

Effectiveness of Individually Tailored Calendars in Promoting Childhood Immunization in Urban Public Health Centers

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Childhood immunization rates are low in many large US cities.¹ In general, rates are lowest in inner-city areas,² among minorities,¹⁻³ in families with lower incomes,³⁻⁸ in single-parent families,^{6,9} in larger families,^{5,10} and in families with less educated parents.⁶

The major barriers to childhood immunization are well established and include parent-related factors (e.g., lack of knowledge of immunization schedule,¹⁰⁻¹⁵ perceptions that vaccination is relatively unimportant^{10,14,16}), factors associated with the social or physical environment (e.g., limited availability or high cost of transportation and child care, work conflicts, family circumstances^{8,14}), and factors associated with the health care delivery system (e.g., restrictive appointment and immunization policies, limited operating hours, insufficient personnel, excessive waiting time, missed opportunities to immunize^{3,5-7,11,13,14,16-19}).

To date, knowledge of the characteristics of high-risk populations has not always resulted in provision of unique or effective immunization programs for their members. Strategies such as mailed or telephone reminders, shown to be effective in general population samples,^{20,21} may have only nominal effects among high-risk populations.²² For example, in 2 Atlanta public health clinics, modest improvement in immunization rates was found among families who received a telephone reminder, but because 20% of the sample could not be reached by telephone, the overall effect of the intervention did not achieve significance.²³

Immunization guidelines and recommendations indicate that providers should use more "patient-oriented" approaches,²⁴ communicate more effectively with families and communities,²⁵ and increase the demand for immunizations through health education.⁷ These recommendations are consistent with a social marketing approach to planning public health interventions—namely, an approach that consists of a consumer orientation and an emphasis on the exchange of goods and services be-

tween providers and consumers.²⁶ Exchange theory suggests that people are most willing to take a particular course of action when they feel they are being appropriately compensated for their efforts.²⁷ In practice, this reasoning supports recognizing and understanding the effort required for poorer families to overcome the barriers to having their children immunized and providing them with incentives and reinforcement they perceive as fair compensation for their timely and continued adherence.

Recent studies have shown that computer-generated educational materials that are tailored to the unique characteristics or needs of a specific audience are more likely than generic materials to catch that audience's attention^{28,29}; to be read and remembered,³⁰⁻³² saved,³⁰ discussed with others,³⁰ and perceived as interesting and personally relevant^{30,32,33}; to stimulate greater information processing³⁴; and to lead to changes in lifestyle and screening behaviors.^{30-32,35-37} In a 1996 pilot study,³⁸ we applied a tailoring approach in creating individualized immunization calendars for new parents at 2 public health centers in St Louis. Response to the calendars was very positive among parents and staff members, and medical chart reviews at 4-month follow-up showed immunization rates to be 91% among participating babies, more than twice the reported rate for all of St Louis at that time. In the present study, we report findings

Objectives. We examined the effectiveness of tailored calendars in increasing childhood immunization rates.

Methods. Parents of babies aged birth to 1 year (n=321) received individually tailored calendars promoting immunization from 2 urban public health centers. For each baby, an age- and sex-matched control was selected from the same center. Immunization status was tracked through age 24 months.

Results. A higher proportion of intervention than of control babies were up to date at the end of a 9-month enrollment period (82% vs 65%, $P < .001$) and at age 24 months (66% vs 47%, $P < .001$). The younger the baby's age at enrollment in the program, the greater was the intervention effect.

Conclusions. Tailored immunization calendars can help increase child immunization rates. (*Am J Public Health.* 2004;94:122-127)

from a larger-scale trial evaluating the effectiveness of an enhanced and fully automated software version of the calendar program. Immunization rates during and after the trial are compared between babies whose parents received the intervention in 2 urban public health centers and age- and sex-matched control babies from the same centers.

