Translating Information into Action*

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Abstract

While models of technology adoption posit learning as the basis of behavior change, information campaigns in public health frequently fail to change behavior. We design an information campaign embedding hand-hygiene edutainment within popular dramas using mobile phones, randomly distributed to households in Bangladesh. We document substantial improvements in handwashing and health, yet no change in hygiene knowledge. Guided by a framework of learning with frictions, we find evidence that recent edutainment exposure—as reminders—and cumulative exposure—by forming cue-action associations—generate behavior change, but not learning strategies that rely on assessing the actual returns to handwashing.

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1 Introduction

Canonical models of how information provision yields behavioral change rely on a connection between actions and beliefs. Specifically, behavior change is precipitated by knowledge acquisition: agents have priors over the returns to a behavior, receive new information, update their priors, and engage if returns outweigh costs. A shift in knowledge is thus a prerequisite to behavior change. It is this theory of change that motivates the profusion of information campaigns in public health.

Against this backdrop, we administer an information campaign that fails to alter explicit knowledge, yet meaningfully improves behavior and health. How does such change transpire? Our high-frequency temporal data on informational inputs and behavioral outcomes sheds light on the observed decoupling of beliefs and behavior. We examine the nature of information provision effects, leveraging a distinction between the recent and cumulative exposure to campaign messages. Guided by a model of learning with frictions, we disentangle several distinct mechanisms of how information can affect actions without affecting knowledge. Intuitively, different constrained learning strategies hinge on different temporal patterns of exposure to information. *Recent* exposure to a message can operate as a reminder that increases the salience of a specific behavior by bringing it top of mind, acting like a local, short-lived prompt to engage in that behavior or assess its current net return. The *cumulative* effect of repeated exposure, by contrast, can generate "cue-based contingent behavior" as in the classical example of Pavlov's dog.[1] By performing an action repeatedly in response to an external stimulus, one may start to implicitly associate this action with otherwise irrelevant contextual factors and become *conditioned* in a way that such contextual factors trigger the behavior even in the absence of the original stimulus.

We explore this process in the context of handwashing with soap in Bangladesh. To focus on the translation of information into action, we choose a setting in which neither the raw materials required for the act nor the social norms surrounding it are constraints: 100% of our households own soap and 99.5% rinse their hands with water before eating. Families possess some, but not complete, knowledge of proper hygiene behavior: 61% of mothers believe soap removes germs from hands, but 38% do not think that soap will make hands clean if they already appear clean. 67% of mothers volunteer handwashing as a method of preventing diarrhea, but only 2% believe handwashing can prevent colds. We therefore operate in a space where an information campaign may alter behavior either by shifting explicit priors about returns, or through the "translation function" of

[1] Pavlov's dog experiment demonstrated classical conditioning, where a dog learned to associate a neutral stimulus (a bell) with an unconditioned stimulus (food), eventually responding to the bell alone by salivating (see, e.g., McSweeney and Murphy, 2014).

beliefs into action.

Such behavior change is critical to health across the developing world. Diarrheal and respiratory illnesses from unsafe sanitation and hygiene practices kill nearly one million people each year and stunt the growth of millions more (WWAP, 2019). Relative to expensive infrastructural investments, improvements in individual hygiene involve small changes with potentially substantial returns: handwashing with soap, for example, can drastically reduce illness by interrupting the transmission of pathogens into the body (Freeman et al., 2014; McGuinness et al., 2018). While hygiene promotion has been successful in intensive and costly programs, practitioners face the challenge of identifying low cost, scalable interventions that yield sustained improvements in behavior and health. This study proposes one such program.

We design an edutainment campaign using existing public service announcements on hand hygiene. To focus on information transmission, the content is composed of simple but engaging depictions of why, when, and how to properly wash, with no celebrity appearances nor gamification. Our medium is the mobile phone, whose penetration in rural Bangladesh has grown rapidly (GSMA, 2014). Network reliability and internet accessibility remain poor, so households forego streaming and typically rely on SD cards that are preloaded with content (see Appendix Figure A1) for their entertainment needs.[2] Our intervention embeds edutainment within popular dramas and movies and distributes call-disabled smartphones with preloaded SD cards to randomly selected households in rural Bangladesh; we provide a platform for all treated households to access and view content by issuing each a simple smartphone (valued at 50 USD). We disable network capabilities to focus the intervention on the preloaded edutainment.

To measure handwashing behavior, we distribute handsoap dispensers embedded with time-stamped sensors to all households. This technological innovation addresses the serious challenges posed by standard participant observation measures of hand hygiene, making data collection unobtrusive, objective, and precise (Hussam et al., 2021; Ram et al., 2010; Biran et al., 2008) (see Appendix Figures A2 and A3 for sensor diagram and installation).

Our analysis proceeds in two steps. We first examine the effects of our intervention on child health and household handwashing behavior. We then pursue a model-guided examination of the mechanisms driving this health and behavior change.

We find that the edutainment campaign has substantial and statistically significant effects on child health. Children in treated households experience a 29.5% reduction (1.5 pp, $p = 0.02$) in symptoms of acute respiratory infection; these health improvements persist over the course of the twelve months of data collection despite an edutainment intervention which lasts only eight months. The campaign also reduces child incidence

[2] Also seen in India (Tenhunen, 2018).

of loose stool, the key symptom of diarrhea, by 56.4% (0.6 pp, $p = 0.07$) over the course of the experiment.

We then study whether these health effects of edutainment exposure are brought about by a measurable change in handwashing behavior, as proxied by the dispenser sensor data. First examining all hours of the day, we find a positive but insignificant main treatment effect of the edutainment campaign on the frequency of handwashing. However, this small average treatment effect masks substantial heterogeneity in handwashing frequency over the course of a day: our dispenser data in the control group reveal that soap use occurs primarily during mealtimes. Narrowing our estimation to these hours, we document a large and statistically significant 24.3% ($p < 0.01$) increase in the frequency of handwashing among treated households relative to their control counterparts.[3] We find no effect of the campaign on other sanitation or hygiene behaviors, suggesting that the estimated health impacts are indeed driven by these changes in hand hygiene.

We then consider the potential mechanisms underlying this behavior change. To discipline our analysis, we develop a simple model of learning with frictions. This model serves to illustrate how different psychological channels that may lead to behavior change can be framed as information acquisition strategies with varying characteristics. We disentangle four candidate mechanisms and test their explanatory power in our setting using empirical proxies for their defining features.

First, the agent may learn the *structure of returns* to handwashing. In other words, through the intervention, the agent develops an understanding of the conditions under which soap use is most beneficial – the intended purpose of an edutainment campaign. To test this information strategy, we collect detailed information about household knowledge of hand hygiene and germ theory via open-ended survey questions; we code these answers in order of the relevance given to them by respondents, allowing us to construct both an absolute knowledge index (a measure of whether households acquire any knowledge about hand hygiene or the returns to handwashing) and a relative knowledge index (a measure of how much importance households place on hand hygiene). These questions vary in level of difficulty: for example, among the control group in our endline survey, we reassuringly find that 96% of households know that colds and coughs can spread via air, while 32% believe handwashing with soap is a way to prevent someone from getting a cold or cough. However, across this set of questions, we find that the edutainment treatment induces no knowledge improvements. Treated households do not exhibit a better understanding of the benefits of handwashing, do not place more

[3]Here and in the following, we use the approximation $e^x \approx 1 + x$ for small x to interpret coefficients in Poisson regressions as percentage changes in frequency. More precisely, these coefficients represent changes in the logarithm of the frequency.

importance on it in general, and are not more likely to understand that handwashing is particularly beneficial prior to meals. Treatment effects on the knowledge indices are statistically indistinguishable from zero and fairly precise: we can reject knowledge gains greater than 4.7% with 95% confidence for both indices.

Second, the campaign may operate as a reminder, i.e, a prompt that directs attention to and thereby *brings to mind* the specific benefits of handwashing. By virtue of reminding rather than informing, this channel does not shift knowledge but rather makes existing knowledge about benefits temporarily available. Unlike the first information strategy discussed above, a reminder therefore has a "local," short-lived effect: its impact fades rapidly because the benefits of handwashing will not occupy the agent's attention for long. To test this, we exploit the detailed time-series data on exposure and behavior change to examine the relationship between recent exposure to edutainment and subsequent washing behavior. We document a positive and robust effect of recent exposure on handwashing: one additional minute of edutainment is associated with 2.2% more instances of handwashing in the hour following the viewing ($p = 0.09$). We also rule out an effect of non-recent exposure to edutainment: for example, viewing edutainment does not impact handwashing behavior two to three hours later. Nor is watching entertainment alone correlated with greater subsequent handwashing. Our results are thus consistent with the edutainment campaign serving as a reminder for the benefits of soap use. As we interpret a reminder (absent knowledge effects) as a quintessentially attentional channel, its effects vanish rapidly.

Note that we define and identify the reminder strategy as operating independently of whether the net return of handwashing is high in the moment when the reminder is received. The third information strategy we consider is a refinement of the above, in which edutainment brings to mind handwashing as a *potentially* beneficial behavior, which then induces the agent to assess its benefit in the present situation. This implies that recent exposure would only translate to greater washing in situations associated with sufficiently high returns to handwashing. Following previous work (Hussam et al., 2021), we leverage mealtimes as a proxy for the benefits of handwashing: as individuals in our setting primarily eat directly with their hands, handwashing has a higher return prior to a meal than outside of mealtime due to the increased risk of ingesting germs while eating. We find a quantitatively small and non-significant interaction between mealtime and recent exposure to edutainment. This casts doubt on our third information strategy: recent edutainment is not more potent before mealtimes, suggesting that it is unlikely to induce the agent to think concretely about the return in the moment the reminder is received.

The fourth information strategy we examine is a *cue-based contingent strategy*. Cue-based habituation emerges when a stimulus for handwashing co-occurs with other contextual factors, such as a specific time of day, another person, or a location. Over time, the repeated co-occurrence of specific contextual factors and handwashing leads people to implicitly associate these contextual factors with the action itself. This way, a contextual factor can become a cue that triggers handwashing on its own, even in the absence of the original stimulus for the behavior. This strategy has two distinctive empirical signatures: it relies on the cumulative process underlying the formation of a context-action association as well as the presence of a cue. Using data from the control group, we establish that meals may take precisely this role of a repeated contextual cue: control households are themselves most likely to use the soap dispenser around mealtimes.[4] As such, people may become conditioned to perceive meals as an independent cue for soap use. We report evidence consistent with a cue-based strategy forming over time: we document a significant and positive interaction effect between cumulative exposure to edutainment and a mealtimes indicator, with a one percent increase in exposure over the course of the experiment correlated with 0.078% more episodes of handwashing during mealtime ($p = 0.01$). Note that this relationship exists *above and beyond* the interaction of recent exposure and mealtime, which remains uncorrelated with handwashing behavior: in other words, the mealtime-washing relationship persists even in the absence of recent edutainment. The magnitude of the cue-based channel we identify in our data is large: we find that it explains 75% of the edutainment treatment effect during mealtimes. It also amounts to 33% of the 'effect' of mealtime alone – the most powerful predictor of handwashing – among the control group.

In sum, we find no evidence that individuals alter their behavior as a result of greater knowledge about the returns to handwashing, the purported intent of an information campaign. Exploiting our high-frequency data on edutainment exposure and handwashing behavior, we instead document patterns consistent with the intervention serving two purposes: a reminder of the benefits of handwashing in the moment it is received, irrespective of whether handwashing is particularly beneficial in the present moment; and a cue-based contingent strategy, in which accumulated exposure to the campaign facilitates an association between mealtime and handwashing such that mealtimes alone can operate as a cue to wash hands.

We discuss two central implications of these results. First, we discuss whether having more information strategies available (in the context of our framework of learning with frictions) can actually worsen the quality of decision-making. By empirically disentangling the frequency of potential false positives from false negatives, we illustrate that the benefit of cue-based contingent learning strategies will critically hinge on how strongly a cue is associated with actual returns to a behavior. In our setting, the behavioral cue

[4] This is unsurprising as, at baseline, 99.5% of households report that they already rinse their hands with water, making the addition of soap minimally effortful.

(mealtime) is simultaneously a powerful proxy for high net returns, which we propose is an ecological feature that is common in practice: we initially perform many health behaviors specifically in situations where we *should* perform them (i.e. those characterized by high net returns), often because an authority figure tells us to or because it is a social norm. Activating such cues to motivate related health behaviors may be welfare-enhancing. Second, we combine our results with those of Hussam and Oh (2023) to explore the external validity of cue-contingent strategies, which is determined by how temporally or locationally specific a cue is. Our mechanism analysis allows us to characterize the acquisition of potential information structures in a systematic way, clarifying that people may not only be drawn to cue-based strategies, but more generally to strategies that are *cheaper-to-acquire*.

Because only treated households can produce data on watching habits, the patterns on temporal mechanisms that we uncover are correlational. However, the placement of the edutainment (both type and order) between entertainment is both unpredictable and varied every month, limiting the role of endogenous viewer choice in information exposure. Our models also include day fixed effects to address concerns of parallel time trends or reverse causality from washing to watching. Our results are also robust to the inclusion of household fixed effects. We uncover a sensible set of patterns around exposure and the timing of washing that we hope may inform the parameters of future mechanism experiments and shape the design and implementation of information campaigns.

We view the contributions of this study as threefold. First, we document that information campaigns can generate meaningful change in behavior despite no measurable change in knowledge. In other words, our findings suggest a decoupling of knowledge and behavioral effects.[5] We present evidence for two mechanisms consistent with this decoupling: reminders and cue conditioning. Designers of behavior change campaigns may be well served to consider the various low-cost information strategies that individ-

[5] In the existing body of literature on edutainment campaigns (see DellaVigna and La Ferrara (2015) and Grady et al. (2021) for helpful reviews), few studies collect data on both beliefs and behavior. Among those that do, we describe four instructive papers: Banerjee et al. (2019) administer an edutainment campaign on HIV testing in Nigeria and document changes in knowledge and attitudes towards HIV as well as changes in STD testing rates; Bjorvatn et al. (2020) administer an entrepreneurship edutainment campaign in Tanzania and document improvements in macroeconomics knowledge, no change in business knowledge, a drop in school performance, and no accompanying improvement in business performance; Paluck and Green (2009) find that a radio program discouraging blind obedience in Rwanda has no impacts on beliefs but does manifest in greater dissent; Ravallion et al. (2015) provide an antipoverty program edutainment campaign in India and document changes in beliefs about village life but no change in objective measures of wellbeing. As is evident, the relationship between beliefs and behavior can and does vary widely. We contribute meaningfully to this literature by seeking to explicitly map the translation function of information into action: we collect extensive data on knowledge and beliefs paired with high frequency data on both information provision and action, allowing us to pursue a detailed mechanism analysis not heretofore performed, to our knowledge, in this literature.

uals engage in, rather than focusing on improving knowledge through the dispensation of facts *per se*. Reminders address attentional constraints that prevent consumers from acting on knowledge they already possess. The act of repeatedly conveying informative content to a captive audience can further serve to associate a cue with the promoted behavior (cumulative cue-action pairing), then trigger the conditioned behavior through the cue alone (mealtime in our case), resulting in increased adoption with no commensurate change in explicit knowledge.

