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## Text message reminders for timely routine MMR vaccination: A randomized controlled trial\*

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### Abstract

**Objective**—Measles–mumps–rubella (MMR) vaccination is important for preventing disease outbreaks, yet pockets of under-vaccination persist. Text message reminders have been employed successfully for other pediatric vaccines, but studies examining their use for MMR vaccination are limited. This study assessed the impact of text message reminders on timely MMR vaccination.

**Study design**—Parents ( $n = 2054$ ) of 9.5–10.5-month-old children from four urban academically-affiliated pediatric clinics were randomized to scheduling plus appointment text message reminders, appointment text message reminder-only, or usual care. The former included up to three text reminders to schedule the one-year preventive care visit. Both text messaging arms included a text reminder sent 2 days before that visit. Outcomes included appointment scheduling, appointment attendance, and MMR vaccination by age 13 months, the standard of care at study sites.

**Results**—Children of parents in the scheduling plus appointment text message reminders arm were more likely to have a scheduled one-year visit than those in the other arms (71.9% vs. 67.4%, relative risk ratio (RRR) 1.07 [95% CI 1.005–1.13]), particularly if no appointment was scheduled before randomization (i.e., no baseline appointment) (62.1% vs. 54.7%, RRR 1.14 [95% CI 1.04–1.24]). One-year visit attendance and timely MMR vaccination were similar between arms.

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### Disclaimer

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention.

*Conflict of interest:* The authors have no conflicts of interest to report.

### Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <http://dx.doi.org/10.1016/j.vaccine.2015.09.042>.

However, among children without a baseline appointment, those with parents in the scheduling plus appointment text message reminders arm were more likely to undergo timely MMR vaccination (61.1% vs. 55.1%, RRR 1.11 [95% CI 1.01–1.21]).

**Conclusion**—Text message reminders improved timely MMR vaccination of high-risk children without a baseline one-year visit.

## Keywords

Measles; MMR; Text message; Reminder; Vaccination; Children

## 1. Introduction

Measles was officially eliminated, defined as interruption of year-round endemic measles transmission, in the United States in 2000 [1,2]. However, measles outbreaks continue to occur. In 2014, the highest number of measles cases (644) was reported since its elimination in 2000 [3]. In January–February 2015, there were 154 cases stemming primarily from one multi-state outbreak [3]. Most cases resulted from importation from endemic areas worldwide, either by U.S. or foreign travellers, and occurred in individuals who were unvaccinated or had unknown vaccination status [4]. Although the racial/ethnic disparities in measles vaccination coverage that contributed to significant outbreaks in 1989 and 1990 no longer exist for children 19–35 months of age [5,6], low-income and minority children are at risk for less timely vaccination overall [7].

The Advisory Committee on Immunization Practices (ACIP) currently recommends routine measles–mumps–rubella (MMR) vaccination at age 12–15 months and booster vaccination at age 4–6 years [2]. The vaccine is highly effective when administered as recommended, with a median two-dose effectiveness of 97% [2]. National Immunization Survey (NIS) data indicate that approximately 92% of 19–35-month-olds have received their first MMR vaccine dose [8], in line with *Healthy People 2020* coverage goals [9]. Nonetheless, pockets of under-immunization continue to exist, including in 17 states with coverage below the 90% target level [8]. Further, 1 in 12 U.S. children have delayed receipt of their first dose, increasing their susceptibility to measles infection [8]. The reasons for this under- and delayed immunization are unclear. Some families may have difficulty remembering to schedule an appointment for the one-year preventive care visit during which the MMR vaccine and other primary care services are routinely offered, while others may not remember to attend the appointment. Such pragmatic barriers for early childhood vaccines have been demonstrated among low-income minority families [10]. Missed opportunities for MMR vaccination or parental refusal of MMR vaccine at these visits are other possible explanations [11].

