Is Price a Predictor of the Quality of Medicines? Quantitative Evidence from Nigeria

S4HS Conference - "Connecting access, quality and trust"

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Prevalence of Substandard and Falsified (SF) Medicines

- SF medicines[1] pose a serious global health threat, especially in low- and middle-income countries (LMICs).
- Around 10.5% of medicines in LMICs are of poor quality, contributing to nearly 1 million deaths annually.
- In Sub-Saharan Africa, prevalence is estimated at 22.6%, with some areas reporting up to 50% *(Maffioli et al., 2024; Ozawa et al., 2018; Webb, 2014)*.
- Most affected drugs: antibiotics, antimalarials, and antihypertensives *(Asrade Mekonnen et al., 2024; Petersen et al., 2017; Zabala et al., 2022)*.

[1] Substandard products are those that do not meet quality standards and specifications, often due to poor manufacturing practices or inadequate quality control. Falsified medical products deliberately misrepresent their identity, composition or source.

Health and Economic Consequences

- SF direct impact health includes adverse effects, treatment failure, & drug resistance undermining efforts to control infectious diseases *(Cavany et al., 2023; Okeke et al., 1999)*.
- The consequences of SF medicines extend to financial burdens on individuals and health systems, eroding trust in medical institutions, and exacerbating poverty through income loss and reduced productivity.

The Challenge

- SF medicines are difficult to detect, as they often closely mimic genuine products in packaging and appearance.
- These medicines typically lack visible indicators of quality and require advanced laboratory testing to confirm their chemical composition.
- In LMICs, weak regulatory systems, poor enforcement, and institutional limitations compound the challenge of ensuring medicine quality.

Perceived Quality and Market Signals

- In imperfect pharmaceutical markets, consumers lack full information on medicine quality.
- Price often serves as a heuristic indicator of perceived quality.
- Observable characteristics, such as pharmacy conditions, storage, and packaging, could also signal quality.
- Similarly, drug packaging features, such as intact seals, undamaged pills, and visible expiration dates, may influence consumer perceptions of quality.
- Consumers may rely on these indirect signals when direct laboratory testing is not feasible.

Study Contribution and Objectives

- This study will explore the extent to which consumers could rely on these observable indicators for pharmacies and drug packaging characteristics, as well as price, as signals of quality of medicines.
- Results aim to inform policy interventions focused on strengthening pharmaceutical regulation and consumer protection in LMICs.

Context: Nigeria

- **Market value:** USD 4.5 billion and growing at a rate of 9% annually.
- **Import-dependent:** sourcing 70% of finished products, and 100% of active pharmaceutical ingredients (APIs) for local manufacturing.
- **Market share:** analgesics (25%), antibiotics (15%), multivitamins (15%), antimalarials (14%), and antihypertensives (8%).
- **SF drugs:** prevalence estimated between 4.95% and 25%.

Study design

- Data collected from retail pharmacies across Nigerias six largest cities in 6 geopolitical zones.
- Cities: **Abuja, Kano, Lagos, Onitsha, Port Harcourt, Yola**, 1:1 urban and rural areas.
- 12 trained mystery shoppers visited pharmacies and purchased a random drug from a list of 20 branded medicines.
- Medicines covered high-demand therapeutic categories: analgesics, antimalarials, antibiotics, antihypertensives, multivitamins.
- 1,214 successful purchases recorded (total pharmacies 1,296, 93.7%).

Pharmacies in Nigeria

Urban pharmacy

Drugs collected

Data Collection and Lab Testing

- After each pharmacy visit, shoppers completed a structured survey to record:
  - Physical characteristics of the pharmacy
  - Observable drug packaging characteristics
  - Drug pricing and storage
- A weighted subsample of 246 drug samples *(excluding multivitamins)*[2] was tested through a quantitative analysis of APIs using High-Performance Liquid Chromatography (HPLC).
- HPLC pass criteria: Active Pharmaceutical Ingredient (API) within the 90 to 110% range.
- 25% of samples failed the test (N = 62). Of these, 35% antihypertensives, 31% analgesics, 19% antibiotics, 15% antimalarials

[2] These were uncommon in the pharmacies sampled and would not allow for enough variation for analysis.

