The Illusion of Sustainability[1]

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Abstract: Foreign aid donors are moving away from the traditional economic analysis of development projects, with its focus on providing public goods and correcting externalities, and towards the concept of "sustainability". The sustainability approach stresses community mobilization, education, and cost-recovery. We examine evidence from randomized evaluations on strategies for combating intestinal worms, which affect one in four people worldwide. We find that an effort to educate Kenyan schoolchildren on worm prevention was ineffective, and a "mobilization" intervention from psychology led to *lower* deworming drug take-up. Take-up was highly sensitive to drug cost: a small increase in cost led to an 80 percent reduction in take-up (relative to free treatment). Our results suggest that, at least in the context of deworming, the pursuit of sustainability may be a chimera and there may be no alternative to continued external subsidies.

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1. Introduction

The publication of a recent World Development Report entitled *Sustainable Development in a Dynamic World* (World Bank 2002) puts an official seal of approval on foreign aid donors' embrace of the concept of “sustainability.” The term “sustainability” has many meanings, including an environmental meaning, but here we focus on financial sustainability. Whereas orthodox public finance analysis suggests that governments should indefinitely fund public goods and activities that generate positive externalities, advocates of sustainability emphasize the importance of local “ownership” of projects, and promote interventions that can be funded and maintained locally without external support. This focus on financial sustainability in development has been motivated by a combination of factors, including a perception of widespread failure by less developed country governments to maintain infrastructure funded by foreign aid once construction is completed[2], growing ideological opposition in some rich country donors to indefinite development assistance “hand-outs”, as well as cuts in donor aid budgets in recent years.

The ideology of sustainability has affected a wide variety of development policies. For example, some donors have only backed microfinance groups if they believed that funding these organizations initially would eventually allow them to achieve financial sustainability, defined as being able to fully cover costs from their lending operations (Morduch 1999). In the area of water supply, advocates of sustainability suggest that rather than relying on external donors, it is preferable to organize community water committees that raise funds locally to maintain and repair wells. In public health, advocates of sustainability concentrate on health education, community mobilization, and cost-recovery from program beneficiaries, rather than focusing on subsidies for medical treatments that generate positive externalities.

Yet little rigorous research has examined the impact of the move towards “sustainability” and its cost-effectiveness remains largely unproven.[3] Indeed, anecdotal evidence suggests that “sustainability” has often been a chimera – and sometimes a costly one at that. Morduch (1999) argues that pursuit of

[2] Refer to Easterly (2001) for many such cases.
[3] Tanner (1998) discusses the concept of sustainable development in regards to health. Meuwissen (2002), Cave and Curtis (1999) and McPake (1993) present evidence on cost-sharing in less developed countries.

sustainability by microfinance organizations has led them to move away from serving the poor, and that it has not, in fact, yielded organizations that break even financially – but rather organizations that learn to better hide their continued subsidies. At least in one case, the move away from donor support for water well maintenance to the establishment of community committees has allowed water infrastructure to fall into terrible disrepair: in one large water project in the area of Kenya we study – which was originally funded with Finnish development assistance through an organization called KEFINCO – 43 percent of bore hole wells were useless ten years after the shift to the "sustainable" local approach, suggesting that community fundraising and mobilization efforts failed often in this setting (Miguel and Gugerty 2002). Despite very low rates of immunization coverage in Uganda, funding for immunization – consistently rated one of the most cost-effective public health interventions – appears to have fallen following a fiscal decentralization reform that granted local sub-county governments increased responsibility for health fund raising (Azfar and Livingston 2002). In another African case, a health cost-recovery program led to unexpectedly large drops in health care utilization, and the local health committees set up to administer the program failed in most of their responsibilities in Niger (Meuwissen 2002).

In this paper, we present empirical evidence on the issue of project sustainability within the context of a public health project designed to reduce intestinal worm infections among Kenyan school children. In doing so, we hope to begin taking the debate over sustainable development policies out of the realm of ideology placing it on firmer empirical grounds. Intestinal worms infect one in four people worldwide, yet can be safely treated with drugs at pennies per dose through school-based mass deworming programs. Such programs were identified as among the most cost-effective health interventions in the 1993 World Development Report (World Bank 1993). In prior work, we examined the impact of deworming on child health, nutrition, and school outcomes (Miguel and Kremer 2003a): after two years, school absenteeism among the deworming treatment group fell on average by approximately one-quarter, or seven percentage points, and there were significant gains in several measures of health status, including worm infection, child growth stunting, anemia, and self-reported health (although there were no significant academic or cognitive test scores gains).[4]

The other main finding of previous research is that deworming significantly reduced worm infection and increased school participation among untreated children in the treatment schools, and among children in neighboring primary schools: the drop in moderate-heavy infection rates among untreated children in treatment schools was 80 percent as large as the drop among the treated, and they also showed large school participation gains. Cross-school externalities were also large for schools located within six kilometers of treatment schools, at over 25 percent of the effect in treatment schools, on average.[5] Thus observed differences across the treated and untreated children within program schools – in other words, the private treatment benefit beyond the external benefits – are substantially smaller than the overall program effect, and the same is true for differences across treatment and comparison schools due to cross-school externalities. In fact, 76 percent of the reduction in worm burden was due to externalities, suggesting that spillovers are extremely important in this setting.

Traditional public finance analysis would suggest that programs to fight worms should be a high priority. Treatment creates positive externalities and therefore is subject to a market failure. Overall, deworming costs only $3.50 per extra year of school participation generated, making it one of the most cost-effective ways we know of to boost school participation. Yet as noted above, one in four people worldwide continues to suffer from worms, and most countries have not implemented full-scale mass school deworming programs. We believe one important reason for this failure is the ideology of sustainability.

Worm infections can be fought in several different ways: one approach emphasizes periodic medical treatment with low-cost drugs, while others have argued that a more sustainable approach instead

[4] Refer to Appendix Tables A1-A3 for a summary of the main results of Miguel and Kremer (2003a).

[5] However, note that the ratio of private benefits to social benefits is almost certainly larger in the short-run, since it takes time for local environmental contamination with worm larvae – and thus re-infection – to fall following mass deworming. The 1999 health survey data presented in Appendix Tables A1, A2, and A3 were conducted up to one year after initial 1998 deworming treatment.

addresses the root causes of infection – which lie in poor hygiene and sanitation – especially since re-infection is rapid and people must be treated twice per year with the drugs to remain largely worm-free. Utzinger et al. (2003, forthcoming *Lancet*), argue that previous effort to fight schistosomiasis have been inappropriately focused on control with drugs, and that a broader approach with greater emphasis on health education, latrine construction, and water provision would be more sustainable.

This paper evaluates the usefulness of various approaches using randomized evaluation. In particular, we examine two potential ways to make anti-worm programs sustainable: requiring cost-sharing payments from those taking drugs, and educating people about ways to avoid infection in the first place. We find that the introduction of a small fee led to a sharp 80 percent reduction in treatment rates relative to free treatment – suggesting that demand for deworming treatment is highly sensitive to price increases from zero to a positive price. However, take-up is not sensitive to changes across a range of positive prices. Other elements of the deworming project seeking to promote "sustainable" health gains through health education and community mobilization also completely failed. In particular, we find that intensive school health education had no impact on child worm prevention behaviors, and thus child health is likely to be worsened to the extent funds are diverted from medical treatment into health education in this setting. A verbal commitment "mobilization" intervention – which asked people to commit in advance to adopt the deworming drugs, taking advantage of a finding from social psychology that individuals strive for consistency in their statements and their actions – led to significantly *lower* treatment rates. In a further non-experimental empirical analysis, we find that household latrine construction and local borehole well density are both far less cost-effective than deworming drugs in reducing the rate of worm infection.

