Statistical Analysis of Peer Detailing for Children's Diarrhea Treatments

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Abstract

Diarrhea is one of the leading killers of children under five years old in Nigeria. To tackle this challenge, many activities were conducted by government institutions, non-governmental organizations, and private companies to promote the usage of the best treatment for the disease: the combination of Zinc and Oral Rehydration Salts (ORS). One of the activities, undertaken by the Clinton Health Access Initiative (CHAI), is hiring and training peer detailers to explain the benefits of the treatment to patent and proprietary medicine vendors (PPMVs), a major source of primary healthcare in Nigeria. This paper investigates the effectiveness of this information dissemination program for treatments of children's diarrhea in Nigeria. Two aspects are considered when evaluating the effectiveness of the program: awareness (knowledge) and availability (inventory) of Zinc and ORS among PPMVs. We performed exploratory data analysis and statistical hypothesis tests, and found that the percentage of PPMVs with the desired knowledge of treatments for children's diarrhea increases significantly in most states in Nigeria after the peer detailing. On the other hand, no significant patterns are detected for the percentage of PPMVs with inventory of the treatments. Logistic regression models with confounding factors suggest that PPMVs promoted by CHAI have significantly higher ratios of both the knowledge and inventory of the best treatment for children's diarrhea.

Introduction

As the second leading killer of children, diarrhea is responsible for more than 700,000 deaths globally each year (Black *et al.*, 2008; Treleaven *et al.*, 2015). Combining Zinc and Oral Rehydration Salts (ORS) has been identified as the most effective treatment, preventing over 90% of diarrhea-related deaths among children (Beyeler *et al.*,

2015; Wardlaw *et al.*, 2010). However, few children in need are receiving this treatment. The reasons for non-usage of the best treatment for diarrhea are multifaceted, possibly involving information asymmetries, decision-theoretic considerations by health providers, and deficiencies in supply (CHAI, 2011). Nigeria ranks near the top in terms of diarrhea burden with an estimated 81,000 deaths each year (Fischer Walker, *et al.*, 2013). To address this challenge, the Ministry of Health (MOH) of Nigeria has developed a National Essential Medicines Scale-up Plan and established a National Essential Medicines Coordinating Mechanism (NEMCM) to bring together resources and investments from government institutions, non-government organizations, and private companies. The Clinton Health Access Initiative (CHAI) is one of the partners supporting the MOH to undertake activities to promote the usage of Zinc and ORS in Nigeria (CHAI, 2016). One specific investment is information dissemination of the best treatment to patent and proprietary medicine vendors (PPMVs), a major source of primary healthcare, conducted by peer detailers (Brieger *et al.*, 2004; Prach *et al.*, 2015).

In this study, we aim to determine whether the peer detailing is effective. We use PPMV inventory of Zinc and ORS as well as their knowledge of these treatments as measures of effectiveness. The results further support CHAI's budget-constrained decisions for future data collection and information dissemination strategies. Specifically, we focus on answering the following questions.

- Does the inventory of Zinc and ORS increase at PPMVs after peer detailing;
- Does PPMV knowledge of the best treatment for children's diarrhea (Zinc and ORS) improve after the peer detailing;
- What is the impact of the peer detailing on the inventory and the knowledge of the best treatment for children's diarrhea; is this impact significant.

	Surveys	# Samples	States Covered	Survey Date Ranges
Before Detailing	2015 3rd Quarter	3777	All (Bauchi, Cross Rivers, Kaduna, Kano, Katsina, Lagos, Niger, Rivers)	7/10/15 – 7/30/15
Detailing	1st Round	29608	All (Bauchi, Cross Rivers, Kaduna, Kano, Katsina, Lagos, Niger, Rivers)	8/11/15 – 11/17/15
After Detailing	2015 4th Quarter	2675	Kano, Lagos, Rivers	11/20/15 – 12/22/15
	2016 1st Quarter	1907	Bauchi, Cross Rivers, Kaduna, Katsina, Niger	1/30/16 – 2/23/16

Table 1 Basic Statistics of the Surveys

Data Availability and Description

This section describes the basic statistics of the survey data collected before and after the peer detailing. The surveys conducted by CHAI cover a broad range of questions touching on knowledge and attitudes of the PPMVs towards diarrhea and its treatments. Medicine inventory information was also collected at the same time. In addition, for each survey, random samples were selected independently. Our analysis focuses on the first round of peer detailing, conducted from August to November, 2015. The coverage of this peer detailing is eight states in Nigeria.

