


## Research Paper

### COVID-19, public health messaging, and sanitation and hygiene practices in rural India

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#### ABSTRACT

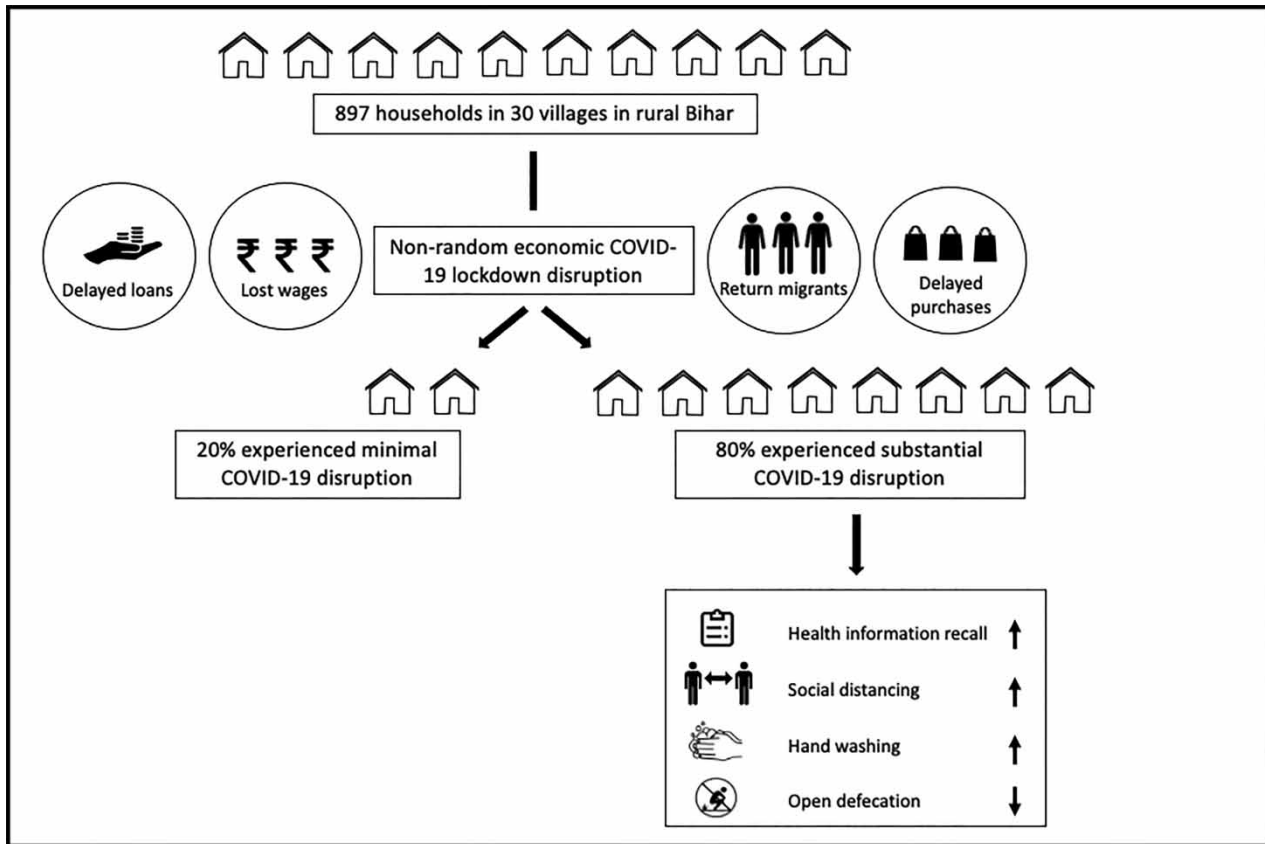
Despite the importance of safe sanitation and hygiene for sustainable development and public health, approximately half of India's rural population lacks access to safely managed sanitation. Policies prioritizing improved sanitation access have accelerated coverage, yet barriers to universal access and use remain. In this paper, we investigate how personal experience with a public health shock impacts recall of public health messages and households' sanitation and hygiene practices. Using a panel survey conducted before and after the first wave of the COVID-19 pandemic, and the resulting lockdown, in Bihar, India, we compare public health messaging recall and hygiene and sanitation behaviors among households that experienced severe economic disruptions due to the COVID-19 lockdown and those that did not. We find that households that experienced economic disruptions had a higher recall of public health messaging around safe sanitation and hygiene. In addition, households that experienced these disruptions reported more social distancing, increased handwashing behavior, and reduced open defecation. A major public health shock, the COVID-19 pandemic, increased messaging around the importance of safe hygiene and sanitation for public health in India. We find that personal experience increased the salience of public health messaging, with positive returns to sanitation and hygiene practices.