We denote these information strategies as distinct from those relying on an explicit calculation of the net returns to a behavior, not unlike Romer (2000)'s theoretical distinction between 'feeling' and 'thinking.' Our findings are consistent with economic models of cue-based habit formation (Volpp and Loewenstein, 2020; Laibson, 2001), work in psychology as well as economics on the influence of the associative and automatic nature of "System 1" (Buyalskaya et al., 2023; Kahneman, 2012; Quinn et al., 2010; Wellsjo, 2022) in routine behaviors, and findings in neuroscience that identify the brain's 'default mode network' to serve the role of autopilot: through repeated exposure and contextual triggers, we engage in behavior with no conscious awareness of why or that we are doing so (Raichle, 2015; Vatansever et al., 2017). These findings also speak to the optimal design of information campaigns: they imply that messages should be delivered repeatedly (rather than once) and should ideally be paired with salient stimuli that can qualify as cues. Our results, however, also offer insight into why impacts of information campaigns may be short-lived: as research on cue-based learning in the cognitive sciences has repeatedly shown, cues can trigger behavior in the absence of the original stimulus, but this effect wanes over time as the stimulus-cue association is not further reinforced. As underlying priors about the returns have not shifted, neither will long-term behavior.

Second, our results on exposure recency contribute to a literature on the value of reminders, often delivered via text messages, for building healthy behaviors (e.g., Patrick et al., 2009; Koshy et al., 2008; Karlan et al., 2016).[6][7] Beyond the binary presence or absence of a reminder, our mobile phone and dispenser technology allow us to examine a broad set of potential temporal relationships between inputs (edutainment exposure) and outputs (handwashing behavior). This high-frequency time-series data on both information stimuli and subsequent behavior has not been collected or utilized, to our knowledge, in existing studies of behavior change or technology adoption, and offers a path forward to empirically constructing the translation function of information expo-

[6]Related is recent work by Bettinger et al. (2021), which finds that 'content-less' text message reminders are as effective as texts bearing informative content about a child's inputs to education. The primary channel in this context, however, remains information acquisition: content-less messages encourage parents to secure the relevant information to encourage their childrens' educational performance.

[7]While the underlying mechanism of increasing salience may be the same, text message interventions require the decision of timing to be made by the experimenter, precluding an exploration of which temporal patterns of exposure are most predictive of behavior change.

sure into action even in the absence of explicit changes in knowledge.

Third, we devise a simple and scalable intervention that manages to not only shift hygiene behavior but also generate meaningful and sustained improvements in child health. The greater part of information campaigns in the hygiene and sanitation space have been unable to produce health improvements (e.g., Biran et al., 2009; Chase and Do, 2012; Galiani et al., 2016; Null et al., 2018; Lewis et al., 2018). Bennett et al. (2018), with its innovative use of microscopes, is a notable exception in health outcomes and affordability. The few that record changes in behavior without subsequent health effects employ self-reports or observational data (such as Tidwell et al. (2019), who also document improvements in handwashing from a media campaign) with their concomitant challenges (Ram et al., 2010; Biran et al., 2008). Among handwashing promotion interventions (with or without the use of information campaigns), two recent meta-analyses (Wolf et al., 2022; Ross et al., 2023) find average impacts of handwashing interventions of 17% and 30% for ARI and diarrhea, respectively; studies with health effects of the magnitudes we document (29% and 56%) remain a small minority. With a lower bound of $6.50 USD per household for the cost of the SD card ($2 USD), dispenser ($3.50 USD), and ten months of soap ($1 USD), and an upper bound of $65 USD for the cost of the SD card, dispenser, soap, card delivery, and phone—both estimates that are likely to drop as phone and internet penetration grow and dispensers are produced domestically at scale across the developing world—the handwashing edutainment intervention we consider may be a highly cost-effective means of improving health.

Beyond hand hygiene, this work may speak to the design and dissemination of public health information campaigns for other low cost, high return, and repetitive behaviors, with particular relevance to behaviors such as water treatment and mask-wearing.

The remainder of the paper proceeds as follows. Section 2 describes the design and implementation of the experiment. Section 3 presents impacts of the intervention on media consumption, child health, and handwashing behavior. Section 4 develops a guiding framework of learning with frictions in service of a mechanism analysis. Section 5 considers alternative stories and potential confounds. Section 6 concludes.

2 Experimental Design

Our study was conducted in Gaibandha District, Bangladesh, among 333 households across 34 villages. We first identified all households who had at least one child of primary school age, access to a latrine, and a female head of household (eg. the wife of a married couple). We then screened out those households in which the female head owned a mobile phone that was used as her primary source of entertainment. Among the remaining 333 households, each one received a handsoap dispenser with a sensor embedded inside. Randomization was executed via computer, with 50% of households allocated to treatment.

Once per month, all households were visited and their dispensers were refilled. Given our limited supply of sensors, a randomly selected one-third of dispensers included sensors in any given month; in the subsequent month these sensors were extracted, data downloaded, and sensors then inserted into the next third of households, and so on over the course of eight months.

The intervention lasted from April 2017 to November 2017. During this period, enumerators collected sensor data as well as data on child health and, for treated households, self-reported entertainment exposure during their monthly visits (with the female head of household, defined as the mother of the young children, being the respondent in all surveys). Using an application preloaded onto the smartphones, enumerators also extracted data on treated households' phone watching patterns. An endline survey was conducted in April 2018. Follow-up rates vary by data type: the endline survey was completed for 99% of the sample, interim health surveys for 97% of the sample, the sensor data for 92% of the sample, and the mobile phone data for 90% of the treated sample. Although a high share of households gave some sensor and mobile phone data, in some rounds data was lost due to technical failures. Enumerators notably faced difficulties transferring data to laptops in the field, and many files were corrupted during extraction. The final dataset containing sensor data for all household and phone data for treated households contains data for 70% of all households. The sample construction is described in detail in Appendix A.5.

Because the core of our mechanism analysis requires the matched sensor-phone event data, we conduct all empirical exercises on this final sample. Table A1 demonstrates balance across treatment and control households at baseline along a host of sociodemographic, hygiene behavior, and hygiene knowledge characteristics. Table A2 confirms that our final analysis sample is representative of the full sample, with baseline observables balanced across treatment and control. Appendix A.4 repeats all main analyses on the largest available sample for each data source and finds nearly identical results.

2.1 Edutainment campaign

The edutainment campaign was delivered via a smartphone for which the phone technology had been disabled, leaving only a screen. After the baseline survey, the device was provided to treatment households with an SD card preloaded with three hours of entertainment and edutainment and a short demonstration by the enumerator on how to operate the device. No instructions were given on when to watch the media.[8]

Interspersed among the preloaded [non-informative] entertainment (an assortment of family friendly Bengali dramas, music videos, and plays), we embedded a series of ad campaigns around proper hand hygiene. These ads ranged from thirty seconds to seven minutes and were drawn from a set of publicly available material designed for both adult and child consumption.[9] Appendix Table A3 describes in detail the information conveyed in each edutainment content. Enumerators delivered SD cards with new dramas and cartoons to all treatment households monthly. These new SD cards would have a different selection of edutainment and entertainment (though some content overlapped from the previous month), with no ability for households to predict when a particular piece of content would arise in the lineup.

3 Results

We present our results in four stages. First, we examine whether the intervention reached its intended audience. Second, we estimate whether the intervention improved child health, the objective of the campaign. Third, we consider the proximate channel for health impacts: behavior change. Finally, we explore the mechanisms behind this behavior change, guided by a simple framework of learning with frictions.

3.1 Impact of edutainment campaign on media consumption

To document that our intervention reached its intended audience, we run the following regression:

$$Media_i = \alpha + \beta \; Edutainment_i + \delta \; Media_{i,baseline} + \eta_{v(i)} + \epsilon_{iv} \tag{1}$$

$Media_i$ represents a series of outcomes around media engagement for household i drawn from the endline data, namely: whether the phone is used for entertainment by the mother, whether she watches the child edutainment content (referred to as 'cartoons' in the field) on the phone, whether she watches daily, and how many minutes per day she spends engaged with the content on her phone. The mother is asked these questions first in reference to herself and then in reference to her children. $Edutainment_i$ is a

[8] We provide the device to only treatment households rather than the full sample for two reasons: first, budget constraints prevented purchasing for all households, and second, we were concerned that provision to control households would make contamination more likely, with control households borrowing the SD cards from their treated neighbors.

[9] For example, see links to the following: Meena Cartoon: `https://www.youtube.com/watch?v=1V0c4ndrW34` and Bangladesh campaign: `https://www.youtube.com/watch?v=-2e0fqX2rdU`.

dummy equal to 1 if the household was treated with the mobile phone and 0 otherwise. $Media_{i,baseline}$ is a control for baseline media outcomes, and $\eta_{v(i)}$ a village fixed-effect.

Results are presented in Table 1. Treated mothers report using a mobile device for entertainment 78.8 pp (799%, $p < 0.01$) more than control households. Treated children are 39.0 pp (68%, $p < 0.01$) more likely to employ a phone as a source of entertainment than control children and 23.0 pp (324%, $p < 0.01$) more likely to watch the device daily. All other measures exhibit comparably large effects and are significant at the one percent level.

Table 1: Entertainment and edutainment consumption

Panel A: Adults

	Watch entertainment	Watch cartoons	Watch daily	Minutes / day
Edutainment Treatment	0.788***	0.862***	0.461***	34.960***
	(0.049)	(0.042)	(0.067)	(4.754)
Mean of control	0.099	0.046	0.079	3.816
q-value	0.00	0.00	0.00	0.00
Baseline control	✓	✓	✓	✓
Village FEs	✓	✓	✓	✓
Observations	232	232	232	232

Panel B: Children

	Watch entertainment	Watch cartoons	Watch daily	Minutes / day
Edutainment Treatment	0.390***	0.747***	0.230***	16.013***
	(0.053)	(0.044)	(0.072)	(2.374)
Mean of control	0.572	0.230	0.507	19.572
q-value	0.00	0.00	0.00	0.00
Baseline control	✓	✓	✓	✓
Village FEs	✓	✓	✓	✓
Observations	232	232	232	232

Notes: Data from the endline survey with a two-week lookback period. Table restricted to the final sample. Outcome measures are as follows. *Watch entertainment:* “Is the phone used for entertainment?” and “Does the child use the phone for entertainment?”. *Watch cartoons:* “Do you watch any children’s cartoons?” and “Does the child watch any children’s cartoons?” (“Cartoons” refer to the children’s edutainment videos). *Watch daily:* “Do you use the phone daily?” and “Does the child use the phone daily?”. *Minutes / day:* “How many minutes do you watch on the phone per day?” and “How many minutes daily does the child watch the phone?”. Regressions include baseline outcome as control, as well as village fixed effects. Standard errors are robust. q-values are computed over all p-values in the Table following Anderson (2008).

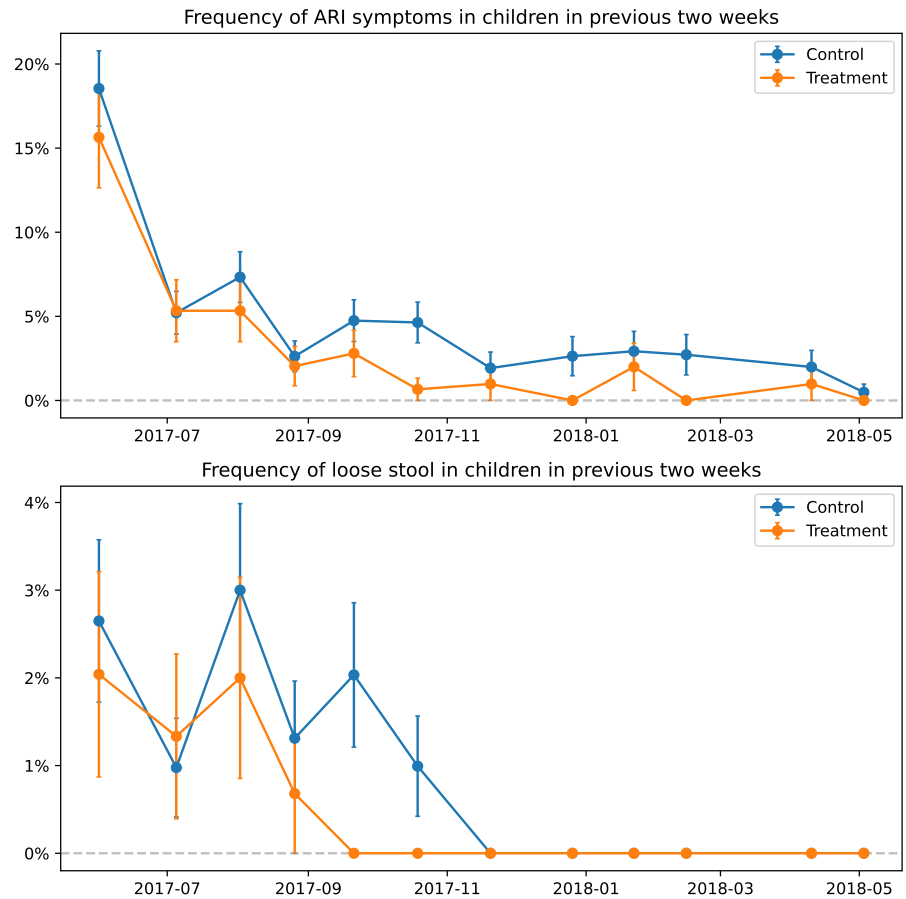
3.2 Impact of edutainment campaign on child health

Having established that the intervention reaches its intended audience, we next evaluate its downstream effect on the key outcome of interest, child health.

Figure 1 plots the temporal evolution of illness over the course of the experiment. Both treated and control households exhibit a decline in ARI symptoms over the first two months, presumably because both households have increased their handwashing rates due to the dispenser. ARI incidence remains low thereafter, with treated households notably hovering near zero during the winter months when ARI rates are typically high.

Consistent with the seasonality of water-borne diseases, rates of loose stool peak during monsoon season (June to October), during which the impact of the edutainment campaign is pronounced; rates fall rapidly thereafter, with nearly zero loose stool incidence reported for both groups in the winter.

Figure 1: Child health over time



Notes: Data from monthly child-level surveys, restricted to the final sample with sensor data for control households, and sensor & phone data for treated households.

We run the following regression using the health data obtained from our monthly surveys:

$$Health_{cit} = \alpha + \beta\ Edutainment_{it} + \gamma_t + \delta\ Health_{i,baseline} + \eta_{v(i)} + \epsilon_{civt} \quad (2)$$

$Health_{cit}$ represents child health for child c in household i in surey round t as measured by (1) the presence of any symptoms of acute respiratory infection (ARI) such as coughs, colds, or runny noses in the previous two weeks, and (2) the presence of loose stool, a proxy for diarrhea.[10] γ_t is a survey round fixed effect and $\eta_{v(i)}$ a village fixed effect. Standard errors are robust. We include all children eighteen years and below at endline to maximize statistical power, and present disaggregated results by age as well.

Results are presented in Table 2. The campaign generates a 29.5% reduction (1.5 pp, $p = 0.02$) in symptoms of ARI and a 56.4% reduction (0.6 pp, $p = 0.07$) in incidence of loose stool over the course of the experiment. If we restrict our analysis to the 6 months when control group loose stool presence is non-zero (all survey rounds after November 2017), the edutainment campaign results in a 58.3% reduction (1.1 pp, $p = 0.06$) in loose stool incidence among children in treated households.[11]

Table 2: Impact of edutainment campaign on child health

	ARI symptoms	Loose stool	(excl. null months)
Edutainment Treatment	-0.015**	-0.006*	-0.011*
	(0.007)	(0.003)	(0.006)
Mean of control	0.052	0.011	0.018
q-value	0.07	0.07	0.07
Round FEs	✓	✓	✓
Village FEs	✓	✓	✓
Observations	4490	4490	2699

Notes: Data from monthly child-level surveys for all grade-school children, restricted to the final sample with sensor data for control households, and sensor & phone data for treated households. *ARI symptoms* is a dummy equal to one if child had a cough, cold, or runny nose in the previous two weeks. *Loose stool* is a dummy equal to one one if a child had any loose stool in the previous two weeks. Column *excl. null months* repeats the analysis for *Loose stool* but drops rounds in which the incidence of loose stool among control households was 0. Regressions include survey round and village fixed effects. Standard errors are robust. q-values are computed over all p-values in the Table following Anderson (2008).

