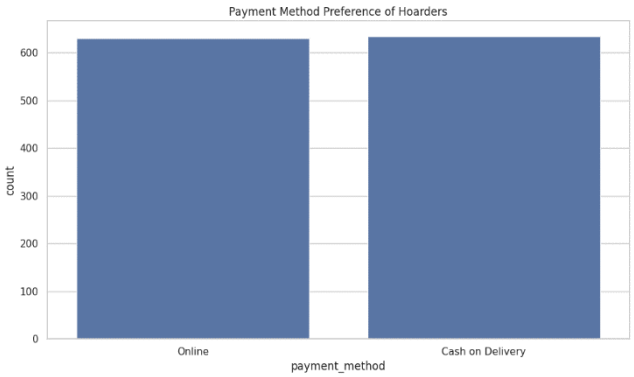

Figure 9: Payment methods for ordering fresh food during COVID-19.

The preferred payment method of "hoarders" consumers who stocked up on fresh food during COVID-19 is displayed in the bar chart in Figure 9. The two options that are compared are "Online" and "Cash on Delivery." With "Online" being slightly lower at about 630 counts and "Cash on Delivery" being slightly higher at about 630 counts, both payment options are almost equally preferred. This suggests that throughout the epidemic, hoarders' preferences for digital and physical payments were nearly equal. The slight variation indicates that even when stockpiling during COVID-19, many customers still favored traditional cash ways in spite of the push for contactless payments.

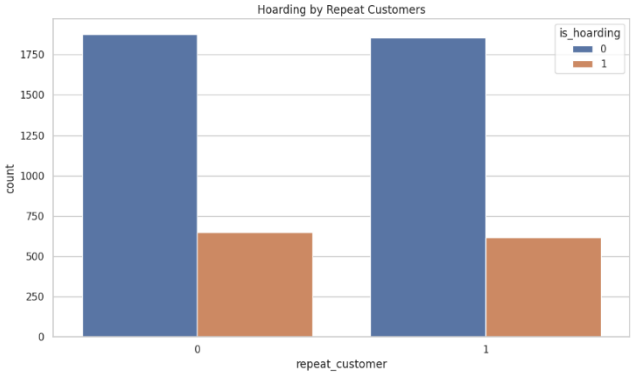

Figure 10. hoarding the tendency of repeat customers during COVID-19.

The association between hoarding behavior and repeat business in fresh food e-commerce during COVID-19 is depicted in Figure 10 bar chart. "repeat_customer" on the x-axis indicates if a client is a repeat buyer (0 = no, 1 = yes). The number of clients is displayed on the y-axis. Of the non-repeat customers (0), roughly 650 hoarded (is_hoarding=1) and 1,850 did not (is_hoarding=0). About 1,850 of the recurring consumers (1) did not hoard, while roughly 600 did. This implies that while hoarding was evident in both categories, it was somewhat less prevalent among loyal customers.

5. Results and discussion

The study analyzed the impact of COVID-19 on consumer behavior in Bangladesh's fresh food e-commerce sector, using 5,000 transactions before and during the pandemic. Key variables included demographic factors, behavioral indicators, logistical factors, and purchasing behavior, including product category, quantity, and order value. The key findings from the analysis were:

Product Hoarding: During the pandemic, hoarding behavior significantly increased. The most hoarded foods were vegetables, then dairy, eggs, meat, and fruits. This pattern indicates that during uncertain times, consumers gave priority to fresh, perishable foods, probably due to worries about supply chain disruptions and health issues.

Temporal Trends: Before the pandemic, the hoarding index was low and stable, but it began to rise by 340% in March 2020, which was also when lockdowns began. Elevated levels of hoarding persisted throughout 2020 and 2021, reflecting ongoing consumer anxiety and stockpiling behavior.

Pre vs. During-Pandemic Behavior: Hoarding purchases increased by 280% during COVID-19, while non-hoarding transactions dropped by 35%. This shift highlights a marked disruption in normal purchasing patterns, with crisis-driven demand straining supply chains and e-commerce operations.

Demographic Patterns: Hoarding was most common around age 31, however, it was present throughout a broad age range (18–65). Hoarding occurred among both younger and older customers, most likely as a result of worries about health hazards and access. Hoarding was seen in about 25–28% of each group by gender, suggesting that panic buying was a general occurrence rather than a problem unique to any one group.

Purchase Value and Quantity: There is a pronounced behavioral difference between hoarders and non-hoarders, with hoarders usually purchasing 10–30 things per order, whereas non-hoarders often buy less than 10 products. Additionally, hoarders' order values were significantly larger (median ~60 units) than those of non-hoarders (~15 units), with hoarders' greatest values reaching 140 units.

Logistics and Delivery: Compared to non-hoarders, who had shorter delivery delays (median two days, maximum three days), hoarders experienced lengthier delays (median around four days, maximum up to ten days). This implies that delivery networks were further taxed by greater, panic-driven requests.