It is also possible that social spillovers in knowledge could lead to sustainability. If treating (or educating) children in certain families leads to higher deworming rates among their social contacts, social learning might eventually lead to high take-up without large subsidies. However, we find no evidence of this. In the original deworming program: the "early treatment" and "late treatment" schools were randomly selected, producing exogenous local variation in the proportion of children in schools exposed to deworming medicine and health education, and thus allowing credible estimation of social effects. In a related project (Miguel and Kremer 2003b), we collected survey data on social networks to explore how variation in social contacts' program exposure affected individuals' own adoption decisions, and find that children whose parents have (randomly) more social links to early treatment schools are themselves significantly *less* likely to take deworming drugs: for each additional social link a parent has to an early treatment school, her child is 3.2 percentage points less likely to take the drugs. As we discuss in Miguel and Kremer (2003b), the large deworming treatment externalities described above provide a plausible explanation for these seemingly anomalous findings: given spillovers, private deworming benefits are considerably smaller than the social benefits. Parents with additional information on the drugs through their social network learn this fact, and thus their children become less likely to take deworming drugs themselves; in essence, social learning promotes free-riding.

Overall, our results suggest that there may be no alternative to continued subsidies for deworming[6]. More broadly, the cost-sharing findings together with the social learning results (in Miguel and Kremer 2003b) indicate that large subsidies may be necessary to sustain high drug take-up for diseases characterized by positive treatment externalities – a finding especially important for Africa, where half the disease burden is associated with infectious and parasitic diseases (WHO 1999).

The remainder of the paper is structured as follows. Section 2 discusses worm infections and describes the Primary School Deworming Project. Section 3 presents the deworming subsidy results. Sections 4 and 5 present the health education and verbal commitment results, respectively. Section 5 discusses wells and latrines, and the final section concludes with a discussion of broader implications for development assistance.

[6] Lengeler (1999) reaches similar conclusions in regard to public health programs in poor countries. Note, however, that another possibility for public health policy is a large up-front investment in deworming treatment in order to reduce worm infection prevalence down near zero, in which case indefinite subsidies would not be necessary. However, this approach is unlikely to be successful for lasting worm control in rural Africa, given the high likelihood of continued contact with untreated individuals and areas, and thus rapid re-infection.

2. The Primary School Deworming Project (PSDP) in Busia, Kenya

Over 1.3 billion people worldwide are infected with hookworm, 1.3 billion with roundworm, 900 million with whipworm, and 200 million with schistosomiasis (Bundy 1994). Most have light infections, which are often asymptomatic, but more severe worm infections can lead to iron deficiency anemia, protein energy malnutrition, stunting, wasting, listlessness, and abdominal pain. Heavy schistosomiasis infections can have even more severe consequences.[7] Due to the immunilogical response they generates, worm infections may also facilitate infection with HIV and speed the transition from asymptomatic HIV infection to AIDS (Harms and Feldmeier 2002).

Helminths do not reproduce within the human host, so high worm burdens are the result of frequent re-infection. The geohelminths (hookworm, roundworm, and whipworm) are transmitted through ingestion of, or contact with, infected fecal matter, which can occur, for example, if children do not use a latrine and instead defecate in the fields near their home or school, areas where they also play.[8] Schistosomiasis is acquired through contact with infected freshwater; for example, in our Kenyan study area people often walk to nearby Lake Victoria to bathe and fish. Medical treatment for helminth infections creates externality benefits by reducing worm deposition in the community and thus limiting re-infection among other community members (Anderson and May 1991).

We study the Primary School Deworming Project (PSDP), a school health program carried out by a Dutch non-governmental organization (NGO), ICS Africa, in cooperation with the Kenyan Ministry of Health. The project took place in Busia district, a poor and densely-settled farming region in western Kenya, and the 75 project schools include nearly all rural primary schools in this area, with over 30,000 enrolled pupils between the ages of six and eighteen, over 90 percent of whom suffer from intestinal worm infections. In January 1998, the PSDP schools were randomly divided into three groups (Group 1, Group 2, and Group 3) of twenty-five schools each: the schools were first divided by administrative sub-

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[7] Refer to Adams et al. (1994), Corbett et al. (1992), Hotez and Pritchard (1995), and Pollitt (1990).

[8] Note that individuals are likely to have at least some knowledge of their infection status, since they can observe certain worms in their stool, and may also see them being expelled from their body after treatment.

unit (zone) and by involvement in other non-governmental assistance programs, and were then listed alphabetically and every third school assigned to a given project group.[9]

Due to administrative and financial constraints, the health intervention – which included both deworming medicine and health education on worm prevention behaviors – was phased in over several years. Group 1 schools began participating in 1998, 1999, 2000 and 2001, and Group 2 schools in 1999, 2000 and 2001, while Group 3 began participating in 2001. This design implies that in 1998, Group 1 schools were treatment schools, while Group 2 and Group 3 schools were the comparison schools; and in 1999 and 2000, Group 1 and Group 2 schools were the treatment schools and Group 3 schools were comparison schools. Starting in 1999, signed individual parental consent was required for deworming, while in 1998 only "community consent" (a series of meetings at which parents were informed of – and could opt out of – the program) had been required. At each school, the project started out with a community meeting of parents, teachers, and the school committee, which included a discussion of worm infections, the nature of medical deworming treatment, and worm prevention measures. All primary school communities in the baseline sample agreed to participate in the project.

The project provided periodic treatment with deworming drugs in all schools where helminth prevalence was sufficiently high. The geohelminths and schistosomiasis can be treated using the low-cost single-dose oral therapies of albendazole and praziquantel, respectively. The World Health Organization has endorsed mass school-based deworming in areas with prevalence over fifty percent, since mass treatment eliminates the need for costly individual screening (Warren et al. 1993, WHO 1987), and drugs delivered through a large-scale school program may cost as little as 0.49 USD per person per year in East Africa (PCD 1999); per child annual costs in the program we study were 1.49 USD, and these higher costs are likely due to the smaller size of the treated population – which did not allow the program to fully exploit economies of scale in drug purchase and delivery – as well as a higher number of field workers than would be needed in a large-scale program that did not feature an evaluation component. Side effects

[9] Appendix Table A4 presents a more detailed project timeline.

are minor and transient, rarely lasting more than one day, but may include stomach ache, diarrhea, dizziness, fever and even vomiting in some cases (WHO 1992). Side effects are more severe for heavier schistosomiasis infections[10], and in our data parents of children with more severe infections are in fact somewhat more likely to claim that the drugs had side effects (although this effect is not statistically significant). The project followed the standard practice at the time in mass deworming programs of not treating girls of reproductive age, due to concern about the possibility that albendazole could cause birth defects (WHO 1992, Bundy and Guyatt 1996, Cowden and Hotez 2000). (The WHO recently called for this policy to be changed to allow older girls to be treated, due to the accumulating record of safe usage by pregnant women – see Savioli, Crompton and Neira 2003).

In addition to medical deworming treatment, the project included intensive health education on worm prevention behaviors, mainly focusing on hand washing, wearing shoes, and avoiding infected fresh water. This included classroom lectures and culturally appropriate health education materials developed by the Tanzanian Partnership for Child Development. This health education effort was considerably more intensive than is typical in Kenyan primary schools, and thus the program should be more likely than existing government programs to impact child behavior. Two teachers in each school (one regular teacher and the head teacher) received a full day of training in the district capital on worm prevention lessons for schoolchildren, as well as on the details of the deworming program, and were instructed to impart these lessons to their pupils during regular school hours. These classroom lessons were supplemented through lectures by an experienced and high-quality NGO field team (the team leader was a trained Public Health Technician), which visited each school several times per year.

