

Using Remote Tracking to Detect and Deter
Medications Theft in Malawi (P170615)
World Bank Strategic Impact Evaluation Fund
(SIEF) Final Report

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1 Introduction

Medicine theft is likely one of the leading causes of preventable disease in low income countries. In Malawi, where our evaluation takes place, Ministry of Health officials estimate that 29% of spending on medicines and medical supplies disappears due to theft alone (Mphande, 2017). Our survey work indicated that 75% of all communities in Malawi have experienced the theft of medical supplies (author surveys). Malawi is a particularly extreme outlier, but these estimates are not far off from estimates in other countries (Bate et al., 2010; Bouchard et al., 2012; Savedoff, 2007; Hope Sr, 2015; Ferrinho and Van Lerberghe, 2002; Lewis, 2006). Additionally, medicine theft costs governments and donors many millions each year between lost medications and spending on supplemental procurement procedures (Vian, 2006; García, 2019; Bruckner, 2019; Ferrinho and Van Lerberghe, 2002; Jones and Jing, 2011).

Documenting and mitigating procurement and corruption challenges is particularly vital amidst the COVID-19 pandemic. Estimates from previous health crises suggest that ineffective health service delivery explains much regional variation in mortality rates and subsequent poverty in poorly institutionalized health settings (Christensen et al., 2020; Maffioli, 2018). Moreover, the rapid expansion of global health aid has created opportunities for higher rates of theft and corruption (Schipani et al., 2020; Thorp, 2020; Gallego et al., 2020; Eze et al., 2022).

One goal of this research was to evaluate how advances in electronic tracking technology might improve the ability of health providers and researchers to measure patterns of medicine diversion and audit procurement networks, particularly in environments where procurement capacity and investment are low (Lewis, 2006; Bruckner, 2019). Existing measurement strategies in such contexts tend to rely on paper audits or reporting hot lines. While such audit strategies can pickup some theft, they are expensive and prone to manipulation and falsification (Hobbs, 2005; Savedoff, 2007; Bate et al., 2010; Kohler, 2011; Johnson et al., 2012). Moreover, traditional audits can only identify whether medicines reach their intended destination. They are less effective at measuring theft or diversion that happens downstream from the point of delivery, for instance as a result of health facility officials reselling medicines to private pharmacies. They also struggle to distinguish between theft and error (such as medicines being delivered to an incorrect location) (Vian, 2013; Zamboni and Litschig, 2018). From the standpoint of anti-corruption policy, audits also suffer from spillover problems: rather than effectively deterring theft, audits can displace theft to non-audited locations or to points on the procurement chain that are less subject to oversight.

To address these challenges, we worked with a technology company, OnAsset, the

Malawi Ministry of Health and the Malawi Drug Theft Investigations Unit to design a system for digitally auditing the procurement of government medicine from the Malawi Central Medical Stores Trust (CMST) to health facilities in Southern Malawi. In October and November 2021, we placed tracking devices in 2,400 medicine boxes being delivered to Southern Region health facilities (N=170). Subsequently, we also conducted a digital audit in person at a representative sample of 104 of the recipient health facilities, 143 private pharmacies and markets, and 40 health facilities that should have received sub-deliveries from district health offices (DHOs). These digital audits provide a real-time snapshot of the entirety of the medicine procurement chain, allowing us to identify both the deliveries of medicines and the fate of medicines that were not delivered as intended. Perhaps most useful, however, is the ability of these digital audits to identify what happens to medicines after the point of delivery. We describe these audit methods in detail in Section 2.3.

Medicine diversion in Malawi occurs primarily downstream in the supply chain, but when it occurs upstream, it is highly clustered. In total, we show that 97% of medicines were originally delivered to their intended destination. While relatively rare, these missed deliveries are still consequential. Six health facilities missed more than 20% of their intended medicines and 15 missed more than 10%. At least some of these missing medicines were missing due to error: of the 3% of missing medicines, we estimate about 30% were identified as having been delivered to an incorrect location.

Downstream medicine diversion is much more prevalent. In follow-up digital audits, we attempted to determine whether medicines went missing after the delivery and—if so—where medicines were located. In these audits, we were only able to locate 60% of the medicines that were originally delivered. In 34 health facilities, none of the originally delivered medicines could be located. As we discuss in Section 8, we cannot conclude from these audits alone that all these medicines were stolen, and we anticipate doing further research to estimate the proportion of missingness that is due to theft as opposed to re-delivery or device tampering. However, these patterns of missing medicines correspond to independent measurements of drug stockouts, and we were also able to confirm in a few cases that medicines delivered to a health facility were subsequently being sold in private facilities.

A second goal of this research was to experimentally identify the deterrent effect of procurement oversight. Across a random sample of approximately 2,400 boxes of medicines, we randomly assigned half of them to a top-down monitoring message intervention (in the form of a sticker placed on medicine boxes) designed to reduce medicine diversion and increase the efficiency of public health procurement. In order to identify treatment effects of the intervention, we rely on the digital tracking and auditing system described above. This allows us to move beyond existing studies

of corruption that focus on changes in corruption levels to present evidence demonstrating how anti-corruption interventions displace corruption to other parts of the system.

Our pre-registered analysis of treatment effects provides some mixed evidence on effectiveness. The monitoring message slightly reduces the rate of diversion during delivery but also slightly increases the rate of diversion after delivery, though the latter results are difficult to interpret given the measurement error in our measure of diversion after delivery. While effects on diversion were small, we do find that the monitoring message was an effective way to deliver information to health facility officials. In follow-up surveys, about half (47%) of health facility officials claim to have seen the messages, and most of these officials were able to describe the messages.

Nonetheless, officials who were aware of the messages were no more likely to perceive that the risk of medicine theft was high. This weak effect on perceptions of risk is not necessarily surprising in light of the oftentimes weak mechanisms of accountability for medicine theft. In surveys with patients in 97 health facilities, we found that over 80% agree that an important reason for theft is that people do not have effective ways to report it. Similarly, in a parallel survey at the same 97 health facilities, a minority of Health Centre Advisory Committee members report fulfilling their mandate to observe deliveries each month. A promising way forward for this research program is to use our digital tracking and auditing system to better empower bottom-up and horizontal accountability mechanisms. For example, our original proposal for this evaluation (which was adjusted due to COVID-19 restrictions) proposed using information from digital tracking and auditing to empower the Health Centre Advisory Committees. Using digital technology to strengthen accountability mechanisms remains a promising area for policy research and investment.

Our research suggests that digital audits and targeted messaging can be effective tools in the anti-corruption arsenal. This low-cost, highly scalable intervention is immediately applicable to the government’s efforts to improve health services delivery. One of our partners, the Drug Theft Investigations Unit (DTIU), is a donor-funded government agency housed under the Malawi Ministry of Health responsible for monitoring corruption (specifically theft) in public health procurement. Like many similar organizations in the developing world, the DTIU has had only limited success. Officials complain of insufficient resourcing and the frequent non-compliance of local officials with procurement regulations. Collaboration between DTIU and other branches of government has also been difficult. We designed our intervention to address these challenges. Unlike typical anti-corruption interventions which can cost more than they save (Hobbs, 2005), the intervention we evaluate does not require

broad institutional reform or a large input of financial resources.¹ This treatment is also designed to speak to the effectiveness of similar public messaging campaigns sponsored by many donors, such as the ispeakoutnow.org campaign sponsored by Global Fund. Finally, this intervention is also efficient in a crisis environment. Typical interventions to prevent corruption in health systems involve audits, training, and local capacity building. During the COVID-19 pandemic, these measures would have put public officials at risk and undermined quarantine measures. This leads to weak procurement oversight during a time when corruption is particularly attractive. By offering a low-cost, low-interaction, and easily fielded intervention, the protocol we developed could be scaled up in similar contexts facing similar health crises, and could inform health policy and crisis procurement management more generally.

2 Theory and Hypotheses

2.1 Theory

The intervention we evaluate builds on the literature considering the effect of bureaucratic oversight on corruption. Typically, the oversight takes the form of an audit, and the corruption takes the form of embezzlement or theft of government funds and materials, particularly during the procurement and provision of public goods and services. Scholars in this literature theorize that audits can reduce corruption via two mechanisms. In one mechanism - a “behavioral effect” - the *threat* of an audit compels politicians to refrain from corruption. As long as politicians believe the probability of an audit is sufficiently high (and, importantly, that the probability of detection of corruption in said audit is sufficiently high), they will refrain from corruption. In the other mechanism, audits have a *selection effect*, whereby audits detect corruption, the corrupt are removed from their posts, and then corruption decreases. While there is empirical evidence supporting both mechanisms linking audits and corruption in the health sector across diverse contexts (Kohler, 2011; Lichand et al., 2016; Zamboni and Litschig, 2018; Vian, 2013), there are only a few studies assessing whether audits can reduce medicine diversion, and no experiments (that we know of) on the effects of audits on medicine diversion in developing countries. Further, some studies of the effect of audits note null or perverse effects on health system outputs, even if corruption is diminished (Zamboni and Litschig, 2018; Lichand et al., 2016).

