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Classification of Online Pharmacy Buyers on Their Covid-19 Experiences Using Neural Network Approach

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ABSTRACT

The COVID-19 epidemic has accelerated the widespread adoption of online pharmacies in India, owing to their convenience and contactless delivery in the face of societal prohibitions. This study investigates how buyers' views of online pharmacy advantages, dangers, convenience of use, contentment, and frequency of usage during COVID-19 might place them in high or low experience categories. A questionnaire-based study was conducted in Northeast India and Sikkim to collect information about these parameters and COVID-19 experiences. Using a multi-layer perceptron neural network, the study discovered that 72.5% of purchasers could be identified correctly based on their beliefs. Despite legal and safety concerns, the findings show that COVID-19 had a considerable influence on raising knowledge and satisfaction with online pharmacies. This study emphasises the changing significance of digital healthcare technology, as well as the importance of informed policy and public education in ensuring safe online pharmaceutical purchase habits.
Keywords: Online pharmacy, COVID-19, Classification, E-pharmacy, Neural Network

INTRODUCTION

In India, online pharmacies have become more and more popular since they provide better access to pharmaceuticals and are more convenient, particularly during the COVID-19 epidemic (Agarwal & Parkhi, 2021; Gupta et al., 2022). According to Agarwal and Bhardwaj (2020) and Gupta et al. (2022), these online platforms provide advantages including competitive price, simplicity of ordering, and contactless delivery. Discounts, product availability, and user experience are factors that affect consumer acceptability (Agarwal & Parkhi, 2021). Nonetheless, worries about security, dependability, and possible problems with order correctness still exist (Agarwal & Bhardwaj, 2020). Research suggests that customers are becoming more inclined to utilise online pharmacies in the future, even with these obstacles (Gupta et al., 2022). In order to thrive in this industry, e-pharmacy companies need to concentrate on offering premium e-services, such as user-friendly websites, fast delivery, and data security (Kumar & Patil, 2023). The e-pharmacy industry has the potential to completely transform healthcare delivery in India as it develops further (Gupta et al., 2022).

Online pharmacies provide various advantages to users, including enhanced convenience, accessibility, and potentially cheaper costs (Agarwal & Bhardwaj, 2020; Agarwal & Parkhi, 2021; Fung et al., 2004). They are especially beneficial to chronic patients, the elderly, and people with limited mobility (Agarwal & Parkhi, 2021). The COVID-19 pandemic has expedited the growth of e-pharmacies, with more people resorting to digital solutions for their healthcare requirements (Agarwal & Parkhi, 2021). However, online pharmacies pose issues regarding self-medication, prescription drug abuse, and pharmaceutical dispensing without a valid prescription (Savant & Kareppa, 2022; Fung et al., 2004). Although regulatory frameworks have been built to address these difficulties, there are still hurdles in assuring patient safety and compliance with pharmaceutical rules (Fung et al., 2004). Despite these issues, online pharmacies are becoming increasingly popular, offering reasonable costs and a diverse choice of items, making them a significant component of the pharmaceutical landscape (Agarwal & Bhardwaj, 2020; Agarwal & Parkhi, 2021).

E-pharmacy research shows that patients are typically satisfied, notably with cost, delivery, and pharmacist abilities (Manoliu-Hamwi et al., 2022). However, there is room for improvement in phone and email patient counselling. According to consumer behaviour research, while online pharmacies provide benefits such as lower prices and easier ordering, worries regarding dependability, security, and product quality remain (Agarwal & Bhardwaj, 2020). A comparative examination of prominent Indian online pharmacies reveals considerable disparities in fulfilment, security/privacy, and overall e-service quality, whereas website design and customer service quality are similar (Kumar & Patil, 2023). Product pricing and availability, customer service, and online information systems are all important components of e-pharmacy service quality (Yang et al., 2001). To thrive, online pharmacies must prioritise increasing overall service quality, resolving consumer problems, and improving the online experience in order to enhance satisfaction and repurchase intent.

