Keeping Punchcard Records in a Mass Immunization

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MEASURES of the success of mass immunization programs have usually included counts of recipients by using registration cards or tally sheets. Effective analysis of registration cards, however, "has rarely, if ever, been accomplished," according to Serfling and Sherman (*1*). "Deciphering the hastily completed records, often illegible and frequently incomplete, is a discouraging task," they explain. "The frustration and delay attending this procedure often results in postponement of analysis until interest wanes, and the project is then shelved." When registration cards are used, a common course of action is to base summary results on a small sample of such records (*2a*). Use of the simple tally sheet has likewise proved inefficient. Inaccuracies in recording and counting tallies, deficiencies in identification of the tally sheets, illegibilities, and errors in combining results tend to reduce confidence in summaries based on these records. Moreover, with either registration cards or tally sheets, much labor is often expended to produce records which are never summarized or are analyzed only in part. Another less obvious disadvantage may be a slowdown at clinics in order to accomplish the recordkeeping.

A less ambitious procedure entails counting only the number of vials of vaccine used, often without correction for waste or overdosage. Serfling and Sherman (*1*) note, however, that " a communitywide figure fails to reveal variations in participation by various segments of the community, as well as differences in response by age groups."

In an effort to avoid some of these disadvantages, punchcards were introduced in the Sabin Oral Sunday mass immunization program carried out in Metropolitan Nashville during the fall of 1963. Punchards for recordkeeping in such a program had been used in Pima County, Ariz., in 1962. In the Nashville program more intensive use of the device was made, and new features were incorporated in the system.

Methods

The Sabin Oral Sunday mass immunization program in Nashville-Davidson County was carried out in a manner similar to that in other communities. The Nashville Academy of Medicine sponsored the program. A public relations firm whose office served as central headquarters for administration of the program managed it. Clinics were held on October 6, November 10, and December 15, 1963, at 79 clinic sites established to provide maximum accessibility for the population of the county. On the Sundays following these dates, vaccine was available at six strategically located makeup clinics. In addition, vaccine was distributed to all institutionalized persons in the county within a few days after the public clinics were held.

Each prospective recipient received a punched card (fig. 1) which was treated as a kind of ticket. These cards were prepunched to indi-

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cate age group and clinic site. Colored strips on the cards corresponding to the five age groups facilitated distribution. The code for age groups was also printed on each card. These groups were broad enough to obviate asking the actual age of each person. It was necessary to ask a general question concerning age for some who were near the age group limits. After the persons received their sugar cubes with vaccine, the cards were deposited in a suitable container.

The cards were later collected and taken to one of two counting depots where they were counted, by age and clinic site, at the rate of 1,000 cards per minute on an IBM counting sorter. The cards brought to the counting depot were already grouped by clinic site, so that they could be counted by age with one pass through the sorter and immediately repacked for distribution to the appropriate clinic site for the succeeding Sabin Oral Sunday.

Since the card system worked relatively smoothly at the first clinics, it appeared that it might be used even more efficiently on succeeding Sundays. Therefore, a plan was initiated to mark sense the cards in an effort to determine the numbers and percentages of participants receiving various combinations of monovalent vaccine during the entire program. This procedure entailed the distribution of electrographic pencils with the cards.

To determine how many participants received the full series and various combinations of the three types, each person at the November and December clinics was queried regarding his previous clinic attendance, and the cards were marked accordingly. Each registrar was furnished instructions on how to mark sense the card in accordance with the response elicited. For the December clinics four responses were possible, so that the question had to be rephrased to elicit the desired information. Although detailed instructions were sent with the punched cards, a group of specially instructed roving registrars visited the various clinics, each registrar serving three to five sites, in order to make sure that the specified procedures for handling and marking the cards were followed.

