Price Subsidies, Diagnostic Tests and the Targeting of Malaria Treatment

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DIME, August 2012
Introduction

- Limiting the spread of infectious disease is a public good

Limitation of the spread of infectious disease is a public good. Prevention and treatment products should be subsidized (Pigou) but in the presence of heterogeneous returns: trade off between access and targeting. Overuse is bad if there is a budget constraint (wasted subsidy dollars) but it's even worse if there are negative social spillovers. For example, use of antibiotics to treat viral infections contributes to antibiotic resistance. Likewise, antimalarial treatment in the absence of malaria can contribute to antimalarial resistance.

Trade-off between affordability today and effectiveness in the future.

Prescription-only drugs are difficult to enforce when weak governance, lack of doctors.

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Subsidies and Malaria Treatment

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Subsidies and Malaria Treatment
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This Paper: Subsidies for Malaria Treatment

▶ Malaria = >1 million deaths every year
▶ New drug called ACT = Artemisinin Combination Therapy
  ▶ Combines Artemisinin with a partner drug to slow resistance development
  ▶ Problem: Unaffordable for most (Kenya: $6.25 to treat adult, $1.56 to treat infant)
▶ Global Fund AMF: Reduce price of over-the-counter ACTs by 92-95 percent

1. Improve access and save lives
2. Fight resistance to artemisinin (by crowding out monotherapy)
▶ Potential problem: risk of overtreatment

Drug Resistance
▶ Wasted subsidy dollars (pilot in 7 countries = $240M in just over a year)
▶ Delays in learning about effectiveness of ACT (Aadhva ryu, 2012)
▶ Delays in appropriate treatment

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1. How worried should policy-makers be about overtreatment?
   ▶ A lot. At proposed ACT subsidy level (92%), only 39% of adults who take ACTs actually have malaria.

2. Does it mean they shouldn't subsidize ACTs?
   ▶ They should. Without subsidy, ACT access is very low, especially among the poor. Children die.

3. So what should they do?
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Moving from the proposed 92% ACT subsidy to a 80% ACT subsidy + RDT subsidy ⇒ increases the share of ACT takers who are malaria positive by 24 percentage points
  - Could be even higher in the long-run once people trust RDT results
How did we generate these findings?

- Field experiment in poor, rural, malaria-endemic area (Western Kenya) in 2009

- Randomized \( \sim 2,700 \) households into three policy regimes:
  - No subsidy (status quo until a few months ago)
  - Subsidy for ACT at the local drug shop (variation: 80-92 percent \( \Rightarrow \$0.50-\$1.25 \) to treat an adult)
  - Subsidy for ACT + subsidy for Rapid Diagnostic Test (RDT) (85 percent \( \Rightarrow \$0.19 \) to test)
1. Background: Treatment-Seeking Behavior in Rural Africa

2. Theoretical Framework

3. Experimental Design

4. Results

5. Conclusion
Baseline Treatment Seeking Behavior

- Three main options
  - Go to health center / Go to drug shop / Do nothing
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- Health center
  - Can consult with trained health professional
  - Microscopic testing available (*but*: high rates of false negatives, test results largely ignored)
  - RDTs introduced in few health centers (*but*: quite rare)
  - ACTs free to those who have malaria (*but*: stockouts, long lines)
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▶ Drug shop
  ▶ Not quite like CVS...
  ▶ No diagnostic testing available
  ▶ Drug shop staff doesn’t have medical training
  ▶ Sell many antimalarials that vary in price and effectiveness
    ▶ Cheaper drugs (SP, AQ, etc) sub-therapeutic (parasite resistance has left them only partly effective)
Baseline Treatment-Seeking Behavior

### Household Level Malaria and Diagnostic Incidence - Past Month

<table>
<thead>
<tr>
<th># of Presumed Malaria Episodes</th>
<th>1.22</th>
</tr>
</thead>
<tbody>
<tr>
<td>If Episode: Malaria Test</td>
<td>0.29</td>
</tr>
</tbody>
</table>

### Provider Choice for All Presumed Malaria Episodes

<table>
<thead>
<tr>
<th>Provider Choice</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health Center Visit</td>
<td>0.41</td>
</tr>
<tr>
<td>Drug Shop Visit</td>
<td>0.37</td>
</tr>
<tr>
<td>No Care</td>
<td>0.18</td>
</tr>
</tbody>
</table>

### Medication for All Presumed Malaria Episodes

<table>
<thead>
<tr>
<th>Medication Type</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Antimalarial</td>
<td>0.22</td>
</tr>
<tr>
<td>ACT</td>
<td>0.21</td>
</tr>
<tr>
<td>SP, AQ, Other</td>
<td>0.35</td>
</tr>
<tr>
<td>Forgot Name</td>
<td>0.22</td>
</tr>
</tbody>
</table>

### Cost Per Episode (Ksh)

| Cost Per Episode | 131 |

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Theoretical Framework

- Policy parameters of interest:

  - The share of true malaria episodes that do not get treated with ACT for under-treatment.
  - The share of non-malaria episodes that are treated with ACT for over-treatment.
  - The objective of the social planner is to decrease UT while limiting the increase in OT.
  - Max $f(UT, OT)$, subject to a budget constraint.
  - A function that we focus on is fraction of ACT takers who are malaria positive:
    \[ T = (1 - UT)\Pi(1 - UT)\Pi + OT(1 - \Pi) \]
    where $\Pi$ represents the fraction of all illness episodes that are actually malaria.
Theoretical Framework

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  T = \frac{(1 - UT) \Pi}{(1 - UT) \Pi + OT (1 - \Pi)}
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  where $\Pi$ represent the fraction of all illness episodes that are actually malaria.
Theoretical Framework

Key questions: What are the derivatives of $UT, OT,$ and $T$ with respect to the ACT subsidy level? the presence of RDTs in the retail sector?

