SANITATION SUBSIDIES

Encouraging sanitation investment in the developing world: A cluster-randomized trial

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Poor sanitation contributes to morbidity and mortality in the developing world, but there is disagreement on what policies can increase sanitation coverage. To measure the effects of alternative policies on investment in hygienic latrines, we assigned 380 communities in rural Bangladesh to different marketing treatments—community motivation and information; subsidies; a supply-side market access intervention; and a control—in a cluster-randomized trial. Community motivation alone did not increase hygienic latrine ownership (+1.6 percentage points, $P = 0.43$), nor did the supply-side intervention (+0.3 percentage points, $P = 0.90$). Subsidies to the majority of the landless poor increased ownership among subsidized households (+22.0 percentage points, $P < 0.001$) and their unsubsidized neighbors (+8.5 percentage points, $P = 0.001$), which suggests that investment decisions are interlinked across neighbors. Subsidies also reduced open defecation by 14 percentage points ($P < 0.001$).

O ne billion people, or about 15% of the world's population, currently practice open defecation (OD), and another 1.5 billion do not have access to improved sanitation (1). Despite the existence of simple, effective solutions such as pour-flush latrines, poor sanitation causes 280,000 deaths per year (2) and may contribute to serious health problems such as stunting or tropical enteropathy (3–5).

The issue has attracted attention and resources from governments and development institutions. In 2012, the United Nations Children's Fund (UNICEF) spent USD 380 million on programs focused on water, sanitation, and hygiene for children (1). The World Bank's Water and Sanitation Program plans to direct USD 200 million in government and private funds to improve sanitation for 50 million people during the 2011–2015 period (6). In India, where over half the population practices open defecation (7), Prime Minister Narendra Modi declared "toilets first, temples later" during a 2013 speech and pledged to eliminate OD by 2019 (8–10).

However, disagreement remains over how best to increase sanitation coverage. Policymakers must allocate scarce resources among strategies such as demand generation (e.g., information campaigns, behavior change programming), direct provision of toilets to schools or households, or subsidizing consumers (11). Subsidies are particularly controversial, with practitioners concerned that subsidies may undermine intrinsic motivation or cause dependency (12, 13). For example, the Government of India's Total Sanitation Campaign (TSC) used the rhetoric of "community-led," "people-centred," and "demand driven" to build one toilet for every 10 rural residents between 2001 and 2011 (14), but critics argue that the program as implemented was "infrastructure-centred" and "supply-led" (15). Recent studies of TSC find modest impacts on sanitation coverage and OD (16, 17).

At the root of this disagreement is uncertainty about the reasons for low coverage. If the major constraints are poverty and the collective action problem posed by negative health externalities, then economic theory suggests that subsidies are necessary. If the key constraints are lack of information about the benefits of sanitation and the absence of strong community norms against OD, then programs such as Community-Led Total Sanitation (CLTS), which seek to change norms and create social pressure, could be sufficient without subsidies. Even when households are willing to pay for hygienic latrines, supply failures such as lack of access to markets where toilet components are sold,

or lack of information about quality or installation methods, may impede adoption (18).

We measured the effects of alternative policies on investment in hygienic latrines using a cluster-randomized trial in 380 rural communities (18,254 households in 107 villages) in the Tanore district of northwest Bangladesh. Although sanitation coverage has increased markedly in rural Bangladesh in recent decades (1), progress in Tanore, located in the poorest region of the country, has been slower. At baseline, 31% of households reported that their primary defecation site was either no latrine (OD) or an unimproved latrine, and only 50% had regular access to a hygienic latrine. The intervention was conducted in 2012, and we collected follow-up data in 2013 (fig. S1).

We randomized communities to different treatments: a community motivation and health information campaign, called the Latrine Promotion Program (LPP); motivation and health information combined with subsidies for the purchase of hygienic latrines; a supply-side market access intervention linking villagers with suppliers and providing information on latrine quality and availability; and a control group receiving no interventions (19).