¹The intervention costs, not including evaluation costs, total just over \$20k. See Section A and Table 1 in the Appendix for details.

The treatment message in our experiment is closely aligned with this literature. We anticipate that messages on medicine boxes that convey the Ministry of Health is tracking medicines will reduce rates of diversion of these boxes. More specifically, we anticipate the messages will heighten the sense of monitoring, which will in turn increase perceived probability of theft detection and punishment (Bruckner, 2019; Johnsen et al., 2012), causing the behavioral effect discussed above and lowering the rate of diversion. While we are unable to empirically identify any selection effect of the treatment message, because we will not be recollecting data after this (or any) audit has resulted in some officials’ removal from office, we will be able to consider the potential for such an effect via the survey data collected from the health facility officials after the intervention period.

2.2 Main Hypothesis

Our main hypothesis relates to the overall effect of the intervention on medicine diversion.

HA1: The Monitoring Message will decrease the rate of medicine diversion.

2.3 Digital Tracking and Auditing Activities

To measure medicine diversion, we rely on long-range and short-range tracking devices manufactured by OnAsset, a US-based company specializing in supply chain visibility technology. Specifically, the tracking protocol involves two types of devices: (1) SENTRY 500; and (2) SENTINEL. The SENTRY 500 is a cellular and GPS tracking device. It is the “parent” device. The SENTINEL is a “child” Bluetooth device automatically read by any SENTRY 500 within their transmission radius. The SENTRY 500 units capture and transmit data from itself and all surrounding SENTINELS to the server at regular intervals. In addition to the location of the devices, the SENTRY also captures data on temperature, light, humidity, and battery. The data on the server can then be accessed via API.

The experiment and corresponding digital delivery tracking occurred during the medicine delivery cycles of October² and November of 2021. Using health facility orders provided to us by the Ministry of Health, and drawing on our pre-experiment survey and interview data, we sampled eight medicines that are both commonly ordered and commonly diverted.

²These deliveries were delayed and were actually delivered in November.

Next, in partnership with the Ministry of Health, we accessed the main warehouse that is responsible for delivery of medicines to public health facilities in the Southern Region. A team of 14 people from the third-party logistics company (9), the warehouse (1), Malawi Ministry of Health (1), and the research team (3) then placed SENTINEL tracking devices in a random sample of the boxes for the medicines (Table 1). The SENTINEL devices were covered with a sticker stating each device was a “SHIPPING TEMPERATURE & HUMIDITY MONITORING DEVICE” and property of the Ministry of Health (Figure 1).

Table 1: Tracked Medicines

Medicine Description	Anticipated Number of Tracked Boxes
Amoxicillin,250mg,capsule,1000	89
Aspirin,300mg,tablet,1000	402
Ibuprofen,200mg,coated tablet,1000	786
Insulin zinc suspension (lente),100 IU/ml,10ml	3
Paracetamol,500mg,tablet,1000	519
Phenobarbitone,30mg,tablet,1000	166
Syringe Luer,10ml,disposable,hypoluer	235
Syringe,autodestruct,5ml,disposable	170

Figure 1: Tracking Device Sticker



In addition to the unique device code and the medicine information, we also recorded the facility destination and treatment status for each box in which a SENTINEL was placed. The boxes in the October and November deliveries were intended for 170 facilities, ranging from large district hospitals to small local health centres. In a parallel process, the same team placed two SENTRIES on each delivery truck. Once this process was complete, the deliveries departed the Central Medical Stores warehouse for the 170 facilities and the trackers provided the digital delivery tracking data.

Then, approximately two weeks after the deliveries were scheduled to occur, two teams of three people each³ conducted a “digital audit” at a sample of 104 health facilities and 143 corresponding markets and private pharmacies.⁴ In this digital audit, they traveled to each intended facility destination with a SENTRY inside a backpack to scan for SENTINEL devices. While on the facility premises, they inconspicuously inquired about possible markets and private pharmacies where medicines were sold and brought the SENTRY to these locations to scan for SENTINELS once more. Finally, approximately two weeks after the first digital audit, the teams went to a purposive sample of 40 facilities that were supposed to have received sub-deliveries from their District Health Office. Figure 2 shows a diagram of these tracking and digital auditing activities, Figure 3 shows a map of these tracking and digital auditing activities, and Figure 4 shows photos from the in-person digital audits.

This process resulted in three complementary datasets: 1) digital delivery tracking data - data from the SENTRIES and SENTINELS stored on the OnAsset server; 2) data about the boxes associated with each SENTINEL (medicine being tracked, facility destination, treatment status), collected via the survey software KoBo; and 3) in-person digital audit data - data from the SENTRIES AND SENTINELS stored on the OnAsset server. Collectively, these three datasets allow us to construct our measures of diversion (see Section 5).

³Each team involved one person from the research team and then two people not previously involved in the device and sticker placement at the warehouse.

⁴This sample consisted of the 97 facilities included in the baseline survey and a small sample of facilities where we knew there had been anomalies in the delivery process (e.g., a SENTRY was turned off).

Figure 2: Diagram of Digital Tracking and Auditing Activities

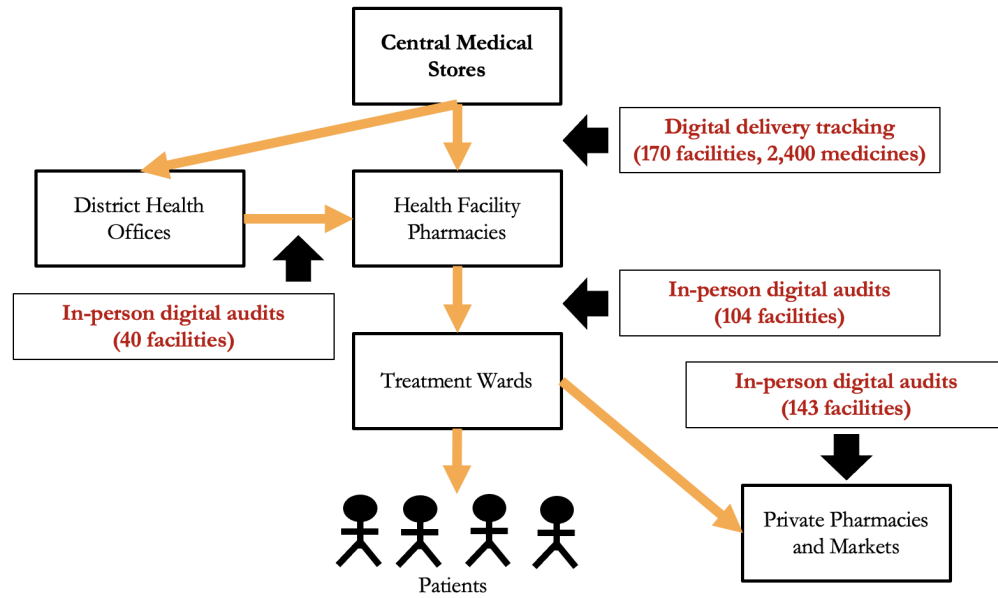


Figure 3: Map of Digital Tracking and Auditing Activities

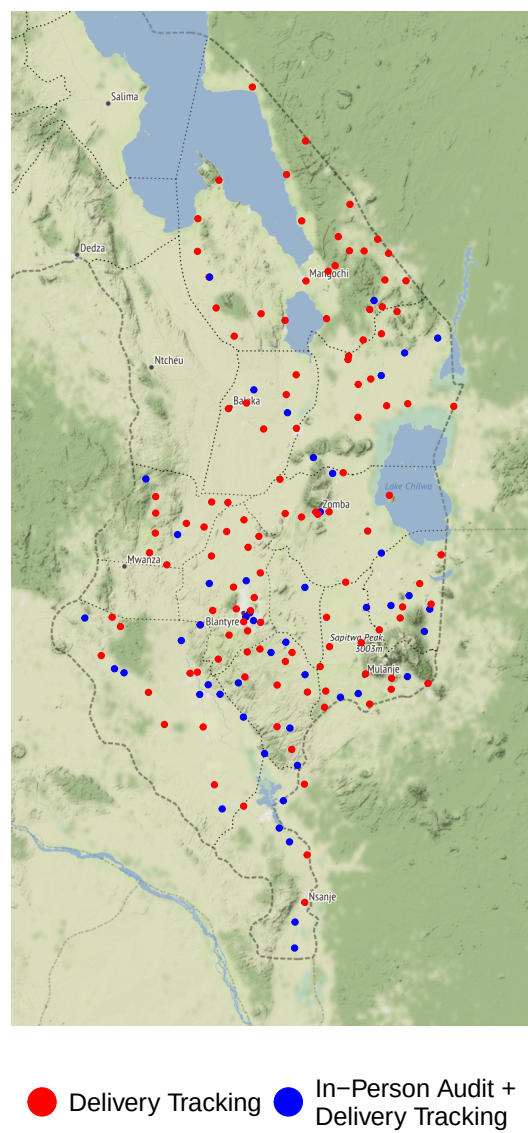


Figure 4: Photos from In-Person Digital Audits



(a) Health Facility During Digital Audit



(b) Market During Digital Audit

3 Experimental Intervention

This evaluation focuses on a top-down monitoring intervention. In cooperation with local partners, we randomly sampled approximately 2,400 medicine boxes scheduled for delivery to local health facilities in Southern Malawi. Using data from previous surveys, we weighted this sample towards commonly ordered and commonly diverted medicines. On a randomly assigned 1,258 of these boxes (approximately one-half), we placed a prominent and government-branded sticker containing information to be read by public officials involved in health services delivery (Figure 5). The remaining 1,112 boxes were randomly assigned to control, which did not receive a sticker.