Text message vaccine reminder/recall is one promising strategy for reaching families, particularly of low-income minority children. Previous studies have shown that most parents of such children have text message-enabled cell phones (88–89%) and are interested in receiving text message appointment reminders (81%) and vaccine reminders (96–100%) [12,13]. Studies have demonstrated the effectiveness of text messaging for improving coverage levels for needed vaccines such as *Haemophilus influenzae type b* (Hib), human

papillomavirus, meningococcal, and tetanus–diphtheria–acellular pertussis, and influenza among low-income minority children and adolescents [14–16]. A pilot study ( $n = 90$ ) of text message reminders for sentinel infant vaccines also showed promise, although findings were not significant, likely due to limited power [17]. The impact of text message reminders on MMR vaccination has yet to be determined.

The primary aim of this study was to examine the effect of text message reminders on timely MMR vaccination – defined here as vaccination by 13 months of age – among low-income minority children from a community in New York City where one of the first measles outbreaks of 2014 occurred. A secondary aim was to assess the impact of text message reminders on the scheduling of and attendance at the one-year preventive care visit. We hypothesized that text message reminders would improve timely receipt of MMR vaccination, in part due to increased scheduling of and attendance at one-year preventive care visits.

## 2. Methods

### 2.1. Study design

This randomized controlled trial examined the impact of text message reminders on timely MMR vaccination as well as scheduling of and attendance at the one-year preventive care visit. The study was approved by the Columbia University Medical Center Institutional Review Board with a waiver of consent.

### 2.2. Setting

This study was conducted in four pediatric practices in an ambulatory care network affiliated with a large academic medical center. At these sites, the standard of care was to administer the first routine MMR vaccine dose at the one-year preventive care visit based upon a history of measles outbreaks in New York City and frequent international travel by community residents. The vast majority of patients were eligible to receive free vaccines through the VFC Program.

### 2.3. Population

Parents were eligible for participation if their child (1) was age 9.5–10.5 months, (2) had a participating clinic visit in the past 6 months, and (3) had a cellular phone number listed in the hospital registration system. If there were twins or triplets, only one child was randomly selected for analysis; text messages pertaining to the twin or triplet siblings were also sent to parents in the text messaging arms to avoid potential confusion.

### 2.4. Data sources

This study utilized a customized text messaging platform integrated with the hospital registration system and its immunization registry, EzVac. The registration system included demographic and visit data for subjects, while the EzVac registry automatically captured from the institution's electronic health record all vaccine doses administered to subjects at the hospital and affiliated clinics [18]. There was also bidirectional exchange of vaccine data between EzVac and the New York City Immunization Registry (CIR). Of note, the CIR was

one of the first immunization information systems (IIS) to offer this bidirectional exchange and remains at the forefront of IIS functionality. Moreover, New York City providers are required to report to the CIR any vaccine administrations to children under age 19 years [19]. It is estimated that 94% of facilities vaccinating children regularly do so [20]. Thus, vaccine administration data in the present study included MMR vaccine doses administered at study sites and non-study sites in New York City.

## 2.5. Study procedures

There were 2333 children who fulfilled age and visit eligibility criteria (Fig. 1). Of these, 237 did not have a parental cellular phone number recorded in the registration system and 42 were twin or triplet siblings; these were excluded from the study. Parents of the remaining 2054 eligible children were stratified by their child's clinic site. Using a random sample algorithm generator in SPSS 19.0, they were then randomized in monthly intervals between June 2011 and October 2012 with a 1:1:1 allocation to receive (1) up to three text message reminders to schedule an appointment plus an appointment text message reminder ("scheduling plus appointment text message reminders" arm), (2) an appointment text message reminder only ("appointment text message reminder-only" arm), or (3) usual care ("usual care" arm). With this sample size ( $n = 2054$ ), randomized with equal allocation, and an estimated baseline coverage of 51%, there was 80% power to detect a 7.5% difference in MMR vaccination by age 13 months between groups, allowing for a 5% type I error. Study analysts were blinded to group assignments.

