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Abstract

Sustained progress in reducing child mortality requires better care for children who are acutely ill. This paper studies how health care subsidies and health workers providing information on symptoms affect the overuse and underuse of primary care, which depend not just on absolute levels of demand, but also on whether care is received when the child is actually sick. In a randomized controlled trial of 1,768 children in Mali, the study collected a unique panel of nine weeks of daily symptom and health care use data to study the impact of each policy on demand conditional on need for care, as defined by World Health Organization standards. Subsidies substantially increase care when it is medically indicated, while overuse remains rare. Health worker visits have no aggregate effect on demand, but they may help the youngest children take advantage of the subsidy.

This paper is a product of the Development Research Group, Development Economics. It is part of a larger effort by the World Bank to provide open access to its research and make a contribution to development policy discussions around the world. Policy Research Working Papers are also posted on the Web at http://www.worldbank.org/prwp. The authors may be contacted at asautmann@worldbank.org.

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1 Introduction

In the last two decades, great strides have been made in reducing child mortality through preventive care programs (e.g. Bhatt et al., 2015). Nonetheless, over five million children under five years died in 2018 alone (Hug et al., 2019). Current consensus is that further progress requires better care for children who are acutely ill. Two demand-side policies have played a key role in this effort: health care subsidies and community healthworker (CHW) home visits, which serve to educate caretakers and monitor the health of the child.

The policy debate on how to fund primary care for children is longstanding, and important developments are currently underway. The Bamako consensus from 1987 mandated charging user fees to maintain sustainability and quality of care. This view has been reversed in policy circles in favor of universal subsidization of basic primary care for small children and mothers, see e.g. Akin et al. (1987); Litvack and Bodart (1993); Jimenez (1995); Save the Children (2008); UK Secretary of State for International Development (2009). In 2019, Mali's Ministry of Health announced its intention to provide free children's and mothers' health care by 2022, at an estimated cost of $120 million, although it acknowledged funding gaps (Adepoju, 2019). While a rise in security incidents, political turbulence, and the Covid-19 crisis have stalled the reforms, this proposal will likely serve as a benchmark for future health policy.

It is known that subsidy and information policies for *preventive* care can greatly improve demand (Ashraf et al. (2010); Dupas and Cohen (2010); Ashraf et al. (2013); Dupas (2014); Miguel and Kremer (2004), see also Kremer and Glennerster (2012)). But unlike for prevention, whether and when *acute* health

care is needed depends on the child's health status, and it is up to the child's caretakers at home to monitor symptoms and make decisions about access to care. This makes an assessment of the demand for acute care more difficult. As African health care systems move towards greater subsidization (Yates (2007), Ridde and Morestin (2012)), effective policy-making requires understanding to what degree subsidies encourage health care use when the child is in need of medical attention vs. not, and whether complementary health information policies can improve utilization. Are unfilled health care needs met? What share of expenses may end up paying for unnecessary treatment?

A priori, subsidies for children's primary care are likely to increase use. This could improve the allocation of care if there are access barriers, for example if caretakers face credit constraints, misjudge the child's health care needs, prioritize the costs to them over the benefits to the child, or disregard the negative externalities of untreated infection. At the same time, subsidies may cause the waste of scarce resources if they lead caretakers to overuse care, in particular if they have little health education and geographical distance is not a primary barrier, as is the case in urban areas. This is a particular concern given that increased demand will in practice challenge existing supply capacities. Health education and information provided by CHWs might in this context help direct those children to formal care who need it most.[1]

Central to interpreting any demand response is the ability to estimate the

[1]While CHWs programs were initially conceived as a way to reach patients in remote rural areas, many CHW work in practice in urban or peri-urban areas. Comprehensive data is sparse, but even in national CHW programs that target rural populations, a significant share of healthworkers operate in urban areas (e.g. 20% of CHW in Pakistan, Brook (2009)). Besides directing children's acute care, CHW typically also promote prevention and prenatal care; aspects we do not focus on here. We document few differences in acute illness incidence with and without CHW (see below).

impact of subsidies and CHW visits on care seeking *conditional on the health status of the child.* As an example, randomized trials of health insurance subsidies in Nicaragua and Mexico have resulted in few health or utilization effects, with low uptake and retention (King et al. (2009); Thornton et al. (2010)). Information on conditional demand could help determine whether this is because there is no significant unfilled need for care, or because the intervention did not succeed in curbing underuse, perhaps due to unobserved supply-side effects. In this study, we address this gap with the help of novel, detailed daily health data collected at home.

In partnership with the NGO Mali Health, we conducted a randomized control trial of a health care subsidy, which reduced primary care cost of children under five years by 72% on average, and a community healthworker (CHW) program, for which CHWs visit families biweekly and teach them basic health knowledge. The interventions were cross-randomized at the compound (dwelling) level, with a final sample of 1768 children from 642 compounds. Comprehensive quality controls at Mali Health's partner clinics and the small sample mitigate general equilibrium effects and allow us to focus on the demand response to the interventions.

Nine months after intervention start, we collected nine weeks of daily data on children's health and health care. Building on the Integrated Management of Childhood Illness (IMCI) guidelines for community healthworkers,[2] we record 14 symptoms that are key in the detection of the main causes of child mortality in resource-poor settings. We construct illness spells and observe demand for

[2]The version adapted for the use by community healthworkers is called C-IMCI, see WHO (2014); WHO Department of Child and Adolescent Health and Development (2005); UNICEF Health Section (1999); Rosales and Weinhauer (2003) and Arifeen et al. (2009).

formal health care during the spell. We can infer when the IMCI would instruct a CHW to seek a formal medical evaluation by a doctor, based on the duration and type of symptoms. The guidelines are quite intuitive – for example, they prescribe immediate care if symptoms indicate a risk of malaria, but treat coughing or diarrhea as harmless unless they last unusually long or cause complications that point to pneumonia or dysentery. We observe children whether or not they seek care and therefore can measure utilization relative to the IMCI benchmark.

The IMCI was developed by Unicef and the World Health Organization and is used by public health systems and NGOs in over 80 countries, including our partner NGO Mali Health, who based their CHW training on it. Classifying when an illness spell requires evaluation by a doctor according to the IMCI allows an assessment of severity from a medical perspective and therefore relative value of care: a policymaker who wants to improve population health should aim to increase care seeking on "care-required" days over other days, all else equal. It also measures whether providing information about care seeking guidelines actually increases parents' adherence to these guidelines. In this manner, the IMCI provides a benchmark for assessing the targeting of care, given that the optimal solution to the social planner's problem cannot be directly observed (see also Section 3 for a discussion).

We organize our empirical results with the help of a framework that treats care seeking as a stopping problem, where parents decide to seek care during a given illness spell conditional on spell length and symptoms. This captures the intuition that a set of initial symptoms will become more concerning as the illness persists or new symptoms arise, and eventually lead to a clinic visit.

The value of waiting instead of seeking care immediately lies in the possibility of avoiding a visit altogether. The policy maker solves a similar optimization problem, but may disagree at what point care should be sought, e.g. because of a different cost-benefit trade-off or a better understanding of the illness. Parents may therefore *overuse* care relative to the policymaker's assessment by going to the doctor too early, before care is required, or *underuse* it, by going too late. Subsidies will lower the cost threshold and lead to earlier (more) care. Information can improve the allocation of care, as long as the parents' cost-benefit assessment is aligned with that of the policymaker.

We observe 3747 illness spells – more than two per child – with an average length of 6.4 days, of which 3.0 are "care-required" days. We find that overuse according to IMCI recommendations is rare in the control group, even though there is surprisingly large scope: about half of all illness spells end without ever requiring care.[3] By contrast, underuse is rampant, with a probability of care-seeking on a care-required day of six percent or lower. As a result, only 11% of spells that reach "care required" status actually receive formal care. Nonetheless, the probability of care is on average more than five times higher on days when care is required than when it is not: parents do seem to differentiate illness severity as embodied in the IMCI care recommendations, even though they delay the doctor visit longer than recommended.

The subsidy increased visits to the doctor by at least 175% and the total

[3]Note that the idea of seeing the doctor too early hinges on the possibility that an illness may pass harmlessly without entering "care required" status. Nonetheless, a spell that enters "care required" status may end without treatment. "Care required" should be interpreted to mean that the risk of harm or death is sufficiently high to warrant the cost of care, even if the illness may ex post pass without apparent harm. Indeed, more than 85% of illness spells in our sample end despite not receiving any formal care, including those that would have required care according to the IMCI.

value of received care by over 80%. Importantly, this increase does not crowd out private spending on acute care, and the bulk of the increase occurs on care-required days. Again, parent behavior emulates the IMCI assessment of relative need for care, and it means that more than 70% of the doctor visits that the subsidy generates are IMCI recommended.

In our sample, providing health information to parents through CHW visits has no aggregate effects on demand, consistent with parents already being able to distinguish need for care. However, exploratory analysis uncovers substantial heterogeneity. For children up to one year old who receive the subsidy, CHW visits lead to a significant additional reduction in underuse of care (IMCI based). This is important because it suggests that the subsidy and information interventions complement each other in improving care for the age group with the highest mortality risk.