3.3 Impact of edutainment campaign on handwashing behavior

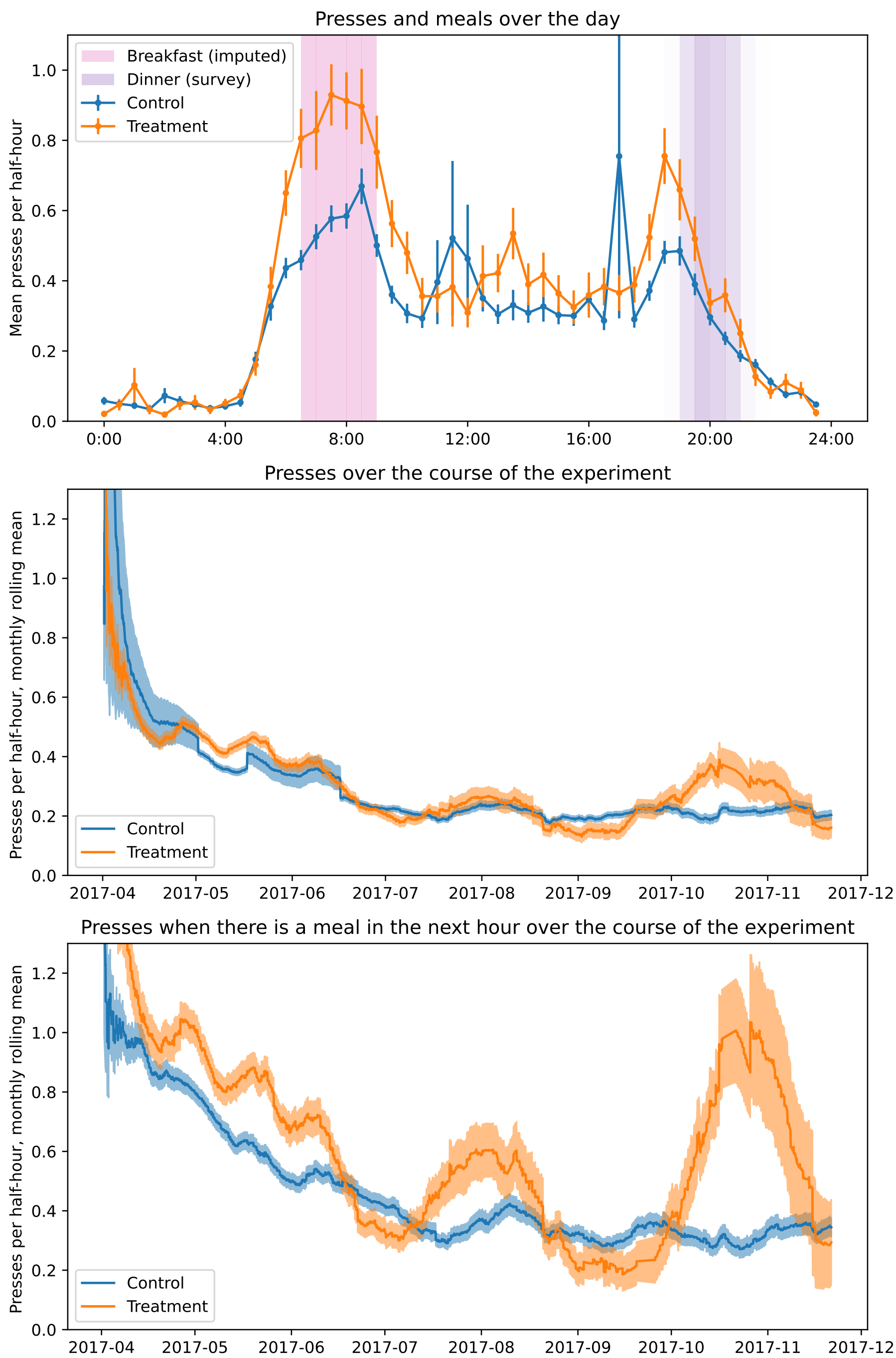
The edutainment campaign results in significant improvements in child health as measured by incidence of acute respiratory infection and loose stool. We now examine whether these health impacts are a product of a change in hand hygiene behavior.

Figure 2 depicts time trends in handwashing behavior over the course of an average day and over the course of the intervention. The top panel illustrates a set of sensible

[10]Diarrhea is defined as three or more loose motions in a day. Because mothers often do not observe every child-motion episode, we elicit any observations of loose stool. The presence of loose stool does not necessitate diarrhea, but it is the key symptom.

[11]Appendix Table A4 disaggregates effects by age; we observe no relative differences in health effects across age groups.

Figure 2: Soap dispenser presses by time of day and over the course of the experiment



Notes: Data from the final treated sample with sensor & phone data.

patterns: the bulk of handwashing occurs during typical waking/daytime hours (6AM to 10PM), with washing concentrated around the breakfast and dinner mealtimes during which families typically eat together. Spikes during mealtime are unsurprising, as nearly all households in our sample report washing their hands *with water* prior to a mealtime, suggesting that this is when handsoap may be both most effective and least effortful to use. Handwashing rates appear differentially higher in the treated group than in the control group prior to and during mealtimes and broadly similar at other times.

The subsequent two panels plot handwashing trends over the course of the experiment, across all hours of the day (middle panel) and when there is a breakfast or dinner meal in the next or current hour (bottom panel).[12] The edutainment campaign does not appear to substantially change overall handwashing rates, but it does raise them significantly around mealtimes.

To analyze the high-frequency data from our soap sensors statistically, we represent handwashing as a point process $a_{it} \in \{0, 1\}$ for household i at time t. We assume a_{it} follows a Poisson process with intensity λ_{it}. We first study the effect of the edutainment treatment via the simple model:

$$\log(\lambda_{it}) = \alpha + \beta \; Edutainment_i + \delta_{d(t)} + \eta_{v(i)} \tag{3}$$

Since occurrences of a Poisson process over a time interval follow a Poisson distribution, we estimate this model by applying a Poisson regression to sensor presses summed over half-hour windows. $d(t)$ is the day of t and $\delta_{d(t)}$ a day fixed effect, included to deal with the time trends in handwashing visible in Figure 2, while $\eta_{v(i)}$ is a village fixed effect.

Column 1 shows positive but statistically insignificant impacts of the edutainment treatment on handwashing when we examine all hours of the day: treated households wash 5.4% ($p = 0.44$) more per half hour interval than their counterparts. Column 3 demonstrates that, when we restrict to those times in which a meal is anticipated within the following hour, the campaign has large and statistically significant impacts on hand hygiene: treated households use the soap dispenser 24.3% ($p < 0.01$) more per half hour interval than their control counterparts. Columns 2 and 4 repeat these analyses using a linear regression and find qualitatively similar results. Appendix Table A5 replicates

[12]We define these times as follows: for dinner time, we ask respondents directly for the typical hour slot when their family has dinner; this is a fairly stable time for most families during which all members come together, and we follow Hussam et al. (2022) in this practice. For breakfast time, we impute the time using the control group handwashing frequencies over the course of the experiment, identifying the peak hour of handwashing in the morning as breakfast time. We then append one hour prior to both mealtimes in order to account for handwashing done in preparation for a meal, again in line with Hussam et al. (2022). Lunchtime is irregular (usually between 12-3pm) and rarely includes all members of the household; as is evident from the figure, there is no peak during this period for control households, which makes it challenging to impute. We therefore exclude this from our main specifications, though a treatment effect is visually evident during this period as well.

this table at a per-household-member level and also finds qualitatively similar results.

Table 3: Effect of treatment on number of presses per half-hour

	All times		Meal in next hour	
	(1)	(2)	(3)	(4)
Treatment	0.054	0.028	0.243***	0.163***
	(0.070)	(0.020)	(0.047)	(0.031)
Observations	351913	351913	75879	76130
q-value	0.44	0.22	0.00	0.00
Day FEs	✓	✓	✓	✓
Village FEs	✓	✓	✓	✓
Regression	Poisson	OLS	Poisson	OLS

Notes: Data from the final sample with sensor data for control households, sensor & phone data for treated households. *Meal in the next hour* includes mealtimes and the preceding hour. Dinner times are identified by household from the rolling survey, breakfast times are imputed uniformly. Regressions include day and village fixed effects. Standard errors are robust. q-values are computed over all p-values in the Table following Anderson (2008).

Our analysis underscores the importance of collecting high-frequency behavioral data, particularly for behaviors that require time-specific repetition in order to be effective (a feature shared by many preventative health behaviors, from treating water to wearing masks); in the absence of this data, we may have concluded that the campaign yielded health improvements with no corresponding changes in behavior. Our high-frequency data captures significant heterogeneity in handwashing patterns over the course of the average day, enabling a clearer understanding of when the campaign may be most effective in altering behavior and health.

4 Mechanisms

Having determined that the edutainment campaign improves both child health and household hand hygiene, we now explore possible mechanisms underlying this behavior change. In Section 4.1, we propose a simple guiding framework that allows us to characterize the empirical signatures of different potential channels in a disciplined manner.[13] In Section 4.2, we present our findings for the corresponding empirical tests.

[13]We thank the editor for very helpful suggestions.

4.1 Conceptual framework: learning with frictions

The objective of this framework is to illustrate, in a concrete and parsimonious way, different avenues through which information may be translated into action. We adopt a canonical rational inattention setup, in which the action of agent i to use soap in moment t, $a_{it} \in \{0,1\}$, has a cost c and a return $r_{it} = R(\theta_{it})$, where R is a function that maps a state θ_{it} to returns. The state θ_{it} encodes relevant environmental factors that determine the returns to handwashing. This set of potentially relevant factors is multi-faceted. To discipline our analysis, we will follow insights from previous work (e.g., Hussam et al., 2022) and focus on food intake as a primary determinant of handwashing returns. Because most individuals in this context eat directly with their hands, handwashing prior to food intake is likely to have direct benefits to health.

The agent seeks to make an optimal decision about whether to handwash or not based on a form of cost-benefit calculation.[14] This cost-benefit calculation is constrained by the fact that determining the rewards of handwashing is subject to cognitive costs associated with acquiring that knowledge. Specifically, an information structure $I \in \mathscr{I}$ is a signal $x_{it} \in X$ correlated with the state θ_{it} and associated returns r_{it} according to some conditional distribution $p_I(x|\theta) \in \Delta(X)$. Given an information structure, the optimal contingent strategy $\alpha^* : X \to \{0,1\}$ of the decision maker solves:

$$\max_{\alpha:X\to\{0,1\}} \mathbb{E}_{x,r}\left[\alpha(x) \times (r-c)\right] \tag{4}$$

Given the signals that the decision maker has *learned to pay attention to*, they seek to optimally correlate taking the costly action with its returns. Conditional on a realized signal x, the optimal action is:

$$\alpha^*(x) = \mathbb{1}_{\mathbb{E}[r|x]>c} \tag{5}$$

Each available information structure I is associated with some cognitive acquisition cost $K(I)$ that we discuss below. For the present application, we distinguish the following set of information strategies.

I_1 **Knowledge effects: learning the structure of returns to handwashing.** A first information strategy corresponds to directly observing the determinant state of handwashing returns: $x_{it} = \theta_{it}$. This means the agent develops a correct, explicit understanding of when soap is most beneficial and can act on it. We take a broad perspective on such knowledge effects: the agent may acquire a deep structural understanding of the benefits of handwashing, e.g. the theory of germs, or a more superficial understanding of

[14] Such a cost-benefit analysis need not involve deliberate reasoning on the part of the agent. In fact, we will argue and confirm empirically that at least a part of the corresponding considerations may best be characterized as occurring implicitly.

some of the associated states during which returns should be high, such as mealtimes, without deeply parsing the underlying rationale. Importantly, we suggest that acquiring I_1 would imply some form of *persistence*: once knowledge is acquired, it can be reliably recalled for some time when prompted. To empirically identify this information strategy, we therefore assume that it has persistent effects on measurable beliefs about either the average benefit of handwashing or the specific states associated with higher returns of handwashing.

I_2 **Reminder: attentional hint to benefits of handwashing.** We model a reminder of the benefits of handwashing as a noisy signal that its imminent returns are high and, more specifically, outweigh its costs, $x_{it} = \mathbb{1}_{r_{it}+\varepsilon_{it}>c}$, with ε_{it} a zero-mean noise term. More precisely, the edutainment campaign may act as a prompt that directs attention to—and thus brings to mind—the benefits of handwashing. The underlying psychological mechanism is that not all of the knowledge we accumulate over time is permanently top of mind; rather, certain pieces of information get selectively retrieved through contextual prompts (e.g. Rogers and Milkman, 2016). Selectively making the benefits or the costs of some behavior available through reminders will thus affect our assessment of its benefits while the reminder operates. By virtue of *reminding* (rather than informing) the agent, this signal neither shifts knowledge about the general usefulness of handwashing nor does it change the agent's understanding about the states under which returns are generally high. Instead, it makes existing knowledge about the benefits of handwashing salient, leading the agent to assess the returns of handwashing more positively *as long as the reminder operates*. So unlike I_1, I_2 has a "local" effect: it puts the benefits of handwashing top of mind, but its impact fades rapidly because the benefits of handwashing will not occupy the agent's attention for long.[15] To empirically identify this information strategy, we assume that it does not shift explicit beliefs about the returns to handwashing and that its effect occurs *in close temporal proximity* after an episode of edutainment exposure.

I_3 **Prompt to assess current return of handwashing.** This is a dynamic two-step information acquisition strategy that is related in spirit to I_2: first, the agent first receives an attentional prompt that brings to mind handwashing as a possibly beneficial behavior. We model this prompt as first receiving a noisy indicator of handwashing benefits, $x_{it} = \mathbb{1}_{r_{it}+\varepsilon_{it}>c}$, akin to I_2. If $x_{it} = 1$, handwashing is top of mind, which then, in a second step, motivates the agent to *determine* whether the current net return of handwashing

[15]Note that a narrow interpretation of a reminder implies that the agent was already aware, to some extent, of the benefits of handwashing, but merely did not have them top of mind prior to the reminder. This is plausible in our setting, where, for example, 61% of respondents already believe at baseline that soap removes germs from hands.

is actually positive. This generates a second "signal" of the actual present net return, $\tilde{x}_{it} = \mathbb{1}_{r_{it}>c}$. This signal, unlike x_{it}, is noise-less. Intuitively, the prompt directs attention to handwashing as a potentially beneficial behavior, which induces the agent to assess the net benefit in the present situation. To empirically identify this information strategy, we note that, like I_2, it is temporally tagged to the recent exposure of an edutainment episode that serves as the attentional prompt. Unlike I_2, however, I_3 predicts actual effects on handwashing only in situations when the net returns are actually high. Thus, the combination of recent edutainment exposure with the presence of a high return context is the signature of this strategy.

I_4 **Cue-based contingent strategy.** Under this information structure, the agent observes an ancillary signal x^0_{it} that is positively correlated to $\mathbb{1}_{r_{it}>c}$. Intuitively, the mechanism underlying a cue-based contingent strategy operates as follows. The starting point is that some stimulus induces the agent to wash hands repeatedly over time. These acts of handwashing naturally co-occur with other contextual factors: in all of or many of the handwashing instances, some other feature of the environment is also present, such as a specific time of day, another person, a scent, or a location. Over time, the repeated co-occurrence of specific contextual factors and handwashing leads the agent to implicitly associate these contextual factors with the action itself. This way, a contextual factor can become a cue that triggers handwashing on its own, even in the absence of the original stimulus for the behavior. This information strategy relates to *classical conditioning* (see, e.g. McSweeney and Murphy, 2014). As in the famous example of Pavlov's dog, the otherwise irrelevant contextual cue of a bell is repeatedly paired with a food reward, which leads to the ensuing behavior of salivating. Over time, the dog learns to associate the bell with food and starts to salivate upon the ring of the bell even in the absence of any food reward. The implication for I_4 is, hence, that this information strategy fundamentally *forms over time* due to a repeated coupling of handwashing with some contextual factor. To empirically identify this information strategy, note that one first needs to identify a stimulus that repeatedly triggers the target behavior. Second, one needs to identify a contextual factor, the occurrence of which is strongly correlated with the action. This way, the cumulative exposure to the stimulus coupled with the contextual cue can generate conditioning over time.