1. How households decide where to go when someone falls sick with a suspected malaria infection, and how this is affected by the subsidy regimes

Trades: convenience, cost, diagnostic services

2. How this varies with the household's prior over whether or not the illness is malaria
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Model Setup

1. Household gets an illness shock, generating a vector of symptoms. Objective probability of having malaria ($\pi$).
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2. Households can take one of three actions, $a$:
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3. Value of action $a$ given person is either malaria positive ($P$) or negative ($N$) is $V_k^a$, $k \in \{P, N\}$ $\Rightarrow$ Each action has expected value:

   $$V^a(\pi) = \pi V_P^a + (1 - \pi) V_N^a$$
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   \[
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   \]

4. Normalize: $V^n(\pi) = 0$
Possible Scenario

\[ V^0(\pi) \]

\[ V^1(\pi) \]

\[ V^2(\pi) \]
Possible Scenario

\[ V^\theta(\pi) \]

\[ V^\theta(\pi) \quad \text{and} \quad V^\theta(\pi) \]

Other Visits Health Center ACT at Drug Shop

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Impact of ACT Subsidy

\[ V^s(\pi) \]
\[ V^n(\pi) \]
\[ V^s(\pi) \]
\[ V^n(\pi) \]

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Crowd-Out of Health Center Visits

\[ V^o(\pi) \]

\[ V^e(\pi) \]

\[ V^n(\pi) \]

\[ V^{n'}(\pi) \]

0

\[ \pi \]

Other

ACT at Drug Shop

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Very Poor Households
Very Poor Households

\[ V_n(\pi) \]
\[ V_h(\pi) \]
\[ V_s(\pi) \]
\[ 0 \]
\[ V_a(\pi) \]
\[ \pi \]
\[ \text{Other} \]

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Very Poor Households: Impact of ACT Subsidy

\[ \pi \]

\[ V_n(\pi) \quad V_h(\pi) \quad V_s(\pi) \quad 0 \]

\[ V^a(\pi) \quad V^c(\pi) \quad V^c(\pi) \]

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Crowd-out no care / subtherapeutic care

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Summary: -UT, +OT, T ambiguous

Figure 1. Theoretical Treatment Seeking Scenarios

A. Rich Households

B. Poor Households

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Subsidies and Malaria Treatment

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Any ACT subsidy will increase rates of ACT access at the drug shop.
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- Crowd-out from health care centers $\Rightarrow$ increases overtreatment
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- Crowd-out from "doing nothing" ⇒ decreases undertreatment and increases overtreatment
- If the subsidy policy crowds in enough high-positivity poor relative to low-positivity rich, then overall targeting may improve, but overtreatment will nevertheless increase in any case
- What's more: if people are clueless w.r.t their π, then ACT subsidy might crowd-in a lot of low-positivity poor too
What if people are clueless?
How to counteract impact of ACT subsidy on overtreatment?

1. Make subsidized ACT a prescription-only drug: you can't get subsidy if you don't show a positive test result
   - Unfortunately we don't live in a best world...
   - Weak governance / regulatory environment makes this impossible (e.g., see what's happening with free ACTs for malaria+ people at health center)

2. Subsidy for over-the-counter RDT
   - Can get tested before buying ACT
   ⇒ improve targeting
   - But will people take RDTs? Will they adhere to test results?
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   - Weak governance / regulatory environment makes this impossible (e.g., see what’s happening with free ACTs for malaria+ people at health center)

2. Subsidy for over-the-counter RDT
   - Can get tested before buying ACT ⇒ improve targeting
   - But will people take RDTs? Will they adhere to test results?
Outline

1. Background: Treatment-Seeking Behavior in Rural Africa

2. Theoretical Framework

3. Experimental Design

4. Results

5. Conclusion
Catchment Area Census: Target 2,928 Households

Households Administered Baseline
2,789

ACT Subsidy
984

ACT+RDT Subsidy
1,625

No Subsidy
180
**Catchment Area Census: Target 2,928 Households**

Households Administered Baseline

2,789

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984

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1,625

**No Subsidy**

180

Within-Subsidy Price Variation

- **ACT Subsidy**
  - 92%: 328
  - 88%: 326
  - 80%: 330

- **ACT+RDT Subsidy**
  - 92%: 394
  - 88%: 619
  - 80%: 612
**Catchment Area Census: Target 2,928 Households**