Immediately following randomization, parents in the *scheduling plus appointment text message reminders* arm received up to three automated weekly text message reminders to schedule the one-year appointment; parents in the other arms did not receive reminders to schedule an appointment (Fig. 2). The text messages, sent in either English or Spanish depending on the primary language specified in the electronic health record, included the clinic contact information and mentioned the child's need for important vaccines like measles following the first birthday. They also included the option to switch the language or "stop" future messages. If the child already had a scheduled one-year appointment before the start of the intervention (i.e., date of the first scheduling reminder), the parent was not sent any scheduling reminders unless that appointment was scheduled to occur before 361 days of age (i.e., outside the grace period for MMR vaccination). Once the intervention was initiated, any newly scheduled appointment after 11 months of age was deemed acceptable given the possibility of "early" (i.e., between 11 months and 361 days of age) scheduling by office staff, and no subsequent scheduling reminders were sent.

Next, parents in both text messaging arms (*scheduling plus appointment text message reminders* and *appointment text message reminder-only*) received one automated text message two days before a scheduled one-year appointment, reminding them about the appointment, letting them know that the doctor would discuss needed vaccines, and asking them to remember to bring the child's vaccination card. The reminder was not sent if the child had already received MMR vaccine (unless given before 361 days of age). Those in the *usual care* arm received no text message reminders.

Children in all arms received “usual care”, which included a routine automated telephone appointment reminder provided directly from the clinic network. A post-intervention text message was sent to parents who received 1 text message to assess their satisfaction with the reminders.

## 2.6. Measures

The pre-specified primary outcome measure was MMR vaccination by 13 months of age. Doses received up to 4 days before the child’s first birthday were accepted [21]. Doses received earlier, e.g., due to international travel, were not accepted. Secondary outcome measures were (1) a scheduled one-year appointment between 11 and 13 months of age; (2) attendance at the one-year appointment between 11 and 13 months of age; and (3) MMR vaccination by 16 months of age.

## 2.7. Analysis

All analyses used the individual child as the unit of analysis. MMR vaccination by age 13 months was compared between the three arms using Pearson’s chi-squared test. One-year visit scheduling and attendance as well as MMR vaccination by age 16 months were similarly compared between arms. Differences and relative risks along with their associated 95% confidence intervals were calculated. Multivariable logistic regression was used to examine interactions between intervention arm and facility. Sub-analyses were conducted among those without a baseline one-year appointment (i.e., an appointment between 11 and 13 months of age that was scheduled before randomization). Additionally, a sensitivity analysis comparing appointment attendance between those with vs. without a delivered appointment reminder was performed. Analyses were performed using SAS Version 9.3 (Cary, NC).

## 3. Results

Of the children of randomized parents ( $n = 2054$ ), most were publicly insured and had a primary language of Spanish (Table 1). Demographic characteristics were similar between arms. Two-thirds (68.9%,  $n = 1415$ ) had a one-year appointment scheduled to occur between 11 and 13 months. Approximately, one-quarter had this appointment scheduled before randomization (26.5% *scheduling plus appointment reminders* arm; 30.2% *appointment reminder-only* arm; 28.3% *usual care* arm;  $p = 0.33$ ); the remaining 1472 children did not have a baseline one-year appointment. Children of parents randomized to receive an appointment scheduling reminder were more likely to have a scheduled one-year appointment than those of parents in the two other arms, particularly if they had no baseline appointment (Table 2). In a multivariable model assessing appointment scheduling, there was no interaction between intervention arm and facility.

Of children with a scheduled appointment by 13 months of age ( $n = 1415$ ), appointment attendance did not differ between arms (77.9%,  $p = 0.46$ ) (Table 2). However, there were 78 children in the text messaging arms whose parents did not receive a text message appointment reminder for their scheduled appointment (52 had undeliverable message(s), 4 requested to stop messaging, 6 had received MMR vaccine before the appointment, and 16

for other reasons). When comparing children whose parents had a delivered text message appointment reminder vs. those who either did not have a delivered message or were in the *usual care* arm, a significant difference in appointment attendance existed (79.8% vs. 74.8%; relative risk ratio (RRR) 1.07 [95% CI 1.00–1.13]). In a multivariable model assessing appointment attendance, there was no interaction between intervention arm and facility. Overall, a small proportion of subjects either canceled (1.6%) or rescheduled (2.5%) their appointment within 48 h before their scheduled visit. Very few appointments (1.1%) were canceled >48 h before their scheduled visit and not rescheduled. These outcomes did not vary by arm.

