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THE MARKET FOR HIGH-QUALITY MEDICINE

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ABSTRACT

This study examines the effect of chain store entry on drug quality and prices in the retail pharmacy market in Hyderabad, India. In contrast to prevailing mom-and-pop pharmacies, chains exploit scale economies to offer high-quality drugs at lower cost. With a unique data set and a natural experiment methodology, we show that chain entry leads to a relative 5 percent improvement in drug quality and a 2 percent decrease in prices at incumbent retailers. These changes do not depend on the socioeconomic status of consumers, suggesting that chain entry improves consumer welfare throughout the market. Despite the likely role of asymmetric information in this market, we show that consumers partially infer these quality improvements. Our findings suggest that in markets with asymmetric information, organizational technologies such as chains may play an important role translating greater demand into higher quality.

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1 Introduction

Substandard medicine is a serious public health concern in many developing countries (Bate and Boateng 2007, Gaurdiano et al. 2007). Counterfeiters produce and sell fake drugs that appear legitimate (Dondorp et al. 2004). In addition, so-called local manufacturers produce small drug batches with little regulatory oversight (Corporate Catalyst India 2012). The public health impact of substandard medicine is potentially severe, since these drugs deny patients effective therapies, expose people to toxic impurities, and contribute to pathogenic resistance (Cockburn et al. 2005). Access to effective medicine also has important direct effects and spillovers on human capital accumulation, labor supply, earnings, and other economic outcomes (Miguel and Kremer 2004, Baird et al. 2012).

Although economic growth in developing countries has increased consumer wealth and the demand for medicine, the effect of these changes on drug quality is ambiguous. Wealthier consumers may demand better drugs if quality is a normal good. With larger markets, firms can also exploit economies of scale by making fixed investments that enhance quality (Berry and Waldfogel 2010).[1] Growth may allow countries to strengthen legal institutions and enforce tort laws, which can foster higher product quality (Spence 1977, Landes and Posner 1987). On the other hand, increases in demand may enhance the market power of firms in markets with capacity constraints (Tirole 1988, Section 5.3), encouraging firms to raise prices or reduce quality. Asymmetric information about drug quality may disincentivize investments in quality, and can reinforce the incentive for suppliers with market power to reduce quality as demand rises (Dranove and Satterthwaite 1992). Because of these considerations, it is unclear whether economic growth and market development lead to higher quality, particularly in developing countries with weak regulatory and legal institutions.

Retail chains may play an important role translating economic growth into higher quality medicine. Recent economic growth has spurred the entry of pharmacy chains in India,

[1] Manufacturers can improve quality by strengthening quality control protocols. Distributors and retailers can develop distribution channels that prevent entry by counterfeiters and protect drugs from quality degradation due to extreme heat and humidity.

where small mom-and-pop stores have traditionally dominated pharmacy markets. Unlike incumbents, chains are able to exploit scale economies by investing in cost-saving and quality-enhancing technologies. By creating their own supply chains, chains can buy directly from manufacturers while standardizing quality control in distribution. Chains can also exploit scale economies in advertising to signal quality to consumers as a way to help overcome information asymmetries (Milgrom and Roberts 1986). These attributes may allow chains to offer high quality medicine despite weak regulation and asymmetric information about drug quality. Although chains may offer higher-quality drugs, the market-wide impact of chain entry depends on the response of incumbent mom-and-pop pharmacies. Chain entry may improve quality among incumbents through retail competition or other mechanisms. Alternatively it may encourage vertical differentiation in which incumbents specialize in cheap, low-quality drugs (Shaked and Sutton 1982), potentially lowering average quality or increasing health disparities.

This study explores the relationship between market development and drug quality by evaluating the impact of chain entry. In 2010, we collaborated with a chain pharmacy, MedPlus, to study the firm's expansion in Hyderabad, India. The chain identified 18 markets it wished to enter. We gathered baseline data in 18 candidate entry markets, as well as two other markets, for a total of 20 markets. Retail space subsequently opened in 7 of the candidate markets, creating a natural experiment to identify the impacts of chain entry on the quality and prices sold at incumbents. We resurveyed in all of these markets one year after the firm opened the new stores. Our data feature a "mystery shopper" audit of pharmacies, in which auditors purchased two antibiotics, ciprofloxacin and amoxicillin, under realistic conditions. We chose these drugs because of their wide use and their public health importance for the treatment of bacterial respiratory and gastrointestinal infections. We then assessed the quality of the drug samples in a laboratory. We interviewed over 5200 consumers in sample markets, distinguishing between people who had and had not just shopped at sample pharmacies. We also interviewed pharmacists and enumerated the

customer traffic at each pharmacy.

The validity of our natural experiment methodology and difference-in-differences identification strategy relies on the assumption that treatment and control markets have similar counterfactual trends in price, quality, and firm performance. We validate this identification strategy by showing that treatment and control markets initially have nearly identical baseline levels of quality, prices, customer traffic, and socioeconomic characteristics. We show that consumers in treatment and control markets do not exhibit different socioeconomic trends between the baseline and either the year-one or year-two follow-up survey rounds. Pharmacy census data show that growth in the number of pharmacies over the study period is similar for treatment and control markets, which suggests that chain entry is uncorrelated with the demand for medicine. These patterns support the claim that control markets provide a plausible counterfactual for treatment markets, and that the "assignment" of suitable retail space among the candidate entry markets is plausibly exogenous.

Chain entry causes incumbents to improve quality and lower prices. Compliance with the Indian Pharmacopeia quality standard improves by 5 percent and prices fall by 2 percent in treatment markets relative to control markets. Among non-national drug brands, over which pharmacies have more price and quality flexibility, pharmacopeia compliance rises by 21 percent and prices fall by 12 percent. We assess the market-wide impact of chain entry by incorporating observations from the chain and interacting chain entry with consumer socioeconomic status. We find no effect for this interaction, implying that chain entry improves consumer welfare regardless of socioeconomic status.

Our results appear to arise primarily through the retail competition, rather than other channels. By reducing local monopoly power, the presence of the chain increases the quality elasticity of demand and induces incumbents to improve quality. In principle, the chain, which buys directly from manufacturers, could affect prices or the product mix in the wholesale market. However the wholesale market spans the entire city, and it is unlikely that chain entry in seven locations would have a large aggregate impact through supply-chain

externalities.[2] Chain entry also appears to increase the share of consumers who report that quality as an important drug attribute, which could also encourage higher quality. The demand increase from this channel alone should *increase* prices. Our finding that prices decline suggests that competition is the dominant effect. The retail competition channel requires that consumers at least partially infer the quality adjustments of firms. We directly analyze these perceptions by regressing perceived quality on chain entry. Although quality is imperfectly observable, customers do infer the incumbent quality changes associated with chain entry to some extent.

Our findings are related to Basker and Noel (2009), Basker (2005) and Jia (2008), who show that chain competition has a large effect on prices in the US, and Matsa (2011) who shows effects of chain entry on quality. We extend this work by studying a context where information asymmetries may contribute to poor quality. By exploiting economies of scale, the chain improves quality and lowers prices, both directly and through retail competition. Incumbents in entry markets are able to achieve the same quality as the chain but at significantly higher prices, which may reflect the lower productivity of these firms. Our findings are also related to Bate et al. (2011) and Bjorkman-Nyqvist et al. (2012) who show that information asymmetries contribute to poor drug quality in developing countries. Bjorkman-Nyqvist et al. (2012) find that an NGO offering subsidized authentic drugs can reduce incumbent sales of counterfeits. Our study builds upon this work by utilizing natural variation due to the expansion of a chain to measure the impact of competition on quality. We show that markets can overcome asymmetric information to improve quality in the absence of strong regulation and external subsidies by adopting more productive organizational technologies.

We proceed in Section 2 to provide a theoretical motivation for our empirical approach and findings. Section 3 describes the context and the data collection. Section 4 explains and justifies our empirical strategy. In Section 5 we present and interpret our empirical results.

[2] A sufficiently large chain expansion could make it more difficult for low-quality manufacturers and wholesalers to exploit scale economies. While this intriguing mechanism may also play a role in quality improvements as markets develop over longer periods, it is beyond the scope of our study.

Section 6 concludes by discussing the policy implications of our findings. An appendix describes several other robustness tests and secondary results.

2 Theoretical Motivation

Our analysis focuses on small independent pharmacies, which compete in local neighborhood markets. Firms compete through price, drug quality, convenience, and other amenities. Pharmacies have some market power because they are differentiated spatially. Consumers must search to gather price and quality information from other pharmacies (Salop 1977, Salop and Stiglitz 1977). We consider the impact of entry by a chain in this setting.[3] Chains may exploit their scale to invest in cost-reducing and quality-enhancing technologies. For present purposes, we assume simply that the chain is able to produce quality at lower cost than incumbents. In principle, entry by chains and non-chains has similar competitive effects. The key distinction between these firms is that chains are more productive, and so have greater ability to lower prices and improve quality.

In general, the effect of competition on product quality is theoretically ambiguous. Firms with market power may exploit their position to lower quality, just as they may raise prices, and earn positive long-run profits. In the canonical model, competition attenuates market power, causing firms to increase quality, decrease prices, or both. This decision depends loosely on the relative magnitudes of the price elasticity and the quality elasticity of demand (Dorfman and Steiner 1954). Firms are likely to compete through quality if quality improvements translate directly into greater demand. In a setting with fixed prices (e.g. through regulation), the price elasticity of demand is zero and competition unambiguously improves quality (Dranove and Satterthwaite 2000). Competition from a high-quality entrant may also reduce incumbent quality if firms respond by differentiating vertically. In the classic model with heterogeneous consumers, firms locate along a quality continuum and serve cus-

[3]Economic development may encourage the entry of chains by creating enough demand so that firms can exploit economies of scale. By comparing treatment and control markets with similar trends, our empirical strategy treats this process as exogenous.

tomers who prefer quality in the nearby range (Hotelling 1929, Shaked and Sutton 1982). Chain entry increases competition in the high-quality market segment, creating an incentive for incumbents to reduce quality and avoid direct competition. If consumers have heterogeneous quality preferences, competition may also affect quality by changing the identity of the marginal consumer (Spence 1975). In Spence's framework, the firm's marginal revenue from quality is a function of the marginal consumer's willingness to pay for quality. A quantity expansion (e.g. through competition) changes the identity of the marginal consumer, which alters firms equilibrium choices of quality. The sign of this response is ambiguous, and depends upon the specification of preference heterogeneity.

Asymmetric information about product quality may affect quality provision. In practice, quality is rarely perfectly observable or unobservable; instead consumers receive noisy but informative quality signals. Consumers may need to search for quality information (Salop and Stiglitz 1977) or may learn about quality by consuming so-called experience goods (Nelson 1970). People also receive quality signals from advertisements (Nelson 1974), public announcements, and conversations with peers (Allen 1984). Regardless of the learning mechanism, these models converge to the completely unobservable case as the quality signal becomes noisy.

The effect of competition on quality depends on how well consumers perceive quality. Within a search model, Dranove and Satterthwaite (1992) explore this relationship by varying the precision of price and quality signals. The incentive for firms to offer high quality strengthens as the quality signal becomes precise. With a weak quality signal, the effective quality elasticity of demand is low, and firms have weak incentives to improve quality in response to competition. An effect of competition on quality implies that consumers receive quality signals that are at least somewhat informative.

In addition to increasing retail competition, chain entry may affect incumbent quality by reducing the wholesale demand for high-quality medicine. The chain bypasses the wholesale market and purchases directly from manufacturers. This shock may reduce wholesale

prices, both overall and particularly for high-quality drugs, which could enable incumbents to improve quality. Finally, chain entry may affect incumbent quality by changing consumer demand. The chain might inform consumers about the distribution of drug quality or alter their preferences for high-quality medicine. Either mechanism shifts out the retail demand for medicine, which should increase the price. The chain may also alter the selection of customers who shop at incumbent pharmacies, which is a possibility we discuss further in the appendix.