The CHW may simply alert parents that the subsidy is available, but another possibility suggested by our model is an interaction of improved information with the cost threshold for care that the caretakers apply. The difference in care seeking when care is vs. is not required is smaller for the youngest children (under one year of age), in line with qualitative evidence on the greater difficulty parents have in recognizing illness in young children (Charlet et al. (2017)). The CHW effect is also lower without the subsidy and exhibits a significant negative age gradient, suggesting *greater* underuse for older, lower-risk children for whom prices remain high. Taken together, it is possible that the CHW *are* helping parents more accurately assess need for care according to IMCI guidelines, but depending on how closely parents' preferences are aligned with these guidelines, this may reduce or increase underuse.

Overall, our results are consistent with cost constituting a primary barrier to appropriate care in our population. The results are encouraging for the planned roll-out of subsidized care in Mali, although they predict a surge in health care utilization that could create bottlenecks in supply. Our work complements a study in Bamako by the NGO Muso and the Malian Ministry of Health in 2008-2015, combining CHW, user fee removal, and health system strengthening measures (Johnson et al. (2013, 2018)). Cross-sectional surveys find improvements in incidence of, and care seeking for, febrile illness, as well as reductions in mortality after the intervention was introduced. Our experiment can directly attribute health behavior changes to the interventions, pointing to formal care demand as a potential pathway for the health outcome effects, and highlighting the differential contributions of the CHW and the subsidy. The ambiguous CHW effects call for further study, given the important role of CHW interventions in health policy in general and in Mali in particular.

Throughout the paper, we apply hazard models to spell data collected at home in order to estimate the effects of our interventions on care seeking conditional on health status. In section 5.4, we discuss the advantages of this approach for making out-of-sample predictions and for understanding selection effects that would arise in demand analysis based on health system contacts only (e.g. records of health consultations or health insurance events).[4] For example, we show that children with the subsidy who visit the clinic have been actually sick weakly *longer*, because the treatment succeeds at bringing

[4]Since sickness spells can and do frequently end without treatment, selection bias in such data is pervasive. In most other spell data economists use, e.g. unemployment spells, there are no equivalent sources of censoring.

children to the clinic whose parents tend to wait long before seeking care.[5]

Our paper contributes to the literature on children's acute health care in low-income countries, aided by novel daily panel data. Research on acute care is still fairly rare (but see Powell-Jackson et al. (2014)).[6] The problem of underuse is thought to be particularly severe for preventive goods, where the benefits are nearly universal, but also often abstract or far off. Our results suggest that underuse is similarly pervasive at the extensive margin of acute care – the decision to visit a doctor – and that subsidies can substantially improve utilization. This complements Cohen et al. (2015) and Lopez et al. (2020), who examine the effect of subsidies for malaria drugs at the point of purchase. There are significant rates of overtreatment that increase with subsidization. This points to a challenging twin problem, where underuse at the extensive margin, in the form of too few contacts with the health care system, can occur simultaneously with overuse at the intensive margin, in the form of overmedication conditional on such a contact, especially when there are no cost controls such as those implemented by Mali Health.[7]

[5]One of the few data sets we are aware of that has panel spell data, the 1987 National Medical Expenditure Survey for the United States, includes only spells that lead to medical care use or work absenteeism. Gilleskie (1998) recognizes the selection problem but can only address it by estimating the probabilities of unobserved health events parametrically. With administrative data e.g. from insurance claims (Manning et al. (1987); Finkelstein et al. (2012)), illness spells can only be studied indirectly, by grouping claims into treatment episodes, see Stoddart and Barer (1981); Hornbeck et al. (1985); Keeler et al. (1988); Santos Silva and Windmeijer (2001). A public health literature studies the covariates of the delay in seeking care for specific diseases (see Storla et al. (2008) and Nguyen et al. (2010) for reviews).

[6]Das and Sánchez-Páramo (2003) have weekly data on illness and document the variation in demand that comes from differential illness incidence, but do not study demand interventions.

[7]Das et al. (2016); Currie et al. (2011) conduct patient audit studies and show similarly low-quality diagnostic and treatment choices, which often result in mis-targeted treatment. Also related is work by Fischer et al. (2014), who test for learning and reference dependence as they vary prices in door-to-door sales of over-the-counter drugs (but do not focus on over-

Section 2 describes the policy environment and the RCT intervention and survey design. Section 3 discusses our use of the IMCI measures. Section 4 introduces a framework for demand for acute care and the effects of subsidy and information policies. Section 5 describes the empirical results and 6 concludes.

2 Study Background and Data Collection

The Malian health care system builds on a network of community health clinics or *centres de santé communautaires* (CSComs). A CSCom has typically one or two trained doctors on duty and sells prescribed medications through an attached pharmacy. At the time of the study, CSCom care was partly subsidized, but primarily funded by user fees, in accord with the Bamako Initiative from 1987, which advocates self-sustaining, decentralized public health care across West Africa. The public health care system is flanked by a private formal sector with higher prices, and informal sources such as market stalls (see below).

This study was conducted in Sikoro, a peri-urban area of the capital of Mali, Bamako. Most roads are unpaved, and many dwellings are not connected to the water supply or the sewage system. In and after the wet season the incidence of waterborne diseases (diarrhea) and malaria is highest. Mali has high rates of maternal and child mortality, especially in rural areas. Poor urban areas have better health care access and lower rates of mortality, but still often lack basic health services. Mali's urban areas resemble those elsewhere in West and Sub-Saharan Africa, although literacy rates in Mali tend to be lower and fertility and child mortality rates higher (see table C.1 in the online appendix).

or underuse).

This makes child health interventions particularly important here.

2.1 Study Design

Mali Health started the Action for Health (AfH) program in 2010 in collaboration with the two local clinics (CSComs) in Sikoro. The full AfH program combines subsidized health care and community healthworker visits (CHW).

The subsidy is administered via a personalized card that entitles the child to unlimited free consultations at a partner clinic, and free treatment and medication for any illness due to diarrhea/malnutrition, malaria, vaccine-preventable diseases, and respiratory infection (together causing the vast majority of child deaths outside of neonatal conditions). Families have to cover remaining expenses for example for services that are not part of the standard treatment course for a given diagnosis.

Families in the CHW program received biweekly CHW visits. The CHW tracks a set of simple indicators including symptoms and malnutrition measures, teaches basic health practices, and advises families when to visit a doctor or alternatively what care to provide at home, such as rehydration in mild cases of diarrhea. CHWs are recruited locally and their training follows the C-IMCI (Rosales and Weinhauer (2003)), a set of guidelines for community healthworkers that incorporates the WHO's and UNICEF's "Integrated Management of Childhood Illness" recommendations for when to refer children to formal health care (WHO (2014); WHO Department of Child and Adolescent Health and Development (2005); see also below).[8]

[8]Outside the focus of this paper, CHWs also monitor nutrition and advise households on preventive care in general. They also dispense water chlorination tablets for households with no access to clean water.

The research design took advantage of the second planned roll-out wave of AfH. Mali Health conducted a census in their expansion area in mid-2012 to enumerate all families with children under five years of age (or a pregnant mother) who satisfied a proxy-means test designed to select approximately the poorest third of households. Data were collected in two survey rounds in 2012 and 2013 during the rainy season (September-November). All households identified in the census that were found at baseline were included in the random assignment to the different treatment groups and revisited in 2013.

In this study we use demographic, location, and household asset data collected in the baseline survey, and daily health diary data on children collected at follow-up. The unit of randomization is the compound. A compound may house more than one household, and typically consists of a few rooms around a common courtyard with shared latrines and other facilities. After stratifying compounds by average household assets, number of eligible children, and location, each was assigned to the subsidy-only group, the CHW-only group, the full treatment group, or the control. The healthworkers in the two CHW treatment groups were trained and managed separately, to avoid spillovers.[9]

The focus of this study is to understand the demand for health care of the typical quality a local medical professional (trained and certified in-country) can provide, holding the supply side constant. There are two supply-side issues

[9]It was not possible to assign healthworkers across the entire intervention area while keeping their travel distances manageable. Mali Health therefore paired healthworkers of similar experience and quality, and one of each pair was assigned to the healthworker only or the healthworker and subsidy group. The pairs were then assigned in an overlapping pattern by stratum. For example, pair 1 and pair 2 were each randomly assigned half of the families in the same stratum, and half of the families in a different stratum, each shared with another pair of healthworkers. In this manner, each stratum was assigned four healthworkers (two in each treatment group), the quality of the healthworkers in the treatment groups was matched, and no two strata had identical sets of healthworkers.

we do not address here. The first is the problem of sometimes low quality of care in public health care systems in developing countries, which may mean in practice that patients receive care from an untrained individual or not at all (e.g. if the doctor is actually absent). Such quality problems would of course affect how desirable the use of the health care system is both from the parents' and the policymaker's point of view (see e.g. Das (2011); Das and Hammer (2005, 2007, 2014); Das et al. (2016); Das and Sohnesen (2006); Leonard and Masatu (2010); Leonard et al. (2002)). The clinics in this study were financially supported by Mali Health during the study and subject to regular quality control. We assume that the standard of care provided at these clinics reflects the level of care that the WHO expects when they formulate treatment recommendations for low-income countries.

