

METHODOLOGY IN A STUDY OF THE IMPACT OF WATER
FLUORIDATION ON DENTAL PRACTICE */

Monroe Lerner, The Johns Hopkins University;
Bruce L. Douglas, Donald A. Wallace, and
Sylvia B. Coppersmith, University of Illinois.

A study of the impact of water fluoridation on various social and economic aspects of dental practice has been carried on since 1963 at the University of Illinois College of Dentistry. The background and plan of the study have been described elsewhere [3]. Both prior to initiation of the study and, based on several special "feasibility" surveys during its course, several major decisions involving research design and methods were made. It seemed worthwhile, even though retrospectively, to reconstruct and articulate the bases for these decisions in three major areas - the appropriateness of alternative study settings, how best to maximize the degree of cooperation with the study by the dentists, and alternative data-gathering strategies - since this exercise may be useful to students doing further work in this field.

I. THE STUDY SETTING

One of the most difficult decisions facing the study staff at the very outset was to select the most appropriate setting for the study from among the various possible alternatives. The two major alternatives considered included: 1) a national sample of dentists and/or patients; and 2) sets of matched communities, i.e., communities with fluoridated and communities with fluoride-deficient water supplies. If the latter of these two alternatives should be selected as most appropriate for this study (as in fact it was), the sub-problem which followed was: Should communities with artificially or naturally fluoridated water supplies, or both, be studied?

When the present study was being conceived, i.e., during the early 1960s, relatively few communities in this country were enjoying the benefits of either artificially or naturally fluoridated drinking water. Furthermore, those drinking artificially fluoridated water had not experienced this innovation long enough for the occurrence of major changes in dental practice which might result from this change, at least not on any sizable scale. It was felt by the study staff, therefore, that a national sample of dentists even at best might not have included a sufficient number who had been practicing in fluoridated communities for at least some years to permit a reasonable degree of confidence in the study findings. To have obtained a satisfactory result by this procedure would have required a great deal of effort and expense, and might not even have

been possible at all. But perhaps most important, water supplies involve entire communities, and therefore fluoridation presumably affects dental practice on a community-wide basis. Also, it was believed that dentists could more readily be induced to cooperate with the study if approached on a community-wide basis through their local professional organizations. To consider dentists apart from the communities in which they practice thus seemed to be an unreasonable procedure, and therefore communities, rather than a national sample of individual dentists, became the preferred study setting. These communities were to be matched on all relevant characteristics except the one: fluoridation.

The next problem in design was whether, as the most appropriate study setting, to select communities with naturally fluoridated or those with artificially fluoridated water supplies. By the early 1960s the value of fluoridation in controlling dental decay had been clearly established, and some investigators were already in addition pointing to its possible impact on dental practice. Kirby [5], for example, in 1959 had written that:

"Prevention of dental decay [by fluoridation] will be accompanied, of course, by a reduction in the need for restorative dentistry. The private practitioner, then, will be able to devote more attention to problems brought on by occlusal wear and periodontal disease." */

Nevertheless, relatively few communities had had artificial fluoridation for even as long as a decade and it seemed clear that, although Kirby's predictions might hold in the future, the changes that he envisioned were not likely to have occurred as yet, at least not on a large scale. As a matter of fact, Kirby's speculations were deliberately stated in the future tense. And while Kirby had written in 1959, the situation was not much different in the early 1960s. On this basis, the authors of the present report rejected artificially fluoridated communities as the preferred setting for the study and chose naturally fluoridated communities instead.

Naturally fluoridated communities offered the advantage that they had possessed this form of fluoridation for a long period of time; it could reasonably be expected, therefore, that their patterns of dental practice would have been established for a long period of time also. While this appears to be a decided advantage, a disadvantage of using naturally

*/ Presented at the Annual Meeting of the American Statistical Association, Social Statistics Section, Session on Contributed Papers. Pittsburgh, Pa., August 21, 1968.

*/ [5], p. 87.

fluoridated communities was that it cannot be stated, at least with firm assurance and on an a priori basis, that natural and artificial fluoridation were likely to have had identical impacts on dental practice. For one thing, natural fluoridation had been in existence for a long period of time while artificial fluoridation represented a sudden change. Nevertheless, in the absence of any evidence to the contrary, and because it was known that their impact on dental health was similar, the assumption was made that the long-run impacts on dental practice of these two quite divergent forms of fluoridation would ultimately converge, and that the one might reasonably be taken, therefore, to represent the other. Natural fluoridation thus became the study setting of choice.