3 Empirical Context, Data and Chain Entry

3.1 Context

India's pharmaceutical sector produces 13 percent of global pharmaceutical output (CCI 2012). The industry consists of around 250 large "national manufacturers" and around 8000 small "local manufacturers." Many national manufacturers work to comply with both domestic and international quality standards. India has 74 FDA-approved manufacturing plants, more than any country besides the United States. National manufacturers advertise heavily to establish brand reputation and enhance market power. In contrast, local manufacturers produce and disseminate small batches of common generic medicines, at times incentivizing local doctors and pharmacies to push their products. Regulators struggle to provide effective oversight for the large number of local manufacturers. To accommodate demand for a wide variety of local brands, retailers commonly stock dozens of brands of popular generic compounds (Kamat and Nichter 1998).

Several factors contribute to heterogenous drug quality in India. To achieve consistent high quality, manufacturers must invest heavily in quality control equipment and protocols (Woodcock 2004, Yu 2008). Quality control investment is more challenging than procuring pharmaceutical components, which are cheap and available. With summertime temperatures that exceed 40 degrees Celsius, distributors and retailers must safeguard inventory from heat

and humidity. Corrupt wholesalers may mix counterfeit and authentic drugs. Counterfeits imitate the appearance of well-known brands but are not intended to be therapeutic. Because pharmaceutical components are inexpensive, counterfeiters may evade detection by including active ingredients in their products (Newton et al. 2008).[4]

Consumers have difficulty observing drug quality. During the sale, a consumer sees the brand, the condition of the packaging, and the manufacture and expiry dates. The consumer's change in health after taking the medicine provides another noisy signal.[5] While they may not know the quality of specific units of inventory, pharmacists are relatively informed about average quality because they maintain longstanding distributor relationships. A pharmacist can influence drug quality by requesting different inventory, changing distributors, or changing storage conditions.

Our audit focuses on ciprofloxacin and amoxicillin, two broad-spectrum antibiotics that are widely used to treat ear, urinary tract, respiratory, and digestive tract infections. Both drugs are sold in blister pack "strips" of 8-10 tablets. Patients often use these drugs incorrectly to treat viral infections. Consumers have difficulty gauging effectiveness because they often do not know whether an illness is bacterial. Ciprofloxacin and amoxicillin are suited to a mystery shopper audit because pharmacies stock many brands of these drugs and sell them frequently.

An examination of the quality-price gradient allows us to gauge the information asymmetry in this market. In a hedonic framework, the price reflects the marginal consumer's valuation of the product. Consumers should be unwilling to pay a premium for quality that they cannot observe. In an approach similar to Bate et al. (2011), Figure 1 shows the kernel density of price for high-quality and low-quality drugs in our data (described below). High-quality medicine is more expensive on average, which suggests that consumers

[4]A literature in public health shows that counterfeits are pervasive in developing countries (Cockburn et al. 2005, Dondorp et al. 2004, Sow et al. 2002, Taylor et al. 2001).

[5]Without observing a counterfactual, the consumer cannot isolate the drug's contribution to her change in health. The consumer's health may improve through a placebo effect or may fail to improve because the drug is not the correct therapy.

receive some quality information. The heavy overlap in these distributions indicates that other factors influence price. In particular, the price distributions are bimodal because of the different pricing strategies of premium and discount brands. A density plot for residual prices (conditional on the manufacturer and other observable product features) shows even greater overlap between high-quality and low-quality drugs. Figure 2 directly considers the availability of information through a scatterplot of actual and perceived market-wide quality. The gradient in this figure is positive and significant but the R^2 of the regression is 0.08, which suggests that consumers perceive quality in a noisy fashion.

The Drugs Control Administration (DCA) is the main pharmaceutical regulator in India. The agency oversees both manufacturers and retailers. The DCA has a reputation as an ineffective regulator because it has repeatedly failed to detect substandard medicine (Kashmir Times 2009). In one instance, the DCA conducted pharmacy audits but did not test the audit samples for 14 months, by which time many samples had expired (Mahesh 2010). The DCA seems to provide more thorough oversight of national manufacturers than local manufacturers. Despite these shortcomings, the agency appears to limit the flagrant counterfeiting that is reported in settings with even weaker governance (e.g. Gaurdiano et al. 2007).

Hyderabad, the fourth largest city in India and the capital of Andhra Pradesh. Small, independent "mom-and-pop" pharmacies predominate in Hyderabad and elsewhere in India. These firms offer most common drugs and rarely require a prescription. Shops are typically small, unenclosed storefronts without air conditioning. In our data, pharmacies occupy a median of 350 square feet of retail space. Pharmacies usually employ workers without formal training.

Pharmacy markets are hyperlocal, with customers shopping a median of 0.5 kilometers from their homes in our data. Markets in our study contain a median of 24 pharmacies per square kilometer. Pharmacies advertise through prominent storefront signage. Each manufacturer determines a "maximum retail price", which appears on the packaging. The wholesale price is tied to the MRP, which restricts the retailer's ability to offer a discount

without losing money. However the MRP varies widely across brands (a 10-tablet strip in our data ranges from US$0.46 to $2.00), so pharmacists can lower the price by substituting a cheaper brand.

Conventionally pharmacies obtain inventory from a multilayered wholesale market. Retail pharmacies buy from wholesalers, who buy from regional "super-stockists", who buy from "carry and forward" agents, who in turn buy from manufacturers. Pharmacies in our sample purchase from a median of eight wholesalers. With many agents in the supply chain, careless or corrupt wholesalers can undermine quality with impunity. The complexity of the supply chain also inflates wholesale and therefore retail prices. Hyderabad does not have a centralized wholesale marketplace. Instead wholesalers deliver inventory directly to shops.

Chain pharmacies have expanded rapidly through Indian cities in recent years. Chains have catered to relatively affluent customers by offering amenities such as air conditioning and more knowledgable staff. With over 250 local stores, MedPlus is the largest of three chains operating in Hyderabad during the study period. MedPlus was established in 2008 and grew rapidly in Hyderabad, Chennai, Bangalore, and elsewhere in southern India. The firm markets itself as an inexpensive, high-quality provider. It obtains discounts on inventory by purchasing in bulk directly from manufacturers and in turn offers consumers a 10 percent discount from the MRP of national-brand drugs. MedPlus also contracts with a handful of manufacturers to offer "own-brand" alternatives to the non-national brands found at incumbent pharmacies. Direct purchasing allows MedPlus to offer high-quality medicine by avoiding the quality issues associated with the wholesale market.

3.2 Data

This study relies on an original data set that measures the quality, price, and performance of retail pharmacies. We surveyed in 20 markets (described below) from May-July of 2010 ("Round 1"), one year later ("Round 2") and in a more limited fashion two years later ("Round 3"). The chain entered seven of the candidate markets between Rounds 1 and 2. In

the Empirical Strategy section below, we validate the assumption that entry into candidate markets was plausibly exogenous. We began by conducting a census of pharmacies within 0.5 kilometers of the center of each market. Within each market, we enrolled the three nearest incumbent pharmacies to where the chain wished to enter, plus two others at random, for a total of 100 incumbent pharmacies. For each sample pharmacy, we conducted mystery shopper audits, drug quality testing, a pharmacy survey and a customer traffic enumeration. We also surveyed local consumers about recent drug purchases, drug quality perceptions, demographics, and health. In Round 3, we repeated all surveys except for the audit and pharmacy surveys. Drug quality and price data are therefore available in Rounds 1 and 2, but not Round 3. In Rounds 2 and 3, we also included the newly-opened chain pharmacies in the sample.

We audited each pharmacy four times per round in order to stratify by drug and auditor SES.[6] Auditors were careful to interact naturally with pharmacists. The auditor requested the compound (ciprofloxacin or amoxicillin) but allowed the pharmacist to choose the brand. This approach gave the pharmacist latitude to substitute between brands with different quality levels and profit margins. The laboratory required three strips (30 tablets) to conduct quality tests, so auditors revisited pharmacies and bought two more strips of the same brand several days later. Audit visits comprise a tiny fraction of total customer traffic over the sample period.

A laboratory in Delhi tested the drugs samples for compliance with Indian Pharmacopeia, the official drug quality standard in India. A sample of ciprofloxacin or amoxicillin complies with Indian Pharmacopeia standards by falling within the official thresholds for active ingredient concentration, dissolution, and uniformity of weight. We conducted tests for all three dimensions of quality. The active ingredient concentration of the samples must be within 90-110 percent of the labeled dosage. Dissolution indicates the percent of the sample's

[6]We validated the distinction between high-SES and low-SES mystery shoppers by asking consumer survey respondents to identify the SES of auditors from photographs. Respondents nearly always answered correctly.

active content that dissolves into a known medium within a predetermined time, and must exceed 80 percent for the sample to comply. To measure uniformity of weight, the analyst weighs 30 individual tablets. The uniformity parameter is a function of both the minimum and the maximum absolute deviation in weight within the sample, and must be less than 5 for amoxicillin and less than 7.5 for ciprofloxacin. Figure 3 shows the sample distributions of these quality components. Drusano (2004) describes how these quality dimensions map into patient health. Patients respond to antibiotics in heterogenous ways. Small quality deficiencies may have important health impacts for patients who already respond poorly to antibiotic treatment.

Overall, over 96 percent of the audit samples comply with Indian Pharmacopeia. Among non-national drugs, only 93 percent comply with the quality standard. This rate is similar for both antibiotics, and is in line with the reported national compliance rate of 91 percent in 2003 (Sheth et al. 2007). Among substandard samples, 69 percent fail the active ingredient requirement, 22 percent fail the uniformity requirement, and 58 percent fail the dissolution requirement. Figure 3 plots the densities of these components. Quality is optimized at the intended active ingredient dosage, and increases monotonically in dissolution and decreases in uniformity of weight. The positive and negative dispersion in active ingredient concentration around 100 percent reinforces that quality control is an important quality determinant. Limited data indicate that pharmacopeia compliance is much higher in developed countries (Trefi et al. 2007).[7]

Our analysis distinguishes between drugs from national and non-national manufacturers. Retailers have limited discretion over the quality and price of national brands. Customers are less willing to substitute away from brands with reputations for high quality. Consequently, many national-brand manufacturers exercise market power and set wholesale prices so that retailers have slim margins. In contrast, quality is more heterogeneous among local brands,

[7]Trefi and coauthors find that ciprofloxacin samples from Germany and New Zealand contain 99.3-99.7 percent of the correct active ingredient dosage ($n = 8$). Bate et al. (2012) audit the authenticity of online drug purchases shipped to the United States. With the exception of Viagra purchased from uncertified pharmacies, they find no counterfeit samples.

and retailers have more discretion over pricing and brand selection. A research assistant collaborated with laboratory officials to categorize each manufacturer as national, local, or other, based on information from manufacturer websites and direct knowledge of large firms. In our analysis, we combine "local" and "other" categories. Since pharmacists select the brand in our audit, the sample's status as national or non-national is endogenous. However a regression of national status on chain entry shows no effect ($\hat{\beta} = 0.004, \hat{\sigma} = 0.08, p = 0.96$).

Our consumer survey is a repeated cross-section that measures demographic characteristics, drug purchases, drug quality perceptions, and health. We enrolled half of the sample from among people who had just visited sample pharmacies ($n = 2602$) and half from among other adults who were present in the area ($n = 2632$). This approach allows us to measure the characteristics of both actual and potential pharmacy shoppers. To enumerate customer traffic, surveyors counted the number of customers entering each pharmacy from 6-7PM and from 7:30-8:30PM on randomly chosen days. We selected these windows because in pilot data the bulk of customer traffic occurs in the evening.

3.3 Chain Entry

In the spring of 2010, MedPlus executives assisted us by identifying 18 candidate markets it wished to enter. At the time, MedPlus operated over 250 stores throughout the city and had nearly exhausted its local expansion opportunities. After the 2010 expansion, the firm shifted its focus toward growth in other cities. These 18 markets are middle-class. Because the firm had already entered the most affluent neighborhoods and had nearly exhausted entry possibilities in the city, candidate entry markets are more socioeconomically homogeneous than the city as a whole. Between Rounds 1 and 2, MedPlus entered 7 of the 18 candidate entry markets. We surveyed in all 18 markets with the expectation that suitable retail space would not become available in every candidate market, and that non-entry markets could serve as controls in this study. Our budget permitted data collection in two additional markets, which we selected for their similarity to the 18 candidate markets and the absence

of chain pharmacies. Compared to the 18 candidate markets, the two additional markets exhibit lower socioeconomic status. Our findings are robust to the exclusion of these two markets.[8] Among the 18 candidate markets, the availability of suitable retail space was the main factor determining entry. The firm was not always able to find available retail real estate in the desired location that was suitable in size and configuration for one of its stores. Figure 4 shows the locations of these markets within the city. Entry markets are an average of 3.4 kilometers farther from the city center than control markets. As we discuss in the appendix, results are not sensitive to limiting the sample to treatment and control markets that have similar proximities to the city center.