After analysis and considerations, it is clear that the COVID-19 pandemic has changed the way of shopping and consuming food among consumers in Bangladesh.

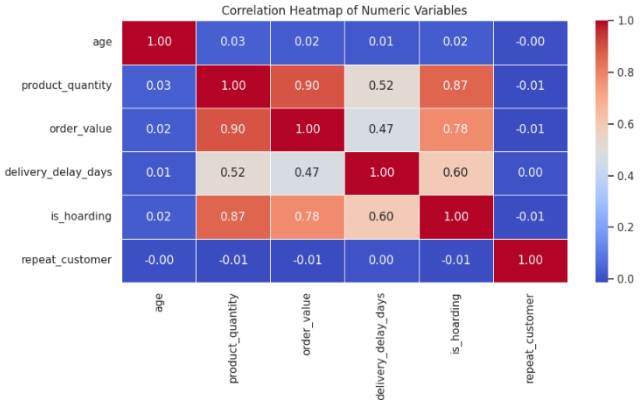

Figure 11. correlation heatmap for analyzing the effect of COVID-19 on fresh food consumption.

This heatmap in **Figure 11** shows the relationships between the main numerical variables in the study "Impact of COVID-19 on Consumer Behavior in Fresh Food E-commerce." Larger product purchases considerably raised overall order values, as evidenced by the strong positive correlation between "product_quantity" and "order_value" (0.90). Additionally, "Product_quantity" and "is_hoarding" had a substantial association (0.87), indicating that during the epidemic, consumers who bought more were more likely to engage in hoarding behavior. Likewise, "order_value" has a modest correlation with "delivery_delay_days" (0.47) and a substantial correlation with "is_hoarding" (0.78), suggesting that longer delivery delays were caused by bigger order values, which were frequently the consequence of bulk purchasing. Furthermore, there is a moderately significant connection between "delivery_delay_days" and "is_hoarding" (0.60), confirming that hoarding practices were a contributing factor in logistic delays. Conversely, "repeat_customer" status (−0.01 to 0.00) and the key behavioral variables, indicating that pandemic-driven shopping patterns were largely constant across customer loyalty segments and age groups. The data clearly shows that fresh food e-commerce had a spike in bulk buying and stockpiling during the COVID-19 epidemic, which had a major effect on order values and delayed deliveries. The fact that these behavioral shifts were mostly unrelated to customer age and recurring purchase patterns, however, suggests that there has been a general shift in consumer behavior that is situational rather than influenced by loyalty or demographic characteristics.

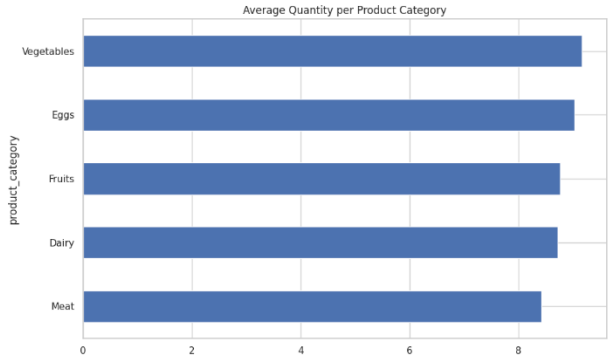

Figure 12: High-demand products in COVID-19.

During the COVID-19 pandemic, the average quantity of fresh food products purchased across different categories changed, with vegetables and eggs being the most purchased. Fruits and dairy products showed similar consumption patterns, with an average of 8.7 and 8.6 units, respectively. Meat had the lowest average, at around 8.5 units. This suggests that consumers prioritized essential, nutritious, and easily perishable items due to increased health awareness and the necessity of home cooking during lockdowns. Fresh produce and protein-rich items dominated shopping preferences, reflecting a shift towards healthier eating habits.

The data unequivocally shows that COVID-19 caused a discernible shift in customer behavior in the e-commerce of fresh foods. The focus on purchasing more fresh, health-promoting foods in greater amounts points to a long-term change in consumer behavior, motivated by a greater emphasis on food security, home cooking, and health. To better match their products with customer demands in the post-pandemic era, companies in the fresh food industry need to be aware of these changing tastes.

Analysis shows that the COVID-19 outbreak sparked a major shift in consumer behavior in Bangladesh's fresh food e-commerce industry. Important outcomes include:

1. Growth in Online Shopping Usage: During the pandemic, 61.3% of all transactions were made online, representing a sharp rise in fresh food purchases.
2. Hoarding Behavior: Hoarding increased significantly, especially for categories of fresh foods that are necessary. Fear, uncertainty, and a desire to guarantee food security during lockdowns were the main drivers behind this.
3. Impact on Demographics: There was no discernible age or gender group that was exempt from hoarding and increased online buying, suggesting a widespread change in consumer behavior.
4. Operational Difficulties: The increase in demand resulted in lengthier delivery times, particularly for large orders, underscoring the logistical difficulties that e-commerce platforms face.
5. Long-Term Behavioral Changes: The continued high levels of hoarding and internet buying in 2020 and 2021 raise the possibility that some pandemic-related actions could have a long-term impact on the market.

