The Impact of Computer-Generated Messages on Childhood Immunization Coverage

Eugene F. Dini, MPA, Robert W. Linkins, MPH, Jennifer Sigafoos, BA

Introduction: Recent evaluations of computer-generated reminder/recall messages have suggested that they are an inexpensive, labor-saving method of improving office visitation rates of childhood immunization providers. This study assesses the sustained impact of computer-generated messages on immunization coverage during the first two years of life.

Design: Randomized, controlled trial.

Setting: County health department in the Denver metropolitan area.

Study Participants: Children (n = 1227) 60 to 90 days of age who had received the first dose of diphtheria-tetanus-pertussis (DTP) and/or poliovirus vaccines.

Intervention: Households of children were randomized into four groups to receive: telephone messages followed by letters (Group A); telephone messages alone (Group B); letters only (Group C); or no notification (Group D). Households in the intervention groups (A, B, and C) received up to five computer-generated telephone messages and/or up to four letters each time their children became due for immunization(s).

Main Outcome Measure: Immunization series completion at 24 months of age.

Results: Children whose families were randomized to receive any of the interventions were 21% more likely to have completed the immunization series by 24 months of age than were children randomized into the control group (49.2% vs 40.9%; RR [rate ratio] = .21; CI [confidence interval] = 1.01, 1.44). While not statistically significant, children in Group A were 23% more likely to complete their immunization series by 24 months of age than those in the control group (50.2% vs 40.9%; RR = 1.23; CI = 1.00, 1.52). No differences were detected among the intervention groups. The costs per additional child completing the series by 24 months of age in Group A was $226 ($79 after start-up costs were discounted).

Conclusion: Computer-generated contacts, either by phone or by mail (or both combined), used each time vaccines become due, are efficacious in increasing immunization coverage of children under 2 years of age.


Introduction

Recent evaluations of computer-generated reminder/recall messages have suggested that they are an inexpensive, labor-saving method of improving office visitation rates of childhood immunization providers; however, the sustained impact of computer-generated messages on immunization coverage during the first 2 years of life has not been examined until now.

Methods

Setting and Subjects

The study was conducted from 1993 through 1996 in a tri-county health jurisdiction within the Denver metropolitan area. The three counties had a total of four public health clinics, each with similar demographic characteristics and size. The four clinics all had computerized databases that were linked to the main office, from which all the interventions were conducted.
All children who were 60 to 90 days of age (inclusive), who had received the first dose of diphtheria-tetanus-pertussis (DTP) or poliovirus (PV) vaccines, and who had telephone numbers listed in the pre-existing computerized health department database were enrolled over 15 months until the target sample size of 1,200 was reached. Children enrolled in the evaluation were randomized to receive telephone messages followed by letters (Group A); telephone messages alone (Group B); letters only (Group C); or no notification (Group D).

Immunizations were scheduled according to then current Advisory Committee on Immunization Practices (ACIP) recommendations for DTP, oral poliovirus vaccine (OPV), and mumps-measles-rubella (MMR),7 but not for Haemophilus influenzae type b (Hib) or hepatitis B. Each series of calls and letters was initiated by a specified “due date,” determined by clinic staff at the end of each previous visit and entered in the computerized immunization records. The due date usually was a specific appointment, but sometimes was simply the date determined by clinic personnel as appropriate for the next immunization visit, based on the ACIP schedule. For this study, no specific computerized algorithm was developed to calculate when a child was due for vaccinations.

Each due date, when entered into the computerized database, signaled a potential number of future contacts, depending on the group to which each patient was assigned. Whenever children became due for any immunization(s) during the 22-month follow-up period, those randomized to receive a computer-generated reminder or recall message were contacted according to a specified schedule (Table 1).

### Intervention
The families of children enrolled in Groups A (telephone and letter) and B (telephone only) received one telephone reminder message prior to the scheduled immunization date and up to four telephone recall messages (1/week) over the 4-week period following the due date. Although the messages were delivered by computer, they were recorded by an employee of the health department. The content of phone messages (and letters) was very simple. No attempt was made to educate parents during these contacts. Messages reminded parents that their child was due for an immunization “shot,” and that immunizations were very important because they prevented children from contracting diseases that make many children very sick every year and asked parents to either keep an existing appointment or make an appointment if one had not already been made. The content did not change for subsequent follow-up messages.