However, the project's health education component was not cheap: our best estimate is that teacher lessons in school, the lectures delivered by the mobile NGO field team, and the classroom wall-charts and other educational materials taken together cost at least 0.44 U.S. dollars per pupil per year in

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[10] The manufacturer of praziquantel (Bayer) states that "Side effects are usually mild and temporary and include abdominal pain, nausea, vomiting, headache, fever, pruritus, drowsiness. Side effects may be more severe in heavy infestations." (home.intekom.com/pharm/bayer/)

the assisted schools – which is comparable to the total cost of deworming drug purchase and delivery in a nearby Tanzanian program, at 0.49 U.S. dollars (PCD 1999). In our case, it is difficult to break out the costs of health education, data collection, and drug delivery since the same field team was responsible for all activities, so the above cost estimates should be seen as particularly tentative; nonetheless, they are roughly in line with estimated school health program costs in Jamison and Leslie (1990).

This rough health education costing is based on an estimate that each health education teacher taught two full hours on worm prevention behaviors in each grade per school year (given an annual teacher salary and benefits of approximately two thousand U.S. dollars), and that the NGO team also lectured to the school for two hours per year (given their annual salary and benefits); of course, costs would be higher under an even more ambitious health education program. The least expensive component of the worm prevention education program, by far, was provision of wallcharts and other teaching materials. We assume in the above calculation that educational materials need to be replaced and teacher training repeated every four years, since materials fall apart and teachers are transferred between schools (or leave the profession, or die), and may need refresher courses.

The NGO has a general policy of introducing community cost-recovery in all its rural development programs, to promote "sustainability" and to confer project "ownership" on the beneficiaries. In the case of deworming, the NGO temporarily waived this policy initially, and then phased it in gradually. The fifty Group 1 and Group 2 schools were stratified by treatment group and geographic location, and then twenty-five were randomly selected (using a computer random number generator) to pay user fees for medical treatment in 2001, while the remaining twenty-five continued to receive free medical treatment that year (and all Group 3 schools received free treatment). The fee was set on a per family basis, like most Kenyan school fees, introducing within-school variation in the cost of deworming since different households have different numbers of children in primary school, variation that we also use to estimate the effect of price on take-up. Of the twenty-five Group 1 and Group 2 schools participating in cost-sharing, two-thirds received albendazole at a cost of 30 Kenya shillings per family (approximately 0.40 U.S. dollars in 2001) and one-third received both albendazole and praziquantel at a cost of 100 Kenya shillings per family (approximately 1.30 U.S. dollars). Since parents have 2.7 children in school on average, the average cost of deworming per child in cost-sharing schools was slightly more than 0.30 U.S. dollars – still a heavily subsidized price, about one-fifth the cost of drug purchase and delivery through this program.[11]

3. The Impact of Subsidies on Drug Take-up

Cost-sharing through user fees has been advocated as necessary for the sustainability of public health services in many less developed countries (World Bank 1993). Revenues from these fees could be used to improve the quality of health services (i.e., through better drug availability), or to fund other government expenditures. User fees could theoretically promote more efficient use of scarce public resources if those in greatest need of health services are most willing to pay for them, while those not in need do not pay. (Note that this does not appear to have been the case for deworming treatment in this program, where more heavily infected individuals were actually slightly *less* likely to receive treatment – refer to Appendix Table A1).

However, although a number of studies from Africa have found massive drops in health care utilization after the introduction of user fees (e.g., McPake 1993, Meuwissen 2002) – including in Kenya, where Mwabu et al (1995) find utilization fell by 52 percent in 1989 – it remains unclear to what extent user fees have causally affected utilization since cost-sharing is typically introduced during periods of fiscal crisis, making it difficult to separate out the effect of cost-sharing from the effect of crisis. In contrast, our analysis uses random assignment to estimate the effect of cost sharing.[12]

Children in 75 percent of households in the free treatment schools received deworming drugs in 2001 (Table 1), while the rate was only 18 percent in cost-sharing schools. In a regression analysis, the

[11] Annual Kenyan per capita income is $340 (World Bank 1999), but incomes are thought to be lower in Busia.
[12] Gertler and Molyneaux (1996) find that utilization of medical care is highly sensitive to price in Indonesia, but since the unit of randomization in their analysis is the district, and their intervention affected only eleven districts, statistical power is relatively low. In a large-scale experimental study, Manning et al (1987) find that the price elasticity of demand for medical services in the United States is a modest –0.2.

introduction of the small deworming fee dramatically reduced the treatment rate by 62 percentage points (Table 2, regression 1), and the effect is similar across households with different socioeconomic characteristics (regression 2) – providing evidence on the low value most households attach to deworming.[13]

Cost-sharing had roughly the same effect on treatment rates regardless of the actual price that the household was required to pay per child (Table 2, regression 3).[14] Variation in the deworming price per child was generated by the fact that cost-sharing came in the form of a per family fee, so that parents with more children in the primary school faced a lower price per child; this specification also includes the inverse of the number of household children in treated primary schools as an explanatory variable in an attempt to control for the effect of household demographic composition on drug demand. Of course while this variable controls for a main effect of family size on the demand for deworming drugs, we cannot control for interactions between family size and changes in price given the school-level randomization project design. There is a moderate, but statistically insignificant, decrease in take-up in the albendazole and praziquantel treatment schools (100 shillings per family) relative to the albendazole treatment only schools (with a deworming fee of 30 shillings per family – regression 4), although the interpretation of this result is complicated by the fact that the treatment regime differs across these schools as well. The reduction in cost-sharing schools is not simply a result of the fact that only the sickest pupils choose to seek treatment in these schools. In fact, sicker pupils were no more likely to pay for deworming drugs than healthier children: the coefficient estimate on the interaction between 2001 helminth infection status and the cost-sharing indicator is not significantly different than zero (results not shown).

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[13] The data used in these regressions is described in more detail in Miguel and Kremer (2003a, 2003b).

[14] This would not be surprising if the bulk of the total deworming cost were the time and money needed to travel to the primary school – which may be several kilometers away – to pay the fee. However, most parents already attend several school meetings per year, and may travel to a market – often located near their child's school – regularly to trade, so we do not believe that travel costs are likely to be prohibitively large in most cases. Most importantly, 2001 treatment rates are high in the Group 3 schools, in which parents received the drugs for free but still had to visit school to sign the consent book, suggesting that the cost of visiting school is not prohibitively high.

[16] Another possibility is that some individuals in cost-sharing schools took away a negative signal about drug quality from the fact that prices increase, the logic being that if the treatment were in fact very effective, the NGO would have continue to give it away for free. We thank Roland Benabou for this point.

The bottom line is that adequate drug subsidies – pushing the price down to zero – had massive positive effects on deworming take-up, and this suggests that the introduction of small positive user fees is a particularly unattractive policy in this context, since this is likely to dramatically reduce take-up and still raise little revenue – especially since the collection of even low user fees typically requires a considerable administrative cost. Yet this is precisely the approach that was implemented by the NGO, and an approach has been adopted in the health sector by many less developed countries, including Kenya (World Bank 1994, McPake 1993). Although user fees play an important and useful role in some contexts – for instance, in rationing limited health care resources – for medical treatments characterized by large externalities they seem likely to reduce drug treatment far below socially optimal levels.