METHODS

Study Setting

The city of St Louis, Mo, is losing its population faster than any other American city (experiencing an 11.4% decline from 1990 to 1996), leaving a high concentration of poor and minority families as its primary residents.³⁹ In the 2 neighborhoods in St Louis in which this project took place, the population is predominately African American (97%) and disproportionately female (56%).⁴⁰ More than one-third (37%) of the African American population in St Louis is below the poverty level, and 27% of adults did not graduate from high school.^{41,42} As many as half of all preschool-aged children in the city have not been fully immunized in recent years.^{1,43,44}

Sample and Study Design

The study sample included babies aged birth to 1 year who visited the pediatrics department at 2 public health centers in St Louis during

the project period. The calendar intervention was offered at each center on 2 days of the week. For every baby whose parent or guardian received the calendar intervention, we selected a matched control baby from a list of all other babies who had been seen at the same health center. Control babies were matched to participants by sex (100% match) and date of birth (95% match within 7 days) and did not receive the calendar intervention. When more than 1 potential control baby matched a given participant, the control baby was selected at random. The 9-month enrollment period was from December 1997 to September 1998. Babies' immunization rates were then tracked through their 24-month birthday. Immunization records for participants and matched controls were obtained from state records and were compared for differences.

Intervention

Parents or guardians of eligible babies participated after signing an informed consent agreement and completing a brief interview with project staff (see "Measures"). Interview responses were entered directly into the ABC Immunization Calendar computer program.⁴⁵ A digital camera linked to the software took a picture of the baby and automatically downloaded the image to a computer, which generated and printed each calendar. The entire process took approximately 5 minutes, and parents left with their calendar or calendars in a protective tube. Parents received calendars for the months leading up to their baby's next scheduled immunization. They could receive subsequent months of the calendar only upon returning to the health center during the enrollment period for their baby's next scheduled immunization and updating their baby's picture, height, weight, and other information.

The full-color, wall-sized (11" × 17") monthly calendars included information about home safety, injury prevention, clinical preventive services, parenting skills, and child development, all matched to the child's current age in months; ongoing tracking of the baby's height and weight; a digital picture of the baby; professional graphics matched to the ethnicity of the baby; a reminder of the baby's next immunization appointment; the name, address, and telephone number of the health center; and monthly birthday greetings for the baby and



FIGURE 1—A sample ABC Immunization Calendar.

yearly greetings for parents and siblings. The messages on each calendar were tailored to the unique characteristics of each baby and family, based on information obtained in the parent interview. The messages were drawn from a computer-based library of 28 different age-matched monthly messages, 254 different daily messages, 111 general graphics, and 189 race/ethnicity-specific graphics. Messages were developed by project staff, and some were reviewed by mothers of young children. Most graphics were original illustrations. Hardware and software requirements for running the program are available from the authors. Figure 1 presents a sample calendar.

Measures

Demographic and other tailoring variables. A 16-question parent interview collected data about the baby (name, birth date, ethnicity, gender, height, weight), the parents and siblings (name, birthdate), the home environment (smoke detector, smoker living in the home, living above the first floor, stairway in the home, car and car-seat ownership), and the baby's health (vaccination history; breastfeeding; Special Supplemental Nutrition Pro-

gram for Women, Infants, and Children [WIC] participation; next appointment scheduled). These data were used to generate tailored calendar messages. Any changes in these variables were noted at each return visit.

Immunization status. "Up-to-date" status was defined as adherence (within 1 month) to a 4-3-1-3-3 (4 diphtheria/tetanus/pertussis; 3 poliovirus vaccines; 1 measles-containing vaccine; 3 *Haemophilus influenzae* type b vaccines; and 3 hepatitis B doses) age-specific immunization schedule.⁴⁶ Up-to-date status for each participant was determined at the end of the study period (September 30, 1998) and at each time interval for childhood immunizations—at 1, 2, 4, 6, 12, and 24 months—as per immunization schedules published by the Centers for Disease Control and Prevention.⁴⁶ Immunization data were obtained from patient records in the Missouri Department of Health's statewide immunization tracking system, Missouri Health Strategic Architectures and Information Cooperative.⁴⁷

Statistical Analyses

Descriptive statistics (e.g., frequencies, means) were used to characterize the study group. The McNemar test⁴⁸ with correction for continuity⁴⁹ was used to determine differences between participants and matched controls for immunization status at ages 1, 2, 4, 6, 12, and 24 months and at the end of the study's enrollment period (September 30, 1998). These time points were selected to determine immediate intervention effects as well as long-term effects. Immunization status was examined at 24 months because national recommendations call for completion of the basic immunization series by a child's second birthday.⁴⁶ Immunization rates for participants and controls also were compared in each of 6 cohorts defined by babies' age at enrollment in the program (<1 mo, 1 to <2 mo, 2 to <4 mo, 4 to <6 mo, 6 to <12 mo, ≥ 12 mo). These analyses were conducted because a baby's age at enrollment could confound intervention effects in 2 ways. First, because younger babies will have to make a greater number of vaccination visits to complete the series, there are more opportunities to miss a vaccination and fall behind schedule. Second, among older babies who fall behind schedule, it is more difficult to reestablish up-to-date status by 24 months of

