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Impact of Health Facility Essential Commodity Out of Stock on Child Care Seeking Behavior and Treatment Rates in Ethiopia: A Multilevel Mixed-Effects Analysis of the 2024/2025 EDHS

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ABSTRACT

Background; Child mortality in Ethiopia remains driven by preventable infectious conditions acute respiratory infections, diarrhea and fever. While demand side factors are widely studied, the impact of supply side health facility readiness specifically the consistent availability of essential pediatric medicines on care seeking and clinical treatment is less clear. This study evaluated the impact of essential commodity stock outs on child care seeking and treatment rates in Ethiopia using the 2024/2025 Ethiopia Demographic and Health Survey.

Methods; A secondary multilevel analysis was conducted using linked data from the 2024/2025 Ethiopia Demographic and Health Survey and facility readiness audits. The sample included 8452 children under five who experienced acute respiratory infections, fever or diarrhea in the preceding two weeks. Outcomes modeled included formal care seeking and receipt of recommended treatment (oral rehydration salt/zinc, dispersible amoxicillin or Artemisinin based Combination). Multilevel mixed effects logistic regression models assessed adjusted odds ratios at a 95% confidence interval.

Results; Formal care seeking occurred for 48.2% of sick children and appropriate treatment was received by 36.5%. Overall, 41.3% of local primary health facilities experienced essential pediatric medicine stock outs in the preceding month. Children served by facilities with stock outs had 42% lower odds of formal care seeking (adjusted odds ratio = 0.58) and 56% lower odds of receiving appropriate clinical treatment (adjusted odds ratio = 0.44). Maternal education, household wealth and urban residence were strong positive predictors of care seeking. Community level differences accounted for 28.4% of the total variance in care seeking.

Conclusion; Health facility commodity stock outs act as a major structural bottleneck in Ethiopia, suppressing treatment rates and eroding care seeking behavior. National authorities must emphasize supply chain digitization and support primary healthcare logistics to increase child survival.

Keywords; Child Care Seeking; Essential Medicine Stock out; Treatment Rates; Ethiopia Demographic and Health Survey. 2024/2025; Multilevel Analysis; Ethiopia; Supply Chain Logistics

Introduction

Child survival remains an imperative global public health priority [1-3]. Despite substantial progress over the past two decades in reducing global under-five mortality, Sub-Saharan Africa continues to bear a disproportionate burden of preventable childhood deaths [3, 4]. In Ethiopia, the under five mortality rate has declined significantly largely due to the rapid expansion of primary healthcare infrastructure under the Health Extension Program (HEP) and the implementation of Integrated Community Case Management (iCCM) of childhood illnesses [5]. However, common treatable infectious conditions, specifically acute respiratory infections (ARI/pneumonia), diarrheal illnesses and fever/malaria remain the leading causes of under five morbidity and mortality across all administrative regions of the country [6, 7].

Prompt seeking of medical care from formal healthcare providers combined with the immediate administration of appropriate first line therapeutics represents a core highly cost effective strategy to prevent child deaths [8, 9]. According to World Health Organization (WHO) and Ethiopian Ministry of Health (MOH) guidelines;

Diarrheal disease requires treatment with oral rehydration salts (ORS) combined with dispersible zinc tablets to prevent dehydration and reduce illness duration(recurrence) [8, 10].

ARI/Pneumonia requires timely oral antibiotic therapy specifically dispersible amoxicillin tablets [6].

Malaria/Fever requires prompt diagnostic confirmation (Rapid Diagnostic Test (RDT) or microscopy) and first line treatment with Artemisinin based Combination Therapy (ACT) such as artemether lumefantrine (Coartem) [11].

Despite the clear clinical guidelines and widespread distribution of primary health posts and health centers in Ethiopia, population coverage of both care seeking and appropriate pediatric treatment remains below national transformation targets [6]. Epidemiological studies in low and middle income countries (LMICs) have traditionally focused on demand side barriers to explain these gaps including maternal education, household wealth status, maternal decision-making autonomy, geographic distance and user fees [8, 12]. While demand side factors are undeniably crucial an increasing body of health systems literature underscores that supply-side readiness specifically the reliable, continuous availability of essential pharmaceutical commodities serves as the primary foundation for effective healthcare utilization [13, 14].

When public health facilities experience chronic or recurrent stock outs of essential pediatric commodities, the immediate clinical consequence is the inability to dispense prescribed first line therapeutics [13]. However, the long term behavioral consequence is far more damaging to health systems [6]. Caregivers who make significant personal, physical and financial sacrifices to travel to local health centers only to discover that prescribed medicines are out of stock experience frustration and loss of confidence in the healthcare system [15, 16]. Over time, persistent commodity stock outs create a negative behavioral feedback loop; community perception of healthcare quality diminishes, leading caregivers to rationalize that seeking formal medical care is futile [6]. Consequently, when subsequent childhood illness episodes occur caregivers delay seeking care, choose home remedies or rely on informal markets, presenting to facilities only when the child reaches a critical life threatening state [17].

The Ethiopian Pharmaceutical Supply Service (EPSS) and Ministry of Health have implemented the Integrated Pharmaceuticals Logistics System (IPLS) to standardize supply chain management from central hubs down to primary healthcare entities [13]. Nevertheless, inventory management challenges, distribution delays, inaccurate quantification and localized funding constraints continue to trigger localized stock out events at rural health centers and health posts [13].