**Key words:** COVID-19, health information, hygiene, sanitation

#### HIGHLIGHTS

- The COVID-19 pandemic increased the salience of public health messaging in India.
- Households impacted economically by COVID-19 increased reported handwashing frequency.
- Households impacted economically by COVID-19 reduced reported open defecation by 22%.
- Increasing the salience of public health messaging can lead to safer health behaviors.

## GRAPHICAL ABSTRACT



## INTRODUCTION

Improving household sanitation remains a pressing priority for global public health. Experimental campaigns have shown that improved household and community sanitation can improve health (Gertler *et al.* 2015); yet, the effectiveness of these programs at scale is mixed, often showing low uptake, unsustainable behavioral change, and limited health benefits (Cameron *et al.* 2019). One contributing mechanism is the failure to impress upon households the importance of changing their sanitation behaviors: where communications are designed to increase the salience of health and other benefits, sanitation and hygiene have improved (Luoto *et al.* 2014). In the last two decades, efforts to promote improved sanitation have used communication as a central design component (Gertler *et al.* 2015; Guiteras *et al.* 2015). While many such interventions have increased latrine use, these campaigns are expensive, and evidence suggests the limited sustainability of behavioral change (Hutton *et al.* 2020). These findings reinforce the continued need to examine the mechanisms behind safe sanitation adoption and sustained use.

The COVID-19 pandemic has demonstrated the importance of safe hygiene for public health. Evaluations of the negative economic consequences of COVID-19 in low- and middle-income countries (LMICs) suggest that pandemic impacts threaten recent progress toward poverty reduction (Alkire *et al.* 2021). Other work, however, shows that COVID-19 awareness increased compliance with prosocial health-related behaviors (Chavarría *et al.* 2021; Tseketse-Akuamoah *et al.* 2022) and demonstrates the importance of information framing to motivate COVID-19 prevention behavior (Howard *et al.* 2020). As a result of increased public health messaging efforts, the pandemic may have unexpectedly positive spillovers for other public health-related behaviors, such as household sanitation and hygiene. Indeed, there is a substantial overlap between COVID-19 prevention measures and longstanding water, sanitation, and hygiene guidance (Hannah *et al.* 2020). Scholars have posited that emphasis on safe sanitation and hygiene could help stem the COVID-19 pandemic, as well as reduce the likelihood of similar diseases in the future (Howard *et al.* 2020).

To test this hypothesis, this study investigates changes in household hygiene and sanitation behaviors during a time of heightened public health awareness – the COVID-19 pandemic. Using a two-wave, panel survey conducted before and after the first wave of the COVID-19 pandemic in Bihar, India, we examine how recall of public health messaging differs by firsthand pandemic experience, measured through economic disruptions to households during COVID-19 lockdowns. We consider this recall a form of messaging salience – households recall more salient messages they receive. Furthermore, we estimate how these economic disruptions influence sanitation and hygiene behaviors, adding evidence to the scholarship on the impacts of messaging salience on environmental health behaviors.

Our study is among the few conducted during the COVID-19 pandemic in a LMIC context in which sanitation and hygiene was an ongoing policy priority, providing valuable insights into the interplay between pandemic response and efforts to improve sanitation and hygiene practices globally. Furthermore, the panel data structure facilitates the examination of hygiene and sanitation behavior change among households that experienced differential economic disruptions during the initial wave of the COVID-19 pandemic, and the resulting lockdown, in India. Our study joins two others in examining the intersection of the COVID-19 pandemic experience and sanitation and hygiene behaviors in LMICs (Ashraf *et al.* 2020; Bauza *et al.* 2021). Our study expands on this literature by offering insights into how households changed their pre-pandemic sanitation and hygiene practices following economic disruptions during the first COVID-19 lockdown. Not only are these insights informative regarding the broader public health impacts of COVID-19, so too can they help to inform best practices for motivating safe sanitation and hygiene.