TABLE 1—Characteristics of Intervention Babies, by Health Center

	Percentage	
	Intervention Health Center 1 (n = 132)	Intervention Health Center 2 (n = 189)
Sex		
Male	53.0	48.1
Female	47.0	51.9
Ethnicity		
African American	99.2	99.5
Other	0.8	0.5
Age at enrollment, mo		
0–0.9	17.0	25.9
1.0–1.9	24.3	23.3
2.0–3.9	15.1	11.4
4.0–5.9	11.8	18.0
6.0–11.9	27.3	18.0
≥ 12.0	4.5	3.4

TABLE 2—Immunization Status^a of Participants at End of Study Period and at 24 Months of Age, by Group and Site

	Health Center 1	Health Center 2	Both Sites
End of study period (n = 321 matched pairs)			
No. of matched pairs	132	189	321
No. (%) up to date: Intervention	104 (78.8)	158 (83.6)	262 (81.6)
No. (%) up to date: Control	87 (65.9)	123 (65.1)	210 (65.4)
χ^2	5.7	20.3	25.5
P	<.025	<.001	<.001
Age 24 months (n = 247 matched pairs) ^b			
No. of matched pairs	103	144	247
No. (%) up to date: Intervention	53 (51.5)	111 (77.1)	164 (66.4)
No. (%) up to date: Control	36 (35.0)	79 (54.9)	115 (46.6)
χ^2	5.7	15.5	21.5
P	<.025	<.001	<.001

^aUp-to-date status was defined as adherence within 1 month to recommended immunization schedules.⁴⁶ By age 1 month: 1 hepatitis B (Hep B); by age 2 months: 1 Hep B, 1 diphtheria/tetanus/pertussis (DTP), 1 poliovirus, 1 *Haemophilus influenzae* type b (Hib); by age 4 months: 2 Hep B, 2 DTP, 2 poliovirus, 2 Hib; by age 6 months: 2 Hep B, 3 DTP, 2 poliovirus, 3 Hib; by age 12 months: 2 Hep B, 3 DTP, 2 poliovirus, 3 Hib; by age 24 months: 3 Hep B, 4 DTP, 3 poliovirus, 3 Hib, 1 measles-containing vaccine.

^bAt time of analyses, 74 participants were not yet 24 months old.

age while still adhering to recommended intervals between immunizations. Thus, for babies enrolled at less than 1 month of age, these analyses examined immunization status at ages 2, 4, 6, and 12 months (for babies enrolled at ages 4–6 months, immunization status was examined at ages 6 and 12 months, etc.).

The intent-to-treat principle was applied for all statistical analyses. All analyses were performed with SPSS software.⁵⁰

RESULTS

Participants

During the 9-month enrollment period, 378 babies were enrolled to receive the calendar intervention. Matched controls were found for 89% of these babies (n = 337), and complete immunization records were obtained for 95% of the pairs (n = 321 matched pairs). At the time of analysis, 74 of the 321 participants (23%) were not yet 24 months old; thus, their immunization status could not be determined for the 24-month endpoint.

Nearly all participants were African American (99%); on average, babies were 4 months old at the time of enrollment in the program (mean = 3.8 months, SD = 3.6). The mean age of parents was 23.6 years (SD = 5.9), and most (98%) were enrolled in WIC. Most (97%) re-

ported having a car seat for their baby, although a majority (65%) had no car. About 1 in 4 parents (27%) reported that they currently smoked, and nearly half (48%) reported that there was a smoker living in the same home with the baby. Characteristics of intervention babies from each health center are summarized in Table 1.

Immunization Status

The state database of immunization records lacked data for 26 (6.9%) of the babies enrolled in the study. Although we have no reason to expect that these babies would be more or less likely than others to be underimmunized, we counted them as underimmunized in sensitivity analyses. Results from these analyses indicated that the magnitude and direction of intervention effects were similar to those reported here.

