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Effect of the Expanded Program on Immunization Contact Method of Data Collection on Health Behaviors in Mali

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Abstract

Background—The Expanded Program on Immunization Contact Method (EPI-CM) is a proposed monitoring and program management tool for developing countries. The method involves health workers tallying responses to questions about health behaviors during routine immunizations and providing targeted counseling. We evaluated whether asking caretakers about health behaviors during EPI visits led to changes in those behaviors.

Methods—We worked in 2 districts in Mali: an intervention district where during immunization visits workers asked about 4 health behaviors related to bed net use, fever, respiratory disease, and diarrhea, and a control district where workers conducted routine immunization activities without health behavior questions. To evaluate the effect of EPI-CM, we conducted a cross-sectional household survey at baseline and 1 year postintervention. We used multivariate logistic regression to compare between districts the change over 1 year in 4 health behaviors: use of insecticide-treated nets, appropriate fever treatment, care-seeking for respiratory complaints, and appropriate diarrhea treatment.

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Results—There were no significant differences between the 2 districts in the change in the 4 health behaviors when controlling for age, sex, maternal education and occupation, immunization history, and wealth.

Conclusions—We found no evidence that EPI-CM increases healthy behaviors. Further evaluation of other potential benefits and costs of EPI-CM is warranted.

The Expanded Program on Immunization Contact Method (EPI-CM) has been proposed as a way to integrate data collection with existing Expanded Program on Immunization (EPI) services to obtain reliable, locally available, real-time data on child health behaviors in developing settings where such data are not routinely available. In EPI-CM, healthcare workers ask about recommended health behaviors when caretakers bring children aged <1 year to clinics for routine immunizations and provide brief targeted counseling according to responses. We evaluate the validity of EPI-CM estimates of health behavior in a separate report [1]. Here we explore the possibility that EPI-CM questions could themselves increase recommended behaviors, both by reminding caretakers and by promoting communication between providers and caretakers.

Delivering public health recommendations in the context of health facilities is not a new concept [2]. The US Preventive Services Task Force recommends screening and brief counseling interventions in clinical settings to reduce cigarette smoking and alcohol misuse [3, 4]. In developing nations, incorporating education into routine clinical contact leads to increased hand-washing and recommended infant-feeding practices [5–7].

Although EPI-CM has been introduced in several sub-Saharan countries for routine monitoring, its effect on community health behaviors has not been evaluated. In 2008 and 2009, we studied EPI-CM in 2 districts in Mali to evaluate its validity for monitoring bed net use and treatment-seeking behavior for priority child-health interventions, and its effectiveness as a behavior-change communication tool. In the intervention district, we trained Malian EPI clinic workers to conduct EPI-CM by asking caretakers about 4 health behaviors: bed net use and proper management of fever, respiratory complaints, and diarrhea. In the control district, clinic workers conducted only routine immunization activities. In this paper, we evaluate effectiveness of EPI-CM for behavior change with 2 cross-sectional surveys to compare the difference between intervention and control districts in the change in 4 health behaviors over 1 year.

MATERIALS AND METHODS

Institutional review boards at the Emory Rollins School of Public Health, the University of Bamako, and the US Centers for Disease Control and Prevention approved this study. We obtained informed consent from all participating households.

Setting

With a per capita gross domestic product of $580 [8], Mali is among the world's poorest countries. The health system relies on local cost recovery, and >20% of the population lives >15 km from a health facility, limiting access to care. Vaccinations are among the few services provided at little or no cost to children <1 year of age. Recent Ministry of Health initiatives have expanded free services for pregnant women and children to include insecticide-treated net (ITN) distribution and treatment of malaria. In December 2007, the Malian Ministry of Health collaborated with a coalition of nongovernmental organizations to conduct a national ITN distribution campaign targeting children <5 years of age [9].

We conducted our study in 2 adjacent Malian health districts. Segou was selected as the intervention district for EPI-CM implementation and Baroueli as a control district. We selected these districts in collaboration with the National Malaria Control Program based on the perception that districts in this region had strong routine vaccination services, similar malaria transmission intensity, and district medical officers willing to participate.

Study Design

From October 2008 through November 2009, we implemented EPI-CM in Segou. We trained vaccine clinic workers in all public health centers to conduct EPI-CM during all routine immunization activities, including weekly vaccination clinics held at health facilities and community outreach activities [10]. They collected information from infant caretakers about 4 health behaviors: whether children slept under a bed net the prior night, whether children with recent fever received care in a recommended medical setting (ie, public and private health facilities where treatment is provided by trained professionals), whether children with recent cough or difficulty breathing received care in a recommended medical setting, and whether children with recent diarrhea received oral rehydration solution. We also trained workers to counsel caretakers about recommended health behaviors if they were not engaging in them. Workers conducted these activities in the context of vaccination clinic encounters in addition to existing responsibilities, without supplemental staffing or funding, as would be the case if the program were introduced at scale. In the control district, clinic workers conducted routine EPI activities but did not ask additional EPI-CM questions.

