Effectiveness of peer detailing in a diarrhea program in Nigeria

Diarrhea causes more than 500,000 deaths of children younger than 5 years, globally, each year. A combination of oral rehydration salts (ORS) and zinc is regarded as the most effective treatment to prevent diarrhea-related deaths among children. We study the effectiveness of a program in Nigeria aimed at increasing usage of ORS and zinc. Peer detailers (educators) reinforce the benefits of the treatment to patent and proprietary medicine vendors (PPMVs), a main source of healthcare in the country. Two aspects of program effectiveness are analyzed: 1) PPMV knowledge that this combination is the most effective treatment and 2) PPMV inventory of ORS and zinc. Hypothesis tests reveal that the percentage of PPMVs with knowledge of the most effective treatment increases significantly in most of the tested Nigerian states after peer detailing. Surprisingly, no significant patterns were detected regarding the percentage of PPMVs with inventory of ORS and zinc. Logistic regression results suggest that PPMVs that were detailed have significantly higher odds ratios for both knowledge and inventory. We discuss our findings regarding the overall effectiveness of the program and the limitations of the study, as well as suggestions for future activities to support information dissemination.

Y. Tao D. Bhattacharjya A. R. Heching A. Vempaty M. Singh F. Lam J. Houdek M. Abubakar A. Abdulwahab T. Braimoh N. Ihebuzor A. Mojsilović K. R. Varshney

Introduction

As the second leading cause of death among children younger than 5 years, diarrhea is responsible for more than 500,000 deaths globally each year [1, 2]. Most deaths occur in low- and middle-income countries where children are exposed to risk factors such as unsafe drinking water, poor sanitation and hygiene practices, micronutrient deficiency, malnutrition, and lack of access to high-quality healthcare [3–5]. Diarrhea is the presence of loose and watery stool, usually caused by viral infection in the digestive system. Diarrhea becomes dangerous and deadly when it depletes body fluids, resulting in profound dehydration. To treat diarrhea, the World Health Organization recommends the combination of oral rehydration salts (ORS) and zinc [6]. ORS prevents dehydration, the primary mechanism by which diarrhea leads to death, and zinc shortens the duration of diarrhea and prevents its reoccurrence in the 2 to 3 months following supplementation. Increasing utilization of this combined treatment may prevent more

than 90% of diarrhea-related deaths among children [7, 8]. However, few children in need are receiving this treatment [9–11] for reasons that are multifaceted, possibly involving policy barriers, manufacturing and supply constraints, low provider and consumer awareness, and demand and decision-theoretic considerations by health providers [12].

Nigeria is a country with a population that suffers from an estimated 77,000 diarrhea-related deaths each year [1]. To address this challenge, the Ministry of Health (MOH) of Nigeria has developed a National Essential Medicines Scale-up Plan and has established a National Essential Medicines Coordinating Mechanism (NEMCM) to bring together resources and investments from government institutions, non-government organizations, and private companies [13]. The Clinton Health Access Initiative (CHAI) is one of the partners supporting the MOH to undertake activities promoting the usage of ORS and zinc in Nigeria (ORS/Zinc Program) [12]. CHAI's efforts focused on eight states in Nigeria: Bauchi, Cross River, Lagos, Kano, Kaduna, Katsina, Niger, and Rivers. Thirty

© Copyright 2017 by International Business Machines Corporation. Copying in printed form for private use is permitted without payment of royalty provided that (1) each reproduction is done without alteration and (2) the Journal reference and IBM copyright notice are included on the first page. The title and abstract, but no other portions, of this paper may be copied by any means or distributed royalty free without further permission by computer-based and other information-service systems. Perupublish any other portion of this paper must be obtained from the Editor.

0018-8646/17 © 2017 IBM

Digital Object Identifier: 10.1147/JRD.2017.2713278

six percent of children younger than 5 years live in these eight states, and diarrhea prevalence ranges from 5% to 25.7% [14, 15].

Patent and proprietary medicine vendors (PPMVs) are private medicine retailers for whom the licensure requirements do not include any formal training [16–19]. These individuals exist to bridge the gap created by a dearth of pharmacists. Access to primary healthcare is poor in Nigeria, and 75% of the Local Government Areas (LGAs) in the country do not have a registered pharmacist [Pharmacy Council of Nigeria, personal communication, September 2016]. PPMVs are therefore an important source of care, and many children with illnesses directly seek healthcare from PPMVs [15]. With 43% of PPMVs' shops located in rural areas, PPMVs play a crucial role in making healthcare accessible to the poor and most vulnerable people [18]. The Pharmacy Council of Nigeria (PCN) is the regulatory body that oversees PPMVs; however, many PPMVs fail to register with PCN, opting rather to register with their professional association, the National Association of Patent and Proprietary Medicine Dealers (NAPPMED) [18].

CHAI aims to increase the usage of zinc and ORS by working with NAPPMED to conduct peer detailing of PPMVs. Peer detailing involves the recruitment of respected members of the NAPPMED to conduct shop-to-shop visits and mentor other retailers on diarrhea management, on topics including identification of danger signs and when individuals should be referred for treatment.

Other programs aimed at increasing the knowledge and usage of zinc and ORS among private providers, particularly in the informal sector, show mixed results and vary greatly in intervention type, environmental context, and scale. The Diarrhea Alleviation Through Zinc and ORS Treatment (DAZT) program in the states of Gujarat and Uttar Pradesh in India included support to the government on policies and procurement, trainings for public clinic and community healthcare workers, continuing medical education sessions to private formal healthcare providers (i.e. trained physicians), and drug detailing visits to private drug vendors and chemists by pharmaceutical representatives. An external evaluation of the program in Gujarat found drug-detailing visits were predictive of self-reported recommendation of zinc and ORS treatment for diarrhea [20]. In other words, the analysis conducted by the paper authors found a statistical relationship between visits by drug detailers and the shop owners recommending the treatment.

In Ghana, a randomized controlled trial was conducted to evaluate the impact of an 8-week SMS (Short Message Service) campaign on knowledge and practices of licensed chemical sellers (LCS). The study results showed the SMS campaign led to a 6.6 percentage point increase ($p \le 0.05$) in self-reported recommendation of ORS and zinc without anti-microbials or anti-diarrheals, but made no difference in treatment recommendation when the LCS was approached by a mystery client [21], i.e., an actor trained to act as if he or she has a sick child.

Interventions using a social franchising model also show differing results. A social franchising and telemedicine program in Bihar, India, did not show improvements in appropriate treatment of diarrhea at the community level. The study found that the World Health Partners (WHP) Sky program's network of providers constituted a small market share of healthcare providers in the study clusters. Only 2.9% of people with diarrhea sought care from the WHP Sky program's network of providers [22].