Table 1 summarizes basic statistics for the surveys conducted before and after the peer detail, including number of samples, the states covered, and the survey date ranges. The first round of the peer detailing is conducted from mid-August to mid-November in 2015, covered all eight states, involved near 30,000 PPMVs. As presented in Table 1, the survey conducted in the 3rd quarter of 2015, covering all eight states, occurred before the peer detailing. Subsequent to the detailing, surveys were conducted: one in the fourth quarter of 2015 and one the first quarter of 2016. Combining these surveys, we have a complete coverage of all eight states (the former covers three states and the latter covers five states). The survey conducted in the third quarter of 2015 and the combined surveys in the fourth quarter of 2015 and in the first quarter of 2016 are referred as before detailing and after detailing in the remainder of the paper.

Table 2 provides number of samples for each state of surveys before and after the detailing. The sample amounts are roughly similar before and after the detailing for most states.

Statistical Methods

Throughout this analysis, a variety of statistical techniques are used including common graphing techniques, hypothesis test and logistic regression models.

To explore raw survey data, multiple statistics and figures are provided. Histograms present the changes of inventory and knowledge over different states.

Hypothesis tests are applied to identify the significance of the change. Particularly, proportional z-tests are conducted to determine whether there are significant changes in the percentages of PPMVs with inventory and proper knowledge on children's diarrhea, respectively.

Logistic regression model is employed to determine the relationship between the inventory or the knowledge and the peer detailing as well as other confounding factors. Specifically, simple models considering each covariate separately are built to determine the effects of the variable of interest as well as potential confounding factors without adjustment of other factors. Then more complex models with adjustment of confounding factors are produced to investigate the effect of peer detailing on the inventory and knowledge level of the PPMVs.

Exploratory Data Analysis

This section presents the descriptions and the exploratory analyses of the features of interests and potential confounding factors.

Table 3 summarizes the features of interests and their corresponding questions in the survey, including the inventory of the co-packs of zinc and ORS, overall inventory of zinc and ORS, and knowledge regarding children's diarrhea treatment.

	Bauchi	Cross Rivers	Kaduna	Kano
Before Detailing	351	185	322	744
After Detailing	471	191	688	1076
	Katsina	Lagos	Niger	Rivers
Before Detailing	191	618	304	1056
After Detailing	188	592	369	1007

Table 2 Number of Samples for Each State

Type	Names	Descriptions	Survey Question Associated	Choices
-	Co-packs	Whether the PPMV has Co-packs of Zinc and ORS in inventory	Do you have a medication in stock today whereby O.R.S. and Zinc are co-packaged?	Binary: Yes/No
-	Zinc	Whether the PPMV has Zinc in inventory	Do you have any ZINC tablets for treating diarrhea in stock today?	Binary: Yes/No
-	ORS	Whether the PPMV has ORS in inventory	Do you have any Oral Drip or O.R.S. in stock today?	Binary: Yes/No
Response Variable	Zinc & ORS	Whether the PPMV has Co-packs or both Zinc and ORS in inventory	Combination of results from the three questions above	-
Response Variable	Knowledge	Whether the PPMV has proper knowledge of the best treatment for children's diarrhea	What treatments would you recommend to treat a child with diarrhea/stooling?	Binary: Yes/No*
Independent Variable	Detailing	Whether the participant was detailed in the past month	In the last month, were you visited by anyone promoting O.R.S. and Zinc?	Binary: Yes/No
Confounding Factor	Degree	Whether the PPMV has someone with health-related qualification	Does anyone working in this place, including yourself (and the owner) have a health-related qualification?	Binary: Yes/No
Confounding Factor	Sector	Whether the PPMV locates in urban or rural idea	-	Binary: Urban/Rural
Confounding Factor	Training	Whether and when the participant received training on diarrhea	During the past 3 years, have you received any training on the diarrhea?	Multiple: Yes, within 1 year; Yes, 2-3 years ago; No

* Multiple Choices are provided in the survey. Only the selection of both Zinc and ORS with no other choices is considered to have proper knowledge on the best treatment for children's diarrhea.