As discussed in 2.2, the goal of the intervention is to inform recipients that a particular box of medicines is being tracked by the Ministry of Health. Building on behavioral theories of crime, we expect that recipients of this intervention will update their beliefs regarding the probability and costs of interdiction and will be less likely to divert the medicines.

Figure 5: Monitoring Sticker



3.1 Implementation

This project benefited from partnerships with two government offices in Malawi. The Drug Theft Investigations Unit (DTIU) is a donor-funded government agency housed under the Malawi Ministry of Health responsible for monitoring corruption (specifically theft) in public health procurement. DTIU leadership have been consulted throughout the lifespan of this project, and DTIU officials were particularly involved in the intervention design and execution. In addition, high-level leaders at the Malawi Ministry of Health and the Malawi Central Medical Stores Trust participated at critical junctures of the project, including in the design of the tracking strategy, the supervision of the intervention, and the dissemination of results (still ongoing).

Project implementation occurred between November 2018 and April 2022. After baseline data collection in the first half of 2019, the intervention period was scheduled for early 2020. Originally, the intervention was an in-person meeting at treatment health facilities that activated both top-down and bottom-up accountability mechanisms. However, the COVID-19 pandemic prevented this intervention from proceeding as planned. After a hiatus for redesign of the intervention to avoid in-person activities and re-engagement with the implementation partners at the Ministry of Health, the intervention described in this report took place in the second half of 2021, with follow-up data collection occurring between November 2021 and April

2022. The large time lapse between baseline data collection and intervention rollout was not ideal, though unavoidable. We therefore focus our analysis and findings at the level of randomization - the medications box - rather than the level of baseline data collection - the health facility.

Ethical review for this project took place in 2018 at the London School of Economics and Political Science, and the project was approved in December 2018. In addition, the Malawi National Health Sciences Research Committee reviewed and approved the project twice: once for the original design in March 2019 and once for the redesign in July 2021.

4 Survey and Administrative Data

To better understand the consequences of medicine theft and our experimental intervention, we conducted two complementary surveys: 1) an in-person survey of citizens and health centre advisory committees collected January-March 2019; 2) a phone-based survey of health facility officials. Our partners in the Ministry of Health and the Drug Theft Investigations Unit also provided administrative data on medicine procurement and audits.

4.1 Baseline Survey of Citizens and Health Centre Advisory Committees

In January-March 2019, we conducted an in-person survey with Malawian citizens in the catchment areas of 97 health facilities. The 97⁵ health facilities were randomly sampled from a list of all of the health facilities in the Southern Region, excluding facilities that were affiliated with the Christian Health Association of Malawi (CHAM) and the Malawi Military, as these health facilities have additional, overlapping procurement processes.

At each sampled health facility, we recruited two distinct groups of participants for the survey. First, the enumeration team completed a random walk sampling protocol to recruit 35 individuals living within 10 km of the health facility. This resulted in a sample of 3,360 individuals. Second, the enumeration team used a purposive sampling procedure to recruit three individuals affiliated with the facility’s Health Centre Advisory Committee. This resulted in a sample of 281 individuals.

⁵We originally sampled 100 facilities but three facilities were inoperable at the time of data collection.

The Health Centre Advisory Committee (HCAC) is a government-mandated oversight committee that is supposed to exist at each health facility in Malawi.⁶ They are typically 10-member elected bodies that serve a social accountability function on behalf of the citizens in the facility’s catchment area, though there is variation in their ability to hold health facility officials accountable, partially driven by variation in integration with other accountability structures (Lodenstein et al., 2019). They have four official duties: (1) bridging the communication gap between community and health staff, (2) inspection of facility conditions and drug stock, (3) formulating recommendations on facility equipment, and (4) complaint management (Lodenstein et al., 2019).

The two survey instruments were similar, and both were conducted in person with trained Malawian enumerators and available in English and Chichewa. The citizens survey included 61 questions for the participant regarding their experiences at the facility, focusing on their observations and perceptions of theft. It also included a list experiment to measure the prevalence of public medication resale and 14 questions for the enumerator to collect information about the survey context. The HCAC survey included 20 questions for the participant regarding the operations and activities of the HCAC and 7 questions for the enumerator.

4.2 Endline Phone Survey of Health Facility Officials

In March and April 2022, we executed a phone-based survey of health facility officials. At each of the 97 facilities included in the baseline survey, the Malawi-based research managers used snowball convenience sampling to conduct a phone interview with two individuals: a pharmacist and one other official involved in medicine stocking and/or disbursement at the facility. Contact information could not be obtained for 12 facilities, so the final sample includes 172 officials from 85 facilities. The survey included 30 questions for the participant regarding their experiences at the facility, focusing on their observations and perceptions of theft, as well as four questions for the enumerator to collect information about the survey context. Surveys were conducted in English.

4.3 Administrative Data

The Ministry of Health has also provided us with administrative data. With one exception noted in the list below, these data will be exclusively used for future

⁶In reality, not all facilities mobilize HCACs, let alone utilize them.

descriptive analysis regarding patterns of accountability, organizational capacity, and diversion.

1. Facility-Level Shipment Records: We obtained the full set of shipment manifests that were used to prepare the October and November deliveries, and we will use these records to construct covariates regarding the volume and density of medicines during the October and November shipments.
2. Delivery Notes: We also obtained the full set of delivery notes from the district health offices (DHOs) for the months of October and November. These records detail the shipments from the DHOs to smaller health centres. These records were provided to us as scanned PDF documents, so we are currently transcribing them for analysis.
3. DTIU Audit Records: DTIU provided us with audit reports at the health facility level for 2016 and 2017. These provide qualitative evidence regarding the pre-existing levels of theft at the sampled health facilities. We have requested the more recent audit records as well.
4. SENTINEL Retrieval: The Ministry of Health began recollecting the deployed SENTINELS in January 2022 and recollection is still ongoing. While the SENTINELS were all labeled with Ministry of Health contact information, some have gone missing, providing an additional unanticipated measure of diversion.

5 Variables and Measurement

5.1 Pre-Specified Outcome Variables

Our primary goal is to measure the diversion of medicines. We measure diversion as follows:

1. *UpstreamDiversion* This variable equals one if a SENTINEL is not originally delivered to its intended destination. It equals zero otherwise.
2. *MedicineNotTraced* This variable equals one if a SENTINEL cannot be found during the in-person digital audit. It equals zero otherwise. This variable can only be coded for facilities where trackers tracing occurred.

5.2 Pre-Specified Covariates

The covariates depicted in Table 2 are included in the main analysis of treatment effects.

Table 2: Covariates

Variable	Level	Description
Medicine Type	SENTINEL (Medicine)	A set of dummy variables identifying the types of tracked medicines.
Health Facility District	Health Facility	A set of dummy variables identifying the districts of the intended health facility destinations.
Health Facility Distance	Health Facility	A continuous variable measuring the logged distance between the central medical store and the intended health facility destination.
Health Facility Type	Health Facility	A categorical measure indicating the classification of the facility.
SENTRY Effects	SENTRY (Route)	A set of dummy variables identifying the SENTRY units reporting tracking data.

6 Analysis Details

6.1 Main Analysis

Our primary estimating approach is given by the linear probability model in Equation 1. Here y_i is a binary variable indicating whether medicine unit i was diverted (as described in Section 5). Let t_{1i} indicate whether unit i is assigned to the Monitoring Message treatment or control. Let u_j be a fixed effect for each route (SENTRY) j . We also show estimates with facility fixed effects. Since the treatment is assigned at the unit level, we do not cluster the standard errors in the main analysis.

$$y_i = \beta_1 t_1 + u_j + e_i \quad (1)$$

We also estimate Equation 1 with the inclusion of the covariates listed in Section 5.2.