In Myanmar, a randomized control trial of a social franchising model using local community health workers found a significant impact of the model on ORS and zinc use among children younger than 5 years with diarrhea. By the end of the study, 13.8% of children younger than 5 years with diarrhea received ORS and zinc in the intervention arm compared to 1.8% in the control arm [23].

Lastly, a census study of PPMVs in the Kogi and Kwara states in Nigeria found PPMVs who had formal healthcare training were associated with stocking ORS, but few other PPMV characteristics were predictive of correct knowledge of optimal treatments and stocking behavior [24]. The study did not include knowledge or stocking of zinc as an outcome.

This paper examines the effectiveness of peer detailing as a method for improving correct knowledge and stocking patterns of ORS and zinc in the context of Nigeria and PPMVs. We rely on two outcome measures for the effectiveness of peer detailing—inventory of zinc and ORS at PPMVs and PPMV awareness that this combination is the most effective treatment. Specifically, we focus on answering the following questions. First, following peer detailing, is there a change in the inventory of ORS and zinc at PPMVs? Second, following peer detailing, does PPMV awareness of the most effective treatment for children's diarrhea improve?

The remainder of this paper is organized as follows. We first describe the data sets that were used as part of the analysis, and then we provide a detailed description of the exploratory data analysis, highlighting key findings. Next, we discuss the statistical methods used to analyze the data. The subsequent section describes our results regarding the effectiveness of peer detailing, based upon our statistical analysis. We then provide a further discussion of the key findings and the limitations of the current study. Finally, we suggest additional data collection programs and the insights they could potentially provide.

Data collection and description

In this section, we describe the survey data that was analyzed. We start by providing background about the peer

	Surveys	No. of samples	States covered	Survey date ranges
Before detailing	2015 3rd quarter	3,777	All (Bauchi, Cross Rivers, Kaduna, Kano, Katsina, Lagos, Niger, Rivers)	7/10/15-7/30/15
After	2015 4th quarter	2,675	Kano, Lagos, Rivers	11/20/15-12/22/15
detailing	2016 1st quarter	1,907	Bauchi, Cross Rivers, Kaduna, Katsina, Niger	1/30/16-2/23/16

Table 1Summary of survey statistics.

detailing process. Specifically, as mentioned, we focus on peer detailing that was implemented in eight states in Nigeria—Bauchi, Cross River, Lagos, Kano, Kaduna, Katsina, Niger, and Rivers. These states collectively account for 36% of children younger than 5 years in Nigeria [14].

Peer detailing involves NAPPMED leaders conducting shop-to-shop visits to mentor other PPMVs on diarrhea management. Before the peer detailing program, centralized, one-day trainings were conducted with PPMVs to orient them to the correct treatment for diarrhea. Through NAPPMED, CHAI encouraged PPMVs to join the one-day training, though PPMVs decided whether to opt in. In total, 17,849 PPMVs attended the one-day trainings. After the training, CHAI recruited and trained 583 NAPPMED executives on peer detailing. Peer detailing was designed to reinforce the messages disseminated at the centralized trainings. The detailers were trained on interpersonal skills and provided mobile devices installed with a softwaremonitoring tool to track how many peer detailing visits were made and to assist the peer detailers in identifying knowledge gaps during their visits. The peer detailers were expected to visit each PPMV in their respective LGA at least once per calendar quarter to provide them educational information regarding diarrhea case management and ORS and zinc. Peer detailers also left behind informational materials, such as posters, on ORS and zinc to reinforce appropriate provider behavior and encourage product stocking. Between August and December 2015, two cycles of peer detailing were conducted, and the monitoring data shows that 42,576 detailing visits were made.

To study the effect of peer detailing, independent surveys were conducted. The first survey, conducted between July 10 and July 30, 2015, before peer detailing (the "Before Detailing" survey), provided a measure of baseline PPMV understanding about diarrhea treatment and the medicines they stocked. This survey covered PPMVs in all eight states of interest in Nigeria. Subsequent to the peer detailing, a second survey was conducted in two phases (the "After Detailing" survey). The first phase occurred between November 20 and December 22, 2015, and the second occurred between January 30 and February 23 of 2016. These two phases jointly covered all eight states of interest in Nigeria (see **Table 1** for details).

The PPMV surveys were conducted with the intention of independently studying the effectiveness of the CHAI peer detailing program. The surveys sampled PPMVs independently from the peer detailing monitoring database. It was not possible to sample from the peer detailing monitoring database since the names of many PPMVs were identical, and the same PPMV may have been detailed more than once during the program, thus appearing more than once in the monitoring database. Additionally, one objective of sampling independently from the monitoring database was to assess whether peer detailers were systematically canvassing all PPMVs during their detailing or potentially detailing only certain PPMVs. To recruit PPMVs for the survey, PPMVs were randomly sampled using stratified multi-stage cluster sampling. The 2006 national census was used as the primary sampling frame. During the 2006 national census, the land area of Nigeria was divided into 665,000 smaller contiguous areas called enumeration areas (EAs). Prior to study selection, the EAs were stratified into urban EAs and rural EAs for each state, as defined by Nigeria's Population Commission (the only exception being Lagos, where all EAs are classified as urban). A computer-generated simple random sample of EAs was taken within each state, with approximately half of the EAs coming from urban areas and the other half from rural areas. Sampling was independent for each survey (Before Detailing and After Detailing). In the Before Detailing survey, the study sampled 80 EAs in Lagos, 144 EAs in Kano, 156 EAs in Rivers, 58 EAs in Bauchi, 58 EAs in Cross River, 55 EAs in Kaduna, 57 EAs in Katsina, and 56 EAs in Niger. In the After Detailing survey, the study sampled 80 EAs in Lagos, 146 EAs in Kano, 156 EAs in Rivers, 95 EAs in Bauchi, 95 EAs in Cross River, 88 EAs in Kaduna, 90 EAs in Katsina, and 90 EAs in Niger.

Using maps obtained from the Population Commission, trained interviewers walked the entire area of the EA and conducted a census of PPMVs in the EAs. In an effort to identify any PPMVs that may influence the health and wellness of individuals residing in any EA, interviewers were also tasked with interviewing community members and leaders to identify PPMVs outside the EA who were common sources of care for people living in the EA. After listing all PPMVs located within the EA and also PPMVs located outside the EA, but commonly used by community members residing in the EA, interviewers explained the survey to the PPMVs and requested verbal informed consent to conduct the survey. Interviewers conducted in-person surveys with PPMVs, asking a broad range of questions touching on subjects relating to knowledge and attitudes of PPMVs towards diarrhea and its treatments. The interviewer also recorded information about the quantities of medication in stock (inventory levels). To identify PPMVs that were detailed, interviewers asked, "In the last one month, were you visited by anyone promoting ORS and Zinc?" The data was captured electronically on Android smartphones programmed with the data collection app SurveyCTO.