LPP was a multiday, neighborhood-level exercise to raise awareness of the problems caused by poor sanitation and to motivate the community to increase coverage of hygienic latrines. The design of LPP follows that of CLTS, an information and motivation intervention that has been implemented in over 60 countries worldwide (20). The nongovernmental organizations that implemented this project, WaterAid Bangladesh and Village Education Resource Center (VERC), were instrumental in the creation of CLTS (13). The design of LPP conformed closely to the principles of CLTS, although LPP differed in emphasizing the importance of hygienic latrines, rather than simply ending OD.

In villages assigned to the "subsidy" treatment, households in the bottom three-quarters of the wealth distribution were eligible to participate in a public lottery awarding subsidy vouchers. These vouchers provided a 75% discount on the components of any of three models of latrine, priced (after subsidy) USD 5.5, USD 6.5, and USD 12. Households were responsible for delivery and installation costs of USD 7 to 10. To study the extent of demand spillovers across neighbors, we randomized the share of lottery winners at the neighborhood level into low, medium, and high intensity, corresponding to approximately 25, 50, and 75%.

The "supply" treatment was intended to improve the functioning of markets by providing

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technical assistance and information. In communities assigned to the supply treatment, VERC selected a local resident with technical skills and trained him as a latrine supply agent (LSA). The LSA received a fixed salary to provide information to neighborhood residents on (i) where to purchase a hygienic latrine, (ii) how to assess the quality of a latrine offered for sale, and (iii) how to install and maintain a latrine.

These treatments were randomized in a two-stage design: First, communities were randomly assigned to treatments; then, within subsidy communities, eligible households participated in household-level lotteries for subsidy vouchers. This randomization resulted in neighborhoods being assigned to five main categories (fig. S3): (1) control (number of neighborhoods, N = 66); (2) LPP only (N = 49); (3) LPP + subsidy (N = 115); (4) supply only (N = 34); and (5) LPP + subsidy + supply (N = 116). Groups 1, 3, 4, and 5 represent a 2 × 2 experimental design, where the demand-side strategies (LPP plus subsidies) and the supply-side strategy are implemented either in isolation or in combination and compared to a pure control group. Adding group 2 (LPP only) allows us to separate the effect of subsidies from the LPP information and motivation campaign. The 231 subsidy neighborhoods (groups 3 and 5) were randomized in equal proportion to low, medium, and high subsidy intensity.

When we consider all treatments jointly, the randomization produced an allocation of villages that was well balanced on key characteristics, including the share of households with access to hygienic latrines (table S1). In pairwise comparisons of individual treatment arms to the control group, we find that the "supply only" group had higher rates of latrine ownership and access at baseline. Because of this imbalance, we include controls for baseline ownership (or access) in our analysis. Adding controls generally affects coefficients on the supply only treatment (21).

The primary outcomes of interest are household access to and ownership of a hygienic latrine, defined as a latrine that safely confines feces (22). For pour-flush latrines, the relevant type in this context, this typically requires a water seal to block flies and other insects and a sealed pit to store fecal matter for safe disposal. We classify a latrine as hygienic if it has an intact slab, has an intact seal, and conveys feces to a sealed pit (23).

We focus on hygienic latrines because the safe confinement and disposal of feces are most likely to improve health (24). We also report effects on access to and ownership of any latrine, including nonhygienic models, because any latrine use that replaces OD is a common policy goal. Finally, we report effects on OD because reductions in reported OD help confirm that latrines are actually being used.

Outcome data were collected in two household surveys: a baseline conducted December 2011 to February 2012 and a follow-up conducted May to July 2013 (fig. S1). Data on the presence and type of latrine come from direct observation by surveyors, with ownership status determined through interviews with the household. Access and OD are based on household self-reports. Data on village and neighborhood treatment assignment and household lottery outcomes were compiled from administrative records. Wealth was proxied by landholdings reported in the baseline survey.

We first estimate overall program effects by comparing outcomes across the randomized community-level treatments, controlling for baseline levels and union fixed effects. Estimates presented here pertain to the households eligible for subsidies (25).