Study Setting: 6 cities

Empirical Strategy

We estimate a probit model to examine the determinants of drug quality, measured by HPLC test results.

$$HLPC_i^* = \alpha_i + \gamma_1 \ln(price)_i + \gamma_2 pharma_i + \gamma_3 drug_i + X_i'\beta + \varepsilon_i \quad (1)$$

$$HLPC_i = \begin{cases} 1 & \text{if } HLPC_i^* > 0 \\ 0 & \text{otherwise} \end{cases} \quad \Rightarrow \quad \Pr(HLPC_i = 1) = \Phi(\cdot)$$

where α_i is a city fixed effect, $HPLC_i$ is an indicator $= 1$ if drug i passed HPLC test, $ln(price)_i$ is the natural log of the purchase price of drug i, $pharma_{icl}$ are pharmacy characteristics, $drug_{icl}$ are drug characteristics, and X_{icl} are a vector of covariates (drug type, pharmacy size, urban/rural category, and athe origin of the manufacturer (Nigerian or international). Errors clustered at the city level. Results are presented as marginal effects.

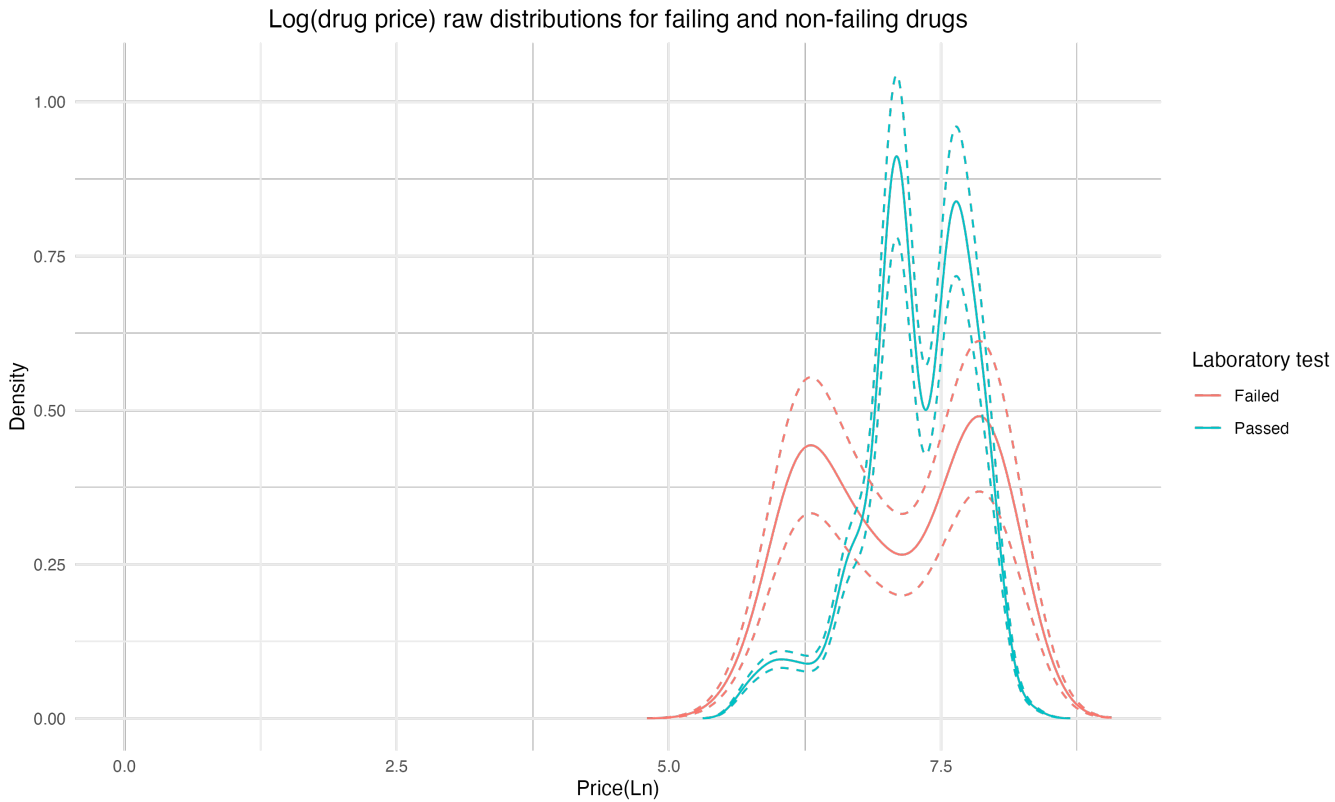
Sample Characteristics

	Full sample (N = 1,214) Mean (%) (SD)	Tested in lab (N = 246) Mean (%) (SD)
Panel A: Pharmacies		
Air conditioning	35.34 (47.82)	31.3 (46.67)
Medicines displayed on shelves	94.15 (23.48)	95.93 (19.79)
Cool-chained devices	26.36 (44.08)	26.02 (43.96)
Medicines exposed to direct sunlight	7.41 (26.2)	7.32 (26.09)