To evaluate health behavior changes, we conducted cross-sectional household surveys in the EPI-CM and control districts at baseline in October 2008 and at 1 year post implementation in October 2009 among children aged 0–23 months. The recommended Malian EPI vaccine schedule includes doses at birth; 6, 10, and 14 weeks; and 9 months of life [10]. However, birth doses may be given outside EPI clinics, so we did not assume that children in Segou were exposed to EPI-CM at birth. Based on recommended vaccine administration, children aged 2–22 months at follow-up in the EPI-CM district had ≥1 exposure opportunities (Figure 1). We considered these children exposed in our primary analysis, and we used control district children of the same age as controls. We estimated the effect of EPI-CM on health behaviors by comparing the change in health behaviors in exposed and control cohorts. Although missing data did not allow confirmation of all vaccine dose–administration dates, assumptions about the relationship between age and opportunity for exposure (Figure 1) were supported by an analysis of vaccine doses for which vaccination dates were available (46% of doses, data not shown).

We conducted household surveys using global positioning system (GPS)–enabled Dell Axim X51 (Dell) handheld computers running Visual CE Version 11 (Syware), in a manner previously described [11]. For each time point, we selected 60 villages in each district by probability proportional to size. With a local guide, trained enumerators visited all village households and mapped by GPS those containing children aged 0–23 months. From those households, we selected 30 households in each village by simple random sample, and interviewed caretakers of children aged 0–23 months. If no caretaker was present, enumerators made 2 additional attempts before using a randomly preselected alternative household. No replacements were made for household refusals.

We collected household survey data on the following 4 primary health behavior outcomes (Table 1): ITN use (whether children slept under an ITN the previous night), appropriate fever treatment (whether children with fever in the past 2 weeks received Ministry of Health–approved malaria treatment, ie, artemether/lumefantrine [Coartem] or quinine, within 2 days of fever onset), respiratory care-seeking (whether children with cough or respiratory problems in the past 2 weeks received care in a recommended medical setting, ie, government or private hospital or clinic), and appropriate diarrhea treatment (whether children with diarrhea in the past 2 weeks received oral rehydration solution). We defined ITN as either a long-lasting insecticide–treated net (determined by net brand) or a net treated with insecticide within 1 year. Survey staff visually confirmed bed net use and type. They also used photographs to facilitate the collection of accurate medication histories. The selected ITN and fever outcomes were more specific than corresponding EPI-CM questions to reflect most precisely the recommended health behavior. We also included survey questions on potential confounders, such as vaccine history. We based vaccine history on EPI vaccine cards when available, and self-reported histories as necessary. We field-tested and revised the questionnaire prior to use.

Statistical Analysis

We did not weight analyses of household survey data because of the self-weighted design. We stratified by district and accounted for clustering by village, the primary sampling unit. We compared baseline prevalence of categorical predictor variables between districts using the Rao-Scott χ^2 test (PROC SURVEYFREQ) in SAS version 9.2 (SAS Institute) [12]. For continuous predictor variables, we used logistic regression (PROC SURVEYLOGISTIC) to model a binary indicator variable for district as a function of the single continuous predictor, and we calculated *P* values using the Wald test for significance of the β coefficient. We analyzed the bivariate relationship of each binary health behavior outcome with predictor variables with logistic regression to model outcomes as a function of individual predictors.

In our multivariate analysis, we used PROC SURVEYLO-GISTIC to model the logarithmic odds of the behavior as:

$$\mathrm{logit(Behavior)} = \beta_0 + \beta_D \mathrm{District} + \beta_{\mathrm{Y}} \mathrm{Year} + \beta_{\mathrm{D*Y}} \mathrm{District} * \mathrm{Year} + \delta_1 C_1 + \ldots + \delta_n C_n$$

where district was an indicator for intervention vs control district, year was an indicator for follow-up versus baseline study year, and C_1–C_n were control variables for age, male sex, mother's education, mother's employment, child's vaccine history, family wealth quintile, and mother's order among wives in polygymous households. We modeled vaccine-seeking behavior as a 3-category variable: up-to-date (all recommended EPI vaccines for age received), partially vaccinated (some but not all EPI vaccines received), or unvaccinated (no

EPI vaccines received). We controlled for socioeconomic status by first calculating a previously validated wealth index for each household described by Gwatkin et al [13–15]. We then calculated locally appropriate wealth index quintiles for the 2 study districts using lower-numbered quintiles for lower wealth.