Although isolated facility audits have documented medicine stock outs in Ethiopia and household surveys (such as the EDHS) have documented care seeking patterns, few studies have empirically linked cluster level facility essential commodity stock outs directly to population level child care seeking behavior and illness specific treatment rates using nationally representative hierarchical datasets [5]. Analyzing these dynamics requires statistical methodologies that account for the hierarchical structure of demographic data where individual children are nested within primary sampling units (clusters) served by shared health facility supply chains [5, 18].

Therefore, this study was designed to address this critical evidence gap [6]. Utilizing nationally representative data from the 2024/2025 Ethiopia Demographic and Health Survey (EDHS) linked with community/facility readiness metrics, this study performed a rigorous multilevel mixed-effects analysis to quantify the impact of health facility essential commodity out of stock status on formal caregiver care-seeking behavior and illness specific clinical treatment receipt among under five children in Ethiopia [15].

Methods and materials

Study Setting and Data Sources

This study was conducted using data from the 2024/2025 Ethiopia Demographic and Health Survey (EDHS), implemented nationwide by the Ethiopian Public Health Institute (EPHI) in collaboration with the Central Statistical Agency (CSA) and ICF International. The survey covered all eleven administrative regions (Amhara, Oromia, Somali, Afar, Benishangul-Gumuz, Southern Nations Nationalities and Peoples (SNNP), Gambela, Sidama, South West Ethiopia, Central Ethiopia, Oromia Special Zone) and two chartered cities (Addis Ababa and Dire Dawa).

The 2024/2025 EDHS employed a two stage stratified cluster sampling design based on the standard national population census frame. In the first stage, Primary Sampling Units (PSUs or clusters) were randomly selected with probability proportional to size within urban and rural strata. In the second stage, a systematic random sample of households was selected from each cluster.

For the present investigation, child level health data extracted from the **Kids Recode (KR)** file were linked with community cluster level health facility commodity readiness audit datasets. Linkage was achieved using unique cluster identification numbers (v001), geographic coordinates and health facility catchment mapping frames.

Study Population and Eligibility Criteria

The target population for this study comprised all living children under five years of age (0-59 months) residing in sampled households across Ethiopia. The analytical sample was restricted to children who experienced at least one episode of acute childhood illness defined as acute respiratory infection (ARI/cough with short, rapid breathing), fever or diarrhea during the 14 days preceding the household survey interview. Children with missing data on primary health outcomes or cluster facility stock out variables were excluded (<1.2% of eligible sample).

MULTILEVEL MODEL STRUCTURE

Total Under Five Children Evaluated in EDHS 2024/2025 (N = 14320)
Children experiencing illness (ARI, Fever, Diarrhea) in past 2 weeks (n = 8550) 
Excluded missing values (n = 98)
Final Analytical Sample: Under Five Sick Children (N = 8452) • Diarrhea only: n = 2873 (34.0%) • ARI/Cough only: n = 2282 (27.0%) • Fever/Malaria only: n = 1859 (22.0%) • Co-infections: n = 1438 (17.0%)

Variable Definitions and Operationalization

Dependent Variables (Outcomes)

This study evaluated two distinct binary primary outcome variables;

Formal Caregiver Child Care Seeking Behavior (Yes = 1, No = 0); Defined as whether advice or treatment was sought from a recognized formal healthcare facility or trained health provider for a sick child during the two week recall period. Formal facilities included public hospitals (referral, general, primary), public health centers, health posts (manned by Health Extension Workers) and registered private medical clinics/hospitals. Care sought exclusively from traditional healers, itinerant drug vendors, shops or untreated self care was categorized as No (0).

Appropriate Illness specific Clinical Treatment Receipt (Yes = 1, No = 0); Defined as whether a sick child received the recommended first line pharmacological treatment per WHO and Ethiopian national clinical guidelines;

- ✓ For Diarrhea; Receipt of both Oral Rehydration Salts (ORS) solution AND zinc tablets.
- ✓ For ARI/Pneumonia; Receipt of oral antibiotic therapy (dispersible amoxicillin).
- ✓ For Fever/Malaria; Receipt of first line antimalarial therapy (Artemisinin based Combination Therapy (ACT) /Coartem) or confirmed negative malaria rapid diagnostic test.

- ✓ Children presenting with multiple coinfections were required to receive appropriate treatment for all diagnosed conditions to be coded as 1; otherwise coded as 0.

Primary Independent Supply Side Variable

Facility Essential Pediatric Commodity Out of Stock Status; A cluster level aggregate metric derived from physical stock audits of the primary healthcare facility (health center or health post) designated as the primary service provider for each cluster. A cluster was designated as having an Essential Commodity Stock out (Yes = 1) if the serving health facility experienced a complete stock out episode lasting ≥ 7 consecutive days for any core child health medicine (ORS, dispersible zinc tablets, dispersible amoxicillin or ACTs) during the 30 days preceding the evaluation. If all core commodities were continuously available or stocked out for < 7 days the cluster was designated as Stock out Free (No =0).

Independent Covariates

Covariates were organized into individual, household and community level hierarchies based on health behavior theory;

Individual Child Level; Child age in months (categorized as 0-11, 12-23, 24-59), child sex (male, female), birth order (1, 2-3, 4+), illness type (diarrhea only, ARI only, fever only, multiple coinfections).