Table 3 Features of Interests and Their Associated Survey Questions

The response variables of interest are the PPMVs' inventory of Zinc and ORS and their knowledge of the best treatment for children's diarrhea. As shown in Table 3, Zinc and ORS can be stocked separately or as a co-package. We combined both cases by indicating a PPMV with inventory of Zinc and ORS if they have the co-package in stock or they have both Zinc and ORS in stock. Knowledge of the best treatment for children's diarrhea is identified by a multiple choice question in the survey, which provided a list of possible treatments for children's diarrhea. A PPMV is considered to have proper knowledge of the best treatment if and only if they selected both Zinc and ORS and no other treatments from the list.
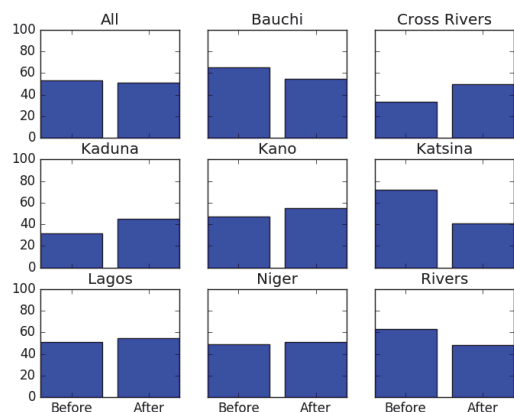

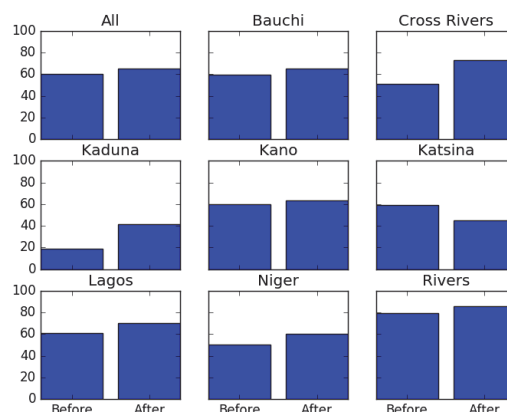*Figure 1 Percentage of the PPMVs with inventory of Zinc & ORS for the country and each state*

Figure 2 Percentage of the PPMVs with proper knowledge of the best treatment for children's diarrhea for the country and each state

	All	Bauchi	Cross Rivers	Kaduna	Kano	Katsina	Lagos	Niger	Rivers
z-statistics	2.194	3.080	-3.189	-3.948	-3.313	6.148	-1.250	-0.585	6.681
P-values	0.986	0.999	0.001**	0.000**	0.000**	1.000	0.106	0.279	1.000

** denotes significant results.

Table 4 Proportional z-tests for percentage increases of inventory of Zinc & ORS for the country and each state

For regression analyses of the association between the inventory or knowledge and the peer detailing, we identify PPMVs being detailed in the previous month based on the corresponding question in the surveys conducted after the peer detailing. In addition, a few potential confounding factors are selected based on the experts' opinion, such as whether someone in the PPMV holds a health-related degree, whether the PPMV is located in an urban or rural area, and whether and when the participant received education on diarrhea.

Figure 1 and Figure 2 show the percentages of PPMVs before and after detailing, respectively, with inventory of Zinc and ORS that have knowledge of the treatment for children's diarrhea. Both figures include percentages for the overall country as well as for each state individually.