We evaluated potential predictors for multicollinearity, and then compared potential models using all possible subsets of control variables. We chose the final model based on the precision of $\exp(\beta_{D*Y})$ estimate and its proximity to the estimate from the model using all control variables. For none of the health behavior models did dropping control variables lead to an appreciable increase in precision. As a result, we chose the model using all 7 control variables for all analyses.

We calculated the odds ratio (OR) comparing follow-up to baseline data in the control district as $\exp(\beta_Y)$ and in the intervention district as $\exp(\beta_Y+\beta_{D*Y})$. We calculated the ratio of ORs comparing intervention to control district as $\exp(\beta_{D*Y})$. Under the null hypothesis of no difference in the change in behavior between intervention and control district, this ratio would equal 1. We conducted hypothesis tests on β coefficients by Wald test.

In addition to the 4 a priori health behavior outcomes, we modeled changes in 4 secondary outcomes (Table 1). In the cases of bed net use and fever management, primary outcomes were more precise than health behaviors used in EPI-CM. We also performed secondary analyses for the change in the behavior assessed through EPI-CM rather than the more specific optimal health behavior. We also considered the possibility that only bed net owners would be able to act on increased interest in bed net use. Therefore, we conducted domain analyses for bed net use and ITN use restricted to bed net and ITN owners, respectively. Finally, we considered the possibility that a beneficial effect of EPI-CM would only be apparent among the most highly exposed children. We conducted an analysis restricted to children who were up-to-date for vaccination and had ≥3 opportunities for exposure to EPI-CM (children aged 4–15 months; Figure 1).

RESULTS

In the control district, we surveyed caretakers of 1093 children aged 2–22 months at baseline and caretakers of 1535 children at follow-up. In the EPI-CM district, we surveyed caretakers of 1109 children aged 2–22 months at baseline and caretakers of 1509 children at follow-up. Most eligible caretakers (97.3%) consented to the survey. Contrary to study protocols, clinic workers in the EPI-CM district collected EPI-CM data only 60.6% of the time. At baseline, a comparable proportion of households in the control and EPI-CM districts owned at least 1 bed net (95.4% and 93.1%, respectively; $P = .16$). ITN ownership was higher in the control district than in the EPI-CM district (92.4% vs 88.1%, respectively; $P = .04$ [Table 2]), and a higher percentage of children in the control district used ITNs compared with those in the EPI-CM district (86.2% vs 76.9%; $P < .01$). The 2 districts had significant differences in mother's employment outside the home ($P < .01$) and proportion in each wealth quintile ($P < .01$). The control district had fewer women employed outside the home and was wealthier. The districts had a comparable proportion of children reporting fever, respiratory complaints, and diarrhea. A higher proportion of children with diarrhea in the control district received appropriate treatment at baseline, but this difference was not statistically significant (P = .06). Management of fever and respiratory complaints in each district were comparable. The districts did not differ significantly by child's age, vaccination history, or mother's education.

In our analysis cohort of children aged 2–22 months at baseline, 52.6% in the control district and 53.7% in the EPI-CM district were up-to-date for vaccination. Vaccine data were obtained from cards and caregiver history 63.7% and 36.3% of the time, respectively. In the cohorts of children aged 12–23 months from the same districts who were old enough to have received all infant EPI vaccines, 62.4% in the control district and 58.4% in the EPI-CM district were fully vaccinated, and 92.9% and 95.4%, respectively, had received ≥1 EPI vaccine. Among children aged 12–23 months, 81.6% in the control district and 85.1% in the EPI-CM district had received a third dose of combined diphtheria–tetanus–acellular pertussis–hepatitis B–*Haemophilus influenzae* type b vaccine. None of the differences in vaccine coverage were statistically significant.

The unadjusted bivariate relationships between the 7 control variables and the 4 recommended health behaviors for all enrolled children (both districts and time points combined) are shown in Table 3. Formal schooling, higher vaccine status, and higher wealth quintiles tended to be associated with recommended health behaviors.

Over the 1-year study, our multivariate model estimated a nonsignificant improvement in most primary outcomes in both the EPI-CM and control districts (Table 4). The only significant estimated change was an increase in appropriate fever treatment from baseline to follow-up in the EPI-CM district (OR, 1.69; 95% confidence interval [CI], 1.00–2.83). The only estimated decrease was a nonsignificant fall in ITN use in the intervention district (OR, 0.87; 95% CI, .64–1.18). Estimated changes in appropriate fever and diarrhea treatment were more favorable in the intervention district than the control district, but estimated changes in ITN use and respiratory care-seeking were more favorable in the control district. The ratios of ORs for the EPI-CM district vs the control district for ITN use, appropriate fever treatment, respiratory care-seeking, and appropriate diarrhea treatment were 0.78 (95% CI, .50–1.21), 1.38 (95% CI, .64–2.99), 0.84 (95% CI, .43–1.66), and 1.18 (95% CI, .61–2.28), respectively. None of these were significantly different from the null value.