According to studies, the usage of online pharmacies is on the rise, fuelled in part by the COVID-19 epidemic. Studies suggest a growth in knowledge and readiness to use online pharmacies, with 89.03% of respondents in one research stating future intention to utilise online pharmacies(Gupta et al., 2022). Since the pandemic began, the frequency of internet medicine purchases has increased dramatically, from 49.16% to 55.48% (Fittler et al., 2022). Convenience, contactless delivery, competitive price, and enhanced access for chronic patients and those with limited mobility are key drivers of this transition (Gupta et al., 2022; Agarwal & Parkhi, 2021). However, many buyers continue to choose traditional pharmacies (Fittler et al., 2022). The e-pharmacy market is changing, with many platforms competing on characteristics including convenience of use, savings, and customer service (Agarwal & Parkhi, 2021). As the trend continues, there is a need to raise knowledge about recognised online pharmacies in order to ensure safe medicine purchasing (Fittler et al., 2022).

The COVID-19 pandemic has substantially influenced patient attitudes regarding online pharmacies and online healthcare services. Studies show that online pharmacies are becoming more popular owing to convenience, competitive cost, and the need for social distancing (Agarwal & Parkhi, 2021; Singh et al., 2020). Factors impacting e-pharmacy choices include convenience of purchase, savings, user experience, and product availability (Agarwal & Parkhi, 2021). The pandemic has expedited the expansion of e-commerce in the pharmaceutical industry, with patients adjusting to online consultations and medicine delivery (Singh et al., 2020; Pranav, 2023). However, worries regarding drug usage and self-medication remain (Singh et al., 2020). Pharmacists' roles have grown, with more patients seeking their help during the pandemic (Grosman-Dziewiszek et al., 2021). Telemedicine is becoming more popular, yet some patients still prefer in-person encounters. Overall, the pandemic has accelerated the use of digital healthcare technologies, including online pharmacies and telemedicine in routine healthcare systems (Grosman-Dziewiszek et al., 2021; Pranav, 2023).

The COVID-19 epidemic has profoundly influenced India's e-pharmacy market, resulting in greater acceptance and growth. Online pharmacies have been essential in ensuring healthcare access during lockdowns and social distancing measures (Maganti et al., 2020; Singh et al., 2020). Consumer perceptions towards online pharmacies have moved positively due to convenience, simplicity of use, and competitive pricing (Pranav, 2023; Agarwal & Parkhi, 2021). The pandemic has expedited the pharmaceutical industry's digital transformation, with more buyers using online platforms for medicine purchases and healthcare consultations (Maganti et al., 2020; Pranav, 2023). However, problems such as regulatory impediments and worries about drug abuse remain (Singh et al., 2020). Discounts, user experience, customer support, and product availability are all factors that influence buyers' choice of e-pharmacy platforms. Overall, online pharmacies have emerged as a critical component of healthcare delivery throughout the epidemic, benefiting both patients and the pharmaceutical industry.

From the literature review we find that covid-19 has provided a historical thrust to the acceptance of online pharmacies. Has this been associated with independent variables such as ease, benefits, risk, satisfaction and frequency of use of online pharmacies? One way to answer this question will be to find how successfully online pharmacy buyers can be classified on the basis of their beliefs about aforementioned independent variables. Study has been undertaken to explore this possibility.

LITERATURE REVIEW

Online pharmacies have made it easier to purchase drugs by offering convenience, contactless delivery, and 24/7 access via online platforms, particularly during the COVID-19 pandemic (Priya & Subbulakshmi, 2022). The growth of online pharmacies in India is being driven by reasons such as rising internet users, long-term disease patients, and the convenience of access to medications over the internet, which is catering to the growing demand for pharmaceuticals (Priyanka & Ashok, 2016). Despite worries regarding regulatory supervision and the hazards of self-medication and drug

usage, online pharmacies provide benefits such as cost-effectiveness, free home delivery, and rapid service, making them a popular choice among customers (Savant & Kareppa, 2022). The rise of online pharmacies is consistent with the larger trend of e-commerce growth, offering customers with cheaper costs, flexible offers, and the opportunity to readily compare items, therefore improving the entire shopping experience (Szewczyk, 2014).