The second issue is demand inducement and moral hazard by doctors, common concerns in particular when care is subsidized. Mali Health controlled costs in the subsidy group using treatment guidelines for common diagnoses, spot checks on diagnosis and prescriptions using bills submitted to Mali Health, and the clinic's treatment records and accounting. The subsidy did not change the average value of services received per visit (see section 2.3).

2.2 Sample Population

Mali Health identified 1804 eligible children in the census. At baseline, 1732 children were included in the study. The roll-out of AfH started three months after the baseline in early 2013. By the second survey round in Fall 2013, there were three refusals and an additional 162 children could not be surveyed, in-

cluding five who passed away.[10] The remaining sample in 2013 contains 1567 children from 990 households in 642 compounds. Attrition between baseline survey (and treatment assignment) and follow-up is 8-11%; the group differences are not significant. At follow-up, 201 children were newly reported by the caretakers of existing study children. Newborn children in the treatment households were enrolled in AfH either by the healthworkers, or by a program officer who visited study households every three months. Since the caretakers' treatment choices are our outcome of interest, we consider these children part of the sample. We only included newly reported children 3-12 months old. Table C.2 in the online appendix shows the sample over the study period.

Table 1 shows sample characteristics and balance. We find few significant differences between the treatment groups. There are on average more than six people in a household, due in part to polygamous marriages. About half of the household heads are literate and 73% speak the *lingua franca* Bambara. Households report on average about US$6600 in assets, with an owner occupancy rate of 41%. Only 13% of household heads earn a regular salary. The closest source of formal health care is on average 546 meters away (less than 0.4 mile). Average child age is about three years. The study children are well below age-typical weight for height (normalized using W.H.O. reference distributions). We control for these covariates in the analyses below, except weight for height, which may be an outcome of parents' health behaviors.

[10] Our sample population moves a fair amount, but households that relocated inside the program area were followed and remained eligible for Action for Health; only children who left the area entirely or could not be tracked are not included.

2.3 Health Calendar

We collected daily information on symptoms, health consultations, and medications taken in weekly visits over the course of nine weeks from the child's primary caretaker (usually the mother). Caretakers could use pictorial diaries (figure B.1 in the online appendix) to mark off symptoms and health-related events. The surveyor then reconstructed the child's health history during the visit. There was a concern that parents would respond to the observation by the surveyors, for example by watching their children more closely. Ultimately this drawback was outweighed by the benefits of detailed coverage without the problems associated with long recall periods (Das et al., 2011). The surveyors were carefully instructed not to comment on the child's health, and to emphasize that they had no medical qualification. While we cannot rule out all Hawthorne effects, we believe our precautions mitigated them, combined with the fact that the data collection had been piloted over six weeks after the baseline in 2012, thus creating some habituation.[11]

Symptom Calendar. The list of symptoms was designed in collaboration with Mali Health staff and based on the C-IMCI. The C-IMCI is designed for use by CHW who have no prior medical experience, and is used in Mali Health's own healthworker training. It consists of simple rule charts that use important and easy-to-spot symptoms to broadly classify a child's illness and

[11]Since the survey took place towards the end of the rainy season, illness rates were declining over the course of the panel, so we cannot assess if a time trend is due to a fading Hawthorne effect. However, in the baseline pilot of the health diaries, initially elevated symptom reporting rates stabilized at a lower level after the first week of surveying and then declined at a slower and more continuous rate (data available on request). This is consistent with data on doctors, who rapidly return to unobserved length and quality of doctor-patient interactions even when observed by other doctors (Das et al., 2008).

establish need for care. These properties mean we can collect symptom reports from mothers and surveyors who are not medically trained, and map them into an IMCI care seeking recommendation.The survey explicitly asks about convulsions, fits, or spasms; lethargy or unconsciousness; inability to drink; vomiting; coughing; difficulty breathing; more than three loose stools; blood in the stool; sunken eyes; and unusually hot (cold) skin. We constructed four more symptoms from the "other" category: skin conditions (e.g. spots, rash, itch), cold symptoms, ear pain, and injuries. We observe on average 60 days per child, and children exhibited symptoms on average on 18 days. Cold symptoms, coughing, and unusually hot skin were most frequent. Section 3 below gives more detail on how symptoms translate into illness spells. Appendix B provides a description of how the health calendar information was collected and shows recorded symptom days by treatment group in table B.1.

Consultations. At each surveyor visit, mothers were asked if they discussed their child's health with anyone in the preceding week, and the surveyors recorded role or occupation of the person seen, facility, waiting time, treatments received and costs incurred.[12]

Table 2 provides an overview of these health care "consultations". The 735 formal consultations in our data are provided by CSComs and CSREFs (reference hospitals), and private doctors, hospitals, clinics, and pharmacies. Parents occasionally see several providers in the same day, for example when they get a prescription at a clinic and then purchase medication elsewhere. We group

[12]In order to facilitate the recording of drugs prescribed, purchased, and taken, mothers were asked to keep the packaging of any medications their child took. The surveyors could search and fill the drug from a database of brand and generic names of about 300 medications commonly sold in Mali.

visit records that are linked in this manner and classify them by the "most formal" consultation in the group. The value of care is approximated using the full price of care.[13] Note that the sizable difference in costs and value of care even without a subsidy is due to families seeking outside help to pay for the child's care, e.g. from relatives or friends.

The table shows that the subsidy program reduced the average cost of a visit to the household by 71%, from CFA 2850 to 933 (476 CFA equaled 1 USD in 2013). Among the formal-care visits in the control and CHW-only groups, 14% and 12% were reported as free, vs. 70% and 77% in the subsidy groups, respectively. Parents paid if they visited other providers than the two partner clinics or did not claim the AfH benefit, or the child received services not covered under AfH.

CSComs provide similar value per visit with and without the subsidy, suggesting that the type and quality of health care received, conditional on visiting a clinic, is similar. A priori, one might expect that doctors respond to the subsidy by raising treatment costs or prescribing unnecessary treatments. This is not the case here, likely due to Mali Health's quality and cost control, implemented after initial increases in costs during earlier program roll-outs.

Wait times at the CSCom are somewhat longer with the subsidy. This could be because subsidized patients have a less acute need for care, or because they receive medical tests such as malaria tests, which require waiting. Another

[13]Value of care is imputed using prices recorded for consultations and medications where the respondent reported having paid the full price themselves. We use these prices combined with provider information, brand name, and point of purchase to construct the median price by source. If the respondent reported another person paying for care or was in the subsidy group, we compare the sum of median prices for the services received with the private expenses the respondent reported and use the higher value. This reflects the cost of care to the family, the NGO, or a third party.

possibility is that they see different personnel, or even are made to wait longer than other patients. For this the clinic staff would need to know in advance of the consultation which patients have the subsidy. Given the good relationship of the cooperating clinics with Mali Health, the income stream AfH patients provide, and Mali Health's efforts at quality control, we deem this possibility unlikely, although we cannot rule it out empirically.

Private formal providers are pricier than CSComs and have longer wait times. Informal visits and purchases are common and come at low monetary and almost no time cost. The low prices (under 50 US cents) suggest that they also provide little value. Typical informal sources are peddlers, stalls, or shops, healers, or Islamic marabouts; individuals who are not trained to diagnose illness. For our analysis, we treat these as home care. We also assign pharmacy purchases not associated with a doctor visit to the "informal" category because pharmacists do not carry out a diagnosis. Pharmacy visits alone are also not subsidized by AfH or promoted by the CHW.

Lastly, we recorded CHW visits if they were mentioned among the consultations (we did not explicitly ask about them to prevent reporting bias from associating the survey with Mali Health, for example if parents believe we are monitoring the healthworkers). Parents report 0.46 visits per child in the CHW-only group, but 1.64 in the full program group (24% and 43% of children report any CHW visit). Similarly, at the start of the survey, parents in the CHW-only and the subsidy-only groups report much lower enrollment in a health program than the full program group. However, we find no differential effects of the full program on health care use (see below). Together, these numbers suggest underreporting that is higher in the partial treatment groups.

3 IMCI Classification and Illness Spells

Throughout the paper, we identify "overuse" and "underuse" of care *relative to the IMCI guidelines* proposed by the WHO. The C-IMCI is part of the community and family arm of the IMCI itself, the WHO's and UNICEF's primary children's health program, which has been adopted by over 80 countries (Bryce et al. (2004)). The C-IMCI goes through a set of simple checks in order to spot danger signs and classify symptoms into gastrointestinal illness, respiratory illness, malaria, and so on. It targets the causes of about 70% of child deaths.[14] All diagnostic tests can be operationalized in the field. The effectiveness of these tests in identifying the underlying disease was rigorously tested (see Gove (1997) and the studies therein).