- Households Administered Baseline: 2,789
  - ACT Subsidy: 984
    - Within-Subsidy Price Variation
      - 92%: 328
      - 88%: 326
      - 80%: 330
    - Endline Follow Up
      - 92%: 306
      - 88%: 310
      - 80%: 317
  - ACT+RDT Subsidy: 1,625
    - 92%: 394
    - 88%: 619
    - 80%: 612
  - No Subsidy: 180
    - Endline Follow Up: 173

- **Balance:**
  - Cohen, Dupas, Schaner
  - Subsidies and Malaria Treatment
  - DIME, August 2012
Sample of 2,911 Illness Episodes

- Collected roster of illness episodes over 4-month study period at endline (7,733 illnesses)
Sample of 2,911 Illness Episodes

- Collected roster of illness episodes over 4-month study period at endline (7,733 illnesses)
  - We focus on first illness episode reported by each household, since we are sure they all had vouchers at that time (2,911 first illnesses)
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  - Need to know this for everyone, whether they buy ACT or not
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- Collected roster of illness episodes over 4-month study period at endline (7,733 illnesses)
  - We focus on first illness episode reported by each household, since we are sure they all had vouchers at that time (2,911 first illnesses)

- Difficulty: need to know malaria status to assess UT, OT and Targeting
  - Need to know this for everyone, whether they buy ACT or not

- Idea: Use data on symptoms to predict malaria positivity
Malaria Status of Illness Episodes

- No clear mapping between symptoms and malaria probability in the medical literature (might be very local anyway)
- So we had to come up with our own mapping
- Posted enumerators at drug shop who tested for malaria a random subset of clients (and also recorded their symptoms and age)
  - Use this data to regress malaria status on symptoms and estimate coefficient for each symptom, by age group (“first-stage”)
  - Use first-stage coefficient estimates and reported symptoms to predict malaria positivity for all illness episodes
  - Wide range of predicted malaria positivity, though higher density at higher probability
- Predicting Malaria Positivity
- Distribution of Predicted Malaria Positivity
- No evidence of reporting bias (those who got ACT subsidy not more likely to report more malaria-looking illnesses)
- No Reporting Bias
1. Background: Treatment-Seeking Behavior in Rural Africa

2. Theoretical Framework

3. Experimental Design

4. Results

5. Conclusion
First let’s check what people are doing at baseline, in the absence of any ACT subsidy or RDT in the retail sector.
Baseline Treatment Seeking by Predicted Positivity

A. All

Predicted Positivity

- ACT at Drug Shop
- Visit to Health Center
- Other

Cohen, Dupas, Schaner
Subsidies and Malaria Treatment
DIME, August 2012
Baseline Treatment Seeking by Predicted Positivity

A. All

B. Literate Head

C. Illiterate Head

Notes: Data from "No Subsidy" group. Local linear regression lines trimmed at 2.5 percent. Tertiles demarcated by gray vertical lines. Median demarcated by dashed gray vertical line.

ACT at Drug Shop  
Visit to Health Center  
Other
Impact of Proposed ACT Subsidy

1. Impact on where people went for treatment
2. Impact on ACT treatment rate
Treatment-Seeking at Drug Shop Increases

- Crowding out of health center at higher malaria probability
- Crowding out of no care at low malaria probability
Crowd-in concentrated among Richer HHs

Cohen, Dupas, Schaner

Subsidies and Malaria Treatment
DIME, August 2012
Impact of Proposed ACT Subsidy

1. Impact on where people went for treatment
2. Impact on ACT treatment rate
Large increase in ACT Access

Illness was Treated with ACT

A. All

B. Literate Head

C. Illiterate Head

- No Subsidy
- ACT Subsidy

Notes: Local linear regression lines trimmed at 2.5 percent. Gray vertical lines demarcate tertiles. Dashed gray vertical line shows median.

Excludes households randomly selected for surprise RDT testing at drug shop.
Type I Errors mostly among Adults
Results from Surprise Malaria Tests among subsidized ACT buyers at Drug Shops

- 86 percent of patients ≤ 13 are malaria positive, 44 percent of patients > 13 are positive
Type I Errors mostly among Adults
Results from Surprise Malaria Tests among subsidized ACT buyers at Drug Shops

- 86 percent of patients $\leq 13$ are malaria positive, 44 percent of patients $> 13$ are positive

Still, some advantageous selection onto ACT taking on unobservables
How big does the ACT subsidy have to be?

- It’s clear that an ACT subsidy through retail sector is needed since access is very low without it (esp. among low SES)

- Could the ACT subsidy be a bit smaller than planned (say 80% instead of 95%)? Would that help deter overtreatment without reducing access (compared to proposed subsidy)?

- Alternatively, introduce RDT subsidy?
How big does the ACT subsidy have to be?