Patient satisfaction with online pharmacies vary depending on several aspects. Studies on customer satisfaction with online pharmaceutical services have yielded conflicting findings. While one study in the Qassim Region found moderate satisfaction with e-prescription services (Alsalem & Al-Owayyid, 2023), another study in Romania found high satisfaction with online pharmacy services in general, particularly with the price of medicines and the professional skills of pharmacists, but lower satisfaction with advice received over the phone or via email (Manoliu-Hamwi et al., 2022). Furthermore, the use of new technologies, such as online platforms for medical prescription orders, has yielded positive results, reducing patient wait times, improving communication between healthcare professionals, and improving safety and information accessibility, resulting in increased overall satisfaction among pharmacy staff (Merino et. al, 2023). In addition, during the SARS-CoV-2 epidemic, a telepharmacy and home delivery programme yielded excellent patient satisfaction ratings, demonstrating the efficacy of such programmes in delivering pharmaceutical care and medicine delivery to vulnerable patients (Casado et. al, 2023).

Online pharmacies provide several advantages for both individuals and healthcare providers. Patients value the convenience, cost savings, doorstep delivery, and expanded product range offered by online pharmacies (Praneetha et. al, 2023). Furthermore, the ability to readily compare costs, shop swiftly, obtain information rapidly, and protect privacy are important aspects in attracting customers to online pharmacies (Cherecheș & Popa, 2021). E-prescribing systems benefit healthcare professionals such as general practitioners and chemists by improving the prescribing and dispensing process, improving patient adherence, and ensuring prescription safety and security, particularly during difficult periods like the COVID-19 epidemic (Tan et. al, 2023). Overall, the transition to online pharmacies is motivated by the need for speed, accessibility, and safety in the healthcare sector, pointing to a bright future for online pharmaceutical services.

The amount of drug purchases through online pharmacies has increased, particularly during the COVID-19 epidemic, according to numerous study publications. Studies in European nations such as the Visegrad Group and the Far Eastern Federal District reveal an upsurge in internet pharmaceutical purchases following the epidemic (Soboleva et al., 2022). Similarly, research in India shows an increasing readiness among customers to use e-pharmacies, with a sizable proportion receptive to future online prescription purchases (Gupta et al., 2022). However, issues remain, with a research concentrating on psychiatric medicines indicating that many internet pharmacies do not require prescriptions, possibly jeopardising patient safety (Monteith & Glenn, 2018). Regardless of these problems, there is a definite trend of rising online drug purchases, emphasising the importance of public awareness initiatives to promote secure and trusted online pharmacies (Fittler et. al, 2018).

The COVID-19 epidemic has dramatically transformed buyers' attitudes about e-pharmacies, resulting in a considerable surge in online purchases of pharmaceuticals and health items (Fittler et al., 2022). The convenience and contactless delivery provided by online pharmacies have been major considerations in people switching to online platforms for their pharmaceutical requirements (Gupta et al., 2022). Following the epidemic, there has been an increase in the number of people purchasing medications and health items online, indicating a shift in consumer views towards online pharmacies (Fittler et al., 2022). The convenience of accessing information and making purchases via multiple internet platforms has expedited the growth of e-pharmacies, with an increasing demand for online consultations and medical aggregators (Pranav, 2023). The boom in internet usage post-lockdown has also played a critical part in the growing utilisation of online pharmacies, showing the changing landscape of healthcare service delivery throughout the epidemic (Sharma, 2022 Ushir & Diana, 2022).

The COVID-19 pandemic has substantially altered the landscape of e-pharmacies, resulting in an increase in online purchases of pharmaceuticals and healthcare supplies (Fittler et al., 2022). According to studies, eHealth was widely used in pharmaceutical treatment during the pandemic, with chemists using a variety of digital platforms to promote continuity and efficiency in patient care (Cen et. al, 2022). Furthermore, the pandemic has hastened the move to online pharmacy services, with a significant rise in the frequency of purchasing medications and health items online recorded during the COVID-19 epidemic (Fittler et al., 2022). The ease of e-pharmacies, along with the need to restrict in-person encounters, has fuelled this shift, emphasising the relevance of e-commerce in the healthcare industry during times of crisis (Pranav, 2023). Furthermore, research has proved the robustness of e-pharmacy supply chains by implementing strong

prediction models, which provide timely delivery of medicinal supplies even during pandemic-induced interruptions (Mariappan et. al, 2022).