For each scheduled contact, as many as nine attempts were made until the message was delivered. To maximize the likelihood of reaching a parent, all attempted contacts were made during weekday evening hours between 6:00 p.m. and 9:00 p.m. and on Saturdays from noon to 8:00 p.m. Calls that resulted in no answers or busy signals were not counted as contacts; however, calls that were answered by answering machines were considered successful contacts and immunization messages were left. If all nine attempts to contact a patient were unsuccessful, or if the patient did not report for immunization after all designated contacts were successfully completed, the patient was inactivated for further contact, unless or until a new due date was established. A new due date would signal that the patient had reported to the clinic or had called for a new appointment. Whenever a new due date was established, the entire series of calls and/or letters was rescheduled to occur at the time of the new date.

The families of children in Group A (telephone and letters) who did not respond to any of the five telephone contacts were mailed a computer-generated written reminder 1 week after the date of the fifth telephone contact. A second computer-generated letter was sent 1 week after the first mailing if the target children remained unimmunized. The families of children in Group C (letters only) received up to four computer-generated letters, the first sent 2 days after a child’s scheduled immunization was missed. If the child remained unimmunized, a second, third, and fourth letter was sent 1 week after each earlier written reminder. Letters were sent to families in Group C (letter-only group) only after the scheduled immunizations were missed, because the strategy of reminding parents before vaccines are due necessitates contacting many families (approximately 50%) that normally return for immunizations even without interventions. The programmatic aim of this

<table>
<thead>
<tr>
<th>Group</th>
<th>Days from Scheduled Immunization Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-2</td>
</tr>
<tr>
<td>A</td>
<td>T</td>
</tr>
<tr>
<td>B</td>
<td>T</td>
</tr>
<tr>
<td>C</td>
<td>L</td>
</tr>
<tr>
<td>D</td>
<td></td>
</tr>
</tbody>
</table>

T, telephone; L, letter.

Table 1. Schedules of contacts

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study was to determine viable alternatives for parent notification, and it was felt that reminder letters would pose an additional expense without commensurate benefit. In Groups A and B, reminder contacts were made by telephone before the scheduled immunizations, because telephone calls incurred no additional expense. However, in Group C the cost of postage to deliver reminder messages by mail (many of which would be unnecessary) would have raised operating costs substantially (approximately 30%).

A language field was established in the computerized immunization record of each study participant. Immunization messages were recorded in Spanish and English, and the computer-generated telephone messages and letters were delivered in the household’s specified language.

**Analysis**

Data were abstracted from the same computerized databases that were used to make decisions about the scheduling of both immunization visits and the interventions associated with those visits. The primary outcome measure was series completion at 24 months of age; secondary outcome measures were up-to-date coverage rates at selected ages based on ACIP recommendations.7 Our primary (randomization) analysis included all children assigned to the intervention groups, regardless of any changes in residence or provider status that would impede delivery of the intervention. However, we also reassessed coverage levels for children whose families had successfully received the interventions only, as documented in the computerized records (receipt analysis). Rate ratios were calculated for each intervention group using the immunization rate in the nonintervention group (Group D) as the baseline rate.

After follow up was complete for all study participants, potential confounding variables were identified by comparing gender, ethnicity, language of household, number of children in the household, and Medicaid coverage among children randomized to each of the four study groups. The likelihood ratio 02 statistic was used to identify statistically significant differences.

Stratified analyses were conducted to assess the independent effect of each intervention on immunization rates. Within each stratum of all potentially confounding variables (i.e., variables associated with the intervention at the 0.05 level of statistical significance), immunization rates and rate ratios (RR) were compared between the intervention and nonintervention groups.