Optimization problem. With each information strategy associated with different returns as laid out above, the agent solves the two-stage problem:

$$\max_{I \in \mathscr{I}} \max_{\alpha : X \to \{0,1\}} \mathbb{E}_{x,r}[\alpha(x) \times (r - c)] - K(I) \tag{6}$$

Acquiring an information strategy in this context may be thought of as learning a heuristic to solve a contingent choice problem. In theory, not only the return profile but also the associated cost of acquiring a specific information strategy, $K(I)$, will determine the agent's optimal solution to the problem. In the rational inattention literature, the cost of information structures are typically thought to increase with their precision. While it is infeasible to conclusively identify the cost structure of different information strategies in the field, we conjecture that strategies involving the assessment of actual net returns exceed the cost of those that do not: $K(I_1), K(I_3) > K(I_2), K(I_4)$.[16] One remark about this approach is in order. We abstain from further specifying the cost structure and do not claim that the information strategies we explore are exhaustive. Instead, we employ this framework as a device to illustrate which behavioral channels should be associated with which empirical signatures. This should allow the reader to somewhat independently assess which behavioral explanations are more or less likely at play in the data.

Empirical strategy. Our framework illustrates several margins of differentiation between the information strategies, each of which we connect to an empirical analog. Concretely, as discussed for the individual strategies, they differ in (i) their relation to shifts in explicit knowledge about handwashing, (ii) their dependence on recent versus cumulative exposure to the handwashing stimulus, and (iii) their relation to the net return of handwashing on average versus in the present moment. In our mechanism analyses below, we exploit precisely these margins.

These differences between information strategies also generate different implications for the prevalence of false positives and false negatives with respect to stimulus exposure and returns to handwashing. A false positive describes a situation where handwashing occurs when a stimulus (e.g., a reminder or a cue) is present, but net returns to washing are in fact negative. Conversely, a false negative describes a situation where handwashing does not occur despite high returns simply because a given stimulus is not present. Concretely, reminders (I_2) and cues (I_4) are consistent with *both* false negatives and false positives. By contrast, an attentional prompt to assess the current net return (I_3) does not create false positives. The presence or absence of these two types of errors may provide further insights into which information strategies treated households in our experiment adopt.

[16] In highly controlled laboratory settings, a recent empirical literature on rational inattention attempts to identify the shape of cognitive cost functions for specific tasks (see, e.g., Caplin et al., 2020).

4.2 Mechanism analyses

4.2.1 Testing knowledge effects

We begin by testing whether the program shifted the knowledge of treated households, our first proposed information strategy and ostensibly the central channel through which an edutainment intervention should alter behavior. At baseline and endline, we ask respondents a series of questions regarding their knowledge of hand hygiene, described in detail in Appendix Figure A4: if and why soap is useful, if and how it differs from washing only with water, and what actions can prevent colds and diarrhea. We designed this knowledge module with two features in mind. First, respondents are asked open-ended questions, rather than being presented with answer choices, in an effort to eliminate anchoring or leading effects and elicit only the knowledge content that the respondent believes to be relevant. Second, we allow respondents to rank up to four answers per question. We do this in order to gauge not only whether the respondent possesses the information imparted by the edutainment campaign, but additionally how pertinent or important she believes it to be.

For example, consider the following question: *"What are some ways in which you can keep from getting a cough or cold?"* A respondent may answer by first reflecting that dressing warmly is important (as 63% of edutainment treated respondents give as their first answer), then suggesting that one should regularly change their clothes (as 33% say as their second answer), then mentioning that washing one's hands can help too (as 10% offer as their third). We score each question not by what is technically correct, but by whether or not the information that is imparted in the edutainment programs (in this case, that handwashing can prevent coughs or colds) appears in the response.

We employ two methods for scoring each question: First, an absolute knowledge metric, in which we consider whether the information exists at all in the respondent's answers. In the case of the question above, the respondent would receive a score of 1, given that she mentioned that washing hands can prevent colds in one of her answer slots. Second, a relative knowledge metric, in which we estimate how much weight the respondent places on this answer, with the first slot receiving a weight of 1, the second a weight of 0.75, and so on, resulting in a score of 0.5 for the respondent in the question above. This method allows us to gauge relative magnitudes of, in this case, the expected returns to handwashing: while most individuals may know that washing hands can reduce vulnerability to colds and coughs, the treated respondent should have learned from the edutainment content that this is among the most effective prophylactics available.

We analyze knowledge effects using the regression:

$$Knowledge_i = \alpha + \beta\ Edutainment_i + \gamma\ Knowledge_{i,baseline} + \eta_{v(i)} + \epsilon_i \qquad (7)$$

We apply this analysis to each knowledge question, as well as to an inverse covariance weighted index of all questions (Anderson, 2008) and a simple average of the same for ease of interpretation. Results are presented in Table 4. Panel A estimates the impact of the edutainment treatment on absolute knowledge. Treated respondents exhibit a 0.079 SD higher knowledge index than their control counterparts, statistically indistinguishable from zero. This is equivalent to a 0.8% improvement in the knowledge index, again statistically indistinguishable from zero. We can reject any gains in knowledge greater than 4.7% with 95% confidence.

Panel B examines relative knowledge, or the relevance individuals give to the key content of the edutainment program within their answers. We observe a similarly precise zero impact: treated respondents exhibit a 0.028 SD lower score than their control counterparts, statistically indistinguishable from zero. The raw average index reports a 0.4% improvement in knowledge, again statistically indistinguishable from zero. We can reject any gains in knowledge greater than 4.5% with 95% confidence.

Result 1. *The treatment does not significantly shift knowledge about the benefits of handwashing.*

We interpret Result 1 as evidence against I_1. Despite the purported intent of the edutainment campaign, we find no indication that the campaign altered behavior by improving treated households' knowledge about the returns to handwashing. What, then, generates the documented change in behavior?

4.2.2 Testing the role of reminders, attentional prompts, and cues

Building on the lack of empirical support for information strategy I_1, we now provide empirical evidence that aims to disentangle I_2, I_3 and I_4. Our approach relies on two core assumptions.

First, we follow previous work (Hussam et al., 2022) and assume that handwashing has a higher return prior to a meal than outside of mealtimes due to the increased risk of ingesting germs while eating. Accordingly, a measure of household mealtimes will serve as our preferred proxy of high returns to handwashing. Moreover, we assume and empirically confirm that the marginal cost of handwashing is lower before a meal. Baseline data reveals that 99.5% of households routinely rinse with water prior to meals in any case, suggesting that the additional use of soap may require comparably little additional effort.

Second, we exploit the dynamic nature of how information structures are acquired in our analysis. Specifically, reminders about the benefits of handwashing (I_2) and prompts to think about handwashing (I_3) operate in isolated instances. Even the very first reminder an agent experiences can have an effect, but its individual impact of bringing

Table 4: Hand hygiene knowledge

Panel A: Absolute knowledge

	ICW	Avg.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Edutainment Treatment	0.077	0.008	-0.004	0.036**	-0.051	0.015	0.024	0.061	-0.016	0.000
	(0.114)	(0.015)	(0.064)	(0.016)	(0.057)	(0.054)	(0.019)	(0.043)	(0.035)	(0.000)
Mean of control	0.000	0.801	0.586	0.961	0.322	0.796	0.967	0.868	0.908	1.000
q-value	0.93	0.93	1.00	0.23	0.92	0.97	0.71	0.71	0.93	1.00
Baseline control	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Village FEs	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Observations	232	232	232	232	232	232	232	232	232	232

Panel B: Relative knowledge

	ICW	Avg.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Edutainment Treatment	-0.023	0.004	-0.014	0.034*	-0.036	0.019	-0.013	0.048	-0.067	0.063
	(0.128)	(0.016)	(0.058)	(0.018)	(0.040)	(0.034)	(0.025)	(0.033)	(0.057)	(0.039)
Mean of control	0.000	0.806	0.498	0.951	0.207	0.408	0.683	0.602	1.155	1.946
q-value	0.86	0.86	0.86	0.48	0.75	0.86	0.86	0.48	0.61	0.48
Baseline control	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Village FEs	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Observations	232	232	232	232	232	232	232	232	232	232

Notes: Data from the endline survey, restricted to the final sample. *ICW* represents an inverse-covariance-weighted index (Anderson, 2008) and *Avg.* a simple average of the knowledge questions in Columns 1-8. Regressions include baseline outcome as control, as well as village fixed effects. Standard errors are robust. *q*-values are computed over all *p*-values in the Table following Anderson (2008). Questions are open-ended, with multiple answers in up to flour slots. In Panel A, respondents receive points for mentioning the correct answer. In Panel B, respondents receive points weighted by the order in which they mentioned the correct answer. Outcome measures are as follows. (1) “What do you think causes your child to have a cough or cold?” Respondent scores a 1 if they say that one can catch a cough or cold from other children or by touching germs, and a 0 otherwise (e.g., from cold weather, playing in water). (2) “Can the cold or cough spread from one person to another? If so, how?” Respondent scores a 1 if they say that sneezing or coughing can cause colds to spread, and a 0 otherwise (e.g., from food allergies, thrashing rice, it cannot spread). (3) “What are some ways in which you can keep a cough or cold from happening in the first place?” Respondent scores a 1 if they say that such illness can be prevented by washing one’s hands, and a 0 otherwise (e.g., dress warmly, put oil on body, eat healthy food). (4) “What do you think causes diarrhea?” Respondent scores a 1 if they say that dirty hands can cause diarrhea, and a 0 otherwise (e.g., something in the water, something in the food). (5) “What are some ways in which you can keep you or your child from getting diarrhea in the first place?” Respondent scores a 1 if they say that diarrhea can be prevented by washing one’s hands, and a 0 otherwise (e.g., don’t eat too much). (6) “What do you think is the difference between washing your hands with water only and washing your hands with soap and water? Perhaps there is no difference?” Respondent scores a 1 if they say that hands are cleaner when washed with soap, and a 0 otherwise (e.g., No difference, hands smell different or look clean). (7) “In what way does [soap] make your hands cleaner?” Respondent scores a 1 if they say that it removes germs or ’worms’ (another word for germs) from hands, and a 0 otherwise (e.g., removes dust). (8) “When do you think it’s most important to wash your hands with soap?” Respondent scores a 1 if they answer before cooking, before eating, or after using the bathroom, and a 0 otherwise (e.g., never, after eating or after returning from outside).

to mind handwashing is transient and short-lived. By contrast, a cue-action association (I_4) is formed through repeated cue-action pairings that an agent experiences over time. Correspondingly, an *accumulation* process underlies the acquisition of this latter information strategy.

The subsequent exercises rely on a unique dataset we are able to assemble in this experiment: high-frequency, minute-level data on behavioral *inputs* (media exposure, via an application within the mobile phones that tracks media consumption) and behavioral *outputs* (handwashing behavior, via the sensors inside the handsoap dispensers that time-stamp dispenser use). As Figure 2 depicts the minute-level data we have on handwashing behavior, Appendix Figure A5 depicts the parallel data we have for media consumption. Patterns are again sensible: watching happens primarily during waking hours, with bunching around mealtime (especially dinnertime). Interestingly, while consumption of entertainment wanes over the course of the experiment, consumption of edutainment appears low but fairly stable throughout the eight months.

Effect of recent exposure (I_2). To investigate the patterns and correlates of handwashing, we augment the Poisson regression model in Equation (3) with covariates related to mealtimes and edutainment exposure. Each observation again corresponds to a household during a half-hour window, with the outcome being the number of presses registered on the dispenser sensor. Results are reported in Table 5.

Column 1 reports a Poisson regression of the number of soap dispenser presses on a treatment indicator, an indicator for whether a meal occurred within the subsequent 60 minutes, and an interaction of the two. This column qualitatively replicates our baseline findings from Table 3.[17] In the control group, handwashing already occurs more frequently in these periods, likely because people are already rinsing their hands with water prior to mealtime. These hours are also when we observe a strongly significant treatment effect on handwashing (as first reported in Section 3). On average, the treatment leads to 29.6% ($p < 0.01$) more handwashing in the hour preceding and during a meal.

The empirically distinguishing feature of the reminder-based strategy is that it triggers handwashing in the specific moments when its benefits are brought to top of mind, i.e. immediately after exposure to an edutainment episode and independent of whether the reminder occurs during a high return moment (e.g., mealtime) or not. In Column 2, we include a measure of recent exposure to edutainment using the number of minutes of edutainment consumed in the household in the preceding hour. We find that one additional minute of edutainment is associated with approximately 2.2% ($p < 0.09$) more

[17] Recall that we define "Meal in next hour" as the hour of breakfast or dinner time and the preceding hour of each.

Table 5: Effect of treatment, meals and edutainment on presses per half-hour

	(1)	(2)	(3)	(4)
Meal in next hour	0.675***	0.675***	0.675***	0.675***
	(0.065)	(0.065)	(0.065)	(0.065)
Treatment	-0.063	-0.066	-0.068	0.046
	(0.093)	(0.093)	(0.093)	(0.183)
Treatment × Meal in next hour	0.296***	0.292***	0.297***	0.094
	(0.087)	(0.087)	(0.088)	(0.131)
Recent edutainment (min in prev. hour)		0.022*	0.039**	0.043**
		(0.013)	(0.019)	(0.019)
Recent edutainment (min in prev. hour) × Meal in next hour			-0.025	-0.033
			(0.024)	(0.025)
Cumulative edutainment (log min)				-0.044
				(0.042)
Cumulative edutainment (log min) × Meal in next hour				0.078**
				(0.031)
Observations	351913	351913	351913	351913
Day FEs	✓	✓	✓	✓
Village FEs	✓	✓	✓	✓
Regression	Poisson	Poisson	Poisson	Poisson

Notes: Data from the final sample with sensor data for control households and sensor & phone data for treated households. *Meal in the next hour* includes mealtimes and the preceding hour. *Recent edutainment* is the number of minutes of edutainment watched in the preceding hour. *Cumulative edutainment* is the logarithm of 1 plus the number of minutes of edutainment watched since the beginning of the experiment. Regressions include day and village fixed effects. Standard errors are robust.

instances of handwashing in the subsequent half-hour interval.[18]

Appendix A.1 reports robustness analyses. Table A7 confirms that the effects of phone-watching are driven by edutainment rather than entertainment consumption. Table A8 shows that non-recent, one-time exposure to edutainment in the second and third hour preceding a given half hour is not correlated with greater handwashing, consistent with the conjecture that one-time exposure has a short-lived effect.

In the context of our framework, we interpret the highly transient effect of an isolated, recent instance of edutainment exposure coupled with the absence of knowledge effects as consistent with a reminder mechanism, I_2. Intuitively, the campaign message increases the salience of the benefits of handwashing. Because the reminder (absent knowledge effects) is a quintessentially attentional channel, its effect vanishes rapidly.

Result 2. *Edutainment consumption has an immediate effect on handwashing that vanishes quickly, consistent with serving the role of a reminder.*

Effect of exposure preceding a meal (I_3). We now exploit the special role of mealtimes for handwashing. Using mealtimes as a proxy for high returns to handwashing, we test whether recent exposure to edutainment is more effective prior to a meal. This is a direct test of strategy I_3: does a prompt to think about handwashing induce the agent to assess its returns in the present moment, realizing that it is high in particular when a meal is imminent?[19] In Column 3 of Table 5, we report a quantitatively small and non-significant interaction between mealtime and recent exposure to edutainment, while the main coefficient for recent exposure remains statistically significant and its magnitude undiminished. This casts doubt on the relevance of I_3: while we find compelling evidence for current edutainment exposure acting as a local reminder, these reminders do not appear to be more potent before mealtimes, suggesting that the agent does not use them to think concretely about the return in the moment the reminder is received.