The C-IMCI algorithms make intuitive recommendations for when care should be sought based on the duration and severity of symptoms during an illness spell. For example, cough and cold symptoms typically point to a viral infection and do not require medical care, unless they persist for 14 days or longer, on suspicion of a more serious illness like tuberculosis. Diarrhea alone can be treated with home remedies, but in the presence of sunken eyes (dehydration) or blood in the stool (dysentery) requires immediate attention. Applying these rules to symptom records, every day in an illness spell can be classified as either an "early" day (i.e. before care should be sought) or a "care required" day (on or after the day at which care should be sought). Appendix B describes the approach in detail. We focus on pre-care spell days up to the first con-

[14]The five main causes are diarrhea, pneumonia, measles, malaria, and malnutrition. According to Unicef estimates, around 50,000 children under five died in Mali in 2017, 17% of whom died of pneumonia, 10% of diarrhea, and 14% of malaria.

tact with the health system, since symptoms might be affected by treatment. The C-IMCI is explicitly tailored to a developing-country context, and we assume that its care-seeking recommendations take into account factors like the expected quality of care and resource constraints.[15]

What justifies the use of the IMCI to assess need for care? The object of interest is the allocation of acute care. Demand for children's health care is likely distorted by market imperfections such as credit constraints. Parents may not fully internalize their children's welfare or externalities due to contagion. Moreover, households may not be able to interpret symptoms and assess the value of visiting the doctor in different health states. All of these imply that parents' health care demand is not socially (or even privately) optimal, and there is a role for policy intervention. However, solving the social planner's problem of optimal resource allocation requires too many parameters for which there are no good estimates, from the production-side trade-off between supplying health care and other goods, to the true preferences of the household.

Given the correlation of the IMCI diagnostic algorithms with serious illness, they provide some guidance for assessing welfare. First, they constitute an approximate solution to an optimization problem: conditional on the limited information an outside observer can use to make a recommendation, for an organization that is prepared to devote resources to children's health, which mapping from health states to care utilization has the greatest effects on ex-

[15]Mayo Clinic recommendations for children in the United States, for example, have lower thresholds for seeking medical advice. They advise to call a doctor after 24 hours of diarrhea, and state on fever: "When in doubt, go ahead and call your child's doctor, whether you think your baby's temperature is abnormally high or abnormally low." (Mayo Clinic (2014, 2016)).

pected mortality and morbidity? At a minimum, this provides a *ranking*; from a medical standpoint, care in the "care required" state is more valuable than otherwise, even if the total amount of care is not globally optimal.

Many policymakers may in addition agree that all children should receive care when the IMCI recommends it. For example, a child with malaria symptoms should be seen by a doctor regardless of parental preferences or wealth. Moreover, while parents may observe symptoms that require medical treatment but are not covered by the IMCI, such as injuries, it is less likely that parents have private information that indicates that no care is needed when the IMCI recommends care. The "care required" designation may then be considered a lower bound for underuse.

Last but not least, comparing parents' behavior to the IMCI recommendations indicates to what degree they follow the CHW's care seeking advice. Thus, even if they do not characterize the social optimum, the WHO guidelines capture important information, giving them a role in evaluating the effects of health care policies on the targeting and level of health care. Studying demand in detail complements measuring mortality or longterm health outcomes. While ultimately the outcome of interest, these depend on many factors besides acute care and do not give us direct information about actual behavior and use of health care in response to policy.

Classifying illness spell days. As described, we group contiguous symptom days into illness spells and classify each spell day as "early" or "care required" according to the IMCI, focusing on "pre-care" spells up to the first formal consultation or recovery. For example, consider a child who is cough-

ing for three days and takes cough drops from a peddler, then develops a fever on day three, and is prescribed paracetamol at the CSCom on day five; symptoms subside after day eight. This is a five day pre-care spell with three care-required days (days 3 to 5). If the child had not received care, it would be an eight-day spell.

Table 3 shows untreated days per child (possibly in several illness spells), and the percentage of days on which each symptom is present, in total and split into early and care-required days. On average, 16.3 of 59.8 observed days per child (27%) were (pre-care) illness spell days, and on six of those there was a need for care. Convulsions, lethargy, inability to drink, and vomiting should trigger immediate care, so they always occur on care-required days. The biggest contributor to need for care is fever (unusually hot skin). While cold symptoms and cough rarely in themselves indicate a need for care, they co-occur on many "care required" days. The data show that the children in our sample are often ill with symptoms that point to dangerous conditions like malaria, but also often experience harmless symptoms, so they are in need of a doctor evaluation only 37% of the time.

The symptoms we collected do not cover all possible illnesses, but focus on conditions that mothers and surveyors can easily recognize. As an example, breaths per minute and "chest in-drawing" are IMCI indicators of respiratory illness, but require experience and training (and a stopwatch) to measure. We also interpret the IMCI guidelines conservatively, for example for diarrhea (where the recommendation is for a CHW to return to the family after five days to check on the child's status, but we assume a need for care only when complications arise). Moreover, the IMCI itself is not exhaustive. As a result,

our classification as "care required" contains noise and generally represents a lower bound for need for care.

Appendix Table B.2 summarizes the observed pre-care spells. Due to spells recorded in the first week of the survey or after survey interruptions, 464 illness spells are potentially left-censored, that is, they may have started before the first recorded day. We exclude these spells from our main analysis.[16] This leaves us with 3747 spells, with an average length of 6.43 days (6.92 st. dev.). Within these spells, there are on average 3.4 early days and 3.0 care-required days. Only 503 spells, or 13.4%, end with a consultation; in all other spells, the child eventually recovers from the illness unaided. Spontaneous recovery is an important feature of the data and of acute illness in general: section 4 describes that "waiting out" an illness can be optimal if unaided recovery is possible, and in this case it may be overuse to visit a doctor early. By contrast, if recovery could only occur with medical care, "too early" use of acute care is not an issue; care should always be provided immediately, and any delay would constitute underuse.[17]

Spell incidence is fairly similar in the four treatment groups; between 907 and 967 spells (see table 5 below), despite the demand effects we document in section 5. A probable reason is that the main causes of acute illness – malaria, respiratory, and gastrointestinal – are infectious, and the children in AfH constitute only a small percentage of the population (about 20% of

[16]Left-censoring means that need for care cannot be determined, because the day of the spell is unknown. Left-censored spells are on average 10.2 days long. Our main results are robust to treating these spells as not left-censored (see also below).

[17]We discuss below that recovery is a form of right-censoring, because we do not observe when parents would have sought care if the child had *not* recovered. Right-censoring is here an integral part of the data generating process, and important for understanding health care demand, especially because a large number of spells do not end in formal care.

people in the study households, which in turn make up a fraction of the local population), so the program is unlikely to reduce infection rates.[18]

Below, we analyze care seeking conditional on symptoms, so even differential incidence would not be a concern, as long as conditional health care choices remain unaffected. If we believe that illness incidence does affect conditional demand, it is an advantage for comparing treatment groups that spell numbers do not significantly differ between them, but external validity would be lower. In Dean et al. (2017), we document a decrease in malnutrition rates and acute diarrhea incidence among children who received the full program by the second year, suggesting that incidence (preventive) effects of AfH may become more important in the long term.

4 Demand for Acute Health Care

We sketch a simple model for the decision to seek health care in response to acute illness, in order to derive notions of overuse and underuse and to make predictions for the impact of AfH policies on health care demand (formal statements in Appendix A). Our framework is based on two central observations. First, demand for acute care arises in response to a negative health shock that causes discomfort – and risk of harm – to the child until it passes. Second, there is learning about the severity of an illness over time. For many illness spells, it is likely that the child will recover without the aid of a clinic visit, and it is worth tolerating some disutility from sickness while waiting. As time goes by, the probability of recovery without treatment decreases, and further

[18]This is consistent with the balanced symptom incidence by treatment group, reported in table B.1 in the Appendix. Treatment rates remain overall low and treatment occurs fairly late in the spell, so the program has only a small effect on pre-care spell length and none on overall spell length (see also below for a discussion in the context of censoring).

suffering (or worse) can only be avoided by seeking care. Thus, the demand decision becomes *when* during an illness spell to visit a formal care provider.

Formally, denote the parent's belief that the illness will continue another day by π_t. Each day t of the spell, the parent decides to either visit a provider who can evaluate and treat the child, or wait another day, and with probability $(1 - \pi_t)$ the illness passes on its own. With uncertainty about the underlying illness, π_t is increasing in illness days t: continued symptomaticity reveals an illness with lower probability of recovery (Lemma 1). This implies a decreasing value of postponing treatment, since it becomes less likely that the child will recover on their own. As a result, parents optimally follow a simple cut-off strategy: seek care when belief π_t exceeds some threshold K (Proposition 1). K depends on the benefits as well as the monetary and non-monetary costs of care C. C is increasing in the (expected) price of care.

We assume that the policymaker faces a similar stopping problem, although with different parameters π^* and K^*. This agrees with expert care seeking recommendations such as the IMCI (see previous section), which take into account duration of symptoms as an indicator for health care needs. Such recommendations cannot be explained without learning and the possibility of recovering without treatment: if π_t^* (or π_t) was constant over time, the choice to seek care would be a simple yes/no decision on the first day of illness, because getting earlier care for the same illness is always better.