Table 1 compares the chain stores to incumbents in Round 2. We prefer to draw a comparison to incumbents in control markets, since chain entry may have influenced the characteristics of treatment incumbents. The table shows that prices are 6 percent lower ($p = 0.02$) and pharmacopeia compliance is 6 percentage points higher ($p = 0.46$) at the chain. All MedPlus stores are air conditioned, compared to just 12 percent of incumbents.

4 Empirical Strategy

4.1 Empirical Approach

In this section, we estimate the effect of chain entry on incumbent drug quality and prices using a difference-in-difference approach. In the following specification, s indexes the audit scenario, i indexes the pharmacy, m indexes the market, and t indexes the time period:

$$y_{simt} = \beta_1 Post_t + \beta_2 Post_t \times Entry_m + \Omega_{mt} + \alpha_m + \varepsilon_{simt} \quad (1)$$

$Post_t$ is an indicator for Round 2 and $Entry_m$ is an indicator for entry markets. Market fixed effects, α_m, control for baseline market heterogeneity. Some regressions include market

[8] Appendix Table 1 reproduces price and quality results for only the 18 candidate entry markets. Results are very similar to estimates that include the two additional markets.

demographic and health controls, Ω_{mt}.[9] We cluster standard errors by market, which may lead us to underestimate the standard errors with only twenty markets (Donald and Lang 2007). Therefore we also report the p-value for each coefficient of interest using Cameron, Gelbach and Miller's (2008) wild cluster bootstrap.

4.2 Identification

For our approach to identify treatment effects, unobserved time-varying determinants of quality and other outcomes must be uncorrelated with chain entry. Differential trends in the supply and demand of high-quality medicine in treatment and control markets could violate this assumption. We examine this assumption in several ways. The comparability of treatment and control markets was built into the chains market selection and expansion process. As we discuss above, chain executives directly report that they had plans to enter 18 candidate markets they considered middle-income neighborhoods. As the last few neighborhoods the chain considered entering in Hyderabad, the 18 candidate markets are relatively similar, and fall within a relatively narrow band of income. Furthermore, the chain executives report that eventual entry within the candidate markets was determined by the availability of suitable retail space, and not any forecast of market conditions subsequent to the initial selection of candidate markets. Our pharmacy and consumer survey data validate the identifying assumption that entry was not correlated with measures of demand for medicine, or trends in those measures. Our pharmacy census indicates that chain entry is not associated with the closure of an incumbent pharmacy, which could otherwise suggest a shift in demand toward high-quality medicine. Furthermore, non-chain entry occurred in a similar fashion in treatment and control markets, with an average of 1.14 entrants in treatment markets and 1.15 entrants in control markets between Rounds 1 and 2.

To assess the identifying assumption further, Table 2 compares baseline characteristics

[9]Regressions that use pharmacy fixed effects yield very similar estimates. Demographic controls include education, income, household size, caste, and vehicle ownership. Health controls include the prevalence of diarrhea, fever, cough and cold, and injuries. We use the non-shopper sample to calculate market $\times$ time averages for all variables.

of pharmacies and consumers in treatment and control markets. In Panel A, audit samples from treatment and control markets have nearly identical prices and quality. The price per tablet differs by US$0.001 ($p = 0.75$) and the rate of Indian Pharmacopeia compliance differs by 0.005 ($p = 0.92$). Samples have similar values for active ingredient concentration and dissolution. Uniformity is somewhat higher in entry markets but does not account for any Indian Pharmacopeia failures in Round 1. In Panel B, treatment and control pharmacies are comparable in terms of air conditioning, cleanliness, and customer traffic. Panel C reports consumer characteristics and focuses on the non-shopper sample. Log income, educational attainment, household size, and vehicle ownership are comparable for treatment and control consumers. Treatment consumers are more likely to belong to a scheduled caste or tribe. The baseline similarity of treatment and control markets is consistent with the comparability of candidate markets and the plausible exogeneity of entry.

Finally we test whether treatment and control markets exhibit differential changes in demographic characteristics, which may shift the demand for high-quality medicine. We may spuriously attribute the effect of a demand shock to chain entry if the chain selectively enters markets with rising demand for high-quality medicine. As one test of the identifying assumption, we examine whether chain entry is correlated with changes in observable demographic characteristics of non-shopping consumers. Table 3 reports the difference-in-differences for these variables. We do not find significant differences in exogenous demographic trends across treatment and control markets between Rounds 1 and 2. Trends in these key variables continue to be similar across markets through Round 3, nearly two years after entry into the treatment markets.[10] This pattern suggests that changes in the composition of pharmacy customers do not influence our estimates. Appendix Table 2 finds no correlation between chain entry and the composition of customers at incumbent pharmacies.

[10]We have not identified administrative data that would allow us to test for differential pre-trends. In principle, we could use the Indian census to calculate 10-year demographic changes from 2001 to 2011, which would encompass Rounds 1 and 2 of our survey. We have not pursued this approach because census geographic units align poorly with the markets in our data set and because 10-year differences do not seem informative for identification.

4.3 Trends by Treatment Status

Our estimates are identified through the differential change in price and quality in entry markets relative to control markets. Figure 5 shows this variation by plotting the trends in price and pharmacopeia compliance. After adjusting for inflation, the price of audited drugs in control markets is constant over time while the price declines by around 2 percent in entry markets.

The figure shows that quality falls by 5 percentage points in control markets but remains constant in entry markets. Marked climate changes from Round 1 to Round 2 may explain this pattern. Humidity and temperature are the most important environmental determinants of quality for antibiotics (Peace et al. 2012). According to weather data from NOAA, peak relative humidity during the data collection was 8.7 points higher ($p = 0.04$) for Round 2 than for Round 1.[11] The combination of high heat and humidity is particularly harmful to drugs (Kiron et al. 2011, Mubengayi et al. 2013). Using a temperature threshold of 30 degrees Celsius and a relative humidity threshold of 60 percent, the share of audit days with poor conditions rose from 54 percent in Round 1 to 97 percent in Round 2 ($p < 0.001$).[12]

[11] Weather readings are from the Hyderabad International Airport. We obtain similar results if we include the two weeks prior to the audit, when some drugs may have been in inventory.

[12] The combination of demand growth and incumbent capacity constraints may also contribute to this pattern. The limited availability of retail space creates a capacity constraint for firms, which may create market power by allowing firms to avoid price competition (Kreps and Scheinkman 1983). Increases in demand accentuate market power as long as capacity lags behind demand. Chain competition in treatment markets counteracts this incentive by reducing excess demand. Table 4 shows that customer traffic grew rapidly for control incumbents but did not change for treatment incumbents. Across markets, the correlation between the changes in customer traffic and pharmacopeia compliance is -0.16, which indicates that quality worsened in markets where demand rose. Customer waiting times, which are available through the mystery shopper audit, proxy for the presence of capacity constraints. We find that the quality change is small and insignificant for the first three quartiles, ranked by wait times. For pharmacies with the longest waiting times, quality falls by 11 percentage points.

5 Results

5.1 The Impact of Chain Entry

Chain entry has a dramatic effect on incumbents. Table 4 shows the effect of chain entry on log customer traffic and market exit. The table shows that shows that customer traffic increased by 25 percent over two years for control incumbents but stagnates for treatment incumbents. 96 percent of control incumbents who were present in Round 1 remain in Round 3, compared to 91 percent of treatment incumbents. Both of these results are statistically significant.[13]

Regression estimates for drug quality appear in Table 5. Columns 1 and 2 use the full sample of drug manufacturers. Column 1, which is the regression analog of the quality graph in Figure 5, shows that chain entry increases pharmacopeia compliance by 4.3 percentage points. This effect rises to 6.6 percentage points after controlling for demographic and health characteristics in Column 2. The rest of the table distinguishes between drugs from national and non-national manufacturers. In Columns 3 and 4, we find no effect of chain entry on the quality of national brands. In contrast, Columns 5-7 show a large and significant effect on the quality of non-national brands: pharmacopeia compliance rises by 20-24 percentage points relative to control markets. Effects are significant using either market-clustered standard errors or Cameron et al.'s (2008) wild cluster bootstrapped standard errors.

Pharmacies may change quality by substituting within or across manufacturers. Quality factors related to distribution and storage, such as counterfeits and climate control, contribute to within-manufacturer quality heterogeneity. Columns 6 and 7 quantify this decomposition by excluding and including manufacturer fixed effects. Controlling for manufacturer fixed effects in Column 7 attenuates the treatment effect estimate by 38 percent, which suggests that substitution within manufacturers is responsible for 62 percent of the

[13]The pharmacy census, which is the source for market exit results, encompasses all firms in the 20 sample markets. Results for quality, price, and customer traffic are based on a sample of 100 pharmacies. Only one of these pharmacies exits from Round 1 to Round 2. Our data do not indicate whether firms with high-quality or low-quality medicine differentially exit.

treatment effect for non-national drugs.

We analyze the impact of chain entry further by examining the impact the components of drug quality. Figures 6 and 7 show the change over time in the distributions of both active ingredient concentration and dissolution in treatment and control markets. A similar graph for uniformity (for which we find no effect) is available from the authors. In Figure 6, quality worsens in control markets because mass shifts from the 95-100 percent range to the 85-90 percent range. The distribution shifts leftward, particularly at the low end of the distribution, where there is an increase in the mass below 90 percent, the minimum for pharmacopeia compliance. In the lower panel, quality improves in entry markets because mass shifts from the 105-115 range to the 95-100 percent range, which reduces high-end failures. In Figure 7, the modal value for dissolution shifts to the right in both treatment and control markets. However, mass in the left tail (which is the source of pharmacopeia failures) is eliminated in treatment markets but expands in control markets.[14] We analyze these effects further further in the appendix.

As we describe in Section 3.2, a sample complies with Indian Pharmacopeia by exceeding predetermined thresholds for active ingredient concentration, dissolution, and uniformity of weight. Table 6 shows the impact of chain entry on these components for the full sample (Panel A) and the sample from non-national manufacturers (Panel B). Columns 1-3 report results for active ingredient concentration.[15] The quantity of active ingredient declines by 6.86 mg in control markets and by 3.33 mg in treatment markets, leading to a (statistically insignificant) treatment effect estimate of 3.53 mg in Column 1.[16] Because quality is non-monotone for active ingredient concentration, and is optimized at the labeled dosage, Column 2 reports the effect on the absolute percent deviation from the labeled dosage. This estimate

[14] All of these shifts are statistically significant. Kolmogorov-Smirnov p-values are 0.002 and 0.034 in the upper and lower panels of Figure 6 and are less than 0.001 for both panels of Figure 7.

[15] Figure 3 shows the frequency distributions for these quality components, pooling samples of ciprofloxacin and amoxicillin from all sample manufacturers.

[16] Column 1 excludes seven observations with a labeled dosage of 250 mg. Pharmacists provided these samples as substitutes for the 500 mg samples the auditors requested. Normalizing the dosage to 100 percent and including these observations does not affect the estimate.

is pronounced and statistically significant for non-national drugs. Column 3 shows that chain entry increases the probability of compliance with the active ingredient requirement by 4.2 percentage points overall and by 18 percentage points for non-national drugs.

The rest of the table shows the impact on dissolution and uniformity of weight. In Columns 4 and 5, chain entry improves dissolution because dissolution improves in treatment markets while it remains constant or declines slightly in control markets. These changes lead to significant effects on this aspect of pharmacopeia compliance. We find no effect of chain entry on uniformity of weight. Because low values indicate greater uniformity, Columns 6 and 7 show that average uniformity rises but pharmacopeia compliance declines in both treatment and control markets. A plot of the uniformity distribution before and after entry (available from the authors) resolves this discrepancy by showing that the uniformity distribution shifts leftward and also incorporates a larger right tail.