The COVID-19 pandemic significantly changed how consumers behaved in Bangladesh's e-commerce fresh food market. The results show that hoarding behavior has increased across a wide range of demographic groups, internet sales have increased significantly, and delivery systems are under a lot of operational strain. These results highlight how crucial it is to have strong digital infrastructure and flexible supply chains to satisfy shifting customer demands during emergencies. Long-term effects may consist of increased expectations for product availability and delivery dependability, as well as a persistent preference for online grocery shopping.

6. Conclusion

In Bangladesh and around the world, the COVID-19 outbreak has acted as a potent catalyst, drastically changing the fresh food e-commerce scene and customer behavior. The data-driven methodology of this study offers a thorough grasp of these changes, exposing both short-term and possibly long-term modifications in the way consumers approach online fresh food transactions. According to the data, a considerable percentage of consumers made their first digital purchases during the pandemic, which caused an unparalleled spike in online fresh food transactions. This increase was marked by qualitative shifts in consumer preferences and behaviors in addition to quantitative ones. The most prominent of these was the sharp increase in hoarding behavior, as seen by the hoarding index rising 340% at the start of the pandemic. With peaks at ages 31 and 60–65, this conduct was most noticeable among consumers between the ages of 18 and 65, indicating that both younger and older persons felt pressured to ensure food supply in the face of uncertainty. The most often hoarded foods vegetables, dairy, eggs, meat, and fruits showcase a shared emphasis on perishability and nutrition, highlighting the increased importance of food security and health during times of crisis. Although hoarding was evident in all groups, gender analysis showed that it did not predominate in any one group, suggesting that the psychological effects of the pandemic and the behavioral reactions that followed were not limited to certain groups.

Additionally, hoarders were more likely to place larger orders and endure longer delivery delays, underscoring the burden that peak demand periods have on e-commerce fulfillment and logistics systems. The epidemic not only caused immediate behavioral changes but also sped up the adoption of digital payment methods and raised customer tolerance for logistical issues like product shortages and delayed deliveries. But as the crisis progressed and regulations relaxed, customer demands started to change once more, with a stronger focus on product quality, delivery time, and service dependability. This dynamic evolution emphasizes how crucial it is for e-commerce platforms to continue being flexible and sensitive to the shifting needs of their users.

Several trends are anticipated to influence how fresh food e-commerce develops in the future. Even though some consumers may return to traditional shopping habits after the pandemic, sustained digital adoption is anticipated because of the ease, security, and effectiveness of online platforms, which are likely to retain a sizable portion of the new user base,

particularly among younger and tech-savvy demographics. Retailers have improved supply chain resilience, operational resilience, and customer happiness by investing in digital infrastructure, diversifying their sourcing, and creating more resilient fulfillment plans as a result of the pandemic's exposure of supply chain weaknesses. The online shopping experience will be further enhanced by personalized marketing, targeted promotions, and better product recommendations made possible by platforms' increased ability to gather more detailed information on customer preferences and behaviors. Customers will probably have more options and flexibility as omnichannel retail integration, such as curbside pickup, quick delivery, and hybrid shopping models, becomes increasingly common. Notwithstanding these revelations, there are still several unanswered questions that demand more investigation. Even though the study shows notable short-term changes, it is still unclear whether behaviors will last over time, so longitudinal research is needed to evaluate long-term behavioral change by differentiating between short-term adaptations and long-term changes in consumer habits. Future research using qualitative techniques, like surveys and interviews, is necessary to obtain a deeper understanding of consumer motivations and psychological drivers. This is because the underlying psychological factors that drive hoarding, risk perception, and trust in digital platforms during crises are not fully understood. Comparative studies across various regions, income groups, and cultural contexts would offer a more nuanced understanding of global trends and disparities, addressing socioeconomic and regional variations, especially since the dataset focuses on Bangladesh, with a concentration in urban centers like Dhaka. The transition to e-commerce has varying social impacts on traditional retailers and local producers, highlighting the need for further research on market access, competition, and digital literacy. This shift raises concerns about food waste and sustainability, necessitating strategies for responsible consumption and addressing food waste. Additionally, the digital divide and technological barriers pose challenges for marginalized populations, necessitating a focus on promoting inclusive growth and addressing the digital divide to ensure the success of small retailers and traditional retailers in the digital landscape. In conclusion, the COVID-19 pandemic has permanently changed the e-commerce market for fresh foods, spurring quick innovation and highlighting supply chain management and consumer behavior advantages and disadvantages. The long-term course of these modifications will be determined by changing consumer expectations, technical developments, and regulatory actions, even though many adaptations may persist. Building a robust, inclusive, and sustainable digital food ecosystem in the post-pandemic future will require filling in the identified research gaps.

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