## METHODS

In the spring 2020, the first wave of the COVID-19 pandemic spread throughout India (Kumar 2021). While the first confirmed COVID-19 case was detected on January 30, 2020, confirmed cases remained low for the following 6 weeks (see Supplementary Material, Figure 1). In early March, cases increased rapidly, and the Government of India ordered a national lockdown that extended from March 24, 2020 to May 31, 2020. The economic effects of the lockdown, which closed businesses and left millions of migrant laborers jobless, contributed to India's largest mass migration since Partition, with workers returning to distant rural homes (Mukhra *et al.* 2020).

### Data

The data for this study came from a two-wave household panel collected using face-to-face interviews among 900 households from 30 rural villages in the Patehdi Belsar and Mahua blocks of the Vaishali district of Bihar, India (see Supplementary Material, Figure 2). Bihar, a state in east India, has among the highest rates of poverty and lowest rates of latrine coverage compared to other Indian states (IIPS and ICF 2021). The Vaishali district is in central Bihar, located outside of the state's capital city, Patna. Villages meeting sample criteria were randomly selected for sample inclusion. These criteria included size – villages had between 100 and 700 households – and sanitation coverage – no villages were declared 'Open Defecation Free', an official designation indicating that 100% of village households have access to and use latrines (Hutton *et al.* 2020). From a complete household listing, 30 households were randomly selected from each study village for inclusion. If a selected household refused to participate or enumerators were unable to reach the household, it was replaced with a neighboring household. An adult knowledgeable about household water and sanitation practices and the health of all household members was the target respondent. In practice, the majority of respondents were household heads or their spouses.

The household survey contained information on open defecation and latrine use among household members (above the age of 2), handwashing practices, soap expenditures, and diarrheal disease incidence. In addition, data were collected on household composition, socioeconomic status, health histories, and social connections. Data were collected using CSPro on tablets and analyzed using Stata 16. We report baseline descriptive statistics in Supplementary Material, Table A1. These show that, similar to the state of Bihar overall, our sample is relatively socioeconomically disadvantaged: over 80% of households are below the poverty line (BPL) status, and only 34% of household heads have at least a secondary education. Furthermore, about a quarter of households have received Swachh Bharat Mission (SBM) subsidies, which are subsidies funded by the national government for latrine construction. Sample households are more likely to receive sanitation and hygiene information from external sources such as radio, television, and public health workers, relative to friends and family. Finally, improved sanitation and hygiene practices are low at baseline: among a list of 12 key times throughout the day, respondents

report an average of 3.7 handwashes (31%) per day; and rates of open defecation are high – between 44 and 47% of households practice open defecation.

The first wave of the panel was collected in October 2019 as part of a multi-state evaluation of social spillovers on sanitation behavior (Pakhtigian & Pattanayak 2022). The second wave was collected in December 2020. Out of the 900 households included in the first wave of the survey, only three were unable to be located for the second wave of data collection, limiting concerns about selective attrition, and yielding a balanced, two-wave panel of 897 households. As December 2020 followed the first wave of the COVID-19 pandemic, and associated first lockdown, in India, additional questions about the economic and social aspects of the pandemic were included in the second-wave survey. Due to concerns about privacy and respondent willingness to share information about previously confirmed or suspected COVID-19 cases in their households, questions about household health in relation to the COVID-19 pandemic were not included. All data collection was conducted with approval by the Institutional Review Board (IRB) at Duke University.