The cards marked with the electrographic pencils were returned to the counting depots and processed on the IBM sorter as before except that after counting and tabulating they were stored and later punched according to the penciled mark on the face of the card. A mark

Figure 1. Facsimile of brown-tipped punchcard used in Nashville-Davidson County Sabin Oral Sunday program. The 5 punch in column 80 designates the age group 40 and over. The 6 and 7 punches in columns 78 and 79 designate the clinic site. The clinic registrar's mark above the 2 on the left-hand side indicates that the recipient had attended an October clinic as well as the one at which this card was used in November. The corresponding 2 in column 77 was punched by the mark sense machine

Table 1. Number of vaccine recipients and percentage of population included, by age group and vaccine type, Sabin Oral Sunday program, Nashville-Davidson County, Tenn., fall 1963 [1]

Age group (years)	Type I	Type III	Type II	At least one dose [2]
	Number of recipients			
All ages	259, 468	265, 616	244, 996	280, 320
Under 1	4, 012	4, 104	3, 403	4, 812
1–4	25, 069	25, 237	22, 756	27, 175
5–14	68, 754	68, 810	64, 700	72, 283
15–39	92, 590	96, 819	86, 580	101, 052
40 and over	69, 043	70, 646	67, 557	74, 998
	Percentage of population			
All ages	60. 6	62. 0	57. 2	65. 3
Under 1	40. 8	41. 7	34. 6	48. 9
1–4	64. 9	65. 4	58. 9	70. 4
5–14	80. 1	80. 1	75. 3	84. 2
15–39	60. 9	63. 7	56. 9	66. 5
40 and over	48. 6	49. 8	47. 6	52. 8

[1] Including institutions.
[2] Estimated total, based on results of mark sensing cards at type III and type II clinics.

sense machine automatically translated the marks into punched holes.

Cards from the November and December clinics processed in this way were later recounted to determine the number of persons receiving various combinations of vaccine types. A simple count of the cards that were mark sensed in December gave the number who had received (*a*) all three types, (*b*) types II and I only, (*c*) types II and III only, and (*d*) type II only. To estimate the number receiving other combinations of vaccine types, the following equations were used:

The number receiving types I and III only=
  the number of November (type III) recipients claiming to have received type I—
  the number of December (type II) recipients claiming to have received types I and III
The number receiving type I only=
  the number of October (type I) recipients—
  the number estimated by the preceding equation to have had types I and III only—
  the number of December (type II) recipients claiming to have previously received type I
The number receiving type III only=
  the total number of November (type III) recipients—
  the number of November (type III) recipients claiming to have received type I—
  the number of December (type II) recipients claiming to have received only type III previously.

An estimate of clinic attendance could have been made on the basis of vials of vaccine actually used. Each vial contained approximately 100 doses of vaccine. A representative of the pharmaceutical company supplying the vaccine provided information on the number of vials used by school (excluding waste due to unusable thawed vaccine). With this information, checks could be made against the counts of recipients obtained by the card system.

Results

One dose or more. Participation rates by age group and by type of vaccine received are shown in table 1. The total number of participants (those receiving at least one dose) also is recorded by age with the corresponding percentages. Of the total population of the area, 65.3 percent attended the clinics and received at least one dose of vaccine.

The complete series. Table 2 shows the percentage distribution of recipients according to vaccine types received by age group. Except for infants, more than three-fourths of those attending the clinics completed the three-dose series of monovalent vaccines. The relatively high percentage of those receiving only types I and III vaccine appears to reflect the small

turnout for the December (type II) clinics. One might speculate that the lack of formal makeup clinics in December, cold weather, and proximity to the Christmas holidays were responsible for the relatively small turnout.

Infant group. A notable feature of the results is the comparatively small number and percentage of the group under 1 year receiving the full series or any part of it (tables 1 and 2). The small percentage of participation does not necessarily indicate failure of this group to receive vaccine. Only infants older than 6 weeks were eligible to participate. Also, many infants not participating had already received vaccine from private physicians before the Sabin Oral Sunday program. An additional explanation is that many of these infants did not become old enough to participate until after inception of the program and for this reason may not have received type I. Again, many of those receiving type I would have become older than 1 year before the second or third clinic and hence be classified in the next higher age group. The low rate of immunization for infants also reflects in part a probable overestimation of the infant population.

Geographic area. Rough estimates were made of the current population by age group for five areas in the county. The problems of assessing relative participation in these areas arise in part from the difficulties in estimating population for denominator data, but they are compounded by migration of recipients as well.