As shown in Figure 1, there is a slight decrease of the percentage of PPMVs with inventory of Zinc and ORS for the country. This suggests that the peer detailing did not increase overall inventory for the covered regions. Comparing the detailed percentages for different states, a rather clear increase can be seen for Cross River, Kaduna, and Kano while Bauchi, Katsina, and Rivers show a noticeable decrease. Particularly, Katsina has a dramatic decrease in the percentage of PPMVs with inventory. We note that factors that drive inventory levels may be complicated, possibly involving warehouse supply issues, distribution networks, and profit considerations.

On the other hand, the percentage of PPMVs with proper knowledge regarding the best treatment for children's diarrhea increased, as shown in Figure 2. This pure knowledge-based feature shows the direct impact of peer detailing on awareness of the best treatment for children's diarrhea in PPMVs. More specifically, most states show

increase patterns in percentage, except Katsina. This suggests the peer detailing successfully spread the information of the best treatment in most regions and thus the lack of inventories of the treatments for children's diarrhea may be associated with some objective causes rather than the PPMVs' lack of awareness.

Results and Discussion

This section provides results of hypothesis tests and regression modeling for both inventory and knowledge. More specifically, proportional Z-tests are conducted to determine the significance of the percentage changes in PPMVs with inventory of Zinc and ORS as well as proper knowledge for children's diarrhea before and after the peer detailing. Logistic regressions are used to quantify the impact of the peer detailing to PPMVs' inventory of Zinc and ORS and their proper knowledge of best treatments for children's diarrhea without and with confounding factors.

Hypothesis Tests
Inventory Change before and after Peer Detailing
Table 4 provides z-statistics and their corresponding P-values for one-sided proportional z-tests for percentage increases of inventory of Zinc and ORS for the country and each state. For the whole country, no significance can be detected. On a state level, Cross Rivers, Kaduna, and Kano show significant inventory percentage increases after detailing as compared with inventory levels prior to detailing. These results are consistent with results from exploratory data analysis. We therefore conclude that there is no significant evidence of increase in percentage of PPMVs with

	All	Bauchi	Cross Rivers	Kaduna	Kano	Katsina	Lagos	Niger	Rivers
Z Statistics	-4.618	-1.571	-4.497	-7.016	-1.519	2.718	-3.512	-2.485	-3.977
P-values	0.000**	0.058*	0.000**	0.000**	0.064*	0.997	0.000**	0.007**	0.000**

** denotes significant results (P-value < 0.05).

* denotes marginally significant results (P-value < 0.1).

Table 5 Proportional Z-tests for percentage change of the PPMVs with proper knowledge of the best treatment for children's diarrhea for the country and each state

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	1.487	(1.320, 1.675)	0.000	1.507	(1.330, 1.707)	0.000
	Yes, within 1 yr	Referent	-	-	Referent	-	-
Training	Yes, 2-3 yrs	1.153	(0.979, 1.357)	0.088	1.207	(1.022, 1.425)	0.027
	No	0.505	(0.442, 0.576)	0.000	0.622	(0.541, 0.716)	0.000

Table 6 Logistic regression model estimates for inventory of Zinc & ORS associated with the peer detailing

inventory of Zinc and ORS for the overall coverage.

Knowledge Change before and after Peer Detailing
Table 5 provides z-statistics and their corresponding P-values for one-sided proportional z-tests for percentage increases of the PPMVs with proper knowledge of the best treatment for children's diarrhea for the country and each state. A significant increase can be identified for the whole coverage. On a state level, increases in percentages for all states except Katsina are significant. These results are consistent with exploratory analysis. Therefore, we can conclude that the percentage of PPMVs with proper knowledge of the best treatment for children's diarrhea significantly increases after the peer detailing, compared to before the peer detailing.

Regression Modeling

Association between Inventory and Peer Detailing
Table 6 provides estimated odds ratios from logistic regressions without and with adjustment of confounding factors for inventory of Zinc and ORS. Confounding factors include whether the PPMV has someone with a health degree, whether the PPMV is in a rural or urban area, and whether and how long ago someone in the PPMV received any training on children's diarrhea. More details are de-

scribed in Table 3.