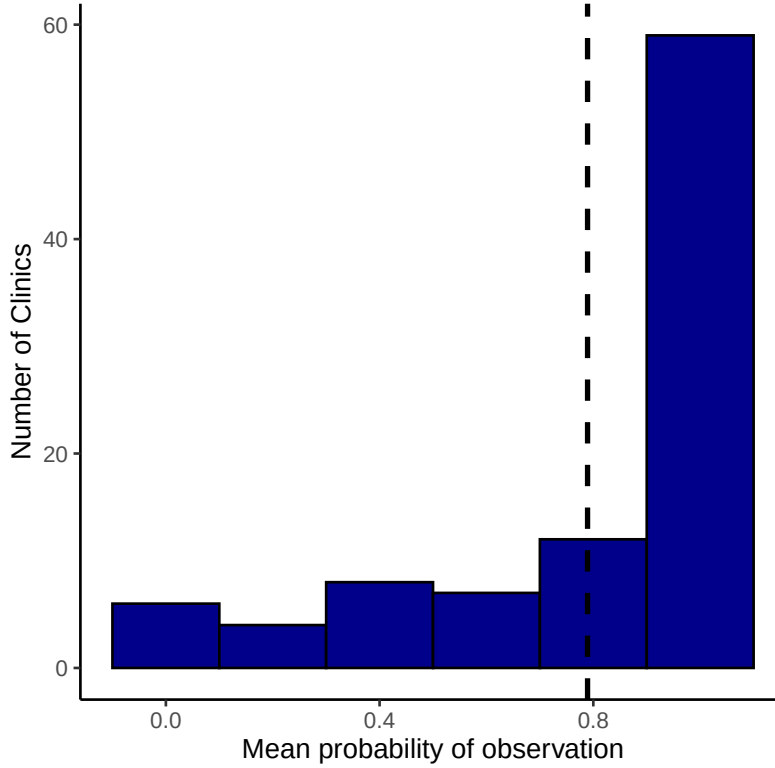
7 Results

7.1 Perceptions of Theft among Citizens, Health Centre Advisory Committees, and Health Facility Officials

One of the primary contributions of this project is to provide descriptive evidence regarding perceptions of theft. In this section, we present the findings of the baseline survey of citizens and Health Centre Advisory Committees and the endline phone survey of health facility officials.

First, we consider citizens' overall perceptions of theft at their local health facility. Figure 6 shows the results of a list experiment designed to anonymously elicit the probability that respondents have observed the sale of medicines in their community that should have been provided for free by government facilities. The results suggest that an estimated 50% of all citizens have observed the sale of medicines that should have been provided for free. Moreover, at approximately 80% of all health facilities, at least one citizen has observed the illegal sale of medicines.

Figure 6: Probability of Theft Being Observed

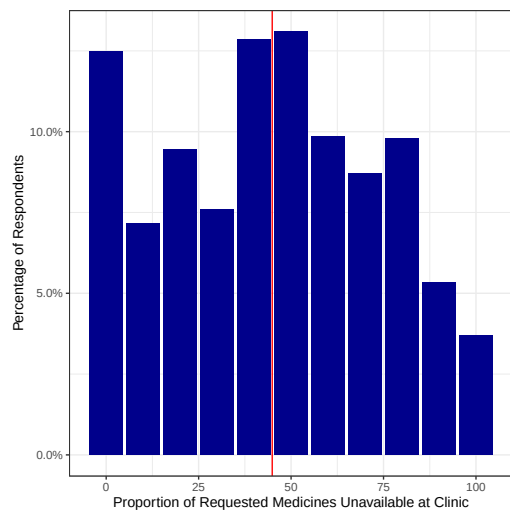


Note: This figure shows estimates of the facility-specific probability that the illegal sale of medicines has been observed. The figure is derived from a list experiment asking whether respondents have observed the sale of medicines that should have been provided for free.

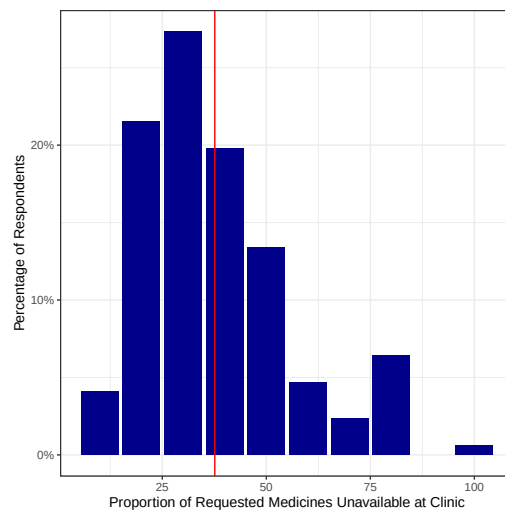
One consequence of medicine theft is that citizens are unable to access medicines that they need. We asked citizens to estimate how often they are unable to access needed medicines from their health facility. On average, approximately 45% of needed medicines were unavailable at health facilities. We also asked this question of health facility officials and get a similar estimate (37%), though the correlation between the estimates from the citizens and officials is not statistically significant ($p = 0.21$). We show the distribution of perceptions of medication (un)availability in 7.

Of course, there are a number of reasons why medicines may not be available, and Malawi has suffered from chronically insufficient public health financing. Nonetheless, it is clear that many citizens blame medicine unavailability (often called “stockouts”) on theft. In Figure 8 we show the geographic distribution of perceived medicine unavailability (stockout) rates and perceived theft rates. It is clear that areas with higher stockout rates are also the areas where citizens perceive the highest rates of theft.

Figure 7: Perceived Rates of Medication Unavailability by Citizens and Officials

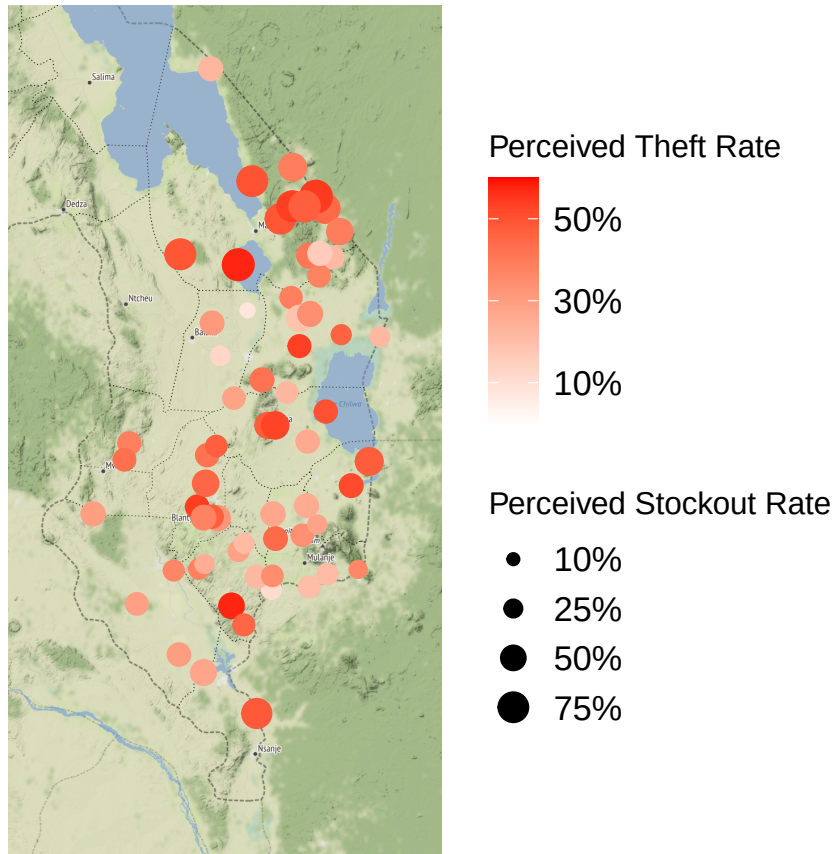


(a) Citizens' Perceptions of Medication Unavailability



(b) Officials' Perceptions of Medication Unavailability

Figure 8: Perceived Rates of Theft and Stockouts



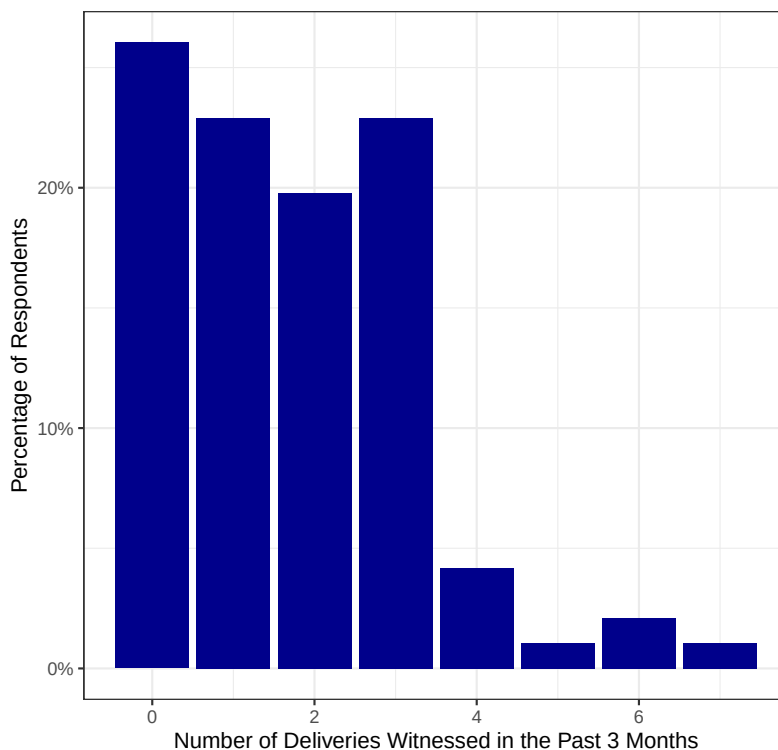
Note: The Perceived Stockout Rate indicates the percentage of times on average patients were unable to obtain needed medicines from their health facility in the last three months. The Perceived Theft Rate indicates the share of those unavailable medicines that the patient believed were stolen by public officials.