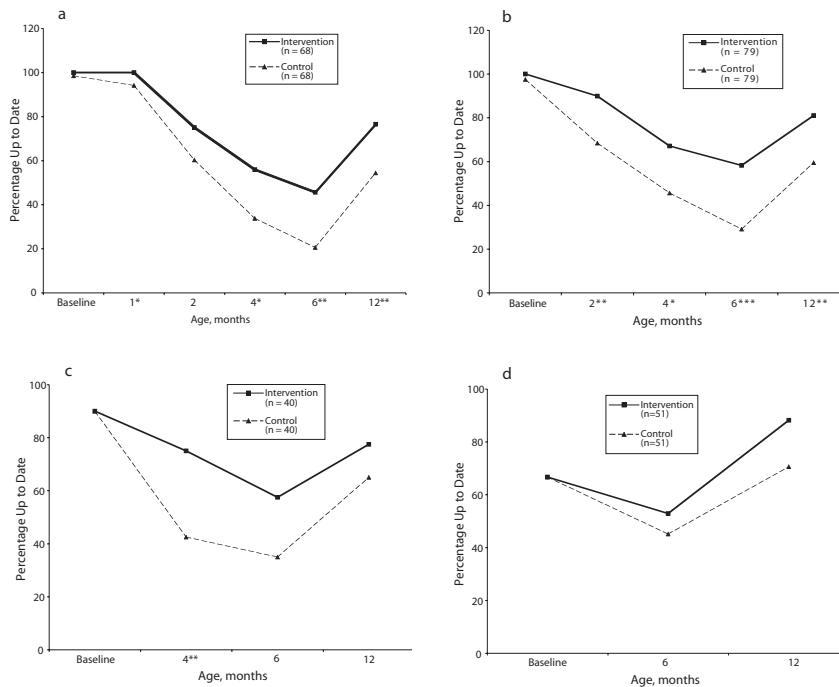
Participants and matched controls had similar rates of immunization before participants' enrollment in the study ($\chi^2 = 0.00$ and 3.36 for sites 1 and 2, respectively, both not significant). As shown in Table 2, 82% of intervention babies were up to date at the end of the enrollment period compared with 65% of matched controls ($\chi^2 = 25.5$, $P < .001$). At 24 months of age, 66% of intervention babies were up to date

compared with 47% of matched controls ($\chi^2 = 21.5$, $P < .001$). Table 2 also displays these data separately for each health center.

Across the first 4 age cohorts (i.e., babies enrolled at ages < 1 mo; 1 mo to < 2 mo; 2 mo to < 4 mo; 4 mo to < 6 mo), we found that the intervention group had higher rates of immunization than did the matched controls at each remaining immunization interval. In addition, the younger a participant's age at the time of enrollment in the calendar program, the greater the intervention effect at each remaining time interval. Because patterns of findings were similar for the 2 sites, we combined them for increased power. Figure 2 shows differences between participants and matched controls at each time interval for each of the 4 age cohorts.

DISCUSSION

Although progress is being made in reducing race- and income-based disparities in child immunization,^{51–53} large numbers of children in poverty remain undervaccinated.⁵⁴ Multiple strategies are needed to effectively address child underimmunization in poor, urban communities. The tailored calendar program appears able to increase immunization rates.



* $P < .05$; ** $P < .01$; *** $P < .001$.

FIGURE 2—Percentage up-to-date at each time interval, by group and age-enrollment cohort: (a) < 1 mo, (b) 1 to 2 mo, (c) 2 to 4 mo, (d) 4 to 6 mo.

The software the program requires is easy to use, and the time needed to enroll a baby and print a set of calendars is nominal (≤ 5 minutes, less than the typical waiting time at most clinics). At present, 6 public health centers in St Louis, Mo, and East St Louis, Ill, and 12 centers in Harlem, New York City, have adopted the program and are running it with existing staff members. The equipment needed to provide the program is also relatively inexpensive. At the outset of the trial, costs for acquiring brand-new equipment were \$6300; today, the same equipment costs \$4500, and costs can drop as low as \$3700 if calendars are provided on 8.5" \times 11" rather than tabloid-sized paper.

Although the study did not formally assess parents' reactions to the calendars, a previous pilot study³⁸ and anecdotal information from parents and clinicians involved in the present trial provide insight into why the calendars may have been effective. First, we believe the baby's photo was as important as any content on the calendar in attracting and retaining parents' interest. It is perhaps not surprising that parents of limited economic means

would find attractive a program that provides free pictures and individualized calendars for their new baby. This finding is consistent with principles of social marketing, which seek to make programs or services more appealing to consumers by adapting them to meet consumers' needs and interests. We believe that the calendars were appealing and were perceived as valuable to many parents. As a parent said, "The calendars are going into a scrapbook. I'll have to fold them or roll them or something, but they're going in a scrapbook." A staff member at one health center also noted, "For months after the program ended, mothers were still calling to see when the program was coming back or where they could take their babies to get the calendars."