Figure 1, A to C, presents the main results (26). Community-based motivation alone did not increase coverage: Relative to the control group, being assigned to an LPP-only village resulted in no change in access to any latrine [−0.5 percentage points (pp), P = 0.82] or in access to a hygienic latrine (−0.6 pp, P = 0.85). However, the combination of demand-side strategies that add subsidies targeted to the poor with community motivation did increase coverage significantly. Compared to the control group, households in LPP + subsidy villages were 7.3 pp more likely to have access to any latrine (P < 0.001) and 14.3 pp more likely to have access to a hygienic latrine (P < 0.001). These are average effects at the village level, aggregating across subsidy lottery winners and losers. In contrast, the supply-side treatment by itself did not lead to a statistically significant increase in either outcome (any latrine +2.7 pp, P = 0.38; hygienic latrine +3.0 pp, P = 0.58). Finally, adding the supply treatment to the combined demand-side strategies (LPP + subsidy) does not change the effectiveness of the subsidies. There are statistically significant increases in latrine access in both groups where subsidies are provided, and the difference between those two treatment arms is not statistically significant (any latrine +0.5 pp, P = 0.72; hygienic latrine −0.2 pp, P = 0.94).

Because 78% of households had access to a latrine at baseline, the 7.3 pp subsidy effect represents a 9.4% increase in latrine access. The effect on ownership of any latrine (12.1 pp; table S2) is larger, representing a 20% increase over the baseline ownership rate. The larger effect on ownership suggests that the intervention moved some households that were previously sharing into individual ownership. The subsidy vouchers were actually provided for investment in hygienic latrines, and the subsidy effects are largest (14 to 15 pp, or 29 to 36% increase relative to control) for those outcomes.

The LPP only and supply only treatments do not have statistically significant effects on adult OD behavior; however, adding subsidies to LPP reduces OD rates among adults by 9.0 pp (P = 0.02), representing a 22% reduction relative to the control group (Fig. 1C). The reductions among men and women are similar (27).

If one household's investment in a toilet has spillover effects on its neighbors' investment decisions, that has implications for the optimal targeting of subsidies and for the share of community members who should be subsidized. To investigate whether there is a social multiplier in sanitation investments, we analyze the effects of the share of other households in the neighborhood offered subsidies [which we randomized into low-, medium-, and high-intensity (L, M, and H) neighborhoods] on latrine investment and OD. Evidence for a social multiplier comes from comparing behavior across L, M, and H neighborhoods, holding constant each household's own lottery outcome. Figure 2 focuses on ownership rather than access, because a simple
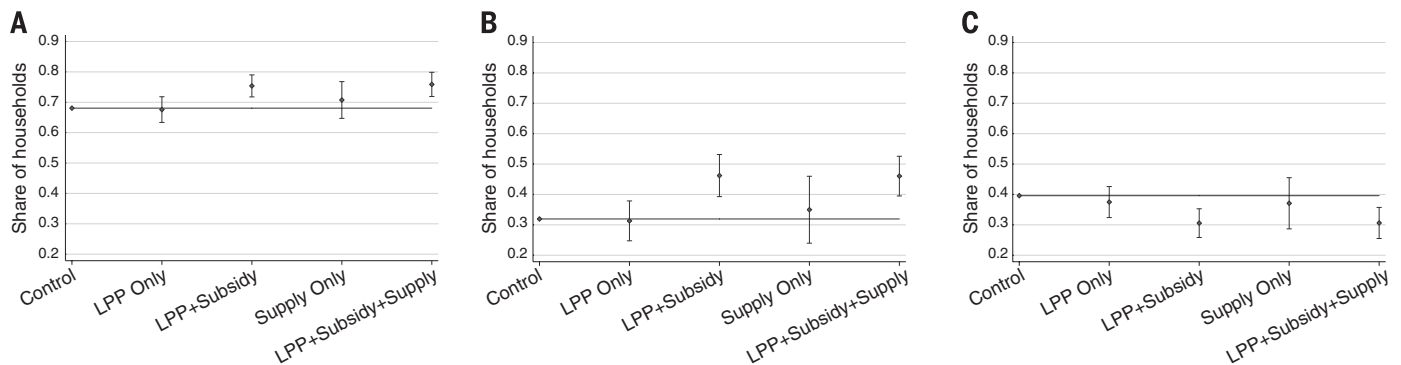
Fig. 1. Effect of supply and demand treatments on latrine access and open defecation. Figure displays the sum of the estimated coefficients and the control group means found in columns (2) and (6) of table S2 and column (2) of table S3. (**A**) Any latrine access; (**B**) hygienic latrine access; (**C**) open defecation among adults.

explanation for greater household latrine access when a larger share of neighbors receive vouchers is that the neighbors offer to share access to their toilets (28).