The Before Detailing and After Detailing surveys both used the same survey instrument. Each survey consisted of five modules including PPMV identification, outlet characteristics, awareness and attitude to diarrhea treatments, medicine inventory audit, and marketing exposure. The survey aimed to collect data on availability of treatments of various children's diseases (e.g., diarrhea and pneumonia). Table 1 provides a summary of the number of PPMVs included in each survey as well as the timeframe for each of these activities.

From the surveys, we extracted the questions that provided insight into the PPMVs' overall awareness of the most effective treatment for children's diarrhea as well as questions that provided information regarding inventory levels of ORS and/or zinc. To determine whether the PPMV was aware of the most effective treatment for children's diarrhea, interviewers asked the PPMV what they would recommend for treating non-bloody diarrhea in a child younger than 5 years. Interviewers recorded the unprompted response of the PPMV using pre-coded, multiple choice options programmed into the data capturing software. If the PPMV selected only ORS and zinc-to the exclusion of any other treatment-then the PPMV was marked as being aware of the most effective treatment for diarrhea. A series of questions were used to determine whether the PPMV had individual ORS sachets in stock, individual zinc blister packs in stock, and ORS-zinc co-packages in stock. If the PPMV either had co-packages in stock or had both ORS sachets and individual zinc blister packs, then the PPMV was marked as having stock of ORS and zinc.

Discussions with subject-matter experts highlighted some confounding factors that may influence a PPMV's awareness of the most effective treatment for children's diarrhea as well as the chance that the PPMV will stock this treatment. For example, PPMV level of education, whether the PPMV has any health-related degree, PPMV location (rural versus urban), and whether the PPMV received any training on children's diarrhea (and if so how recently) were all suggested as factors that could impact PPMV stocking of the most effective treatment. Our analysis considered the potential impact of these confounding factors. **Table 2** lists the questions in the survey and also highlights the associated confounding factors.

Results

For our analysis, we deployed a variety of statistical techniques, including exploratory data analysis, descriptive analyses, and hypothesis testing.

Exploratory data analysis helped provide some initial insight into the data that was gathered in the surveys. Figure 1 shows the percentage of PPMVs with ORS and zinc inventory, in each of the eight states, before and after detailing. Based on the survey results, the percentage of PPMVs across the eight states in Nigeria included in our study (a case we refer to as "All") with ORS and zinc in stock after detailing is lower than the percentage prior to detailing. Looking at the results for each state, Cross River, Kaduna, and Kano show increased inventory levels, while Bauchi, Katsina, and Rivers display a noticeable decrease. These results suggest that detailing did not increase availability of ORS and zinc. We note, however, that factors that may contribute to inventory levels are complicated and may possibly involve warehouse supply issues, distribution networks, and profit considerations. In the "Discussion" section of this paper, we discuss this in greater detail and provide suggestions for additional data that may be collected and analyzed to yield further insights.

Figure 2 shows the percentage of PPMVs surveyed, before and after detailing, with awareness of the most effective treatment for children's diarrhea. We observe a noticeable increase in the percentage of PPMVs with awareness of the most effective treatment for children's diarrhea. With the exception of Katsina, all states in our study show an increase in the percentage of PPMVs with awareness of the most effective treatment. This suggests that peer detailing may have been successful in spreading information that the combination of ORS and zinc is the most effective treatment. The observed lack of inventory for zinc and ORS may potentially be associated with an increased distribution of treatment to patients rather than PPMV lack of awareness. This sort of co-dependence illustrates some of the challenges in evaluating the intervention.

Hypothesis tests

We conducted hypothesis tests to determine the significance of these changes before and after detailing. In particular, we conducted proportional z tests to determine whether there are significant differences in both proxy measures, i.e., the percentages of PPMVs with inventory of ORS and zinc as

No.	Type	Names	Descriptions	Survey question associated	Choices
CP1	_	Co-packs	Presence of co-packs of zinc and ORS in PPMV inventory.	Do you have a medication in stock today whereby ORS and Zinc are co-packaged?	Binary: Yes/No
ZN1	—	Zinc	Presence of zinc in PPMV inventory.	Do you have any ZINC tablets for treating diarrhea in stock today?	Binary: Yes/No
OR1		ORS	Presence of ORS in PPMV inventory.	Do you have any Oral Drip or ORS in stock today?	Binary: Yes/No
_	Response Variable	Zinc and ORS	Presence of co-packs or both Zinc and ORS in PPMV inventory.	Combination of results from the three questions above	
KA1	Response Variable	Knowledge	PPMV knowledge of the best treatment for children's diarrhea.	What treatments would you recommend to treat a child with diarrhea/stooling?	Binary: Yes/No
ME8	Independent Variable	Detailing	Detailed in the past month.	In the last month, were you visited by anyone promoting ORS and Zinc?	Binary: Yes/No
OC7	Confounding Factor	Degree	Health-related qualifications of PPMV workers.	Does anyone working in this place, including yourself (and the owner) have a health- related qualification?	Binary: Yes/No
ID5	Confounding Factor	Sector	Location of PPMV (urban or rural area).	_	Binary: Urban/Rural
OC9(A)	Confounding Factor	Training	Received diarrhea treatment related training in the past 3 years.	During the past 3 years, have you received any training on diarrhea treatment?	Multiple: Yes, within 1 year; Yes, 2–3 years ago; No

Table 2Features of interest and their associated survey questions.

well as the awareness that their combination is the most effective treatment for children's diarrhea. Here, the null hypothesis is that there is no increase in the proportion of PPMVs with inventory or awareness of the most effective treatment for children's diarrhea. The alternative hypothesis is that there is an increase in the corresponding proportions. In other words, we used one-tailed tests. We used 5% as the significance level. Note that the *z* statistic is calculated as

$$z = rac{p_{ ext{after}} - p_{ ext{before}}}{\sqrt{p_{ ext{all}}(1 - p_{ ext{all}}) \left(rac{1}{n_1} + rac{1}{n_2}
ight)}},$$

where p_{before} and p_{after} are the proportions of PPMVs with inventory or awareness of ORS and zinc before and after peer detailing, respectively; p_{all} is the pooled sample proportion; n_1 and n_2 are the numbers of samples (surveys) before and after peer detailing, respectively.