Among children of randomized parents ( $n = 2054$ ), there was no significant difference in MMR vaccination by 13 months between arms (62.2%,  $p = 0.30$ ; Table 2). However, among children without a baseline appointment ( $n = 1472$ ), those in the *scheduling plus appointment reminders* arm were more likely to receive MMR vaccine by 13 months than those in the other arms. In a multivariable model assessing MMR vaccination by 13 months, there was no interaction between intervention arm and facility. Among those who attended their one-year appointment by 13 months ( $n = 1102$ ), 89.2% received MMR vaccine by 13 months. Of those who were not vaccinated at that visit ( $n = 119$ ), 82 were ineligible since the appointment occurred before 361 days of age. The remaining 37 were eligible by age to receive their MMR vaccine, but were not given this dose for a variety of reasons, including febrile illness, perceived contraindications, and provider decision to preferentially administer other needed vaccines at that visit. The parents of three of these children deferred/declined MMR vaccination. There was no difference in MMR vaccination by 16 months between arms (86.0%,  $p = 0.99$ ).

Of parents in the text messaging arms who were sent 1 text message ( $n = 1254$ ), 0.8% elected to “stop” subsequent messages and 7.1% experienced 1 undeliverable message. Of those sent a follow-up text message assessing satisfaction ( $n = 1213$ ); 16.9% ( $n = 205$ ) replied: 86.8% reported that they liked the messages, 3.9% thought they were “so-so”, and 9.3% did not like them.

## 4. Discussion

In this study, text message reminders increased MMR vaccination coverage, but only among high-risk children lacking a scheduled one-year appointment at the beginning of the study period. These findings illustrate a potential target population that may benefit most from reminders to schedule and attend the one-year preventive care visit, particularly since the vast majority of children who came to this appointment received MMR vaccine. Considering the 644 reported measles cases from 27 states in 2014 – including one outbreak centered in the community in which this study took place – and the 154 reported cases in January–February 2015, interventions to promote timely MMR vaccination are needed [3]. Optimizing protection against measles may be particularly important for urban minority populations at potentially increased risk of measles infection and related complications [5].

It is worthwhile noting other potential benefits of timely MMR vaccination. A recent study found that MMR vaccine administration before 15 months of age reduced hospitalizations



for any infection between 16 and 24 months of age, with 201 children needing to receive their first MMR vaccine dose by 15 months to prevent one hospitalization [22]. Another investigation observed a reduction in fever and seizure risk following MMR vaccination when administered early (12–15 months) compared to late (16–23 months) [23]. Conversely, some data suggest that MMR vaccine effectiveness may be enhanced when administered later (i.e., on/after 15 months of age) [24–26]. Thus, while routine MMR vaccination should occur within the 12–15 month age range, text message reminders may be adapted to promote best practices in diverse settings with variable infection risk.

In this study, an important effect of the text message reminders was to increase scheduling of the one-year preventive care visit. The reminders not only may have served as a “cue to action” for parents with competing priorities, but also may have facilitated scheduling by including the clinic telephone number and suggesting a visit time frame. Our recent study found that nearly half (44%) of urban low-income minority parents, like those included in this current study, reported obstacles to scheduling appointments, and this was associated with a higher likelihood of missing an immunization visit [10]. Our study observed a greater impact of the scheduling text message reminders among the higher risk children who lacked a baseline scheduled one-year appointment.