Figure 2B shows that voucher winners are more likely to own hygienic latrines than households in LPP only villages or lottery losers in subsidy villages. Furthermore, among winners, a household is more likely to convert the subsidy voucher covering half the cost of the latrine into an actual latrine investment if a larger share of its neighbors also receive vouchers. A voucher winner in a low-intensity neighborhood is 13.7 pp (P < 0.001) more likely to own a hygienic latrine than an eligible household in an LPP-only community. A voucher winner in a medium-intensity neighborhood is 20.9 pp (P < 0.001) more likely to own a hygienic latrine than an eligible household in an LPP-only community. The +7.2 pp difference between medium- and low-intensity neighborhoods is statistically significant (P < 0.001). Similarly, a voucher winner in a high-intensity neighborhood is 20.4 pp more likely to own a hygienic latrine than an eligible household in an LPP-only community, and the +6.7 pp difference between high- and low-intensity neighborhoods is statistically significant (P = 0.01). This social multiplier levels off, as there is no detectable difference in hygienic latrine ownership between winners in medium- and high-intensity neighborhoods. A similar pattern occurs in ownership of any (not necessarily hygienic) latrine (see Fig. 2A), although the estimated differences (+3.2 pp for winners in medium-intensity versus winners in low-intensity neighborhoods; +4.1 pp for winners in high-intensity versus winners in low-intensity neighborhoods) are not statistically significant (P = 0.17 and P = 0.11).

We find a similar social multiplier among eligible households that did not win a voucher. Although losing households in low-intensity neighborhoods are statistically indistinguishable from eligible households in LPP-only villages (any latrine +1.5 pp, P = 0.56; hygienic latrine +0.9 pp, P = 0.70), detectable differences emerge for losing households in medium-intensity neighborhoods (any latrine +5.8 pp, P = 0.03; hygienic latrine +2.7 pp, P = 0.26) and losing households

in high-intensity neighborhoods (any latrine +5.5 pp, P = 0.04; hygienic latrine +6.9 pp, P = 0.01). The social multiplier is smaller for losing households than for winning households, which is expected because latrines were not subsidized for these households (Fig. 2C).

The more intense subsidy treatments induced not only latrine construction among neighbors but also latrine use: Households become less likely to practice OD if more of their neighbors receive subsidies (Fig. 2C). OD among adults in lottery-winning households in low-, medium-, and high-intensity neighborhoods falls by 7.2 pp (P = 0.01), 13.8 pp (P < 0.001), and 11.6 pp (P < 0.001) relative to adults in eligible households in control communities. These represent reductions of 18 to 35% relative to the control group mean. Even those who fail to win vouchers reduce their OD propensity (relative to the control group) by 8.8 pp (P < 0.001) if 50% of their neighbors win vouchers and by 8.1 pp (P = 0.01) if 75% of neighbors win vouchers. The decrease in OD among lottery losers in medium- and high-intensity villages is comparable to the decrease among lottery winners in low-intensity villages.

Further evidence of a social multiplier comes from the least-poor quartile of households in subsidy villages. Although they were ineligible for subsidies, they invested in latrines and reduced OD at a greater rate if a larger fraction of their poor neighbors were subsidized (25).

These results are consistent with a growing literature showing the importance of price as a primary barrier to adoption of health products (29–31). Current practice in sanitation sector demand-generation programming reflects a strong belief that community-based motivation is effective at moving households away from OD and toward basic latrines (12, 13). However, in this context, information and motivation alone were not sufficient to increase adoption of hygienic latrines. Similarly, there was no detectable effect of an intervention providing information on the supply side (32). Subsidies increased coverage and reduced OD across the entire population.