Medicines placed on the floor	8.26 (27.53)	8.94 (28.59)
Panel B: Drug Samples		
Package in normal condition	98.11 (13.64)	97.15 (16.66)
Expiration date on package	92.50 (26.34)	92.68 (26.09)
Storage temperature on package	82.37 (38.12)	82.11 (38.40)
Medicines organized by brand	72.73 (44.55)	73.98 (43.96)
Passed lab test	-	74.80 (43.50)

cont Sample Characteristics

	Full sample (N = 1,214) Mean (%) (SD)	Tested in lab (N = 246) Mean (%) (SD)
Panel C: Other Covariates		
Abuja	16.72 (37.33)	15.45 (36.21)
Lagos	17.13 (37.70)	15.45 (36.21)
Onitsha	16.47 (37.11)	18.70 (39.07)
Port Harcourt	17.05 (37.62)	19.11 (39.39)
Yola	16.31 (36.96)	16.26 (36.98)
Rural	50.41 (50.00)	51.22 (50.09)
Small pharmacy	69.19 (46.19)	71.54 (45.21)
Medium pharmacy	20.10 (40.09)	16.26 (36.98)
Analgesics	30.72 (46.15)	44.72 (49.82)
Antimalarials	30.40 (46.02)	27.24 (44.61)
Antibiotics	18.29 (38.67)	15.45 (36.21)
Antihypertensives	15.57 (36.27)	12.60 (33.25)
Price (Naira)	1660.8 (894.3)	1598.2 (811.39)
Price Analgesics	1398.4 (683.8)	1326.1 (638.86)
Price Antibiotics	1705.8 (992.3)	1700.0 (930.2)
Price Antihypertensives	2461.8 (922.3)	2280.6 (835.3)
Price Antimalarials	1662.1 (720.7)	1671.6 (783.6)
Manufacturer (Nigerian)	65.35 (47.60)	64.63 (47.90)