### Variation in household experience with the COVID-19 pandemic

The COVID-19 pandemic impacted the provision, sources, and frequency of public health information in India (Purohit & Mehta 2020). Existing work on public health messaging has found that messaging salience is an important factor in how effective messaging is in motivating safer health behaviors (Luoto *et al.* 2014). Furthermore, evidence from efforts to promote the adoption and use of safe sanitation shows that experiential messaging is more effective in stimulating demand and use (Guiteras *et al.* 2015). Taken together, this suggests that differential firsthand experience with the COVID-19 pandemic may generate variation in public health messaging recall and salience, leading to disparate responses in terms of household sanitation and hygiene practices. Given the data available for this study, we measure firsthand experience with the COVID-19 pandemic using economic disruptions during the first COVID-19 lockdown.

### Measuring economic disruptions of COVID-19

The survey data contain four measures of household experience with the COVID-19 pandemic from an economic perspective. These measures, summarized in Table 1, include indicators for (i) lost wages because of the COVID-19 lockdown; (ii) return of migrant household members during the COVID-19 lockdown; (iii) delayed purchases due to the COVID-19 lockdown; and (iv) loans taken during the COVID-19 lockdown. Many households experienced various types of economic disruptions during the first COVID-19 lockdown. A quarter of households had migrant members return; 86% lost wages; three quarters held off on purchases; and nearly half took loans. Using this data, we define two measures of economic COVID-19 disruption: (i) a continuous count (ranging from 0 to 4) of the number of economic disruptions (return of migrants, lost wages, delayed purchases, and loan taking) a household experienced during the first COVID-19 lockdown and (ii) an indicator for households that experienced at least two economic disruptions during the first COVID-19 lockdown. The average household in our sample experienced 2.3 economic disruptions as a result of the COVID-19 lockdowns, and approximately 80% of the sample experienced at least two economic disruptions. While we also have data on lost wage

**Table 1** | Dimensions of economic COVID-19 disruption

	Mean	Standard deviation	Minimum	Maximum	Observations
Return migrants (%)	25.1		0	1	897
Lost wages (%)	85.9		0	1	886
Lost wages (Rs.) (among impacted)	12,459	11,789	1,000	80,000	308
Delayed purchases (%)	77.0		0	1	880
Loan (%)	49.3		0	1	897
Loan amount (Rs.) (by takers)	55,976	76,147	1,000	600,000	442

*Notes:* Return migrants refer to the percent of households that had migrants return during the COVID-19 lockdown in spring 2020. Lost wages refer to the percent of households that reported losing wages due to the COVID-19 lockdown in spring 2020. Lost wages (Rs.) were calculated among households that reported lost wages due to the COVID-19 lockdown in spring 2020. Delayed purchases refer to the percent of households that held off on household purchases as a result of the COVID-19 lockdown. Loan refers to the percent of households that reported taking loans as a result of the COVID-19 pandemic. Loan amount (Rs.) is calculated among households that reported taking loans due to the COVID-19 pandemic. Share practicing social restrictions refers to households that limited social interactions to immediate neighbors, family members, and household members during the COVID-19 lockdown.

*Source:* All data are from the endline household survey wave collected in December 2020–January 2021.

and loan amounts, due to reporting inconsistencies we use only the indicator variables for having experienced lost wages or taken loans in our construction of economic COVID-19 disruptions.

### Measuring the recall of sanitation and hygiene information and reported behavior

We define two metrics of public health information recall based on information source. Households are considered attentive to public health messaging if they recalled receiving sanitation- or hygiene-related information from (i) familiar (family and friends) and (ii) external (public health workers, radio, and television) sources in the year preceding the survey. This information included messages such as the relationship between sanitation and hygiene practices and disease; shifting sanitation behavior away from open defecation and toward latrine use; the importance of regular hand washing with soap; and ways to safely manage food and drinking water.

We construct four primary measures of reported public health-related behaviors. First, we define an indicator for social distancing, which takes a value of one for households that reported limiting their social interactions with those outside of their households during the COVID-19 lockdown. We include social distancing as a public health behavior within the COVID-19 context as social distancing offered rural households a low-cost option to reduce disease transmission (Banerjee *et al.* 2020). Second, we calculate handwashing frequency as the percent of times a respondent reported washing hands with soap out of a (prompted) list of 12 key handwashing times throughout the day (e.g., before/after eating or preparing food, after using the toilet, and after returning from working with animals). Third, we measure soap expenditures as the amount (in rupees) spent on a soap in the previous month. Fourth, we measure household open defecation, defined as any household member (above the age of 2) regularly openly defecating as reported by the respondent. Recognizing that responses about open defecation may differ when asked at the household compared to individual levels, we also expand our definition of open defecation to examine open defecation behavior among adult males, adult females, male children, and female children. For these household groups, we measure open defecation as an indicator that household members in the group regularly openly defecate as reported by the respondent. We include two additional sanitation-related measures in supplementary analyses – reported latrine use (at the household and intrahousehold levels) and reported diarrhea incidence.