We also asked citizens a number of questions about the reasons that officials might engage in theft. Citizens perceive information and capacity gaps to be a main constraint. Fifty-three percent of citizens said that they lack effective ways to report the diversion of medications and cited this as a primary reason officials choose to steal medications in Malawi. Another reason cited was that patients simply have no

way of knowing whether medications in their health facility were stolen.

In addition, it seems that formal accountability institutions are weak. For instance, Health Center Advisory Committees have been ineffective in overseeing deliveries of medicines. Figure 9 shows that nearly three-quarters (74%) of interviewed Health Center Advisory Committee (HAC) report witnessing a delivery at the health center in the past three months. However, very few witnessed three or more deliveries in three months, despite a mandate to witness each monthly delivery. Furthermore, approximately one-quarter (26%) of HAC respondents report witnessing no deliveries in the past three months.

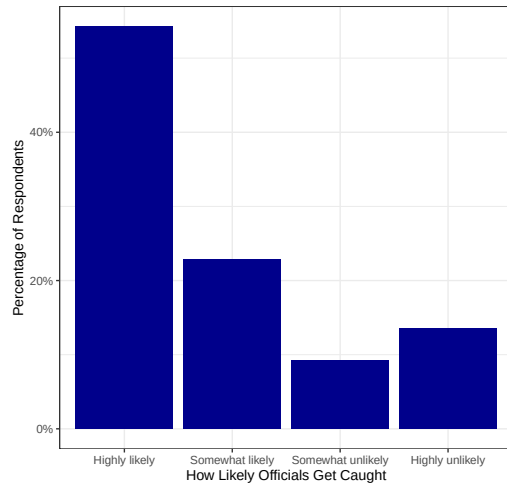
Figure 9: Health Centre Advisory Committees (HACs) Attendance at Deliveries



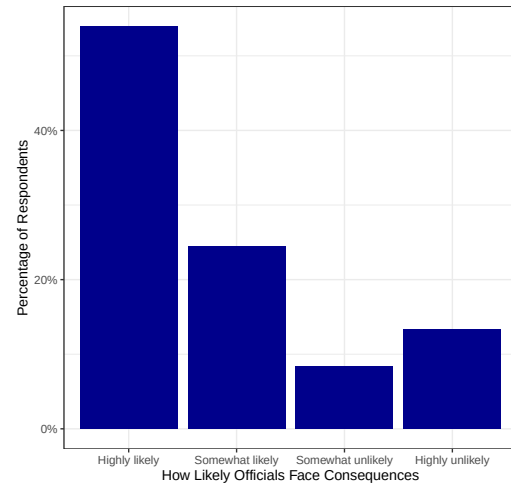
Despite recognizing the weaknesses of accountability mechanisms, more than half of citizens believe that officials that steal medicines are highly likely to be caught and highly likely to face consequences (Figure 10a and Figure 10b). Among the officials, however, we observe a different reality. The median perceived probability of getting caught and facing consequences according to health facility officials is 51-75%. Only

20% of health facility officials perceive a 75-100% chance of getting caught, and 30% perceive a 75-100% chance of facing consequences (Figure 10c and Figure 10d).

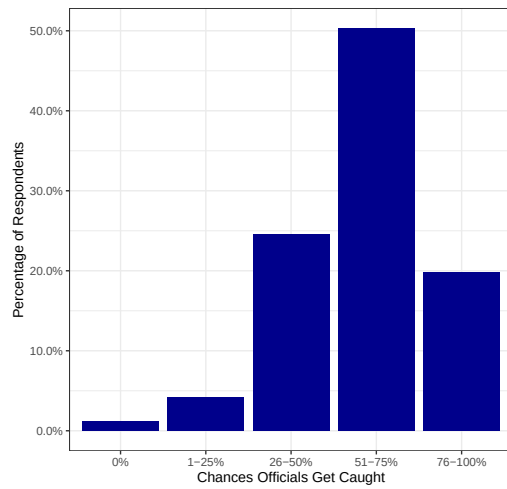
Figure 10: Perceived Rates of Theft Detection and Punishment by Citizens and Officials



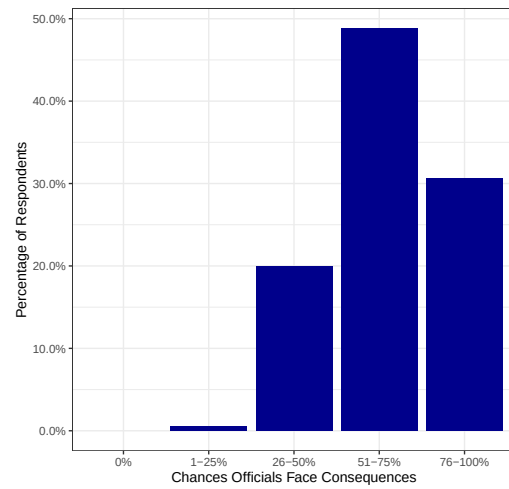
(a) Citizens' Perceptions of Theft Detection