It is worth bearing in mind the sequencing of the project in understanding these results. In the parent meetings held to introduce the project, NGO facilitators explained that deworming medicine would be provided for free during an initial introductory period, and that, following standard NGO policy, cost-sharing would be introduced later. Schools then received free treatment for two or three years, after which half the schools were assigned to cost-sharing. Some have argued that it is essential to introduce cost-sharing from the beginning of a project, the logic being that once people become accustomed to receiving treatment for free, they will develop a sense of entitlement to it and will refuse to pay when positive prices are subsequently introduced. On the other hand, it could be argued that people are more likely to spend money on a new product if they have the chance to "try it out" first to see its value first-hand. Although we are unable to directly test either hypothesis here given the study design, it is worth noting that there was no significant difference in the impact of cost-sharing between Group 1 and 2 schools despite their differing length of exposure to free treatment (three versus two years, respectively), exposure that could have provided a stronger sense of entitlement to treatment or additional information on drug effectiveness.[16] In any case, given that the fall in drug take-up was enormous even with the introduction of a very small fee – constituting approximately one-fifth of actual program costs – even if the impacts would have been somewhat smaller with different treatment sequencing, it is likely that the drop in take-up associated with fees would still be large.[17]

Some might argue that the social benefit of the drug treatment would be internalized in a small community, where formal and informal institutions could enforce participation in the program once cost-sharing is introduced and punish free riders. The fact that the deworming program we study was run through local primary schools, and that meetings were held to discuss the program, provides a possible centralized mechanism for enforcing payment; in the U.S., for example, primary schools require child vaccinations for enrollment. Miguel and Gugerty (2002) find related evidence that a variety of social sanctions are employed in rural Kenyan primary schools to enforce payment of school fees and contributions to school projects. However, through interviews with NGO field staff and program participants, we have found no evidence that this sort of community coordination took place in any primary school in the study.

Note that people rarely purchased deworming drugs prior to the project, and little market for drugs has developed independently of the project in this area. While many medicines, such as aspirin and anti-malarials, are cheaply available in nearly all local shops, deworming is only available in a few shops and only at high mark-ups – where the markups are high presumably because the market is quite thin; in fact, none of 64 local shops surveyed in 1999 had either albendazole (or its close substitute, mebendazole) or praziquantel in stock, though a minority of shops carried less effective deworming drugs (levamisole hydrochloride and piperazine). Fewer than five percent of people reported taking deworming drugs prior to the program.

[17] Take-up of the deworming drugs fell somewhat in Group 1 schools between 1998 and 1999 (from 78 to 73 percent among those still enrolled in school – see Miguel and Kremer 2003a). This may be due to the change from community consent to individual consent between 1998 and 1999, since in the community consent system the default was deworming treatment, while in the individual consent system the default was no treatment; in the literature on enrollment in 401(K) plans, changing from an opt-in to an opt-out system leads to much higher participation in 401(K) plans and, in addition, people who are automatically enrolled are likely to remain with the default benefit level (Madrian and Shea, 2001; Choi, Laibson, Madrian and Metrick, 2003). However, it is also possible that people learned between 1998 and 1999 that the private benefits of treatment were lower than they had anticipated, which led them to avoid taking the drug themselves in order to avoid the side effects. Of course, there may also be other reasons for year-to-year variation in take-up rates: for instance, El Niño flooding took place in early 1998 and may have affected take-up both in late 1998 and early 1999.

There are several potential reasons why use of drugs fell so dramatically with the introduction of a small fee, and why private demand for deworming drugs outside the program is so low in this area. First, the private gains from deworming may not have been larger than the private costs for many households. Miguel and Kremer (2003a) estimate that the social value of increased future income generated by school participation gains due to deworming externalities exceeds deworming costs by at least three times, using conservative assumptions. However, since school participation gains are nearly identical for treated and untreated children in the treatment schools, the private gains in school participation are likely to be modest. (It is difficult to determine the magnitude of private gains in school participation due to deworming since untreated children in treated schools initially had lower school participation on average, and thus may have had more scope for gains in school participation.)[19] (Nonetheless, deworming may affect welfare in important ways other than increasing school participation – by reducing child fatigue and abdominal pain, for instance.)

It is also possible that people simply did not recognize the benefits of deworming. In the traditional view, worms are an integral part of the human body and necessary for digestion, and many infection symptoms – including abdominal pain and malnutrition – are attributed to malevolent occult forces ("witchcraft") or breaking taboos (Government of Kenya 1986).[20] Geissler (1998a, 1998b, 2000) studies deworming take-up in a Kenyan district that borders our study area, with a nearly identical worm infection profile, and finds that, while the Western bio-medical paradigm is making inroads into traditional health views (especially among the younger and better educated), most people do not place much value on deworming treatment because worms are not seen as a pressing health problem - especially compared to malaria and HIV/AIDS.[21] As a result, there was essentially no deworming outside

[19] See Miguel and Kremer 2003a.
[20] Although serious worm infection levels had fallen substantially in Group 1 and 2 schools by 2001 – several years after mass deworming began in these communities – leaving fewer heavily infected children who would gain the most from treatment (Miguel and Kremer 2003a), the vast majority of children still have some level of infection.
[21] Geissler studies an ethnically Luo area (Luos speak a Nilotic language), while the majority of our sample are ethnically Luhya (a Bantu-speaking group) though Luos are a sizeable minority in our sample. However, traditional

the school health program Geissler studies, and most children instead relied on herbal remedies to alleviate the abdominal discomfort caused by worms.

The existence of frequent health shocks from many sources (e.g., malaria, typhoid, cholera) also complicates learning about new health treatments in this area, especially given the timing of deworming costs and benefits: deworming entails immediate costs (i.e., the effort needed to obtain treatment and possible drug side effects) while benefits emerge only gradually as individual nutritional status improves in the months after treatment, potentially obscuring health gains. The immediate drug side effects may be particularly salient for many individuals. In contrast, cost-sharing could conceivably lead to less of a drop in take-up for diseases like malaria for which health impacts are more acute.

To the extent that many people in this area believed that worms were not a serious health problem at the start of the program, and there are psychological fixed costs to "re-categorization" along the lines of Mullainathan (2002) – in other words, to begin believing that worms in fact are a serious problem – the modest observed private deworming benefits might not be large enough to justify shifting one's beliefs, further dampening take-up. A final factor is that the individuals (parents) who provide consent for treatment, and pay for treatment in cost-sharing schools, are not the same people who directly benefit from treatment (their children). This further reduces drug take-up to the extent that there is imperfect altruism and inefficient bargaining within households, which may be especially likely for the parent-child relationship.[23]

4. The Impact of Health Education

We find that the cost of inducing behavioral change through health education appears much greater than the cost of affecting behavior through drug subsidies. Indeed, the worm prevention education program in Kenya had a minimal impact on short-run behavior: there were no significant differences across treatment

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Luo views toward worms are closely related to views found among Bantu-speaking groups in other parts of Africa, including Mozambique (Green et al. 1994, Green 1997) and South Africa (Zondi and Kvalsig 1987).

and comparison school pupils in early 1999 (one year after the start of the program) on three worm prevention behaviors: pupil cleanliness (of hands and uniform) observed by enumerators[24], the proportion of pupils observed wearing shoes, or self-reported exposure to fresh water (Table 3, Panel A), and the results do not vary substantially by pupil age, gender, or grade (results not shown). Our results are thus broadly consistent with Pant et al's (1996) study in Nepal, which shows that hygiene education for mothers is considerably less cost-effective than Vitamin A capsules in reducing infant morbidity and mortality.

It is conceivable that some treatment school children neglected to adopt worm prevention practices precisely because they were also taking deworming drugs, and thus felt protected from infection; however, we also fail to find evidence of behavioral change even among older girls excluded from medical treatment (due to its potential embryotoxicity, Table 3, Panel B), providing further evidence that health education did not lead to measurable behavioral change here. Of course, to the extent that the older girls in treatment schools realized that they were benefiting from treatment spillovers, they too may have neglected to adopt better worm prevention practices. However, this seems implausible. First, the lack of even basic knowledge regarding worm infection symptoms and transmission among most residents in this area makes this claim seem very unlikely: the median resident in this area is able to name just one of ten common worm infection symptoms, and fewer still can accurately describe transmission mechanisms (Miguel and Kremer 2003b). Second, there are no significant cross-school externalities in worm prevention behaviors: children attending comparison (Group 2) primary schools located near deworming treatment schools in early 1999 showed large reductions in worm infection levels (Miguel and

[23] Udry (1996) and Dercon and Krishnan (2000) present evidence on inefficient within-household resource allocation in other rural African settings. Note, however, that child orphan status is not related to take-up (results not shown).

