RESEARCH PAPER

Last-Minute Delivery of Medicines via E-Commerce Platforms: Effects on Adherence, Anxiety, and Unnecessary Urgency – A 12-Week Empirical Study

Ms. Priyanka Patel[1], Ms. Bhakti Vyas[2], Ms. Gopi Pandya[3], Ms. Shibi Rai[4], Ms. Manasi Patel[5], Mr. Tarun Rohira[6]

[1] Assistant Professor, Parul Institute of Business Administration, Parul University.
Email: Priyankapandya04@gmail.com
[2] Assistant Professor, Parul Institute of Business Administration, Parul University. Email: bhaktibhatt37@gmail.com
[3] Assistant Professor, Parul Institute of Business Administration, Parul University. Email: gopi.h.bhatt@gmail.com
[4] Assistant Professor, Parul Institute of Business Administration, Parul University. Email: shibirai1397@gmail.com
[5] Assistant Professor, Parul Institute of Business Administration, Parul University.
Email: manasiriteshpatel@gmail.com
[6] Assistant Professor, Parul Institute of Business Administration, Parul University.
Email: tarunrohira1249@gmail.com

Received: 2nd Mar, 2026 | **Revised:** 14th Mar, 2026 | **Accepted:** 4th Apr, 2026 | **Available Online:** 20th Apr, 2026

ABSTRACT

There is a growing trend toward last-minute (≤ 3 h) medicine delivery by e-pharmacy platforms; however, little is known about its clinical and psychological effects. This research aims at evaluating if the effect of last-minute delivery mode on medicine adherence is better than that of next-day and regular delivery modes, to find out what percentage of orders placed in last-minute mode was not clinically urgent and to evaluate if the effect of reduced anxiety is an intermediate factor affecting the effect of faster delivery on loyalty to the platform. A partially randomized control trial involving 452 patients from six Indian metro cities with diagnoses of hypertension, diabetes, and asthma over a period of 12 weeks is described. A special mobile application offering last-minute (LM: 2-3 h), next-day (ND: 24 h), and regular (ST: 3-5 days) delivery modes was employed for all patients. The analyses employed included ANOVA, mixed model, logistic regression, and mediation analysis using bootstrapping. The study indicated that last-minute delivery resulted in higher adherence (92%) than next-day (81%) and normal delivery (73%) ($p<.001$) while decreasing stockouts by 62% (OR=0.38). Anxiety was significantly decreased in the last-minute delivery group ($\Delta=1.7$; $d=1.63$), and mediation analysis demonstrated that anxiety was reduced by 41.1% in mediating the relationship between delivery speed and purchase intention. Nonetheless, 22% of orders made last-minute deliveries were found clinically unnecessary. Therefore, although last-minute deliveries improve adherence and reduce anxiety, there is still a tendency to increase usage, thus necessitating the integration of clinical triaging systems and policy regulations based on medical necessity.

Keywords: e-pharmacy, last-mile logistics, medication adherence, pharmaceutical e-commerce, anxiety, health behavior, unnecessary care.

How to cite this article: Patel P, Vyas B, Pandya G, Rai S, Patel M, Rohira T. Last-Minute Delivery of Medicines via E-Commerce Platforms: Effects on Adherence, Anxiety, and Unnecessary Urgency – A 12-Week Empirical Study. Int J Drug Deliv Technol. 2026;16(32s):929-937. DOI: 10.25258/ijddt.16.32s.102

Source of support: Nil.

Conflict of interest: The authors declare no conflict of interest.

1. Introduction

1.1 The rise of rapid pharmaceutical e-commerce

From 2020 to 2025, the worldwide market for online pharmacies experienced a compound annual growth rate of 17.8%, propelled by the factors of convenience,

increased cases of chronic diseases, and digital health after the coronavirus pandemic [1]. One of the most disruptive technologies in this field includes late-hour delivery, which involves the delivery of medicines ordered through an online portal within three hours after confirming the order. Leading firms like Netmeds, PharmEasy, Amazon Pharmacy, and 1mg provide this facility in cities. Supporters of rapid delivery claim that it addresses an age-old behavioral issue known as "temporal discounting," where individuals place less value on long-term rewards compared to short-term investments [2]. Rapid delivery could help address this issue by decreasing the delay between identifying the need for a service and its fulfillment [3].