Inventory change before and after peer detailing **Table 3** provides (unnormalized) *z* statistics and their corresponding *p* values for one-sided proportional *z* tests of percentage increases of inventory of ORS and zinc, for all states combined and each state separately. No significant change is detected when analyzing consolidated results across all eight states. On a state level, however, Cross Rivers, Kaduna, and Kano display an increase in percentage of PPMVs with ORS and zinc after detailing compared with prior to detailing. These results are consistent with the results found in the exploratory data analysis. With respect to overall availability, there seems to be no evidence of an increase in percentage of PPMVs with inventory of ORS and zinc.

Knowledge change before and after peer detailing Similarly, **Table 4** provides (unnormalized) z statistics and their corresponding p values for one-sided proportional ztests of percentage increases of the PPMVs with awareness of the most effective treatment for children's diarrhea across all eight states and for each individual state. In contrast to the findings regarding treatment availability, a significant increase with respect to PPMVs with awareness of best treatment across all eight states is identified after detailing. On a state level, increases in percentages for all states except Katsina are significant. These results are also



Figure 1

Percentage of the PPMVs with inventory of zinc and ORS for all the samples and for each state.

consistent with the exploratory data analysis suggesting that the percentage of PPMVs with awareness of the most appropriate treatment for children's diarrhea increases after peer detailing.

Regression modeling

A logistic regression approach was taken to determine the proxy measures and peer detailing, after including relevant confounding factors. Specifically, we built simple models considering each covariate separately to determine the



Figure 2

Percentage of the PPMVs with proper knowledge of the best treatment for children's diarrhea for all the samples and for each state.

effect of the variable of interest as well as potential confounding factors without adjustment of other factors. Then, we developed more complex models with adjustment of confounding factors to investigate the effect of peer detailing on the inventory and knowledge level of the PPMVs. In addition, we analyzed the effects of the interaction between detailing and training to determine whether previous related training had an impact on the effect of detailing. For the regression analysis, we identify PPMVs as having been detailed in the previous month

Table 3 Proportional *z* tests for percentage change of inventory of zinc and ORS for (1) each of the eight states included in the study and (2) combined results across all eight states included in the study. The ** symbol indicates significant result.

	All	Bauchi	Cross Rivers	Kaduna	Kano	Katsina	Lagos	Niger	Rivers
Differences $(p_{after} - p_{before})$	-2.41	-10.68	16.23	13.09	7.89	-31.29	3.59	2.26	14.62
p values	0.986	0.999	0.001**	0.000**	0.000**	1.000	0.106	0.279	1.000

Table 4 Proportional *z* tests for percentage change of the PPMVs with proper knowledge of the most effective treatment for children's diarrhea for (i) each of the eight states included in the study and (ii) combined results across all eight states included in the study. The ** and * symbols indicate significant and marginally significant results, respectively.

	All	Bauchi	Cross Rivers	Kaduna	Kano	Katsina	Lagos	Niger	Rivers
Differences $(p_{after} - p_{before})$	4.89	5.35	22.49	22.48	3.52	-13.95	9.60	9.56	6.64
p values	0.000**	0.058*	0.000**	0.000**	0.064*	0.997	0.000**	0.007**	0.000**

Table 5	Logistic	regression	model	estimates	for	inventory	of zi	nc a	and	ORS	associated	with	the	peer	detailing.
C.I. refers t	to confide	ence interva	l. Refer	ent indicat	tes th	ne referenc	e leve	el ca	itego	rical	factors with	n mult	iple	choic	es.

Factors		Unadjusted		Adjusted					
	Odds ratio	95% C.I.	p value	Odds ratio 95% C.I. p value					
Detailing	1.998	(1.756, 2.270)	0.000	1.694 (1.478, 1.941) 0.000					
Degree	1.829	(1.626, 2.056)	0.000	1.418 (1.252, 1.606) 0.000					
Sector: Urban	1.487	(1.320, 1.675)	0.000	1.507 (1.330, 1.707) 0.000					
Training: <1 yr	Referent	_		Referent —					
Training: 2–3 yr	1.153	(0.979, 1.357)	0.088	1.207 (1.022, 1.425) 0.027					
Training: None	0.505	(0.442, 0.576)	0.000	0.622 (0.541, 0.716) 0.000					

based on responses to a question in the After Detailing surveys.

Association between inventory and peer detailing

As discussed in the section on data collection and description, we considered confounding factors that may influence the effectiveness of peer detailing. As a reminder, Table 2 provides a detailed description of these confounding factors. In **Table 5** we provide the estimated odds ratios from logistic regressions with and without adjustment of confounding factors for inventory of ORS and zinc.

When ignoring the confounding factors, the estimated odds ratio of holding inventory of zinc and ORS for PPMVs who were detailed and of those who were not detailed in the previous month is 1.998 [95% confidence interval (C.I.): 1.756 to 2.270]. This effect is significant. In logistic regressions of inventory with confounding factors, all confounding factors were identified as significant.

When considering confounding factors, keeping all other factors the same, the estimated odds ratio of holding inventory of zinc and ORS for PPMVs who were detailed and of those who were not detailed in the previous month is 1.694 (95% C.I.: 1.478 to 1.941). This effect is also

significant. Again, the effects of all confounding factors were significant.

Association between knowledge and peer detailing We next study the impact of peer detailing on PPMV awareness of the most effective treatment for children's diarrhea. **Table 6** provides estimated odds ratios from

diarrhea. **Table 6** provides estimated odds ratios from logistic regressions with and without adjustment of confounding factors.

Without consideration of confounding factors, the estimated odds ratio of awareness of the most effective treatment for PPMVs who were detailed and of those who were not detailed in the previous month is 2.497 (95% C.I.: 2.158 to 2.889). This effect is significant. In logistic regressions of inventory with confounding factors, all confounding factors were significant.

When considering confounding factors in a multiple regression model and keeping all other factors the same, the estimated odds ratio of awareness of the most effective treatment for PPMVs who were detailed and of those who were not detailed in the previous month is 1.861 (95% C.I.: 1.597 to 2.173). Again, this effect is significant and all the confounding factors were found to be significant.

 Table 6
 Logistic regression model estimates for proper knowledge of the most effective treatment for children's diarrhea associated with the peer detailing.