Children of parents with a delivered text message appointment reminder were more likely to attend that appointment than children of parents who did not receive the reminder. We recently found that, among parents of children with a missed vaccine appointment, approximately 21% forgot their child’s appointment [10]. Thus, a text reminder may serve as a valuable prompt for parents to attend their child’s appointment. A recent meta-analysis of studies among adults concluded that text message appointment reminders have a positive impact on attendance that is equivalent to telephone reminders and potentially better than written or no appointment reminders; they are also more cost-effective than other reminder types [27]. Further examination in the pediatric setting is needed.

In this study, the vast majority of children who scheduled and attended their one-year appointment received MMR vaccine during that visit. There were a small number of missed vaccination opportunities, which could be minimized through greater provider education, e.g., related to appropriate vaccine contraindications. Very few of the study’s predominantly low-income, minority, Spanish-speaking parents refused/declined MMR vaccination. This finding is consistent with 2010–2013 NIS data showing that three-quarters of children unvaccinated against measles had missed being vaccinated for reasons other than negative vaccine-related beliefs [11]. These findings differ from those described elsewhere. For example, among the unvaccinated U.S. residents who acquired measles in 2013, 79% had declined MMR vaccine for philosophical reasons [28]. Similar findings were reported in the recent California outbreak [29]. Certainly, parental misperceptions about the MMR vaccine could underlie these beliefs. Thus, strategies should be employed to address these other concerns in communities where such barriers may be more prevalent. Text messages could incorporate educational information about MMR vaccine importance, effectiveness, and safety [14,16] – potentially using embedded links or interactive features to provide additional information [15–18] – to prime parents for a discussion with their child’s

providers. Other studies have shown that the use of leaflets, parent meetings, and decision aids may also promote MMR vaccine uptake [30,31].

There are limitations to this study. First, although this study aimed to include active patients at the four participating clinics, some children may have transferred care elsewhere during the study period. We observed that 320 children (15.6% of the randomized population) never had a clinic visit on or after their first birthday. This could have lessened the intervention impact, particularly with respect to appointment outcomes that could not be captured using the data available. Second, despite their best efforts, parents may have encountered unforeseen scheduling difficulties, i.e., too early (<361 days of age) or too late (>13 months of age). However, there is no evidence that such scheduling obstacles would not have differed by study arm. Finally, this study was conducted in one ambulatory care network serving predominantly low-income, minority, Spanish-speaking families; thus, its findings may not be generalizable to other clinic settings and/or populations.

## 5. Conclusion

This study illustrates the impact of text message reminders on scheduling and attending preventive care visits for MMR vaccination. It is also worth noting the potential to capitalize on existing text message vaccine reminder/recall systems to promote wide-spread MMR vaccination during community outbreak situations such as those in New York City and elsewhere in 2014.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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## Abbreviations

<b>ACIP</b>	Advisory Committee on Immunization Practices
<b>CIR</b>	New York Citywide Immunization Registry
<b>EzVac</b>	hospital immunization registry
<b>IIS</b>	immunization information systems
<b>MMR</b>	measles–mumps–rubella