The ratios of estimated changes in each district for the secondary outcomes of any bed net use and fever care-seeking at a recommended medical facility, which matched EPI-CM questions, were not significantly different from 1 (Table 4). When analyses were restricted to bed net owners, changes in bed net use did not differ significantly between districts. When restricted to ITN owners, ITN use rose nonsignificantly in the control district (OR, 1.42, 95% CI, .96–2.09) and fell non-significantly in the EPI-CM district (OR, 0.78; 95% CI, .56–1.09). The ratio of ORs was 0.55 (95% CI, .33–.91), indicating that the reduction in the EPI-CM district was significantly different from the increase in the control.

When restricted to up-to-date children aged 4–15 months—a cohort highly exposed to EPI-CM in the EPI-CM district—the ratio of OR estimates for all of the a priori outcomes remained not significantly different from the null value (Table 5). Among ITN owners, estimated ITN use again increased nonsignificantly in the control district (OR, 1.81; 95% CI, .86–3.81) and decreased nonsignificantly in the intervention district (OR, 0.60; 95% CI, .35–1.04). The ratio of the odds ratios was 0.33 (95% CI, .13–.84), indicating a significant difference between the changes in each district.

Based on the multivariate model used to calculate primary outcomes for all children regardless of vaccine history, older children had significantly lower odds of using ITNs than younger children, though the estimated effect was small (Table 6, OR for each month increase in age, 0.99; 95% CI, .97–1.00). Male children were significantly less likely than females to receive appropriate diarrhea treatment (OR, 0.64; 95% CI, .47–.85). Formal maternal schooling was associated with increased recommended health behaviors. Children of mothers with formal non-Koranic schooling had 1.42 times the odds of using ITNs as children whose mothers had no formal schooling (95% CI, 1.02–1.99), and children of mothers with formal Koranic schooling had 1.59 times the odds of appropriate diarrhea treatment as children whose mothers had no formal schooling (95% CI, 1.14–2.22). Higher vaccination status was associated with other recommended health behaviors. Up-to-date children had almost 3 times the odds of unvaccinated children of using ITNs (OR, 2.76; 95% CI, 2.09–3.63) and twice the odds of receiving appropriate diarrhea treatment (OR, 2.01; 95% CI, 1.06–3.79). Higher wealth quintiles were associated with recommended health behaviors, though the effect was modest. The odds of ITN use were 1.28 times higher in the highest wealth quintile compared with those of the lowest (95% CI, 1.02–1.61).

DISCUSSION

In this study, we were unable to demonstrate any significant difference between the change in any of 4 a priori health behavior outcomes among children aged 2–22 months exposed to EPI-CM compared with children in a control district where EPI-CM was not implemented. There was no consistent tendency toward benefit or harm associated with EPI-CM. The absence of beneficial effect of EPI-CM was insensitive to whether health behavior outcomes were chosen to match optimal health behaviors or to match EPI-CM questions. Restricting the analysis of bed net use to bed net owners did not affect our conclusions.

For the secondary outcome of ITN use restricted to ITN owners, EPI-CM was associated with a fall in ITN use that was significantly different from the rise in the control district; in other words, there was a suggestion of harm associated with EPI-CM. However, the fact that significant association with a negative outcome was seen in only 1 secondary outcome among 8 primary and secondary outcomes does not support an overall conclusion of harm. It is possible that this finding may be due to unmeasured confounders, secular trends in 1 but not the other district, or chance in the setting of multiple testing. Using a conservative Bonferroni correction for 8 comparisons (α = .006), the corresponding CI for the ratio of ORs loses statistical significance (0.55; 99.4% CI, .27–1.12).

A limitation of our primary analysis is the heterogeneity of exposure (ie, vaccination visits) in our intervention group (Figure 1). It is possible that mixing weakly exposed children with highly exposed children could mask a beneficial effect of EPI-CM. If there were a dose-dependent benefit, we would expect to find a stronger effect in strata of more highly exposed children. However, restricting the analysis to up-to-date children with ≥3 opportunities for exposure to EPI-CM showed no significant effect of EPI-CM on any of the a priori outcomes. Again, the rise in the secondary outcome, ITN use among ITN owners, in the control district was significantly different from the fall in the EPI-CM district. However, this difference was not statistically significant after Bonferroni correction (ratio of ORs, 0.33; 99.4% CI, .09–1.22).