Factors		Unadjusted		Adjusted					
	Odds ratio	95% C.I.	p value	Odds ratio	95% C.I.	p value			
Detailing	2.497	(2.158, 2.889)	0.000	1.861	(1.597, 2.173)	0.000			
Degree	1.910	(1.689, 2.162)	0.000	1.306	(1.142, 1.493)	0.000			
Sector: Urban	1.306	(1.154, 1.478)	0.000	1.318	(1.153, 1.507)	0.000			
Training: <1 yr	Referent		—	Referent		—			
Training: 2–3 yr	0.766	(0.638, 0.919)	0.004	0.796	(0.662, 0.958)	0.016			
Training: None	0.330	(0.285, 0.381)	0.000	0.448	(0.385, 0.522)	0.000			

Factors		Inventory		Р	Proper knowledge			
	Odds ratio	95% C.I.	p value	Odds ratio	95% C.I.	p value		
Detailing	1.802	(1.467, 2.217)	0.000	1.662	(1.313, 2.106)	0.000		
Degree	1.274	(1.106, 1.467)	0.000	1.309	(1.142, 1.493)	0.000		
Sector: Urban	1.446	(1.255, 1.478)	0.000	1.317	(1.151, 1.505)	0.000		
Training: <1 yr	Referent		_	Referent		_		
Training: 2–3 yr	0.931	(0.736, 1.669)	0.554	0.777	(0.621, 0.974)	0.029		
Training: None	0.775	(0.640, 0.939)	0.009	0.419	(0.351, 0.500)	0.000		
Detailing * <1 yr	Referent		—	Referent				
Detailing * 2–3 yr	0.659	(0.458, 0.948)	0.025	1.059	(0.715, 1.567)	0.777		
Detailing * None	0.723	(0.511, 1.023)	0.068	1.332	(0.936, 1.896)	0.111		

 Table 7
 Logistic regression model estimates for inventory and proper knowledge of the most effective treatment for children's diarrhea associated with the peer detailing interacted with training history. The * symbol indicates interaction terms.

Association between inventory/knowledge and interaction of detailing and training

Prior studies have shown that previous training (within 1 year or in 2 to 3 years) has a positive effect on both inventory and awareness of the most effective treatment of children's diarrhea. Here, we study whether this related training can enhance the effect of detailing. **Table 7** provides estimated odds ratios from logistic regressions with interaction of detailing and training for inventory and proper knowledge of the most effective treatment for children's diarrhea.

With respect to inventory of both zinc and ORS, keeping all other factors the same, the effect of detailing on PPMVs who received related training within a year is significantly higher than on PPMVs who received training 2 to 3 years prior or who never received training. This is suggestive of the potential benefit of frequent information dissemination as this may result in PPMVs maintaining higher levels of inventory of ORS and zinc.

On the other hand, regarding awareness of the most effective treatment for children's diarrhea, keeping other factors the same, there is no significant effect of detailing for PPMVs who previously (within 1 year or 2 to 3 years prior) received related training compared with those who never received training.

Discussion

In this section, we discuss lessons learned from the process of applying data analysis techniques to a pre-existing real-world survey dataset and also highlight some potential implications of our work. We begin by delving into the limitations of the study. Since one of our objectives was to provide initial recommendations to guide the program's future strategies, we also provide suggestions on additional data collection activities that could potentially be instituted, along with the analyses and insights that they may enable.

Study limitations

A limitation of our study is that a complete database of PPMVs is nonexistent, as PPMVs are informal drug sellers who, due to regulatory challenges, often operate without registering with the PCN. PPMVs open and close their businesses frequently. As a result, the study utilized a random sampling procedure adopted from other similar drug outlet studies [25]. A result of the random sampling data collection strategy was that the same PPMVs were not necessarily surveyed before and after detailing. As such, we were unable to accurately pair before-and-after detailing responses for each PPMV. Such a pairing would have provided the benefit of yielding additional insight into PPMV behavior and into the effectiveness of the CHAI program. Further, our analysis relied on the assumption that the random samples collected for each survey are representative of the universe of PPMVs in the region of study. However, it is difficult to verify whether the samples collected are representative of the large number of PPMVs in Nigeria, particularly as there is a rapidly changing status of these workers.

Another challenge is the inability to understand the effect of peer detailing on the most pertinent measures, such as actual dispensing practices by PPMVs or the number of diarrheal deaths. Other studies have shown informal healthcare providers do not often practice what they know, even for seemingly simple-to-treat diseases such as diarrhea [21, 26]. Measuring actual practice through direct observation, standardized patient interviews, or client exit interviews would provide better measures of provider practice.

The limited time period over which data was collected restricted our ability to analyze the impact of potentially important factors such as pre-existing time trends. Absent multiple years of historical data, we were unable to measure the possible impact of seasonality in inventory or cyclical patterns in the disease.

Classification of PPMVs regarding whether they were detailed may also be subject to recall bias, since PPMVs self-reported this in the survey. We were unable to match PPMVs from the detailing database to the surveys since the names of PPMVs and their shops were not uniquely identifiable. We find no reason for PPMVs to misreport being detailed other than a general positive response bias. Additionally, the recall period for detailing was one month, and this short recall period did not cover the entire detailing period from August to December 2015. Peer detailers were expected to detail all PPMVs in their area, once a quarter. Thus, some PPMVs detailed more than a month in the past may have been classified as having not been detailed due to the short recall period.

As we have alluded to earlier, a host of potential confounding factors may have an impact on the accuracy of our findings. For example, our data set does not contain information regarding differences in education levels of PPMV owners. Other important factors that could be relevant include the locations of medication storage facilities, roads (availability and conditions), regional health differences, etc. Absent available data on these and other potential confounding factors, we recognize that the conclusions of this study serve as a preliminary indication of the effectiveness of peer detailing. Availability of more data would likely provide more substantial insights regarding the information dissemination activities.

Suggestions for future activities

Our results hint that the recency of detailing and training is important, but the collection of longitudinal data would enable a better understanding of this phenomenon. Analytical time series and intervention models with specific functional forms that measure the knowledge decay of detailing could be fit to such data. The results of these models could then be used to optimize detailing schedules. However, we acknowledge that such longitudinal data may be difficult to collect. Specifically, discussions with subject matter experts have identified two challenges. First, it is difficult to uniquely identify PPMVs, since many have similar names. As such, a database that records names of each PPMV would prove to be difficult to maintain. We also considered uniquely identifying the location of PPMV shops based upon their geocoordinates. This too proved to be challenging as many are in close spatial proximity. An additional challenge in maintaining an accurate listing of PPMV shops is the frequency with which these shops open and close.

Another suggested stream of analysis is to characterize how additional features—such as gender, location, years of experience, and the education level of PPMVs have an impact on the effectiveness of detailing. With the impact of these factors better understood, these insights may be used to prioritize and schedule detailing efforts to maximize health outcomes. Such analysis requires sufficient samples to identify significant relationships regarding these features, as well as data connecting the stocking of ORS and zinc to actual morbidity and mortality data as well as disease burden information, which is difficult to acquire at the appropriate granularity.