Table 7 shows the impact of chain entry on log price. As above, we examine the full sample and then distinguish between national and non-national drugs. Columns 1 and 2 show an insignificant 2-4 percent effect on price in the full sample. The effect on price for national drugs is also insignificant in Columns 3 and 4. However chain entry leads to a significant 12-15 percent price decline for non-national drugs. Columns 6 and 7 decompose this effect into inter-manufacturer and intra-manufacturer components. The coefficient is the same in both specifications, which suggests that firms reduce prices by offering discounts rather than substituting toward cheaper brands.

5.2 Robustness Tests

We investigate the robustness of our results by controlling for the interaction of $Post_t$ and baseline observable characteristics. If unobservable trends are correlated with these characteristics, these regressions will attenuate the treatment effect estimate. Table 8 reports these robustness tests for the quality and price of non-national drugs. Columns 1, 2, 5, and 6 control for the interaction of $Post_t$ and baseline market demographic or health character-

istics. Columns 3 and 7 control for the interaction with baseline pharmacy characteristics, including customer traffic, age, signage, and space allocated to medicine. The treatment effect on quality is statistically significant and varies from 0.14 to 0.22, compared to 0.20 as reported in Table 5. The treatment effect on log price is also significant (except for Column 7) and ranges from -0.10 to -0.20, compared to -0.11 in Table 7.

Our results may arise because of regression toward the mean if the chain enters markets where quality is unexpectedly low or price is unexpectedly high. We investigate this possibility by interacting $Post_t$ with the baseline value of the dependent variable (averaged by pharmacy) in Columns 4 and 8 of Table 8. These controls do not affect the magnitude or significance of our treatment effect estimates. We carry out several additional robustness tests in the appendix.

5.3 Consumer Perceptions

Next we examine the effect of chain entry on perceived quality. Quality competition is only profitable if consumers perceive quality adjustments and increase demand at firms that improve quality. The consumer survey elicits the respondent's perception of quality on a four-point Likert scale for "nearby pharmacies" and for "national brand" and "local brand" drugs. We focus on the subsample of non-shopping consumers because shoppers are a selected sample whose quality perceptions are more difficult to interpret. Results for shoppers, which are available from the authors, closely resemble the estimates below.

Table 9 reports the effect of chain entry on perceived quality. With three consumer survey rounds, we estimate separate effects for Rounds 2 and 3. Columns 1 and 2 show a positive and significant effect of chain entry on the perceived quality of nearby pharmacies. Standard errors are smaller and effects are more significant in Round 3 because the data from Round 2 have a higher intracluster correlation. Columns 3 and 4 show a generally insignificant effect on the perceived quality of national drugs. These findings are consistent with the small actual impact on quality for these drugs; however the large coefficient in

Column 4 suggests that consumers sometimes hold inaccurate perceptions. In contrast, Columns 5 and 6 show a large and significant effect for local drugs, which is consistent with actual increases in quality in entry markets over this period.[17]

5.4 Interpretation

Retail competition is the most plausible explanation for our results. Chain entry reduces the demand and increases the elasticity of demand for treatment incumbents. These effects are particularly clear for non-national drugs, over which firms have the greatest discretion. These effects appear to arise through *chain* competition. In addition to seven MedPlus stores, an average of 1.15 non-chain stores enter treatment markets and 1.14 non-chain stores enter control markets from Round 1 to Round 2, an insignificant difference. The key distinction between treatment and control markets is the entry of a chain store, which suggests that chain and non-chain pharmacies have distinct competitive effects. The chain's impact may be especially large because the chain competes aggressively through price and signals quality more effectively than mom-and-pop firms.

Alternatively, chain entry may affect incumbent quality via the wholesale market. By purchasing directly from manufacturers, the chain reduces the wholesale demand for medicine. However, our results are unlikely to arise through this channel because the wholesale market spans the city and is geographically diffuse. Any impact on wholesale demand is localized in treatment markets, which are a very small subset of all markets in the city. The seven new chain stores represent less than three percent of MedPlus stores, and less than 0.2 percent of pharmacies in the city

Chain entry may directly increase the demand for high-quality medicine by shifting consumer perceptions or quality preferences. In the consumer survey, respondents indicate whether drug quality, store convenience, and store familiarity are important considerations

[17]Firms may signal higher quality in either observable or unobservable ways. Appendix Table 3 shows mixed and statistically insignificant evidence of pharmacy and drug improvements in terms of several observable dimensions. We discuss quality signaling further in the appendix.

when purchasing medicine. We restrict the sample to non-shopping consumers; the responses of shoppers are more difficult to interpret because these respondents have elected to purchase medicine. Appendix Table 5 shows that chain entry increases the importance that consumers report placing on drug quality, which suggests that the chain increases the preference for high-quality medicine. Chain entry does not increase the perceived importance of other pharmacy characteristics. An increase in demand for high-quality medicine cannot, alone, explain our findings on its own because greater demand should increase prices. The price reductions in Table 7 suggest that competition over price and quality is the dominant channel.

5.5 The Market-wide and Distributional Impacts

Although incumbents respond to chain entry by lowering prices and improving quality, they remain at a competitive disadvantage to the chain. In Table 10, we restrict the sample to treatment markets after entry and regress pharmacopeia compliance and log price on an indicator for the chain. Columns 1 and 2 show that while quality is similar, the chain offers 6 percent lower prices than incumbents in entry markets ($p = 0.16$). Columns 3 and 4 focus only on brands that both the chain and incumbents carry. For these brands, drugs from the chain are 5 percentage points more likely to comply with the pharmacopeia standard and are priced 9 percent lower. These patterns suggest that the chain continues to benefit from its distinctive supply chain even after incumbents have responded to entry.

A welfare assessment of chain entry should incorporate both the presence of the chain and the incumbent response. We measure the market-wide impact of chain entry by including observations from the seven new chain outlets in Round 2. We also weight the regressions by customer traffic to account for heterogeneity in pharmacy size. Estimates of the market-wide impact of chain entry appear in Table 11. In Columns 1 and 2, chain entry increases pharmacopeia compliance by 5-7 percent, which is a slightly larger than our previous estimate. In Columns 5 and 6, chain entry reduces price by 5-6 percent, which is roughly double the previous result. Including observations from the chain strengthens the

price result because the chain consistently underprices incumbents.

We also examine whether the effect of chain entry depends upon the socioeconomic status of consumers. High-SES consumers may better perceive drug quality heterogeneity and more strongly prefer high-quality medicine. Similarly, low-SES consumers may be more price sensitive, leading to greater price competition for these customers. These consumer attributes could influence the optimal incumbent response to chain competition. Firms may cater to consumers of a particular socioeconomic status or may discriminate by treating high-SES and low-SES consumers differently.

The remainder of Table 11 explores possible heterogeneous treatment effects by consumer SES. In Columns 3 and 4, we compute the average education of each pharmacy's shoppers and distinguish between pharmacies that are above and below the median. Column 3 shows that quality rises differentially (but insignificantly) for pharmacies that serve high-SES customers. With a positive coefficient on $Post_t \times Entry_m$, chain entry also improves the quality of low-SES shops. Columns 4 and 8 exploit the audit stratification by mystery shopper SES to investigate possible SES-based discrimination. The regressions show small and insignificant interactions with auditor SES, which suggests that firms do not discriminate across customers within stores. Therefore, both high-SES and low-SES consumers appear to benefit from the competitive effects of chain entry.

6 Conclusion

We show that chain entry leads to higher quality and lower prices, both for incumbent pharmacies and for the overall retail market. This impact is the greatest for non-national brands, which have the most baseline quality heterogeneity, and over which pharmacies have the most quality and price discretion. The lack of clear socioeconomic heterogeneity in these effects suggests that chain entry has broad market-wide consumer benefits. The chain's ability to undercut incumbents in terms of price suggests that chains will continue to succeed in Indian pharmacy markets.

Our results are informative about the information asymmetry between pharmacies and consumers, and possible channels through which quality improvements can take place in light of information asymmetries and weak regulatory institutions. Consumers accurately infer quality changes associated with chain entry, which indicates that they do receive informative quality signals. In the appendix, we show mixed evidence of investment in quality signals and discuss how incumbents may communicate quality information to consumers in other ways.

Markets plagued by information asymmetries typically call for regulation. However implementing strong regulation is not usually feasible in developing countries. This study suggests that in settings with weak regulation, productivity-enhancing technologies such as chains may help overcome information asymmetries. The results also imply that policymakers may be able to encourage drug quality by facilitating pharmacy chains. While dynamic considerations are beyond the scope of this study, we note that by Round 2, incumbents are able to achieve the quality levels attained by the chain, but at higher cost. The productivity differences suggest that chains may replace mom-and-pop pharmacies as the dominant organizational model. In the short run, the implications for quality and price as incumbents exit are ambiguous. In the long run, this scenario is likely lead to competition among more productive chains, a pattern seen in more developed countries.