**Evaluation of Parental Acceptance of Repeated Reminders**

To determine whether repeated telephone contacts resulted in negative reactions by parents, a 10% sample of children whose households received successful telephone calls was generated 4 weeks after successful calls had been made. A systematic sample was selected, with the selection of every tenth family successfully contacted by phone 1 month after they had reached a specific immunization marker (i.e., DTP2, DTP3, and DTP4). Each family was chosen just once; thus if a family had been previously selected, it was replaced by the next family on the list. Both the families who answered the phone and those whose answering machines received the calls were called back. Information from adult household members was solicited to identify who in the household received the contact, whether the recipient’s reaction to the intervention was positive, and whether the recipient thought that the contact would be a positive motivator for other parents to get their children immunized.

The specific questions focused, first, on who in the household received the telephone call: (1) “Can you or any other member of your household recall receiving a telephone call reminding you of (name)’s appointment to receive an immunization (shot)?” and (2) “Which household member received that call?” Then the questions focused on the reaction to the phone calls: (3) “How did you feel about receiving the telephone call(s)?” (thankful to have received the call because I would have forgotten the appointment; pleased to have been reminded, although I probably would have remembered, anyway; thought the call was unnecessary, a waste of time; was irritated by the call—don’t call again.); and (4) “Do you think calls such as these would be helpful to remind other parents about immunizations (Yes, No)?” A “positive response” to question number 3 was either the first or second option—i.e., “thankful” or “pleased.”

**Project Expenditures**

Project expenditures were divided among start-up costs and operating costs during the 34-month period of the study. Start-up costs were one-time expenditures to procure and install hardware, software, and a dedicated telephone line essential for the three intervention limbs of the study. Operating costs were continuing expenditures needed to implement the interventions on a daily basis after the system was initiated (i.e., monthly phone-line charges, clerical costs, and postage).

The automated dialing equipment used in this study was a proprietary, stand-alone unit manufactured by Telecorp Systems, Inc (Roswell, GA). The unit (no longer available) required phone numbers to be downloaded from the health department database. The software company that developed and maintained the health department’s database provided the software required to group and track patients, to download phone numbers to the autodialer prior to the due date
(and subsequently, if no new due date was established—indicating that the child had been to the clinic), to provide needed documentation, and to produce computer-generated letters at appropriate times. Training for the clerical staff was also provided by the software company.

Results

Enrollment took much longer than expected (15 months vs 9 months); thus only 861 of the 1227 children originally enrolled (70%) reached 24 months of age by the end of the study period. Study completion rates, however, did not differ by group or by demographic characteristics. Children who did not reach 24 months of age by the end of the study were, nevertheless, followed for intermediate time periods (i.e., 6, 9, 12, 15, and 18 months) and were included in the secondary analysis to determine up-to-date status for as long as they were in the study. Of those who had reached 24 months of age by the end of the study period, 126 had moved from the health jurisdiction or had identified another provider for immunization services, leaving 735 children whose parents had received the intervention during the entire 22-month follow-up period (from 2 months of age to 24 months of age).

Characteristics

No significant differences were noted between groups with regard to gender ($p = 0.12$), number of children in the household ($p = 0.69$), or whether children were insured by Medicaid ($p = 0.72$). However, significant ethnic and language differences were noted between groups ($p < 0.05$). While approximately 25% of white children and English-speaking children were randomized to each of the four study groups, 35% of African American children were randomized to Group B (telephone only) and 16% were randomized to Group C (letters only). Only 19% of Hispanic children were randomized to Group C, and only 3% of children from Spanish-speaking households were assigned to Group A (telephone and letters). Demographic characteristics of 126 children who had reached 24 months of age but who were identified as having moved or gone elsewhere for immunizations during the study period were similar to the 735 children who did not change their residence or provider.

Outcomes Measures

Children whose families were randomized to receive any of the interventions were 21% more likely to have completed the immunization series by 24 months of age than were children randomized into the control group (49.2% vs 40.9%; RR = 1.21; CI = 1.01, 1.44). Children in each of the three intervention groups had higher series-completion rates at 24 months of age compared with children in Group D (controls), although the differences were not statistically significant for any individual intervention in the primary (randomization) analysis (Table 2). Secondary outcome measures also reflected higher age-specific series-completion rates at each selected age (6, 9, 12, 15, and 18 months of age) for each of the intervention groups, compared with children in Group D (Figure 1). Differences were significant at 15 and 18 months, but only for children in Group A (telephone and letters).