Effect of a subsidy: Consistent with current policy consensus, we assume that the parents' treatment threshold K is weakly greater than that of the policymaker K^*. The policymaker may evaluate the financial costs differently

from a parent with credit constraints, or she may incorporate the long-run human capital benefits or reduced infection risk for others. This case is illustrated in Panel A of figure 1 (numerical details in the appendix). Since there is learning over time, Bayesian updating implies that $\pi_t < \pi_{t+1}$ (solid black line, parent and policymaker assumed to share beliefs π). Conditional on not having recovered, the policymaker would like the child to receive care in period $t+1$ when $\pi_{t+1} > K^*$, but since $\pi_{t+1} < K$, the parent will not take the child to the doctor in $t+1$. This is an incidence of *underuse,* or visiting the doctor *too late* relative to policymaker preferences.

A subsidy lowers the care-seeking threshold of parents by reducing the treatment cost C. Panel A illustrates how this (weakly) increases utilization in all periods. However, if K is reduced by too much, for example to K', *overuse*, or *early* care, may now occur (since $K > \pi_t > K'$). In a heterogeneous population, a subsidy policy may eliminate some, but not all, underuse, yet simultaneously create some overuse.

Effect of information: Disagreement may additionally occur due to differences in beliefs about the recovery probability, so that $\pi_t \neq \pi_t^*$. If these differences are due to the parents' poor information, a situation might arise as in Panel B of figure 1: the policymaker can distinguish a more severe and a less severe illness (π^{*S} and π^{*L}) while the parent holds average beliefs π. Examples are diarrhea spells with or without signs of dehydration, or a generalized fever vs. a fever combined with symptoms that point to malaria (see also appendix). Lack of information can lead to both *overuse and underuse,* because parents take the same action regardless of illness severity. For example, at K

the parent will always seek care in period $t+1$ – but for many thresholds K^*, including K, the policymaker would prefer care for the severe illness in t, but no care for the less severe illness in $t+1$.

Subsidies cannot address simultaneous overuse and underuse from poor information, because they will only monotonically increase utilization. By contrast, a successful information policy may improve allocative efficiency. Take behavior at threshold K^*: an uninformed parent with belief π will always seek care in t and $t+1$, but an informed parent will exactly share policymaker preferences and delay care in period t in the case of the less severe illness. Thus, if the CHW intervention *aligns the beliefs of the parents with those of the policymaker* it may complement the subsidy by directing care (only) to the children who need it.

To summarize, if the main barrier to a good allocation of care is high cost, parents in the control group will seek care primarily on care-required days, but we will see significant underuse. If poor information is an important allocative barrier, then care seeking will be only weakly correlated with "care required" status and we may see both overuse and underuse (observation 1). A subsidy will increase utilization, thus decreasing underuse, but also potentially increasing overuse (observation 2). If the subsidy aligns the cost thresholds K and K^* and the CHW intervention aligns beliefs π and π^*, then the two interventions may complement each other in decreasing both underuse and overuse (observation 3). Observation 3 is the motivation for combining subsidies with information policies, delivered e.g. through CHW visits, as in AfH: subsidized care gives families access to health services, while better information ensures that they make efficient use of this benefit.

A few notes are in order. First, the degree to which the effects above are realized depends on the severity of the various constraints families experience, and is therefore an empirical question. Second, as the reader may notice from the graph, whether information unambiguously improves the allocation of care from the policymaker perspective depends on whether the cost cutoffs K and K^* are aligned. This is because upon receiving information that alters π, parents will align their behavior with their own cutoff K, not with K^*. This may be a positive or negative change from the policymaker perspective. We will return to this point when we discuss age-specific CHW effects in section 5.3. Last, in Action for Health (as in most CHW programs), the CHW do more than just providing information about when to visit a clinic. However, in the context of health care demand conditional on symptoms, we interpret this as the main potential channel through which they may affect care seeking.

5 Results

We begin the empirical analysis by documenting the impact of subsidies and CHW on unconditional utilization of acute care. We then study the impact of our three treatments on health care use *conditional* on health care status. Finally, we present exploratory analysis which examines the impact of each treatment by age and discuss potential explanations.

5.1 Unconditional Health Care Utilization

Table 4 shows regressions of a set of per-child outcomes on dummies for the three treatment groups along with a statistical test that the effects in the subsidy-only group are the same as in the full treatment group. All standard errors are clustered at the compound level. Columns (1) to (3) show the

number of formal consultations per child, in total and split into CSCom and other formal care. (4) to (6) report the effect of the program on private expenditure per child, again first in total and then for CSCom and other formal care separately. Column (7) reports wait times, and (8) and (9) report total and CSCom value of care (see above) per child.

Subsidies increase the number of formal care visits by 175-202 percent (0.38-0.44 visits), and the total value of care consumed by 83-84 percent (CFA1386-1409) relative to the control. The demand elasticity is clearly high: the subsidy increases the number of CSCom visits per child by 263-312%, relative to the decrease in the CSCom visit cost by 71% (table 2). There may be some substitution out of other formal care, but overall demand for private care is low, and none of the effects are significant. Remarkably, the subsidy has almost no effect on families' total health expenditure on their children. This implies that there is no crowding out; the subsidies fully translate into additional health care consumption. The subsidy groups also pay higher non-pecuniary costs for their child's health care, as evidenced by the increase in time spent waiting for treatment by about 17 minutes per child.

In stark contrast to the effects of the subsidy, the CHW intervention has no average effects on unconditional health care use.

5.2 Health Care Use Conditional on Need for Care

While the unconditional effect of the subsidy is encouraging, it could be a real increase in health care access for sick children but also unnecessary doctor visits. The CHW may have no impact on care seeking at all, or improve the allocation of care without changing overall use. To differentiate these

possibilities we examine conditional demand.

Analysis. In order to understand the impact of each treatment on conditional demand, we present three complementary pieces of analysis. First, table 5 shows disaggregated pre-care spells by treatment group and "care required" status, and the number and proportion that receive formal care.[19]

Table 5 is the joint outcome of illness incidence and demand, and does not allow us to isolate the effect of the policy interventions on parents' behavior. Based on our model of care seeking, we therefore estimate the daily hazard of formal care, that is, the daily probability that the parents seek care on pre-care spell day t conditional on not having seen a doctor yet.

Figure 2 shows the simple average hazard of seeking care on each spell day, by treatment group and "care required" classification, estimated by regressing care seeking on a full set of interacted indicators for day of the pre-care spell, care-required status, and treatment group. Since this non-parametric approach does not show treatment effects in a concise way, we additionally estimate a Cox proportional hazard model. Formally, the hazard at t conditional on covariates x_{it} is

$$h(t|x_{it}) = \lambda_0(t)e^{x'_{it}\beta}.$$

[19]Table C.3 in the appendix shows a complete breakdown of all formal consultations during and outside a spell. Only 5% of visits occur outside a spell, reported by mothers as follow-ups, visits for prevention (e.g. vaccinations), or "other". Of the remaining consultations, 88% (or 494) constitute the first formal visit during a spell of illness. These "acute care" visits are the target of the WHO care-seeking recommendations. Visits after a first acute visit cannot directly be judged using the C-IMCI standards. However, almost all of them occur after a spell entered "care required" status and when the child is still exhibiting symptoms. This might indicate a more hands-on treatment approach by doctors when care is subsidized. Anecdotally, CSCom doctors lament that it is very hard to convince patients to come back after a first visit, so that they often prescribe treatments for a range of conditions at once. We also know that patients often do not buy everything prescribed at a doctor visit. With subsidized care, doctors may be able to ask the parents to return to try a different treatment approach if the child's condition has not improved.

This assumes an unrestricted baseline hazard $\lambda_0(t)$, but the covariates shift the probability of seeking care proportionally on every day t of the illness spell.[20] Treatment effects are captured by CHW and subsidy indicators and their interaction. Table 6 reports the estimated hazard ratios (the proportional increase in the probability of seeking care). Models (2), (4), and (6) control for basic household characteristics. All regressions include stratum fixed effects.[21]

Specifications (3) to (6) separately interact the CHW and the subsidy$\times$CHW indicators with an indicator for "care required" and "early" in order to understand to what degree the CHW may lead parents to behave differently on early and care-required days. If the CHW reduce both overuse and underuse, the effect of the CHW should be negative on early, but positive on care-required days. Models (5) and (6) additionally interact subsidy and care-required indicators. In appendix table C.7 we replicate the same estimates but including left-censored spells as if they were not censored as a robustness check; the results are very similar.

Results The illness profiles in our sample provide significant *scope* for both underuse and overuse (IMCI based). Table 5 shows that out of 955 spells in the control (2.1 per child), half (476) eventually require care. On the other hand, 479 spells (about one per child) never enter care-required status before recovery. The parents' decision is a dynamic problem: 210 spells enter care-required status only later on. Put another way, out of 689 spells that initially do not indicate a need for care, 30.5% eventually require care.