The intent of our study was to measure the benefits of peer detailing. It is clear that true benefit would be gauged by associating the intervention with improved health outcomes and reduced number of deaths in the geographical areas in which the detailing was deployed. As mentioned earlier, improved PPMV knowledge of the most effective treatment for diarrhea as well as changes in inventory levels are only intermediate process measures of the true desired improved outcomes that one hopes to measure. We suggest future studies include measurements of patient health outcomes using household surveys and measurements of provider practice using standardized patient interviews, client exit interviews, and direct observation.

Finally, as our results also hint, the overall problem of disseminating the most effective treatment for diarrhea is as much a supply and distribution issue as it is a PPMV education issue. We suggest future research involving mathematical modeling formulations to help study these issues in detail; problems of potential interest include, but are not limited to, decisions regarding warehouse location to minimize the cost of distribution, allocation of ORS and zinc stock to maximize impact, and determining who to train for detailing—and more generally, allocating resources for detailing activities.

Conclusions

In this paper, we presented an initial data analysis of surveys to study the effectiveness of peer detailing in the context of an ORS/zinc program in Nigeria. Based on the results of hypothesis tests and logistic regressions, we find some evidence that peer detailing improves the PPMVs' overall knowledge of the most effective treatment for children's diarrhea. The percentage of PPMVs with awareness of the most effective treatment increased in seven of the eight states included in our study. Analysis of logistic regressions reveals the estimated odds ratio of awareness of the most effective treatment for PPMVs who were detailed and of those who were not detailed in the previous month is 1.861 (95% C.I.: 1.597 to 2.173), given the other confounding factors remain the same.

On the other hand, it is difficult to identify general patterns over the entire survey area regarding the impact of detailing on inventory levels. At a state level, compared to the percentage of PPMVs with inventory of zinc and ORS before detailing, Cross Rivers, Kaduna, and Kano show significant increases after detailing. In addition, the logistic regression analysis suggests that detailed PPMVs have higher odds of having both zinc and ORS in stock as compared with PPMVs that were not detailed in the previous month, given other confounding factors remain the same. That is, the detailed PPMVs are more likely to have both zinc and ORS in stock, while no significant increase can be detected on the overall inventory of the region. This suggests that further investigation should be conducted to learn about the supply distribution.

The differences in the impact of detailing on inventory levels and awareness of the most effective treatment for childhood diarrhea suggest that additional activities are required to address the high-level objective of reducing diarrhea-related death in Nigeria among children. The lack of proper awareness of the most effective treatment for children's diarrhea may not be the sole issue preventing children in need from receiving zinc and ORS.

Ethical considerations

Ethical approval for the CHAI surveys was obtained from the National Health Research Ethics Committee of Nigeria (NHREC). All PPMVs were provided information on the benefits and risks of the study, and verbal informed consent was sought prior to the interviews. CHAI also obtained permission from each of the state governments.

Acknowledgments

The Norwegian Agency for Development Cooperation (NORAD) and Global Affairs Canada (GAC) funded the implementation of CHAI's program and data collection. Practical Sampling Institute Nigeria (PSI) implemented the survey data collection. This project was conducted under the auspices of the IBM Science for Social Good initiative.

References

- L. Liu, S. Oza, D. Hogan, Y. Chu, J. Perin, J. Zhu, J. Lawn, S. Cousens, C. Mathers, and R. Black, "Global, regional, and national causes of under-5 mortality in 2000-15: An updated systematic analysis with implications for the sustainable development goals," *Lancet*, vol. 388, no. 10063, pp. 3027–3035, 2016.
- H. Wang, M. Naghavi, C. Allen, R. Barber, Z. Bhutta, and A. Carter, "Global, regional, and national life expectancy, allcause mortality, and cause-specific mortality for 249 causes of death, 1980-2015: A systematic analysis for the Global Burden of Disease Study 2015," *Lancet*, vol. 388, no. 10053, pp. 1459–1544, 2016.
- C. Walker, I. Rudan, L. Liu, H. Nair, E. Theodoratou, Z. Bhutta, KL O'Brien, H Campbell, and RE Black, "Global burden of childhood pneumonia and diarrhea," *Lancet*, vol. 381, no. 9875, pp. 1405–1416, 2013.
- Z. Bhutta, J. Das, N. Walker, A. Rizvi, H. Campbell, I. Rudan, R. Black, and Lancet Diarrhoea and Pneumonia Interventions Study Group, "Interventions to address deaths from childhood pneumonia and diarrhoea equitably: What works and at what cost?" *Lancet*, vol. 381, no. 9875, pp. 1417–1429, 2013.