[24] This also holds controlling for initial 1998 cleanliness, or using a difference-in-differences specification.

Kremer 2003a) but did *not* receive health education, and there was no significant change in their worm prevention behaviors (Table 3, Panel C) – although these effects are imprecisely estimated statistically.

The attractiveness of health education versus indefinitely subsidizing inputs depends on the relative cost and effectiveness of subsidies and of health education activities on recipients behaviors (discussed above), as well as the rate at which health education depreciates, and the rate at which new practices spread to others through social learning. There is reason to believe that depreciation of health education knowledge and practices is often substantial, even in settings where the direct short-run program impact was positive. Many existing studies focus on hygiene education, which is closely related to worm prevention education. In an experimental study in an African setting – eighteen villages in rural Zaire (now Congo) – Haggerty et al (1994) find that hygiene education intervention communities showed moderate 11 percent drops in infant diarrhea immediately after the intervention, but this effect diminished to less than 6 percent (not statistically significant) after only one year, an annual depreciation rate of nearly half. In a Bangladesh hygiene education project which found large short-run reductions in diarrhea (Aziz et al 1990), all hygiene knowledge and behavioral gains had disappeared by the time of the five-year follow-up (Hoque et al 1996), further evidence on the often rapid depreciation of health knowledge. Thus, in our view, in both African and Asian settings, the often claimed long-term "sustainability" of health education programs appears largely unproven empirically.

It is possible that sustainability might be promoted through knowledge spillovers between treated and untreated individuals. In related work mentioned above (Miguel and Kremer 2003b), however, we examine the diffusion of health knowledge and behaviors – another component needed to assess the relative cost-effectiveness of the two public health approaches – and find that children whose parents have (randomly) more social links to early treatment schools are themselves significantly *less* likely to take deworming drugs, as discussed above.

5. The Impact of Verbal Commitments

Advocates of sustainability often argue that local "ownership" is important for sustainable development projects. At a minimum, development projects should only take place if beneficiaries are willing to make an affirmative commitment to them. In the deworming project we study, for instance, treatment only took place only after a community collectively decided to participate during a large village meeting.

This notion of community ownership is also related to the claim in social psychology that asking individuals if they plan to take an action can make it much more likely that they carry through with it, the so-called "self-prophecy" or "commitment" literature. For example, Greenwald et al. (1987) asked U.S. university students whether they would vote in an upcoming election. All voters in the sample were reminded that Election Day was coming up, and a random half of these voters were also asked if they intended to vote; all answered that they did. Using county election records, Greenwald et al. found that 81 percent of the voters who made the verbal commitment actually did vote in the election, compared to only 57 percent of those just reminded about Election Day. In a closely related study, Cioffi and Garner (1998) find large impacts of such commitments on blood donation in a U.S. university campus.

In an application of this technique that attempted to promote individual ownership for deworming, a random subsample of pupils in PSDP schools were asked whether they would take deworming drugs in the upcoming treatment round, providing experimental evidence on the impact of this technique on take-up. During 2001 Pupil Questionnaire administration, all children were told that worms and schistosomiasis can lead to poor health and nutrition and make children feel weak and tired, but they were also told that drugs can eliminate the worms and were given the date of the ICS intervention. A random subsample of pupils were then asked whether they were planning to come to school on the treatment day and whether the PSDP workers should bring pills for them on that day; ninety-eight percent of children answered "Yes" to both questions. All pupils selected for the Pupil Questionnaire – including both those offered the opportunity for verbal commitment and those not offered this opportunity – were provided the information on the upcoming date of medical treatment and the effects of deworming (all were of course informed that participation in data collection and treatment was completely voluntary).

The verbal commitment intervention appears to have backfired, reducing drug take-up by nearly six percentage points in 2001 (Table 4, regression 1). This result is robust to controls for pupil age and gender (regression 2), and the impact of the intervention did not vary significantly with age or sex (regression 3), although the effect was somewhat more pronounced for boys. The effect is somewhat more negative for pupils in cost-sharing schools and those with moderate-to-heavy worm infections – although in neither case are the coefficient estimates on these interactions significantly different than zero at traditional confidence levels (results not shown).

These results dramatically illustrate that mobilization or marketing techniques found to be effective in the U.S. may fail in other contexts. The precise explanation for this surprising negative effect of "verbal commitment" on take-up is somewhat elusive, however, although are some interesting possibilities. First, some students may have simply resented being asked these questions about their intentions. Second, students may have taken away a negative signal about deworming from the fact that the interviewer was urging them to participate in the project; they may have suspected that the costs to deworming (e.g., side effects) were higher than they had thought, and that this was why the interviewer felt additional encouragement was necessary. In contrast, potential voters in the U.S. are unlikely to draw inferences about the desirability of voting from the fact that others urge them to vote.

However, there is a counter-argument to this "additional information" explanation for the unexpected results: if the verbal commitment intervention was perceived as providing negative information, this effect should be smaller for pupils who knew more about deworming already; but, in fact, we find that there is no significant difference in the effect of the intervention on pupils in the three program treatment groups, with their varying years of exposure to deworming (results not shown).

6. The Impact of Latrines and Borehole Wells

Although prospective cost-sharing, health education, and verbal commitment interventions were largely unsuccessful in combating worm infections, there remains the possibility that other types of "sustainable" health-related interventions could be. Two such potential interventions are constructing additional latrines, and digging borehole wells, both of which could conceivably reduce worm infection rates, and have recently been advocated by Utzinger et al (2003) as important elements of "sustainable" schistosomiasis control.

Although the current project did not include either of these two interventions, it is useful to examine the observed relationship between latrines, wells, and worm infection, and their cost effectiveness using non-experimental methods. Note, however, that it is problematic to interpret the relationship between latrine ownership and worm infections (or borehole well density and infection) as a causal effect, due to omitted variable biases that could be either positive or negative. This also makes it difficult to place bounds on the estimates. One possibility is that unobservably wealthier individuals may both have fewer worms and build more latrines without any causal link between the two – in which case the observed correlation would overestimate the impact of infrastructure on worm infections. There are also potential biases that could go in the other direction, for instance, if individuals (or communities) construct latrines and wells in response to serious worm and other health problems.

Children in households with a latrine at home are statistically significantly less likely to have moderate-heavy worm infections (Table 5), with a reduction of nearly 10 percentage points, in specifications without (regression 1) and with (regression 2) extensive individual and community controls. In contrast, the effect of latrines in the local primary school community on moderate-heavy infection is never statistically significant, and has positive or negative signs depending on the specification; we thus do not consider these effects in the cost-effectiveness calculations below. The lack of a community latrine density effect also suggests that the household latrine results may be driven in part by omitted variable bias – i.e., households where parents are unobservably more interested in child health issues, or wealthier, have more latrines. If this is indeed the case, the household latrine ownership estimates would constitute upper bounds on the true latrine effects. The coefficient estimates on other terms largely have the expected signs: cleaner children are significantly less likely to have moderate-heavy worm infections (regression 2), while wearing shoes is negatively, but insignificantly, related to infection. Reported days of contact with fresh water is not strongly associated with moderate-heavy worm infection.