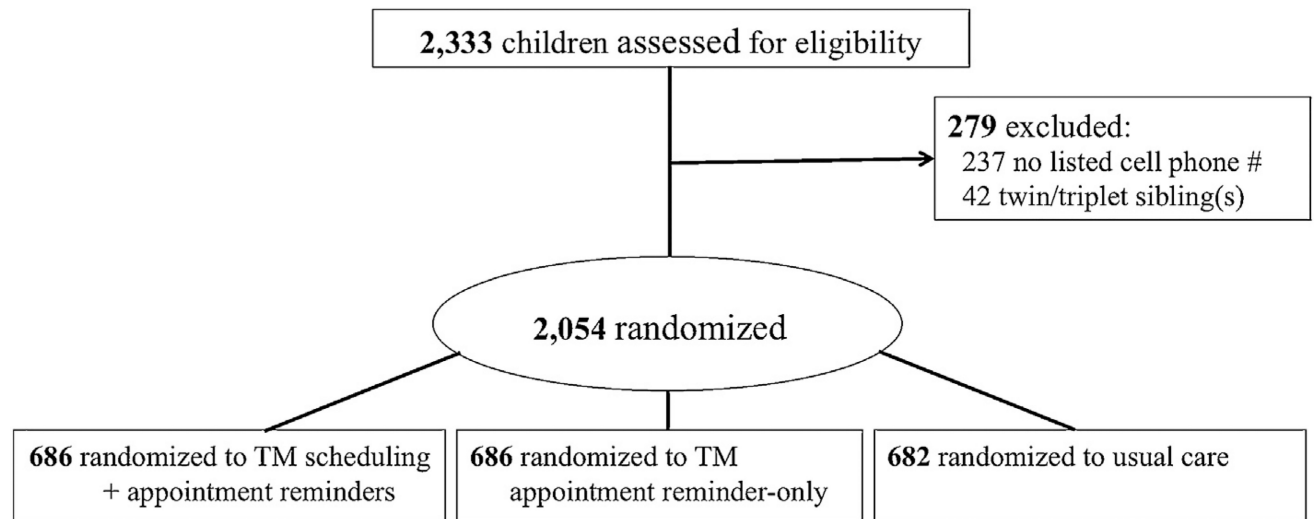


VFC vaccines for children.

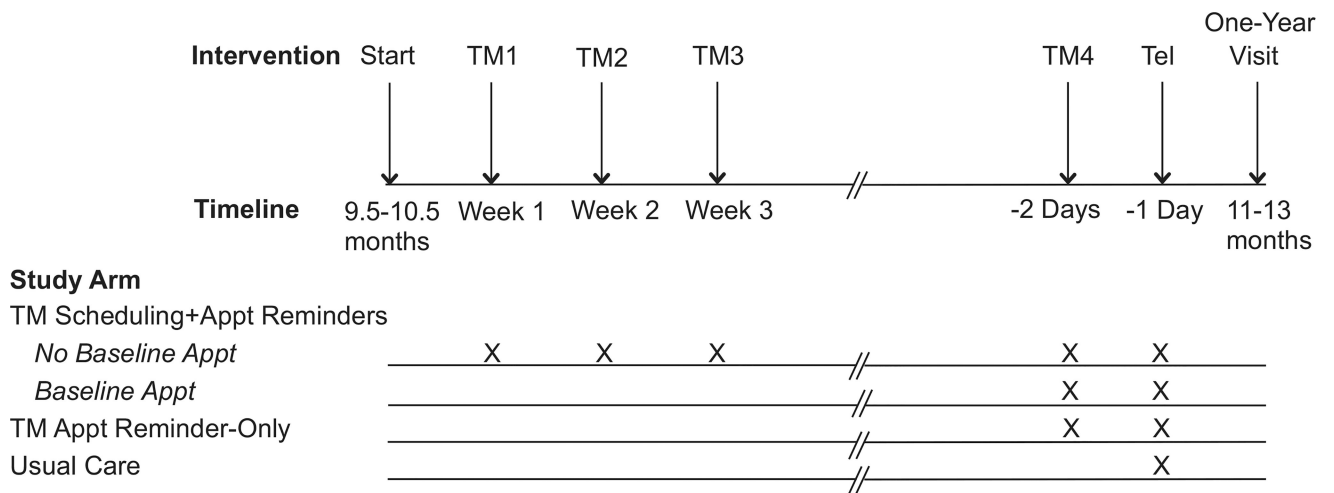
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**Fig. 1.**  
Schematic of study population.



TM: Text Message Reminder; Tel: Automated Telephone Reminder; Appt: Appointment; X: Reminder Sent/Provided Weeks (1, 2, 3): Post-Intervention Start Date; Days (-2, -1): Prior to One-Year Visit

**Fig. 2.**  
Overview of study procedures.

**Table 1**

Characteristics of study population.