1.2 The adherence crisis and potential solution

Non-compliance to medications results in 125,000 deaths per year in the US and incurs $100-$300 billion costs for the healthcare system [4]. Medication compliance rates among chronic illness patients average 50-70% for oral drugs [5]. Forgetfulness, costs, and most importantly, being out of medications without prompt replenishment, represent the major barriers to compliance [6].

From this perspective, e-pharmacies seem like an ideal solution, allowing for reordering from the comfort of one's home. Nevertheless, most conventional delivery times (3-7 days) will not reduce the timeframe even if ordering happens only after the medication runs out. Immediate delivery reduces the time frame to less than 3 hours.

1.3 The psychological mechanism: anxiety reduction

However, aside from its logistical benefits, there could be another affective channel for rapid delivery. Stockouts for medication have been found to correlate highly with anxiety especially for individuals suffering from asthma (fear of having an asthma attack) and hypertension (fear of stroke) [7]. In qualitative research, simply offering the service of rapid delivery without actually availing of it was observed to lessen stress [8]. Nonetheless, the degree to which anxiety plays a role in this equation has yet to be determined.

1.4 The dark side: unnecessary urgency

On the other hand, behavioral economics suggests the risk of creating induced demand, whereby the provision of a faster service induces patients to use it, although not necessarily necessary from a clinical perspective [9]. In such cases, the patient tends to opt for a faster service because of their perception of safety, thus using logistics capacity inefficiently and contributing to the higher carbon footprint. More than 30% of the urgent deliveries have been reported as non-urgent [10].

1.5 Research gaps and objectives

Growth has not led to much scientific evidence:

- There has been no experiment comparing the effects of late vs. early delivery on objective adherence (these studies have used self-reports and refills).
- There has been no study on the dynamics of patients' anxiety before and after rapid delivery.
- There has been no study calculating unnecessary urgency in prescription medications based on necessity perceived by patients.
- Mediating mechanisms of customer retention through rapid delivery have never been studied. Therefore, this study addresses three research questions:

RQ1: Is there any significant difference in medication adherence between last-minute delivery (3 hours or less), next-day delivery (24 hours), and standard delivery (3-5 days)?

RQ2: How many last-minute prescriptions are considered unnecessary from a clinical perspective, and which factors determine patient necessity for such urgency?

RQ3: Does anxiety alleviation play a mediating role between last-minute delivery and repurchase intention?

1.6 Hypotheses

- **H1:** The mean adherence percentage will be higher in last-minute delivery, then next-day delivery, and lastly standard delivery (LM > ND > ST).
- **H2:** There will be a higher pre- to post-delivery decrease in GAD-2 scores among patients taking last-minute delivery relative to those taking next-day delivery or standard delivery.
- **H3:** Reduction in anxiety will partially mediate the positive relationship between last-minute delivery and repurchase intention**.**
- **H4 (exploratory):** At least 15% of last-minute deliveries will be deemed clinically unnecessary by patients.

2. Methods

2.1 Study design

This study was a 12-week, partially randomized, parallel-group, multicenter study involving repeated measures. By partially randomized, we refer to our combined approach whereby 60% of the orders received random assignments of delivery speed (which helped us make causal inferences), while 40% of them were selected based on patient choice (which mimicked patient behavior). The allocation process involved stratification

along two dimensions: disease (high blood pressure, diabetes, and asthma) and baseline adherence (low, 60%-79%, and high (>80%) adherence).

2.2 Ethical approval and registration

This research project received approval from the Institutional Ethics Committee of [University] with IEC no. PH-456-2025 on 15 March 2025. Prospectively registered under Clinical Trials Registry – India (CTRI/2025/09/089234). Informed consent obtained from all subjects.

2.3 Participants

Eligibility Criteria:

- Age ≥18 years
- A diagnosis of hypertension (JNC 8 criteria), type 2 diabetes (HbA1c ≥6.5%), or asthma (GINA criteria) for ≥6 months
- Use of at least one maintenance drug (amlodipine, metformin, inhaled corticosteroids) on a daily basis
- Have a smartphone with internet access
- Live in one of the following cities: Delhi, Mumbai, Bengaluru, Chennai, Kolkata, and Hyderabad
- Willing to utilize the application for all medication refills during the next 12 weeks

Ineligibility Criteria:

- Cognitive impairment that will hinder app usage (screened over phone through a 6-item test)
- No stable internet access
- Pregnant or plan to conceive (because of modification in medications)
- Currently participating in other adherence trials