[20] As we show in appendix figure C.1, the proportionality assumption delivers a good description of our data.

[21] Of the controls, only assets affect health care demand positively and significantly, while the distance to the closest provider as a measure of non-monetary costs has the expected (negative) sign, but is not significant.

We organize our results using the observations from Section 4. First off, parents behave very differently on early and care-required days. From table 5, spells that enter care-required status are three times more likely to get care than other spells. Table 6 shows that a parent in the control group is 5.3 to 5.7 times more likely to seek care when it is required according to the C-IMCI. In figure 2, the probability of care-seeking on any "early" day is below one percent, but much higher when care is required, although never higher than six percent. As a result, there is significant underuse but relatively little overuse. Table 5 shows that 89% of spells that require care do not get it, whereas 4% of "early spells" receive treatment.[22] These results suggest that information is not a primary barrier to care. The stark difference in care seeking by care-required status implies that parents are able to gauge the relative seriousness of their child's illness, much more so than perhaps expected *ex ante*. High levels of underuse coupled with low levels of overuse instead suggest a high cost barrier (Observation 1).

Next, we examine the impact of the subsidy (Observation 2). The subsidy should decrease underuse, but may also increase overuse. In models (1) to (4) in table 6, the subsidy increases the conditional probability of care-seeking significantly and by at least 249 percent. We cannot reject that the *proportional* impact of the subsidy is roughly the same on early and care-required days (see tests $Se = Sr$ and $Se + CHWe + SCHWe = Sr + CHWr + SCHWr$). However, given the higher baseline hazard, this implies that the *absolute* increase in care seeking is much larger on care-required days. This can be seen clearly

[22]The difference in the care-seeking probabilities per day and per spell is driven by the ratio of early to care-required days within a spell. Note that we are considering pre-care spells (not illness spells), so that the consultation always occurs on the last day of the spell.

in Figure 2 and it suggests again that an important barrier to needed health care is simply the cost of care.

As a result, 9% and 11% percent of "early" spells end in a consultation in the subsidy treatment groups, vs. 29 percent of "care-required" spells. By this metric, the subsidy increases overuse by 5-7 percentage points and decreases underuse by 18-19 percentage points. The last column of Table 5 also shows overuse vs. use when care is required as a proportion of *consultations*. 25 percent of consultations on average occur on an early day in the control, and thus constitute overuse. This number is essentially unchanged in the subsidy groups. However, our analysis reveals that there is little room to reduce overuse, given that the hazard of care on any given early day is so low. By contrast, with 71% of "care-required spells" without a consultation, there is substantial room to decrease underuse further.

Again, unlike the encouraging findings about subsidizing care, we find little impact of the CHW treatment on conditional demand, either in overall terms or separately on early and care-required days. The hazard rates plotted in Figure 2 look similar between the groups with and without the CHW, a result confirmed by the estimates in table 6; on average the CHW do not appear to improve the allocation of care. Given the extremely low probability of early care seeking to begin with, it is perhaps not surprising that the CHW do not significantly decrease overuse; however, they also does not significantly increase care-seeking on care-required days. There is also little evidence of an interaction between CHW and subsidies.

5.3 Health Worker Effects by Child's Age

Very young children are much more vulnerable to illness than older children. The World Bank reports in 2013 that 63% of all under-five mortality in Mali occurred in infants. Worldwide, this proportion ranged from 57-93%. This suggests that the benefits from subsidizing acute health care may be greatest very early in life. The benefits of providing information may also be greater, both because parents may be less experienced, and because it is harder to determine illness severity in a non-verbal infant. We therefore conduct an exploratory analysis in which we examine treatment effects by age. Figure 3 shows nonparametric care seeking probabilities by treatment group and care-required status for ages 0 to 5. In the appendix, we also estimate Cox hazard models for the youngest and oldest children separately (table C.5) and with a linear age variable interaction (table C.6).

A few observations about age-specific effects emerge. First, care-seeking probabilities tend to decrease in age, suggesting that parents see care as more valuable for younger children. The low probability of care seeking for age-0 children in the "subsidy only" group, especially when care is required, is a stark break from this pattern, compared to other ages and compared to the full program group. In addition, the point estimates suggest that the difference in care-seeking for age-0 children between early and care-required days is somewhat smaller than for other children. Lastly, for older children, care seeking appears lower in the groups with than without CHW. The Cox hazard point estimates support this (detailed discussion in the appendix). In particular, for the youngest children, the increase in care-seeking in the group that receives

both interventions is large and significant.

The sample is small and power low, so these results are tentative. However, they support the notion that parents are less certain about when care is required when their child is very young, that is, information barriers are higher. They also support that the CHW complement the subsidy for the youngest children, in the sense that the full program group seeks care significantly more often than the other groups. We find that this increases overuse somewhat, but primarily reduces underuse. This suggests that the healthworkers may have an important role for the success of the program among the youngest children, even if there are no average effects on all children.

There are several possible explanations for these effects. One is prosaic: the high care-seeking probability for age-0 children in the full program group could simply be the result of better access to the subsidy. Sample households were visited in three-months intervals by Mali Health employees, and during those visits, any newborn children or children of program mothers who moved (back) into the household were enrolled into Action for Health. It is possible that parents in the subsidy-only group more often missed the enrollment visits, or did not understand the child's eligibility change. Some features of the design guarded against this issue;[23] nonetheless, it remains possible that the most valuable information the CHW provide is not about symptoms, but about subsidy eligibility.

Alternatively, the results could suggest that the CHW do provide information that affects care seeking, but the effect is ambiguous, consistent with

[23]For example, all parents already had at least one child in the program and thus knew how the program worked. Our analysis is also restricted to children four months and older who should have received at least one enrollment visit.

the framework we proposed earlier. When policymaker and parent share the cost threshold K^*, more accurate beliefs π have the potential to reduce both overuse and underuse. But the earlier graph also shows a potential *negative* effect when K and K^* are not aligned. Specifically, a parent with threshold $K > K^*$ who learns to distinguish severe and less severe illness will actually *stop seeking care* for the less severe case in $t + 1$, and thus increase underuse. They use new information to align better with their own preferences based on K, not K^*, which is here counterproductive for the goals of the policymaker.

IMCI care-seeking rules (and thus K^*) are the same for all children under five. For the youngest children with the subsidy, parents' cost threshold K may be close to that of the policymaker, and they may also find it more difficult to assess their child's need for care. Thus, the healthworkers improve the allocation and may in particular reduce underuse (observation 3). However, for older children without the subsidy, parents may apply a much higher K than the policymaker, and so the healthworkers may actually increase underuse, as observed for the oldest children in the CHW-only group. Essentially, parents use the additional information to decide *against* health care visits that the policymaker deems necessary.

In summary, our results suggest that the CHW might create complementarities with subsidies for the youngest children, who are most vulnerable to adverse consequences of serious illness, and contribute most to continued high child mortality rates. Given the widespread use of and advocacy for CHW interventions, our findings point to a need for further research about both the overall CHW effects and the exact mechanisms behind them. Our model suggests some important caveats to health information policies that aim to

change caretaker choices about acute care.

5.4 Advantages of estimating demand conditional on health status

Censoring and Selection Bias. Our data make a strong case for collecting illness data in the home and analyzing spells with a hazard model, due to the issue of censoring with spontaneous recovery: we do not observe how long parents would have waited to see a doctor when the child gets better without care. Spontaneous recovery is integral to the decision to delay care in the first place – there would be otherwise no benefit to waiting. Even care-required spells often end with unaided recovery, illustrating the challenge of improving child mortality through acute care: we need to treat many spells in order to prevent the small portion that may become truly dangerous to the child.

One effect of censoring is that the observed pre-care spell length systematically underestimates true time-to-care, and effects on spell length do not fully reflect changes in daily care seeking probability. For example, there will be spells that are censored (ending without care) at high K, but uncensored (ending in care) at low K (leading to increases in utilization). Table C.4 in the appendix correspondingly shows that the subsidy reduces (pre-care) spell length by only 14 percent, even though we found that it increases the care seeking probability five-fold.

This problem is exacerbated in data that contains only uncensored spells—unfortunately often the only data we have. Table C.4 shows in fact that the average uncensored spell in our sample is weakly *longer* in all treatment groups than in the control. Our hazard estimates confirm that this is entirely selection bias: the large number of additional visits in the subsidy groups tend

to be from families who wait on average longer for care, and so they raise the overall time to care in the group.[24] Even recognizing that selection bias may occur, data of uncensored spells only would not permit the researcher to distinguish it e.g. from moral hazard (parents waiting longer before getting care with the subsidy).[25] In other words, where underuse is rampant but responds strongly to an intervention, we show that data collected at the point of use (e.g. during consultations with the health care provider, or from health insurance events as in Gilleskie (1998)) are subject to selection effects so strong that they reverse the estimated impact of the intervention on some aspects of care-seeking behavior.

