THE USE OF MEDICAL RECORDS IN A SAMPLE SURVEY OF BRAIN TUMORS

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1. The Problem

The survey problem faced in what we have called the SIN project (SIN standing for Survey of Intracranial Neoplasms) was conceptually fairly clear. It was to secure, using methods of probability sampling, a national estimate of the incidence, prevalence and costs of tumors of the brain, a relatively rare but serious site of neoplasms. General strategy for solution at first seemed reasonably straightforward. Clearly, a household sample would be inefficient because of the hundreds of households one would have to visit to find an eligible case, or even a relative of an eligible case. But, surely, cases would always be admitted to a hospital at some point during the course of the disease (except for those cases diagnosed for the first time at autopsy which were excluded in the definitions adopted). Hospitals, if they are to be accredited, must keep diagnostic cross index files of the cases they treat. So hospitals could be sampled and cases sampled from the files of the sampled hospitals.

We were also aware, of course, that in order to avoid bias in such a sample one must make sure that either a unique counting rule is used, so that persons hospitalized more than once do not have multiple chances to fall into the sample, or, alternatively, that weighting procedures give appropriate weights to such persons when they do fall into the sample.

We recognized that obtaining the needed information about the cases, particularly about costs, was not going to be easy. However, we certainly did not anticipate the full range and complexity of the problems we would encounter until we got well into the design phase. Some have had to do with sampling, some with other aspects of the design, and some with implementation of the design in the field. It was soon decided that the customary pilot survey would in this case have to be a major endeavor to get answers to a number of questions, not simply a dress rehearsal for the national survey.

In this paper we shall outline what we have called the Basic Plan; that is, the one we considered to be our first choice; the questions about that design that we decided needed testing in the pilot survey; the results of the pilot survey; and some special features of the sampling plan for the national survey.

But, first, a little background must be given and some of the key definitions.

The SIN project is being carried out by Westat, Inc., under a contract with the Office of Biometry of the National Institute of Neurological and Communicative Disorders and Stroke (NINCDS) as a part of that office's program of surveys of chronic diseases with which the Institute's research programs are concerned. The surveys have as their objective securing measures of the national magnitude of and the costs associated with, several disease conditions. Some of the diseases are quite rare when compared to, say, arthritis or atherosclerosis, but they are invariably either highly disabling, associated with high mortality, or both. The Institute needs data of these kinds to establish priorities and to support budget estimates. Thus, the purposes of the surveys are not primarily epidemiological nor are they intended as a basis for planning programs of care. Nevertheless, a limited amount of demographic and medical detail is needed in the estimates.

The SIN project is advised and supported by an outstanding committee consisting of physicians in the appropriate medical specialties, an epidemiologist, a professor of social work, a medical economist, and a professor of public health. The committee has had considerable influence on the survey design, particularly in defining the basic terms and medical scope.

For the purpose of the project brain tumors, or more properly intracranial neoplasms, were defined as benign, malignant and unspecified tumors of the brain, cranial nerves, cerebral meninges, pituitary and pineal glands. Secondary tumors at these sites are also included under certain conditions.

Incidence was defined as the number of cases of these neoplasms first diagnosed within a specified two-year period of time, the two calendar years preceding the survey.

The prevalence definition, about which we shall have more to say later, was tentatively defined as the average number of persons living at a point in time (averaged over the same two-year period) who had ever been diagnosed as having a neoplasm in the defined group and whose disease had required hospitalization during the last four calendar years preceding the survey.

The costs of these intracranial neoplasms were defined to include all the direct and indirect costs incurred by living patients during the two calendar years immediately preceding the survey. The costs were to be counted in terms of charges incurred during this period, regardless of whether bills had been paid or not. Direct costs would include all charges for medical, hospital, nursing, rehabilitative, and other charges for care. Indirect costs would include lost income due to disability resulting from the disease or its sequelae, plus an estimate of the present value of lost future income for all deaths of patients in the sample caused by the neoplasm and occurring during the two calendar years for which costs were being measured.