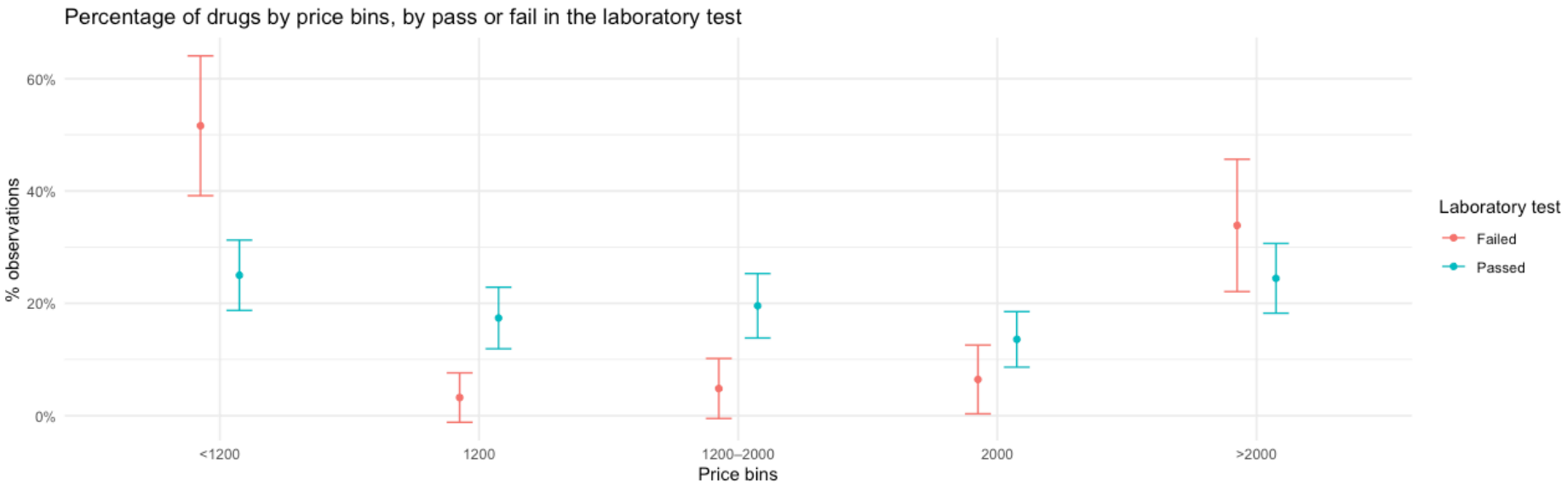
Density of Price of Medicines



Density of price (log)

- Average price of drug samples that did not fail the laboratory test (NGN 1620) is slightly higher than that of those samples that failed (NGN 1530).
- Price distribution for passed samples is right-skewed, suggesting a positive link between price and quality (KS test, $p < 0.001$).

Medicines samples by price bins



Density of price (log)

- Allows for non-parametric comparisons and for observing any potential threshold effects in pricing.
- In the lowest price bin (<NGN 1,200), over 50% failed the lab test.
- Higher-priced drugs are more likely to pass, but even in the highest bin (>NGN 2,000), about one-third (33.9%) still failed.
- While very low prices may signal poor quality, a high price is not a guaranteed indicator of high-quality medicine.

Price Density and Bins by Drug Type

- Price–quality relationship varies across medicine categories.
- Analgesics and antibiotics show more dispersed price distributions, indicating a stronger link between price and quality.
- Among analgesics, 78.9% of failures occur in the lowest price bin (<NGN 1,200).
- For antibiotics, all failures (100%) are confined to the lowest price bin, suggesting a clear low-price quality threshold.

Low prices appear to be a strong signal of poor quality, particularly for antibiotics and analgesics.