In our ecological study design, we assumed that secular trends in control and EPI-CM districts were identical and that the EPI-CM effect could be teased out mathematically. However, the control district was different from the EPI-CM district at baseline; it had higher ITN ownership and use, was wealthier, and had fewer women employed outside the home. It is possible that the beneficial effects of EPI-CM were counterbalanced by negative trends in the EPI-CM district. However, if EPI-CM conferred benefit across all 4 health behaviors, it is unlikely that counterbalancing trends would explain negative results for all 4 behaviors. Although including more intervention and control sites might have strengthened our design, we had in-sufficient resources to implement and evaluate EPI-CM in a larger sample or cluster-randomized design.

An assumption underlying our study design is that persons who received EPI vaccines in a given district largely received vaccines in the same district and resided in that district at follow-up. Nondifferential misclassification of exposure due to migration or care-seeking out of district would tend to bias our ratio of OR estimates toward the null, and might partially explain nonsignificant results. However, we would still expect trends toward benefit if the true benefits were meaningful, and these were not consistently seen. Finally, our results were limited by small sample sizes in some analyses.

In the context of this study, health workers encountered many barriers to correct and consistent EPI-CM implementation resulting in imperfect adherence to study protocols. However, our results are likely representative of the effect of EPI-CM as it has been similarly proposed and implemented without additional staff or incentives in other settings. Data from a corresponding process evaluation showed that EPI staff offered counseling about fever and ITN use during only 43 of 168 (26%) and 1 of 257 (0%) opportunities, respectively. These and other findings to be published separately suggest that far more resources would be needed for implementation and supervision of EPI-CM to ensure consistent and accurate data collection. It is possible that if vaccine clinic workers were to have additional time, training, and incentive to fully participate in EPI-CM, we might see consistent implementation, and a positive effect of EPI-CM might emerge. However, the lack of even a consistent tendency toward benefit raises questions about pursuing a more expensive implementation as a way to improve child health behaviors, particularly when other interventions, such as ITN distribution and point-of-use water treatment, have documented benefits [16–20]. Further research is necessary to evaluate whether the potential of EPI-CM as a low-cost source of valid, timely, and locally available data may be realized.

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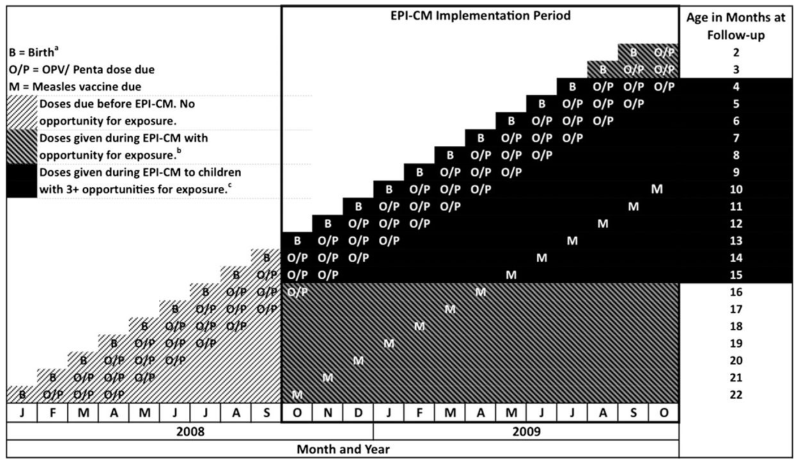

Figure 1.

Vaccination coverage analysis by age cohort showing potential exposures to the Expanded Program on Immunization Contact Method (EPI-CM). [a]BCG vaccine and oral poliovirus vaccine (OPV) due at birth may not have been given in routine EPI clinics with exposure to EPI-CM. We do not include this vaccine visit when counting potential exposures. [b]Children born between January 2008 and September 2009 (2–22 mo of age at follow-up) were administered vaccine(s) during the intervention and had opportunity for ≥1 exposure to EPI-CM. We included this cohort in the primary analysis. [c]Children born between August 2008 and July 2009 (4–15 mo of age at follow-up) had ≥3 opportunities for exposure to EPI-CM. We included children up-to-date for vaccinations in this cohort in a secondary analysis of "highly exposed" children.

Table 1

A Priori and Secondary Health Behavior Outcomes, Their Definitions, and Relevant Populations as Used in the Household Survey

Outcome	Definition	Population
A priori outcomes		
ITN use	Did child sleep last night under a long-lasting ITN or a net treated with insecticide in the past year?	All children aged 2–22 mo
Appropriate fever treatment	Did child receive artemether/lumefantrine (Coartem) or quinine within 2 d of fever onset?	Children aged 2–22 mo with fever in the past 2 wk
Respiratory care-seeking	Did child receive care in a government or private hospital or clinic for a respiratory problem?	Children aged 2–22 mo with cough or respiratory problems in the past 2 wk
Appropriate diarrhea treatment	Did child receive oral rehydration solution for diarrhea?	Children aged 2–22 mo with diarrhea in the past 2 wk
Secondary outcomes		
Any bed net use	Did child sleep last night under any bed net?	All children aged 2–22 mo
Any bed net use (net owners)	Did child sleep last night under any bed net?	All children aged 2–22 mo living in households with a bed net
ITN use (ITN owners)	Did child sleep last night under a long-lasting ITN or a net treated with insecticide in the past year?	All children aged 2–22 mo living in households with an ITN
Fever care-seeking	Did child receive care in a government or private hospital or clinic for fever?	Children aged 2–22 mo with fever in the past 2 wk

Abbreviation: ITN, insecticide-treated net.