Result 3. *The immediate effect of edutainment consumption is not stronger before meals, suggesting it does not act as a prompt to assess the current net returns of handwashing.*

[18]In Appendix Table A6, we also report the results of this regression with "*log* minutes of edutainment in preceding hour" for consistency with "log minutes of cumulative edutainment exposure," discussed further in the subsequent section on information strategy I_4. In this case, the interpretation of the coefficient is that 1% greater edutainment exposure is associated with a statistically significant 0.156-0.288% increase in handwashing rates in the following hour.

[19]Note that, technically, we are testing a joint hypothesis: that the reminder induces the agent to think about current returns, and that the agent then manages to assess that mealtime is a proxy of return. Not knowing that mealtimes are related to returns alone would break this relationship even if the reminder is a prompt to think of current returns. However, we note that the edutainment messages specifically address the benefit of handwashing before mealtimes, making it unlikely that, in the very moment of receiving the reminder, the agent fails to internalize that mealtimes are related to returns.

Effect of cumulative exposure and cues (I_4). We now analyze the features of a cue-based contingent strategy. Recall that this strategy is formed when an action is repeatedly performed in the presence of some contextual cue, even if this contextual cue is not the original stimulus of the behavior. This strategy can thus be identified using two distinctive features: the cumulative process underlying the formation of a context-action association and the presence of a cue.

First, we construct an empirical measure of cumulative exposure as the logarithm of one plus the total number of minutes of edutainment consumption to date.[20] Second, given that the range of potential contextual cues is manifold, how do we identify a potentially relevant cue in this setting? The cue should represent an environment where the agent is particularly likely to perform a certain behavior when triggered by the external stimulus. Indeed, the temporal patterns of handwashing among the control group suggest that mealtimes may take precisely this role of a repeated contextual cue. Intuitively, the observation that mealtimes are highly predictive of handwashing even in the absence of any treatment intervention (Table 5, Column 1) suggests that meals are a potentially strong environmental correlate of handwashing: whenever people do use soap, it is likely to occur prior to a meal, because they tend to rinse their hands in any case. This means that before meals, many people are already at the margin of handwashing. Our Result 2, which finds that recent edutainment is correlated with greater handwashing, suggests that edutainment can serve to activate, or strengthen, this association between mealtime and handwashing, thereby differentially spurring greater handwashing among treated households who have repeatedly watched the edutainment. As such, people may become conditioned to perceive meals as an independent cue for handwashing.[21] This scenario is analogous to Pavlov's dog, in which food leads a dog to salivate, but repeated exposure to food in the environment of a bell ringing ultimately results in a bell ring leading to salivating. In our setting, recent edutainment exposure leads to handwashing; repeated exposure to edutainment in the environment of mealtime, when it is already most common, may result in mealtime leading to handwashing, even in the absence of recent edutainment exposure.

In Column 4, we add to the regression a measure of cumulative edutainment exposure as well as its interaction with mealtimes. Note that the specific pattern consistent

[20]Working with this transformation is a standard procedure in the literature, e.g. to measure the effect of political ads on voting and knowledge (Freedman and Goldstein, 1999; Ridout et al., 2004; Stevens, 2008). Using the logarithmic (instead of linear) functional form implies that the marginal impact of additional edutainment consumption accumulated over time, while positive, declines with each additional unit of exposure. The log transformation also compresses extremes, ideal for a cumulative measure in which outliers appear given the many observations over many days. As discussed above, while we prefer not to log transform the recent edutainment covariate since observations are few and outliers not a concern, we present the log transform version in Appendix Table A6. Results remain robust.

[21]We discuss the dual role of mealtime as both a signal of high returns and a cue at the end of this subsection, arguing that it is a natural, common and important feature in practice.

with a cue-based strategy I_4 would be a positive interaction effect, whereas there is no prediction about the remaining effect of cumulative edutainment exposure (outside of mealtimes).[22] Column 4 shows that a 1% increase in cumulative exposure increases the number of presses by 0.078% ($p = 0.01$) when there is a meal in the next hour, while there is no significant effect of cumulative exposure *per se*. Reassuringly, Appendix Table A9 demonstrates that our results are robust to the inclusion of household fixed effects.

These results provide evidence in favor of a cue-based contingent strategy that relies on a connection between the key features of context-action associations that previous work has identified: a cue formation period that relies on repeated exposure (our measure of cumulative edutainment exposure), a potent cue that frequently co-occurs with the stimulus leading to the target behavior in the formation period (mealtimes have this precise feature, as shown by patterns in the control group), and a mechanism (edutainment) that occurs without explicit knowledge about the returns to handwashing in the presence of the cue (as suggested by the absence of knowledge effects). Note further that, unlike the reminder-based strategies I_2 and I_3, the cue-based strategy leads to handwashing *even without any recent exposure* to edutainment: only cumulative exposure and the presence of the cue are associated with greater handwashing.[23]

Result 4. *Cumulative exposure to edutainment increases the likelihood of washing hands before a meal. Given the absence of knowledge effects, this result is consistent with a cue-based contingent information strategy, where a meal acts as a cue.*

Benchmarking effects How important is a reminder or a cue-based strategy relative to other predictors of handwashing? We find that a single recent instance of edutainment exposure has a statistically significant but small impact on handwashing: one extra minute of edutainment in a given hour generates 2.2% more handwashing in the subsequent half-hour. The average household is exposed to approximately 1 minute of edutainment per five hours per day, implying that the "reminder" can explain approximately 0.2% greater handwashing among treated households in a given half hour. We benchmark this against an imminent mealtime, which is correlated with 67.5% more

[22]This is because, outside of the mealtime cue, individuals may experience other cues that we are not capturing that may generate greater handwashing with more exposure to the edutainment. We only test one potential cue, which is mealtime.

[23]The absence of an interaction between recent exposure and mealtimes is exactly consistent with a context-action association being formed: because handwashing is already more frequent before meals, a higher potency of reminders before meals is not required. Put differently, for the association to form in the treatment group, an exogenous push is required that leads to more handwashing, but it is not necessary for this external stimulus to have a *differential* effect when the cue occurs. Mealtime is already associated with greater handwashing as seen in the control group (Row 1 of Table 5); as such, recent edutainment need not differentially raise handwashing rates during mealtime. Edutainment exposure only needs to activate handwashing.

handwashing in a given half-hour. In other words, the effect of the reminder itself appears, while statistically significant, quantitatively small.

However, the accumulation of these reminders over time, when attached to a relevant cue, appears to be consequential. To provide a sense of the magnitude, consider that average log cumulative exposure to edutainment among treated households across all periods is 2.86, implying that the total effect explained by cumulative exposure during mealtimes is approximately $0.078 * 2.86 = 0.223$. Note that the *Treatment * Meal* effect in Column (3) of Table 5 is 0.297, and this diminishes to a statistically insignificant 0.094 upon the inclusion of cumulative edutainment exposure in Column (4). In other words, *Cumulative edutainment * Meal* explains $0.223/0.297 = 75\%$ of the treatment effect during mealtimes. This also amounts to $0.223/0.675 = 33\%$ of the 'effect' that mealtime alone has on handwashing in control households, which is quite substantial.

We note that, in the empirical translation of our theoretical framework above, we employ mealtime in two ways: first, to proxy for a high-return context for handwashing, and second, as an environmental cue that can trigger washing. We view this dual role as a feature of our context that is representative of many real-world applications, as discussed further in the following section. Our empirical context and data allow us to explicitly test whether our engagement in these behaviors is a matter of habit, triggered by a contextual cue, or a matter of explicitly evaluating at every instance whether the behavior has positive net returns. While not mutually exclusive, our evidence suggests that in our context, individuals are not engaged in the latter constrained learning strategy, but instead act through a process of associative memory.

4.3 Discussion

Our mechanism evidence points against two information strategies: a knowledge-based strategy (I_1) and a strategy in which the edutainment serves as a prompt to induce agents to assess the current net return (I_3). On the other hand, we document patterns that are consistent with both a reminder-based information strategy (I_2) and a cue-based contingent strategy (I_4). We consider two implications of these findings.

Can having more information strategies available worsen the quality of decision-making? Our guiding framework assumes that subjects optimize in picking their contingent heuristic. This means, however, that information strategies may be picked because they are associated with lower costs, rather than because they induce better (health) decisions. While (constrained) optimal from the individual's perspective, a policymaker may care more about the quality of resulting behavior—namely, the amount and timing of handwashing.

Although difficult to pin down conclusively in the field, we approximate that the cost of acquiring the two information strategies that require an assessment of actual net returns exceeds the cost of the other two: $K(I_1), K(I_3) > K(I_2), K(I_4)$. Under this interpretation, our findings would imply that people's behaviors are indeed shaped by the *cheaper* information strategies. We note that I_1 and I_3 can never lead to handwashing in an instance where it is not associated with a positive net return. In contrast, both lower-cost strategies—I_2 and I_4—come at the cost of failing to induce handwashing in some instances where it would be beneficial (for example, after defecation or before food preparation) and potentially inducing handwashing in other instances where its net returns are comparably low or even negative. Notably, in the context of this study, given that mealtimes serve both as a cue *and* a high-return moment for washing, agents who rely on I_4 (cue-based contingent strategy) may be less likely to wash at unnecessary times, while those who rely on I_2 (reminder strategy) may still do so.

We return to our data to directly consider implications for the quality of decision-making and the prevalence of different types of "mistakes," or false positives and false negatives, in our context. Underlying the following analysis is the – arguably strong – assumption that mealtimes can serve as a binary proxy for whether the net returns to handwashing are positive. Put differently, to identify false positives, we will assume that handwashing outside of mealtimes is undesirable.

Under this definition, Appendix Figure A6 plots the prevalence of false positives and negatives for the case of recent exposure to edutainment. It depicts the likelihood of handwashing in any given half-hour episode, split by whether edutainment was consumed in the previous 60 minutes as well as whether a meal was imminent in the subsequent 60 minutes. In the context of our model, these data shed light on the nature of reminders: we distinguish between strategy I_2, an unconditional effect of a recent reminder, i.e. a reminder that triggers handwashing independent of the current actual net return, and I_3, a strategy in which prompting handwashing induces the agent to evaluate the present return and only wash if the net return is positive, i.e. before mealtimes. Central to this analysis is that I_3 does *not* predict false positives: specifically, it predicts that the reminder has no effect outside of mealtimes.

The two left bars shed light on the prevalence of false positives by comparing handwashing frequency between people who were recently exposed to edutainment versus not, in situations where *no meal ensued*. We document a large and statistically significant difference in the likelihood of handwashing, more than doubling from 3.9% to 8.7% ($p < 0.01$). This suggests that edutainment is also effective in moments when handwashing is not actually beneficial (as proxied by mealtimes), evidence against I_3 but consistent with I_2.

By contrast, both I_2 and I_4 can generate false negatives, i.e. the absence of handwashing when no edutainment is consumed in situations where it is actually beneficial, i.e. mealtime. Indeed, the two right-hand bars point to a statistically significant increase in handwashing associated with recent edutainment provision in situations where *meals are imminent*, from 9.5% to 12.7% ($p = 0.01$). Jointly, we document evidence for both false positives and false negatives associated with recent edutainment exposure and mealtimes, corroborating the evidence of the preceding regression analysis which remained consistent with I_2 but not I_3.[24]

What, then, are the welfare implications of having available to us information strategies beyond explicit learning? The central insight gained from our mechanism analyses is that whether and how beneficial a cue-based contingent strategy is will hinge on how strongly the cue is associated with actual returns. Is the cue a good proxy for the net benefit of the action, or is it unrelated to it (or even misleading, implying a negative relationship)? In our setting, we suggest that the cue and returns are in fact strongly aligned. Indeed, we use mealtime as the central proxy for both. This is unlikely to be an idiosyncratic feature of our setting: rather, we propose that it is a common feature in practice. The reason is that a behavioral stimulus (in our case, edutainment) will most frequently co-occur with the desired behavior (handwashing) precisely in those situations where the behavior is already common. Those situations are likely to be those where net returns are comparably high (mealtimes). Thus, the environmental factors that qualify as cues (such as mealtime) are at the same time correlated with high net returns. Note that this is an integral feature of how conditioning naturally emerges in practice that differs from classical experiments on cue condition: in the case of Pavlov's dog, the experimenter introduces and controls the unrelated environmental cue (the bell), whereas in our field setting, we capitalize on the existing association between mealtime and handwashing.

From turning away from a person when sneezing, to fastening our seat-belts when we sit in the driver's seat, to exercising in the morning, to washing our hands before mealtime, all share this dual feature: we initially perform them specifically in situations where we *should* perform them, i.e. those characterized by high net returns (often because someone else instructs us to do so, not necessarily because we deeply understand their benefits). Over time and repetition, we form cue-action associations in these high-net-return contexts that lead us to take the action automatically in the presence of a contextual cue.[25] In general, developing these associations may be an adaptive evolu-

[24]The caveat to this analysis is that net returns of handwashing outside of mealtimes may not actually be negative. However, our data also shed light on whether this concern undermines our conclusion regarding the different information strategies. Specifically, we note that the effect associated with recent edutainment provision is, if anything, *larger* in the absence of an imminent meal than before a mealtime. This means that edutainment is associated with stronger effects on handwashing when false negatives might occur. This comparative static finding clearly points against the prediction of I_3.

[25]Successful behavior change programs are therefore often aimed at the intensive rather than the

tionary strategy. However, this strategy may fail or even lead to welfare loss in settings where the cue lacks "external validity," in the sense that it is only valid in a limited set of circumstances, or where the environment changes over time such that the cue becomes less predictive of net returns. We now consider one such setting.

The external validity of cue-contingent strategies. In a separate field experiment in rural Bangladesh, Hussam and Oh (2023) consider whether behavior change transcends geographic contexts. In a subset of elementary schools, the authors manipulate handwashing rates by randomizing, at the classroom level, the administration of the same edutainment campaign studied in the present paper. In a randomized subset of schoolchildren's homes, the authors exogenously manipulate handwashing rates by distributing handsoap dispensers, randomly varying the proportion of students per classroom who have a dispenser installed in their home. Hussam and Oh (2023) then study both school-to-home and home-to-school transmission using these interventions, finding that more handwashing at school *reduces* handwashing at home and more handwashing at home in turn reduces handwashing at school. The paper then examines the specific patterns underlying such negative behavioral transmission in both directions.

First, the authors find evidence of crowding out: handwashing at home is significantly lower among students exposed to edutainment at school, but only in the hours of the day following school. They then consider how this daily crowding out may evolve into cue-based habit formation: a signature of this channel would be that, in the same way that the "cue" of the school environment raises handwashing rates for those exposed to edutainment at school, the "cue" of the home environment will be associated with reduced handwashing (by way of the crowd-out); this should then manifest even on days when children *do not* have school. The paper tests and confirms a negative treatment effect for children exposed to edutainment not only after school, but also on weekends and holidays. Notably, in contrast to the present paper which documents large improvements in health, edutainment-exposed children in Hussam and Oh (2023) exhibit no, and potentially negative, health impacts. In other words, the authors identify a setting in which an apparently successful school behavior-change campaign results in zero (or potentially negative) welfare impacts because the school-environment cue is not generalizable to other sites, such as the home, in which handwashing may have high returns.