	<b>Scheduling + appointment text message reminders</b>	<b>Appointment text message reminder-only</b>	<b>Usual care</b>	<b><i>p</i> Value</b>
Total, <i>n</i>	686	686	682	
Gender, % ( <i>n</i> )				0.88
Female	49.4 (339)	48.1 (330)	49.0 (334)	
Male	50.6 (347)	51.9 (356)	51.0 (348)	
Language, % ( <i>n</i> )				0.43
Spanish	59.8 (410)	58.2 (399)	57.5 (392)	
English	37.4 (257)	37.3 (256)	39.6 (270)	
Other	1.3 (9)	2.8 (19)	1.5 (10)	
Unknown	1.5 (10)	1.7 (12)	1.4 (10)	
Insurance, % ( <i>n</i> )				0.72
Public	82.9 (569)	84.0 (576)	84.5 (576)	
Private	3.4 (23)	4.2 (29)	3.5 (24)	
Uninsured	13.7 (94)	11.8 (81)	12.0 (82)	

**Table 2**

Appointment outcomes and MMR vaccination by 13 months.

	Scheduling + appt TMs ( <i>n</i> = 686)	Vs. appt TM-only ( <i>n</i> = 686)			Vs. usual care ( <i>n</i> = 682)			Vs. appt TM-only or usual care ( <i>n</i> = 1368)		
		% ( <i>n</i> )	Difference % (95% CI)	RRR (95% CI)	% ( <i>n</i> )	Difference % (95% CI)	RRR (95% CI)	% ( <i>n</i> )	Difference % (95% CI)	RRR (95% CI)
Scheduled visit <sup>a</sup>										
All subjects	71.9 (493)	67.6 (464)	4.2 (−0.8 to 9.2)	1.06 (0.99–1.14)	67.2 (458)	4.7 (−0.3 to 9.7)	1.07 (1.00–1.15)	67.4 (922)	4.5 (0.2–8.8)	<b>1.07 (1.00–1.13)</b>
No baseline appt <sup>b</sup>	62.1 (313)	54.1 (259)	8.0 (1.7–14.4)	<b>1.15 (1.03–1.28)</b>	55.2 (270)	6.9 (0.6–13.2)	<b>1.12 (1.01–1.25)</b>	54.7 (529)	7.5 (2.0–12.9)	<b>1.14 (1.04–1.24)</b>
Visit attendance <sup>c</sup>										
All subjects	77.5 (382)	79.7 (370)	−2.3 (−7.7 to 3.1)	0.97 (0.91–1.04)	76.4 (350)	1.1 (−4.5 to 6.6)	1.01 (0.95–1.09)	N/A	N/A	N/A
No baseline appt <sup>b</sup>	77.6 (243)	81.1 (210)	−3.4 (−10.4 to 3.6)	0.96 (0.88–1.04)	74.8 (202)	2.8 (−4.5 to 10.1)	1.04 (0.95–1.14)	N/A	N/A	N/A
MMR vaccination <sup>d</sup>										
All subjects	64.6 (443)	60.9 (418)	3.7 (−1.6 to 8.9)	1.06 (0.98–1.15)	61.1 (417)	3.5 (−1.8 to 8.7)	1.06 (0.97–1.15)	61.0 (835)	3.5 (−1.0 to 8.1)	1.06 (0.99–1.13)
No baseline appt <sup>b</sup>	61.1 (308)	54.9 (263)	6.2 (−0.2 to 12.6)	<b>1.11 (1.00–1.24)</b>	55.2 (270)	5.9 (−0.4 to 12.2)	1.11 (1.00–1.23)	55.1 (533)	6.1 (0.6–11.5)	<b>1.11 (1.01–1.21)</b>

TMs, text message reminders; Appt, appointment; RRR, relative risk ratio; CI, confidence interval.  
Bold notates significance.

<sup>a</sup>One-year preventive care visit scheduled between 11 and 13 months of age.

<sup>b</sup>No baseline appointment, no one-year preventive care visit scheduled before randomization (i.e., 9.5–10.5 months of age).

<sup>c</sup>One-year preventive care visit attended between 11 and 13 months of age (among those with a scheduled appointment during this time).

<sup>d</sup>MMR vaccination between 361 days and 13 months of age.