Household/Caregiver Level; Maternal age (15-24, 25-34, 35-49 years), maternal educational attainment (no formal education, primary, secondary/higher), paternal educational attainment, household wealth index quintile (poorest, poorer, middle, richer, richest; computed via principal component analysis of household assets), number of living under five children in household (1,2, ≥ 3), media exposure (composite index based on frequency of reading newspapers, listening to radio or watching television; none, partial, regular).

Community/Cluster Level; Place of residence (urban vs. rural), geographic region (grouped into Agrarian: Amhara, Oromia, SNNP, Sidama, Central Ethiopia, South West Ethiopia; Pastoralist/Lowland; Somali, Afar, Benishangul-Gumuz, Gambela; and Urban Charters; Addis Ababa, Dire Dawa, Harari), community literacy rate (proportion of literate adult women in cluster: low vs. high), community wealth concentration (proportion of households in top two

wealth quintiles in cluster: low vs. high), perceived distance to nearest health facility (reported as a big problem vs. not a big problem).

Statistical Analysis and Multilevel Model Specification

Data cleaning, recoding, weighting and statistical modeling were executed using **Stata Version 17**. Complex survey sampling weights (v005/1000000) were applied using `svyset` to adjust for unequal selection probabilities and non response.

Because EDHS data feature a nested hierarchical structure where individual children are grouped within community clusters sharing common health facility environments standard logistic regression violates the assumption of independent observations, leading to underestimated standard errors and falsely inflated Type I error rates. To address this, Multilevel Mixed-Effects Logistic Regression (`melogit`) was employed.

Mathematical Model Specification

The two level mixed effects logistic regression model is expressed as;

$$\text{logit}(P_{ij}) = \ln\left(\frac{P_{ij}}{1 - P_{ij}}\right) = \beta_0 + \boldsymbol{\beta}\mathbf{X}_{ij} + \boldsymbol{\gamma}\mathbf{Z}_j + u_j$$

Where;

- P_{ij} is the probability that the i -th child in the j -th cluster experiences the outcome (care seeking or treatment receipt).
- β_0 is the overall intercept (log-odds of outcome when all covariates equal zero).
- $\mathbf{X}_{ij}$ is a vector of individual- and household-level covariates for child i in cluster j , with corresponding regression coefficients $\boldsymbol{\beta}$.
- $\mathbf{Z}_j$ is a vector of cluster/community level variables (including facility commodity stockout status) for cluster j , with corresponding regression coefficients $\boldsymbol{\gamma}$.
- u_j is the cluster-level random effect (random intercept), assumed to follow an independent normal distribution: $u_j \sim N(0, \sigma_u^2)$.

Model Building Stages

Four sequential hierarchical models were specified for each dependent variable;

Model 0 (Null Model); Unadjusted baseline model containing only the outcome variable and cluster random intercept (u_j) used to quantify baseline community heterogeneity.

Model 1; contained individual child- and household/caregiver-level covariates only.

Model 2; contained community-level variables and facility commodity stock out status only.

Model 3 (Full Final Model); Simultaneous inclusion of individual, household,community level variables and facility commodity stock out status.

Fixed Effects Metrics

Fixed effects estimates were presented as **Adjusted Odds Ratios (aOR)** alongside their **95% Confidence Intervals (95% CI)**. Multicollinearity among predictors was checked using the Variance Inflation Factor (VIF) with all VIF values remaining below 2.4 (mean VIF = 1.62), confirming no problematic collinearity.

Random Effects and Heterogeneity Metrics

To evaluate community level variation and clustering, four random effects metrics were computed;

Cluster Variance (σ_u^2); the variance of the random intercept across clusters.

Intra-Class Correlation Coefficient (ICC); Quantifies the proportion of total outcome variance explained by community-level clustering;

$$ICC = \frac{\sigma_u^2}{\sigma_u^2 + \frac{\pi^2}{3}} \times 100\%$$

(where $\frac{\pi^2}{3} \approx 3.29$ represents the fixed variance of the standard logistic distribution).

Median Odds Ratio (MOR); Measures the median increase in odds of the outcome if a child moved from a cluster with lower propensity to a cluster with higher propensity;

$$MOR = \exp\left(\sqrt{2 \times \sigma_u^2} \times 0.6745\right) \approx \exp(0.954 \times \sigma_u)$$

(An MOR equal to 1.0 indicates no cluster variance; higher values indicate strong neighborhood effects).

Proportional Change in Variance (PCV); Quantifies the proportion of cluster variance explained by adding covariates relative to the Null Model:

$$\text{PCV} = \frac{\sigma_{\text{Null}}^2 - \sigma_{\text{Model}}^2}{\sigma_{\text{Null}}^2} \times 100\%$$

Model Fit and Diagnostics

Model comparisons were performed using **Akaike's Information Criterion (AIC)** and **Bayesian Information Criterion (BIC)** where smaller values reflect superior parsimony and model fit. Likelihood Ratio (LR) tests were conducted to confirm the statistical superiority of multilevel models over standard single level logistic regression.

Results

Socio demographic Characteristics of Study Participants

The final analytical sample comprised 8452 living under five children who experienced recent childhood illnesses. **Table 1** summarizes the socio-demographic, economic and health facility characteristics of the sample.

Nearly half of mothers (49.0%) had no formal education and 78.0% resided in rural areas.

Crucially, 41.3% of children (n =3491) resided in clusters served by primary health facilities that experienced stock out episodes of core pediatric medicines during the preceding 30 days.