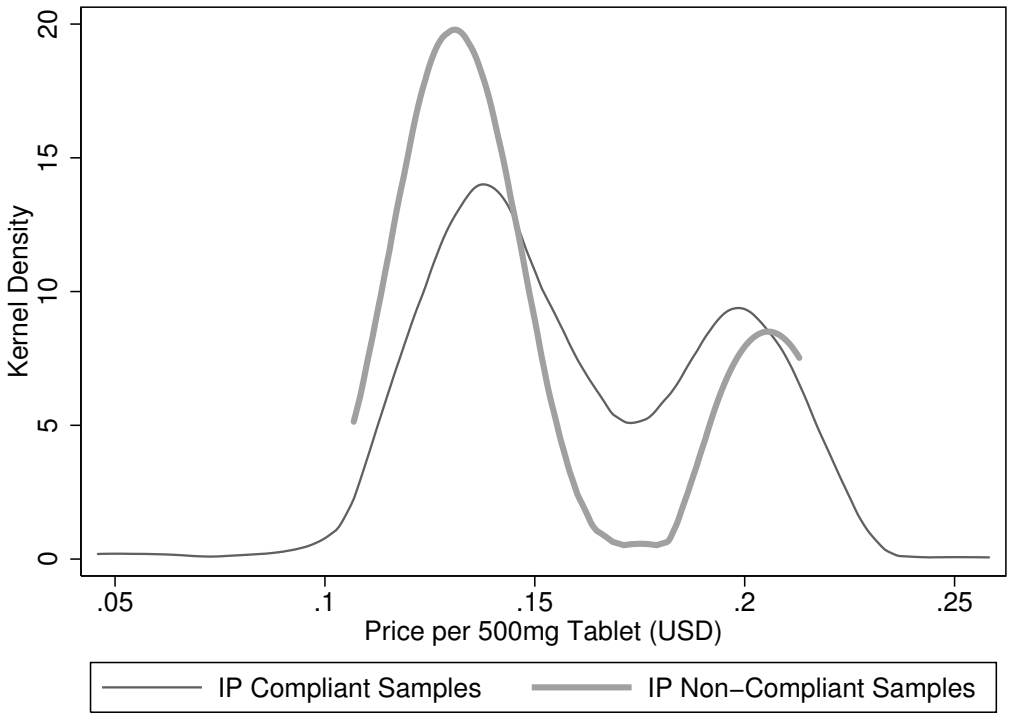


Figure 1: The Price Distribution for IP Compliant and Non-Compliant Samples

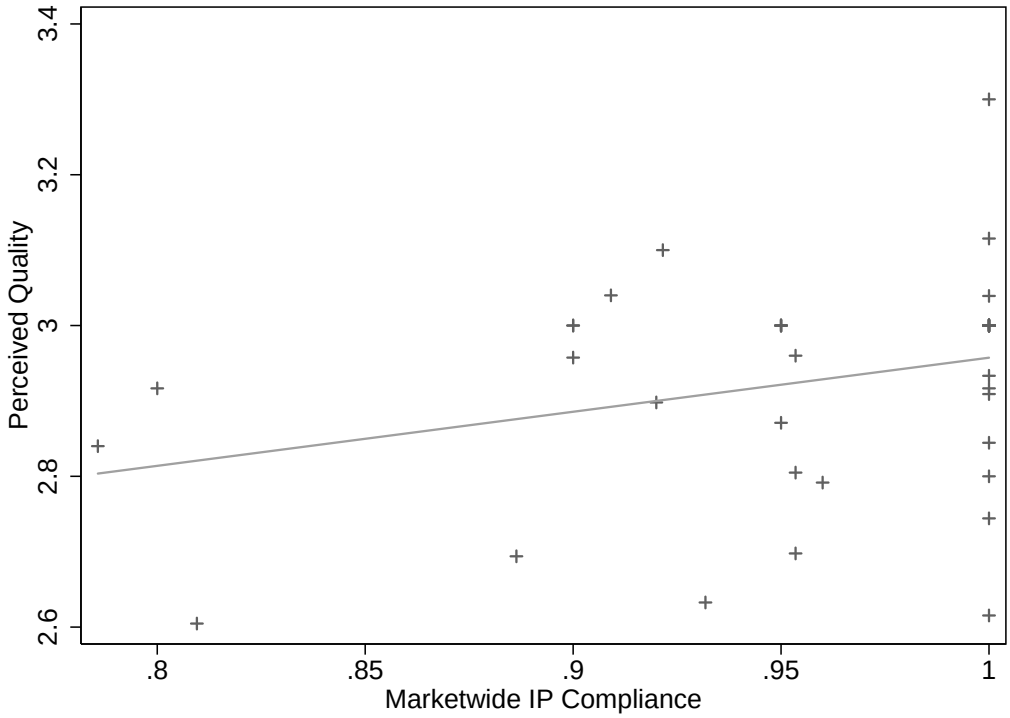


Figure 2: Actual and Perceived Quality by Market

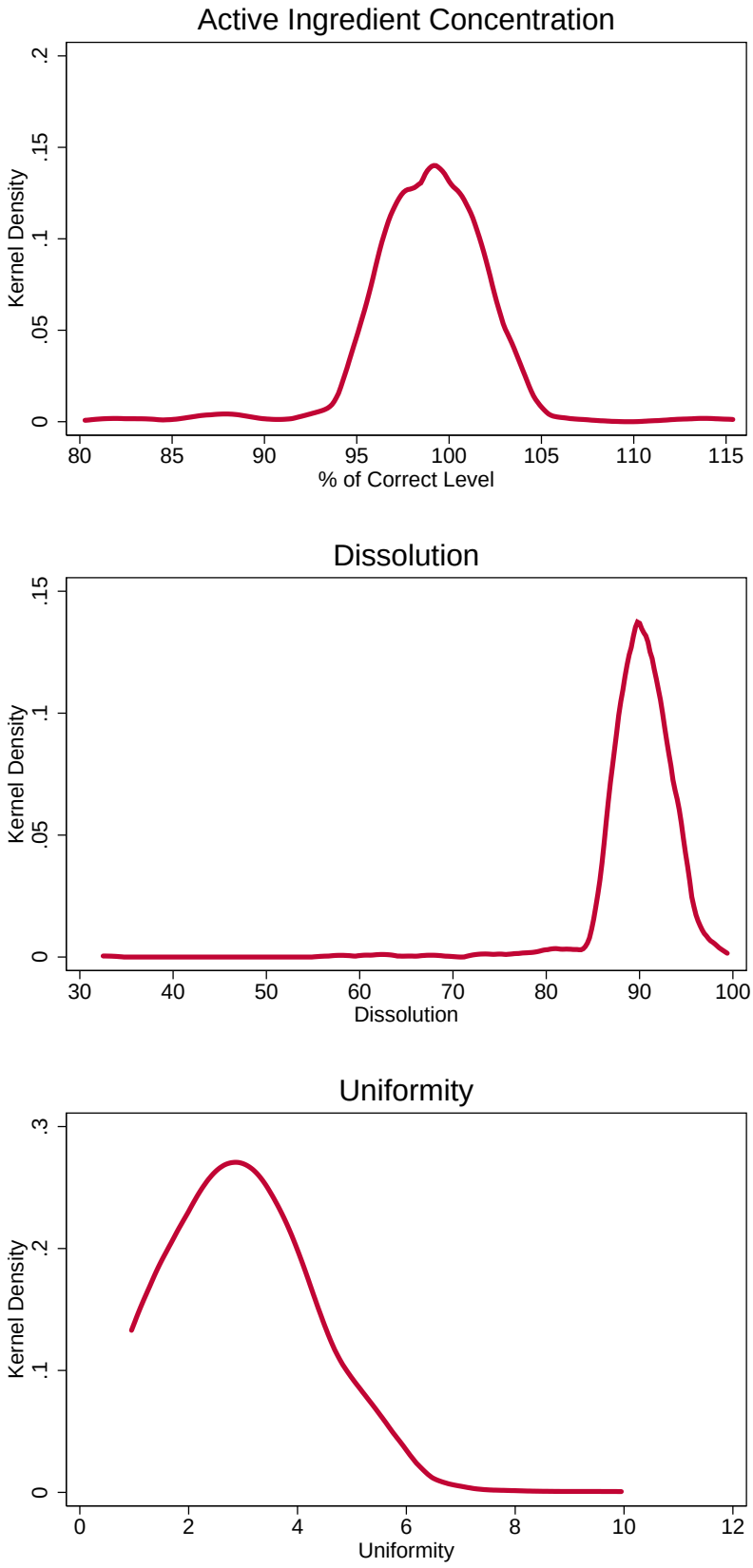


Figure 3: The Distribution of Quality Components

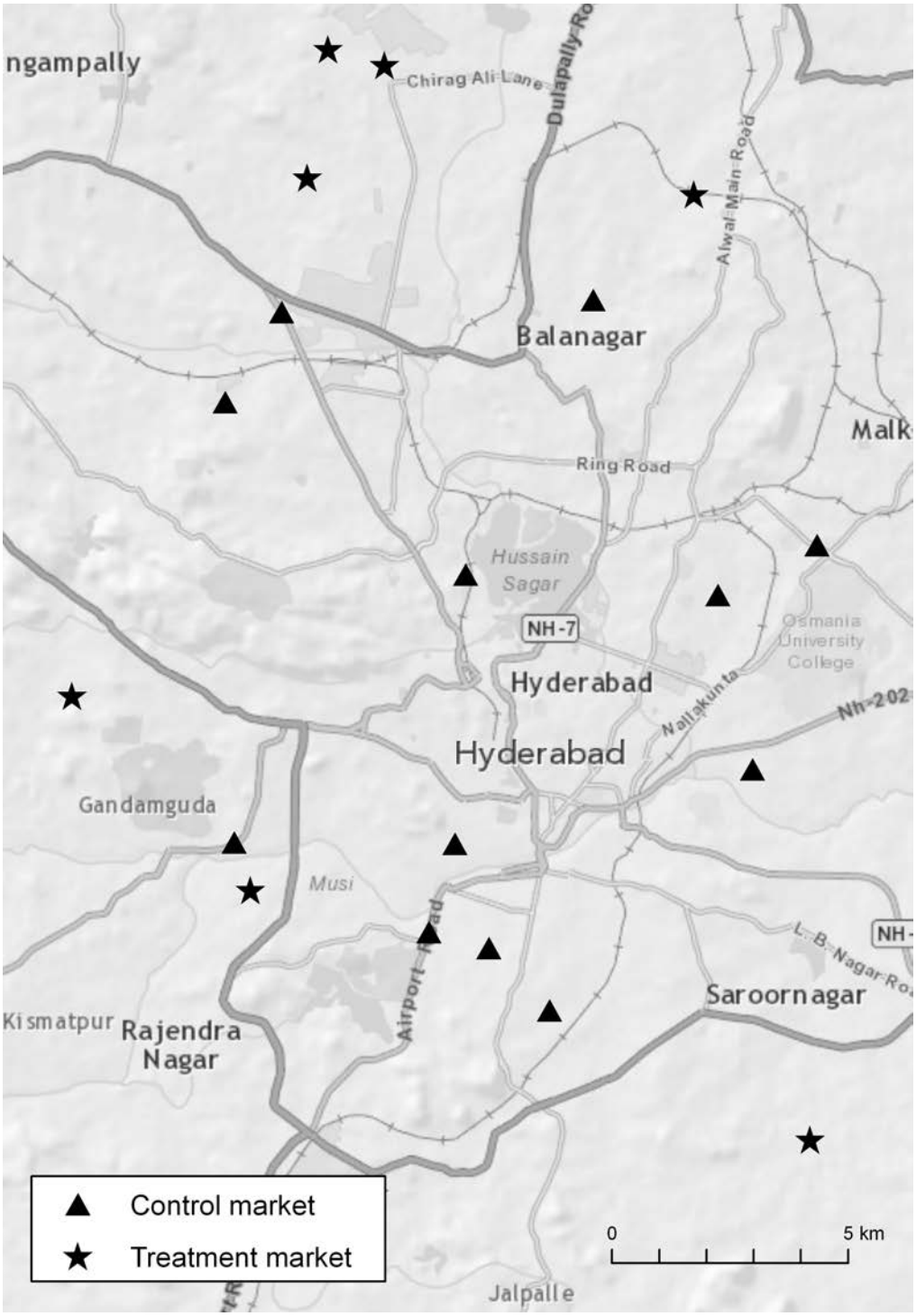


Figure 4: The Location of Sample Markets in Hyderabad

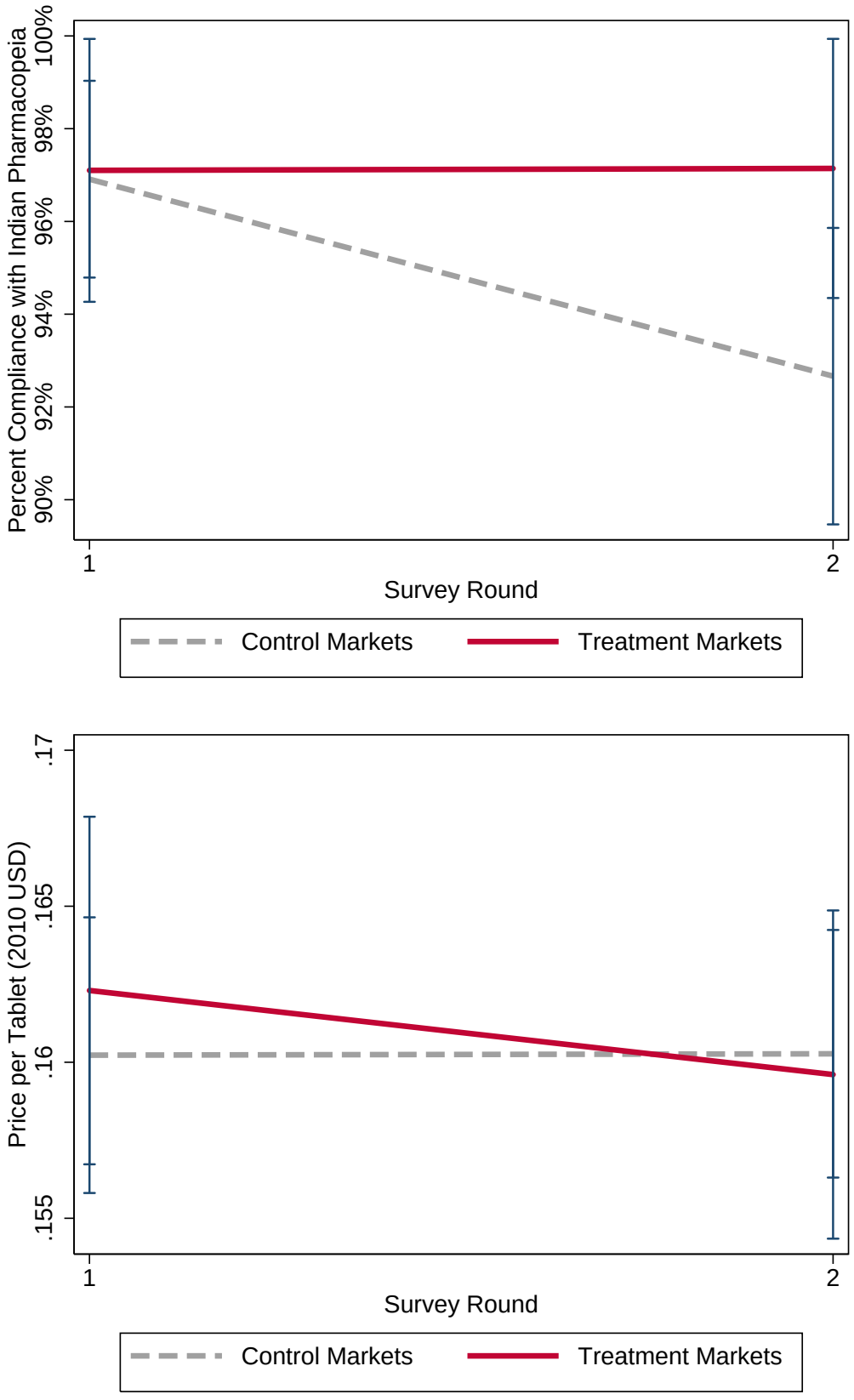


Figure 5: Quality and Price Changes

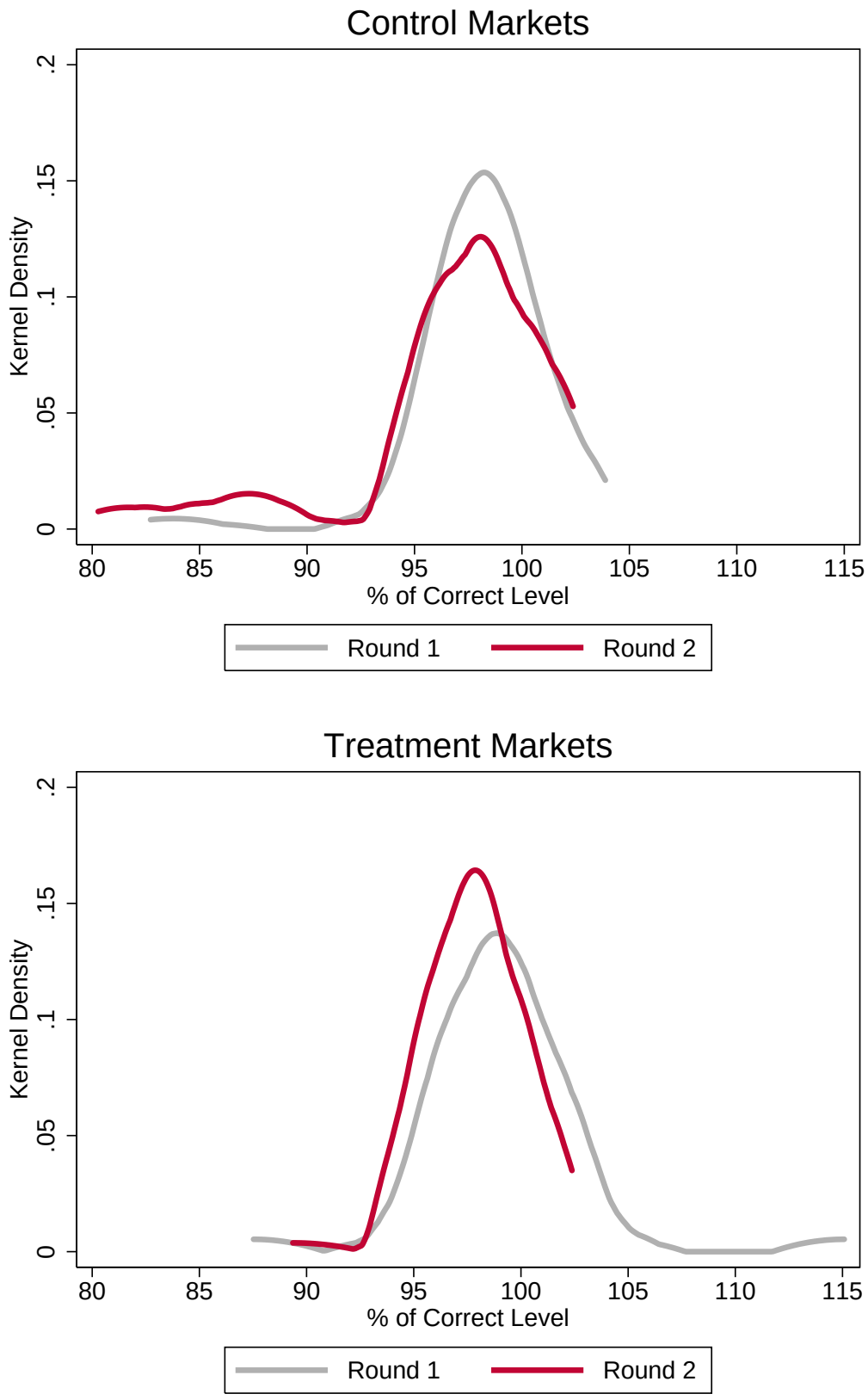


Figure 6: The Density of Active Ingredient Concentration for Non-National Drugs

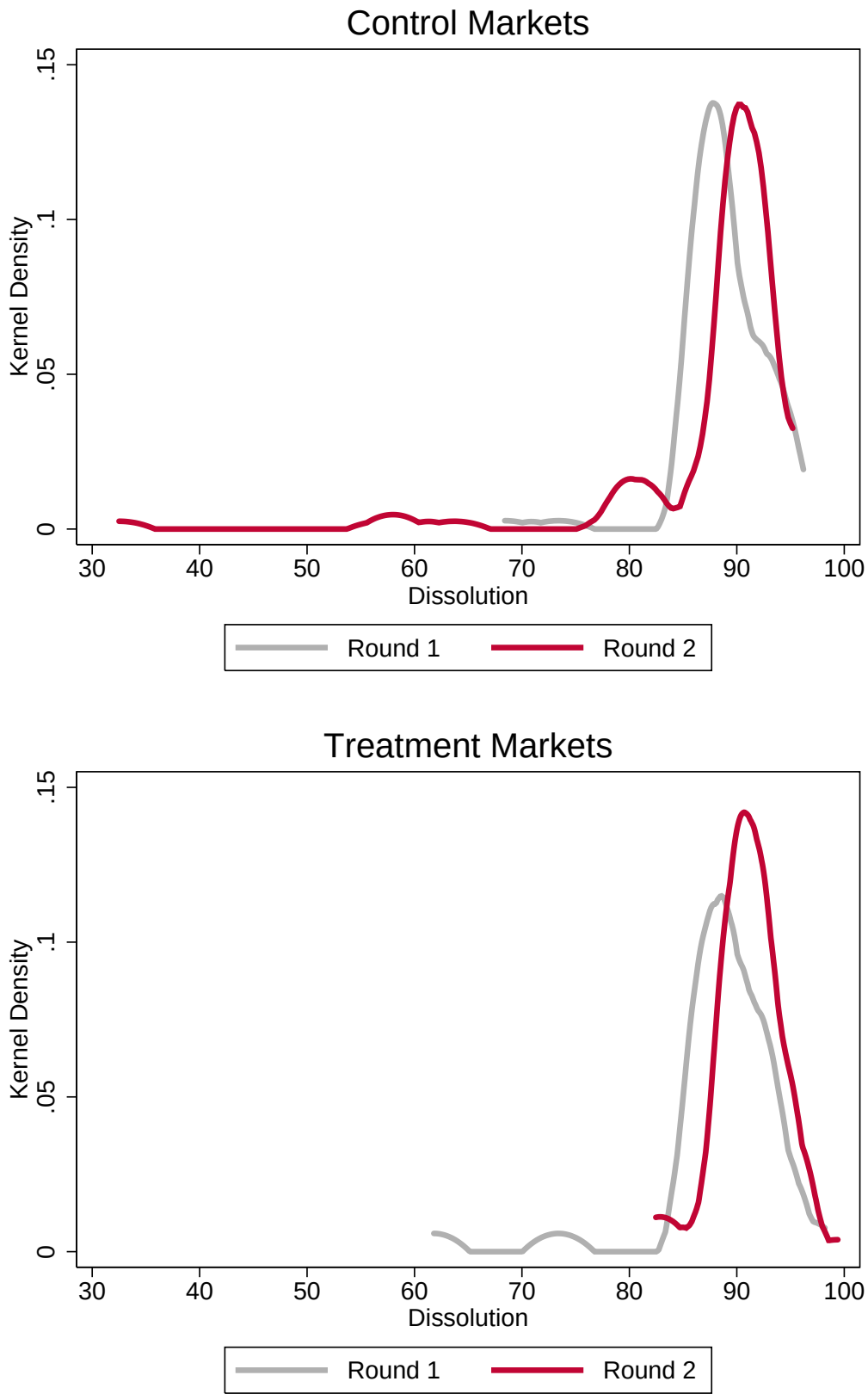


Figure 7: The Density of Dissolution for Non-National Drugs

Table 1: Characteristics of MedPlus and Control Incumbents After Entry

	MedPlus	Control Incumbents
	(1)	(2)
Panel A: Drug and Pharmacy Characteristics		
Price per 500mg Tablet (USD)	0.148	0.160*
Complies with Indian Pharmacopeia	0.964	0.927
Air conditioning	1.00	0.12***
Cleanliness (1-5)	4.9	4.0***
Panel B: Shopper Characteristics		
Log Monthly household income (USD)	5.36	5.36
Education (years)	11.7	11.8
Distance from home	1.53	1.66

Note: The table reports characteristics in Round 2. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2: Baseline Characteristics of Treatment and Control Markets

	Control Markets (1)	Treatment Markets (2)
Panel A: Drug Sample Characteristics		
Price per 500mg Tablet (USD)	0.161	0.163
Complies with Indian Pharmacopeia	0.969	0.971
Active ingredient (deviation from 100%)	0.025	0.023