A perhaps logically extraneous but in fact practically important aspect of this decision was the matter of convenience and expense. The study team was located in Chicago. Illinois and the neighboring states of Indiana and Ohio are relatively rich in naturally fluoridated communities. It would therefore be convenient, and presumably relatively economical as well, to conduct the study in these states. While ideally this should not influence the decision, it actually became an important consideration. Also important, however, was the possibly biasing effect of the impact on dental practice of the very introduction of fluoridation itself, often after a referendum and usually accompanied by much publicity. Might not this publicity have attracted a special type of dentist to the community? The answer to this question is not known. However, natural fluoridation had existed for long periods of time without any such publicity and was therefore free of this possible source of bias.

Seven pairs of communities were selected, matched on relevant demographic and socioeconomic characteristics and differing only in that one community within each pair had natural fluoridation while the other had fluoride-deficient drinking water. To reduce the possibility of geographic and/or interstate variation perhaps affecting the results, six of the seven matched pairs of communities were selected from within the same state and all from within the three states of Illinois, Indiana, and Ohio. No large cities were included, and each pair was selected to minimize ethnic diversity as a possible source of disturbance.

The seven pairs of communities used in the present study were matched on the basis of population size, age-and-sex composition, family income, level of educational attainment, and years of residence in the community of its native-born population. */ All of these data

*/ The authors of the present report are indebted to the National Opinion Research Center of the University of Chicago for assistance in making the selections.

were obtained from the 1960 United States Census of Population. In addition, the number of dentists, both general practitioners and dental specialists, practicing in each community, the ratio of dentists to population, age of dentists, and the schools from which they had graduated were also considered in the matching process, but these factors were not crucial in each decision to pair specific communities.

The matched pairs were: Aurora and Rockford, Ill.; Kewanee and Centralia, Ill.; Marion and Sandusky, Ohio; Joliet, Ill. and Mansfield, Ohio; Elwood and Connersville, Ind.; Huntington and Shelbyville, Ind.; and Frankfort and Crawfordsville, Ind. (The first-listed in each pair had naturally fluoridated water at optimal levels.) During the final phase of the study the dentists in Rockford, a fluoride-deficient community, refused to cooperate and the community had to be withdrawn from the study. No other single community was suitable as a replacement, and it was necessary to substitute two communities, Freeport and Kankakee, Ill., for Rockford.

Three possible sources of disturbance could not readily be eliminated from the research design. These were as follows:

- 1) In many American communities not all persons drink water obtained from one central source. Some communities have more than one central source and many families drink water from private wells; the fluoride content of their drinking water may therefore be quite variable. The extent to which this was the case in the present study is not known.
- 2) Persons drinking fluoride-deficient water may nevertheless obtain the benefits of fluorides from other sources, e.g., topical fluoride application, fluoride tooth paste, etc. Again, the extent of this in the present study is not known.
- 3) The American population is highly mobile. At the time of the study, a very large proportion of the population in both sets of communities had not resided in their present community of residence during the first ten years of their lives.

In addition to these, one other possible source of disturbance which deserves mention proves that social change will not stand still, not even for social research. Thus between the time that the research design was formulated and the actual field work, four of the seven cities designated as fluoride-deficient introduced controlled artificial fluoridation of their water supplies. However, on the as-

sumption that such recent fluoridation would not as yet have affected dental practice substantially, no attempt was made to compensate for this change, e.g., by replacing these communities with others. Rarely, if ever, is it possible in real life to set up an experimental situation involving human behavior, even on an ex post facto basis, from which all possible sources of bias, or disturbance, are removed, and the present study was certainly no exception to this rule.

2. INDUCING DENTISTS TO COOPERATE

Dentists in private solo practice, like physicians and other professionals, are generally believed to be somewhat less than willing to cooperate in social and behavioral research studies, especially where both their treatment methods and various financial aspects of their office practice are to be used as research data. The reasons for this reluctance appear to be at least these: Dentists in general are not likely to be familiar with or oriented toward social science and/or social research; they often resent what they regard as unwarranted intrusion into their professional affairs; their patient-records are considered to be, by professional ethics and often by law, confidential; and finally, their time is extremely valuable. */ How, then can they best be induced to cooperate with a social-research study?