▶ It’s clear that an ACT subsidy through retail sector is needed since access is very low without it (esp. among low SES)

▶ But it’s also clear that willingness-to-pay for malaria treatment is not low (we observe large expenses per episode at baseline)
Preferred Subsidy Scheme

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- Alternatively, introduce RDT subsidy?
Illness was Treated with ACT

- ACT 80% Subsidy
- ACT 92% Subsidy
- No Subsidy

Cohen, Dupas, Schaner
Subsidies and Malaria Treatment
DIME, August 2012
Price Sensitivity within ACT Subsidy Group

Used ACT Voucher

Subsidy Level

Literate Head

Illiterate Head

Cohen, Dupas, Schaner

Subsidies and Malaria Treatment

DIME, August 2012
Does higher price crowd-out those less likely to have malaria?
Targeting Results

Share Malaria Positive

Subsidy Level

Mean 95% CI

Cohen, Dupas, Schaner
Subsidies and Malaria Treatment
DIME, August 2012
Higher ACT Price Crowds-out Adults

<table>
<thead>
<tr>
<th>Panel A. Retail-Sector ACTs</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Redeemed First ACT Voucher</td>
<td>Redeemed First ACT Voucher for Child (Ages 13 and Below)</td>
<td>Redeemed First ACT Voucher for Adult (Ages 14 and Above)</td>
<td>First ACT Voucher was Redeemed for Malaria Positive Patient (RDT Result)</td>
<td>Predicted Malaria Positivity of Patient for Whom First ACT Voucher was Redeemed</td>
<td></td>
</tr>
<tr>
<td>ACT Subsidy = 88%</td>
<td>-0.027</td>
<td>0.032</td>
<td>-0.058**</td>
<td>0.187**</td>
<td>0.112***</td>
</tr>
<tr>
<td></td>
<td>(0.038)</td>
<td>(0.034)</td>
<td>(0.027)</td>
<td>(0.080)</td>
<td>(0.042)</td>
</tr>
<tr>
<td>ACT Subsidy = 80%</td>
<td>-0.055</td>
<td>0.027</td>
<td>-0.082***</td>
<td>0.182**</td>
<td>0.107***</td>
</tr>
<tr>
<td></td>
<td>(0.037)</td>
<td>(0.034)</td>
<td>(0.026)</td>
<td>(0.084)</td>
<td>(0.043)</td>
</tr>
<tr>
<td>P-value: 88%–80%=0</td>
<td>0.338</td>
<td>0.603</td>
<td>0.006***</td>
<td>0.036**</td>
<td>0.011**</td>
</tr>
<tr>
<td>DV Mean (ACT 92%, no RDT)</td>
<td>0.439</td>
<td>0.268</td>
<td>0.171</td>
<td>0.563</td>
<td>0.424</td>
</tr>
<tr>
<td>N</td>
<td>2609</td>
<td>2609</td>
<td>2609</td>
<td>687</td>
<td>685</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Panel B. Overall ACT Access</th>
<th>If Child (Ages 13 and Below): Ilness Treated With ACT</th>
<th>If Adult (Ages 14 and Above): Ilness Treated With ACT</th>
<th>If Illness was Treated With ACT: Predicted Malaria Positivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACT Subsidy = 88%</td>
<td>-0.042</td>
<td>0.001</td>
<td>-0.128</td>
</tr>
<tr>
<td></td>
<td>(0.060)</td>
<td>(0.081)</td>
<td>(0.087)</td>
</tr>
<tr>
<td>ACT Subsidy = 80%</td>
<td>-0.017</td>
<td>0.021</td>
<td>-0.091</td>
</tr>
<tr>
<td></td>
<td>(0.058)</td>
<td>(0.080)</td>
<td>(0.083)</td>
</tr>
<tr>
<td>P-value: 88%–80%=0</td>
<td>0.783</td>
<td>0.951</td>
<td>0.323</td>
</tr>
<tr>
<td>DV Mean (ACT 92%, no RDT)</td>
<td>0.457</td>
<td>0.462</td>
<td>0.450</td>
</tr>
<tr>
<td>N</td>
<td>1880</td>
<td>1085</td>
<td>794</td>
</tr>
</tbody>
</table>

Notes: Panel A: The unit of observation is the household. Panel B: The unit of observation is the first illness episode that the household experienced following the baseline. 14 is the cutoff age above which the “adult dosage” is recommended (see Figure A1). Robust standard errors clustered at the household level when applicable in parentheses. All regressions include an RDT dummy and its interactions with the ACT price dummies. Regressions in first three columns control for a full set of strata dummy variables. Regressions in columns 4 and 5 omit strata and age controls so as not to absorb selection effects, which these regressions aim at identifying. ***, **, and * indicate significance at the 99, 95, and 90 percent levels respectively.
Preferred Subsidy Scheme?

- An 80% ACT subsidy gets almost the same reduction in undertreatment as 95% subsidy, but leads to lower overtreatment rate.

Still, about 50% of adult ACT takers at that price are malaria negative. Suggests need for diagnostic testing.

Next we look at impact of RDT subsidy.
Preferred Subsidy Scheme?

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- Still, about 50% of adult ACT takers at that price are malaria negative.
- Suggests need for diagnostic testing.
Preferred Subsidy Scheme?