METHODOLOGY:

This study has been undertaken to understand how the benefits that online pharmacies bring in according to buyers are associated with the covid-19 experiences and resultant social restrictions. It is being hypothesized that covid-19 underlined the importance of online pharmacies and the benefits associated with it. It is being assumed that those who strongly believe that online pharmacies are beneficial are also the ones who experienced online pharmacies during covid-19 restrictions. The aim of the study is to find if the buyers of online pharmacies can be classified into high/low experiencers of online pharmacies during covid-19, on the basis of their beliefs regarding risk, benefits, ease, satisfaction and frequency of use associated with online pharmacies. To achieve the purpose a questionnaire was developed to measure latent constructs namely risk (7 items), ease (5 items), benefits (8 items), satisfaction (6 items) and frequency (5 items) of use. Covid-19 experiences of online pharmacies has been measured using 4 items. However, the sum of these continuous scales is made categorical by keeping high/low values. The survey has been conducted online (Northeast India, except Sikkim) and offline (Sikkim). The data has been collected from June 22 to August 23). Face validity of the questionnaire was achieved by taking views of 5 healthcare researchers. Data analysis has been done using multi-layer perception networks. For the analysis covid-19-usefulness (categorical) is the dependent variable and risk, ease, benefits, satisfaction and frequency of use are independent variables.

Result and Analysis:

The details of findings of this study are discussed below. An artificial neural network consists of interconnected layers. Multi-layer perceptron networks are a type of neural network with multiple interconnected layers. These networks are trained using the backpropagation method. The multilayer perceptron is a kind of deep learning algorithm. The network includes three main layers: input, hidden, and output, which together form a complete Artificial Neural Network. Table 1 provides a summary of case processing. Out of 493 valid examples, 340 (69.0%) were used for training, and 153 (31.0%) were used for final testing.

Table-1: Case Processing Summary

		N	Percent
Sample	Training	340	69.0%
	Testing	153	31.0%
Valid		493	100.0%
Excluded		9	
Total		502	

Table-2 displays the network information. The input layers are Risk, Ease, Benefit, Satisfaction and Frequency, and there is only one hidden layer. The dependent variable, Covidcat, is categorized into two possible values: high or low. The activation function used is softmax, which is beneficial because it not only scales the output to a range between 0 and 1 but also ensures the sum of the outputs equals 1, creating a probability distribution. The error function, representing the difference between the desired and actual output, is calculated using cross-entropy, which is mathematically represented as follows:

$\text{Loss} = -(y\log(p)+(1-y)\log(1-p))$

where:

- p is the predicted probability, and
- y is the indicator (00 0 or 111 in the case of binary classification)

The Binary Cross Entropy Loss significantly penalizes incorrect predictions, especially when they deviate more from the actual y label, by applying the negative logarithm.

Table-2: Network Information

Input Layer	Factors	1	Risk

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		2	Ease
		3	Benefit
		4	Satisfaction
		5	Frequency
	Number of Units		105
Hidden Layer(s)	Number of Hidden Layers		1
	Number of Units in Hidden Layer 1[a]		3
	Activation Function		Hyperbolic tangent
Output Layer	Dependent Variables	1	Covid-usefulness
	Number of Units		2
	Activation Function		Softmax
	Error Function		Cross-entropy
a. Excluding the bias unit			

Model summary (Table-3) shows that cross entropy value as 200.051 and corresponding percent incorrect prediction as 31.5% for training and 91.010 (corresponding percent incorrect prediction 33.3%).

Table-3: Model Summary		
Training	Cross Entropy Error	200.051
	Percent Incorrect Predictions	31.5%
	Stopping Rule Used	1 consecutive step(s) with no decrease in error[a]
	Training Time	0:00:00.14
Testing	Cross Entropy Error	91.010
	Percent Incorrect Predictions	33.3%
Dependent Variable: Covidcat		
a. Error computations are based on the testing sample.		