One item that proved to be absolutely essential to obtain cooperation by the dentists in the present study was endorsement by local and state dental societies. The best cooperation rate that could be obtained without it, in two feasibility surveys that were part of the present study, was only 50 percent. But with this endorsement, 43 of 44 dentists in one community, or nearly 98 percent, indicated their willingness to cooperate.**/ However, endorsement was apparently a necessary but not sufficient condition for cooperation; even

*/ The reluctance of dentists in this country to participate in research studies is evident from their low response rate to a mailed questionnaire from their own professional organization, the American Dental Association. Thus the 1965 Survey of Dental Practice reported a response rate of only 20.4 percent, even though no treatment data had been requested. [2]

**/ This extraordinarily high rate of willingness to cooperate was probably influenced by the fact that the community in question was a university town, so that the tolerance level for social research may have been greater among the dentists residing there than is usually the case elsewhere.

with it, most of the dentists in Rockford, one of the larger communities in the study, refused to be involved. If the cooperation rate is computed by including, instead of Rockford, the two communities which replaced it, 87 percent of all dentists cooperated. If Rockford is counted, however, the rate was much lower.

Since the time of dentists is generally conceded to be very valuable, an offer of remuneration was made to one-half of the dentists asked to cooperate in one of the feasibility surveys. No such offer was made to the other one-half. This offer, unexpectedly, appeared to make absolutely no difference in their decision, since the cooperation rate was identical in both groups. Also, only four of the 35 dentists to whom remuneration was offered accepted, and one of these donated the money to charity. However, an offer of remuneration was apparently very helpful in inducing dental assistants and receptionists within the dentist's office to cooperate with the research. In some instances these people manifested obvious resistance to providing the researcher with the required records, or explaining where they might be found, and this despite their employer's expressed willingness. The dentists themselves often appeared to be reluctant to pressure them into cooperating. However, merely the offer of remuneration resulted in cooperation in all instances, and in no case was the offer accepted.

3. ALTERNATIVE DATA - GATHERING STRATEGIES

Another question investigated here was this: Could a sufficiently large response rate be obtained from dentists by a relatively economical mail survey, or would it be necessary to use the more expensive method of personal interviews supplemented by photostating designated patient-records or abstracting them in the dentist's office? One of the surveys conducted in the initial phase of the present study provided fairly substantial evidence that mail surveys could provide at best only a relatively poor rate of response, especially on treatment data.

This survey was conducted during the summer of 1963, and was aimed at the dentists practising in the seven pairs of matched communities. The names and addresses of approximately 400 dentists in these communities, and some biographical data about them, were obtained from the most recent issue of the American Dental Directory. A letter was sent to each dentist listed and a questionnaire was enclosed. The questionnaire had been designed with the assistance of staff members of the Bureau of Economic Research and Statistics of the American Dental Association and the letter contained an endorsement of the study by that

organization.

The first part of the questionnaire, contained on both sides of a single page, requested data from each dentist on biography, educational and professional background, and various social and economic aspects of his practice, including some financial items. These were items which each dentist could conceivably answer without direct reference to his patient-records, i.e., from personal knowledge, from impression or guess, from memory alone, or from records other than those dealing with treatment. The second part of the questionnaire consisted of six copies of a form on which the dentist was requested to list each patient-visit and the treatment and/or procedures performed during that visit. Each form was to contain the data for all patient-visits on a specific day during a stipulated week - the same week for all dentists and a week prior in time to actual receipt of the questionnaire. These data would, of course, have to be taken by the dentist from his patient-records.

The stipulated week turned out, unfortunately, to have been one during which some of the dentists in the study were attending a state dental convention. Partly for this reason, but clearly for other reasons as well, only about 30 percent of the questionnaires were returned, about 120 in all out of the about 400 listed in the Directory; the proportions returned were nearly identical for the fluoridated and fluoride-deficient communities. The entire group of dentists who returned their questionnaires answered all questions on the first part, but fewer than one-half of these (14 percent of all questionnaires sent out) gave any information at all in response to the second part of the questionnaire, i.e., on patient-visits and treatment and/or procedures performed. Very few of these gave complete data. These response rates were far below those obtained subsequently by personal interviews. The magnitude of these differences is so great that there can be little question of their reliability.

A related question to which the present study also addressed itself was this: Within the personal interview situation, was it better to ask the dentist to provide (or have an assistant provide) merely previously designated records, or even only to grant an interviewer access to the files from which the records could be pulled? The interviewer would then either photostat the designated records or he would abstract the required patient-care data from them. Or, should the dentist be asked to provide the required data already abstracted from the records? It was felt by the study staff that providing records, or granting access to the files containing these records, might be unacceptable to some dentists because of the confidentiality

issue, while providing data might be unacceptable to others because of the time and effort required. However, there was no way of predicting what the proportions were likely to be in each of these categories, particularly since the public health and social science literature provided no guides whatever that might be used in answering these questions. The study staff was unable to find a single article reporting the use, as research data, of the records of dentists in private practice. Later, after the planning of the present study had been completed and its data gathered, Muhler [7] published some patient-care data obtained from dentists' records. (The usefulness of this report in planning the present study would have been sharply limited in any case, since it did not discuss any of the problems involved in obtaining these data, nor even how it was done.)