Determination of sample size:

Power analysis was conducted using G*Power 3.1.9.7 software, considering a one-way ANOVA with three groups. Values: effect size f = 0.25 (pilot study data revealed that the standard deviation of the difference between groups is ~0.10 for compliance), alpha value = 0.05, power = 0.80, allocation ratio = 1:1:1. The required sample size = 402. Considering

Participants were selected through:

(1) Three major hospital outpatient departments (Apollo, Fortis, and AIIMS-related)

(2) Online advertisements on social media platforms (Facebook, WhatsApp) targeting chronic disease patient communities

(3) Referrals from existing customers of the e-pharmacy

Screening was done through telephone calls based on a detailed questionnaire. Selected participants were invited to attend an orientation session either offline or online, where the application was configured, and electronic monitoring caps (E-cap) were provided.

2.5 Intervention platform: "Medi Speed" app

A customized mobile application (Medi Speed v2.1) was created acting as an e-pharmacy simulator for the patients. Features included:

- Prescription upload and confirmation by the licensed pharmacist (consistent for all groups)
- Three delivery options offered with each purchase:
  - Last-minute (LM): 2–3 hours (without fee throughout the study)
  - Next-day (ND): 24 hours (without fee)
  - Standard (ST): 3-5 days (without fee)
- Randomization algorithm: In case of 7 out of 12 weekly purchases, randomization (stratified) was applied overriding patient selection. For 5 out of 12 purchases, the patients could select their delivery option voluntarily. The randomization vs. selection conditions were not disclosed to the patients.
- Monitoring: Medications were dispensed in bottles with electronic caps (AdhereTech SmartCap) capturing time-stamped data upon bottle openings; pill counts were conducted in weeks 4, 8, and 12 using a video call.
- Surveys: GAD-2 test completed right before the purchase and two hours after confirming the delivery; intention to repurchase assessed in week 12; unnecessary urgency question posed ("Was this medication needed for you within the next 3 hours?") right after each LM delivery.

2.6 Outcomes

Primary outcome:

- **Medication adherence** – proportion of prescribed doses taken over the 12-week period, calculated as:

$$\text{Adherence} = \frac{\text{Number of doses taken (E-cap + pill count)}}{\text{Number of prescribed doses}}$$

Doses taken were cross-validated: E-cap provided timestamp; if cap was removed but pill count showed no reduction, that event was excluded (false opening). Adherence was treated as a continuous proportion (0–1).

Secondary outcome measures:

1. Anxiety – GAD-2 scales (range 0-6) prior to ordering and after delivery. "Anxiety reduction" defined as pre-order score minus post-delivery score.
2. Stock-outs – self-reports (binary variable: "In the past week, did you have stock-out of your medication before the refill was delivered?") evaluated weekly.
3. Urgency not justified – ratio of "No" responses to the question: "Did you really need this medicine within 3 hours?" for each LM order.
4. Potential repurchases – 7-point Likert item "If I required the medicine again, I would choose this same speed of delivery", modified from Zeithaml et al. [11] evaluated at week 12.

Covariates:

Age, gender, education (school, university, higher), diagnosis category, baseline compliance level measured with the 2-week run-in period before randomization, number of co-morbidities, history of online pharmacy purchases (yes/no).

2.7 Randomization and blinding

For the 60% allocation (randomization), a computer-based random number sequence (blocks of 6, stratified) was used. The allocations were concealed in numbered opaque envelopes. Because of the characteristics of delivery speed, blinding was not possible in this study due to the nature of the delivery speed. But the outcome assessor (pill count calculation) was blinded to the delivery speed group.

2.8 Statistical analysis

Analyses were performed according to the ITT paradigm, with missing data on adherence imputed through LOCF approach as part of the primary analysis; the secondary analysis employed MI with 20 imputed datasets.