Uniformity	3.27	3.09*
Dissolution	89.6	89.6
Days until expiry	608	640
Sample size	*517*	*276*
Panel B: Pharmacy Characteristics		
Air conditioning	0.16	0.09
Cleanliness (1-5)	4.03	3.97
Customer traffic	71.5	69.5
Sample size	*65*	*35*
Panel C: Consumer Characteristics		
Log monthly household income (USD)	5.30	5.37
Education (years)	12.2	12.0
Household size	4.1	4.0
Scheduled caste/tribe	0.06	0.17***
Owns a vehicle	0.64	0.57
Sample size	*317*	*177*

Note: Stars indicate significant differences with Column 1. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 3: Trends in Socioeconomic Status Among Non-Shoppers

	Rounds 1 and 2			Rounds 1 and 3		
	First Difference		DD	First Difference		DD
	Control	Treatment	(2) - (1)	Control	Treatment	(5) - (4)
	(1)	(2)	(3)	(4)	(5)	(6)
Log monthly household income (USD)	0.05	-0.03	-0.08	0.05	0.03	-0.08
	(0.07)	(0.15)	(0.15)	(0.07)	(0.15)	(0.15)
Education (years)	0.05	-1.19	-1.23	0.05	-1.18	1.23
	(0.53)	(0.75)	(0.88)	(0.53)	(0.75)	(0.88)
Household size	0.18	0.18	-0.002	0.18	0.18	-0.002
	(0.19)	(0.17)	(0.24)	(0.19)	(0.17)	(0.24)
Scheduled caste/tribe	0.03	-0.02	-0.05	0.03	-0.02	-0.05
	(0.03)	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)
Owns a vehicle	-0.07	-0.03	0.04	-0.07	-0.03	0.04
	(0.08)	(0.08)	(0.11)	(0.08)	(0.08)	(0.11)
Sample size	970	601	1571	1293	845	2138

Note: Market-clustered standard errors appear in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 4: Chain Entry, Customer Traffic, and Market Exit for Incumbents