### Empirical specification

To estimate the effects of economic disruptions during the first COVID-19 lockdown on the recall of public health messaging and household hygiene and sanitation practices, we use a difference-in-difference design, comparing between households impacted and not impacted economically by the first COVID-19 lockdown before and after the first wave of the COVID-19 pandemic in Bihar. For the analysis, we consider four categories of dependent variables as described above: messaging recall, social distancing, handwashing behavior, and open defecation. We estimate the following linear regression model:

$$y_{it} = \alpha + \beta \text{Shock}_i \times \text{Post}_t + \gamma_i + \rho_t + \nu X_{it} + \varepsilon_{it} \quad (1)$$

where  $y_{it}$  measures messaging recall, social distancing, or hygiene or sanitation behavior of household  $i$  in time  $t$ ;  $\text{Shock}_i$  is an indicator for experiencing an economic COVID-19 disruption (as a robustness check we also use a continuous COVID-19 disruption variable); and  $\text{Post}_t$  is an indicator for the 2020 wave. We include a household fixed effect ( $\gamma_i$ ) and a survey-wave fixed effect ( $\rho_t$ ), and we control for time-varying household characteristics including household size, television ownership, household education, and receipt of a latrine building subsidy under the widespread Swachh Bharat policy, which ended in 2019 and has been demonstrated to have increased latrine ownership and use (Pakhtigian *et al.* 2022). We cluster standard errors at the village level, the sampling frame used for data collection.

The estimate of interest,  $\beta$  from Equation (1), identifies the influence of experiencing economic disruptions during the first COVID-19 lockdown on messaging recall, social distancing, and household hygiene and sanitation behaviors under the assumption that, in the absence of the COVID-19 pandemic, sanitation and hygiene behaviors among households that experienced substantial economic COVID-19 disruptions and those that did not would have had common trends. While not directly testable with our data, there are several reasons we believe this assumption does not threaten our identification. First, we examine economic disruptions that resulted in a COVID-19 lockdown that was unexpected, wide-sweeping, and previously unexperienced (Kumar 2021). Accordingly, we do not expect that households were able to quickly shift into or out of experiencing economic COVID-19-related disruptions. Second, we include household fixed effects in our model to control

for time-invariant household characteristics and to examine within-household changes between panel waves. Third, while there were some differences in baseline characteristics between households that experienced and did not experience economic COVID-19 disruptions (see Supplementary Material, Table A1), we control for these time-varying characteristics in our model.

## RESULTS

We first estimate effects of experiencing economic disruptions during the first COVID-19 lockdown on information source recall, social distancing, and hygiene behaviors (Table 2). We find that households that experienced substantial economic COVID-19 disruptions recall more public health messaging in the previous year from familiar and external sources. Households that experienced disruptions are 16 (familiar sources) to 21 (external sources) percentage points more likely to recall recent public health messaging related to sanitation and hygiene – increases of 80% and 38% from the baseline means from familiar and external sources, respectively (Table 2, columns (1) and (2)).

We also find that households shifted their hygiene behavior concurrent with economic disruptions during the first lockdown. Respondents in households that experienced economic COVID-19 disruptions report a 11 percentage point increase in handwashing frequency, a 35% increase from the baseline mean (Table 2, column (4)). We do not find evidence of changes to household soap expenditures (Table 2, column (5)). Finally, using only data from the post-wave (2020) and a cross-sectional linear regression without a household fixed effect, we find a positive, marginally significant, correlation between experienced economic COVID-19 disruptions and social distancing: economically disrupted households are 8 percentage points more likely to report social distancing (Table 2, column (3)).