Unlike latrines, we find that having more borehole wells nearby does not have any substantial association with worm infection rates (Table 5, regressions 1 and 2). In fact, for geohelminth infections, the correlation of borehole wells and worm infection is unexpectedly *positive* in some specifications – suggesting that omitted variable bias may be substantial – although the association with schistosomiasis infection is negative, but typically not statistically significant (results not shown). The results are similar if we restrict attention to the density of wells with "normal" water flow (results not shown). Overall, there is no evidence of a strong relationship between local well density and worm infection rates, and we thus do not consider well construction in the cost-effectiveness calculations.

We use the regression estimates from Table 5 to calculate the cost-effectiveness of latrines in reducing moderate-heavy worm infections, interpreting the estimates as causal impacts (although as we argue above, these estimates may overstate true causal effects due to omitted variable bias). The construction cost of a high-quality two-hole latrine in rural western Kenya is approximately $750, including labor costs. We estimate that such a latrine lasts for approximately ten years before it either fills up, or the water table rises and thus the latrine ceases to be useable. (Note that cheaper low-quality latrines have shallower holes and would likely last for fewer years.) Under the assumption that two households share the latrine, and that each household has three primary-school age children (the approximate number of schoolchildren in our dataset), a total of six children would benefit from the latrine construction. Ignoring intertemporal discounting, the rough cost of latrine construction is $750 / (6 children x 10 years) = $12.50 per child-year, and thus the cost per moderate-heavy worm infection eliminated is $12.50/0.096 = $130 per child-year.

We find large differences between this $130 figure and the cost-effectiveness of deworming subsidies. In fact, as discussed in Miguel and Kremer (2003a), the cost per moderate-heavy infection eliminated in the original deworming project in this area was only $0.93 per child-year, and thus the home latrine cost figure is *140 times greater than the cost of drugs*. Even if our household latrine impact estimates suffer from severe omitted variable bias, latrine construction would be considerably less cost-effective than free deworming drugs: for instance, if latrine construction reduced the rate of moderate-heavy infection by 40 percentage points – a truly massive effect, with infection rates dropping to near zero – the cost per child-year of infection eliminated would still be over thirty times the cost per child-year with deworming drugs. However, note that household and community members are likely to benefit from latrine construction along a variety of other health dimensions – for instance, in terms of reductions in diarrhea – but we are unable to estimate the magnitude of those benefits here.

7. Conclusion

This paper provides several lessons regarding how the design of public health programs affects individual health choices. A "sustainable" public health strategy relying on a combination of health education, an individual mobilization technique, and cost-recovery was ineffective at fighting worm infections in rural Kenya. Latrine and water well construction appear far less cost-effective than subsidized deworming drugs in combating worm infections. However, providing the deworming drugs for free led to high drug take-up and large reductions in serious worm infection rates. Our results suggest that cost-sharing is inappropriate when there are large externalities, as for deworming (recall that we estimate that three-quarters of deworming health benefits were due to externalities). Standard public finance analysis suggests that it is precisely in areas like this where private and social incentives differ dramatically that donors should focus their resources.

In this conclusion, we first consider some caveats, then discuss why the idea of sustainability remains so powerful, and finally discuss potential ways forward. The most important caveat to our results is that it remains possible that different health education and community mobilization interventions could be developed that are more effective than the ones evaluated in this study. However, in our opinion it is unlikely that most large-scale government programs would implement those programs as effectively as the NGO we studied. Moreover, in the absence of credible empirical evidence demonstrating that the increasingly popular package of health education, community mobilization, and local cost-recovery is in fact effective at promoting the adoption of new health technologies and practices, we feel that the burden of proof should rest with those advocating such an approach – especially given the relatively large costs associated with health education programs. Instead, the results of this paper suggest that scarce public health resources in less developed countries should be focused on providing subsidies – potentially even negative prices – for a limited set of highly-cost effective treatments that generate positive externalities.[26]

Given the paucity of evidence in support of the idea that programs can become sustainable through local fund raising or community education, it is worth considering why the idea has been so appealing. One motivation is the long history of development projects that have financed capital investments but not recurrent costs, and have subsequently failed when donors have withdrawn. Yet in our view donors could instead simply fund recurrent costs, and to understand the reasons why they do not, it is important to consider political economy issues.

There are a number of interesting possibilities. First, more development aid workers are needed to design new projects than to administer old ones; in fact, a large proportion of aid is devoted to "technical assistance" – which consists of hiring consultants rather than providing needed goods directly. Second, while our analysis suggests that donors could achieve more with foreign aid if they provided long-term financial support for activities (such as deworming) that are cost-effective and generate positive externalities, if donors are unwilling to fund projects on a long-term basis for ideological reasons, it makes sense for individual project officers in donor organizations to take this constraint into account during project selection; an individual World Bank loan officer interesting in worm control, for instance, may quite reasonably gamble on finding a "sustainable" project if she knows that at the end of her stint a new loan officer will replace her, and this replacement is likely to have a different set of project priorities. Third, it may be difficult to attract popular (or politician) support for development programs in donor nations – in an era of shrinking international aid budgets – without promising extraordinary returns, in

[26] The well-known Mexican child health, nutrition, and education program PROGRESA has successfully employed negative prices to boost program participation (see Gertler and Boyce 2001).

particular, returns associated with claiming that a simple one-shot intervention, such as providing health education, will provide indefinite flow of benefits.

There are several promising policy alternatives to the sustainable approach in light of these political economy issues. To the extent that donors are unable to commit future budget allocations, they may wish to promote sustainability by not simply focusing on capital infrastructure investment, but instead by endowing funds to cover recurrent costs. Consider, for example, the KEFINCO water project mentioned in the introduction to this paper, which installed thousands of wells across western Kenya. The Government of Finland initially paid for the maintenance of these wells, but in accordance with the concept of sustainability, it later trained local water technicians to repair the wells and established community groups charged with raising funds for maintenance. This approach has been a failure: as mentioned above, ten years after the Finnish government withdrew, fully 43 percent of the wells had fallen into disrepair and were no longer providing clean water (Miguel and Gugerty 2002). Perhaps a better approach would have been for the Finnish government to have endowed a fund covering ten years of maintenance costs for each well; contracts for repairing and maintaining the wells could then have been let out to local firms.[27]

An alternative approach in the context of funding worm control would be to subsidize deworming drug production at source, which should lead to lower drug prices in local pharmacies and shops and thus boost deworming treatment rates. This approach has the added benefit of reducing the public health project administrative costs associated with local drug purchase and distribution, since distribution would be left to private sector firms.

[27] One approach which is increasingly popular among donors is to provide broad budgetary support to governments rather than financing specific development projects. However, while this approach does have the virtue of allowing recurrent costs to be covered, it is designed to address a different set of issues and is not appropriate in all contexts. In particular, while this approach may be desirable in countries with good institutions and governance, it is much less appropriate for countries where governments are likely to misuse funds, and unfortunately, this latter group includes many of the poorest countries. Thus, for example, U.S. assistance under the Millennium Challenge Account is slated to be provided to lower middle-income countries as well as poor countries because of fears that not enough poor countries will call for it. Still, while some argue that project aid will not be effective in countries with weak institutions, in fact, the empirical evidence cited on behalf of this view is fairly weak (refer to Easterly 2003). It seems just as likely that project assistance has the most potential in countries with weak governments since it is in these countries that investments with high social returns are most neglected.

How do we move forward from here? It is worth emphasizing that while we agree with advocates of sustainability that many existing development programs will not survive in the absence of external finance, we think that in many cases the current "sustainability" approach will not lead to sustainable and successful projects, either. In such an environment, it would be better for donors to accept the reality of the need for continued subsidies for development projects than to continue pursuing the illusion of sustainability.