Price is Associated with the Quality of Medicines

	(1)	(2)	(3)	(4)
Price (ln)	0.161***	0.158***	0.170***	0.167***
	(0.0510)	(0.0506)	(0.0485)	(0.0487)
Air conditioning		-0.0446		-0.0835*
		(0.0516)		(0.0468)
Drugs displayed on shelves		0.0652		-0.103***
		(0.04)		(0.0247)
Cool-chained devices		0.00281		0.0444
		(0.0561)		(0.0511)
Exposed to sunlight		0.143***		0.174***
		(0.0349)		(0.0442)
On floor		-0.08		-0.0848
		(0.06)		(0.0754)
Package normal			0.0536	0.0520
			(0.158)	(0.134)
Expiration date visible			0.14**	0.246***
			(0.0556)	(0.0668)
Storage temp listed			-0.0874***	-0.118***
			(0.0272)	(0.03446)
Organized by brand			0.109*	0.135**
			(0.0588)	(0.0544)
City FE's	Yes	Yes	Yes	Yes
Type of drug	Yes	Yes	Yes	Yes
Size of pharmacy	Yes	Yes	Yes	Yes
Geographical type	Yes	Yes	Yes	Yes
Mean dep. var.	74.79	74.79	74.79	74.79
Observations	246	246	246	246
R-squared	0.257	0.263	0.275	0.287

Notes: Clustered robust SE at city level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Main findings

- Price is strongly and positively associated with quality.
- A 1% increase in price is associated with a 1617 percentage point increase in the probability of passing the laboratory test.
- The coefficient remains stable when controlling for pharmacy characteristics, drug sample characteristics, and city, manufacturer type, and location.
- Higher prices generally indicate higher quality–but price alone is an imperfect predictor.

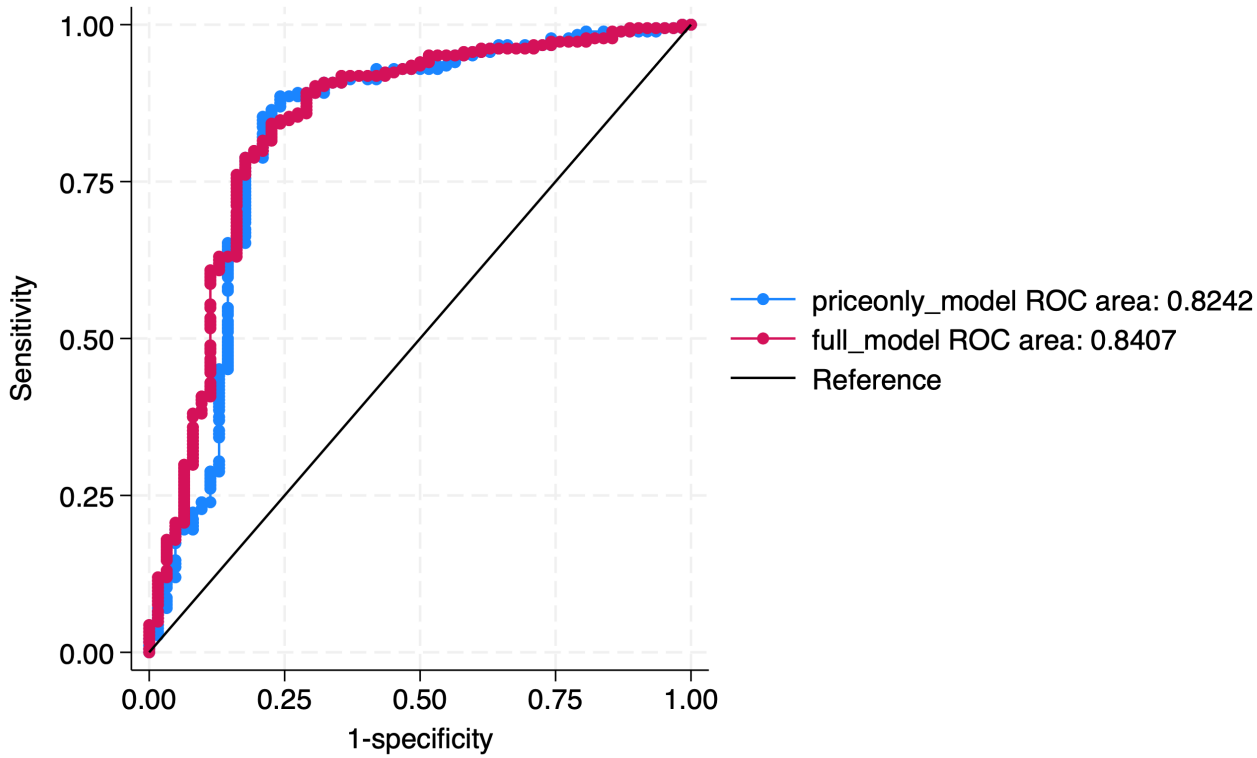
Policy Implication

Consumers reliance on price as a quality signal has some empirical validity, but cannot replace systematic regulation and testing.