Table 2

Baseline Characteristics of Children Aged 2–22 Months From Household Survey Data in Baroueli (Control) and Segou (Expanded Program on Immunization Contact Method–Exposed) Health Districts in Mali

	Baroueli, Control (n = 1093)	**Segou, EPI-CM (n = 1109)**	***P* Value[a]**
Any bed net ownership	1043 (95.4)	1033 (93.1)	.16
Any bed net use among all children	986 (90.2)	949 (85.6)	**.03**
ITN ownership	1010 (92.4)	977 (88.1)	**.04**
ITN use among all children	942 (86.2)	853 (76.9)	**<.01**
Children with fever in past 2 wk	454 (41.7)	482 (43.5)	.50
Appropriate fever treatment among children with fever	27 (6.0)	31 (6.4)	.79
Children with respiratory complaints in past 2 wk	235 (21.6)	254 (23)	.55
Respiratory care-seeking among children with respiratory complaints	49 (20.9)	50 (19.8)	.79
Children with diarrhea in past 2 wk	237 (21.8)	248 (22.4)	.77
Appropriate diarrhea treatment among children with diarrhea	51 (21.5)	35 (14.2)	.06
Age, mean mo (SE)	13.3 (0.1)	13.1 (0.2)	.50
Male sex	538 (49.2)	566 (51)	.35
Mother’s education: none	731 (69.3)	784 (70.8)	.88
Mothers education: Koranic school	240 (22.7)	240 (21.7)	
Mother’s education: non-Koranic school	84 (8.0)	83 (7.5)	
Mother’s outside employment: none	947 (86.6)	852 (76.8)	**<.01**
Mother’s outside employment: agricultural	103 (9.4)	171 (15.4)	
Mother’s outside employment: other	43 (3.9)	86 (7.8)	
Vaccination status: none	103 (9.4)	92 (8.3)	.87
Vaccination status: partial	415 (38.0)	422 (38.1)	
Vaccination status: up-to-date	575 (52.6)	595 (53.7)	
Wealth quintile 1	169 (15.5)	396 (35.7)	**<.01**
Wealth quintile 2	222 (20.3)	203 (18.3)	
Wealth quintile 3	262 (24.0)	183 (16.5)	
Wealth quintile 4	206 (18.8)	181 (16.3)	
Wealth quintile 5 (wealthiest)	234 (21.4)	145 (13.1)	
Wife type: mother is only wife	732 (67.3)	689 (62.5)	**.04**
Wife type: mother is first of multiple wives	137 (12.6)	183 (16.6)	
Wife type: mother is ≥ second of multiple wives	219 (20.1)	230 (20.9)	

Data are no. (%) unless otherwise indicated.

Abbreviations: EPI-CM, Expanded Program on Immunization Contact Method; ITN, insecticide-treated net; SE, standard error.

[a]We calculated *P* values for categorical variables using the Rao-Scott χ^2 test. We calculated *P* values for continuous variables using logistic regression analysis to model district as a function of the predictor and the Wald test for significance of the β coefficient. *P* values significant at the .05 level are shown in bold.

Table 3

Overall Unadjusted Odds Ratios and 95% Confidence Intervals for the Relationship Between Recommended Health Behaviors and the Control Variables for All Enrolled Children[a]