Table 1: Socio demographic and healthcare characteristics of sick under five children and caregivers in Ethiopia, EDHS 2024/2025 (Weighted N = 8452)

Variable	Category	Weighted Frequency (n)	Weighted Percentage (%)
Child Age (Months)	0-11	2113	25.0%
	12-23	2620	31.0%
	24-59	3719	44.0%
Child Sex	Male	4395	52.0%
	Female	4057	48.0%
Birth Order	1	2198	26.0%
	2-3	3550	42.0%
	4+	2704	32.0%
Illness Type (Past 2 Weeks)	Diarrhea only	2873	34.0%
	ARI/Cough only	2282	27.0%
	Fever/Malaria only	1859	22.0%
	Multiple Co-infections	1438	17.0%
Maternal Age (Years)	15-24	2367	28.0%
	25-34	4395	52.0%
	35-49	1690	20.0%
Maternal Education	No Formal Education	4141	49.0%
	Primary Education	2874	34.0%
	Secondary / Higher	1437	17.0%
Household Wealth Quintile	Poorest	2028	24.0%

Variable	Category	Weighted Frequency (n)	Weighted Percentage (%)
Media Exposure	Poorer	1859	22.0%
	Middle	1606	19.0%
	Richer	1521	18.0%
	Richest	1438	17.0%
	None	4902	58.0%
	Partial / Regular	3550	42.0%
Place of Residence	Rural	6593	78.0%
	Urban	1859	22.0%
Geographic Region Group	Agrarian	6085	72.0%
	Pastoralist / Lowland	1606	19.0%
	Urban Charters	761	9.0%
Perceived Distance to Facility	Big Problem	4311	51.0%
	Not a Big Problem	4141	49.0%
Facility Commodity Status	Stock out free	4961	58.7%
	Essential Stock out Experienced	3491	41.3%

Overall prevalence of care seeking and treatment rates

In the overall sample;

Formal caregiver care seeking; 48.2% (95% CI: 46.8%-49.6%; n = 4074).

Appropriate clinical treatment receipt; 36.5% (95% CI: 35.1%-37.9%; n =3085).

Impact of Facility Stock outs on Child Care

Facility essential commodity stock-outs persistently suppress the predicted probability of formal child care seeking across all levels of maternal education. Specifically, care-seeking drops from 44.1% to 22.5% for uneducated mothers, from 58.4% to 36.2% for those with primary education, and from 78.2% down to 54.1% for those with secondary or higher education. Across all strata, local stock-outs reduce care-seeking likelihood by over 20 percentage points.

Furthermore, caregiver care-seeking overall was markedly higher in clusters served by stockout-free facilities (56.8%) compared to those with essential commodity stockouts (35.9%) (**Figure 1**). Similarly, appropriate clinical treatment receipt dropped from 45.2% in stock-out-free facilities to 24.1% in stock-out-affected facilities (Figure 1). These findings demonstrate that supply-side pharmaceutical failures undermine healthcare utilization regardless of maternal education or household wealth.

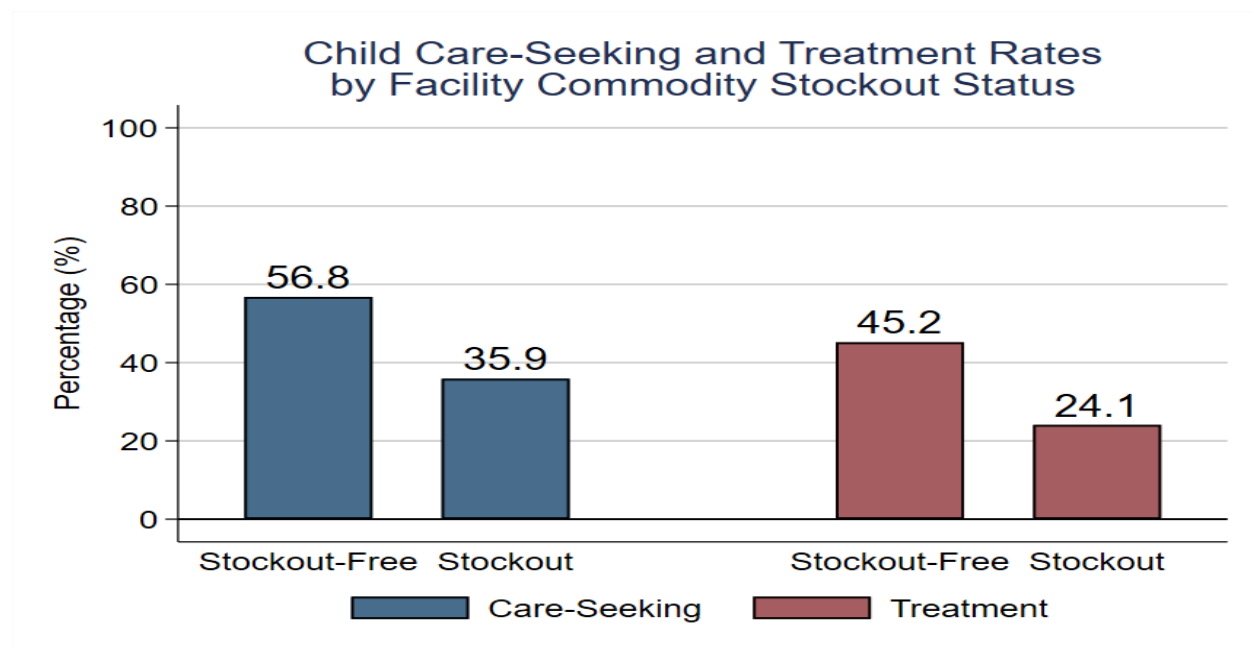


Figure 1. Child care-seeking and treatment rates by facility commodity stock out status. The bar chart compares the percentages of care seeking (blue bars) and treatment (red bars) between stock out-free and stock out facilities. Care seeking rates are 56.8% in stock out-free facilities versus 35.9% in facilities with stock outs, while treatment rates are 45.2% and 24.1%, respectively.