(b) Citizens' Perceptions of Theft Punishment



(c) Officials' Perceptions of Theft Detection

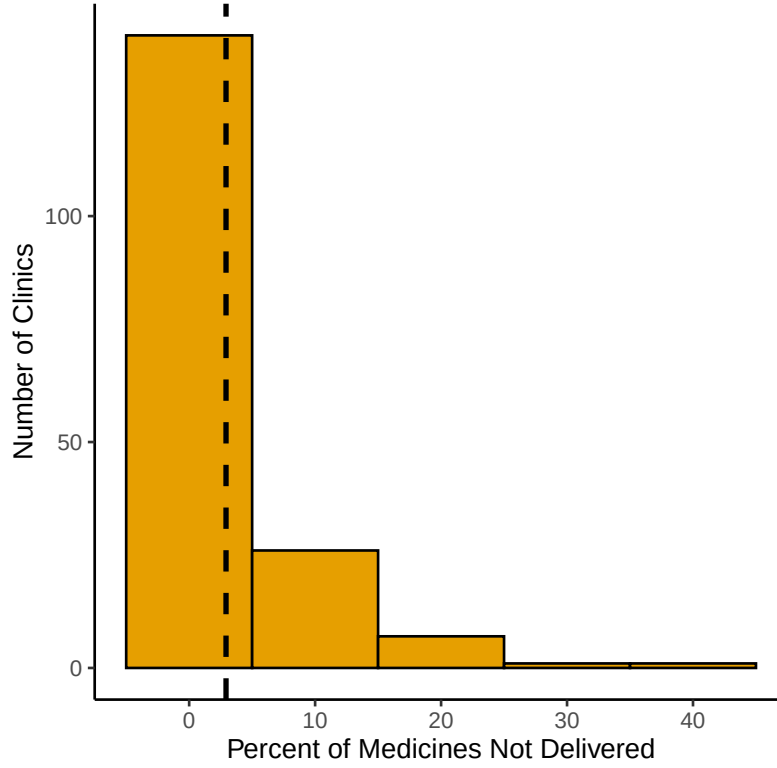


(d) Officials' Perceptions of Theft Detection

7.2 Digital Tracking and Auditing Data on Medicine Diversion

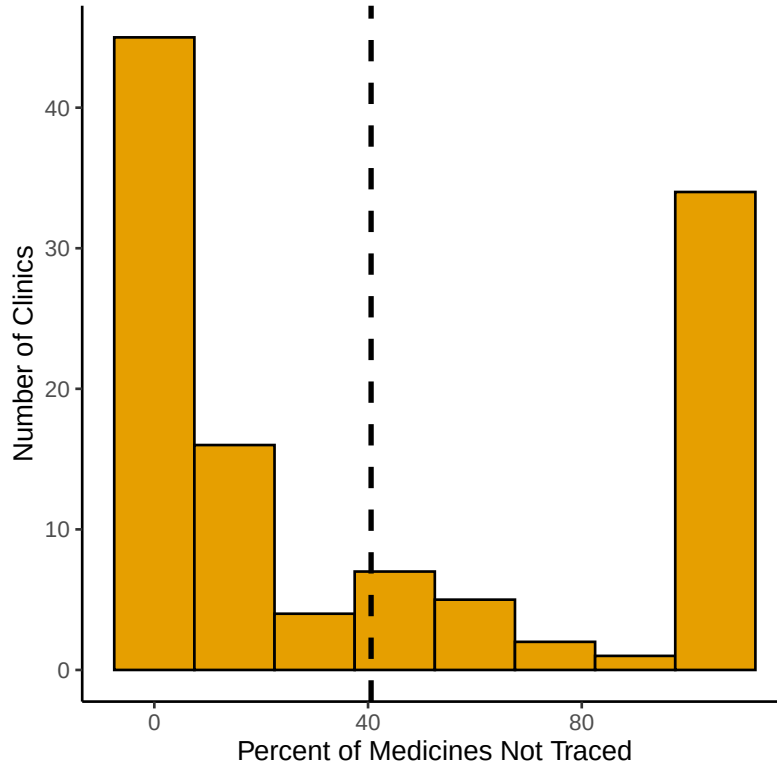
In this section, we provide summary data on the rate at which medicines are diverted during delivery (*UpstreamDiversion*) and the rate at which medicines are diverted after delivery (*MedicineNotTraced*) based on data from our digital tracking activities. Overall, we see only small levels of theft during the delivery process. As shown in Figure 11, 97% of medicines reached their intended destination. However, a meaningful minority of health facilities still had considerable rates of *UpstreamDiversion*: diversion during delivery. Six health facilities had more than 20% of their medicines go missing during the delivery process and 15 health facilities had more than 10% of their medicines go missing. Our in-person digital audit activities suggest that a large proportion (30%) of these missing medications were cases of deliveries being sent to the wrong location rather than deliveries being diverted outside of the supply chain entirely.

Figure 11: *UpstreamDiversiion* across Health Facilities



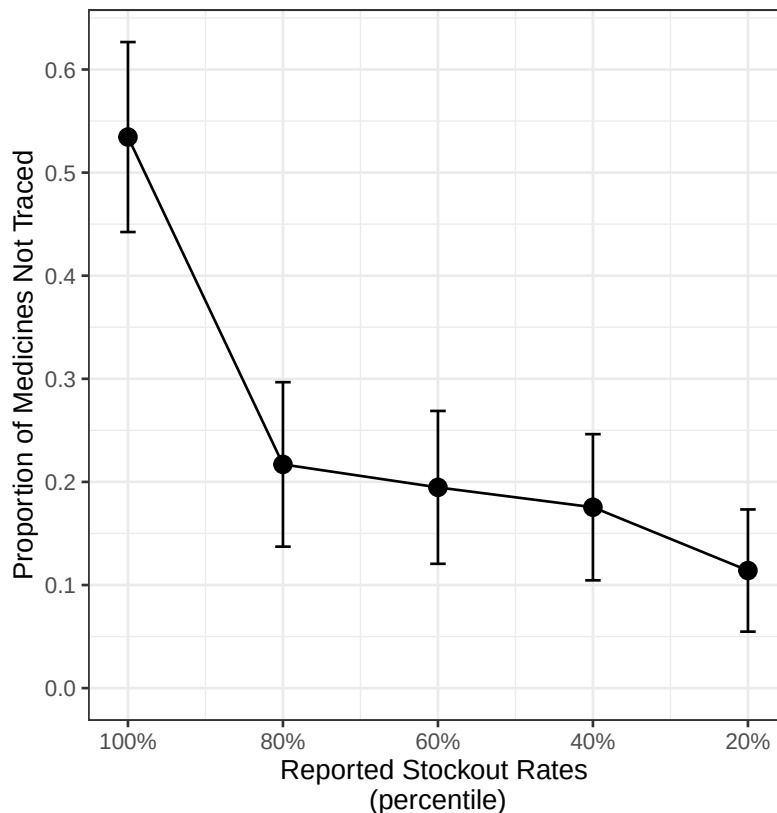
In Figure 12 we show rates of diversion during the in-person digital audits (*MedicineNotTraced*). We see much higher rates of missing medicines at this point in the procurement process. In total, we were only able to later locate 60% of medicines that were originally delivered. As we discuss in Section 8, the current calculation of *MedicineNotTraced* is unable to differentiate between medications found at a health facility or medications found in the surrounding area (at, for example, a private pharmacy or market), which makes the 40% rate of diversion even more egregious. For 34 health facilities, we could not locate any of the medicines that were delivered either at the facility or in the surrounding area.

Figure 12: *MedicineNotTraced* across Health Facilities



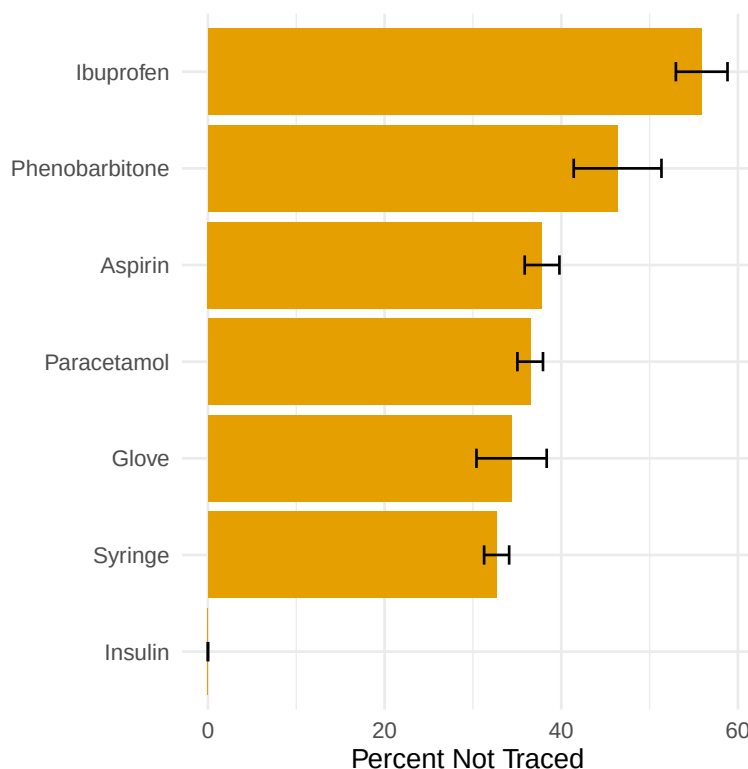
As *MedicineNotTraced* is measured with error, we compare it to citizen perceptions of stockouts: the perceived percentage of times patients were unable to obtain needed medicines from their health facility. As shown in Figure 13, we see a large and significant positive correlation between stockout rates and *MedicineNotTraced*.

Figure 13: Relationship Between *MedicineNotTraced* and Citizen Perceptions of Stockouts



Finally, we consider disaggregated patterns of diversion. In terms of medicine or supply type, as shown in Figure 14, the rate of post-delivery diversion (*MedicineNotTraced*) is greatest for the medications Ibuprofen and Phenobarbitone and lowest for supplies like gloves or syringes. Our models of treatment effects include district fixed effects (though these coefficients are omitted from Table 3 and Table 4). We note that *UpstreamDiversion* is significantly higher in Neno and Thyolo and significantly lower in Chikwawa. *MedicineNotTraced* is significantly higher in Balaka and Blantyre, and significantly lower in Chikwawa and Thyolo. As can be seen in Table 3, the rate of *MedicineNotTraced* increases significantly with distance from the Central Medical Stores distribution center, and both forms of diversion are significantly lower in NGO-run health facilities.

Figure 14: *MedicineNotTraced* by Medicine or Supply Type



7.3 Monitoring Message Intervention Fidelity and Compliance

The phone survey conducted among health facility officials provides some indication of the fidelity of the monitoring message intervention. Over three-fourths of the surveyed officials (76%) answered “yes” to the question, “Recently your facility was sent medicines from Central Medical Stores Trust with devices attached. Have you heard of these devices?” and all of those who had heard of them correctly said that the Ministry of Health (or Central Medical Stores Trust or Drug Theft Investigations Unit) was the source of the devices. Two-thirds (67%) of those who had heard of the devices stated they were used for “tracking,” though only 4% of those who had heard of the devices said they were used to detect or track **theft** specifically.

The treatment stickers were less well-remembered. Approximately half (47%)

of the surveyed officials answered “yes” to the question, “Have you noticed any stickers or messages on recent deliveries of medicines from Central Medical Stores Trust?” However, ninety-one percent of the officials who answered yes to this question recalled what the sticker said, with 60% mentioning something about the sticker conveying an anti-theft medicine, 38% mentioning something about the sticker conveying theft would be punished, and 25% of them mentioning something about the sticker conveying the medicines were being tracked. Despite these relatively high rates of intervention recognition and recall, officials who noticed the stickers did not perceive a greater likelihood of getting caught for theft, facing consequences for theft, or specifically going to prison for theft.⁷ This, in turn, indicates that the treatment did not significantly shift officials’ perceptions of risks or costs associated with engaging in theft, which, as discussed in Section 2.1 was the theorized causal mechanism underpinning the intervention.

7.4 Monitoring Message Treatment Effects on Diversion

In this section, we consider the treatment effects of the randomized monitoring message. We find mixed evidence of effectiveness. If we consider the raw rates of diversion across treatment and control groups, we see a slightly lower rate of *UpstreamDiversion* in the treatment group and a slightly higher rate of *MedicineNotTraced* in the treatment group (Figure 15).