	ITN Use (n = 5179)[a,b], OR (95% CI)	Appropriate Fever Treatment (n = 2205)[a,b], OR (95% CI)	Respiratory Care-Seeking (n = 1124)[a,b], OR (95% CI)	Appropriate Diarrhea Treatment (n = 1117)[a,b] OR (95% CI)
Age, mo	1.00 (.99–1.02)	**1.04 (1.01–1.07)**	1.02 (1–1.05)	1.02 (.99–1.04)
Male sex	0.88 (.76–1.02)	0.84 (.61–1.16)	1.00 (.78–1.29)	**0.67 (.50–.88)**
Mother's education: Koranic vs none	1.13 (.93–1.38)	**1.54 (1.02–2.33)**	1.32 (.97–1.79)	**1.66 (1.21–2.29)**
Mother's education: non-Koranic vs none	**1.68 (1.19–2.38)**	**1.95 (1.1–3.46)**	1.34 (.77–2.34)	1.13 (.63–2.06)
Mother's employment: agricultural vs none	0.82 (.64–1.04)	0.61 (.33–1.14)	1.32 (.9–1.93)	1.02 (.68–1.54)
Mother's employment: other vs none	1.29 (.94–1.77)	1.01 (.54–1.88)	1.03 (.59–1.81)	1.16 (.67–2.03)
Vaccines: partial vs unvaccinated	**1.53 (1.19–1.96)**	2.00 (.9–4.45)	**2.14 (1.15–3.99)**	**1.92 (1.01–3.65)**
Vaccines: up-to-date vs unvaccinated	**2.55 (1.96–3.32)**	2.28 (.99–5.25)	**3.21 (1.74–5.92)**	**2.23 (1.22–4.08)**
Wealth quintile: 2 vs 1	0.99 (.80–1.22)	0.9 (.5–1.63)	1.31 (.81–2.11)	0.99 (.6–1.64)
Wealth quintile: 3 vs 1	**1.35 (1.08–1.70)**	1.45 (.85–2.46)	1.36 (.79–2.32)	0.88 (.53–1.44)
Wealth quintile: 4 vs 1	**1.77 (1.38–2.28)**	1.30 (.76–2.22)	**1.87 (1.2–2.92)**	1.47 (.93–2.32)
Wealth quintile: 5 vs 1	**1.63 (1.27–2.08)**	1.40 (.81–2.43)	**1.95 (1.19–3.19)**	**1.74 (1.09–2.78)**
Wife order: first vs only wife	1.03 (.82–1.29)	1.07 (.68–1.69)	1.07 (.72–1.6)	1.20 (.83–1.75)
Wife order: ≥ second vs only wife	1.02 (.84–1.25)	0.68 (.41–1.12)	0.88 (.61–1.28)	0.99 (.67–1.46)

Abbreviations: CI, confidence interval; ITN, insecticide-treated net; OR, odds ratio.

[a] CIs that do not overlap the null value of OR = 1 are shown in bold.

[a,b] Exact sample sizes for each predictor may vary slightly because of missing data.

Table 4

Final Odds Ratio Estimates and 95% Confidence Intervals Based on a Multivariate Model Estimating the Change in Health Behaviors Between Baseline and Follow-up in the Control and Intervention Districts and the Ratio of the Changes[a]

	Follow-up vs Baseline		Ratio of ORs
	Control, OR (95% CI)	Intervention, OR (95% CI)	Intervention/Control, Ratio (95% CI)
A priori outcomes			
ITN use (n = 5059)	1.12 (.81–1.55)	0.87 (.64–1.18)	0.78 (.50–1.21)
Appropriate fever treatment (n = 2159)	1.22 (.69–2.14)	**1.69 (1.00–2.83)**	1.38 (.64–2.99)
Respiratory care-seeking (n = 1096)	1.39 (.81–2.37)	1.17 (.76–1.8)	0.84 (.43–1.66)
Appropriate diarrhea treatment (n = 1096)	1.42 (.94–2.14)	1.67 (.99–2.82)	1.18 (.61–2.28)
Secondary outcomes			
Any bed net use (n = 5121)	1.20 (.84–1.71)	**1.60 (1.1–2.31)**	1.33 (.80–2.21)
Any bed net use (net owners; n = 4871)	**1.67 (1.05–2.66)**	1.30 (.89–1.9)	0.78 (.42–1.42)
ITN use (ITN owners; n = 4543)	1.42 (.96–2.09)	0.78 (.56–1.09)	**0.55 (.33–0.91)**
Fever care-seeking (n = 2153)	1.33 (.96–1.82)	1.14 (.85–1.54)	0.86 (.56–1.34)

Estimated associations with a priori and secondary health behavior outcomes are shown (n = 1093 and n = 1535 in the control district in 2008 and 2009, respectively; n = 1109 and n = 1509 in the EPI-CM district in 2008 and 2009, respectively).

Abbreviations: CI, confidence interval; ITN, insecticide-treated net; OR, odds ratio.

[a]Confidence intervals that do not overlap the null value of OR = 1 are shown in bold.