Pharmacy & Drug Characteristics

- Unexpectedly, medicines exposed to sunlight were more likely to pass (possibly due to display practices to avoid detection during audits).
- Displayed on shelves or in air-conditioned pharmacies were less likely to pass.
  - Medicines from visually appealing pharmacies may reflect market aesthetics rather than quality assurance.
- Contrary to our expectations, we found that packages showing temperature instructions negatively associated with quality.
  - About 18% of samples had vague temperature labels (do not store above 30C), suggesting labeling may reflect regulatory compliance more than real handling conditions.
- Presence of a visible expiration date and pharmacies that organize by brand linked to a higher probability of passing (14 and 11 pp). These features may reflect more rigorous manufacturing standards or inventory management practices.

Receiver Operating Characteristic (ROC)



- Models ability to distinguish between high and poor-quality drugs across a range of classification thresholds. Both models show strong discriminative ability.
- The small AUC difference suggests that price-only model captures a lot of the variation in the laboratory-confirmed quality of medicines. Additional characteristics are "marginal."

Robustness Checks

- Results in Maffioli et al (2024) shows that our drug sample (n=246) failed the laboratory test due to either low (26%), high (14%), or both low and high APIs (60%, for samples with two ingredients).
- Price remains a strong predictor when using different API failure definitions i.e., not failing based on at least one low API (Appendix Table 1) or at least one high API (Appendix Table 2)
- Heterogeneity of the findings by category of medicine -> effects of positive association between price and quality largely driven by antibiotics and analgesics (Appendix Table 3.)

Policy Implications

- Price may serve as a useful–but imperfect–signal of medicine quality.
- Very low prices often signal poor quality, but high prices are not always reliable indicators (34% of drugs in the highest price bin still failed).
- Observable cues (shelving, packaging, sunlight exposure) are often unreliable or counterintuitive indicators of quality.
- Findings align with prior LMIC evidence showing higher-priced drugs tend to be higher quality in weakly regulated markets.
- Policies should enhance consumer access to reliable quality information and promote transparency.
- Strengthening regulatory oversight, authentication systems, and consumer education is key to reducing SF medicines.

Limitations and Future Directions

- The study identifies associations, not causality, between price and quality.
- Observable proxies of quality were field-collected via mystery shopping and may omit unobserved characteristics.
- The sample includes only specific branded drugs in four therapeutic categories; generalizability may be limited.
- Some proxies (e.g., packaging or storage indicators) may reflect superficial compliance rather than true handling quality.
- Future work should explore causal mechanisms and test information or inspection interventions to strengthen market signals.

Thank You

Questions or Comments?

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5 Robustness Checks

Table 1. Alterative Measure of Quality Based on Low APIs

	(1)	(2)	(3)	(4)
Ln(Price)	0.0777	0.0767	0.0941*	0.0936*
	(0.0566)	(0.0583)	(0.0545)	(0.0556)
Air conditioning		-0.0420		-0.0805
		(0.052)		(0.049)
Displayed on shelves		0.0155		-0.075***
		(0.047)		(0.026)
Cool-chained devices		0.00597		0.051
		(0.0596)		(0.055)
Exposed to sunlight		0.111**		0.144***
		(0.0495)		(0.0525)
Placed on the floor		-0.0779		-0.0870
		(0.054)		(0.069)
Package in normal condition			0.081	0.081
			(0.142)	(0.121)
Expiration date visible			0.005	0.097
			(0.069)	(0.075)
Storage temp. listed			-0.096***	-0.129***
			(0.030)	(0.044)
Organized by brand			0.164**	0.192***
			(0.068)	(0.067)
City FE's	Yes	Yes	Yes	Yes
Size of pharmacy FE's	Yes	Yes	Yes	Yes
Geographical type FE's	Yes	Yes	Yes	Yes
Type of drug FE's	Yes	Yes	Yes	Yes
Mean dep. var.	78.45	78.45	78.45	78.45
Observations	246	246	246	246
R-squared	0.239	0.243	0.270	0.282