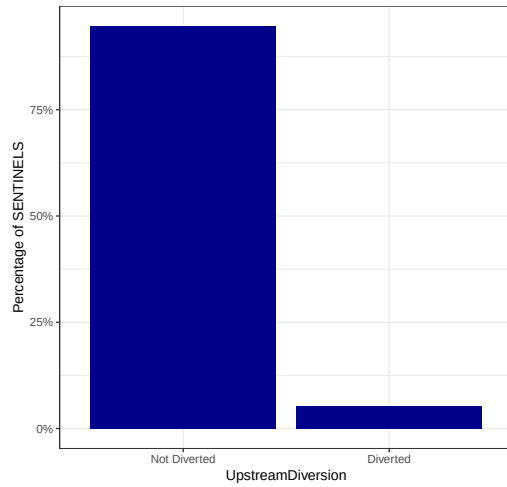
The results are even more mixed in our pre-specified linear probability models. In the set of health facilities excluding the district health centers (DHOs) and including SENTRY fixed effects, the monitoring message reduces the rate of diversion during delivery (*UpstreamDiversion*) by 2% (Table 4, Model 1). In the models including DHOs (Table 3) and the model without DHOs but with covariates (Table 4, Model 2), the results are substantively consistent but statistically insignificant.

When it comes to post-delivery diversion (*MedicineNotTraced*), we see an approximately 4.5% increase in diversion due to the treatment, though this effect is only significant at the 10% level and only significant in the models with control variables (Model 4 in Table 3 and Model 4 in Table 4). However, we caution against concluding that the monitoring message increased diversion. As we discuss in Section 8, our current calculation of *MedicineNotTraced* conflates instances of finding a medicine (SENTINEL) at a private pharmacy or market **nearby** a health facility and instances of finding it **within** a health facility. We are working with the University of North Carolina GIS librarian to incorporate more granular data about satellite

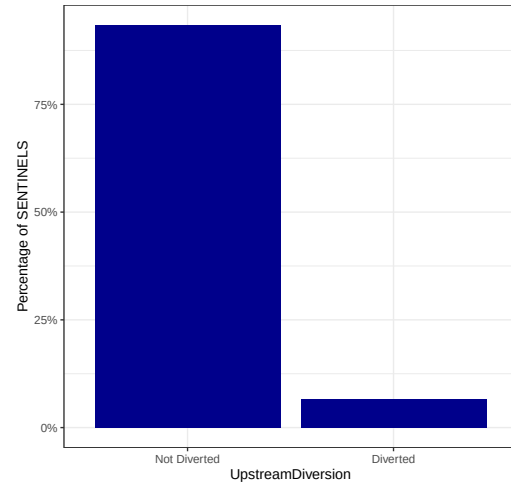
⁷This statement is based on a series of unpaired, two-tailed difference in means *t* tests, with *p*-values of 0.845, 0.324, and 0.579, respectively.

and cell tower strength in Malawi to improve the accuracy of *MedicineNotTraced*.

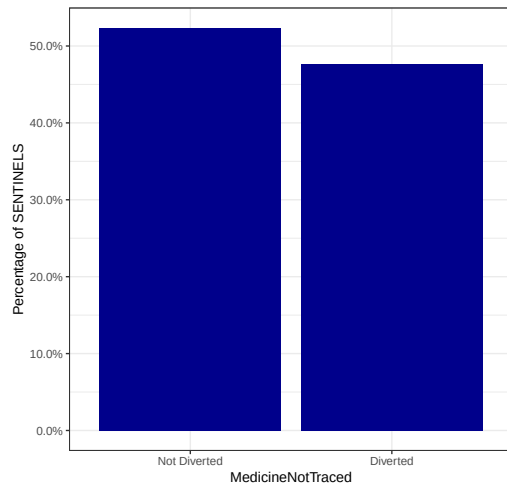
Figure 15: Histograms of *UpstreamDiversions* and *MedicineNotTraced* by Monitoring Message Status



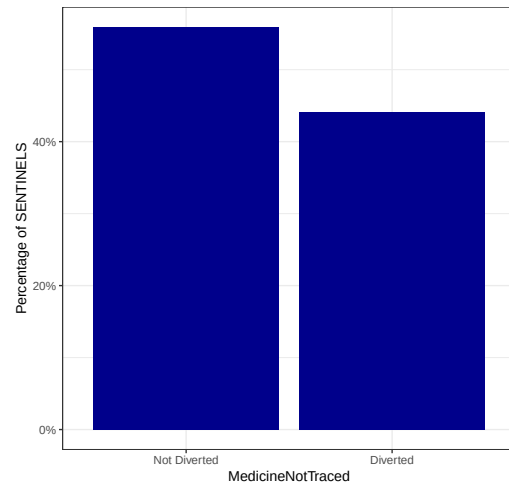
(a) *UpstreamDiversions* in Treatment Group



(b) *UpstreamDiversions* in Control Group



(c) *MedicineNotTraced* in Treatment Group



(d) *MedicineNotTraced* in Control Group

Table 3: Effects of Monitoring Message on Diversion During Delivery (*UpstreamDiversion*) and Diversion Post-Delivery (*MedicineNotTraced*), Full Sample

	<i>Dependent variable:</i>			
	UpstreamDiversion		MedicineNotTraced	
	(1)	(2)	(3)	(4)
Monitoring Message	−0.008 (0.009)	−0.004 (0.010)	0.037 (0.024)	0.044* (0.023)
Amoxicillin		−0.012 (0.173)		0.527 (0.346)
Phenobarbitone		0.065 (0.157)		0.216 (0.315)
Syringes		0.025 (0.156)		0.100 (0.313)
Ibuprofen		0.0002 (0.156)		0.263 (0.313)
Aspirin		0.017 (0.156)		0.113 (0.313)
Paracetamol		0.031 (0.156)		0.174 (0.313)
Gloves		0.032 (0.078)		−0.357** (0.161)
Distance from CMST (log)		0.014 (0.010)		0.246*** (0.030)
Private Facility		−0.370 (0.235)		
Government Facility		−0.133*** (0.037)		−0.005 (0.088)
NGO Facility		−0.219** (0.103)		−0.706*** (0.211)
Constant	0.032** (0.015)	−0.210 (0.211)	0.562*** (0.035)	−1.889*** (0.539)
Observations	2,299	2,032	1,629	1,465
SENTRY Fixed Effects	Yes	Yes	Yes	Yes
Covariates Included	No	Yes	No	Yes
Adjusted R ²	0.150	0.170	0.091	0.225

Note:

*p<0.1; **p<0.05; ***p<0.01

Table 4: Effects of Monitoring Message on Diversion During Delivery (*UpstreamDiversion*) and Diversion Post-Delivery (*MedicineNotTraced*), Sample without DHOs

	<i>Dependent variable:</i>			
	UpstreamDiversion		MedicineNotTraced	
	(1)	(2)	(3)	(4)
Monitoring Message	-0.020** (0.009)	-0.014 (0.009)	0.036 (0.027)	0.046* (0.026)
Amoxicillin		-0.004 (0.029)		-0.159* (0.084)
Phenobarbitone		-0.028 (0.025)		-0.110 (0.068)
Syringes		-0.040** (0.018)		-0.134*** (0.049)
Ibuprofen		-0.024 (0.015)		0.054 (0.044)
Aspirin		-0.019 (0.017)		-0.127*** (0.048)
Paracetamol				
Gloves				
Distance from CMST (log)		0.024*** (0.009)		0.243*** (0.030)
Private Facility		-0.295 (0.211)		
Government Facility		-0.180*** (0.041)		-0.573*** (0.118)
NGO Facility		-0.237*** (0.087)		-0.719*** (0.204)
Constant	0.040*** (0.015)	-0.118 (0.138)	0.630*** (0.040)	-0.207 (0.474)
Observations	1,828	1,604	1,215	1,091
SENTRY Fixed Effects	Yes	Yes	Yes	Yes
Covariates Included	No	Yes	No	Yes
Adjusted R ²	0.126	0.188	0.099	0.267

Note:

*p<0.1; **p<0.05; ***p<0.01

8 Discussion of Challenges and Limitations

The results presented above require several caveats regarding challenges and acknowledgements of limitations. This section delineates these issues.

8.1 Sample Size versus Spillover

There are two important notes regarding tradeoffs made in the design phase. The first tradeoff was between sample size and spillover. After the COVID-driven redesign, we initially planned to complete a factorial experiment with two independently randomized messages at the level of the delivery route or health facility. This would have allowed us to study the effects of two strong treatments (a monitoring message or a social norms message) on officials' choices along treated routes or at treated health facilities. This would also have reduced spillover, as officials are unlikely to work multiple routes or multiple health facilities.