Both Hussam and Oh (2023) and the present paper suggest that, because cues are temporally and/or locationally specific, they may lead to specific actions in situations where they are not beneficial and fail to trigger desired actions in cases where they would be beneficial. Reliance on this information strategy has distinct welfare implications depending on how highly correlated one's cue is to the net returns of the action.

extensive margin: we seek to increase the frequency of a desired behavior, not move from zero to one.

The present paper further allows us to characterize the features of individuals' acquired information strategies in a more disciplined manner: we find that individuals may not only be drawn to cue-based strategies, for which we find micro-evidence on cumulative exposure to stimuli, but more generally to potentially cheaper-to-acquire strategies that compromise on the accuracy of any individual stimulus to wash hands, as shown by our evidence on local reminders. At the same time, our data allow for direct evidence that alternative strategies that deliver more precise behavior, but are likely costlier, are less likely to be employed.

Implications for the design of information interventions. The evidence above highlights the role of attention, over knowledge, in the translation of information into action. We discuss two potential implications for the design of information interventions more broadly.

First, the *repetition of stimuli* plays a critical role. Because messages are less likely to shift knowledge (or retrieve knowledge in relevant situations), their impact may be confined to a local effect on the audience's attention. This suggests that repeated messaging that merely redirects attention may be more effective than one-time messaging that conveys substantial information. Note also that the repetition of stimuli is required for the development of cue-action associations that evolve over time, leading to the next implication.

Our findings point to the importance of *embedding stimuli in the audience's attention environment*. To the extent that a message only operates transiently through an attentional channel, it should be delivered at times and in places where the desired behavior is likely to actually occur. In the context of handwashing, this may be before mealtimes or after defecation. This both increases the likelihood of triggering the behavior in the moment and, in turn, supporting the formation of cue-action associations. A perhaps even more powerful implication is that effective campaign messaging should aim to co-occur with environmental factors that qualify as "advantageous cues." The benefits of a potential cue for behavioral outcomes are informed by two factors, which we refer to as internal and external validity. Internal validity means that the occurrence of the cue is strongly associated with instances of the target behavior when returns are high in the training context. In other words, the cue should be present when a person performs the desired behavior *and* returns to the behavior are high. The cue should be absent when returns are low or the behavior is not performed.[26] External validity means that the cue "extrapolates well" beyond the training context. Ideally, a cue is also strongly associated

[26]Note that a cue that is only associated with high returns, but not actual behavior, is ineffective, since cue-contingent behavior relies on *cue-action* associations. There may be some high-return situations in which people never or rarely take the action, due to high costs or other barriers.

with high returns in settings beyond the training environment or that the decision-maker has not experienced before.

5 Robustness

5.1 Potential confounds for behavior impacts

In the remainder of the paper, we return to our main results, in which we find significant impacts of the edutainment campaign on handwashing behavior and health with no commensurate change in knowledge, and consider potential confounds.

We first explore alternative channels beyond the edutainment itself through which a change in handwashing behavior may have transpired.

1. TV as an incentive to wash: Perhaps parents use the phone entertainment as a means of incentivizing, or bribing, their children to wash their hands: "You can only watch TV if you go wash your hands after." In order to use the entertainment as an incentive, however, this channel requires that parents first recognize the value of proper hand hygiene. Our null effect on hygiene knowledge suggests that such conscious knowledge acquisition is unlikely. Alternatively, parents may already possess sufficient knowledge of the importance of hand hygiene and simply need a proper bribing instrument, which arrives with the experiment in the form of the phone entertainment. Two pieces of evidence suggest this is not the case. First, recent exposure to entertainment, rather than edutainment alone, should then be predictive of handwashing; Appendix Table A7 demonstrates that only edutainment is predictive of greater handwashing. Second, effect sizes should be smaller in households where the 'carrot' of phone entertainment already existed at baseline. Appendix Table A10 presents the impacts of the intervention on handwashing behavior for the subsample of households who report at baseline that their children already use mobile phones for entertainment (27% of the sample, approximately balanced between treatment and control). We find that the magnitude of the treatment effect persists and is in fact stronger (with a 52% increase in daily handwashing, and a 74% increase in mealtime handwashing). These effect sizes among those families who already possess a bribing instrument suggests that such a strategy is unlikely to be a primary mechanism in the effects we estimate.

Notably, because we examine households who already utilize a phone for entertainment purposes, this subsample exercise further underscores that the *edutainment* content of the intervention, rather than the phone or entertainment provision, is the plausible driver behind the intervention's impacts on handwashing and health.

Finally, we note that being granted television time as a reward for washing is precluded by our structural exercise, in which we find that *lags* in watching are predictive of washing.

2. A change in children's beliefs: Several of the edutainment pieces were designed for children, but we do not directly measure childrens' hygiene knowledge and beliefs. It may thus be possible that the edutainment indeed altered child beliefs, which then translated into increased handwashing. Because our dispenser data cannot identify the user, we cannot rule this channel out. However, we can exploit variation in the presence of a child in the home to observe whether parents' behavior was affected by the edutainment. Specifically, we zoom into the subsample of households (61%) in which all children were of school-age (six years and above). We then restrict our data to school days only (weekdays). We compare the handwashing behavior of this subsample with the subsample of households (37%) which include at least one child below the age of six.

Appendix Figure A7 plots the average hourly handwashing rate for each subsample over the course of a day. We highlight the plausible lunchtime hours of 12-2pm. On weekdays, any handwashing treatment effect in households with only school-age children can be reliably attributed to *adults* in the household, since all children are away at school during these hours (typically returning home between 2-4pm). As is evident in a comparison of treatment effects between those households with only adults at home and those who also have children at home, those with only adults exhibit arguably *larger* treatment effects on handwashing. As such, while we cannot rule out that children's beliefs did change along with their behavior, we can conclude with some certainty that parents' beliefs did *not* change while their behavior did.

3. Experimenter demand:

Knowledge Did edutainment treated respondents alter their responses to the knowledge questions in order to please the enumerators? This would require that they mention hand hygiene or germ theory, the key dimensions along which the experiment intervened, differentially more than control households. We document a null effect of the intervention on such responses in the knowledge module.

Behavior Did edutainment treated respondents utilize the handsoap dispenser more to reciprocate enumerators for their generosity? Recall that all participants, control and treatment alike, received handsoap dispensers and soap and were informed of their value. It is plausible that such a gift would generate reciprocal behavior in the form of using the gift, but this should be equally true across treated and control households. Increased handwashing as reciprocal behavior for the phone and media content (our treatment) is less plausible: this would require treated households to explicitly recognize that the purpose of the media intervention was to improve handwashing *and* wish to please enumerators by acting on this awareness, two channels that the null impact on hygiene knowledge suggests did not transpire. The patterns we uncover around recency and cue-based behavior are likewise inconsistent with experimenter demand.

4. Potential spillovers: Might control households have had exposure to the edutainment content from their treated neighbors? Anecdotal evidence from our conversations in the field suggest that this is almost certainly true: many control households we visited several months after the intervention reported having enjoyed watching the dramas and cartoons with their neighbors in the evenings. While we lack the statistical power to perform a nearest-neighbor analysis of spillovers, such spillovers would suggest that the impacts we find on behavior and health are underestimates of the true impact of the program.

5. Features of edutainment content: Finally, we consider whether specific features of the media content may have precipitated behavior change.

Visual role models Perhaps viewers of the edutainment encountered role models to emulate (Chong and La Ferrara, 2009; Bernard et al., 2019). The edutainment content we provided included no celebrity actors nor high-status roles (with adult characters playing village housewives and children's characters in the form of cartoons and puppets in schools and villages), so it is unlikely that viewers internalized prestige-related returns to handwashing. However, it is certainly possible that viewers found these characters fun and appealing and thus wished to mimic their behavior.

Engaging content Relatedly, while simple, the content was likely to be engaging in other ways: the children's edutainment cartoons had songs and bright colors, and 56% of parents reported that these cartoons were their children's favorite piece of media content; similarly, 46% of adults reported one of the edutainment pieces to be their own favorite piece of media content provided.

We cannot rule out the possible role of these features in catalyzing behavior change, nor do we seek to: they may in fact be the operative mechanisms behind our results. Interesting content with appealing characters and storylines is likely essential to the behavior change we document and underpins the central argument of this paper: the provision of information, and subsequent explicit knowledge acquisition, is not the driving mechanism for behavior change in our context of preventive health behavior adoption, despite being the central intent of the educational intervention. Rather, an association between watching the media and the hand hygiene behaviors enacted, likely strengthened through engaging content, compels behavior change. We leave a dissection of precisely what features of the content maximize engagement to future work.

5.2 Potential confounds for health impacts

We now consider alternative channels through which the edutainment campaign may have produced improvements in health.

1. Change in other behaviors: Our results point to the direct impact of an edutainment program on child health. Can these health improvements be attributed to better hand hygiene alone, or might the intervention have precipitated other hygiene and sanitation improvements among exposed households? Table A11 estimates the impact of the campaign on water treatment practices, open defecation, and construction of a sanitary latrine by endline, and finds no effect on any other margin.[27]

2. Time away from peers: Perhaps the time children spend watching media substitutes away from time spent playing with children, an activity located further away from handsoap dispensers (potentially less washing) and more prone to germ transmission (poorer health). While plausible, treated children watch 36 minutes of phone media daily, relative to 20 minutes among control children. While nearly a doubling of the control mean, the magnitude of the difference is small relative to the total time children are likely to be exposed to their peers each day: 87% of our sample attends pre-school or school for at least four hours per day, after which they return home and are likely to play outside until sundown. The remainder are likely to spend their entire day playing outside in the dirt and local ponds with neighborhood children, as is typical in this environment. While we cannot rule this channel out definitively, we suspect that a 16 minute reduction in exposure to peers during a full day of engagement is unlikely to drive the large health effects we document.

3. Experimenter demand: Did edutainment treated respondents wish to appear healthier to impress enumerators? While we cannot rule this out, the seasonality we document in both health levels and treatment effects suggests this is not the case (described further in Section 3.2): households report health statuses in a manner consistent with expected

[27]Notably, while the edutainment programs stressed the importance of using sanitary latrines (rather than open defecating), all households in our sample already owned sanitary latrines at baseline, and less than 1% reported practicing open defecation, leaving no room to move on either of these behaviors.

variation in the incidence of respiratory and water-borne illnesses over the course of the year. Alternatively, perhaps the edutainment intervention made health more salient to treated households. Salience, however, should lead to increased parental attention to child health, resulting in a heightened awareness and reporting of children's coughs, colds, and loose stool, the opposite of the impacts we document.

4. Asynchronicity of behavior and health effects: We document treatment effects on health twelve months after the onset of the experiment despite treatment effects on behavior fluctuating throughout the data collection period. While not an explicit confound, this asymmetry in temporal effects may be puzzling if health improvements are a direct result of recent improvements in hand hygiene.

While we cannot offer a definitive link, we suspect that the proximate cause of sustained and longer term health effects is physiological, not behavioral. Specifically, our result is consistent with existing empirical evidence on the long term health consequences of early childhood illness (Bowen et al., 2012; Lorntz et al., 2006; Patrick et al., 2005; Berkman et al., 2002) and the physiological pathways through which pathogen exposure may affect a child's body. Diarrhea and ARI weaken an immune system, making the body vulnerable to further ARI or diarrhea from pathogen infection, while a strengthened immune system may ingest the same quantity of pathogens but not suffer from either illness. Bowen et al. (2012) find that a nine-month handwashing intervention, which significantly reduces diarrhea and acute respiratory infection in the short run, results in marginally lower diarrhea rates two years after the intervention (with no parallel difference in the purchase or use of hand soap, their behavioral measure) (Luby et al., 2006) and substantially higher child development indices five years after the intervention (Luby et al., 2009). Hussam et al. (2022) also find large and significant health impacts of a handwashing intervention – the distribution of the sensored hand-soap dispensers – eight months after it concludes, which is long after treated groups' soap dispenser use has fallen *below* the self-reported mean handwashing rate of control households. While not conclusive on its own (since the control group may have over-reported handwashing), the results are consistent with the findings of this experiment and the limited existing work on the long-term health effects of temporary reductions in children's pathogen exposure.[28]

[28]Note also that our first round of health data commences in June of 2017, at which point the handwashing rates of treated and control households have already largely converged. This makes it impossible to observe whether health effects were larger during the time when behavior effects were significant, a result we may expect. We can only confirm that *subsequent* health effects remain persistent once behavior converged between the two treatment arms. Note also that dispenser use can only tell us about the quantity and frequency of handwashing, not the quality of each handwash. Edutainment treated households may have been more likely to wash carefully or at other critical moments like after defecating, raising the health impacts of each handwashing episode. We collect no data on these features, as they would require

6 Conclusion

Using sensors in handsoap dispensers, this study finds that a simple hand hygiene edutainment campaign, viewed amidst popular dramas via SD cards in mobile phones, yields significant improvements in both handwashing behavior and health with no commensurate improvement in knowledge.

Our results raise questions about a common framing of knowledge acquisition. In classical models of technology and behavior adoption, consumers are Bayesian updaters who learn about the returns to a behavior, update beliefs, and alter their behavior accordingly. Related policy recommendations of subsidizing experimentation or information provision assume a conscious acquisition of knowledge. However, knowledge change does not guarantee behavior change, a fact that comes to bear in study after study of information campaigns which document improvements in self-reported hygiene awareness with no corresponding change in behavior or health. The results of this study suggest that the reverse may also be true: behavior change does not require a change in explicit knowledge. The value of an edutainment campaign, when embedded into an everyday activity such as watching television, may be not to educate, but rather to serve as a visual reminder of, and over time habituate oneself to, an activity. In other words, campaigns may be more impactful as tools to remind and condition individuals to – rather than consciously shift priors around the returns of – an activity. A promising avenue for future work is to investigate the role of the *medium* of an information campaign: some formats, such as pictures and videos or stimuli delivered within specific physical contexts, might be systematically more potent in creating cue-action associations than others (such as mere text). Other formats not studied in this paper, such as those involving interaction with the audience through discussion and open dialogue, may be more powerful in generating knowledge effects.

Our study suggests that behavior change programs must consider not merely the provision of information, but also the means by which such information is delivered, to be effective. And importantly, impact evaluations that estimate improvements in knowledge as well as behavior may be misattributing the latter to the former. As we find here, behavior may change regardless of the state of one's explicit beliefs, so evaluations that ignore the timing, frequency, and context by which information interventions are presented may be missing the central mechanism behind the behavior change they document.

self-reports or enumerator observations that would likely be highly susceptible to experimenter demand effects.

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A Online Appendix

A.1 Tables

Table A1: Descriptives and balance

		Control	Edutainment treatment	*p*-value	*N*
Household and mother	Number of rooms	1.69	1.74	0.57	333
	Age at marriage	16.11	16.12	0.95	333
	Education	0.83	0.77	0.17	333
	Eat fish or meat every day	0.57	0.61	0.46	333
Hygiene practice	Drinking water is filtered	0.02	0.01	0.42	333
	Open defecates	0.01	0.02	0.41	333
	Owns a latrine	0.97	0.98	0.74	333
	Own soap	1.00	1.00	1.00	333
	Soap cost	73.11	71.75	0.62	333
	Number of times washes hands with soap	4.48	4.40	0.79	333
	Washes hands before eating	0.99	1.00	0.18	333
	Washes hands with soap before eating	0.45	0.46	0.86	333
	Washes hands with soap before cooking	0.51	0.52	0.71	333
	Child washes hands with soap before eating	0.46	0.45	0.76	333
	Washes hands with soap after defecation	0.16	0.16	1.00	332
	Washes hands with soap after urination	0.50	0.52	0.61	333
Hygiene knowledge	Can get cold from germs	0.17	0.17	0.90	333
	Handwashing with soap can prevent cold	0.02	0.03	0.47	333
	Handwashing with soap can prevent diarrhea	0.65	0.69	0.51	333
	Soap makes hands clean even when they look clean	0.77	0.81	0.37	333
	Soap removes germs	0.63	0.58	0.35	333
Entertainment practice	Watches mobile phone for entertainment	0.22	0.16	0.13	333
	Minutes watched mobile phone for entertainment	7.13	5.66	0.34	333
	Child watches mobile phone for entertainment	0.29	0.34	0.39	333
	Minutes child watched mobile phone for entertainment	10.78	13.34	0.26	333
Children $\leq$5y	Any ARI symptoms in last two weeks	0.23	0.20	0.56	172
	Any loose stool in last two weeks	0.01	0.02	0.63	172
	Child height (cm)	81.23	79.70	0.70	172
	Age (months)	37.52	39.07	0.62	172
	Male	0.56	0.57	0.84	172

Notes: Table reports the means, *p*-value and number of observations in a comparison between treated and control groups using data from the baseline survey.