Table 3 presents estimates of the effects of experiencing economic disruptions during the first COVID-19 lockdown on open defecation at the household and sub-household levels. At the household level, reported open defecation declines by 11 percentage points, a 22% decline from the baseline mean among these households (Table 3, column (1)). Among different groups of household members, reported open defecation declines from 6 percentage points (a 13% decline from the baseline mean) for female children to 13 percentage points (a 26% decline from the baseline mean) for male children, although the results for female children are not statistically significant (Table 3, columns (2)–(5)). As a supplementary analysis, we examine if economic COVID-19 disruptions increase latrine use at the household and intrahousehold levels (see Supplementary Material, Table A2). While we find increased latrine use among households and among the four intrahousehold member categories for households that experienced economic disruptions during the first COVID-19 lockdown, all the estimates are insignificant or marginally significant. Taken together, these results on sanitation and hygiene behaviors suggest that

**Table 2** | Information, social distancing, and hygiene behavior

	(1) Familiar information source	(2) External information source	(3) Social distancing	(4) Average handwashing	(5) Monthly soap expenditures
Economic COVID-19 disruption × Post <sup>a</sup>	0.16** (0.06)	0.21*** (0.07)		0.11*** (0.04)	−0.63 (10.17)
Economic COVID-19 disruption <sup>b</sup>			0.08* (0.04)		
Observations	1,794	1,794	869	1,794	1,786
Household fixed effects	Y	Y	N	Y	Y
R <sup>2</sup>	0.53	0.56	0.02	0.59	0.63
Baseline mean (disrupted households)	0.2	0.54		0.31	103.00

Notes: Results are reported as coefficient (standard error). Economic COVID-19 disruption refers to households that experienced at least two economic consequences of the COVID-19 lockdown in spring 2020 (out of return migrants, lost wages, deferred purchases, and loan taking). Post refers to the post-lockdown wave of data collection (December 2020–January 2021). Economic COVID-19 disruption × Post is the interaction of these two variables. Columns (1)–(5) include household head secondary education, family size, television ownership, and receipt of Swachh Bharat subsidies as household controls. Column (3) includes household below poverty line status as an addition control. Columns (1), (2), (4), and (5) include a post wave indicator and household fixed effects. All standard errors are clustered at the village level. The baseline mean is calculated among households that experienced substantial economic disruptions during the first COVID-19 lockdown. \* $p < 0.1$ ; \*\* $p < 0.05$ ; \*\*\* $p < 0.01$ .

Source: All data come from the baseline (October 2019) and endline (December 2020–January 2021) household surveys.

<sup>a</sup>Coefficient estimates in this row were obtained from a difference-in-differences specification using data from the baseline (October 2019) and endline (December 2020–January 2021) household surveys.

<sup>b</sup>Coefficient estimates in this row were obtained using a linear regression using data from the endline (December 2020–January 2021) household survey only.

**Table 3** | Open defecation

	(1) Household	(2) Male adults	(3) Female adults	(4) Male children	(5) Female children
Economic COVID-19 disruption × Post	−0.11** (0.04)	−0.08* (0.04)	−0.09* (0.05)	−0.13** (0.06)	−0.06 (0.08)
Observations	1,794	1,794	1,794	1,070	992
Household fixed effects	Y	Y	Y	Y	Y
R <sup>2</sup>	0.83	0.81	0.81	0.86	0.87
Baseline mean (disrupted households)	0.49	0.47	0.46	0.50	0.48

Notes: Results are reported as coefficient (standard error). Economic COVID-19 disruption refers to households that experienced at least two economic consequences of the COVID-19 lockdown in spring 2020 (out of return migrants, lost wages, deferred purchases, and loan taking). Post refers to the post-lockdown wave of data collection (December 2020–January 2021). Economic COVID-19 disruption × Post is the interaction of these two variables. Columns (1)–(5) include household head secondary education, family size, television ownership, and receipt of Swachh Bharat subsidies as household controls, a post wave indicator, and household fixed effects. All standard errors are clustered at the village level. The baseline mean is calculated among households that experienced substantial economic disruptions during the first COVID-19 lockdown. \* $p < 0.1$ ; \*\* $p < 0.05$ ; \*\*\* $p < 0.01$ .