This study also presents evidence of the importance of social influence and the possibility of

a virtuous cycle where adoption spurs further adoption (33, 34). The presence of interlinked decision-making implies that interventions will be more cost-effective if they can identify the relevant network and target that group jointly. If neighbors' decisions are interlinked, smaller subsidies targeted to multiple households in a network can generate more investment than large subsidies deployed to a few in an uncoordinated manner. Our experiments suggest that cost-effective "smart subsidy" policies should identify the threshold of investment in latrines where the social multiplier in demand is largest. The move from subsidizing 25% to subsidizing 50% of the poor produces the largest demand spillovers in our context. Asking community members to make a joint investment commitment, as in CLTS, is a potentially useful intervention, but our results suggest that this should be accompanied by targeted subsidies. Future programs could attempt to harness the interplay between subsidies and interlinked decision-making by combining financial incentives with a forum for community cooperation. More research is needed to understand the underlying mechanisms (35), which may include learning, changes in social norms, or technical complementarities (benefits of investment are greater when others invest).

Our study has several limitations. First, results from one study in Bangladesh may not generalize to other populations. However, the disease burden from OD is largest in the high-density rural areas of the Ganges Delta (36), so the results from rural Bangladesh (the most densely populated rural area of the world) are relevant for areas where the problem is most acute. Second, this study reports results for one level of subsidy (~50% of the cost of an installed latrine), and results may vary at other levels. Third, we did not include a subsidy-only treatment because the evidence suggests that providing subsidies without education is not a useful policy (15). We therefore cannot distinguish the effect of subsidies from the combined effect of subsidies and LPP. However, we show that LPP alone was not sufficient in this context to increase investment in hygienic latrines. Fourth, we used household self-reports of OD as a proxy for latrine use,
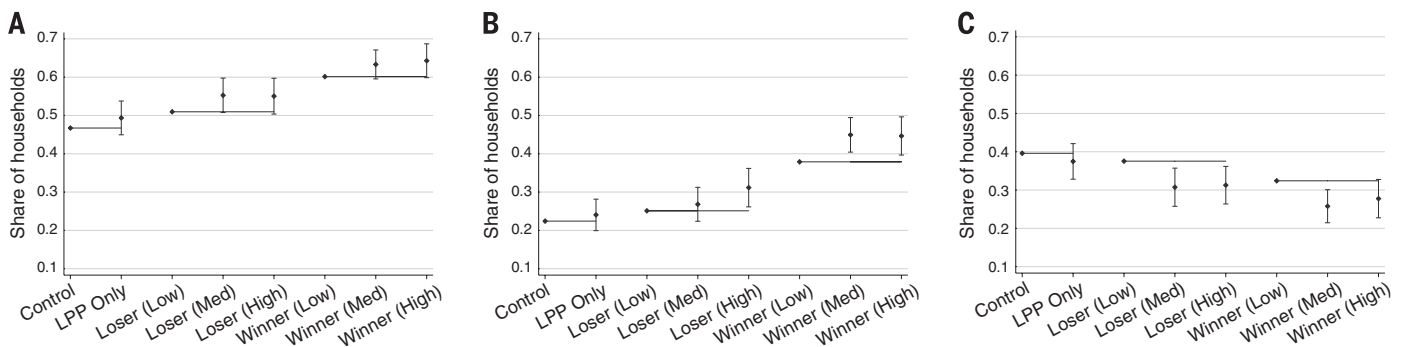
Fig. 2. Effects of the proportion of community treated on latrine ownership and open defecation for those eligible for subsidies. Figure displays the sum of the estimated coefficients and the control group means found in columns (4) and (8) of table S4 and column (2) of table S5. (**A**) Any latrine ownership; (**B**) hygienic latrine ownership; (**C**) open defecation among adults.

which may be subject to bias (*37, 38*). Fifth, we do not measure health outcomes in this demand study, but combining our results on reductions in OD with studies that measure the relationship between OD and health outcomes (*14, 39–41*) suggests that sanitation marketing interventions could plausibly produce improvements in health. Finally, the scale of this study, covering over 18,000 households and 100% samples of four subdistricts, allows us to document some of the general equilibrium changes operating via a social influence mechanism, but our results remain silent on wider general equilibrium effects operating via price mechanisms.