The primary outcome for children whose parents successfully received the interventions during the 22-month follow-up period, as documented in the computerized records (receipt analysis), revealed even higher series-completion rates at 24 months of age for all three intervention groups (Table 2), and the difference was significant for children in Group A (telephone and letters), compared to Group D (controls)—61% vs 47% (RR = 1.30; 95% CI = 1.08, 1.58). Significant differences were also seen in Group A at 6, 12, 15, and 18 months of age for children whose parents received the interventions (Figure 1).

Children in each of the intervention groups had higher up-to-date rates at each time point compared

### Table 2. Up-to-date immunization rates (per 100) and rate ratios (RR)

<table>
<thead>
<tr>
<th>Group</th>
<th>Immunization coverage at 24 months of age</th>
<th>No.</th>
<th>Rate</th>
<th>RR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (phone + letters)</td>
<td></td>
<td>215</td>
<td>50.2</td>
<td>1.23 (1.00–1.52)</td>
</tr>
<tr>
<td>B (telephone only)</td>
<td></td>
<td>217</td>
<td>49.3</td>
<td>1.21 (0.98–1.49)</td>
</tr>
<tr>
<td>C (letters only)</td>
<td></td>
<td>216</td>
<td>48.2</td>
<td>1.18 (0.95–1.46)</td>
</tr>
<tr>
<td>Any intervention (phone and/or letters)</td>
<td></td>
<td>648</td>
<td>49.2%</td>
<td>1.21 (1.01, 1.44)</td>
</tr>
<tr>
<td>D (controls)</td>
<td></td>
<td>213</td>
<td>40.9</td>
<td>—</td>
</tr>
</tbody>
</table>

CI = confidence interval.
with children in Group D. These findings were similar within each ethnicity and language category. Rates of up-to-date immunization were generally higher in the intervention groups compared with similar children in Group D (data not shown) for each subgroup analyzed, including white, African American, Hispanic, other ethnicity, and nonwhite (i.e., African American, Hispanic, and other ethnic groups combined) children, as well as children from English- and Spanish-speaking households. Although neither race nor ethnicity was found to be a confounder, the small number of ethnic minorities and children from Spanish-speaking households made within-group comparisons difficult. Statistically significant increases over immunization rates in Group D were noted primarily for white children and for children from English-speaking households assigned to Group A (phone and letters); most up-to-date rates were significantly higher in these children. However, Hispanic children and children from Spanish-speaking households assigned to Group B (phone only) had significantly higher rates than similar children assigned to Group D for some comparisons. The number of children from Spanish-speaking households assigned to Group A was insufficient to assess any rate differences with Group D children.

Parental Acceptance

Results from the 10% callback of households contacted by telephone indicated that 100% of the 206 households contained the target families. One hundred sixty-six (80.6%) of the households recalled having received a telephone call. One hundred fifty-five (93.4%) of these 166 families stated that the telephone message was received by the child’s mother or father, and 142 (85.5%) gave a positive response about the telephone contact. No families expressed negative feelings about the contact. The positive response rate was similar after the DTP2, DTP3, and DTP4 contacts. One hundred fifty-nine families (95.8%) thought the message would be a helpful reminder to other parents to get their children vaccinated.

Project Expenditures

The total cost for the interventions used in this study was $11,292 for the 34-month study period (Table 3). Although the overall expenses were approximately twice as high for Groups A and B compared with Group C, the operating costs (after start-up costs are discounted) were quite similar for the single-intervention groups (B and C), and only 32% higher for the combined-intervention group (A).