- An 80% ACT subsidy gets almost the same reduction in undertreatment as 95% subsidy, but leads to lower overtreatment rate.
- Still, about 50% of adult ACT takers at that price are malaria negative.
- Suggests need for diagnostic testing.
- Next we look at impact of RDT subsidy.
Only modest impact of RDT on Targeting

Share Malaria Positive

Subsidy Level

No RDT  RDT

Share Malaria Positive

Cohen, Dupas, Schaner

Subsidies and Malaria Treatment

DIME, August 2012
Even though people are willing to experiment with RDTs

![Graph showing impact of Retail Sector RDT Subsidy on Malaria Testing](image)

Notes: Local linear regression lines trimmed at 2.5 percent. Gray vertical lines demarcate tertiles. Dashed gray vertical line shows median. Excludes households without RDT vouchers that were randomly selected for surprise RDT testing at drug shop.

- A. All
- B. Literate Head
- C. Illiterate Head

Took Malaria Test

![Graphs for different literacy levels](image)
Problem: Compliance with RDT results is imperfect

- 46 percent of individuals aged 9 and older took an ACT when they tested negative
- Not surprising? Rural microscopy very unreliable (Batwala et al 2010)
- Could RDTs become more effective in the long run?
- Even if compliance is not perfect, benefits to getting test:
  1. More likely to seek alternative diagnosis
  2. Less likely to negatively update about ACT if health does not improve after taking it
### Experimental Estimates of Access and Drug Shop Targeting (from Table 4)

<table>
<thead>
<tr>
<th></th>
<th>No Subsidy</th>
<th>ACT 92% Subsidy</th>
<th>ACT 80% Subsidy</th>
<th>ACT 80% + RDT Subsidy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Share Taking ACT A</td>
<td>0.282</td>
<td>0.457</td>
<td>0.437</td>
<td>0.432</td>
</tr>
<tr>
<td>Share Taking ACT at Drug Shop S</td>
<td>0.170</td>
<td>0.355</td>
<td>0.334</td>
<td>0.338</td>
</tr>
<tr>
<td>Share Taking ACT at Health Center 1-S</td>
<td>0.113</td>
<td>0.101</td>
<td>0.104</td>
<td>0.094</td>
</tr>
<tr>
<td>Targeting at Drug Shop Ts</td>
<td>0.745</td>
<td>0.563</td>
<td>0.745</td>
<td>0.806</td>
</tr>
</tbody>
</table>

### Assumptions for Estimates of Under- and Over-Treatment

- Share of illness episodes that are malaria $\Pi$: 0.386
- Targeting at Health Center (Medium) $T_{h1}$: 0.75

### Under- and Over-Treatment: Preferred Estimates (assuming Medium Targeting at Health Center)

- Overall Targeting $T_1 = (S \times Ts + (1 - S) \times T_{h1}) / A$: 0.747
- Over Treatment $OT_1 = S \times (1 - T_1) / \Pi$: 0.116
- Under Treatment $UT_1 = (1 - S) \times T_1 / \Pi$: 0.453

Notes:
- Targeting ($T$) is the share of ACTs taken for illness episodes that are malaria.
- Overtreatment ($OT$) is the share of non-malaria episodes treated with an ACT.
- Undertreatment ($UT$) is the share of malaria episodes not treated with an ACT.

*a* The assumption on the share of illness episodes that are malaria ($\Pi$) is based on the rate observed in the symptoms database collected through unannounced household visits during which rapid diagnostic tests for malaria were administered. See text for details.

*b* We consider three possible levels of targeting at health centers since there is no clear evidence from the literature on this parameter.
## External Validity

<table>
<thead>
<tr>
<th>Table 6. External Validity Comparisons</th>
<th>Central Uganda</th>
<th>Eastern Uganda</th>
<th>Western and Southeastern Tanzania</th>
<th>Southern Malawi</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Malaria Burden (reported/perceived)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HH Had at least one (Presumed) Malaria Episode (Past Month)</td>
<td>0.590</td>
<td>0.354</td>
<td>0.273</td>
<td>0.410</td>
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<tr>
<td><strong>Treatment Seeking for Malaria</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public Sector</td>
<td>0.250</td>
<td>0.333</td>
<td>0.417</td>
<td>0.760</td>
</tr>
<tr>
<td>Private Sector*</td>
<td>0.660</td>
<td>0.426</td>
<td>0.392</td>
<td>0.120</td>
</tr>
<tr>
<td>No Treatment Sought</td>
<td>0.090</td>
<td>0.221</td>
<td>0.187</td>
<td>0.120</td>
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<tr>
<td><strong>Malaria Diagnosis (Any Blood Malaria Test)</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Last Month</td>
<td>0.150</td>
<td>0.225</td>
<td></td>
<td>0.360</td>
</tr>
<tr>
<td>Last Suspected Episode</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Medication Taken</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Took ACT (Suspected Malaria)</td>
<td>0.330</td>
<td>0.376</td>
<td>0.496</td>
<td></td>
</tr>
<tr>
<td>Antimalarial Cost</td>
<td>1.690</td>
<td>1.355</td>
<td>1.366</td>
<td></td>
</tr>
<tr>
<td><strong>Malaria Positivity Among Drug Shop Patients Buying Subsidized ACTs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under 5</td>
<td>0.740</td>
<td></td>
<td></td>
<td>0.496</td>
</tr>
<tr>
<td>Ages 5 - 13</td>
<td>0.780</td>
<td></td>
<td></td>
<td>0.470</td>
</tr>
<tr>
<td>Ages 14 and Up</td>
<td></td>
<td></td>
<td></td>
<td>0.351</td>
</tr>
<tr>
<td><strong>Malaria Positivity Among The General Population</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under 5</td>
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<td>0.512</td>
<td></td>
<td></td>
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<tr>
<td>Ages 5 - 13</td>
<td></td>
<td>0.644</td>
<td></td>
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</tr>
<tr>
<td>Ages 14 and Up</td>
<td></td>
<td>0.351</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Includes private clinics and retail sector
Outline