- S. Huttly, S. Morris, and V. Pisani, "Prevention of diarrhoea in young children in developing countries," *Bull. World Health Org.*, vol. 75, no. 2, pp. 163–174, 1997.
- 6. The United Nations Children's Fund/World Health Organization, "WHO/UNICEF joint statement: Clinical management of acute diarrhoea," 2004. [Online] Available: https://www.unicef.org/ nutrition/files/ENAcute_Diarrhoea_reprint.pdf
- M. Munos, C. Fischer Walker, and R. Black, "The effect of oral rehydration solution and recommended home fluids on diarrhoea mortality," *Int. J. Epidemiology*, vol. 39, pp. 75–87, 2010.
- C. Fischer Walker, I. Friberg, N. Binkin, M. Young, N. Walker, O. Fontaine, E. Weissman, A. Gupta, and R. Black, "Scaling up diarrhea prevention and treatment interventions: A lives saved tool analysis," *PLoS Med.*, vol. 8, no. 3, Mar. 22, 2011, Art. no. e1000428, doi:10.1371/journal.pmed.1000428.
- 9. T. Wardlaw, P. Salama, C. Brocklehurst, M. Chopra, and E. Mason, "Diarrhoea: Why children are still dying and what can be done," *Lancet*, vol. 375, no. 9718, pp. 870–872, 2010.
- C. Unger, S. Salam, S. Sakar, R. Black, A. Cravioto, and S. Arifeen, "Treating diarrhoeal disease in children under five: The global picture," *Arch. Dis. Child*, vol. 99, pp. 273–278, 2014.
- L. Carvajal-Velez, A. Amouzou, J. Perin, A. Maiiga, H. Tarekegn, A. Akinyemi, S. Shiferew, M. Young, J. Bryce, and H. Newby, "Diarrhea management in children under five in sub-Saharan Africa: Does the source of care matter? A Countdown analysis," *BMC Public Health*, vol. 16, 2016, Art. no. 830.
- Clinton Health Access Initiative, shaping local markets to scale-up zinc and oral rehydration salts in Nigeria, 2016. [Online] Available: http://www.clintonhealthaccess.org/content/uploads/ 2016/02/Progress-over-a-Decade-of-Zinc-and-ORS-Scale-Up.pdf
- Federal Ministry of Health, National Primary Health Care Development Agency [Nigeria], "Essential childhood medicines scale-up plan: 2012-2015," 2012. [Online] Available: http:// ccmcentral.com/wp-content/uploads/2016/01/c.-Nigeria_ EssentialMedicinesScaleUpPlan_SIGNED_PRINT.pdf
- National Population Commission (NPC) [Nigeria], "National population census 2006," 2006. [Online] Available: http://www. population.gov.ng/index.php/censuses
- National Population Commission (NPC) [Nigeria] and ICF International, "Nigeria demographic and health survey 2013," 2013. [Online] Available: http://dhsprogram.com/pubs/pdf/ FR293/FR293.pdf
- W. Brieger, P. Osamor, K. Salami, O. Oladepo, S. Otusanya, "Interactions between patent medicine vendors and customers in urban and rural Nigeria," *Health Policy Planning*, vol. 19, no. 3, pp. 177–182, 2004.
- L. Prach, E. Treleaven, C. Isiguzo, and J. Liu, "Care-seeking at patent and proprietary medicine vendors in Nigeria," *BMC Health Services Res.*, vol. 15, no. 1, 2015, Art. no. 231.
- J. Liu, L. Prach, E. Treleaven, M. Hansen, J. Anyanti, T. Jagha, V. Seaman, O. Ajumobi, and C. Isiguzo, "The role of drug vendors in improving basic health-care services in Nigeria," *Bull. World Health Org.*, vol. 94, no. 4, pp. 267–275, 2016.
- J. Barnes, T. Chandani, and R. Feeley, "Nigeria private sector health assessment," Private Sector Partnerships-One Project, Abt Associates Inc., 2008. [Online] Available: http://www. shopsproject.org/sites/default/files/resources/5137_file_ FINAL_Nigeria_Private_Sector_Health_Assessment_rev.pdf
- C. Walker, S. Taneja, A. LeFevre, R. Black, and S. Mazumder, "Appropriate management of acute diarrhea in children among public and private providers in Gujarat, India: A cross-sectional survey," *Global Health: Sci. Pract.*, vol. 3, no. 2, pp. 230–241, 2015.
- W. Friedman, B. Woodman, and M. Chatterji, "Can mobile phone messages to drug sellers improve treatment of childhood diarrhoea?—A randomized controlled trial in Ghana," *Health Policy Planning*, vol. 30, suppl_1, pp. i82–i92, 2015.
- M. Mohanan, K. Babiarz, J. Goldhaber-Fiebert, G. Miller, and M. Vera-Hernandez, "Effect of a large-scale social franchising and telemedicine program on childhood diarrhea and pneumonia outcomes in India," *Health Affairs*, vol. 35, no. 10, pp. 1800–1809, 2016.

- 23. T. Aung, D. Montagu, H. Khin, A. San, and W. McFarland, ORS+Zinc Study Group, "Impact of a social franchising program on uptake of oral rehydration solution plus zinc for childhood diarrhea in myanmar: A community-level randomized controlled trial," *J. Tropical Pediatrics*, vol. 60, no. 3, pp. 189–197, 2014.
- E. Treleaven, J. Liu, L. Prach, and C. Isiguzo, "Management of paediatric illnesses by patent and proprietary medicine vendors in Nigeria," *Malaria J.*, vol. 14, no. 232, 2015, Art. no. 232.
- 25. K. O'Connell, S. Poyer, T. Solomon, E. Munroe, E. Patouillard, J. Njogu, I. Evance, K. Hanson, T. Shewchuk, and C. Goodman., "Methods for implementing a medicine outlet survey: Lessons from the anti-malarial market," *Malaria J.*, vol. 12, no. 52, 2012, Art. no. 52.
- J. Das, A. Holla, V. Das, M. Mohanan, D. Tabak, and B. Chan, "In urban and rural India, a standardized patient study showed low levels of provider training and huge quality gaps," *Health Affairs*, vol. 30, no. 12, pp. 2774–2784, 2012.

Received January 13, 2017; accepted for publication February 8, 2017

Yumeng Tao Civil and Environmental Engineering, University of California, Irvine, CA 92697 USA (yumengt@uci.edu). Ms. Tao is a Ph.D. candidate in the Civil Engineering Department at University of California, Irvine. Her Ph.D. work focuses on application of deep neural networks to precipitation estimation from satellite information. She was a Science for Social Good Fellow in the IBM Thomas J. Watson Research Center in the summer of 2016. She received her M.S. degrees in both Statistics and Civil Engineering from University of California, Irvine.

Debarun Bhattacharjya IBM Research, Thomas J. Watson Research Center, Yorktown Heights, NY 10598 USA (debarunb@us. ibm.com). Dr. Bhattacharjya is a Research Staff Member in the Cognitive Computing Research division at the IBM T. J. Watson Research Center. He holds M.S and Ph.D. degrees in management science and engineering from Stanford University and a B. Tech. degree in industrial and production engineering from the Indian Institute of Technology, Delhi. His research is in decision analysis, as applied to various problems in management science, artificial intelligence and machine learning. His applied work has spanned domains including energy, sales, business services, transportation, and public policy.

Aliza R. Heching IBM Research, Thomas J. Watson Research Center, Yorktown Heights, NY 10598 USA (ahechi@us.ibm.com). Dr. Heching is a Research Staff Member at the IBM T. J. Watson Research Center. She received her Ph.D. degree in operations research from Columbia University Graduate School of Business. Her research interests concern the modeling, analysis, and optimization of service systems with a focus on healthcare.

Aditya Vempaty IBM Research, Thomas J. Watson Research Center, Yorktown Heights, NY 10598 USA (avempat@us.ibm.com). Dr. Vempaty is a Research Staff Member at the IBM T. J. Watson Research Center. He received his B.Tech. degree in electrical engineering from the Indian Institute of Technology, Kanpur, in 2011, and his Ph.D. degree in electrical engineering from Syracuse University in 2015. His research interests include human-machine inference networks, data analytics and statistical signal processing, and network security. He received the Syracuse University Graduate Fellowship award in 2013 and the All University Doctoral Prize 2016 from Syracuse University for superior achievement in completed dissertations.