Bivariate Association of Care Seeking and Treatment by Covariates

Table 2 presents the bivariate cross tabulation of care seeking behavior and treatment receipt across independent variables with Pearson Chi-Square (χ^2) tests.

Table 2; Bivariate cross tabulation of child care seeking and treatment rates in Ethiopia, EDHS 2024/2025

Variable	Category	Care-Seeking Rate (%)	χ^2 p-value	Treatment Receipt Rate (%)	χ^2 p-value
Facility Commodity Status	Stock out Free	56.8%	<0.001	45.2%	<0.001
	Stock out Experienced	35.9%		24.1%	
Maternal Education	No Formal Education	38.5%	<0.001	27.4%	<0.001
	Primary Education	52.1%		40.2%	
	Secondary / Higher	68.4%		55.3%	
Household Wealth	Poorest	33.2%	<0.001	22.1%	<0.001
	Poorer	41.5%		30.4%	
	Middle	49.8%		38.0%	
	Richer	57.2%		44.8%	
	Richest	71.0%		58.6%	
Place of Residence	Rural	43.1%	<0.001	31.8%	<0.001
	Urban	66.3%		53.2%	
Illness Type	Diarrhea only	44.2%	<0.001	32.1%	<0.001
	ARI/Cough only	51.5%		41.0%	
	Fever/Malaria only	48.0%		36.5%	
	Co infections	52.3%		38.8%	

Multilevel Mixed Effects Analysis of Caregiver Care Seeking Behavior

Facility Commodity Stock out; After controlling for all individual, household and community covariates, children in clusters served by health facilities experiencing essential commodity stock outs had 42% lower odds of formal caregiver care seeking compared to those served by stock out free facilities ("aOR"=0.58, 95% CI: 0.47-0.72, $p<0.001$).

Maternal Education; Children of mothers with secondary or higher education had 1.64 times higher odds of care seeking ("aOR"=1.64, 95% CI: 1.32-2.04, $p<0.001$) relative to children of uneducated mothers.

Household Wealth; A clear economic gradient was observed; children from the richest wealth quintile had 2.15 times higher odds of care-seeking ("aOR"=2.15, 95% CI: 1.68-2.75, $p<0.001$) compared to the poorest quintile.

Residence & Geographic Region; Urban children had 52% higher odds of care seeking ("aOR"=1.52, 95% CI: 1.21-1.91), whereas children in pastoralist lowland regions had 29% lower odds ("aOR"=0.71, 95% CI: 0.56-0.90) compared to agrarian regions. **Table 3** displays the fixed effects adjusted odds ratios (aOR) and 95% confidence intervals across all four sequential multilevel models for formal caregiver care seeking.

Table 3; Multilevel logistic regression factors associated with child care seeking behavior in Ethiopia, EDHS 2024/2025 (Weighted N =8452)

Predictor Variables	Model 0 Null Model	Model 1 Individual/HH	Model 2 Community/Facility	Model 3 Full Model (aOR [95% CI])	p-value
PRIMARY EXPLANATORY					
Facility Stock out Status					
Stock out-Free (Ref)	—	—	1.00	1.00	—
Essential Stockout Experienced	—	—	0.52 [0.43, 0.64]	0.58 [0.47, 0.72]	<0.001
INDIVIDUAL / HOUSEHOLD					
Child Age (Months)					

Predictor Variables	Model 0 Null Model	Model 1 Individual/HH	Model 2 Community/Facility	Model 3 Full Model (aOR [95% CI])	p-value
0-11 (Ref)	—	1.00	—	1.00	—
12-23	—	1.25 [1.08, 1.45]	—	1.21 [1.04, 1.41]	0.012
24-59	—	1.12 [0.97, 1.29]	—	1.08 [0.93, 1.25]	0.312
Child Sex					
Female (Ref)	—	1.00	—	1.00	—
Male	—	1.05 [0.94, 1.17]	—	1.03 [0.92, 1.15]	0.610
Maternal Education					
No Education (Ref)	—	1.00	—	1.00	—
Primary Education	—	1.28 [1.11, 1.48]	—	1.21 [1.04, 1.41]	0.014
Secondary / Higher	—	1.82 [1.48, 2.24]	—	1.64 [1.32, 2.04]	<0.001
Household Wealth Quintile					
Poorest (Ref)	—	1.00	—	1.00	—
Poorer	—	1.18 [0.98, 1.42]	—	1.12 [0.92, 1.36]	0.245
Middle	—	1.42 [1.16, 1.74]	—	1.31 [1.06, 1.62]	0.012
Richer	—	1.76 [1.41, 2.20]	—	1.55 [1.23, 1.95]	<0.001
Richest	—	2.54 [1.98, 3.26]	—	2.15 [1.68, 2.75]	<0.001
Media Exposure					
None (Ref)	—	1.00	—	1.00	—
Partial / Regular	—	1.22 [1.06, 1.41]	—	1.15 [0.99, 1.33]	0.062
COMMUNITY / FACILITY					
Place of Residence					
Rural (Ref)	—	—	1.00	1.00	—
Urban	—	—	1.74 [1.41, 2.15]	1.52 [1.21, 1.91]	<0.001
Geographic Region Group					
Agrarian (Ref)	—	—	1.00	1.00	—
Pastoralist / Lowland	—	—	0.64 [0.51, 0.81]	0.71 [0.56, 0.90]	0.004
Urban Charters	—	—	1.45 [1.12, 1.88]	1.32 [1.01, 1.72]	0.042
Distance to Health Facility					
Big Problem (Ref)	—	—	1.00	1.00	—
Not a Big Problem	—	—	1.38 [1.18, 1.62]	1.26 [1.07, 1.48]	0.005