1. Background: Treatment-Seeking Behavior in Rural Africa

2. Theoretical Framework

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4. Results

5. Conclusion
Subsidizing ACTs increases ACT access by nearly 50 percent

- Good news – large increases at high predicted probabilities, largely crowding out less effective medicine
- Bad news – large increases at low predicted probabilities – wasted subsidy money, drug resistance development

Crucial need for better access to reliable diagnostic testing

Ideally: make accessibility conditional on positive test result

Diverting part of the ACT subsidy towards an RDT subsidy may be a cost-effective move

But RDTs are no immediate panacea

Our sample was very willing to experiment with RDTs, but adherence was incomplete. Also, RDTs do not draw people to the drug shop.

Are people just learning about a new technology?
Conclusion

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  - Bad news – large increases at low predicted probabilities – wasted subsidy money, drug resistance development
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- Are people just learning about a new technology?
Predicting Malaria Positivity

### Appendix Table A3. Predicting Malaria Positivity - Probit Marginal Effects

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cough</td>
<td>-0.001</td>
<td>(0.061)</td>
</tr>
<tr>
<td>Chills</td>
<td>0.132</td>
<td>(0.097)</td>
</tr>
<tr>
<td>Headache</td>
<td>0.125*</td>
<td>(0.072)</td>
</tr>
<tr>
<td>Diarrhea</td>
<td>0.247***</td>
<td>(0.084)</td>
</tr>
<tr>
<td>Runny Nose</td>
<td>-0.119**</td>
<td>(0.060)</td>
</tr>
<tr>
<td>Vomiting</td>
<td>0.063</td>
<td>(0.072)</td>
</tr>
<tr>
<td>Body Pain</td>
<td>0.197*</td>
<td>(0.111)</td>
</tr>
<tr>
<td>Malaise</td>
<td>-0.052</td>
<td>(0.149)</td>
</tr>
<tr>
<td>Poor Appetite</td>
<td>0.131</td>
<td>(0.104)</td>
</tr>
<tr>
<td>Age 14 or Above</td>
<td>0.398*</td>
<td>(0.239)</td>
</tr>
<tr>
<td>Age</td>
<td>0.106***</td>
<td>(0.032)</td>
</tr>
<tr>
<td>Age Squared</td>
<td>-0.008***</td>
<td>(0.003)</td>
</tr>
<tr>
<td>(Age 14 or Above)×Cough</td>
<td>-0.096</td>
<td>(0.126)</td>
</tr>
<tr>
<td>(Age 14 or Above)×Chills</td>
<td>-0.235**</td>
<td>(0.113)</td>
</tr>
<tr>
<td>(Age 14 or Above)×Headache</td>
<td>-0.070</td>
<td>(0.126)</td>
</tr>
<tr>
<td>(Age 14 or Above)×Diarrhea</td>
<td>-0.221*</td>
<td>(0.131)</td>
</tr>
<tr>
<td>(Age 14 or Above)×Runny Nose</td>
<td>0.222</td>
<td>(0.147)</td>
</tr>
<tr>
<td>(Age 14 or Above)×Vomiting</td>
<td>0.089</td>
<td>(0.155)</td>
</tr>
<tr>
<td>(Age 14 or Above)×Body Pain</td>
<td>-0.106</td>
<td>(0.133)</td>
</tr>
<tr>
<td>(Age 14 or Above)×Malaise</td>
<td>-0.075</td>
<td>(0.171)</td>
</tr>
<tr>
<td>(Age 14 or Above)×Poor Appetite</td>
<td>0.005</td>
<td>(0.260)</td>
</tr>
<tr>
<td>(Age 14 or Above)×Age</td>
<td>-0.138***</td>
<td>(0.034)</td>
</tr>
<tr>
<td>(Age 14 or Above)×Age Squared</td>
<td>0.009***</td>
<td>(0.003)</td>
</tr>
<tr>
<td>DV Mean / N</td>
<td>0.003</td>
<td>1386</td>
</tr>
</tbody>
</table>