Analysis Plan:

1. Baseline differences between groups - ANOVA for continuous predictors, chi-square test for categorical variables, among three speed conditions (randomized orders only).
2. H1 (Adherence Differences) – One-way ANOVA (speed as fixed factor), followed by Tukey's HSD post hoc. Effect size: η^2 (small=0.01, medium=0.06, large=0.14). Furthermore, LMM with random intercept for participants and fixed factors: speed, week, speed*week, other covariates.
3. H2 (Anxiety Reduction) – paired t-test within speed groups, and repeated measures ANOVA with Greenhouse-Geisser correction (2 weeks * 3 speeds).
4. H3 (Mediation) – Hayes PROCESS Macro Model 4 with 5000 bootstrapped samples. X = Last Minute Delivery (dummy coded; LM=1, ND/ST=0). M = Anxiety reduction (continuous). Y = Repurchase intent (continuous). Covariates: adherence baseline, age, disease. Mediation is significant if the 95%CI of indirect effect does not include zero.
5. H4 (Unnecessary Urgency) – Descriptive proportion with 95% Wilson CI. Binary logistic regression model predicting unnecessary urgency (yes, no) by number of LM orders, baseline anxiety, disease, age.
6. Stockout Analysis – Logistic regression for stockouts, based on LM versus ND/ST predictor.

Software: SPSS v28 (IBM), PROCESS v4.2, R v4.2.1 (for mixed models, lme4 package). **Significance threshold:** α=0.05, two-tailed. No adjustment for multiple comparisons due to confirmatory hypotheses [12], but secondary exploratory analyses report unadjusted p-values with caution.

2.9 Sensitivity and subgroup analyses

- Analysis per protocol (participants with >20% missing adherence data excluded)
- Stratification by disease category (hypertension, diabetes, or asthma) to assess interaction
- Stratification by initial level of adherence (low or high)
- Sensitivity analysis on unnecessary urgency with "Unsure" categorized as unnecessary (conservative) or necessary (liberal)

3. Results

3.1 Participant flow and baseline characteristics

Out of 480 patients, 452 (retention rate 94.2%) successfully participated in the study for 12 weeks. Withdrawal causes included loss to follow-up (N=14), technical problems (N=8), and voluntary withdrawal (N=6). The final study population was 452 subjects, aged 58.4±12.3 years (51% females). Table 1 shows the baseline information of patients according to their delivery speeds at the end of the study (randomized

Table 1. Baseline characteristics of participants (N=452)

Characteristic	Total (N=452)	LM group* (n=151)	ND group (n=151)	ST group (n=150)	p-value**
Age, mean±SD	58.4±12.3	59.1±11.9	57.8±12.7	58.2±12.4	0.64
Female, n(%)	231 (51.1)	78 (51.7)	77 (51.0)	76 (50.7)	0.98
Disease:					
Hypertension	189 (41.8)	63 (41.7)	63 (41.7)	63 (42.0)	0.99
Diabetes	158 (35.0)	53 (35.1)	53 (35.1)	52 (34.7)	
Asthma	105 (23.2)	35 (23.2)	35 (23.2)	35 (23.3)	
Baseline adherence	0.71±0.18	0.72±0.17	0.71±0.18	0.70±0.19	0.71
Prior e-pharmacy use, n(%)	201 (44.5)	68 (45.0)	67 (44.4)	66 (44.0)	0.98

*LM group defined as participants who received ≥50% of their randomized orders as LM.

**p-values from ANOVA (continuous) or chi-square (categorical), no significant differences.

3.2 Descriptive adherence data

Over 12 weeks, 3,457 unique delivery events were recorded. Mean adherence by speed (aggregated across all orders, both randomized and patient-chosen):

- **Last-minute (1,482 orders):** 0.92 (SD=0.11)
- **Next-day (1,107 orders):** 0.81 (SD=0.16)
- **Standard (868 orders):** 0.73 (SD=0.19)

Figure 1 (see Appendix) shows adherence over time: LM group maintained >90% adherence from week 2 onward, while ST declined slightly (0.75 at week 1 to 0.70 at week 12).

3.3 Hypothesis testing results

H1: Adherence differences

One-way ANOVA: $F(2,449)=34.71$, **p<.001**, $\eta^2=0.134$ (large effect).

Post-hoc Tukey HSD:

Comparison	Mean difference	95% CI	p-value	Cohen's d
LM vs. ND	0.11	[0.07, 0.15]	<.001	0.82
LM vs. ST	0.19	[0.14, 0.24]	<.001	1.31
ND vs. ST	0.08	[0.02, 0.14]	.012	0.45

Linear mixed-effects model (controlling for time, baseline adherence, disease) confirmed significant main effect of speed ($F(2, 412)=29.4$, $p<.001$). Speed×time interaction was not significant ($p=0.18$), indicating that differences remained stable across weeks.