Table 2. Percentage distribution of recipients by vaccine types for 5 age groups, Sabin Oral Sunday program, Nashville-Davidson County, Tenn., fall 1963

Vaccine type	Age group (years)				
	Under 1	1–4	5–14	15–39	40 and over
Total	100.0	99.9	99.9	100.1	100.0
I, II, and III	56.8	77.0	85.0	78.9	84.3
I and III	13.3	8.5	5.5	9.1	2.3
III and II	9.9	5.5	3.6	5.0	4.7
I and II	2.6	.8	.6	1.2	.8
I only	10.7	5.9	3.9	2.5	4.7
III only	5.3	1.8	1.1	2.8	2.9
II only	1.4	.4	.2	.6	.3

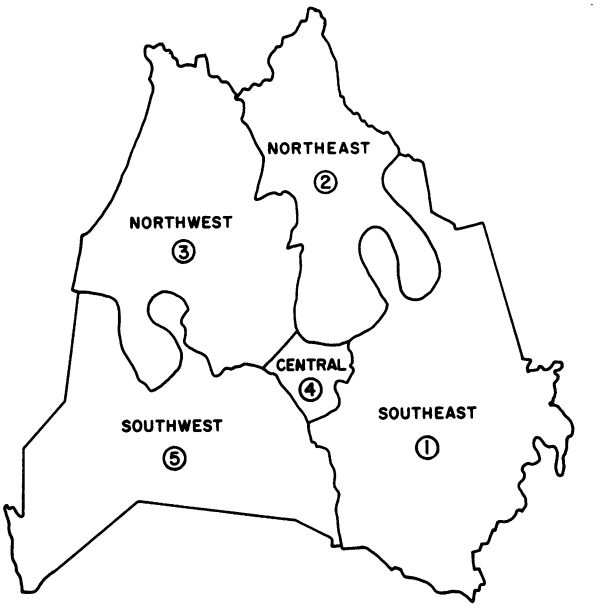


Figure 2. Nashville-Davidson County, Tenn., subdivided into areas based on locations of Sabin Oral Sunday makeup clinics.

For example, a resident of one area might have obtained one or more of the three types of vaccine at a clinic or clinics in another area. As noted in the Pima County, Ariz., program, "The statisticians apparently had counted on most of the people turning out at clinics closer to their homes and overlooked the fact that many would go to the clinic closer to the church they attended" (*3*). In Nashville, migration to an area other than that of residence to obtain the vaccine also appears to have occurred more often than would have been expected at the outset.

Attempts were made to assess geographic differences in spite of the difficulties of estimating population and migration. The locations of the six makeup clinic sites were selected to draw residents throughout the county but from wider geographic areas than the original clinics. An arbitrary definition of the areas which these makeup clinics served is indicated on the outline map of figure 2. Because the makeup clinic results had to be included in any appraisal of the data by area, no segments smaller than those shown could be considered. Table 3 shows the percentages of the population receiving all three types of Sabin vaccine in the areas depicted on the map.

More than one-half of the population of Metropolitan Nashville received the full three-dose series of Sabin oral vaccine during this program and were presumably immunized. The 5–14 year age group was most completely immunized. It should be noted that the low participation rates in the infant group prevailed universally in all five areas. For other age groups, data by area indicate a consistently high participation rate for area 1 and a consistently low one for area 5. The pattern of the rates by age group is similar for all five areas.

Discrepancies. Participation rates for at least one dose and at least two doses of vaccine (table 3) reveal two types of discrepancy which require explanation. The most striking anomaly concerns age group 5–14 years, which for certain areas shows more than 100 percent participation. One explanation for this contradiction is underestimation of the populations in that age group in those areas; another is migration. The relative contribution of either factor is difficult to evaluate. A third less likely factor is the possible attendance of persons outside

Table 3. Estimated number receiving all 3 doses of Sabin vaccine and estimated percentages of population receiving these 3 doses, 2 doses, or 1 dose, by age group and broad geographic area, Sabin Oral Sunday program, Nashville-Davidson County, Tenn., fall 1963 [1]