Notes: Probit regression with marginal effects. Outcome: passing HPLC due to no low API. Standard errors

Table 2. Alterative Measure of Quality Based on High APIs

	(1)	(2)	(3)	(4)
Ln(Price)	0.00978	0.00434*	0.0155*	0.0137**
	(0.0506)	(0.0515)	(0.0479)	(0.0476)
Air conditioning		-0.042		-0.048
		(0.045)		(0.047)
Displayed on shelves	0.049*			-0.029
	(0.026)			(0.026)
Cool-chained devices	-0.014			-0.001
	(0.038)			(0.048)
Placed on the floor	-0.043			-0.041
	(0.031)			(0.041)
Expiration date visible			-0.011	0.022
			(0.060)	(0.073)
Storage temp. listed			0.025	0.017
			(0.021)	(0.021)
Organized by brand			0.096*	0.112*
			(0.054)	(0.060)
City FE's	Yes	Yes	Yes	Yes
Size of pharmacy FE's	Yes	Yes	Yes	Yes
Geographical type FE's	Yes	Yes	Yes	Yes
Type of drug FE's	Yes	Yes	Yes	Yes
Mean dep. var.	83.74	83.74	83.74	83.74
Observations	246	228	239	221
R-squared	0.335	0.326	0.359	0.351

Notes: Probit regression with marginal effects. Outcome: passing HPLC due to no low API. Standard errors clustered at city level.

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Table 3. Predictors of Quality by Drug Type

	(1) Analgesics	(2) Antibiotics	(3) Antihypertensives	(4) Antimalarials
Ln(Price)	0.789***	0.662***	0.626*	-0.280
	(0.148)	(0.0362)	(0.257)	(0.220)
Air conditioning	-0.061	0.043	-0.344	-0.174
	(0.068)	(0.090)	(0.439)	(0.100)
Displayed on shelves	-0.452***	0.078	0.413	0.349*
	(0.062)	(0.117)	(0.515)	(0.146)
Cool-chained devices	-0.122	-0.084	0.285	0.065
	(0.084)	(0.061)	(0.328)	(0.092)
Exposed to sunlight	0.243**	-0.074		0.325**
	(0.087)	(0.160)		(0.089)
Placed on the floor	-0.047	0.193	-0.030	-0.024
	(0.036)	(0.261)	(0.304)	(0.089)
Package in normal condition	0.162		-0.832	-0.228*
	(0.180)		(0.625)	(0.092)
Expiration date visible	0.843***			-0.325
	(0.115)			(0.340)
Storage temp. listed	-0.361***	-0.199*	-0.440	0.047
	(0.056)	(0.082)	(0.560)	(0.199)
Organized by brand	0.042	0.105	0.091	0.460*
	(0.118)	(0.068)	(0.650)	(0.225)
City FE's	Yes	Yes	Yes	Yes
Size of pharmacy FE's	Yes	Yes	Yes	Yes
Geographical type FE's	Yes	Yes	Yes	Yes
Type of drug FE's	Yes	Yes	Yes	Yes
Mean dep. var. (%)	82.73	68.42	29.03	86.57
Observations	110	38	31	67
R-squared	0.334	0.920	0.526	0.235

Notes: OLS regression by drug category. Outcome: passing HPLC test. Standard errors clustered at city level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

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