Source: All data come from the baseline (October 2019) and endline (December 2020–January 2021) household surveys.

households that experienced economic COVID-19 disruptions may have been able to shift their intensive margins of safe sanitation and hygiene behavior, but not their extensive margins. That is, households that experienced these disruptions could increase the frequency of safe sanitation and hygiene behaviors but did not have the resources to invest in additional products or technologies.

Building on the evidence that households that experienced economic disruptions during the first COVID-19 lockdown are more attuned to sanitation-related public health messaging and improve their sanitation and hygiene practices, we assess if these households experience reductions in diarrhea incidence (see Supplementary Material, Table A3). We find that while households that experienced lockdown disruptions saw declines in household diarrhea incidence, the effect was not significantly distinguishable from zero.

Finally, recognizing that our results may be sensitive to the construction of our measure of economic disruption during the first COVID-19 lockdown, we re-estimate our main results using the number of economic disruptions experienced, rather than the binary indicator for substantial economic disruption. These results, reported in Supplementary Material, Tables A4 and A5, are substantively similar to those estimated using our binary measure of disruption.

## DISCUSSION

We show that public health messages are more salient among households that experienced economic disruptions during the first COVID-19 lockdown. We find that reports of recent, public health messaging increased between 38% and 80% among households that experienced substantial economic disruptions compared to those households that did not. We also show that households that experienced these disruptions improve their hygiene and sanitation behaviors through social distancing, increased handwashing, and reduced open defecation. Households that experienced economic disruptions increased handwashing frequency by 35% and decreased open defecation by 22%. These increases in handwashing align with existing evidence from similar settings in India that shows increased handwashing behavior during the COVID-19 pandemic in Tamil Nadu (Ashraf *et al.* 2020) and Odisha (Bauza *et al.* 2021), especially among households with previous exposure to safely managed sanitation.

We argue that the salience of public health messaging and the sanitation and hygiene improvements among households that experienced economic COVID-19 disruptions are interrelated. Households in rural Bihar saw a significant increase in public health messaging between the fall of 2019 and the winter of 2020; other work has shown that these increases resulted from intensive public health messaging campaigns around the COVID-19 pandemic (Bauza *et al.* 2021). These messaging campaigns focused on the importance of improved hygiene and sanitation as critical in the fight against the spread of COVID-19. Our results suggest that these COVID-focused public health messages had positive spillovers on household sanitation, particularly among households that experienced economic disruptions as a result of the lockdowns.

The importance of the salience and reception of public health messaging to motivate safe health behaviors has also been established in the public health literature outside of the COVID-19 context. Piltch-Loeb *et al.* (2017), for example, showed

that adherence to public health measures during the emerging Zika virus outbreak varied based on individuals' understandings of their own disease risk, suggesting that the salience of public health messaging is a critical component for promoting safe health behaviors. Similarly, a growing literature on mobile health applications shows that tailoring messages to recipients improves the effectiveness of public health communications (Hall *et al.* 2015). Our results suggest that these same trends in public health communications are important in the face of a novel, infectious disease. Furthermore, they align with findings of spillovers related to COVID-19 public health messaging that show social spillovers in COVID-safe behaviors as well as behavioral spillovers in public health behaviors following COVID-19 informational interventions (Banerjee *et al.* 2020).

Our results on behavioral change and public health messaging suggest that public health messaging was more salient – and, thus, potentially more motivating – to households that experienced economic disruptions during the first COVID-19 lockdown. During the first COVID-19 lockdown, households experienced economic disruptions such as return migrants, lost wages, and needs to delay purchases or take loans with little autonomy over these experiences. Yet, households had an agency to respond to the COVID-19 pandemic, and reduce their exposures to the health risks it posed, by limiting social interactions and by increasing their safe hygiene and sanitation behaviors. Our results provide related evidence: public health messaging is more salient to households that experienced economic COVID-19 disruptions and these households also improve their sanitation and hygiene practices by socially distancing, regular handwashing, and reduced open defecation. Our results do not suggest that households must experience negative disruptions to motivate shifts to safer sanitation and hygiene practices. Rather, they are consistent with the idea that making public health messaging more salient to households' everyday experiences may improve the motivational power of such messaging efforts. Evidence that information salience is critical for motivating safe behavior during a public health crisis has been found in other contexts as well; for example, Chavarría *et al.* (2021) found COVID-related knowledge to be a primary predictor for protective health behaviors in Aceh, Indonesia.