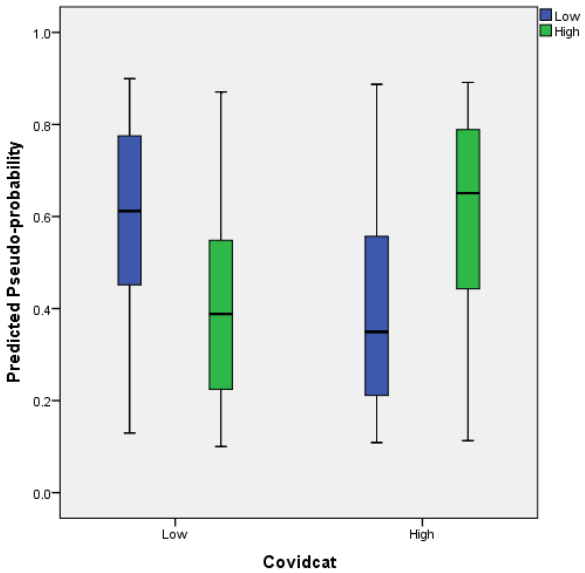

Figure-1: Predicted by observed chart

The predicted vs. observed chart compares the projected and actual values for each dependent variable. In the boxplots of anticipated pseudo-probabilities for categorical dependent variables, the observed response category serves as the cluster variable. The first boxplot, with values greater than 0.5, indicates a correct prediction. This figure shows boxplots categorizing the anticipated pseudo-probability for the dependent variable Covid-usefulness' based on the entire data set. The first boxplot illustrates the predicted probability that a low Covid-usefulness is correctly classified as low-Covid-

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usefulness. The second boxplot shows the likelihood that a high Covid-usefulness is incorrectly labeled as a "low Covid-usefulness." These results are based on the observed data.

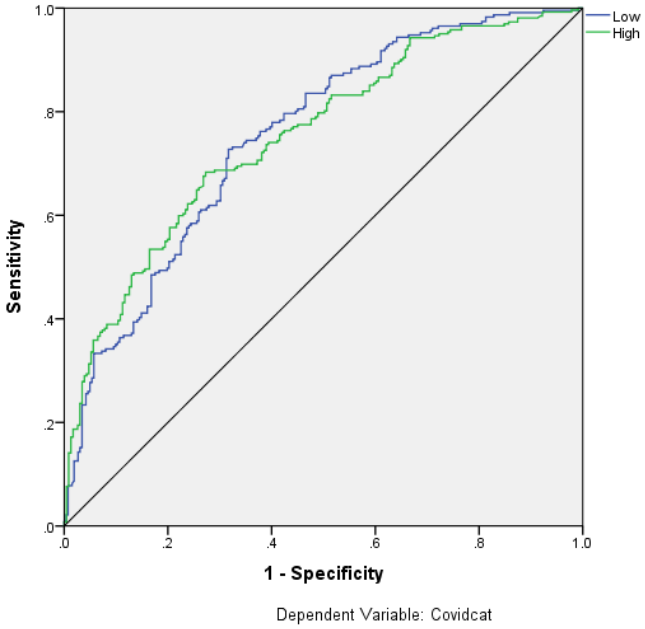

Figure-2: ROC Curve

ROC (Receiver Operating Characteristic) analysis and AUC (Area Under the Curve) are widely used tools in Data Science.

Key performance indicators (KPIs) like accuracy and recall rely heavily on positive observations. In contrast, ROCs and AUCs use True Positive (TPR) and False Positive (FPR) rates, which consider both TPR and FPR observations.

Precision is the ratio of true positives to all predicted positives. The ROC curve is a summary tool that visualizes the trade-off between precision and recall by plotting the False Positive Rate on the x-axis and the True Positive Rate on the y-axis

Table-4: Area Under the Curve

		Area
Covidcat	Low	.753
	High	.753

The Area Under the Curve (AUC) ranges from zero to one, with values theoretically expected to be above 0.5. As shown in Fig-2, both low and high Covid-usefulness have AUC values above 0.9, indicating successful classification. Table-4 presents the exact AUC value of 0.753, significantly higher than 0.5, which is a positive sign.