Moninder Singh IBM Research, Thomas J. Watson Research Center, Yorktown Heights, NY 10598 USA (moninder@us.ibm.com). Dr. Singh has been with IBM Research since 1998. He received his Ph.D. degree in computer and information science from the University of Pennsylvania in 1998. Dr. Singh is a member of the Data Science Department and is primarily interested in developing and deploying solutions for interesting problems in business analytics and decision support. His main research areas are machine learning and data mining, data privacy, information retrieval, probabilistic modeling and reasoning, and text mining.

Felix Lam Clinton Health Access Initiative (CHAI), Boston, MA 02127 USA (flam@clintonhealthaccess.org). Mr. Lam is a Monitoring and Evaluation Senior Manager at the Clinton Health Access Initiative. He received a B.A. degree in economics from University of California, Berkeley, in 2007 and an M.S. degree in public health from the Harvard T.H. Chan School of Public Health in 2011. He subsequently joined CHAI, where he is working on implementation research in malaria, diarrheal disease, and pneumonia.

Jason Houdek Clinton Health Access Initiative (CHAI), Boston, MA 02127 USA (jhoudek@clintonhealthaccess.org). Mr. Houdek is a Senior Technical Advisor for the Essential Medicines program at CHAI. He received a B.Sc. degree in molecular and cellular biology at University of Michigan in 2007 and an MPH degree from Tulane University School of Public Health and Tropical Medicine in 2009. Mr. Houdek was an Allan Rosenfield Global Health Fellow from 2009 to 2011. He provides technical and management support to CHAI's Essential Medicines program.

Mohammed Abubakar Clinton Health Access Initiative (CHAI), Maitama, Abuja, 900271 Nigeria (mabubakar@clintonhealthaccess. org). Mr. Abubakar is a Monitoring and Evaluation Senior Associate at the CHAI. He received a B.Sc. degree in Industrial Chemistry from Bayero University, Kano, in 2006. He subsequently joined The Nielsen Company Nigeria and served as a Senior Research Executive until 2014. He joined the CHAI in 2014, where oversees implementation research in diarrheal disease and pneumonia.

Ahmad Abdulwahab Clinton Health Access Initiative (CHAI), Maitama, Abuja, 900271 Nigeria (aabdulwahab@clintonhealthaccess. org). Dr. Abdulwahab is the Deputy Country Director CHAI Nigeria and the Program Director for Essential Medicines. He received an M.B. B.S. degree from University of Maiduguri, Nigeria, in 1994 and an MPH degree from Ahmadu Bello University, Nigeria, in 2001. Dr. Abdulwahab oversees all aspects of CHAI's Essential Medicines Program.

Tiwadayo Braimoh Clinton Health Access Initiative (CHAI), Maitama, Abuja, 900271 Nigeria (tbraimoh@clintonhealthaccess.org). Mr. Braimoh is a Senior Manager at CHAI where he develops and leads the implementation of strategies for improving the demand for ORS and zinc in Nigeria. He has extensive expertise in health program management and pharmaceutical business development, marketing, and sales. He earned a Bachelor of Pharmacy degree from Ahmadu Bello University, Zaria, in 2001 and an M.B.A. degree from University of Lagos in 2010. He is a Fellow of the West African Postgraduate College of Pharmacists and Member of the Pharmaceutical Society of Nigeria.

Nnenna lhebuzor National Primary Health Care Development Agency (NPHCDA), Garki, Abuja, 900247 Nigeria

(*inennaihebuzor@yahoo.com*). Dr. Ihebuzor is the Director of Primary Health Care Systems Development at NPHCDA. She earned an M.B.B. S. degree from the University of Ibadan and a MPH from the University of Lagos. She was also a British Chevening Scholar at the University of London and earned a M.Sc. with distinction in Mother and Child Health. Dr. Ihebuzor was awarded a fellowship in pediatrics by the West African College of Physicians. She is also Chair of the National Essential Medicines Coordinating Mechanism, which is implementing the country's Essential Childhood Medicines Scale-Up Plan to reduce childhood mortality due to pneumonia, diarrhea, and malaria.

Aleksandra Mojsilović IBM Research, Thomas J. Watson Research Center, Yorktown Heights, NY 10598 USA (aleksand@us.ibm. com). Dr. Mojsilović is an IBM Fellow and scientist at the IBM T. J. Watson Research Center. She received her Ph.D. degree in electrical engineering from the University of Belgrade, Belgrade, Serbia in 1997. She was a Member of Technical Staff at the Bell Laboratories (1998-2000), and then joined IBM Research, where she currently leads the Data Science Department. Dr. Mojsilović is a founder and co-director of the IBM Science for Social Good initiative. Her research interests include multidimensional signal processing, predictive modeling, and pattern recognition. She has applied her skills to problems in computer vision, healthcare, multimedia, finance, human resources, public affairs and economics. She is one of the pioneers of business analytics at IBM and in the industry; throughout her career she championed innovative uses of analytics for business decision support. For her technical contributions and the business impact of her work Dr. Mojsilović was appointed an IBM Fellow, the company's highest technical honor. She is the author of over 100 publications and holds 16 patents. Her work has been recognized with several awards including IEEE Signal Processing Society Young Author Best Paper Award, Institute for Operations Research and the Management Sciences (INFORMS) Wagner Prize,

IBM Extraordinary Accomplishment Award, IBM Gerstner Prize, and Best Paper awards at the European Conference on Computer Vision (ECCV) and the Conference on Service Operations and Logistics, and Informatics (SOLI). She is an IEEE Fellow and a member of INFORMS and Society of Women Engineers (SWE).

Kush R. Varshney IBM Research, Thomas J. Watson Research Center, Yorktown Heights, NY 10598 USA (krvarshn@us.ibm.com). Dr. Varshney is a Research Staff Member and manager in the Data Science Department at the IBM T. J. Watson Research Center. He received his Ph.D. degree in electrical engineering and computer science from the Massachusetts Institute of Technology in 2010. He applies data science and predictive analytics to human capital management, healthcare, olfaction, public affairs, and international development. He conducts academic research on the theory and methods of statistical signal processing and machine learning. His work has been recognized through best paper awards at the 2009 International Conference on Information Fusion, 2013 IEEE Conference on Service Operations and Logistics, and Informatics (SOLI), 2014 ACM SIGKDD (Association for Computing Machinery's Special Interest Group on Knowledge Discovery and Data Mining), Conference on Knowledge Discovery and Data Mining, and 2015 SIAM (Society for Industrial and Applied Mathematics) Conference on Data Mining (SDM). Dr. Varshney is codirector of the IBM Science for Social Good initiative.