Table A2: Test for differential attrition in followup data

		Monthly survey		Endline survey		Phone/sensor sample	
		N	p-value	N	p-value	N	p-value
Household and mother	Number of rooms	323	0.45	331	0.59	233	0.90
	Age at marriage	323	0.83	331	0.88	233	0.88
	Education	323	0.20	331	0.19	233	0.03
	Eat fish or meat every day	323	0.27	331	0.38	233	0.57
Hygiene practice	Drinking water is filtered	323	0.46	331	0.42	233	0.94
	Open defecates	323	0.36	331	0.40	233	0.23
	Owns a latrine	323	0.82	331	0.76	233	0.87
	Own soap	323	1.00	331	1.00	233	1.00
	Soap cost	323	0.78	331	0.58	233	0.24
	Number of times washes hands with soap	323	0.78	331	0.79	233	0.20
	Washes hands before eating	323	0.19	331	0.18	233	0.33
	Washes hands with soap before eating	323	0.92	331	0.87	233	0.87
	Washes hands with soap before cooking	323	0.97	331	0.79	233	0.78
	Child washes hands with soap before eating	323	0.76	331	0.67	233	0.75
	Washes hands with soap after defecation	322	1.00	330	1.00	232	1.00
	Washes hands with soap after urination	323	0.54	331	0.71	233	0.64
Hygiene knowledge	Can get cold from germs	323	0.99	331	0.83	233	0.39
	Handwashing with soap can prevent cold	323	0.64	331	0.46	233	0.23
	Handwashing with soap can prevent diarrhea	323	0.53	331	0.48	233	0.81
	Soap makes hands clean even when they look clean	323	0.37	331	0.32	233	0.64
	Soap removes germs	323	0.41	331	0.36	233	0.16
Entertainment practice	Watches mobile phone for entertainment	323	0.12	331	0.15	233	0.10
	Minutes watched mobile phone for entertainment	323	0.32	331	0.36	233	0.23
	Child watches mobile phone for entertainment	323	0.44	331	0.35	233	0.70
	Minutes child watched mobile phone for entertainment	323	0.25	331	0.23	233	0.80
Children $\leq$5y	Any ARI symptoms in last two weeks	167	0.44	170	0.61	113	0.48
	Any loose stool in last two weeks	167	0.60	170	0.62	113	0.67
	Child height (cm)	167	0.62	170	0.81	113	0.57
	Age (months)	167	0.77	170	0.53	113	0.98
	Male	167	0.85	170	0.94	113	0.80

Notes: Table reports the p-values and numbers of observations in a comparison of means between treated and control groups for the subsamples followed up in each specified data source, using data from the baseline survey. *Phone/sensor sample* is the final sample with sensor data for control households and sensor & phone data for treated households.

Table A3: Sample of run-time and edutainment content on an SD card

Video	Genre	Time	Minutes	Features of edutainment
Introductory Message	Animated Video Clip	00:00:00 - 00:02:00	2.00	
Hand washing, Bangladesh 3, IYS International Year of Sanitation [YouTube]	Cartoon	00:02:00 - 00:03:50	1.83	Cartoon characters of various illnesses (typhoid, jaundice, diarrhea, etc.) discussing their fear of people who wash their hands. A woman acting as a community health worker demonstrates the proper way to wash hands, surrounded by observing children. Cartoon characters discuss how washing hands will eliminate germs and commiserate over their impending doom.
Maya Kanna	Bangla Natok	00:03:50 - 00:40:00	37.17	
Meena and Mithu on Toilets in Schools [YouTube]	Cartoon	00:40:00 - 00:40:21	0.35	Cartoon character Meena and her little bird Mithu describe how their schools have toilets for boys and girls so that no one need open defecate.
Tumi amai korte sukhi jibone: Salman Shah	Bangla Movie Song	00:40:21 - 00:40:25	3.93	
Prem Nogorer	Bangla Movie Song	00:40:25 - 00:45:40	5.17	
Kutta chor	Bangla Natok	00:45:40 - 01:20:04	34.35	
Meena's three wishes Part 1 [YouTube]	Cartoon	01:20:04 - 01:28:59	8.95	Cartoon character Meena dreams of meeting a genie who will grant her three wishes. They observe that all the children in their village are sick. They see a child defecating in a river, and people bathing in the same river and drinking the river water. Meena's wishes are (1) everyone have access to a sanitary latrine; (2) everyone uses clean water from a tubewell; and (3) everyone washes their hands with soap. The video demonstrates washing with hands during food preparation and after defecation.
Meena's three wishes Part 2 [YouTube]	Cartoon	01:28:59 - 01:38:23	9.40	Meena wakes from her dream. She now knows how to help her community. Her family builds a sanitary latrine and helps others do the same. She then encourages her family and friends to use clean water from a tubewell for drinking and washing. She then realizes that, even if people use latrines and clean water, illnesses will continue unless people wash their hands. She teaches her friends to wash their hands after defecating and before touching food.
ICDDRB Video [YouTube]	Drama Edutainment	01:38:23 - 01:44:23	6.00	Actors depicting a family in Bangladesh, with each person feeling ill. Mother pours water without washing her hands. Son uses the bathroom and then joins for lunch without washing his hands. Doctor in clinic offers advice: every day we are exposed to germs that, if they enter our bodies, can make us ill. One way to prevent these illnesses is by washing hands with soap regularly, especially before eating or feeding children. Doing so will improve your own health, your children's health and schoolwork, and the general well-being of your household. Video ends showing a happy, healthy, successful family.

Table A4: Impact of edutainment campaign on child health by age

Panel A: Children aged 5 and under

	ARI symptoms	Loose stool	(excl. null months)
Edutainment Treatment	-0.017	-0.018	-0.028
	(0.026)	(0.016)	(0.025)
Mean of control	0.084	0.024	0.038
q-value	0.51	0.40	0.40
Round FEs	✓	✓	✓
Village FEs	✓	✓	✓
Observations	662	662	411

Panel B: Children aged 6 to 12

	ARI symptoms	Loose stool	(excl. null months)
Edutainment Treatment	-0.022**	-0.007	-0.012
	(0.011)	(0.004)	(0.007)
Mean of control	0.061	0.012	0.020
q-value	0.11	0.11	0.11
Round FEs	✓	✓	✓
Village FEs	✓	✓	✓
Observations	1921	1921	1122

Panel C: Children aged 12 to 18

	ARI symptoms	Loose stool	(excl. null months)
Edutainment Treatment	-0.013**	-0.005	-0.008
	(0.007)	(0.004)	(0.007)
Mean of control	0.031	0.006	0.010
q-value	0.12	0.26	0.26
Round FEs	✓	✓	✓
Village FEs	✓	✓	✓
Observations	1907	1907	1166

Notes: This Table replicates Table 2 separately for children aged 0-5, 6-11 and 12-18.

Table A5: Effect of treatment on presses per household member per half-hour

	All times		Meal in next hour	
	(1)	(2)	(3)	(4)
Treatment	0.080	0.009**	0.268***	0.044***
	(0.064)	(0.004)	(0.049)	(0.008)
Observations	350061	350061	75512	75763
q-value	0.21	0.03	0.00	0.00
Day FEs	✓	✓	✓	✓
Village FEs	✓	✓	✓	✓
Regression	Poisson	OLS	Poisson	OLS

Notes: See notes for Table 3. Presses per member is the number of pressed divided by the total number of household members, identified from the endline survey.

Table A6: Effect of edutainment and entertainment on presses per half-hour

	(1)	(2)	(3)	(4)
Meal in next hour	0.675***	0.675***	0.675***	0.675***
	(0.065)	(0.065)	(0.065)	(0.065)
Treatment	-0.063	-0.068	-0.073	0.044
	(0.093)	(0.093)	(0.094)	(0.183)
Treatment × Meal in next hour	0.296***	0.288***	0.299***	0.095
	(0.087)	(0.087)	(0.088)	(0.131)
Recent edutainment (log min in prev. hour)		0.156**	0.266***	0.288***
		(0.061)	(0.086)	(0.087)
Recent edutainment (log min in prev. hour) × Meal in next hour			-0.176	-0.215*
			(0.118)	(0.119)
Cumulative edutainment (log min)				-0.045
				(0.042)
Cumulative edutainment (log min) × Meal in next hour				0.078**
				(0.031)
Observations	351913	351913	351913	351913
Day FEs	✓	✓	✓	✓
Village FEs	✓	✓	✓	✓
Regression	Poisson	Poisson	Poisson	Poisson

Notes: See notes for Table 5. *Recent entertainment* is the logarithm of 1 plus the number of minutes of edutainment watched in the preceding hour.

Table A7: Effect of edutainment and entertainment on presses per half-hour

	(1)	(2)	(3)
Meal in next hour	0.675***	0.675***	0.675***
	(0.065)	(0.065)	(0.065)
Treatment	-0.068	-0.067	-0.069
	(0.093)	(0.093)	(0.093)
Treatment × Meal in next hour	0.297***	0.303***	0.302***
	(0.088)	(0.088)	(0.088)
Recent edutainment (min in prev. hour)	0.039**		0.035*
	(0.019)		(0.021)
Recent edutainment (min in prev. hour) × Meal in next hour	-0.025		-0.016
	(0.024)		(0.026)
Recent entertainment (min in prev. hour)		0.007	0.004
		(0.006)	(0.007)
Recent entertainment (min in prev. hour) × Meal in next hour		-0.011	-0.010
		(0.010)	(0.011)
Observations	351913	351913	351913
Day FEs	✓	✓	✓
Village FEs	✓	✓	✓
Regression	Poisson	Poisson	Poisson

Notes: See notes for Table 5. *Recent entertainment* is the number of minutes of edutainment watched in the preceding hour.

Table A8: Effect of non-recent edutainment on presses per half-hour

	(1)	(2)	(3)	(4)
Meal in next hour	0.675***	0.675***	0.675***	0.675***
	(0.065)	(0.065)	(0.065)	(0.065)
Treatment	-0.066	-0.065	-0.064	-0.067
	(0.093)	(0.093)	(0.093)	(0.093)
Treatment × Meal in next hour	0.292***	0.296***	0.297***	0.292***
	(0.087)	(0.087)	(0.087)	(0.087)
Recent edutainment (min in prev. hour)	0.022*			0.021
	(0.013)			(0.013)
Recent edutainment (min in prev. hours 1 to 2)		0.013		0.009
		(0.017)		(0.016)
Recent edutainment (min in prev. hours 2 to 3)			0.008	0.006
			(0.020)	(0.019)
Observations	351913	351913	351913	351913
Day FEs	✓	✓	✓	✓
Village FEs	✓	✓	✓	✓
Regression	Poisson	Poisson	Poisson	Poisson

Notes: See notes for Table 5. *Min. in prev. hour*, *Min. in prev. hours 1 to 2* and *Min. in prev. hours 2 to 3* are edutainment minutes viewed in the first, second and third preceding hours respectively.

Table A9: Effect of edutainment on presses per half-hour, including household FE

	(1)	(2)	(3)	(4)
Meal in next hour	0.677***	0.677***	0.677***	0.677***
	(0.065)	(0.065)	(0.065)	(0.065)
Treatment	0.000	0.000	0.000	0.000
	(.)	(.)	(.)	(.)
Treatment × Meal in next hour	0.278***	0.274***	0.280***	0.068
	(0.081)	(0.081)	(0.081)	(0.115)
Recent edutainment (min in prev. hour)		0.020	0.040**	0.045**
		(0.013)	(0.019)	(0.019)
Recent edutainment (min in prev. hour) × Meal in next hour			-0.031	-0.039
			(0.025)	(0.025)
Cumulative edutainment (log min)				-0.073
				(0.061)
Cumulative edutainment (log min) × Meal in next hour				0.081***
				(0.029)
Observations	351910	351910	351910	351910
Day FEs	✓	✓	✓	✓
Household FEs	✓	✓	✓	✓
Regression	Poisson	Poisson	Poisson	Poisson

Notes: See notes for Table 5. The coefficient on *Treatment* cannot be estimated since we include household fixed-effects and it has no within-household variation.

Table A10: Effect of treatment on number of presses per half-hour, among households with children who use phone for entertainment at baseline

	All times		Meal in next hour	
	(1)	(2)	(3)	(4)
Treatment	0.524***	0.037***	0.743***	0.094***
	(0.085)	(0.008)	(0.127)	(0.021)
Observations	96995	97859	20432	21283
q-value	0.00	0.00	0.00	0.00
Day FEs	✓	✓	✓	✓
Village FEs	✓	✓	✓	✓
Regression	Poisson	OLS	Poisson	OLS

Notes: See notes for Table 3.

Table A11: Other sanitation and hygiene actions

	Filters water	Open defecates	Has latrine
Edutainment Treatment	0.005	-0.008	-0.000
	(0.008)	(0.008)	(0.000)
Mean of control	0.013	0.007	1.000
q-value	0.58	0.58	0.58
Baseline control	✓	✓	✓
Village FEs	✓	✓	✓
Observations	232	232	232

Notes: Data from the endline survey, restricted to the final sample with sensor data for control households, and sensor & phone data for treated households. Regressions include baseline outcome as control, as well as village fixed effects. Standard errors are robust. *q*-values are computed over all *p*-values in the Table following Anderson (2008).

Table A12: Self-reported handwashing behavior

	Number of washes with soap	Washes with soap before eating	Children wash with soap before eating
Edutainment Treatment	0.683**	-0.000	0.003
	(0.340)	(0.016)	(0.004)
Mean of control	5.059	0.987	0.997
q-value	0.13	0.99	0.55
Baseline control	✓	✓	✓
Village FEs	✓	✓	✓
Observations	232	232	232

Notes: Data from the endline survey, restricted to the final sample with sensor data for control households, and sensor & phone data for treated households. Regressions include baseline outcome as control, as well as village fixed effects. Standard errors are robust. *q*-values are computed over all *p*-values in the Table following Anderson (2008).

A.2 Illustrations

Figure A1: SD cards and mobile phone entertainment

Notes: Top two figures depict a typical street stall from which SD cards with pre-loaded entertainment are often rented or purchased. In the present study, we distribute these directly in households. Bottom figure depicts a family watching the entertainment through the SD card on the distributed mobile phone together.

Figure A2: Soap dispenser anatomy

Notes: The dispenser is a standard wall mounted handsoap dispenser with a foaming pump. It is opened with a special key available only to the surveyors. The sensor module is secured inside between the pump and the liter container.

Figure A3: Child using dispenser

Notes: A child uses the dispenser by pushing the black button once or twice. The foaming soap can be rubbed on the hands without water. He then goes to the nearby water pail or tube well in the courtyard and rinses the soap off with the help of the mother, who pours the water.

Figure A4: Hygiene knowledge questions

Hygiene Knowledge: Now I would like to ask you some questions about hygiene.

SURVEYOR: Do not read out the codes. Wait for the respondent to answer, and fill in as many of the codes as they mentioned in order of importance.