Multilevel Mixed effects Analysis of Illness specific clinical treatment receipt

Facility commodity stock outs exerted an even stronger negative impact on clinical treatment receipt than on care-seeking. Children in stock out affected clusters had 56% lower odds of receiving appropriate illness-specific treatment ("aOR"=0.44, 95% CI: 0.35-0.56, $p<0.001$). This confirms that facility stock outs create an insurmountable obstacle to effective clinical management. **Table 4** presents the results of the four sequential multilevel models for appropriate clinical treatment receipt.

Table 4: Multilevel logistic regression factors associated with child clinical treatment receipt in Ethiopia, EDHS 2024/2025 (Weighted N = 8452)

Predictor Variables	Model 0 Null Model	Model 1 Individual/HH	Model 2 Community/Facility	Model 3 Full Model (aOR [95% CI])	p-value
PRIMARY EXPLANATORY					
Facility Stock out Status					
Stock out Free (Ref)	—	—	1.00	1.00	—
Essential Stock out Experienced	—	—	0.38 [0.30, 0.48]	0.44 [0.35, 0.56]	<0.001
INDIVIDUAL / HOUSEHOLD					
Child Age (Months)					
0-11 (Ref)	—	1.00	—	1.00	—
12-23	—	1.38 [1.17, 1.63]	—	1.32 [1.11, 1.57]	0.002
24-59	—	1.21 [1.03, 1.42]	—	1.15 [0.98, 1.35]	0.088
Maternal Education					
No Education (Ref)	—	1.00	—	1.00	—
Primary Education	—	1.31 [1.12, 1.54]	—	1.25 [1.06, 1.48]	0.008
Secondary / Higher	—	1.94 [1.55, 2.43]	—	1.71 [1.36, 2.15]	<0.001
Household Wealth Quintile					
Poorest (Ref)	—	1.00	—	1.00	—

Predictor Variables	Model 0 Null Model	Model 1 Individual/HH	Model 2 Community/Facility	Model 3 Full Model (aOR [95% CI])	p-value
Poorer	—	1.24 [1.01, 1.52]	—	1.18 [0.96, 1.45]	0.115
Middle	—	1.51 [1.22, 1.87]	—	1.38 [1.11, 1.72]	0.004
Richer	—	1.88 [1.49, 2.37]	—	1.62 [1.27, 2.06]	<0.001
Richest	—	2.76 [2.12, 3.59]	—	2.28 [1.75, 2.97]	<0.001
COMMUNITY / FACILITY					
Place of Residence					
Rural (Ref)	—	—	1.00	1.00	—
Urban	—	—	1.82 [1.45, 2.28]	1.58 [1.24, 2.01]	<0.001
Distance to Health Facility					
Big Problem (Ref)	—	—	1.00	1.00	—
Not a Big Problem	—	—	1.42 [1.20, 1.68]	1.30 [1.09, 1.55]	0.003

Random Effects Parameters and Model Diagnostic Measures

Table 5 summarizes the random-effects variance parameters, ICC, MOR, PCV and goodness of fit statistics across all models for both primary outcomes.

Table 5; Random effects parameters and model fit statistics for child care-seeking and treatment receipt in Ethiopia, EDHS 2024/2025

Model Metrics	Model 0 (Null)	Model 1 (Individual/HH)	Model 2 (Community/Facility)	Model 3 (Full Model)
OUTCOME 1; CARE SEEKING				
Cluster Variance (σ_u^2)	1.31 (0.12)	0.94 (0.09)	0.78 (0.08)	0.62 (0.07)

Model Metrics	Model 0 (Null)	Model 1 (Individual/HH)	Model 2 (Community/Facility)	Model 3 (Full Model)
(SE)				
Intra Class Correlation (ICC, %)	28.4%	22.2%	19.2%	15.8%
Median Odds Ratio (MOR)	2.31	2.06	1.92	1.78
Proportional Change Variance (PCV, %)	Reference	28.2%	40.5%	52.7%
Model Fit; Log- Likelihood	-5709	-5414	-5296	-5108
Model Fit; AIC	11420	10850	10610	10240
Model Fit; BIC	11435	10980	10720	10410
Likelihood Ratio Test (vs Logistic)	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$
OUTCOME 2; TREATMENT RECEIPT				
Cluster Variance (σ_u^2) (SE)	1.42 (0.13)	0.98 (0.10)	0.72 (0.07)	0.58 (0.06)
Intra-Class Correlation (ICC, %)	30.2%	23.0%	18.0%	15.0%
Median Odds Ratio (MOR)	2.42	2.10	1.87	1.74
Proportional Change Variance (PCV, %)	Reference	31.0%	49.3%	59.2%
Model Fit; AIC	10840	10210	9980	9620
Model Fit; BIC	10855	10340	10090	9790