Unfortunately, we realized in the final stages of intervention design that the volume of deliveries and health facilities involved in the intervention period (or, indeed, in the months before or after) was not going to be enough to allow for randomization at those levels. We were therefore compelled to drop one treatment arm and randomize at the level of the medication box. This level of randomization undoubtedly brought significant spillover, as officials who viewed a treatment box were likely to also view a control box, and vice versa. Therefore, we take the effects discussed above as the lower bound of potential treatment effects from similar interventions.

8.2 Treatment Strength versus Treatment Efficiency and Feasibility

Similarly, we dealt with a tradeoff between treatment strength versus treatment efficiency and feasibility. The originally designed intervention entailed a strong treatment: a facility-level, in-person meeting between government officials, representatives from the citizen oversight committee for that facility, and officers from the Drug Theft Investigations Unit (DTIU). Based on past literature as well as preliminary reports from the field in the first few weeks of the intervention phase, we believe this intervention would have resulted in significant treatment effects that we could have identified at the facility level. Unfortunately, the COVID-19 pandemic compelled us to design a replacement intervention that required minimal in-person interaction and was extremely low-cost. While we ultimately feel that the final intervention represents an efficient and scalable policy solution to the looming problem of medications

theft, we also recognize that it is a much weaker treatment. Again, we conclude that the effects discussed above could be greater with a stronger intervention.

8.3 Measuring Diversion: Deliberate Malfeasance versus Administrative Low Capacity

There are several limitations of our measures of diversion. First, and most importantly, they do not perfectly operationalize theft. They partially capture theft and partially capture administrative low capacity - for example, disorganization, insufficient record-keeping, or inadequate training. Of course, theft and administrative capacity may be inversely correlated (Hope Sr, 2015; Lewis, 2006). Still, future research could consider how to use the tracking system we developed to more precisely identify theft distinctly from these administrative issues.

A second limitation is that our coding of *UpstreamDiversion* and *MedicineNotTraced* is currently quite coarse. Specifically, we allow for a medicine (SENTINEL) to be delivered or traced during the in-person digital audit within a large area around the health facility, and it is only coded as diverted outside that area. We established this coding rule because much of the GPS data was received through Malawi's cell network rather than GIS satellites. We have more granular information about which GPS data came from which source and the relative signal strength of each cell tower in Malawi. We are in the process of working with the University of North Carolina GIS librarian to incorporate that information and will be able to more precisely code the diversion variables in the future. In the case of *MedicineNotTraced*, in particular, this will allow us to separate instances of finding a medicine (SENTINEL) at a private pharmacy or market **nearby** a health facility versus instances of finding it **within** a health facility. With the current measurement assumptions, these two instances are often observationally equivalent, which may explain the treatment's positive effect on post-delivery diversion.

8.4 Device Manipulation

One important form of non-compliance is tampering. Though we took steps to obfuscate tracking devices, we have anecdotal evidence of at least a few instances where SENTRIES were damaged or simply switched off to stop their tracking capability. Similarly, some SENTINELs were unable to be found after leaving the delivery trucks, even once the logistics company managing the deliveries deployed a team to retrieve them. In the analysis above, we interpret these instances as diversion. Future research could examine this behavior in more detail.

9 Policy Implications and Lessons Learned

Collectively, our project findings lead to three policy implications and two more general lessons learned. First, despite diligent work within the Ministry of Health and ample attention and funding from international donors, we find that the diversion of medications and medical supplies is still rampant in Malawi, particularly after the delivery of medications from Central Medical Stores to health facilities (40% diversion), for some medications (e.g., Ibuprofen, at approximately 55% diversion), and areas far from the Central Medical Stores distribution center. However, a corollary finding is that not all instances of diversion occur due to theft: we estimate that nearly one-third (30%) of medicines diverted during delivery were simply delivered to the incorrect health facility. Collectively, these findings imply that the Malawian government and donors to Malawi should continue to invest in anti-theft interventions, and should do so alongside interventions that build the organizational capacity of Central Medical Stores, health facilities, and other stakeholders involved in the medications supply chain in Malawi.

As a more general lesson learned, the digital tracking and auditing system we developed should be refined to identify theft separately from administrative low capacity, a refinement which could simply entail more donor and government investment in in-person digital auditing post-delivery, a skill set that personnel at the Ministry of Health now possesses as a result of this project. In the interim, however, we find that health facility officials noticed both the monitoring message and the tracking devices and most of these officials were able to accurately recall the content of both the device and treatment stickers. In fact, more of the officials remembered the tracking devices than the monitoring message stickers, and a second lesson learned is that the tracking devices were a “treatment” in and of themselves, and may have diluted the effect of the monitoring message treatment. The intervention design could be easily replicated and strengthened in the future to capitalize on the effects of the tracking devices in addition to delivering the monitoring message, for example including aggregated findings from the digital tracking and auditing activities. This would reinforce the monitoring message by adding credibility to the tracking claims.

Our research suggests that digital audits and targeted messaging can be effective tools in the anti-corruption arsenal. This low-cost, highly scalable intervention is immediately applicable to the government’s efforts to improve health services delivery. One of our partners, the Drug Theft Investigations Unit (DTIU), is a donor-funded government agency housed under the Malawi Ministry of Health responsible for monitoring corruption (specifically theft) in public health procurement. Like many similar organizations in the developing world, the DTIU has had only limited success.

Officials complain of insufficient resourcing and the frequent non-compliance of local officials with procurement regulations. Collaboration between DTIU and other branches of government has also been difficult. We designed our intervention to address these challenges. Unlike typical anti-corruption interventions which can cost more than they save (Hobbs, 2005), the intervention we evaluate does not require broad institutional reform or a large input of financial resources.⁸ This treatment is also designed to speak to the effectiveness of similar public messaging campaigns sponsored by many donors, such as the ispeakoutnow.org campaign sponsored by Global Fund. Finally, this intervention is also efficient in a crisis environment. Typical interventions to prevent corruption in health systems involve audits, training, and local capacity building. During the COVID-19 pandemic, these measures would have put public officials at risk and undermined quarantine measures. This leads to weak procurement oversight during a time when corruption is particularly attractive. By offering a low-cost, low-interaction, and easily fielded intervention, the protocol we developed could be scaled up in similar contexts facing similar health crises, and could inform health policy and crisis procurement management more generally.

A third policy implication pertains to other opportunities for future interventions. We find that officials who remembered the monitoring message did not perceive higher risks of detection and punishment for theft. This null effect on perceptions of risk is not necessarily surprising in light of the oftentimes weak mechanisms of accountability for medicine theft. Citizens report an inability to report theft and Health Centre Advisory Committees report inconsistent observation of deliveries, one of their primary anti-theft initiatives. A promising way forward for this research program is to use our digital tracking and auditing system to better empower bottom-up and horizontal accountability mechanisms. For example, our original proposal for this evaluation (which was adjusted due to COVID-19 restrictions) proposed using information from digital tracking and auditing to empower the Health Centre Advisory Committees. Using digital technology to strengthen accountability mechanisms remains a promising area for policy research and investment.

⁸The intervention costs, not including evaluation costs, total just over \$20k. See Section A and Table 1 in the Appendix for details.

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A Intervention Costs

Table 1 includes all of the costs associated with running the intervention, estimated based on Malawi administrative data and project records. It does not include evaluation or monitoring and evaluation costs, although we note that the items “Equipment-Trackers” and “Printing Costs - Trackers Stickers” are costs that are required for the intervention to occur but, now that they have been paid, would not need to be incurred again. In total, the total estimated costs of the intervention are US\$121,163, or US\$20,993 without the costs of the tracking devices and their stickers included.

Table 1: Intervention Costs

Cost Description	Unit	Unit Cost	Number Units	Total Amount (in MK)	Total Amount (in USD)	Notes
Communications	Intervention Total Cost	MK1800000	1	1800000	2222	Airtime for minutes and data used to coordinate the intervention
Equipment - Trackers	Intervention Total Cost	US\$98274	1	N/A	98273	80 parent tracking devices and 2400 child tracking devices
Printing Costs - Trackers Stickers	Intervention Total Cost	MK1536000	1	1536000	1896	Stickers for the tracking devices
Printing Costs - Treatment Stickers	Intervention Total Cost	MK960000	1	960000	1185	Anti-theft stickers
DTIU Director salary	Monthly Cost	MK610000	0.75	457500	565	3 months of quarter-time work to coordinate the intervention
DTIU/MOH officer salary	Monthly Cost	MK490000	8	3920000	4840	2 months of 4 people working full-time to execute the intervention
CMST manager salary	Monthly Cost	MK812000	0.75	609000	752	3 months of quarter-time work to coordinate the intervention
Vehicle maintenance costs	Monthly Cost	MK300000	4	1200000	1482	Maintenance for 2 months of 2 vehicles
Fuel costs	Intervention Total Cost	MK6500000	1	6500000	8025	
Training costs	Intervention Total Cost	MK1070000	1	1070000	1321	Training DTIU/MOH officers on intervention execution
Workshop stipend	Daily Cost	MK45000	5	225000	278	Workshop attendance for results dissemination (at MoH)
DTIU office space	Monthly Cost	MK350000	0.75	262500	324	Overhead for DTIU office space for intervention coordination and execution