Result: H1 supported. Last-minute delivery yields a clinically meaningful absolute adherence gain of +19% over standard delivery.

H2: Anxiety reduction

Pre-delivery GAD-2 scores did not differ by group (LM: 3.1±1.4, ND: 3.2±1.5, ST: 3.0±1.4; p=0.41). Post-delivery scores (2 hours after receipt):

- LM: 1.4±0.9 (reduction Δ=1.7, paired t(1481)=31.4, p<.001, Cohen's d=1.63)
- ND: 2.2±1.1 (reduction Δ=1.0, t(1106)=18.2, p<.001, d=0.78)
- ST: 2.7±1.2 (reduction Δ=0.3, t(867)=6.1, p<.001, d=0.21)

Repeated-measures ANOVA (time × speed): $F(2,449)=28.9$, p<.001, partial $\eta^2=0.114$. Post-hoc: LM reduction significantly larger than ND (p<.001) and ST (p<.001).

Result: H2 supported. Last-minute delivery produces a very large anxiety reduction effect.

H3: Mediation analysis

PROCESS Model 4 (5,000 bootstrap samples). Covariates: baseline adherence, age, disease type.

Path coefficients (unstandardized):

- a path (LM → anxiety reduction): β=0.82, SE=0.09, p<.001
- b path (anxiety reduction → repurchase intent): β=0.62, SE=0.07, p<.001
- c path (total effect, LM → repurchase intent): β=1.24, SE=0.15, p<.001
- c' path (direct effect, LM → repurchase intent controlling for M): β=0.73, SE=0.21, p=.002

Indirect effect (ab): 0.51, 95% CI [0.38, 0.66] (bootstrap).

Proportion mediated = 0.51 / 1.24 = **41.1%** (95% CI for proportion: 30.2%–52.7%).

Result: H3 supported. Anxiety reduction partially mediates the effect of last-minute delivery on repurchase intent. The mediation is statistically significant and substantial.

H4: Unnecessary urgency (exploratory)

Of 1,482 last-minute orders, 326 (22.0%, 95% CI 20.0%–24.2%) were rated "No" (unnecessary) to "Did you truly need this within 3 hours?". Another 118 (8.0%) answered "Unsure".

Reasons among "No" responses (multiple allowed):

- "Just to test the speed" – 41%
- "I felt anxious but had ≥2 days' supply" – 33%
- "Habit – I always choose fastest" – 26%

Logistic regression predicting unnecessary urgency (excluding "Unsure"):

Predictor	OR	95% CI	p-value
≥3 prior LM orders (vs. <3)	2.41	[1.62, 3.58]	<.001
Baseline GAD-2 (per 1 point)	1.12	[0.98, 1.28]	0.09
Age (per 10 years)	0.86	[0.74, 0.99]	0.04
Asthma (vs. hypertension)	1.34	[0.91, 1.97]	0.14

Younger age and repeated exposure to LM delivery increased likelihood of unnecessary urgency.

Result: H4 supported – unnecessary urgency exceeds 15% threshold and is associated with habituation.

3.4 Secondary outcome: Stockout events

Logistic regression (LM vs. ND/ST combined):

- Crude OR = 0.32 (95% CI 0.21–0.49), p<.001
- Adjusted (age, disease, baseline adherence) OR = 0.38 (95% CI 0.24–0.59), p<.001

Absolute stockout rate: LM 8.2%, ND/ST 21.6% → **62% relative reduction**.

Number needed to treat (NNT) with LM to prevent one stockout = 1 / (0.216 – 0.082) = 7.5. For every 8 LM deliveries, one stockout is avoided.

3.5 Sensitivity analyses

- **Multiple imputation** for missing adherence (n=41 participants with any missing week): adherence difference LM vs. ST remained significant (Δ=0.17, p<.001).
- **Per-protocol analysis** (n=428): virtually identical results (Δ=0.18, p<.001).
- **Subgroup by disease:** No significant interaction (p=0.34); effect of LM was largest for asthma (Δ=0.22) and smallest for hypertension (Δ=0.16).
- **Subgroup by baseline adherence:** Among low-baseline (<60%), LM improved adherence from 0.52 to 0.87 (Δ=0.35); among high-baseline (>80%), from 0.86 to 0.94 (Δ=0.08).
- **Conservative unnecessary urgency (including "Unsure" as unnecessary):** 30.0% (95% CI 27.7–32.4%).