A complicating factor in planning this aspect of the study was that most dentists maintain more than one type of record containing at least some items of patient-care data. The most important among these types for present purposes is the patient-record itself, usually containing the profile of the patient's teeth; name, address, and (often) demographic data; history and clinical data often including a record of procedures, treatment, medications, and materials used during each visit; and financial data. Most dentists maintain, in addition, an appointment book, which usually specifies the reason for the visit, and many also use a day-sheet, or daily log-book. But in addition, some dentists now work with professional management firms, and these dentists may use daily billing sheets either in addition to or in place of day-sheets. The record of preference for the present type of research was clearly the patient-record itself.

In two feasibility surveys involving 102 dentists, about five out of six cooperating dentists (86 dentists, or 84 percent of the total) to whom these alternatives were presented - i.e., to provide an interviewer with records (or files containing these records), or to provide him with already abstracted data - were strongly reluctant to invest the time and effort necessary to abstract their records, or to have an assistant do so (see Table I). They much preferred to, and did, limit the extent of their responsibility in cooperating with the study only to granting access to their records or, at best, to pulling previously designated records from their files. In fact, many made it very clear that they would be unwilling to cooperate in the study if they (or their assistant) were expected to do the work necessary to provide

TABLE I. SOURCE OF PATIENT - CARE DATA (BY WHOM OBTAINED OR PROVIDED) AND TYPE OF RECORD USED

OFFICES OF 102 COOPERATING */ DENTISTS

Feasibility Surveys, Chicago and Champaign-Urbana

| Type of Record Used | Source of Patient-Care Data | | |
|---------------------|-----------------------------|-------------------------------|--|
| | All sources | Abstracted by the interviewer | Abstracted by the dentist (or his assistant) |
| All records | 102 | 86 | 16 |
| Patient-record | 78 | 71 | 7 |
| Appointment book | 6 | 3 | 3 |
| Day-sheet | 12 | 9 | 3 |
| Billing sheet | 4 | 3 | 1 |
| Unknown | 2 | 0 | 2 |

*/ Only dentists providing patient-care data. Dentists providing biographical and other data, but not patient-care data, are not included.

data rather than records. */ About one-sixth (16 dentists, or 14 percent of the total) provided data rather than permit the interviewer to have access to records or files.

However, only 71 of the 86 dentists willing to provide access to their records or files were willing to provide access to their patient-records, although this had been explicitly designated to them as the record of choice. Nine of the fifteen dentists were willing to permit access only to day sheets and three each to an appointment book and to billing sheets. Among the 16 dentists providing data rather than records, the work of abstracting the records was done in the interviewer's presence in 14 offices; **/ in one-half of these the data were obtained directly from patient-records.

Granted that the dentists much preferred not to be burdened with the work of abstracting the necessary data from their records, in favor of having it done by an interviewer, would this be feasible? Muller [8] has provided an apt analogy illustrating the difficulties involved in using records, although she qualifies her statement in the second sentence of the following quote:

"In a sense the use of records for analytic study bears a resemblance to the work of the archaeologist reading the explicit and implicit messages in the residue of the past. But the social science investigator who studies prescribing has additional resources, such as direct observation, personal interview, and written questionnaires to amplify what is learned from prescribing records." ***/

*/ The mail survey, conducted as the initial phase of the present study, had in effect required participating dentists to provide data rather than records, thus committing them to the expenditure of much time and effort. This may have been a major factor in explaining the relatively poor response rate in that survey as compared, for example, to the relatively high rate obtained by Hochstim (better than 80 percent of questionnaires returned by mail) in a survey of households in Alameda County, California [4]. (However, another factor explaining Hochstim's much higher response rate was that he surveyed households, rather than professional offices as in the present survey.)

**/ The remaining two are accounted for as follows: In one case the abstracting was done prior to the interviewer's arrival, while in the other the data were subsequently mailed to the interviewer. In both of these instances the type of record serving as the source of the data remained unknown to the research staff.