### Study limitations

Our study examines how a major shock to the salience of sanitation and hygiene-focused public health messaging impacts household hygiene and sanitation behaviors. In this study, we examine the impacts of firsthand household experience as measured by economic disruption. Due to data limitations, however, we did not examine a highly critical COVID-19 shock – health. While our dataset and setting limit our ability to examine responses to COVID-19 morbidity and mortality shocks, this is an important, and likely fruitful, avenue for future research.

A second limitation arises in the potential endogeneity of economic disruptions during the first COVID-19 lockdown in India. While COVID-19 impacted all households in our study – and, indeed, all households globally – we use variation in the severity of these disruptions to assess how the recall of public health messaging impacts household hygiene and sanitation. We argue that, in response to the first, unexpected and unusual COVID-19-induced lockdown in India, households did not have the time or opportunity to sort into or out of substantial economic disruption. The results in our analysis provide evidence that firsthand experience with a public health crisis such as COVID-19 increases public health messaging recall, motivating improved hygiene and sanitation practices among households in rural Bihar. More research is needed to fully assess the causality of these relationships and examine if the relationships are moderated by the severity of the public health crisis.

Third, our study is limited by the timing and nature of the household survey data. With regard to timing, our analysis is limited to investigating short-term responses to the first wave, and the resulting lockdown, of the COVID-19 pandemic in India. We are unable to assess if improved sanitation and hygiene practices are sustained impacts or if subsequent lockdowns increase or diminish the effects over time. The timing of the waves – approximately 1 year – dictated the, rather long, recall period of 1 year for information related to sanitation and hygiene behavior. Future work could examine if there are differences in public health information salience depending on recall period length. With regard to household survey data, our understanding of household hygiene and sanitation behaviors is limited by household recall and self-reporting. While using self-reported hygiene and sanitation behaviors allowed for collecting data from a larger sample of households and limiting contact with survey participants in line with data collection best practices during the COVID-19 pandemic, future work would benefit from observational data collection and more objective measures of sanitation and hygiene behavior. Finally, we assume that households across the 30 study villages had access to similar types of messaging regarding sanitation and hygiene behaviors. As mobile phone access is nearly universal and additional public health messaging took place during the COVID-19 pandemic, this assumption seems appropriate for our context, yet future work should examine how patterns of public health targeting – especially from external sources – impact improved sanitation and hygiene behaviors.



## CONCLUSIONS

Changing household sanitation and hygiene practices is a challenging, yet essential, public health priority. Improving safe sanitation and hygiene has been a consistent policy priority in India (Hutton *et al.* 2020). A series of national sanitation policies aimed at building latrines and increasing demand for safe sanitation has reduced open defecation, yet recent estimates suggest that nearly a quarter of India's rural population still lacks access to basic sanitation services (World Bank 2017). This pattern is present in many other LMICs, making it an issue of global public health concern.

The results from this study suggest that the salience of public health messaging could be one key to improving household sanitation and hygiene practices in areas where adoption of safe sanitation has remained low. While the COVID-19 pandemic has exerted disastrous morbidity and mortality costs globally, it has also increased the urgency of public health messaging around safe sanitation and hygiene. We find that the salience of these messaging campaigns is stronger among households that had experienced economic disruptions during the COVID-19 lockdown firsthand, and that these same households increase their handwashing behavior and reduce open defecation. Thus, policies to promote public health through safe sanitation and hygiene could look to messaging salience as an important component for effective design.

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## DATA AVAILABILITY STATEMENT

All relevant data are available from an online repository or repositories (doi.10.17632/79fss5rwg4.1).

## CONFLICT OF INTEREST

The authors declare there is no conflict.

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