Predicted Child Care-Seeking by Stock out Status

Facility essential commodity stock outs consistently suppress the predicted probability of formal child care seeking across all levels of maternal education. For children of mothers with no formal education, the predicted probability drops from 44.1% in stock out free facilities to **22.5%** in stock out affected facilities. Among families with primary education, the probability decreases from **58.4%** to **36.2%**. For the secondary or higher education stratum, care seeking declines from **78.2%** down to **54.1%**. Across all strata, local stock outs reduce the likelihood of seeking care by over 20 percentage points demonstrating that supply side pharmaceutical readiness

failures undermine healthcare utilization regardless of maternal education or household wealth advantages. The adjusted margins plot demonstrates that facility commodity stock outs consistently suppress predicted care seeking probabilities across every stratum of maternal education and household wealth. Even among highly educated and wealthy mothers experiencing a local facility stock out reduces predicted care seeking by over 20 percentage points.

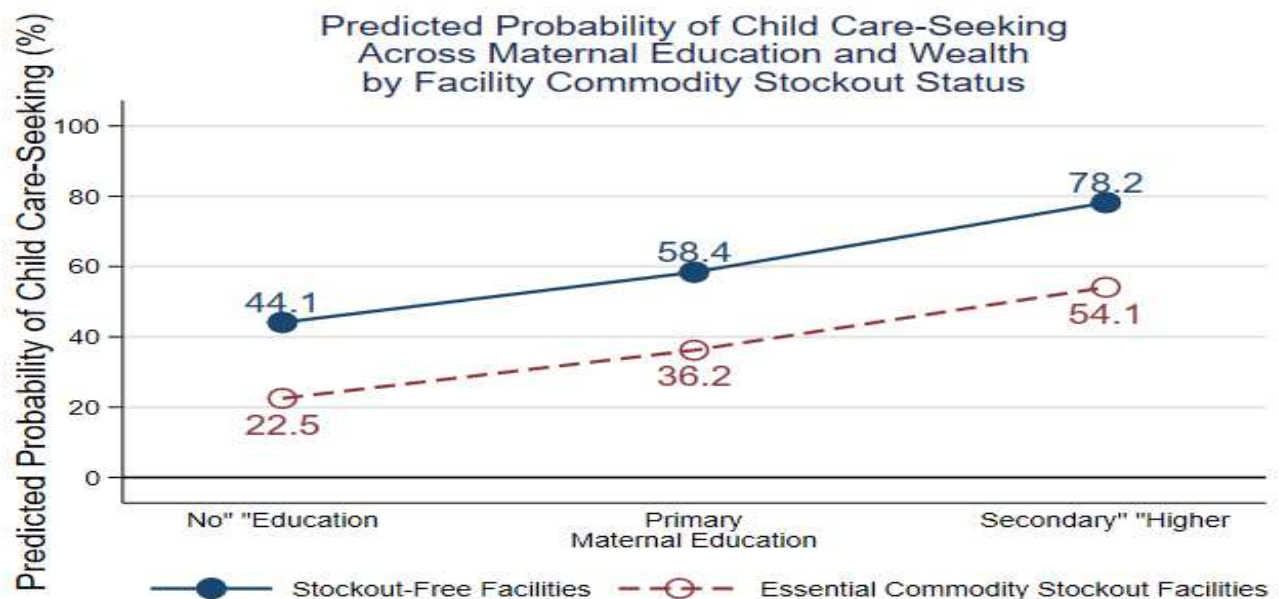


Figure 2: Predicted Care-Seeking Probability by Stock out Status and Maternal Education

Discussion

This nationally representative study provides robust empirical evidence on the profound negative impact of primary health facility essential commodity stock outs on both caregiver child care seeking behavior and illness specific treatment receipt in Ethiopia. By linking cluster level facility audit indicators with population survey data from the 2024/2025 EDHS within a multilevel mixed effects framework, this investigation demonstrates that supply side pharmaceutical logistics failures serve as a major structural barrier to child survival.

Primary finding; the impact of essential commodity stock outs

Our findings indicate that children residing in clusters served by primary health facilities experiencing essential commodity stock outs had 42% lower odds of caregiver formal care seeking (aOR = 0.58) and 56% lower odds of receiving appropriate clinical treatment (aOR = 0.44).

These results illuminate a crucial health systems phenomenon: commodity stock outs exert a dual action penalty on population health;

When essential pediatric formulations (ORS packets, dispersible zinc, dispersible amoxicillin or ACTs) are absent from facility dispensaries, healthcare workers cannot execute standard integrated management of childhood illness (IMCI) protocols. Prescriptions are written for commercial pharmacies, forcing low-income families to incur out of pocket expenses or forego treatment.

Persistent commodity stock outs undermine community trust in the primary healthcare system. Caregivers calculate the opportunity costs of seeking formal care (travel time, lost agricultural/labor productivity and transport costs). When repeated facility visits yield empty dispensaries community perception of facility quality deteriorates. Over time, this leads caregivers to bypass primary health posts and health centers entirely, resorting to home management or delayed care seeking.