Costs per month (and per year) were as follows: Group A, $139 ($1,672); Group B, $126 ($1,518); and Group C, $66 ($796). However, start-up costs accounted for 64% of the total expenditures; after investing in these one-time capital outlays, the monthly operating costs for Groups A (telephone and letters), B (telephone only), and C (letters only) were $49, $36, and $37, respectively. The total cost per child enrolled in Group A (the only intervention group with statistically significant outcomes) was $15.38 ($4738/308); the cost per child after discounting for start-up costs was $5.37. For the primary (randomization) analysis, the cost per additional child in Group A (telephone and letters) completing the immunization series by 18 months of age was $132; by 24 months, it was $226. After discounting for start-up costs, however, the cost for each additional child completing the series was $46.
and $79 by 18 months and 24 months of age, respectively.

The base prices for automated dialing systems currently on the market range from about $1600 (computer not included) to $19,000. Automated dialing systems can also be employed in noncomputerized settings, because 1,000 to 1,200 telephone numbers per hour can be manually entered into the system.5

Discussion

This study suggests that vaccine coverage of preschool children can be increased by the repeated use of automated parent notifications during the first 2 years of the child’s life, extending earlier findings that computer-generated telephone reminder and recall messages are an effective strategy to improve pediatric immunization visits.3–6 Furthermore, most parents (86%) gave a positive response about the telephone contact, regardless of the age of their children or the number of prior telephone contacts they had received. Multiple telephone messages and multiple mailings were equally effective over a 2-year period, and this effect was strengthened somewhat when the two interventions were combined. The results demonstrate that computer-generated messages, if applied in an aggressive manner, can significantly increase coverage by 24 months of age among children whose parents receive the intervention.

Intervention effectiveness may have been even higher if children who began their immunization series late were included in the cohort, because previous work suggests that telephone messages may be most effective in children who are late for their immunizations.3–6 Furthermore, most parents (86%) gave a positive response about the telephone contact, regardless of the age of their children or the number of prior telephone contacts they had received. Multiple telephone messages and multiple mailings were equally effective over a 2-year period, and this effect was strengthened somewhat when the two interventions were combined. The results demonstrate that computer-generated messages, if applied in an aggressive manner, can significantly increase coverage by 24 months of age among children whose parents receive the intervention.

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computer-generated messages and to determine the optimal number and sequence of telephone and mailed messages.

Limitations
This study is limited by having only one source (health department database) for immunization histories; funding did not allow pursuit of vaccinations obtained at other sites, probably resulting in an underestimation of true rates. The generalizability of the study may also have been affected by the radical shift of health delivery in recent years, from the public to the private sector, because clients remaining in the public sector now may have different characteristics than patients enrolled in this study 6 years ago had. In addition, our secondary analysis excluded children who had moved or gone elsewhere for services. Although this was done in order to assess the efficacy of the interventions on parents who actually received them, it may have introduced a bias, because we were more likely to find changes in resident and provider status from households that received the interventions.

Conclusion
We conclude that children in this public setting who begin their immunization series on time and whose parents receive a series of computer-generated telephone calls and/or letters for each scheduled immunization over 22 months are 20% more likely to complete their immunization series by 24 months of age than are children who begin their series on time but who receive no reminder or recall messages. Although this study does not have a true factorial design, we believe it shows that aggressive strategies employing up to five phone calls and up to four letters are equally effective with equivalent operating costs, whereas a combined-intervention strategy provides a modest increase in effectiveness at a somewhat higher (approximately 30%) cost, after start-up costs are discounted.

However, even in the most responsive intervention group in this evaluation, up-to-date immunization rates were only 61% at 24 months of age. It is clear that reminder/recall strategies alone are not sufficient to raise series-completion rates among 2-year-old children to optimal levels. Automated parent reminder/recall messages can lead to increases in vaccine coverage; however, additional strategies and interventions will be needed to reach the U.S. health objective of 90%. Such strategies include removal of physical, psychological, and other practice-based barriers to immunization delivery, development of linkages with the Special Supplemental Food Program for Women, Infants, and Children programs, and employment of assessment and feedback strategies among public and private providers. In addition, the development of registries at state and local levels should support and facilitate both reminder/recall and assessment strategies.

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References