Notes: Standard errors in parentheses. Data source: Symptoms database (see text sections 4.3 and 4.4 for details). ***, **, and * indicate significance at the 99, 95, and 90 percent levels respectively. We do not include the most commonly cited symptom of malaria, fever, in order to avoid endline reporting bias. In Kiswahili, the word for "fever" (homa) is commonly used to refer to "malaria". A concern is that if the subsidy regimes we study affected the likelihood that people get a formal diagnosis, this would make the reporting of homa endogenous. The pseudo R² on the probit declines from 0.2191 to 0.2103 when excluding fever and its interaction with the age variables. In practice, our results are very similar when including fever in predicting malaria positivity (though including fever does appear to introduce some reporting bias).
Predicted Malaria Positivity Among Illness Episodes Enumerated at Endline

Cohen, Dupas, Schaner

Subsidies and Malaria Treatment

DIME, August 2012
Predicted Malaria Positivity Among Illness Episodes Enumerated at Endline

Density

Predicted Malaria Positivity

Adults

Cohen, Dupas, Schaner
Subsidies and Malaria Treatment
DIME, August 2012
No Significant Reporting Bias Among Endline Illness Episodes

<table>
<thead>
<tr>
<th></th>
<th>Reported Episode</th>
<th># Episodes Reported</th>
<th>Predicted Positivity</th>
<th>Episode Days Ago</th>
<th>Patient Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACT Subsidy</td>
<td>-0.00246</td>
<td>-0.0767</td>
<td>0.0295</td>
<td>3.24</td>
<td>-2.10</td>
</tr>
<tr>
<td></td>
<td>(0.0198)</td>
<td>(0.147)</td>
<td>(0.0207)</td>
<td>(3.58)</td>
<td>(1.54)</td>
</tr>
<tr>
<td>ACT × RDT Subsidy</td>
<td>0.00340</td>
<td>-0.0414</td>
<td>-0.00170</td>
<td>-1.02</td>
<td>0.839</td>
</tr>
<tr>
<td></td>
<td>(0.00967)</td>
<td>(0.0768)</td>
<td>(0.0102)</td>
<td>(1.85)</td>
<td>(0.765)</td>
</tr>
<tr>
<td>Surprise RDT</td>
<td>0.00387</td>
<td>0.103</td>
<td>-0.0125</td>
<td>5.00***</td>
<td>0.994</td>
</tr>
<tr>
<td></td>
<td>(0.0103)</td>
<td>(0.0780)</td>
<td>(0.0105)</td>
<td>(1.93)</td>
<td>(0.796)</td>
</tr>
<tr>
<td>DV Mean</td>
<td>.95</td>
<td>3.05</td>
<td>.626</td>
<td>64.7</td>
<td>19.1</td>
</tr>
<tr>
<td>N</td>
<td>2621</td>
<td>2621</td>
<td>2473</td>
<td>2438</td>
<td>2473</td>
</tr>
</tbody>
</table>

***, **, and * indicate significance at the 99, 95, and 90 percent levels.
### Characteristics of Interviewed Household Head

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Control</th>
<th>ACT</th>
<th>+RDT</th>
<th>C=T1</th>
<th>C=T2</th>
<th>T1=T2</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>0.867</td>
<td>0.895</td>
<td>0.907</td>
<td>0.292</td>
<td>0.125</td>
<td>0.333</td>
<td>2789</td>
</tr>
<tr>
<td>Age (years)</td>
<td>41.7</td>
<td>38.8</td>
<td>38.8</td>
<td>0.041*</td>
<td>0.036*</td>
<td>0.981</td>
<td>2646</td>
</tr>
<tr>
<td>Education (years)</td>
<td>5.10</td>
<td>5.36</td>
<td>5.54</td>
<td>0.424</td>
<td>0.158</td>
<td>0.253</td>
<td>2774</td>
</tr>
<tr>
<td>Literate</td>
<td>0.575</td>
<td>0.621</td>
<td>0.621</td>
<td>0.258</td>
<td>0.236</td>
<td>0.973</td>
<td>2782</td>
</tr>
<tr>
<td>Married</td>
<td>0.783</td>
<td>0.789</td>
<td>0.777</td>
<td>0.860</td>
<td>0.841</td>
<td>0.456</td>
<td>2784</td>
</tr>
<tr>
<td>Num. dependents</td>
<td>4.12</td>
<td>4.07</td>
<td>4.13</td>
<td>0.822</td>
<td>0.979</td>
<td>0.586</td>
<td>2663</td>
</tr>
</tbody>
</table>

### Household Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Control</th>
<th>ACT</th>
<th>+RDT</th>
<th>C=T1</th>
<th>C=T2</th>
<th>T1=T2</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number members</td>
<td>5.48</td>
<td>5.29</td>
<td>5.34</td>
<td>0.382</td>
<td>0.521</td>
<td>0.585</td>
<td>2789</td>
</tr>
<tr>
<td>Acres land</td>
<td>2.72</td>
<td>2.08</td>
<td>2.28</td>
<td>0.045*</td>
<td>0.175</td>
<td>0.0870*</td>
<td>2250</td>
</tr>
<tr>
<td>Drug shop dist. (km)</td>
<td>1.68</td>
<td>1.66</td>
<td>1.67</td>
<td>0.873</td>
<td>0.966</td>
<td>0.809</td>
<td>2788</td>
</tr>
</tbody>
</table>