Application: Predicting Care-Seeking for Alternative Illness Environments. Our study estimates demand for care conditional on detailed health information. A benefit of this approach are more accurate out-of-sample predictions, e.g. in other disease environments. In Appendix C.6, we demonstrate this by predicting health care demand for a set of hemorrhagic fever spells (Ebola and Marburg disease). This illustrates how records of tconditional care-seeking behavior might help improve estimates of undetected infections and time-to-care for those who contract a specific illness, for instance

[24]Similar effects arise when asking retrospective information on health for a specific period of time. An example are the Demographic and Health Surveys (DHS). The DHS questionnaire asks about diarrhea and fever spells and treatment sought within the last two weeks. Shorter spells are observed in full, but longer spells are likely to be censored by the visit date. Moreover, detailed questions about treatment are asked only about spells that are ongoing at the time of the survey. See Heger Boyle et al. (2018), especially questions 518 and 527 and following.

[25]Note that the Cox model assumes proportionality and so does not permit for demand changes that exhibit both selection into care *and* an increase in time-to-care under the subsidy (which might occur with a decrease in care seeking on early spell days but an increase later in the spell). However, figure 2 and the proportionality test in Appendix C.5 show that the proportionality assumption reflects the data well.

in the initial phases of new outbreaks. In Mali, policymakers might be for example interested in predicted behavior in the dry season, when respiratory illness is more prevalent than malaria and diarrhea.

6 Conclusion

The prevailing view in international health policy today is that subsidies are needed to close remaining gaps in access to care. The potential benefits are large: by some estimates, improved access to primary care could prevent 29%–40% of post-neonatal deaths in developing countries. Less than 26% of malaria cases in children are estimated to receive adequate treatment, and 411,000 children died of malaria in 2013 in Africa alone.[26] Many countries have begun to remove health care user fees for children, and Mali just announced that it would adopt this policy by 2022. However, we have relatively sparse evidence how this affects patterns of utilization.

This study aims to open the "black box" of health care demand. We estimate health care use conditional on health status to remove confounding effects of illness incidence, and benchmark care-seeking against the need for care according to WHO medical standards. By surveying all (potential) health care users we can account for selection bias due to spontaneous recovery.

Our results have very encouraging implications for the subsidy debate. First, a primary barrier to effective care seeking in the urban population we study is indeed the cost of care. Underuse is rampant: care is either sought late in the spell or, in the majority of cases, not at all. The welfare cost of subsidies could be prohibitive if they lead to substantial mis-targeting and overuse of health

[26]United Nations Inter-Agency and Expert Group on MDG Indicators (2015); WHO Global Malaria Programme (2015); Bhutta et al. (2008).

care, risking overburdening the severely limited capacity of health care systems in poor countries and thus diverting resources away from those most in need. However, while subsidies nearly triple health care usage in our sample, they do not result in substantial overuse, because the additional demand comes largely from children for whom medical care is required according to WHO guidelines. One reason is that parents have some ability to recognize differences in illness severity and are nearly six times more likely to seek care on 'care required' days compared to 'early' days.

The degree to which parents can spot illness suggests that information about the health status of the child *a priori* can only have limited additional effects, and in aggregate this is what we find; the healthworkers do not affect care-seeking probabilities significantly. However, the healthworkers do reduce underuse among the most vulnerable (youngest) children who receive the subsidy. This points to an role for policies that guide parents' use of existing subsidies for young children. At the same time, the age-specific effects suggest that parents may make differential use of information they are given, depending on the cost threshold they apply in deciding about seeking care, and this may not always be in the interest of the policymaker. This could be a potential caveat for health information policies in general. For Action for Health, it may mean that the CHW should focus their advice on the youngest children for whom the effects are likely highest. Further research could confirm these findings and help understand the underlying mechanisms.

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Tables and Figures

Table 1: Demographics and balance.

	Child characteristics				Characteritics of household head				Household characteristics			Compound
	Gender	Age (yrs)	Weight for height	Is literate	Speaks Bambara	Gender	Has salary	Age > median	Number of members	Owner occupiers	Total assets in log USD	Log distance to closest formal care
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Subsidy only group (S)	0.016	-0.018	0.112	0.033	-0.062	-0.018	-0.000	-0.002	0.175	0.073	0.424	-0.066
	(0.04)	(0.09)	(0.12)	(0.05)	(0.05)	(0.03)	(0.04)	(0.05)	(0.32)	(0.05)	(0.28)	(0.06)
CHW only group	-0.015	0.036	0.042	-0.027	-0.044	-0.026	0.001	-0.011	-0.073	0.074	0.266	-0.004
	(0.04)	(0.10)	(0.14)	(0.05)	(0.05)	(0.03)	(0.03)	(0.05)	(0.32)	(0.05)	(0.27)	(0.06)
Subsidy x CHW group (SCHW)	0.025	-0.018	0.032	0.117**	-0.079	-0.003	-0.037	0.043	0.321	0.042	0.149	-0.079
	(0.03)	(0.10)	(0.13)	(0.05)	(0.05)	(0.03)	(0.03)	(0.05)	(0.31)	(0.06)	(0.27)	(0.07)
Control group mean	0.515***	2.706***	-0.655***	0.467***	0.729***	0.903***	0.131***	0.418***	6.234***	0.405***	6.458***	6.238***
	(0.02)	(0.06)	(0.09)	(0.04)	(0.04)	(0.02)	(0.03)	(0.03)	(0.21)	(0.04)	(0.18)	(0.04)
Observations	1763	1768	1306	1242	1242	1241	1242	1256	1238	1208	1208	642

Notes: Coefficients from a regression of the outcome variable on treatment indicators. Standard errors clustered at the compound level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 2: Consultation numbers, average costs to the patient's family, value of services received, and wait times per visit in hours.

	Number of visits	Cost per visit (to household)		Value per visit (total cost)		Waiting time per visit in hours (caretaker)	
CSCom (all)	646	1344	(106)	3767	(114)	0.74	(0.04)
CSCom (with subsidy)	508	933***	(108)	3794	(129)	0.78**	(0.04)
CSCom (without subsidy)	138	2850	(254)	3666	(252)	0.59	(0.07)
Private provider	89	5470	(543)	-	-	1.24	(0.19)
Informal/no consultation	2691	218	(11)	-	-	0.04	(0.01)

*Notes: CSCom refers to local clinic or associated reference hospital (CSRef). Private provider is a private doctor, hospital, or health center provided e.g. by the Red Cross. Informal includes peddlers, market, traditional or religious healers, midwives, and pharmacy visits without a formal consultation. Costs, prices, and wait times are added for all connected consultations, e.g. doctor visit and medication purchase. Costs per visit are for consultation and treatment as reported by the caretaker. Value/total cost is imputed from private cost and median prices, by consultation type and treatment received. Standard errors in parentheses. Significance levels for a t-test between free care and no-free care consultations. *** p<0.01, ** p<0.05, * p<0.1.*

Table 3: Days of (untreated) illness per child, by need for care (IMCI); and proportion of days on which each symptom is observed.

Pre-care days per child:	All		Early		Care required	
	Mean	SD	Mean	SD	Mean	SD
Total number	16.31	(14.32)	10.34	(9.38)	5.97	(8.68)
Percentage of total number on which each symptom is present:						
Convulsions, fits, or spasms	0.32%		0%		0.66%	
Lethargic or unconscious	3.95%		0%		10.27%	
Unable to drink or breastfeed	1.17%		0%		3.29%	
Vomiting everything	5.39%		0%		15.58%	
Coughing	33.42%		62.56%		35.38%	
Difficulty breathing	4.46%		8.58%		5.85%	
> 3 loose stools	8.54%		11.84%		12.75%	
Blood in the stool	0.61%		0.06%		1.39%	
Sunken eyes	2.18%		0.31%		5.27%	
Unusually hot skin	32.04%		17.68%		74.00%	
Other: rash, spots, or itch	2.85%		5.74%		1.28%	
Other: cold symptoms	50.76%		92.01%		37.31%	
Other: ear ache	1.01%		1.13%		1.90%	
Other: wound, injury, or burn	3.62%		6.82%		1.60%	
Other symptoms	4.90%		9.04%		2.54%	

Notes: The first four symptoms are danger signs and always occur on "care required" days. Symptoms that do not themselves indicate need for care can co-occur on care-required days

Table 4: Utilization, private expenditure, and value of treatment by treatment group.