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9. Tables and Figures

Table 1: Summary Statistics

	Mean	Std dev.	Obs.
Panel A: Deworming Treatment Take-up			
Took deworming drugs in 2001 (Group 2 and 3)	0.61	0.49	1690
Took deworming drugs in 2001, free treatment schools (Group 2 and 3)	0.75	043	1269
Took deworming drugs in 2001, cost-sharing schools (Group 2 and 3)	0.18	0.38	421
Panel B: Cost-Sharing and Verbal Commitment Interventions			
Cost-sharing school indicator	0.25	0.43	1690
Effective price of deworming per child (Kenyan shillings)	6.2	15.4	1690
Cost-sharing school indicator, albendazole only treatment	0.17	0.38	1690
Cost-sharing school indicator, albendazole and praziquantel treatment	0.08	0.27	1690
Verbal commitment intervention indicator	0.43	0.50	1312

Notes for Table 1: From 2001 PSDP Parent and Pupil Surveys and 2001 administrative records. The sample for the verbal commitment intervention indicator is the 2001 Pupil Survey.

Table 2: The Impact of Cost-sharing

	Dependent variable: Child took deworming drugs in 2001 (1)	(2)	(3)	(4)
Cost-sharing school indicator	-0.62*** (0.08)	-0.47*** (0.14)	-0.62*** (0.12)	
Cost-sharing * Respondent years of education		0.005 (0.007)		
Cost-sharing * Community group member		0.022 (0.069)		
Cost-sharing * Total number of children		-0.012 (0.015)		
Cost-sharing * Iron roof at home		-0.04 (0.07)		
Effective price of deworming per child (=Cost / # household children in that school)			-0.001 (0.002)	
1 / (# household children in that school)			-0.34*** (0.07)	
Cost-sharing school indicator, albendazole treatment (30 shillings / parent)				-0.58*** (0.10)
Cost-sharing school indicator, albendazole and praziquantel treatment (100 shillings / parent)				-0.73*** (0.07)
Social links, other controls	Yes	Yes	Yes	Yes
Number of observations (parents)	1690	1690	1690	1690
Mean of dependent variable	0.61	0.61	0.61	0.61

Notes for Table 2: Data from 2001 Parent Survey, and 2001 administrative records. Marginal probit coefficient estimates are presented. Robust standard errors in parentheses. Disturbance terms are clustered within schools. Significantly different than zero at 99 (***), 95 (**), and 90 (*) percent confidence. Social links controls include total number of links, number of links to Group 1, 2, 3 schools (not own school), and number of links to non-program schools. Other controls include respondent years of education, community group member indicator variable, total number of children, iron roof at home indicator variable, and distance from home to school in km, as well as the Group 2 indicator. We cannot reject that the two terms in regression 4 are equal (p-value=0.17). Summary statistics from the 2001 Parent Questionnaire (Mean [s.d]): Respondent years of education (4.6 [3.9]), Community group member indicator (0.58 [0.49]), Total number of children (5.5 [2.3]), Iron roof at home indicator (0.61 [0.49]). The social link controls are described in Miguel and Kremer (2003b).

Table 3: PSDP Health Behavior Impacts (1999)

	Group 1	Group 2	Group 1 – Group 2
Panel A: Health Behaviors, all pupils (Grades 3-8)			
Clean (observed by field worker), 1999	0.59	0.60	-0.01 (0.02)
Wears shoes (observed by field worker), 1999	0.24	0.26	-0.02 (0.03)
Days contact with fresh water in past week (self-reported), 1999	2.4	2.2	0.2 (0.3)
Panel B: Health behaviors, girls ≥ 13 years old			
Clean (observed by field worker), 1999	0.75	0.77	-0.02 (0.02)
Wears shoes (observed by field worker), 1999	0.39	0.42	-0.03 (0.06)
Days contact with fresh water in past week (self-reported), 1999	2.3	2.2	0.0 (0.3)
Panel C: Health behaviors, all pupils (Grades 3-8)	Overall cross-school externality effect for Group 2		
Clean (observed by field worker), 1999	0.09 (0.21)		
Wears shoes (observed by field worker), 1999	-0.01 (0.08)		
Days contact with fresh water in past week (self-reported), 1999	0.98 (0.68)		

Notes for Table 3: These results use the data from Miguel and Kremer (2003a). These are averages of individual-level data for grade 3-8 pupils; disturbance terms are clustered within schools. Robust standard errors in parentheses. Significantly different than zero at 99 (***), 95 (**), and 90 (*) percent confidence.

The effects in Panel C are the result of a regression in which the dependent variable is the change in the health behavior between 1998 and 1999 (school average), and the local density of Group 1 pupils within 3 km (per 1000 pupils), Group 1 pupils within 3-6 km (per 1000 pupils), Total pupils within 3 km (per 1000 pupils) and Total pupils within 3-6 km (per 1000 pupils) are the key explanatory variables (in a specification analogous to Appendix Table A3, as in Miguel and Kremer 2003a). Grade indicators, school assistance controls (for other NGO programs), and the average school district mock exam score are additional explanatory variables.

Table 4: The Impact of a Verbal Commitment Intervention

	Dependent variable: Child took deworming drugs in 2001 (1)	(2)	(3)
Verbal commitment intervention indicator	-0.058**	-0.059**	-0.31
	(0.025)	(0.025)	(0.22)
Pupil age		-0.001	-0.007
		(0.006)	(0.010)
Pupil female		-0.053	-0.090
		(0.042)	(0.064)
Commitment*Age			0.018
			(0.017)
Commitment*Female			0.079
			(0.088)
Social links, other controls	Yes	Yes	Yes
Number of observations (pupils)	1312	1312	1312
Mean of dependent variable	0.65	0.65	0.65

Notes for Table 4: Data from 2001 Parent and Pupil Surveys, and administrative records. Marginal probit coefficient estimates are presented, robust standard errors in parentheses. Disturbance terms are clustered within schools. Significantly different than zero at 99 (***), 95 (**), and 90 (*) percent confidence. Social links controls are described in Miguel and Kremer (2003b). Other controls include respondent years of education, community group member indicator variable, total number of children, iron roof at home indicator variable, and distance from home to school in km, as well as the Group 2 and Cost-sharing school indicators. Summary statistics from the 2001 Pupil Questionnaire (Mean [s.d.]): Pupil age (12.9 [2.3]), Pupil female indicator (0.23 [0.42]) (older girls were dropped from the sample because they were not eligible for deworming, due to the potential embryotoxicity of the drugs).

Table 5: The Impact of Latrines and Wells

	Dependent variable: Any moderate-heavy infection, 1998	
	(1)	(2)
Latrine at home, 1998	-0.099*** (0.039)	-0.096*** (0.037)
Proportion of children in the primary school with a latrine at home, 1998	-0.49 (0.40)	0.22 (0.25)
All bore-hole wells within 3 km of the child's primary school (measured in 2000)	0.001 (0.003)	0.001 (0.003)
Clean (observed by field worker), 1998		-0.035** (0.017)
Wears shoes (observed by field worker), 1998		-0.048 (0.032)
Days contact with fresh water in past week (self-reported), 1998		-0.000 (0.005)
Child grade controls; school program assistance, exam, population density, geographic controls	No	Yes
Number of observations (children)	1779	1779
Mean of dependent variable	0.37	0.37

Notes for Table 5: Data from 1998 Pupil Survey, 1998 Parasitological Survey, 2000 Kefinco Survey, and administrative records. Marginal probit coefficient estimates are presented. Robust standard errors in parentheses. Disturbance terms are clustered within schools. Significantly different than zero at 99 (***), 95 (**), and 90 (*) percent confidence.