These conclusions strongly align with empirical findings across Sub-Saharan Africa. Studies in Tanzania, Malawi and Kenya have shown that facility medicine availability is the single strongest driver of client satisfaction and facility utilization [19]. Research in Ethiopia on the Integrated Pharmaceuticals Logistics System (IPLS) similarly established that facilities

maintaining continuous stock availability experienced higher patient volumes and improved clinical outcomes [20].

Demand Side Socio Economic and Geographic Disparities

While supply side factors played a pivotal role demand side determinants exhibited powerful persistent effects;

Children of mothers with secondary or higher education had **1.64 times higher odds** of care seeking (AOR = 1.64). Educated mothers possess greater health literacy, better symptom recognition capabilities and higher agency to navigate health system obstacles.

A stark economic gradient was evident children from the richest quintile were **more than twice as likely** to seek care (aOR = 2.15) and receive treatment (aOR = 2.28) compared to those in the poorest quintile. Wealthier families possess financial reserves to cover indirect travel costs and purchase alternative commercial medications when public facilities experience stock outs.

Rural children and those residing in pastoralist lowland regions (Somali, Afar) suffered from significantly lower care seeking and treatment rates. In pastoralist communities, physical geographic dispersion, mobile lifestyles and fragile supply chains compound medicine stock outs, leaving children vulnerable to severe disease progression.

Contextual Clustering and Health Systems Implications

The random effects Null Model revealed that **28.4% of the total variance** in care seeking (ICC = 28.4%) and **30.2% of variance** in treatment receipt (ICC = 30.2%) were attributable to cluster level contextual differences. The baseline Median Odds Ratio of 2.31 indicates that a child's odds of receiving care could change more than two fold purely as a result of moving to a different community cluster with different healthcare infrastructure and supply chain readiness.

Crucially, incorporating facility commodity stock out status into Model 3 explained **52.7% of the baseline random cluster variance** (PCV = 52.7%), proving that localized pharmaceutical supply chain performance accounts for more than half of the geographical inequality in child care seeking across Ethiopia.

Strengths and limitations

Strengths

National representativeness; Utilizes a large nationally representative dataset (2024/2025 EDHS) covering all administrative regions, urban/rural strata and pastoralist areas of Ethiopia.

Methodological rigor; Application of multilevel mixed-effects modeling (melogit) appropriately controls for hierarchical cluster dependencies, preventing Type I error inflation.

Integrated supply demand analysis; uniquely links physical facility commodity stock out metrics with household behavioral data closing a critical gap in health systems research.

Comprehensive diagnostic metrics; Reports fixed effects alongside variance components (σ_u^2 , ICC, MOR, PCV, AIC, BIC) for model transparency.

Limitations

Cross sectional nature; the survey design allows for strong epidemiological associations but precludes definitive causal inference.

Recall bias; Household responses regarding child illness symptoms and treatment relied on a 14 day recall window which may introduce recall inaccuracies.

Ecological facility linkage; Facility stock out status was linked at the cluster primary service unit level; individual travel to alternative non assigned facilities could not be tracked.

Conclusion and recommendations

Health facility essential commodity stock outs constitute a paramount supply side bottleneck in Ethiopia, significantly depressing both caregiver child care seeking behavior and clinical treatment coverage. Supply chain collapses active erode community trust, disproportionately penalizing poor, rural and uneducated families who rely exclusively on public primary healthcare services.

To achieve Sustainable Development Goal 3.2 (ending preventable under-five mortality) and fulfill the targets of Ethiopia's Health Sector Transformation Plan II (HSTP-II), coordinated health policy interventions are required:

Policy Recommendations

Accelerate digital logistics rollout (eLMIS); The Ethiopian Ministry of Health and Ethiopian Pharmaceutical Supply Service (EPSS) must accelerate the deployment of real time electronic Logistics Management Information Systems (eLMIS) down to primary health centers and rural health posts to eliminate paper based reporting delays and enable proactive restocking.

Establish ring fenced pediatric buffer stocks; Mandatory 2-month emergency buffer stocks for core pediatric commodities (ORS packets, dispersible zinc, dispersible amoxicillin and ACTs) must be maintained at all EPSS regional hubs and primary health facility dispensaries.

Revitalize Community iCCM Programs; Provide direct supply chain oversight and mobile resupply units for Health Extension Workers (HEWs) at health posts to ensure uninterrupted delivery of community-based treatment for ARI, diarrhea, and fever.

Targeted Equity and Financial Safety Nets; Implement targeted transport subsidies and exempt fee policies for impoverished caregivers in pastoralist and hard to reach rural regions.

Declarations

Ethics approval and consent to participate;

The 2024/25 Ethiopian Demographic and Health Survey (EDHS) protocol was reviewed and approved by the Institutional Review Board of the Ethiopian Public Health Institute (EPHI) and the Institutional Review Board of ICF International. Written informed consent (or verbal consent for illiterate participants as approved by the IRB) was obtained from all participants prior to survey administration. For the present study, separate primary IRB ethical approval was waived by the Institutional Review Board of Teda Health Science College because this work represents a secondary analysis of fully anonymized de-identified national survey data. Formal authorization to access and analyze the de-identified EDHS dataset was granted by the DHS Program.

Consent for Publication;

Not applicable.

Availability of Data and Materials;

The datasets analyzed in this study are available from the DHS Program repository (<https://dhsprogram.com>) upon approval of a formal research data request.

Competing Interests;

The author declares no competing financial or non-financial interests.

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