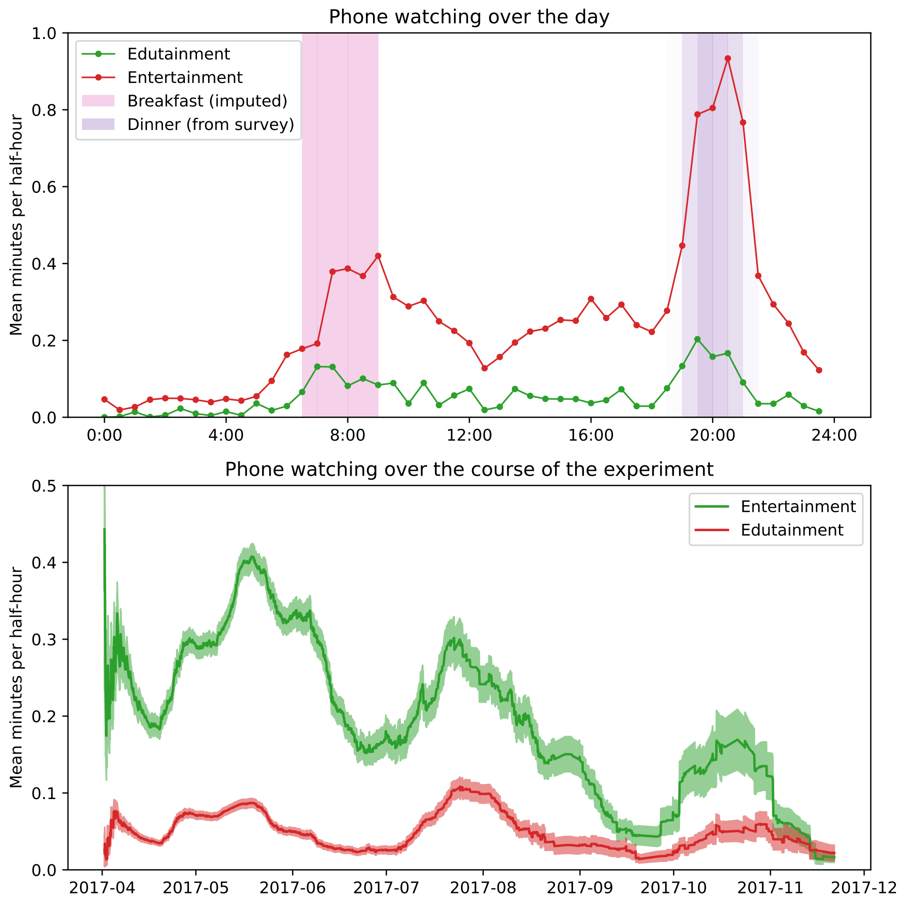
What do you think causes your child to have a caugh or cold? (0=don't know; 1=chance; 2=it is cold outside; 3=they eat something bad; 4=they catch it from other children; 5=they touch germs that get into their body; 6=playing in water; 7=they don't wear proper clothing; 8=seasonal changes (beginning of winter, beginning of summer); 9=playing in dirt; 10=other (please specify))	**1**					Multi-select
How can you make a caugh or cold go away? (0=don't know; 1=nothing you can do, just wait; 2=give them medicine; 3=give them fluids; 4=feed them a specific food; 5=dress warmly; 6=take to doctor; 7=nothing I can do since I can't supervise them, I'm working; 8=other (please specify))	**2**					Multi-select
Can the cold or cough spread from one person to another? (0=don't know; 1=yes; 2=no)	**3**					Pick one
[IF YES] How does it spread? (0=don't know; 1=sneezing, coughing; 2=dust allergy, dhan thrashing; 3=food allergy; 4=other (please specify))	**4**					Multi-select
What are some ways in which you can keep a caugh or cold from happening in the first place? (0=don't know; 1=dress warmly; 2=eat healthy food; 3=drink clean water; 4=wash your hands; 5=stay clean (keep your whole body clean);6=changing clothes regularly, wearing clean clothes; 7=put oil on body; 8=nothing I can do since I can't supervise them, I'm working; 9=not playing in water; 10=other (please specify))	**5**					Multi-select
What do you think causes diarrhea? (0=don't know; 1=chance; 2=something bad or dirty in the food you eat/spoiled food; 3=something in the water you drink; 4=something on your hands; 5=other (please specify))	**6**					Multi-select
How can you make diarrhea go away? (0=don't know; 1=medicine; 2=drink extra fluids; 3=treat your water (boil, etc.); 4=eat a specific food; 5=saline-sugar solution; 6=take to doctor; 7=nothing I can do since I can't supervise them, I'm working; 8=other (please specify))	**7**					Multi-select

What are some ways in which you can keep you or your child from getting diarrhea in the first place? (0=don't know; 1=drink clean water; 2=eat healthy foods; 3=wash your hands with soap; 4=stay clean (keep your whole body clean); 5=moderate eating (don't eat too much); 6=nothing I can do since I can't supervise them, I'm working; 7=other (please specify))	**8**					Multi-select
What do you think is the difference between washing your hands with water only and washing your hands with soap AND water? Perhaps there is no difference? (0=Don't Know; 1=No difference, 2=Hands smell different, 3=Hands look cleaner, 4=Hands are cleaner; 5=other (please specify))	**9**					Multi-select
[If 9 > 1] In what way does it make your hands cleaner? (0 = Don't know, 1 = Makes hands worm free, 2 = Removes dust/dirt, 3 = Removes germs, 4 = Other (please specify)	**10**					Multi-select
When do you think it's most important to wash your hands with soap? (0 = Don't know, 1 = Never, 2 = before cooking, 3 = before eating, 4 = after eating, 5 = after using the restroom, 6 = after picana, 7 = after returning from outside, 8 = others (please specify)	**11**					Pick one
Do you think that using soap on your hands can help prevent a sickness? (0=Don't know, 1=Yes, 2=No)	**12**					Pick one
If your hands look clean, is there any need to wash them with soap? (0=Don't know, 1=Yes, 2=No)	**13**					Pick one
IF YES, why? (0=Don't know, 1=to clean germs, 2 = to clear of invisible worms, 3 = to clear off dirt you can't see; 4=to continue the habit; 5=other (please specify))	**14**					Multi-select

Notes: Hygiene knowledge module of the baseline and endline surveys. To build the hygiene knowledge index, we exclude questions 2 and 7, since these are not related to the content of the edutainment, as well as questions 12 and 13, since these are answered correctly by all but one participant at endline and therefore do not generate any analyzable variation.

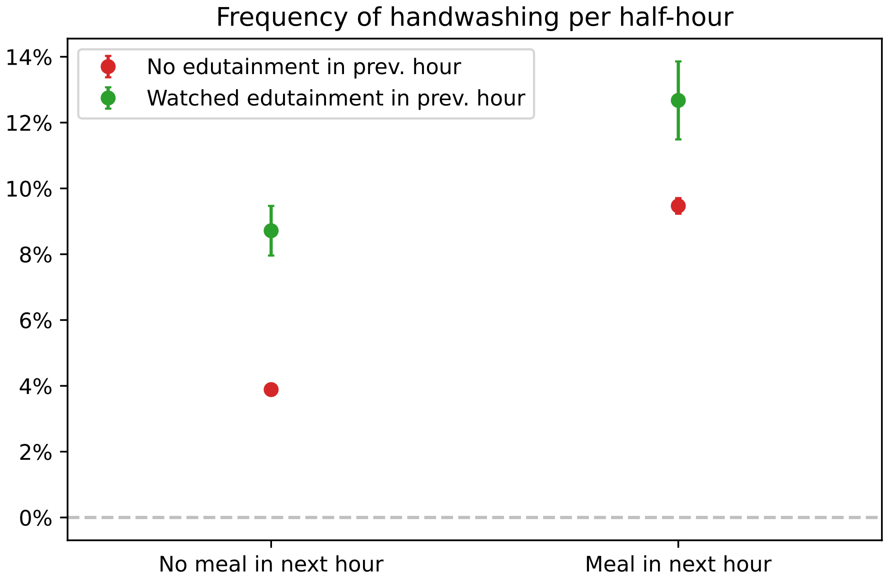
A.3 Figures

Figure A5: Phone watching by time of day and over the course of the experiment



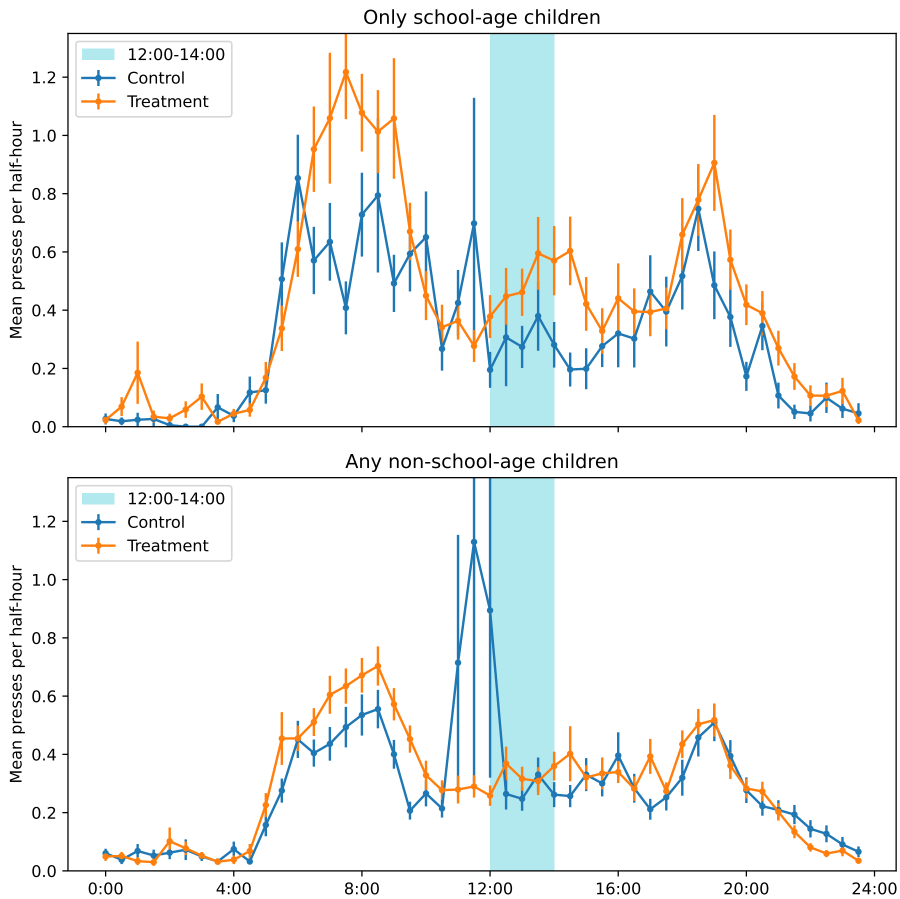
Notes: Data from the final treated sample with sensor & phone data.

Figure A6: False positives and negatives



Notes: Data from the final sample with sensor & phone data for treated households. *Frequency of handwashing* indicates the share of households that pressed the soap sensor at least once. *Meal in the next hour* includes meal-times and the preceding hour. Dinner times are identified by household from the rolling survey, breakfast times are imputed uniformly.

Figure A7: Soap dispenser presses by time of day and age of children



Notes: Data from the final treated sample with sensor & phone data. Sample is restricted to school days (Monday-Friday). *Any school-age children* further restricts the sample to households with in which *any* children aged five or below reside. *Only school-age children* restricts to households with *only* children aged six or above.

A.4 Tables for full sample

Table A13: Entertainment and edutainment consumption – Full sample

Panel A: Adults

	Watch entertainment	Watch cartoons	Watch daily	Minutes / day
Edutainment Treatment	0.718***	0.775***	0.424***	30.197***
	(0.042)	(0.038)	(0.051)	(2.477)
Mean of control	0.114	0.060	0.084	4.371
q-value	0.00	0.00	0.00	0.00
Baseline control	✓	✓	✓	✓
Village FEs	✓	✓	✓	✓
Observations	331	331	331	331

Panel B: Children

	Watch entertainment	Watch cartoons	Watch daily	Minutes / day
Edutainment Treatment	0.358***	0.639***	0.220***	14.773***
	(0.044)	(0.043)	(0.055)	(1.837)
Mean of control	0.587	0.246	0.515	19.946
q-value	0.00	0.00	0.00	0.00
Baseline control	✓	✓	✓	✓
Village FEs	✓	✓	✓	✓
Observations	331	331	331	331

Notes: This Table replicates Table 1 for the full endline survey sample.

Table A14: Impact of edutainment campaign on child health – Full sample

	ARI symptoms	Loose stool	(excl. null months)
Edutainment Treatment	-0.014***	-0.005**	-0.010**
	(0.005)	(0.003)	(0.004)
Mean of control	0.048	0.011	0.019
q-value	0.02	0.03	0.03
Round FEs	✓	✓	✓
Village FEs	✓	✓	✓
Observations	6181	6181	3605

Notes: This Table replicates Table 2 for the full endline survey sample.

Table A15: Hand hygiene knowledge – Full sample

Panel A: Absolute knowledge

	ICW	Avg.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Edutainment Treatment	0.097	0.008	0.024	0.009	-0.020	-0.037	0.040**	0.052	-0.003	0.000
	(0.098)	(0.012)	(0.045)	(0.019)	(0.046)	(0.043)	(0.018)	(0.035)	(0.028)	(0.000)
Mean of control	0.000	0.801	0.581	0.964	0.329	0.808	0.958	0.862	0.904	1.000
q-value	0.82	0.82	0.82	0.82	0.82	0.82	0.30	0.66	1.00	1.00
Baseline control	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Village FEs	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Observations	331	331	331	331	331	331	331	331	331	331

Panel B: Relative knowledge

	ICW	Avg.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Edutainment Treatment	0.076	0.016	0.029	0.005	-0.012	0.008	0.025	0.040	-0.031	0.069**
	(0.105)	(0.013)	(0.044)	(0.020)	(0.034)	(0.027)	(0.021)	(0.026)	(0.042)	(0.030)
Mean of control	0.000	0.805	0.494	0.952	0.214	0.412	0.681	0.593	1.147	1.951
q-value	0.74	0.57	0.74	0.79	0.79	0.79	0.57	0.57	0.74	0.21
Baseline control	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Village FEs	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Observations	331	331	331	331	331	331	331	331	331	331

Notes: This Table replicates Table 4 for the full endline survey sample.

A.5 Sample construction

Although the sensor and phone data is very rich, collecting it in the field is challenging, and we therefore carefully process it before our high-frequency analysis.

There are three primary sources of errors in the data. First, enumerators faced difficulties transferring data to laptops in the field, leading a number of files to be corrupted and lost.

Second, bugs sometimes cause the internal clocks of the phone or the sensor to reset, e.g. to the manufacturing date. For each collection round, we therefore drop observations outside of the dates when a household was provided with a phone/sensor and when its data was transferred.

Third, processing sensors and phones sometimes led to data entry errors, e.g. mixing up files belonging to different households. We detect these by identifying when multiple files correspond to a household-round, or when subsequent rounds of the same household overlap, and drop the associated observations.

In the end, this leads us to drop 21.53% of sensor presses, and 64.76% of phone watch events, primarily due to internal clock resets. Since file corruptions and clock resets are effectively random, we do not expect them to affect the identification of the treatment effect or the subsequent mechanism analysis. Data entry errors represent a much smaller number of observations, are presumably also unrelated to the handwashing behavior of households, and appear as an unavoidable by-product of field work.

We then merge the sensor data, which covers the treatment and control group, with the phone data, which covers the control group only, to obtain a final half-hourly dataset on media consumption and handwashing. This final dataset contains 233 households (out of 333, i.e. 70% of the sample), each observed for 33 days on average, ranging from April 1st to November 21st 2017.