REFERENCES AND NOTES

1. WHO/UNICEF, "Progress on Drinking Water and Sanitation - 2014 Update," tech. rep. (WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation, Luxembourg, 2014). URL (accessed 9 April 2015): http://apps.who.int/iris/bitstream/10665/112727/1/9789241507240_eng.pdf?ua=1.
2. A. Prüss-Üstün et al., *Trop. Med. Int. Health* **19**, 894–905 (2014).
3. A. D. Dangour et al., *Cochrane Database Syst. Rev.* **8**, CD009382 (2013).
4. A. Lin et al., *Am. J. Trop. Med. Hyg.* **89**, 130–137 (2013).
5. D. Spears, A. Ghosh, O. Cumming, *PLOS ONE* **8**, e73784 (2013).
6. World Bank WSP, "Water and Sanitation End of Year Report Fiscal Year 2013", tech. rep. (World Bank Water and Sanitation Program, Washington, DC, 2013). URL (accessed 9 April 2015): https://wsp.org/sites/wsp.org/files/publications/WSP-End-Year-Report-FY13.pdf.
7. Census Organization of India, *15th Indian Census - Houses, Household Amenities and Assets: Sanitation - Total Latrine Table*, 2011. URL (accessed 9 April 2015): www.devinfolive.info/censusinfodashboard/website/index.php/pages/sanitation/total/Households/IND.
8. S. Mojumdar, *Untitled Memorandum, no. W-11042/34/2014-NBA* (July 2014). URL (accessed 9 April 2015): www.mdws.gov.in/sites/upload_files/ddws/files/pdf/Swachh_Bharat_by_2019.pdf.
9. S. Prasad, *Swachchh Bharat by 2019* (July 2014). URL (accessed 9 April 2015): http://mdws.gov.in/hindi/sites/upload_files/ddwshindi/files/Swachh_Bharat_by_2019.pdf.
10. Press Trust of India, "Modi's new mantra: Toilets first, temples later," *Hindustan Times* (October 2013). URL (accessed 9 April 2015): www.hindustantimes.com/newdelhi/modis-new-mantra-toilets-first-temples-later/article1-1130281.aspx.
11. E. Perez et al., "What Does It Take to Scale Up Rural Sanitation?" Water and Sanitation Program Working Paper (July 2012). URL (accessed 9 April 2015): www.wsp.org/sites/wsp.org/files/publications/WSP-What-does-it-take-to-scale-up-rural-sanitation.pdf.
12. K. Kar, K. Pasteur, "Subsidy or self-respect?: Community led total sanitation; an update on recent developments," IDS Working Paper 257 (Institute of Development Studies, University of Sussex, Brighton, UK, 2005).
13. K. Kar, "Subsidy or self-respect? Participatory total community sanitation in Bangladesh." IDS Working Paper 184 (Institute of Development Studies, University of Sussex, Brighton, UK, 2003).
14. D. Spears, *Effects of Rural Sanitation on Infant Mortality and Human Capital: Evidence from India's Total Sanitation Campaign* (July 2012). URL (accessed 9 April 2015): www.dartmouth.edu/~neudc2012/docs/paper_86.pdf.
15. A. Hueso, B. Bell, *Water Policy* **15**, 1001–1017 (2013).
16. S. Barnard et al., *PLOS ONE* **8**, e71438 (2013).
17. S. R. Patil et al., *PLOS Med.* **11**, e1001709 (2014).
18. S. Trémolet, "Sanitation Markets: Using economics to improve the delivery of services along the sanitation value chain," tech. rep. (SHARE, London, UK, December 2012). URL (accessed 9 April 2015): www.shareresearch.org/LocalResources/SHARE_sanitation_markets_pathfinder_Dec_2012.pdf.
19. Materials and Methods, section S1.2.
20. R. Sigler, L. Mahmoudi, J. P. Graham, *Health Promot. Int.* **30**, 16–28 (2015).
21. Materials and methods, section S1.6.
22. S. Hanchett, M. H. Khan, L. Krieger, C. Kullmann, paper presented at the 35th WEDC International conference, "The future of water sanitation and hygiene: Innovation, adaptation and engagement in a changing world," Loughborough, UK, 2011. URL (accessed 9 April 2015): http://wedc.lboro.ac.uk/resources/conference/35/Hanchett-S-1036.pdf.
23. Materials and methods, section S1.5.
24. D. Mara, J. Lane, B. Scott, D. Trouba, *PLOS Med.* **7**, e1000363 (2010).