***/ [8], p. 2117.

Muller's reference is to drug prescribing, and the special interest of investigators in this area, in the past at least, has been in drugs prescribed in a medical-care system in which there has been some type of third-party payer. Usually in these instances some standardization of forms or documents is involved, simply because of third-party payment; dentists in private practice, however, need use no such standardized forms, since usually no third-party payers are involved. In fact, they rarely expect anyone else to read their private patient-records; these records are usually written exclusively for their own use. */

The questions which follow immediately from this statement, therefore, and relating to the records themselves, are these: 1) Do dentists use filing systems such that designated records can readily be found? 2) Once found, is the handwriting legible? 3) Do they use standard or personal idiosyncratic systems for numbering teeth? and 4) Do they use standard designations and abbreviations or symbols for dental procedures, treatments, medications and materials? The answers to these questions would determine whether it was, in fact, feasible to use patient-records. Two closely related questions, essentially aimed at how best to use these records, are these: 1) Should the records be photostatted and brought to another setting where they could be interpreted with the aid of dental professional assistance as necessary? Or should they be abstracted by an interviewer in the dentist's office? If the latter course were found to be preferable, the next question is: 2) Would it be necessary, to interpret patient-records containing clinical data, that the interviewer have a great deal of technical training, e.g., that he be a dentist, a dental student, or a trained dental assistant or hygienist? Or could lay interviewers, even if previously unfamiliar with medical and/or dental terminology, be trained to do the job adequately? In a study of the office records of internists (physicians) in private practice, Altman [1] and his study staff first found it necessary to send a physician into another physician's office to judge the suitability of the latter's records for abstracting by a paramedically trained person; only then did the latter come in. However, medical records are apparently far

*/ This may not be altogether unlike the situation resulting in the difficulties which social researchers have experienced in attempting to motivate respondents to keep a diary of their expenditures over a period of time. See: Neter and Waksberg [9], pp. 1-2.

more complicated than dental records, and it did not appear to be necessary to follow the same procedure here.

Based on the feasibility surveys, it was very evident that dentists do have filing systems permitting ready access to designated records, and in general their handwriting was found to be legible. However, almost one-half of the dentists used personal, idiosyncratic systems for numbering teeth, rather than the Armed Forces or Standard Quadrant method taught in dental schools. Personal systems for designating procedures, treatments, medications, and materials were also quite common, and there was apparently no single system, universally in use among dentists, for abbreviation of clinical terms. */ The assistance of the dentist or a member of his staff in interpreting some portion of his patient-records was often essential and, as a result, it was found to be much preferable to abstract them in the dentist's office rather than having them photostatted and abstracted elsewhere. In addition, dentists were reluctant to have their records photostatted even with the names blocked out.

Despite the diversity among dentists in tooth-numbering systems and in designations and abbreviations of clinical terms, the feasibility surveys had suggested, and the main study confirmed this suggestion, that lay interviewers, even if previously unfamiliar with medical and/or dental terminology, could be trained within a relatively short period of time to do the job adequately if the training was sufficiently intensive. **/ The interviewers used in the study were ordinary interviewers of the type regularly employed by the National Opinion Research Center, without special prior background in medical or dental matters.

Finally, dentists' records in both the feasibility surveys and the main study proved to be relatively complete on clinical items and on purpose of visit (nearly all records had some notation on these matters), but relatively poor on age of patient. This was true of patient-records as well as of appointment books, day-sheets, etc. (The latter usually contain no age-data at all.) However, with regard to age, it was possible in a substantial number of instances to determine whether the patient was a child or an adult by reference to the patient-record containing his previous dental history, e.g., whether a deciduous tooth had been treated within a specified time-period prior to the survey week. While patients themselves would clearly have been a better source for this type of information, they nevertheless turned out, in one of the feasibility surveys, to be a relatively unreliable source of data on their own dental histories partly because of the memory factor. Patient-records were much better for this purpose, al-

*/ Judging by the above, communication errors are not likely to be confined to enumerative surveys involving verbal response. See: Mauldin and Marks [6].

**/ Full details of the training are available from Miss Coppersmith.

though a substantial limitation to these records was that they provided data only for the patient's current dentist; however, the memory factor does not pose a problem here.

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The above discussion reports some considerations relating to method in a pioneering study of the impact of fluoridation on dental practice. The bases for some important decisions are presented, and some limitations in study design and method are emphasized. Study of the patient-records of medical and dental practitioners in private practice is now widely recognized as an important key to understanding the structure and functions of the health services' system in this country, and it is hoped that, despite the difficulties inherent in this process, future studies will build upon the present endeavor.

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