Age group (years)	Total county	Area 1 southeast	Area 2 northeast	Area 3 northwest	Area 4 central	Area 5 southwest
	Number of recipients of all 3 doses					
All ages	221, 890	57, 680	58, 180	31, 470	18, 970	55, 590
Under 1	2, 730	690	700	410	270	660
1–4	20, 910	5, 940	5, 350	3, 360	1, 910	4, 350
5–14	61, 290	16, 490	15, 990	10, 260	5, 690	12, 860
15–39	77, 280	22, 160	20, 080	10, 400	5, 530	19, 110
40 and over	59, 680	12, 400	16, 060	7, 040	5, 570	18, 610
	Percentage of population receiving all 3 doses					
All ages	52. 7	77. 3	50. 8	54. 5	46. 1	41. 7
Under 1	27. 9	36. 7	26. 2	26. 7	28. 8	23. 9
1–4	54. 4	79. 6	50. 7	55. 7	52. 3	40. 5
5–14	72. 5	96. 1	67. 6	81. 8	78. 6	53. 6
15–39	52. 1	81. 9	50. 1	53. 7	39. 5	40. 0
40 and over	42. 6	58. 8	42. 8	38. 6	36. 3	38. 7
	Percentage receiving at least 1 dose					
All ages	65. 3	86. 8	62. 1	75. 6	59. 5	53. 3
Under 1	48. 9	55. 3	48. 4	55. 9	54. 3	39. 4
1–4	70. 7	94. 4	66. 4	81. 0	78. 0	50. 1
5–14	85. 3	100. 7	77. 5	114. 2	99. 5	62. 0
15–39	66. 5	92. 2	63. 4	73. 7	54. 6	55. 2
40 and over	52. 0	68. 6	50. 6	50. 9	40. 9	48. 6
	Percentage receiving at least 2 doses					
All ages	60. 1	85. 1	58. 4	66. 0	51. 3	47. 7
Under 1	40. 5	51. 6	38. 6	44. 2	38. 3	33. 3
1–4	64. 7	92. 3	61. 1	70. 5	64. 9	45. 8
5–14	80. 4	103. 8	75. 5	96. 4	83. 5	58. 6
15–39	61. 5	91. 7	59. 3	67. 4	46. 3	48. 4
40 and over	46. 5	61. 7	47. 3	44. 0	38. 1	42. 8

[1] Institutions not included. Numbers rounded to nearest 10.

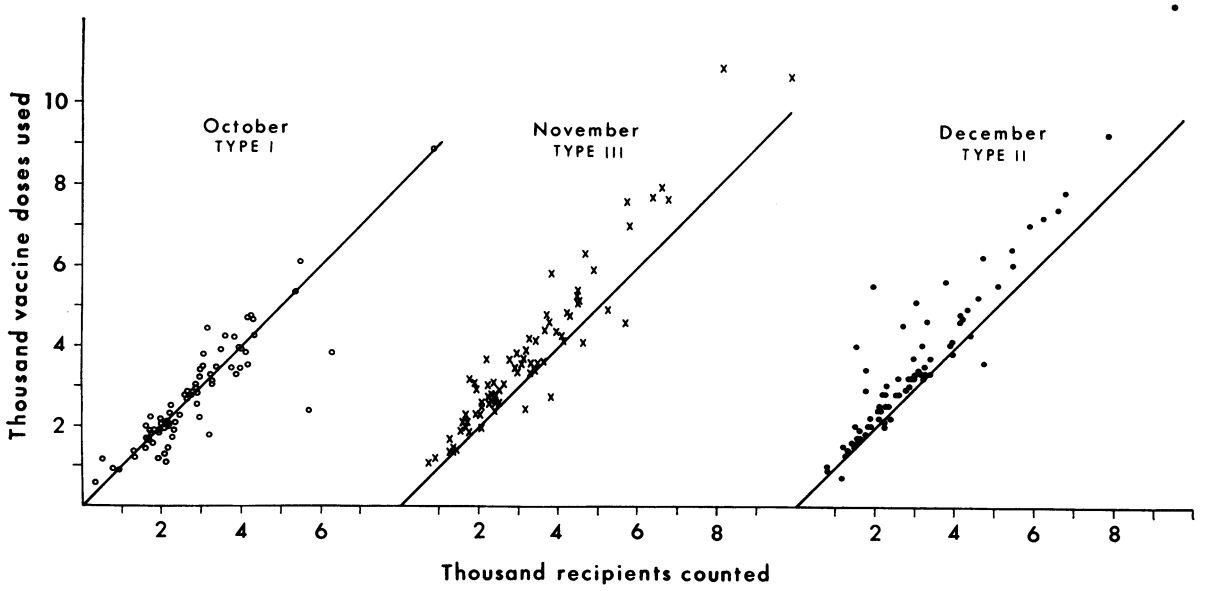
the Metropolitan Nashville area. This phenomenon of more than 100 percent participation is not unique. It is indicated, though not explicitly noted, in previously published data (*2b*).