***, **, and * indicate significance at the 99, 95, and 90 percent levels.
### Variable Means

<table>
<thead>
<tr>
<th>Baseline Malaria Knowledge and Health Practices</th>
<th>Control</th>
<th>ACT</th>
<th>+RDT</th>
<th>C=T1</th>
<th>C=T2</th>
<th>T1=T2</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number bednets</td>
<td>1.77</td>
<td>1.77</td>
<td>1.78</td>
<td>0.994</td>
<td>0.929</td>
<td>0.875</td>
<td>2784</td>
</tr>
<tr>
<td>Share slept under net</td>
<td>0.561</td>
<td>0.585</td>
<td>0.573</td>
<td>0.450</td>
<td>0.698</td>
<td>0.455</td>
<td>2661</td>
</tr>
<tr>
<td>Heard of ACTs</td>
<td>0.399</td>
<td>0.425</td>
<td>0.427</td>
<td>0.519</td>
<td>0.467</td>
<td>0.904</td>
<td>2771</td>
</tr>
<tr>
<td>Heard of RDTs</td>
<td>0.128</td>
<td>0.153</td>
<td>0.140</td>
<td>0.365</td>
<td>0.646</td>
<td>0.375</td>
<td>2786</td>
</tr>
<tr>
<td>Treats water regularly</td>
<td>0.408</td>
<td>0.390</td>
<td>0.416</td>
<td>0.648</td>
<td>0.841</td>
<td>0.190</td>
<td>2779</td>
</tr>
<tr>
<td>Malaria eps. last month</td>
<td>1.20</td>
<td>1.20</td>
<td>1.23</td>
<td>0.985</td>
<td>0.744</td>
<td>0.508</td>
<td>2789</td>
</tr>
</tbody>
</table>

### Cost Per Episode (Among Those Seeking Any care)

| Total Cost (Ksh) | 127 | 120 | 131 | 0.694 | 0.825 | 0.405 | 1319 |

***, **, and * indicate significance at the 99, 95, and 90 percent levels.
Empirical Specifications

Start with roster of all illness episodes at endline

- Limit to first episode (all treatment households will have ACT and/or RDT vouchers)

\[ y_{eh} = g(p_{eh}) + \epsilon_{eh} \]

1. Local linear regression on predicted positivity by treatment group

2. Regressions to estimate average impacts of each treatment

\[ y_{eh} = \delta + \alpha_{actsub_{h}} + \beta_{actrdtsub_{h}} + \gamma_{age} + \lambda_{strata} + \epsilon_{eh} \]

3. Examine average impacts by tertile of predicted malarial positivity

\[ y_{eh} = \delta + \sum_{t=1}^{3} (\alpha_t \times \text{tertile}_{th} + \beta_t \times \text{tertile}_{th}) + \gamma_{age} + \lambda_{strata} + \epsilon_{eh} \]
Empirical Specifications

Start with roster of all illness episodes at endline

- Limit to first episode (all treatment households will have ACT and/or RDT vouchers)

For outcome $y_{eh}$ (episode $e$ in household $h$)

1. Local linear regression on predicted positivity by treatment group

$$y_{eh} = g(p_{os_{eh}}) + \epsilon_{eh}$$
Empirical Specifications

Start with roster of all illness episodes at endline

- Limit to first episode (all treatment households will have ACT and/or RDT vouchers)

For outcome $y_{eh}$ (episode $e$ in household $h$)

1. Local linear regression on predicted positivity by treatment group

$$ y_{eh} = g(p_{os_{eh}}) + \epsilon_{eh} $$

2. Regressions to estimate average impacts of each treatment

$$ y_{eh} = \delta + \alpha_{actsb_{h}} + \beta_{actrdtsub_{h}} + \gamma_{age} + \lambda_{strata} + \epsilon_{eh} $$
Empirical Specifications

Start with roster of all illness episodes at endline
- Limit to first episode (all treatment households will have ACT and/or RDT vouchers)

For outcome $y_{eh}$ (episode $e$ in household $h$)

1. Local linear regression on predicted positivity by treatment group

$$y_{eh} = g \left( pos_{eh} \right) + \epsilon_{eh}$$

2. Regressions to estimate average impacts of each treatment

$$y_{eh} = \delta + \alpha_{actsub} + \beta_{actrdtsub} + \gamma_{age} + \lambda_{strata} + \epsilon_{eh}$$

3. Examine average impacts by tertile of predicted malaria positivity

$$y_{eh} = \delta + \sum_{t=1}^{3} \left( \alpha_{t} \times actsub_{h} \times \text{tertile}_{th} + \beta_{t} \times actrdtsub_{h} \times \text{tertile}_{th} \right) + \gamma_{age} + \lambda_{strata} + \epsilon_{eh}$$
Typical Drug Shops ("Chemists")

[Image of a drug shop]
<table>
<thead>
<tr>
<th></th>
<th>USA</th>
<th>Kenya</th>
<th>Malawi</th>
<th>Mali</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physicians (per 1,000 people)</td>
<td>2.7</td>
<td>0.14</td>
<td>0.02</td>
<td>0.08</td>
</tr>
<tr>
<td>Nurses (per 1,000 people)</td>
<td>8.8</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>