In the study, parents received calendars for only those months leading up to their baby's next scheduled immunization; they would have to return to the health center and have their child vaccinated to receive the next set of calendars. As a result, the calendars served as an incentive for immunization. Such programs—ones that reward desirable behaviors or outcomes—can help address public health

problems such as low childhood immunization rates. The Advisory Committee on Immunization Practices has recommended that programs consider a variety of strategies, including the use of incentives.⁵⁵ In a systematic review of immunization interventions,⁵⁶ incentive-based programs were found to increase immunization rates by 2%–9% (median 6%).^{57–60} Such incentive programs can vary in design, location, incentive, and outcomes evaluated; thus, the programs examined in this review may not be directly comparable with our use of tailored calendars. However, we found larger increases than those resulting from these incentive programs: 13%–19% by the end of the enrollment period and 17%–22% by age 24 months.

The racial composition of our sample was very similar to that of neighborhoods where the health centers are located. However, because the study was conducted with a limited sample of patients from only 2 public health centers, it would be inappropriate to generalize our findings to other populations, including other inner-city or minority populations. Further testing of the tailored calendar program should be performed among other racial/ethnic groups.

In conducting the study, enrollment of babies and creation of calendars were carried out by research assistants and not by health center staff. Thus, the study's findings may not reflect potential challenges (e.g., staffing) to health centers offering the program without outside assistance. It is often the case that successful programs are not adopted by agencies and organizations because of such implementation challenges.⁶¹ To help individual health centers adopt and use the *ABC Immunization Calendar* program, we developed an implementation guide⁶² and software user's manual.⁶³ To date, more than 18 health centers in the St Louis metropolitan area and in Harlem have used these materials to begin offering the program to their patients.

The main limitation of the study is the unknown equivalence of intervention babies and their matched controls. Because the Missouri Health Strategic Architectures and Information Cooperative database includes only minimal demographic data, we could compare matched pairs only on health center, age, and sex. It is most likely the case that control babies were simply seen on different

days of the week than the days on which the intervention was offered. Although characteristics of intervention and control babies are very similar to patient census data from each health center, it is certainly possible that intervention and control babies differ on other characteristics not measured in the study. However, we know that the 2 groups are similar in several important ways. All babies were seen at the same 2 public health centers, indicating equivalence of access, parent motivation, and likely socioeconomic status. Matched control babies were also the same age and sex of intervention babies.

It is also possible that the improved immunization rates observed at the 2 intervention sites were not the result of the calendar intervention, but rather were related to some other planned child health activity or secular trend. However, no other child immunization programs or initiatives were introduced at either intervention site during the study period, and comparisons between same-age program participants and matched controls at the same site indicate that the effects are indeed intervention based.

The aforementioned limitations notwithstanding, we see several ways that programs like the *ABC Immunization Calendar* might be applied to reach a broader audience and to help achieve Healthy People 2010 objectives.⁶⁴ For example, the Advisory Committee on Immunization Practices and the US Department of Agriculture have recommended that immunization services be linked with services provided for children enrolled in WIC.⁵⁵ This recommendation would require documented vaccination records of each WIC client, preferably at each WIC visit. In our study, 98% of the participants were enrolled in WIC. Linking a program such as the *ABC Immunization Calendar* with WIC programs could streamline outreach services, tracking, and provide opportunities for individualizing health education materials.⁶⁵ Programs like the *ABC Immunization Calendar* also could help Medicaid managed care plans improve their immunization rates and could provide a means of tracking and documenting a baby's immunization status.⁶⁶

Practical, affordable applications of computer technology are much needed in public health practice. Results of this trial demonstrate that such programs can have a measur-

able effect on important and challenging public health problems. We encourage other researchers, practitioners, and administrators to consider how programs like this might be integrated into their own public health efforts. ■

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Contributors

M. W. Kreuter designed the study and intervention. C. A. Caburnay developed and delivered the intervention and collected and analyzed the data. J. C. Chen planned and supervised the data analysis. M. J. Donlin assisted in developing the intervention. All authors contributed to the writing of the article.

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Human Participant Protection

This study was approved by the institutional review board at Saint Louis University.

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