Dependent variable:	ln(Customer Traffic)		Market Exit	
	(1)	(2)	(3)	(4)
Round 2	0.19***	0.12*	-0.021**	-0.031**
	(0.052)	(0.057)	(0.0099)	(0.015)
Round 2 × entry market	-0.27***	-0.20**	-0.0055	0.0064
	(0.069)	(0.083)	(0.016)	(0.021)
Round 3	0.26***	0.20	-0.042***	-0.086**
	(0.045)	(0.20)	(0.013)	(0.033)
Round 3 × entry market	-0.24***	-0.19**	-0.055**	-0.047*
	(0.078)	(0.074)	(0.026)	(0.026)
Market demo and health controls	-	Yes	-	Yes
Wild bootstrap p-value:				
Round 2 × entry	0.002	0.16	0.07	0.01
Round 3 × entry	0.05	0.21	0.03	0.04
Observations	298	298	1053	1053
R^2	0.26	0.27	0.05	0.05

Note: Market-clustered standard errors appear in parentheses. All regressions include market fixed effects. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 5: Chain Entry and Incumbent Drug Quality

Dependent variable:	Complies with Indian Pharmacopeia						
Manufacturers:	All		National		Non-National		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Post entry	-0.043**	-0.078***	-0.0030	-0.063***	-0.15**	-0.21***	-0.11
	(0.019)	(0.013)	(0.021)	(0.021)	(0.058)	(0.062)	(0.080)
Post entry × entry market	0.043**	0.066***	-0.018	0.0067	0.20***	0.24***	0.15*
	(0.019)	(0.017)	(0.025)	(0.025)	(0.067)	(0.044)	(0.076)
Market demo and health controls	-	Yes	-	Yes	-	Yes	Yes
Manufacturer fixed effects	-	-	-	-	-	-	Yes
Wild bootstrap p-value (post × entry)	0.04	0.03	0.50	0.95	0.005	0.12	0.34
Observations	796	796	520	520	276	276	265
R^2	0.062	0.073	0.062	0.086	0.246	0.347	0.551

Note: Market-clustered standard errors appear in parentheses. All regressions include market fixed effects. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 6: The Impact on Quality Components

Quality Component:	Active Ingredient Concentration			Dissolution		Uniformity	
Dependent variable:	Raw	Abs. % Dev.	Pass	Raw	Pass	Raw	Pass
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: All Manufacturers							
Post entry	-6.86***	0.018	-0.018	0.11	-0.024*	-0.50***	-0.020**
	(1.37)	(0.28)	(0.016)	(0.50)	(0.013)	(0.081)	(0.0092)
Post entry × entry market	3.53	-0.24	0.042**	1.30	0.032*	-0.11	-0.0036
	(2.45)	(0.37)	(0.019)	(0.89)	(0.015)	(0.18)	(0.014)
Wild bootstrap p-value (post × entry)	0.20	0.53	0.05	0.19	0.05	0.56	0.80
Panel B: Non-National Manufacturers							
Post entry	-9.21**	1.69**	-0.12***	-0.90	-0.050	-0.64***	-0.029
	(3.27)	(0.61)	(0.035)	(1.42)	(0.033)	(0.17)	(0.030)
Post entry × entry market	1.06	-2.10**	0.18***	3.76*	0.11**	-0.093	0.0026
	(4.94)	(0.83)	(0.055)	(2.01)	(0.045)	(0.23)	(0.039)
Wild bootstrap p-value (post × entry)	0.82	0.01	< 0.01	0.09	0.03	0.69	0.93

Note: Market-clustered standard errors appear in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 7: The Impact of Chain Entry on Prices

Dependent variable:	ln(Price per Tablet)						
Manufacturers:	All		National		Non-National		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Post entry	0.0047	0.019	-0.016	-0.016	0.046	0.045	0.049
	(0.024)	(0.031)	(0.022)	(0.032)	(0.047)	(0.051)	(0.074)
Post entry × entry market	-0.024	-0.040	0.021	0.037	-0.12**	-0.15**	-0.15
	(0.030)	(0.040)	(0.036)	(0.046)	(0.053)	(0.066)	(0.089)
Market demo and health controls	-	Yes	-	Yes	-	Yes	Yes
Manufacturer fixed effects	-	-	-	-	-	-	Yes
Wild bootstrap p-value (post × entry)	0.53	0.49	0.57	0.59	0.07	0.19	0.21
Observations	787	787	520	520	267	267	265
R^2	0.124	0.130	0.155	0.161	0.180	0.221	0.658

Note: Market-clustered standard errors appear in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 8: Robustness to Unobservable Trends

Dependent variable:	Complies with IP				ln(Price per Tablet)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post entry	-1.91	-0.032	-0.82**	0.57***	-2.18*	0.24	-0.63**	0.55***
	(1.49)	(0.31)	(0.37)	(0.17)	(1.11)	(0.17)	(0.26)	(0.16)
Post entry × entry market	0.22**	0.16**	0.14***	0.19**	-0.20***	-0.13**	-0.096	-0.084*
	(0.082)	(0.058)	(0.047)	(0.068)	(0.065)	(0.057)	(0.062)	(0.046)
Post entry × baseline:								
-Market demographic controls	Yes	-	-	-	Yes	-	-	-
-Market health controls	-	Yes	-	-	-	Yes	-	-
-Pharmacy characteristics	-	-	Yes	-	-	-	Yes	-
-Dependent variable (pharmacy mean)	-	-	-	Yes	-	-	-	Yes
Wild bootstrap p-value (post × entry)	0.07	0.02	0.02	0.01	0.10	0.07	0.36	0.08
Observations	271	271	269	271	261	261	259	261
R^2	0.272	0.278	0.337	0.276	0.207	0.199	0.250	0.430

Note: Market-clustered standard errors appear in parentheses. All regressions include market fixed effects. All regressions are limited to the sample of non-national brands. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 9: Chain Entry and Perceived Quality among Non-Shoppers

Dependent variable:	Perceived quality of:					
	Nearby pharms		National brands		Local brands	
	(1)	(2)	(3)	(4)	(5)	(6)
Round 2 × entry market	0.081	0.19	0.19	0.49**	0.37	0.62**
	(0.095)	(0.11)	(0.20)	(0.21)	(0.26)	(0.26)
Round 3 × entry market	0.10**	0.17**	-0.13	0.10	0.28**	0.52***
	(0.046)	(0.065)	(0.10)	(0.16)	(0.14)	(0.13)
Market demo and health controls	-	Yes	-	Yes	-	Yes
Wild bootstrap p-value:						
Round 2 × entry	0.44	0.20	0.39	0.10	0.20	0.08
Round 3 × entry	0.05	0.004	0.26	0.57	0.05	0.002
Observations	2143	2143	1677	1677	1505	1505
R^2	0.05	0.05	0.11	0.16	0.19	0.23

Note: Market-clustered standard errors appear in parentheses. All regressions include market fixed effects. Dependent variables are measured on a scale of 1 (low) to 4 (high). * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 10: Quality and Prices in Entry Markets

Sample:	Overall		Common Brands	
Dependent variable:	Quality	ln(Price)	Quality	ln(Price)
	(1)	(2)	(3)	(4)
Chain pharmacy	-0.0068	-0.061	0.051	-0.090**
	(0.032)	(0.037)	(0.051)	(0.032)
Wild bootstrap p-value (Chain pharmacy)	0.80	0.17	0.49	0.05
Observations	361	359	98	98
R^2	0.00	0.01	0.01	0.24

Note: Market-clustered standard errors appear in parentheses. The regressions in Columns 3 and 4 only include brands that both the chain and incumbents carry. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 11: The Market-wide Impact of Chain Entry

Dependent variable:	Complies with IP				ln(Price per Tablet)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post entry × entry market:								
–	0.049**	0.068***	0.023	0.054	-0.055	-0.073*	-0.043	-0.055
	(0.021)	(0.021)	(0.026)	(0.037)	(0.035)	(0.036)	(0.052)	(0.041)
× high-education customers			0.048				-0.017	
			(0.035)				(0.066)	
× high-SES mystery shopper				-0.010				0.00021
				(0.064)				(0.036)
Market demo and health controls	-	Yes	-	-	-	Yes	-	-
Wild bootstrap p-value:								
Post × entry	0.03	0.05	0.27	0.17	0.16	0.13	0.77	0.21
Post × entry × customer educ.	-	-	0.71	-	-	-	0.13	-
Post × entry × shopper SES	-	-	-	0.89	-	-	-	0.87
Observations	824	824	824	824	813	813	813	813
R^2	0.057	0.069	0.058	0.059	0.135	0.146	0.141	0.138

Note: Market-clustered standard errors appear in parentheses. All regressions include market fixed effects. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

A Appendix

A.1 Differences Between Treatment and Control Markets

This subsection explores three potential differences between treatment and control markets. First, our sample includes two control markets that were not candidate entry markets. Consumers in these markets have lower socioeconomic status, with 23 percent lower household income and 1.7 fewer years of schooling ($p < 0.01$ for both variables). Including these markets leads to greater socioeconomic heterogeneity and allows us to gauge the relationship between SES and drug quality. Panel A of Appendix Table 1 reproduces our main estimates while excluding these markets. Estimates closely resemble our baseline estimates in Tables 5 and 7, which indicates that our findings are not sensitive to whether these markets are included.

Secondly, treatment markets are located further from the city center than control markets on average. The average distance to the center is 13.0 kilometers for treatment markets and 9.6 kilometers for control markets ($p = 0.19$). The distance to the center is not significantly correlated with the demographic characteristics of consumers. To explore this issue further, Panel B of Appendix Table 1 reproduces our main results for a subsample of 15 markets for which the distance from the city center ranges from 8 to 16 kilometers. This approach reduces the difference in city-center proximity between treatment and control markets. Estimates for quality closely resemble our baseline results. Estimates for prices are qualitatively similar but smaller. The comparability of these results suggests that this form of spatial heterogeneity is not a serious confound.

Next we compare the growth in customer traffic in treatment and control markets after accounting for chain traffic. Table 4 excludes the chain in order to focus on the impact for incumbents. As another test of the identifying assumption, we include chain traffic in order to compare total traffic growth in treatment and control markets. This exercise is not straightforward for several reasons. We only observe traffic for a subset of each market's

pharmacies, which creates measurement error for market-wide traffic estimates. Secondly, our consumer survey indicates that chain shoppers purchase 25 percent more medicine by volume than incumbent shoppers.

Nevertheless, we examine traffic growth by treatment status, and find that traffic growth is slightly lower but insignificantly different in treatment markets once we include traffic at the chain. Traffic in treatment markets is 3 percent lower in Round 1 ($p = 0.75$), 12 percent lower in Round 2 ($p = 0.15$), and 8 percent lower in Round 3 ($p = 0.40$). We account for heterogeneity across stores in the quantity per customer using estimates from our consumer survey. Scaling customer traffic by the average quantity per customer does not change these estimates but cause the differences by treatment status to become highly insignificant ($p > 0.5$).

Panel C of Appendix Table 1 explores this issue further by estimating our main results for a subsample of 14 markets for which traffic growth is comparable across treatment and control markets.[18] There is no difference in average traffic growth across treatment and control markets under this restriction. The table shows that quality results closely resemble our baseline estimates. Price results are weaker but are qualitatively similar to our main findings.

A.2 The Composition of Shoppers

Chain entry may affect incumbent prices or quality by changing the selection of incumbent shoppers. Because the chain offers both higher quality and lower prices, it does not necessarily draw away high-SES or low-SES customers differentially. If it steals high-SES customers, the chain may encourage incumbents to cater to the remaining low-SES customers through lower prices and quality. Because both quality preferences and drug demand are positively correlated with SES, customer selection cannot explain why chain entry has different effects on quality and prices. We investigate the role of selection further by regressing the demo-

[18] We restrict the sample to markets for which the change in traffic from Round 1 to Round 2 ranges from -61 to 85, which excludes several high-growth control markets.

graphic characteristics of incumbent customers on chain entry in Appendix Table 2. With estimates that are small and statistically insignificant, the table shows no effects of chain entry on shoppers characteristics. These results cast doubt on selection-based explanations for the price and quality effects of chain entry.

A.3 Quality Signaling

We argue in Section 5.4 that treatment incumbents improve quality in order to compete with the chain. For this mechanism to explain our findings, consumers must perceive and reward incumbents for quality improvements. Table 9 shows that consumers perceive higher quality after chain entry, but it is unclear how firms communicate this information. An industrial organization literature considers how firms signal quality in theory (e.g. Nelson 1974, Allen 1984), but no studies (to our knowledge) address whether or how firms signal in this market. Pharmacies may make costly investments such as air conditioning, advertise, or improve visible product attributes. Alternatively, they may communicate directly to consumers, relying on repeated interaction to establish credibility.