Table-5: Classification of low and high Covid-usefulness

Sample	Observed	Predicted		
		Low	High	Percent Correct
Training	Low	122	54	69.3%
	High	39	123	75.9%
	Overall Percent	47.6%	52.4%	72.5%
Testing	Low	35	21	62.5%
	High	27	73	73.0%
	Overall Percent	39.7%	60.3%	69.2%
Dependent Variable: Covid-usefulness				

Finally, we classify low and high Covid-usefulness, as shown in Table-5. During training, 122 (69.3%) low Covid-usefulness were correctly identified, while 54 (41.7%) were misclassified. Conversely, 123 (75.9%) high Covid-usefulness

were correctly classified, and 39 (34.1%) were misclassified. In the testing phase, the correct classification rates were 62.5% for low Covid-usefulness and 73.0% for high Covid-usefulness. The overall classification success rate is 69.2%, which can be considered excellent.

DISCUSSION

Online pharmacies flourished in India despite no apparent regulations regulating it. Since 2000 online pharmacies emerged in India though there was no legal mandate to do so. It was stated that member online pharmacies of India under IIPA (Indian Internet Pharmacies Association) will self-regulate until the law of the land catches up to advancements in technology with conditions (2015). In an effort to control the online sale of medications throughout India and give patients access to real medications from reliable online portals, the Union Health Ministry of India has released draft regulations on the selling of drugs via online or e-pharmacies. (E-harmacy draft, 2018). The buyers, therefore, have been reluctant to seek services of e-pharmacies. Covid-19 crisis however led to a wide acceptance of online pharmacies across the world (Cen *et al* (2022); Unni *et al* (2021); Jairoun *et al* (2021). Therefore, it is logical to assume that buyers understood the risk, ease, benefits and resulting satisfaction with online pharmacies during the pandemic. From this study we find that buyers of online pharmacies can be classified on their experience of usefulness of online pharmacies during covid-19 pandemic into high/low on their scores on risk, benefits, ease, satisfaction and usage frequencies. How does this conclusion find acceptance with findings of other researchers? Dat *et al* (2023) States that online pharmacies have played an essential role in addressing pharmacist shortages and helping patients both safely and effectively. Another study states that *frequency of purchasing medications online has significantly increased during the past years* (Fittler et al (2022). In a study (Manoliu-Hamwi et al, 2022) almost 100% respondents agreed that they purchased medicines from online pharmacies during covid 19. Same study found satisfaction levels to be high. Most studies, therefore, echo the findings of present study. This integration of the study with wide literature confirms that covid-19 pandemic has greatly influenced the buyers to buy from online pharmacies and also enhanced their understanding of risks, benefits and satisfaction with these.

The COVID-19 pandemic has had a substantial impact on the supply and demand sides of the online pharmaceutical and healthcare product business since patients' and buyers' shopping experiences have grown at the same time that their perceptions on buying medications online have probably changed. As e-pharmacy shopping continues to grow and approaches the tipping point towards the new normal, public awareness campaigns about the risks involved in buying medicines online from unidentified sources must be widely disseminated to internet users. This will help to prevent the use of unregistered, substandard, and falsified medicinal products. To encourage online customers to assess drug-selling websites, steer clear of those with poor trustworthiness, and favour nationally recognised, verified stores, public awareness efforts are required.

It is not being recommended that online pharmacies should be promoted. Despite their distinct advantages they provide challenges to healthcare outcomes. Strong regulatory system is the need of the hour. It is highly recommended that upcoming research emphasise the negative consequences resulting from online drug purchases. A new field of medical study known as "digital" research or "infoveillance" is supported by rapidly developing technology such as "machine learning algorithms," which are used to "Big Data." This means that there are several ways to quantify the risk of patient safety in outpatient settings. Public education about the safe practices of internet pharmacies necessitates improved patient-healthcare professional education, communication, and promotion efforts.

CONCLUSION

This study has been undertaken to determine the possibility of classification of online pharmacy buyers on their beliefs on usefulness of this agency, on the basis of their stated beliefs related to risks, ease, benefits, satisfaction. Our findings reflect that it is possible to do so to a moderate extent. We have shown that as many as 72.5% buyers can be correctly classified. ROC curve obtained also points in this direction. The study is important as it clearly establishes a link between covid-19 experiences with advantages, dangers and satisfaction with online pharmacies. This establish that a forced behaviour also modifies beliefs related to risk, benefits and similar factors. Interventions, intended or unintended, are useful to modify buyer behaviour.

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