25. Effects on ineligibles discussed in the supplementary text, section S2.2.
26. Details in tables S2 and S3.
27. Supplementary text, section S2.1.
28. Details, including effects on access, in tables S4 and S5.
29. A. Ahuja, M. Kremer, A. P. Zwane, *Annu. Rev. Resour. Econ.* **2**, 237–256 (2010).
30. P. Dupas, *Science* **345**, 1279–1281 (2014).
31. A. M. Mobarak, P. Dwivedi, R. Bailis, L. Hildemann, G. Miller, *Proc. Natl. Acad. Sci. U.S.A.* **109**, 10815–10820 (2012).
32. Supplementary text, section S2.2.
33. K. Dickinson, S. K. Pattanayak, "Open sky latrines: Do social effects influence technology adoption in the case of a (very) impure public good?" (2009). URL (accessed 9 April 2015): www.isid.ac.in/~pu/conference/dec_09_conf/Papers/SubhrenduPattanayak.pdf.
34. S. K. Pattanayak et al., *Bull. World Health Org.* **87**, 580–587 (2009).
35. A. Banerjee, A. G. Chandrasekhar, E. Duflo, M. O. Jackson, *Science* **341**, 1236498 (2013).
36. D. Spears, "How Much International Variation in Child Height Can Sanitation Explain?" Working Paper (World Bank Policy Research, 2013). URL (accessed 9 April 2015): www-wds.worldbank.org/external/default/WDSContentServer/IW3P/IB/2013/02/05/000158349_20130205082533/Rendered/PDF/wps6351.pdf.
37. T. Clasen et al., *Environ. Sci. Technol.* **46**, 3295–3303 (2012).
38. M. W. Jenkins, M. C. Freeman, P. Routray, *Int. J. Environ. Res. Public Health* **11**, 8319–8346 (2014).
39. D. Coffey, "Sanitation externalities, disease, and children's anemia," Working Paper (Princeton University, March 2014). URL (accessed 9 April 2015): http://paa2014.princeton.edu/papers/140309.
40. M. Geruso, D. Spears, "Neighborhood Sanitation and Infant Mortality," Working Paper (RICE Institute, January 2015). URL (accessed 9 April 2015): www.amse-aixmarseille.fr/sites/default/files/_evenements/muslim_v2.pdf.
41. D. Spears, S. Lamba,"Effects of Early-Life Exposure to Sanitation on Childhood Cognitive Skills" (The World Bank Sustainable Development Network Water and Sanitation Program Unit, October 2013, Working Paper 6659). URL (accessed 9 April 2015): http://elibrary.worldbank.org/doi/pdf/10.1596/1813-9450-6659

NEUROPHYSIOLOGY

Decoding motor imagery from the posterior parietal cortex of a tetraplegic human

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Nonhuman primate and human studies have suggested that populations of neurons in the posterior parietal cortex (PPC) may represent high-level aspects of action planning that can be used to control external devices as part of a brain-machine interface. However, there is no direct neuron-recording evidence that human PPC is involved in action planning, and the suitability of these signals for neuroprosthetic control has not been tested. We recorded neural population activity with arrays of microelectrodes implanted in the PPC of a tetraplegic subject. Motor imagery could be decoded from these neural populations, including imagined goals, trajectories, and types of movement. These findings indicate that the PPC of humans represents high-level, cognitive aspects of action and that the PPC can be a rich source for cognitive control signals for neural prosthetics that assist paralyzed patients.

The posterior parietal cortex (PPC) in humans and nonhuman primates (NHPs) is situated between sensory and motor cortices and is involved in high-level aspects of motor behavior (*1, 2*). Lesions to this region do not produce motor weakness or primary sensory deficits but rather more complex sensorimotor losses, including deficits in the rehearsal of movements (i.e., motor imagery) (*3–7*). The activity of PPC neurons recorded in NHPs reflects