4. Discussion

4.1 Summary of key results

The first empirical investigation into late delivery of medicines produced four key results:

1. Adherence gain: Late (≤3 hours) delivery resulted in an 92% adherence rate, which was considerably greater than the rate for next-day (81%) and normal (73%) delivery – a difference of 19% points.

2. Anxiety gain: The effect size of LM delivery on anxiety is very large (d = 1.63), accounting for 41% of the effect on purchase intention.

3. Unnecessary urgency: Clinically unnecessary orders represented 22% of late deliveries; 30% when "unsure" orders included, too. Repeated exposure to unnecessary urgency increased.

4. Stockout reduction: The frequency of stockouts decreased by 62% due to LM delivery.4.2 Mechanisms and clinical significance

Adherence improvement (H1) is one of the largest observed in any pharmacy intervention. Meta-analyses of adherence interventions usually report adherence improvements of 4% to 15% [13]. A 19% increase in adherence to anti-hypertensive medications would result in a 28% reduction in serious cardiovascular events in terms of proportional risk calculations [14].

In terms of mediation (H3), the importance of affect in the mechanism by which rapid delivery works is demonstrated. It is not simply the presence of the medication but also the effect of rapid delivery on reducing the anxiety of having the medication run out. It is analogous to the "security blanket" concept in health psychology [15]. For platforms, it means that logistic measures such as delivery times do not measure fully the value proposition – psychological reassurance is a key driver of loyalty.

4.3 Problem of unnecessary urgency

The 22-30% unnecessary urgency rate is a red flag. While this represents wastage, it can affect consumer behavior negatively. Consumers who always seek fast delivery might develop the inability to plan ahead, an effect termed deskilling [16]. Furthermore, urgent delivery causes increased carbon emissions, considering that last-mile logistics contribute 30% of the carbon emissions in e-commerce [17]. One-fifth of the unnecessary LM orders translates to significant costs both economically and environmentally.

Curiously, unnecessary urgency was linked to younger consumers and multiple exposures to LM deliveries. This indicates the existence of a habit formation process. Consumers become desensitized to necessity after multiple exposures to urgent deliveries. "Necessity check" interventions must be directed towards such customers.

4.4 Comparison with the existing literature

This paper has made advancements in the field of e-pharmacy research through the following points:

- Nair & Antony [18] concluded an association between usage of e-pharmacy and medication adherence, but not causation; we used the randomized controlled trial approach to validate causation.
- A study by Ding [19] argued that the fast delivery time decreases "refill friction," but did not investigate anxiety. Our findings demonstrate that anxiety explains 41% of the impact of loyalty.
- As far as we know, there are no previous studies on quantifying the unnecessary urgency for prescription drugs. However, the rate of 22% is comparable to overuse rates in tele-medicine.

4.5 Policy and practice implications

For e-pharmacy platforms:

- **Implement clinical triage:** Before offering LM delivery, ask "Do you have less than 2 days of medication left?" If yes, offer LM free; if no, offer LM with a fee or recommend next-day. This could reduce unnecessary orders by an estimated 60% based on our data.
- **Nudge toward slower delivery:** Default to standard, require active selection of LM.
- **Anxiety-sensitive design:** For patients with high baseline anxiety (GAD-2 ≥4), offer reassurance messages ("You have 5 days left, no need for LM") but retain LM as an option.

For regulators (e.g., FDA, DCGI, EMA):

- Consider mandating **necessity disclosure** before urgent delivery.
- Require platforms to report unnecessary urgency rates annually.
- Explore differential pricing or insurance coverage: cover LM only for verified low-supply states.

For clinicians:

- When prescribing, discuss refill planning. For anxious patients, prescribe a 90-day supply with automatic refills to reduce reliance on LM delivery.
- Educate patients that "just-in-time" delivery is not always clinically better.

4.6 Limitations

Several limitations warrant caution:

1. **Generalizability:** Urban Indian sample with good smartphone access. Results may differ in rural areas, older populations, or countries with different logistics infrastructure.
2. **Short duration:** 12 weeks may not capture long-term habituation or burnout. Extended trials (≥6 months) are needed.
3. **Unnecessary urgency measurement:** Single-item post-hoc question subject to recall and social desirability bias. However, anonymity was assured and responses varied plausibly.
4. **No health outcomes:** Adherence is a process measure, not a final clinical outcome (e.g., BP, HbA1c). We assume but did not measure the link to hard endpoints.
5. **Simulated platform:** Although real medicines were delivered, the study environment might have increased vigilance (Hawthorne effect). However, this would affect all groups equally.
6. **Partial randomization:** 40% patient-chosen orders may introduce confounding. We repeated analyses on randomized orders only and found identical patterns (results available in supplement).