10. Appendix

Appendix Table A1: PSDP Health and Education Treatment Effects and Externalities (1998-1999)

	Group 1, Treated in 1998	Group 1, Untreated in 1998	Group 2, Treated in 1999	Group 2, Untreated in 1999	(Group 1 Treated 1998) – (Group 2, Treated 1999)	(Group 1, Untreated 1998) – (Group 2, Untreated 1999)
Panel A: Health Outcomes						
Any moderate-heavy infection, 1998	0.39	0.44	-	-	-	-
Any moderate-heavy infection, 1999	0.24	0.34	0.51	0.55	-0.27***	-0.21**
					(0.06)	(0.10)
Panel B: School Participation						
School participation rate, May 1998 to March 1999	0.872	0.764	0.808	0.684	0.064**	0.080**
					(0.032)	(0.039)
Panel C: Selection into Treatment						
Access to latrine at home, 1998	0.84	0.80	0.81	0.86	0.03	-0.06
					(0.04)	(0.05)
Grade progression (=Grade – (Age – 6)), 1998	-2.0	-1.8	-1.8	-1.8	-0.2**	-0.0
					(0.1)	(0.2)
Weight-for-age (Z-score), 1998 (low scores denote undernutrition)	-1.58	-1.52	-1.57	-1.46	-0.01	-0.06
					(0.06)	(0.11)
Malaria/fever in past week (self-reported), 1998	0.37	0.41	0.40	0.39	-0.03	-0.01
					(0.04)	(0.06)
Clean (observed by field worker), 1998	0.53	0.59	0.60	0.66	-0.07	-0.07
					(0.05)	(0.10)

Notes for Table A1: These results use the data from Miguel and Kremer (2003a). These are averages of individual-level data for grade 3-8 pupils in the parasitological survey subsample; disturbance terms are clustered within schools. Robust standard errors in parentheses. Significantly different than zero at 99 (***), 95 (**), and 90 (*) percent confidence. Obs. for the 1999 parasitological survey: 670 Group 1 treated 1998, 77 Group 1 untreated 1998, 873 Group 2 treated 1999, 352 Group 2 untreated 1999. The data are for all boys, and for girls age 13 years and under (older girls are ineligible for deworming in mass treatment programs due to the potential embryotoxicity of the drugs).

School participation averages are weighted by pupil population. The participation rate is computed among pupils enrolled in the school at the start of 1998. Pupils present in school during an unannounced NGO visit are considered participants. Pupils had 3.8 participation observations per year on average. Participation rates are for grades 1 to 7; grade 8 pupils are excluded since many graduated after the 1998 school year, in which case their 1999 treatment status is irrelevant. Preschool pupils are excluded since they typically have missing take-up data. Characteristics in Panel C are for grades 3 to 7, since younger pupils were not administered the Pupil Questionnaire.

Appendix Table A2: PSDP Health and Nutrition Impacts (1999)

	Group 1	Group 2	Group 1 – Group 2
Panel A: Nutritional and Health Outcomes			
Sick in past week (self-reported), 1999	0.41	0.45	-0.04**
			(0.02)
Sick often (self-reported), 1999	0.12	0.15	-0.03**
			(0.01)
Height-for-age Z-score, 1999	-1.13	-1.22	0.09*
(low scores denote undernutrition)			(0.05)
Weight-for-age Z-score, 1999	-1.25	-1.25	-0.00
(low scores denote undernutrition)			(0.04)
Hemoglobin concentration (g/L), 1999	124.8	123.2	1.6
			(1.4)
Proportion anemic (Hb < 100g/L), 1999	0.02	0.04	-0.02**
			(0.01)

Notes for Table A2: These results use the data from Miguel and Kremer (2003a). These are averages of individual-level data for grade 3-8 pupils; disturbance terms are clustered within schools. Robust standard errors in parentheses. Significantly different than zero at 99 (***), 95 (**), and 90 (*) percent confidence. Obs. for hemoglobin results: 778 (292 Group 1, 486 Group 2).Obs. for 1999 Pupil Questionnaire health outcomes: 9,102 (3562 Group 1, 5540 Group 2 and Group 3).

Hb data were collected by Kenya Ministry of Health officials and ICS field officers using the portable Hemocue machine. The self-reported health outcomes were collected for all three groups of schools as part of 1999 Pupil Questionnaire administration.

<u>Appendix Table A3:</u> Deworming health externalities within and across schools, January to March 1999

	Any moderate-heavy helminth infection, 1999 (1)	Moderate-heavy schistosomiasis infection, 1999 (2)	Moderate-heavy geohelminth infection, 1999 (3)
Indicator for Group 1 (1998 Treatment) School	-0.25***	-0.03	-0.20***
	(0.05)	(0.03)	(0.04)
Group 1 pupils within 3 km (per 1000 pupils)	-0.26***	-0.12***	-0.12*
	(0.09)	(0.04)	(0.06)
Group 1 pupils within 3-6 km (per 1000 pupils)	-0.14**	-0.18***	0.04
	(0.06)	(0.03)	(0.06)
Total pupils within 3 km (per 1000 pupils)	0.11***	0.11***	0.03
	(0.04)	(0.02)	(0.03)
Total pupils within 3-6 km (per 1000 pupils)	0.13**	0.12***	0.04
	(0.06)	(0.03)	(0.04)
Grade indicators, school assistance controls, district mock exam score control	Yes	Yes	Yes
Number of observations	2328	2328	2328
Mean of dependent variable	0.41	0.16	0.32

<u>Notes for Table A3:</u> Grade 3-8 pupils. Probit estimation, robust standard errors in parentheses. Disturbance terms are clustered within schools. Observations are weighted by total school population. Significantly different than zero at 99 (***), 95 (**), and 90 (*) percent confidence. The 1999 parasitological survey data are for Group 1 and Group 2 schools. The pupil population data is from the 1998 School Questionnaire. The geohelminths are hookworm, roundworm, and whipworm. We use the number of girls less than 13 years old and all boys (the pupils eligible for deworming in the treatment schools) as the school population for all schools. The local densities are constructed using GPS data on program schools.

Appendix Table A4: Primary School Deworming Project (PSDP) timeline, 1998-2001

Dates	Activity
1998	
January	75 Primary schools first stratified by geographic zone, and then randomly divided into three groups of 25 schools (Group 1, Group 2, Group 3)
March-April	First round of 1998 treatment (albendazole, praziquantel) in Group 1 schools
November	Second round of 1998 treatment (albendazole) in Group 1 schools
1999	
March-June	First round of 1999 treatment (albendazole, praziquantel) in Group 1, Group 2 schools
October-November	Second round of 1999 treatment (albendazole) in Group 1, Group 2 schools
2000	
March-June	First round of 2000 treatment (albendazole, praziquantel) in Group 1, Group 2 schools
October-November	Second round of 2000 treatment (albendazole) in Group 1, Group 2 schools
2001	
January-March	2001 Parent Survey (Wave 1) data collection in Group 2, Group 3 schools
	2001 Pupil Survey (Wave 1) data collection in Group 2, Group 3 schools. Verbal commitment intervention carried out during Pupil Survey, among a random subsample of pupils.
March-June	First round of 2001 treatment (albendazole, praziquantel) in Group 1, Group 2, Group 3 schools. Cost-sharing in 25 (randomly selected) Group 1, Group 2 schools
May-September	2001 Parent Survey (Wave 2), and household GPS data collection in Group 2, Group 3 schools.
	2001 Pupil Survey (Wave 2) data collection in Group 2, Group 3 schools. Verbal commitment intervention carried out during Pupil Survey, among a random subsample of pupils.
October-November	Second round of 2001 treatment (albendazole) in Group 1, Group 2, Group 3 schools. Cost-sharing continues in 25 (randomly selected) Group 1, Group 2 schools