2. The Basic Plan

The Basic Plan consisted of the following steps, listed in only rough chronological order:

a. Seek the support and, if possible, formal endorsement of national organizations of medical specialists particularly concerned with the treatment of intracranial neoplasms and of the American Hospital Association.

b. Draw a national sample of hospitals within geographically defined primary sampling units (PSU's) following a sample design that will be described in a subsequent section.

c. Working through a cooperating medical specialist located in the PSU present the plan of the survey to the hospital medical staffs in advance of any field work, and, if possible, secure their support of the survey.

d. Recruit and train field workers for four types of tasks in the PSU's: first, finalizing arrangements for the cooperation and participation of hospitals that fall into the sample; second, completing advance questionnaires to record necessary information about the hospitals and their record systems and, later, about attending physicians and their record systems; third abstracting the needed medical history information from hospital and attending physicians' records; and, fourth, interviewing those patients or relatives of patients residing in the PSU's to obtain a complete record of sources of care, direct medical costs, disability status and certain socio-economic items needed for the estimation of indirect costs. While the first, second and fourth tasks could be performed by experienced interviewers of the usual types, the third task was judged to require persons with some medical records background, such as medical records administrators, or nurses.

e. Write to sampled hospitals to formally request their participation in the survey and follow-up by telephone to attempt to convert reluctant hospitals and to negotiate the terms of participation, in advance of the visit of a field representative.

f. Send field representatives to the sampled hospitals to make final arrangements with the hospitals and to fill out the preliminary questionnaires.

g. Secure from each hospital a listing of all patients discharged from that hospital in the four calendar years preceding the survey whose cases had been indexed to certain categories in the hospital's diagnostic cross index file, making sure that the listing consisted of different people and that repeated hospitalizations of the same person for the intracranial neoplasm would be consolidated.

h. Return this list to headquarters for inspection and, if needed, the selection of cases for inclusion in the sample.

i. Request the hospital to pull the medical record for the sampled cases.

j. Abstract, using the specialized field staff, the needed information from the medical history of the case. The items desired for substantive analysis will not be covered here, but certain items needed to accomplish the survey design, and, hence, of particular importance, are the following:

   1) The date when a first diagnosis of intracranial neoplasm was first made.

   2) The record of the dates of all prior hospitalizations for this condition in any U.S. hospital, including the name of the hospital to permit checking against the sampling frame.

   3) The name of the attending physician.

   4. The name and latest address of the patient.

   5) The condition of the patient at discharge, whether living or dead, and, if dead, the cause of death, and also, if contained in the record, the date and cause of subsequent death.

k. Abstract in the hospital's business office the needed information on hospital and professional charges to the extent that these were incurred in the two calendar years preceding the survey.

l. Visit the attending physicians whose names were picked up in the hospital record and complete the preliminary questionnaire about their practices and record systems.

m. Abstract on a patient record the needed substantive information from the physician's records on treatment provided to the sample patients and charges incurred during the two calendar years for which costs are being measured. Again, certain items relating to each patient are of particular importance to complete the design:

   1) Confirmation of the date of first diagnosis.

   2) Confirmation of the record of prior hospitalizations.

   3) The dates of hospitalization and names of any hospitals in which this patient had been treated for the neoplasm other than the one in whose records the case had been found (referred to as the "index hospital"). Specifically this informa-

tion must be extended to include other hospitals the patient had been in subsequent to the index hospital experience.

4) The latest address of the patient or his family known to the physician.

5) The latest information on the status of the patient, living or dead, and if subsequently dead, the date, State and cause of death.

n. Seek copies of death certificates for all deceased patients who did not die in the index hospital.

o. At the time of the abstracting of the attending physician's record, determine whether the patient, if alive, knows the nature of his disease and whether there is any strong contra-indication to conducting an interview with the patient.

p. Interview the patient, unless contra-indicated, or a close relative if the patient is unable to respond or is deceased. The questionnaire makes no mention of the nature of the disease but refers to the condition for which the patient was hospitalized at such-and-such a time. The questionnaire would attempt to complete the record of medical care and hospitalization, secure information on charges to the extent they are known to the patient or family, and other data needed for estimating indirect costs. In the case of patients living too far from the PSU, the questionnaire would be mailed, and non-response follow-up would be by telephone.

Full data from patients or family will be sought from only a subsample of persons. But selected items of information, such as identification of all hospital episodes in the four-year period must be secured for every sample person, from one or another of the potential data sources.

This completes the data collection steps of the Basic Plan. The analytical plan will not be covered except to say that, on the basis of the information gathered, the cases would be divided into four partially over-lapping groups:

a. Persons in the sample who were given a diagnosis of an intracranial neoplasm in the two calendar years preceding the survey.

b. All persons in the sample who had been given a first diagnosis of intracranial neoplasm before the beginning of the two-calendar-year period.

c. The combination of groups a. and b. but less those who died before the beginning of the two-year-period; in other words, all the diagnosed persons who were alive at any time during the two-year-period.

d. Persons in the sample who died at any time in the two-year period.