Table 5

Odds Ratio Estimates and 95% Confidence Intervals Based on a Multivariate Model Restricted to Children Highly Exposed to the Expanded Program on Immunization Contact Method Estimating the Change Between Baseline and Follow-up Years in the Control and Intervention Districts and the Ratio of the Changes[a]

	Follow-up vs Baseline		Ratio of ORs[a]
	Control, OR (95% CI)[a]	**Intervention, OR (95% CI)**	**Intervention/Control, Ratio (95% CI)[a]**
A priori outcomes			
ITN use (n = 1273)	1.34 (.72–2.47)	0.82 (.54–1.26)	0.62 (.29–1.31)
Appropriate fever treatment (n = 554)	3.49 (.91–13.47)	0.80 (.32–1.97)	0.23 (.04–1.16)
Respiratory care-seeking (n = 267)	1.47 (0.65–3.29)	1.23 (.52–2.87)	0.84 (0.26–2.64)
Appropriate diarrhea treatment (n = 307)	1.69 (.71–4.02)	0.79 (.34–1.83)	0.47 (.14–1.54)
Secondary outcomes			
Any bed net use (n = 1287)	1.42 (.73–2.79)	1.31 (.67–2.55)	0.92 (.36–2.39)
Any bed net use (net owners; n = 1254)	**2.39 (1.01–5.65)**	0.85 (.37–1.94)	0.35 (.11–1.17)
ITN use (ITN owners; n = 1205)	1.81 (.86–3.81)	0.60 (.35–1.04)	**0.33 (.13–.84)**
Fever care-seeking (n = 552)	1.48 (.87–2.49)	0.88 (.52–1.48)	0.59 (.28–1.25)

Estimated associations with a priori and secondary health behavior outcomes are shown (n = 310 and n = 328 in the control district in 2008 and 2009, respectively; n = 346 and n = 337 in the EPI-CM district in 2008 and 2009, respectively).

Abbreviations: CI, confidence interval; ITN, insecticide-treated net; OR, odds ratio.

[a]CIs that do not overlap the null value of OR = 1 are shown in bold.

Table 6

Final Odds Ratio Estimates and 95% Confidence Intervals for the Relationship Between Control Variables and Primary Health Behavior Outcomes Based on a Multivariate Model Used to Estimate the Change in Health Behaviors Between Baseline and Follow-up Years in the Control and Intervention Districts and the Ratio of the Changes[a]

	ITN Use (n = 5059), OR (95% CI)[a]	**Appropriate Fever Treatment (n = 2159), OR (95% CI)**	**Respiratory Care-Seeking (n = 1096), OR (95% CI)**	**Appropriate Diarrhea Treatment (n = 1096), OR (95% CI)[a]**
Age in mo	**0.99 (.97–1.00)**	0.97 (.92–1.03)	0.99 (.93–1.05)	1.01 (.99–1.04)
Male sex	0.90 (.77–1.04)	0.76 (.49–1.17)	0.90 (.63–1.28)	**0.64 (.47–.85)**
Mother's education: Koranic vs none	1.03 (.84–1.26)	1.48 (.9–2.43)	1.19 (.78–1.81)	**1.59 (1.14–2.22)**
Mother's education: non-Koranic vs none	**1.42 (1.02–1.99)**	1.94 (.94–4.02)	1.43 (.68–3.03)	1.1 (.60–2.04)
Mother's employment: agricultural vs none	1.02 (.8–1.31)	0.60 (.26–1.41)	1.26 (.72–2.22)	1.12 (.71–1.76)
Mother's employment: other vs none	**1.49 (1.05–2.1)**	1.20 (.55–2.63)	0.77 (.34–1.78)	1.27 (.74–2.17)
Vaccination: partial vs unvaccinated	**1.55 (1.2–2)**	2.63 (.7–9.88)	1.38 (.51–3.74)	1.74 (.91–3.32)
Vaccination: up-to-date vs unvaccinated	**2.76 (2.09–3.63)**	2.49 (.70–8.83)	2.59 (.99–6.8)	**2.01 (1.06–3.79)**
Wealth quintile: 2 vs 1	0.86 (.69–1.07)	0.59 (.28–1.27)	1.22 (.65–2.29)	0.83 (.5–1.37)
Wealth quintile: 3 vs 1	1.16 (.92–1.46)	1.18 (.61–2.26)	0.95 (.5–1.78)	0.71 (.44–1.15)
Wealth quintile: 4 vs 1	**1.54 (1.2–1.98)**	1.20 (.62–2.33)	1.25 (.71–2.21)	1.19 (.75–1.91)
Wealth quintile: 5 vs 1	**1.28 (1.02–1.61)**	1.21 (.6–2.45)	1.58 (.86–2.91)	1.38 (.85–2.24)
Wife order: first vs only wife	1.10 (.88–1.37)	1.22 (.68–2.19)	1.10 (.65–1.86)	1.26 (.84–1.89)
Wife order: ≥second vs only wife	0.98 (.81–1.19)	0.89 (.49–1.64)	0.82 (.47–1.44)	1 (.67–1.49)

These results are not restricted by degree of exposure to the Expanded Program on Immunization Contact Method.

Abbreviations: CI, confidence interval; ITN, insecticide-treated net; OR, odds ratio.

[a]CIs that do not overlap the null value of OR = 1 are shown in bold.