Without consideration of confounding factors, compared to PPMVs who were not detailed in the previous month, the estimated odds of having both Zinc and ORS in stock for PPMVs detailed is 99.8% higher; this effect is significant. In single logistic regressions of inventory with confounding factors, all confounding factors are significant.

When considering confounding factors, , keeping other factors the same, compared to PPMVs that were not detailed, the estimated odds of having both Zinc and ORS in stock for PPMVs detailed in the previous month increase by 69%, which is slightly lower than the estimated odds without consideration of the confounding factors. This effect is also significant. In addition, the effects of all confounding factors are significant.

Association between Knowledge and Peer Detailing
Similarly, Table 7 provides estimated odds ratios from logistic regressions without and with adjustment of confounding factors for proper knowledge of the best treatment for children's diarrhea.

Without consideration of confounding factors, compared to PPMVs that were not detailed, the estimated odds of having proper knowledge of the best treatment for children's diarrhea for PPMVs detailed in the previous month

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	1.306	(1.154, 1.478)	0.000	1.318	(1.153, 1.507)	0.000
	Yes, within 1 yr	Referent	-	-	Referent	-	-
Training	Yes, 2-3 yrs	0.766	(0.638, 0.919)	0.004	0.796	(0.662, 0.958)	0.016
	No	0.330	(0.285, 0.381)	0.000	0.448	(0.385, 0.522)	0.000

Table 7 Logistic regression model estimates for proper knowledge of the best treatment for children's diarrhea associated with the peer detailing

is 131% higher; this effect is significant. In single logistic regressions of inventory with confounding factors, all confounding factors are significant.

When considering confounding factors, keeping other factors the same, compared to PPMVs that were not detailed, the estimated odds of having proper knowledge on diarrhea treatments for PPMVs detailed in the previous month increase by 86%. The effects are all significant. In addition, all the confounding factors are significant.

Summary and Conclusions

This study evaluates the effectiveness of CHAI's information dissemination in Nigeria of the best treatment for children's diarrhea based on data regularly collected by surveys. The effectiveness is measured by both the percentage of PPMVs with inventory of Zinc and ORS and the percentage of PPMVs with proper knowledge of the best treatment for children's diarrhea. The analysis aims to provide insights from the surveyed data and support CHAI's future information dissemination strategies.

Based on the results of hypothesis tests and logistic regressions, peer detailing is considered effective in terms of improving the overall knowledge level of PPMVs for children's diarrhea. The percentage of PPMV with proper knowledge significantly increased in seven of the eight states. Analysis of logistic regressions reveals that the estimated odds of a detailed PPMV having proper knowledge of the best treatment for children's diarrhea is 86% higher than a PPMV not detailed in the previous month, given the other confounding factors remain the same; this effect is significant.

On the other hand, it is difficult to identify general patterns over the entire survey area regarding the impact of detailing on inventory levels. However, compared to 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 regressions suggest that detailed PPMVs have significantly higher odds (69% higher) to have both Zinc and ORS in stocks compared to 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 is an interesting finding, which might suggest further investigation should be conducted in the supply distribution.

The differences in performance between inventory and knowledge suggest that additional activities are required to reach the ultimate goal of reducing diarrhea-related death in Nigeria among children. The lack of proper knowledge of best treatment for children's diarrhea may not be the sole issue preventing children in need from receiving Zinc and ORS.

With more data collected, plenty of future work can be done. One interesting direction is to develop a time series model with decay of the performance of PPMV, to take people's memory into account. This can be used to analyze the effective frequency of the detailing. However, consistent samples across time are essential for time series models. Another interesting direction is supply chain related analysis, focusing on exploring best ways to distribute the treatments to increase the overall inventory. Finally, the ultimate goal of CHAI's project is to reduce the death rate of children's diarrhea. Thus, collecting and analyzing data from patients is very valuable to measure changes in mortality.

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