The first group would be the basis of the incidence count. The persons in the third group would be labeled as to the number of days within the two-year-period they were alive following their first diagnosis. (This could range from a few days, if they were diagnosed near the end of the period or were diagnosed and died very shortly thereafter, up to 730 days if they were diagnosed before the beginning of the period and lived throughout the two years.) The grand total number of days of life divided by 730 would be the basis of the estimate of average point prevalence.

The persons in the third group would also be the basis of the estimate of costs. All of their costs incurred during the two-year-period would be aggregated and divided by two to give average annual costs and divided by the incidence to give a rough estimate of average lifetime costs per case.

The fourth group represents a special universe of completed cases. Records for these cases will be compiled retroactively to onset, so that a duration measure can be calculated. Coupled with an assumption of stable population and the estimates of incidence derived from group one, these duration data permit a second estimate of prevalence, which is the product of incidence and average duration.

3. Difficulties with the Basic Plan and Objectives of the Pilot Survey

The difficulties with this plan were of two general types. One type had to do with the problem of securing access to medical records and the names and addresses of patients so that they could be followed up through the attending physicians and into their homes. Would hospitals permit access to the records, particularly when medical details and names and addresses linked to the medical information were to be taken out of the establishment by an outside group of researchers? Would the physicians allow access to their records and would they concur in the study plan to interview the patients? Would either or both of these two proposed sources of information insist on a prior patient release form, and, if so, how could that patient release form be secured without direct participation by the study staff?

The second type of difficulty had to do with the definition of prevalence and, associated with that, the measurement of costs. The proposed methods in the Basic Plan for getting at these two measurements depended principally on the third analytic group mentioned above. i.e., all persons with a diagnosis of intracranial neoplasm who were alive at any time during a period of two calendar years. But the cases examined to determine this were all cases that had been hospitalized at some time during that period or the preceding two years, since the

original search of the hospital files covered the four calendar years preceding the survey.

We were quite certain that a newly diagnosed case of this serious form of tumor, whether it was determined to be benign or malignant, would be hospitalized at the time of or shortly after the initial diagnosis. Hence, the incidence count seemed reliable when based on hospitalized cases. Likewise, cases newly diagnosed in the first two of the four years would be well covered if they lived into the second two-year period. But what about cases first diagnosed five, ten, or fifteen or more years before the survey took place? They could only be included in the prevalence count if they had been hospitalized at some time in the most recent four years.

The number who would be excluded obviously depended upon the survival rate in cases of intracranial neoplasm. Furthermore, supposing many of such older cases did survive, was it appropriate to include them as prevalent cases at all? For example, a child might have been diagnosed with a benign tumor of the brain 15 years before, been hospitalized for the surgical removal of the tumor, followed up medically for 10 years and, thereafter, dismissed as cured. Should such a case be counted in the prevalence count?

Here members of the Advisory Committee had somewhat differing opinions but the majority view was that such old cases, which we have labeled NRH cases (meaning "not recently hospitalized"), should be included if it was practical to do so, for two reasons. First, good medical practice suggests that such cases should be re-checked at intervals for the rest of their lives; and, second, many having had an operation on the brain are left with some permanent impairment of hearing, vision, speech, or mobility.

As we began to look into the question of survival, it appeared that more brain tumor cases survive 10 and 15 years than we had originally supposed. This was true of cases of cancer of the brain, including primary malignant tumors as well as some benign tumors, followed up by the National Cancer Institute in the End Results Studies. In those studies, among white males, for example, about 13 percent were surviving 15 years after first diagnosis. Survival rates for benign cases studied for us by the Veterans Administration were, as might be expected, even higher. It seemed likely that there might be considerable numbers of these old cases surviving at the present time, and many might not have been hospitalized for their condition in recent years.

The two types of difficulty we have mentioned are linked in a way. The only purpose of the effort to obtain names and addresses of patients is to permit follow-up to attending physicians and the patients or their families, and the most important need for the follow-up is to determine status of the patients, and dates of death for the prevalence count, certain direct and indirect costs, and hospital experience, not included in the hospital records. If the study related only to incidence, there would be no real need to follow-up the cases.

The pilot survey, then, was designed to throw light on those two methodological problems.

Obviously, a third purpose of the pilot survey was to pretest all the other steps in the Basic Plan, the approach to hospitals, the listing of cases, the abstracting of medical and charges information, the state of the attending specialist's files, the interview questionnaire, and a number of administrative and quality control parts of the Plan.