This subsection shows the effect of chain entry on incumbent signaling behavior. Our survey records the tidiness of the store, whether the store has air conditioning, and the number of storefront signs. We also track the packaging condition and the days until expiry for samples in the mystery shopper audit. Appendix Table 3 shows the effect of chain entry on these outcomes. Estimates are mixed and statistically insignificant. In the strongest result, chain entry is associated with an increase of 0.4 incumbent signs, although this result is not significant.

We may fail to find effects for several reasons. Firms may not signal through any of these channels. Margins like air conditioning and the tidiness of the physical space may be difficult to adjust in the short run. Signaling by the pharmacist - for example, through more productive customer service, or non-productive advertising - may be a more relevant in the short run, but were not measured in our study. Similarly, commercial advertising, by the

pharmacies or local brand manufacturers, through local print media was not measured, but may be another mechanism by which suppliers signal quality improvements.

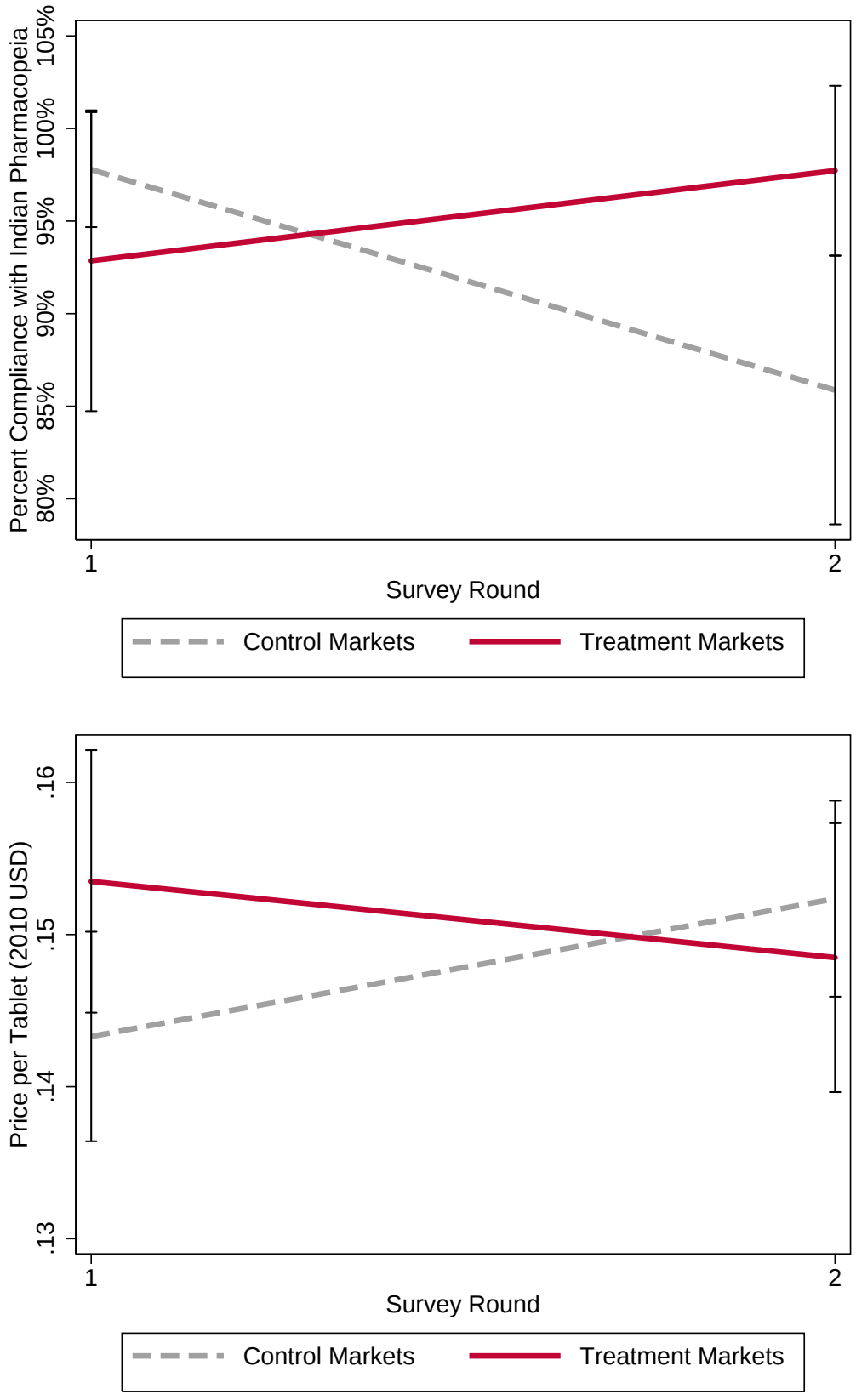
A.4 Treatment Spillovers

This subsection discusses the possibility that chain entry could indirectly affect prices and quality in control markets. We proxy for markets spatially using the area within a 0.5 kilometer radius from the candidate entry site. Markets do not overlap or share borders. For control markets, the closest treatment market is an average of 8.1 kilometers away and a minimum of 2.4 kilometers away, suggesting that spillovers are unlikely. More formally, Appendix Table 4 tests whether results are sensitive to the proximity of treatment and control markets by excluding nearby control markets from the analysis. Odd columns exclude four control markets that are within 5 kilometers of a treatment market while even columns exclude eight control markets that are within 10 kilometers of a treatment market. The remaining control markets are an average of 10 kilometers away from a treatment market under the first restriction and 12 kilometers away under the second restriction. Estimates in the table closely resemble our baseline estimates, suggesting that treatment spillovers do not confound our results.

A.5 Changes over Time for Non-National Brands

Treatment effect estimates for non-national brands are identified through changes over time in quality and price within this subsample. To clarify this source of variation, Appendix Figure 1 reproduces the plots in Figure 5 for non-national manufacturers. Pharmacopeia compliance is initially 5 percentage points higher in control markets ($p = 0.22$). The non-national treatment effect estimate of 0.20 (Column 5 of Table 5) is based on a 5 percentage point quality improvement in treatment markets over time and a 15 percentage point deterioration in control markets. As we discuss previously, the secular decline in quality is most likely caused by the marked increased in both humidity and temperature during the second

survey round. Prices are initially 8.4 percent higher in treatment markets ($p = 0.09$). The 12 percent price decline (Column 5 of Table 7) is based on a 5 percent increase in control markets and a 7 percent decrease in treatment markets.



Appendix Figure 1: Quality and Price Changes for Non-National Drug Samples

Appendix Table 1: Sample Selection Robustness Tests

Dependent variable:	Complies with IP		ln(Price per Tablet)	
Manufacturers:	All	Non-Nat.	All	Non-Nat.
	(1)	(2)	(3)	(4)
Panel A: Only Candidate Entry Markets				
Post entry × entry market	0.046*	0.22**	-0.019	-0.11*
	(0.022)	(0.077)	(0.031)	(0.062)
	[0.05]	[0.005]	[0.59]	[0.07]
Panel B: Comparable Distances to the City Center				
Post entry × entry market	0.057**	0.24**	-0.00063	-0.046
	(0.026)	(0.10)	(0.030)	(0.051)
	[0.04]	[0.01]	[0.98]	[0.36]
Panel C: Comparable Traffic Growth				
Post entry × entry market	0.050*	0.25**	-0.061	-0.057
	(0.028)	(0.11)	(0.035)	(0.052)
	[0.10]	[0.01]	[0.12]	[0.28]

Note: Market-clustered standard errors appear in parentheses. Wild cluster bootstrap p-values appear in brackets. All regressions include market fixed effects. Panel A includes 18 candidate entry markets. Panel B includes 15 markets that are 8-16 kilometers from the city center. Panel C includes 14 markets with changes in measured customer traffic from -62 to 85. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Appendix Table 2: Chain Entry and Incumbent Shopper Characteristics

Dependent variable:	ln(Income)	Education	Household size	Scheduled caste/tribe	Owns a vehicle
	(1)	(2)	(3)	(4)	(5)
Round 2 × entry market	-0.045	-0.41	0.18	-0.010	0.033
	(0.17)	(1.00)	(0.23)	(0.079)	(0.13)
Round 3 × entry market	0.0085	-0.033	-0.27	-0.027	0.084
	(0.14)	(0.86)	(0.17)	(0.056)	(0.097)
Wild bootstrap p-value					
Round 2 × entry	0.81	0.73	0.45	0.90	0.82
Round 3 × entry	0.96	0.97	0.16	0.62	0.42
Observations	2224	2224	2224	2224	2224
R^2	0.06	0.06	0.07	0.03	0.04

Note: Market-clustered standard errors appear in parentheses. The sample is limited to shoppers at incumbent pharmacies. All regressions include market fixed effects. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Appendix Table 3: Chain Entry and Observable Signaling by Incumbents

Dependent variable:	Pharmacy Cleanliness	Number of Signs	Air Conditioning	Days Until Expiry	Packaging Condition
	(1)	(2)	(3)	(4)	(5)
Post entry	-0.034	0.050	-0.034	3.53	-0.22***
	(0.082)	(0.20)	(0.032)	(23.5)	(0.072)
Post entry × entry market	-0.17	0.35	0.034	-18.1	-0.045
	(0.14)	(0.27)	(0.032)	(28.8)	(0.11)
Wild bootstrap p-value (post × entry)	0.24	0.20	0.28	0.54	0.71
Observations	199	199	199	1605	1642
R^2	0.142	0.408	0.265	0.022	0.105

Note: Market-clustered standard errors appear in parentheses. All regressions include market fixed effects. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Appendix Table 4: A Test for Treatment Spillovers into Control Markets

Dependent variable	Complies with IP				ln(Price per Tablet)			
Manufacturers	All		Non-National		All		Non-National	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post	-0.044	-0.070*	-0.18**	-0.25	0.034	0.043	0.10	0.17*
	(0.026)	(0.036)	(0.085)	(0.15)	(0.029)	(0.037)	(0.067)	(0.094)
Post × entry market	0.045	0.071*	0.24**	0.30*	-0.052	-0.061	-0.15**	-0.22**
	(0.026)	(0.036)	(0.091)	(0.15)	(0.035)	(0.042)	(0.071)	(0.097)
Drop control markets within	5 km	10 km	5 km	10 km	5 km	10 km	5 km	10 km
Wild bootstrap p-value (post × entry)	0.14	0.07	< 0.01	0.01	0.17	0.21	0.05	0.06
Observations	629	472	202	149	629	472	202	149
R^2	0.06	0.05	0.26	0.28	0.13	0.13	0.24	0.20

Note: Market-clustered standard errors appear in parentheses. Odd columns omit 4 control markets that are within 5 kilometers by road of the nearest treatment market. Even columns omit 8 control markets that are within 10 kilometers by road of the nearest treatment market. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Appendix Table 5: The Impact of Chain Entry on Consumer Preferences

	Perceived Importance of:					
	Drug Quality		Store Convenience		Store Familiarity	
	(1)	(2)	(3)	(4)	(5)	(6)
Round 2 × entry market	0.28***	0.28***	0.045	0.076	-0.014	0.0065
	(0.077)	(0.079)	(0.063)	(0.053)	(0.069)	(0.092)
Round 3 × entry market	0.28***	0.30***	-0.0025	0.019	-0.13**	-0.11
	(0.074)	(0.073)	(0.014)	(0.050)	(0.047)	(0.071)
Market demo and health controls	-	Yes	-	Yes	-	Yes
Wild bootstrap p-value:						
Round 2 × entry	0.0005	0.0001	0.51	0.26	0.84	0.95
Round 3 × entry	0.003	0.001	0.87	0.74	0.01	0.20
Observations	2575	2575	2632	2632	2631	2631
R^2	0.08	0.10	0.09	0.12	0.23	0.24

Note: Market-clustered standard errors appear in parentheses. All regressions include market fixed effects. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

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