4.7 Future research agenda

- **Longitudinal RCT** with 6–12-month follow-up and clinical outcomes (BP, HbA1c, asthma exacerbations).
- **Cost-effectiveness analysis** comparing LM, next-day, and standard delivery from health system and societal perspectives (including environmental costs).
- **Behavioral intervention trial:** Test whether a "necessity check" pop-up reduces unnecessary urgency without harming adherence.
- **Cross-cultural replication** in high-income (US, Germany) and low-income (Kenya, Bangladesh) settings.
- **Qualitative study** exploring why patients order LM unnecessarily – fear, convenience, habit, or distrust of slower delivery.

5. Conclusion

Last-minute delivery of prescription medicines via e-commerce platforms significantly improves medication adherence and reduces anxiety, with anxiety reduction explaining 41% of the effect on customer loyalty. However, approximately one in five rapid orders is clinically unnecessary, indicating overuse driven by habituation rather than need. The pharma e-commerce industry should move away from uniform rapid delivery toward **clinically triaged speed** – offering last-minute delivery only when medically justified, while preserving its powerful anxiety-reducing benefits for true emergencies. Policy makers should consider mandating necessity checks and monitoring unnecessary urgency rates. For chronic disease patients, rapid delivery is a valuable tool, but like any tool, it requires appropriate use.

6. References

1. Grand View Research. (2025). *E-Pharmacy Market Size Report 2025-2030*. GVR-4-68039-221-5.
2. O'Donoghue, T., & Rabin, M. (1999). Doing it now or later. *American Economic Review*, 89(1), 103-124.
3. Bosworth, H. B., et al. (2011). Medication adherence: a call for action. *American Heart Journal*, 162(3), 412-424.
4. Iuga, A. O., & McGuire, M. J. (2014). Adherence and health care costs. *Risk Management and Healthcare Policy*, 7, 35-44.
5. DiMatteo, M. R. (2004). Variations in patients' adherence to medical recommendations. *Medical Care*, 42(3), 200-209.
6. Briesacher, B. A., et al. (2020). Running out of medications: prevalence and predictors. *Medical Care*, 58(3), 211-217.
7. Horne, R., et al. (2013). Understanding patients' adherence-related beliefs. *Health Psychology*, 32(5), 508-517.
8. Smith, M. Y., et al. (2021). "I feel safer knowing it can come fast": qualitative insights on rapid delivery. *Patient Preference and Adherence*, 15, 891-902.
9. Lu, Y., et al. (2018). Induced demand in e-commerce. *Management Science*, 64(7), 3011-3030.
10. PharmEasy internal data (2024, unpublished). Percentage of urgent orders for OTC supplements.
11. Zeithaml, V. A., et al. (1996). The behavioral consequences of service quality. *Journal of Marketing*, 60(2), 31-46.
12. Rothman, K. J. (1990). No adjustments are needed for multiple comparisons. *Epidemiology*, 1(1), 43-46.
13. Conn, V. S., et al. (2015). Interventions to improve medication adherence. *Patient Education and Counseling*, 98(12), 1469-1481.

14. Simpson, S. H., et al. (2006). Adherence and cardiovascular outcomes. *Circulation*, 114(9), 924-929.
15. Lacey, J., et al. (2019). The security blanket hypothesis in chronic illness. *Journal of Health Psychology*, 24(6), 789-798.
16. Illich, I. (1974). *Medical nemesis*. Calder & Boyars.
17. Weber, C. L., et al. (2021). Last-mile emissions in e-commerce. *Environmental Science & Technology*, 55(12), 7980-7989.
18. Nair, S., & Antony, J. (2021). E-pharmacy and adherence in chronic disease. *International Journal of Medical Informatics*, 149, 104412.
19. Ding, B. (2022). Last-mile delivery in pharma e-commerce. *Journal of Pharmaceutical Innovation*, 17, 112-124.
20. Mehrotra, A., et al. (2020). Unnecessary telemedicine visits. *JAMA Internal Medicine*, 180(7), 978-985.