The second inconsistency revealed in table 3 centers around the entries in area 1 for the 5–14 year age group, which shows that 100.7 percent received at least one dose, while 103.8 percent received at least two doses. These are obviously impossible results and must be explained in terms of the estimation procedures described in the section on methods. If a large number appeared in December claiming to have received vaccine in October (type 1) and November (type III) when in fact they did not, a negative estimate of those receiving types I and III only could result. The same kind of calculation was used to account for those receiving type I only and those receiving type III only. Analysis for certain areas reveals that in some cases a "negative number of people" were estimated to have received type I only. These negative estimates probably reflect responses of recipients at the time of the November and December clinics, when they falsely stated that they had received type I vaccine in October. The tendency to give such false responses when a favorable reply is expected is not uncommon in such situations and can lead to such contradictory findings as these. It is possible that to a minor degree miscoding or mismarking the mark sense cards would contribute to this type of error.

These combined errors, resulting from migration, underestimation of the population, false responses regarding participation, and miscoding, likely contribute to the unusually high percentage of children 5–14 years of age in area 1 who were found to have completed the series.

Other participation figures. Participation figures obtained through the punchcard method were compared with estimates of participation based on the amount of vaccine distributed (fig. 3). The number of doses of vaccine distributed by vials was plotted against the count of recipients by clinic site for October 6, November 10, and December 15, respectively. These edited data refer only to clinic sites where no discrepancy in the recipients counted or vials of vaccine administered was thought to exist. At least in the November and December clinics, the number of recipients was grossly overestimated when vaccine use was the basis of estimation (fig. 3). The wide variation in the size of drop per dose and the occasional tendency to use more than the dosage recommended by the pharmaceutical company probably accounts for this overestimation. On the basis of regression estimates, a reasonable rule of thumb to gauge the

Figure 3. Doses of vaccine used compared with counted recipients at each clinic, Sabin Oral Sunday mass immunization program, Nashville-Davidson County, fall 1963



number of recipients of vaccine would be to deduct 10 or 15 percent from the estimate based on the number of doses used.

Discussion

Advantages of punchcards. The advantages in using punchcard records in this type of mass program are:

1. There is little confusion in counting vaccine recipients because one person receives only one card—a physical item more easily identifiable than a mark on a tally sheet.

2. The color code on the card reduces confusion concerning age of the recipient.

3. A reduction in waiting time is effected by merely passing out a card rather than having to record information. Reluctance of people to wait in line while paper work is done may decrease participation and handicap a program.

4. Cards of recipients may be counted with extreme rapidity and accuracy.

5. Evaluation of complete and partial participation is possible through use of a mark sense device.

Disadvantages of punchcards. Some of the possible shortcomings are:

1. Distribution of sufficient cards to each clinic site and subsequent collection of these after the clinics close may present logistic difficulties.

2. The lack of availability of punchcard machinery and personnel may preclude using such a system in some localities.

Logistic problems decreased considerably after the first clinic since the idea of using cards was quickly accepted. Also, preliminary estimates of the attendance at each clinic were necessarily poor until the first Sunday's count provided a reasonable basis for estimating the number of cards of each color to distribute to each clinic site. Even fewer logistic problems would have occurred had mark sensing not been used since there would have been no need to distribute and collect electrographic pencils. The work entailed in distributing and collecting cards and other supplies and counting and tabulating results increased with the number of clinic sites. It was very easy to distribute cards and supplies and supervise procedures at the six makeup clinics, but with operations at 79 clinic sites on the Sabin Oral Sundays, it was difficult at times to cope with all the problems. Also, with the larger number of sites, more cards were required to assure a sufficient number of each color with allowance for error.