	Number of visits per child			Private cost per child (CFA)			Wait time per child (hrs)	Value per child (CFA)	
	All formal	CSCom	Other formal	Total	CSCom	Other formal		Total	CSCom
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Subsidy only group (S)	0.379***	0.402***	-0.023	-77.523	215.880	-129.134	0.275***	1386.066***	1665.570***
	(0.06)	(0.05)	(0.03)	(275.29)	(134.08)	(175.97)	(0.10)	(374.75)	(263.11)
CHW only group	0.022	0.017	0.005	459.660	207.295	-33.815	0.039	387.381	126.962
	(0.04)	(0.03)	(0.03)	(295.11)	(134.88)	(179.80)	(0.08)	(313.59)	(154.89)
Subsidy x CHW group (SCHW)	0.439***	0.478***	-0.039	-220.833	186.633	-231.538	0.307***	1409.314***	1773.584***
	(0.06)	(0.05)	(0.02)	(245.47)	(128.40)	(166.57)	(0.09)	(315.97)	(221.90)
Control group mean	0.217***	0.153***	0.065***	1461.672***	353.302***	369.797**	0.264***	1671.343***	523.071***
	(0.03)	(0.02)	(0.02)	(192.35)	(60.64)	(153.38)	(0.06)	(204.40)	(81.12)
p-value S = SCHW	0.421	0.286	0.309	0.565	0.859	0.343	0.771	0.953	0.739

Notes: Coefficients from a regression of the outcome variable on treatment indicators. 1768 observations. Standard errors clustered at the compound level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 5: All spells vs. spells with a consultation by treatment group; conditional care-required status.

	spells	consultations (spells with consultation)	consultations as % of all spells	consultations as % of all consultations
Control				
care never required	479	18	4%	25%
care required	476	53	11%	75%
entered during spell	*210*	*22*	*10%*	
total	**955**	**71**	**7%**	100%
CHW group				
care never required	402	13	3%	20%
care required	516	52	10%	80%
entered during spell	*308*	*30*	*10%*	
total	**918**	**65**	**7%**	100%
Subsidy group				
care never required	449	40	9%	23%
care required	458	133	29%	77%
entered during spell	*195*	*57*	*29%*	
total	**907**	**173**	**19%**	100%
Full program group				
care never required	463	50	11%	26%
care required	504	144	29%	74%
entered during spell	*275*	*80*	*29%*	
total	**967**	**194**	**20%**	100%

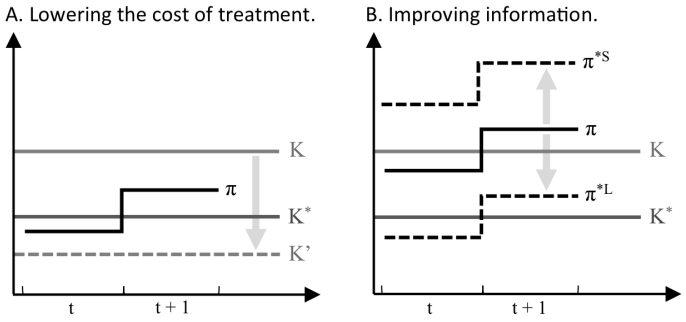
Notes: includes only uncensored and right-censored spells. "Care never required" indicates spells with early days only. "Care required" includes spells that either consist entirely of care-required days, or start with an early day and eventually enter care-required status ("entered during spell"). A spell cannot revert from care-required status except through recovery.

Table 6: Treatment effects in a Cox proportional hazard model.

	(1)	(2)	(3)	(4)	(5)	(6)
Care required	5.284***	5.366***	5.592***	5.714***	5.367***	5.509***
	(0.63)	(0.64)	(0.88)	(0.92)	(1.40)	(1.45)
Subsidy	2.563***	2.525***	2.561***	2.523***		
	(0.45)	(0.45)	(0.45)	(0.45)		
Subsidy x early (Se)					2.450***	2.426***
					(0.74)	(0.74)
Subsidy x care req. (Sr)					2.599***	2.557***
					(0.50)	(0.50)
CHW	0.915	0.886				
	(0.20)	(0.19)				
CHW x early (CHWe)			0.910	0.877	0.882	0.853
			(0.34)	(0.33)	(0.36)	(0.35)
CHW x care req. (CHWr)			0.914	0.884	0.923	0.892
			(0.21)	(0.20)	(0.21)	(0.21)
Subsidy x CHW	1.218	1.240				
	(0.31)	(0.31)				
Subsidy x CHW x early (SCHWe)			1.366	1.414	1.428	1.471
			(0.56)	(0.58)	(0.68)	(0.70)
Subsidy x CHW x care req. (SCHWr)			1.176	1.192	1.159	1.176
			(0.31)	(0.31)	(0.32)	(0.32)
Covariates		Y		Y		Y
p-value Se = Sr					0.855	0.872
p-value CHWe = CHWr			0.991	0.983	0.916	0.917
p-value CHWe+SCHWe=CHWr+SCHWr			0.568	0.532		
p-value Se+CHWe+SCHWe = Sr+CHWr+SCHWr					0.752	0.704
N	23836	23836	23836	23836	23836	23836

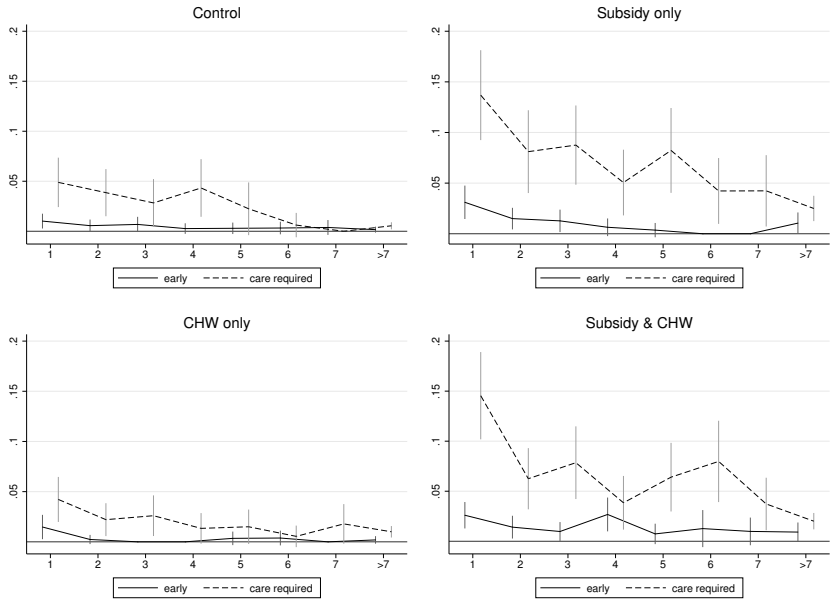
Notes: table reports hazard ratios, uncensored and right-censored spells only. Covariates include household assets; distance to closest formal care provider; gender, age, literacy of household head; and child gender. Stratum FE included. Standard errors clustered at the compound level in parentheses. * $p < 0.10$, ** $p < 0.05$, * $p < 0.01$.

Figure 1: The effect of providing a subsidy (A) and of aligning parents' beliefs with those of the policymaker (B).



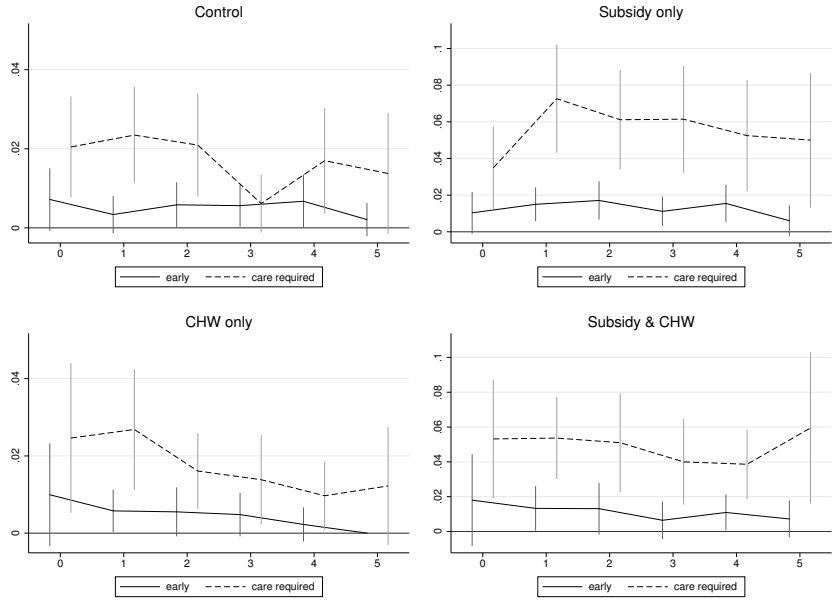
Notes: the probability of not recovering π is increasing conditional on the spell continuing, due to learning about the illness. We assume parents have a higher cost threshold than the policymaker ($K \geq K^*$). Panel A: beliefs are aligned so $\pi = \pi^*$, Panel B: parental beliefs π are the average of the policymaker's beliefs π^{*S} and π^{*L}.

Figure 2: Average daily probability of care seeking by day of the spell and treatment group, early vs. care-required classification according to the C-IMCI.



Notes: x-axis shows day of the spell; spell days after day seven are grouped. Graphs show point estimates of a fully dummied-out linear regression model along with 95% confidence intervals. Standard errors clustered at the compound level.

Figure 3: Average daily probability of care seeking by age of the child in years and treatment group, "early" vs. "care-required" classification according to the C-IMCI.



Notes: x-axis shows age of the child in years; children over 5 years are dropped. Graphs show point estimates of a fully dummied-out linear regression model along with 95% confidence intervals. Standard errors clustered at the compound level. Note difference in scale on the y-axis in Control and CHW only group (left) vs. subsidy only and full program group (right).