Had the mark sense device not been employed, the same punchcards could have been used repeatedly by redispatching them to the proper clinic sites on later Sundays. Additional cards would have been needed only to allow for attrition and increases in attendance. Less than 500,000 cards would have been required. Actually, about 750,000 were used with the mark sense procedure described.

Difficulties encountered. Specific difficulties and points of interest in our experience were:

1. At the time of the first clinic, cards were returned completely disarranged in large cardboard boxes. A considerable amount of manual rearrangement had to be done before the cards could be put through the machine. These large boxes also included debris such as sugar cubes, candy, chewing gum, and rubberbands. These difficulties were averted after the first Sunday by supplying card boxes and instructions leading to more orderly arrangement.

2. Only a few damaged cards were returned. They presented little difficulty since they were simply reproduced on a key punch whenever they were encountered.

3. As far as we know there were no losses of cards which were not subsequently recovered. In one instance, a partially filled box of cards fell off a truck en route to the counting depot and was returned several days later.

4. There was one mistake in card distribution. After one of the type III clinics, a small deck of perfectly marked cards was returned bearing the code of a site which was not used as a clinic on that date. (The site coded had been used as a type I clinic.) These cards represented bona fide recipients from some undetermined location.

5. There were two instances in which clinic sites borrowed cards from a neighboring school with a consequent mixup by site. In these cases, the results from the two schools were pooled.

6. There were no known cases where cards distributed to recipients were mixed with "unused" cards.

7. A few cards from one clinic site were

marked with an inadmissible code for clinic attendance.

8. Mark sensing was occasionally done using markers other than the required pencils. For example, after the November clinics 36 pencils not designed for mark sensing were returned with 3 ballpoint pens and 5 wax pencils. A small amount of difficulty was experienced in getting people to mark heavily and accurately enough so that the cards punched properly. These problems were solved easily when the cards were processed, however.

9. In December one roving registrar discovered that a clerk was routinely checking the code to indicate perfect attendance without questioning the recipients. This procedure was immediately corrected and accounted for only a small number of "negative recipients" estimated.

Cost and purpose of records. The expense entailed for cards, personnel, and machine time is usually not important in considering the desirability of this procedure over that of more conventional ones, since the cost of a dose of vaccine is about one hundred times the cost of a card. In most situations of this type, the cost of cards and card handling, as well as of vaccine, is more than compensated for by the generous contributions of recipients.

It should be emphasized that the mark sensing procedure used to ascertain the number of people receiving various combinations of monovalent vaccine is not necessary for the successful use of the punchcard system. Nor does this feature need to be used during every phase of a program. If evaluation of the level of complete participation is desired, mark sensing with a simple code could be used at the time of the last clinic only.

Should records for mass immunization programs be kept at all since a record of the amount of vaccine dispensed can be used to estimate the total number of doses administered? If the total number of doses of vaccine given is all the information a community desires, estimates based on the amount of vaccine dispensed will suffice. Under proper surveillance, however, consideration may need to be given to age group participation, geographic distribution of the participants, socioeconomic status, and the number of doses of vaccine that participants have received. This type of information would aid the physicians and health authorities of a community to evaluate the status of community protection against poliomyelitis and would indicate age groups and geographic areas needing concentrated effort for more complete protection. The punchcard system can provide information by age group, and we consider it superior to registration cards and tally sheets. For more refined estimates, however, the survey procedures outlined by Serfling and Sherman (*4*) are desirable. These survey procedures make it possible to estimate immunization status by area, socioeconomic group, and other variables. They also allow for more general estimates of protection than those obtained in a specific program.

Summary and Conclusions

Prepunched cards indicating age group and clinic site were used to count participants in the Sabin Oral Sunday mass immunization program carried out in Nashville, Tenn., during the fall of 1963. For the clinics after the first Sunday, the punchcards were mark sensed so that the numbers and percentages of participants receiving various combinations of the three vaccine types could be calculated. Comparison of edited data from the punchcards with estimates of recipients based on vaccine usage showed gross overestimation in the count based on vaccine use.

In localities where punchcard equipment and personnel are available, this method offers advantages over registration cards and tally sheets for counting participants in mass immunizations.

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