4. The Pilot Survey and its Results

The Pilot Survey, therefore, was designed to follow the Basic Plan except that it had some added features. These were included particularly to learn what we could about NRH cases.

First, we added a query to all the neurologists and neurosurgeons with offices in the primary sampling units, not simply those who were named as attending physicians of cases found in the hospital files. This query, which was carried out through a prearranged visit by the field worker to the specialist's office, included questions about the physician's practice and his usual charges for certain services, but it also included a question about living patients with a diagnosis of intracranial neoplasm (which we shall abbreviate from here on as IN), who had not been hospitalized in the years 1971 through 1974. If any were known, the physician was asked to provide the name and address of such patients and dates of onset of symptoms and diagnosis.

Second, a very much abbreviated postcard type questionnaire was sent to all other physicians in the PSU except interns, residents, and certain specialty groups that seemed very unlikely to have seen an IN patient. These physicians were asked only whether they had seen patients who had ever had a diagnosis of IN and who had not been under the care of one of the neurologic disorders specialists nor hospitalized in the period 1971-1974.

In addition to efforts to learn something about the size of the NRH cases problem, it was determined that if hospitals agreed to participate in the study only under certain conditions, we would, within limits, go along with those conditions in order to gain experience about the effect that such conditions might have on the conduct of the study.

The details of the experience in the Pilot Survey will not be covered in this paper, and we shall concentrate on the results. It should be explained, however, that the Pilot Survey was conducted in three PSU's that will not be included in the main study. These were the

Richmond, Virginia, and Topeka, Kansas, SMSA's and a primary sampling unit in a largely rural part of central Pennsylvania.

For the Pilot Survey all short-term hospitals in these PSU's were included. We had excellent success in recruiting the type of field workers we wanted for abstracting and interviewing, and these people were given a heavy week of training near the survey headquarters. They performed in an intelligent and enterprising manner, and the debriefing near the end of the field work plus a good deal of telephone communication along the way taught us a great deal about what would and would not work in the national survey.

Much of that detail will have to be omitted here, so that the results of a number of experiments can be reported. To speak of them as "experiments," however, is a misnomer since they were not controlled trials of alternative methods. Furthermore, the pressure of the timetable for the entire project required that at some points work on one or another step of the data collection be cut off before a desired level of completion was obtained in order to proceed to the next phase and gain some experience with that. Most of the timing problems arose from the unexpectedly long time that had to be devoted to negotiating with hospitals to secure their participation, in some cases, as will be seen, with eventual failure.

In the three PSU's of the pilot survey there were 23 hospitals to be covered in the pilot survey. Five of these hospitals could not be persuaded to participate. Three of these hospitals were quite small. One insisted it had treated no brain tumor cases; one had instituted and was in the middle of changes in its record room procedure; and the third cited hospital policy as the reason. A fourth moderately small hospital claimed lack of record room staff to list and pull the case files. A fifth somewhat larger hospital was the subject of lengthy negotiation but finally rejected participation on the advice of a research committee. It was estimated on the basis of other data that these last two hospitals would have had about 800 discharges for malignant brain neoplasm in the four-year period.

Thus, the problem of enlisting hospitals in the national survey is one that gives us considerable concern. A good deal was learned, however, during the two months spent in attempting to persuade these 23 hospitals to take part in the study, and it is believed that better procedures in the national survey should give us considerably better than this 78 percent participation rate. The participation rate expressed in terms of numbers of hospital beds was 85 percent.

Three of the hospitals participated only under special conditions, and in all three of these the conditions had to do with problems of invasion of privacy. In two instances the hospital insisted that some form of release from the patient or a close relative be obtained by the hospital before Westat staff could be permitted to abstract the medical records, regardless of the purposes of the study or the confidential handling of the identifiable information which Westat guaranteed. We have the impression, though we certainly can not state it as a fact, that had the study only involved contacts with the attending physicians, we would have been given names and addresses without a release.

The third hospital participating with a special condition was the only VA hospital in the sample. Here the policy was determined at VA headquarters in Washington. The hospital was permitted to take part provided the patient questionnaires were mailed by the hospital itself and returned to the hospital. The medical abstracting was permitted to go ahead in the meantime. However, we were told this was only an interim policy since the VA was then considering the implication for studies of this sort of the Privacy Act of 1974, which goes into effect in September 1975.

One large hospital which required that a release from the patient be obtained before the abstracting of records accepted with only minor changes a letter drafted by the study staff. This letter described for the patient the intention of the hospital to permit the records to be used in the study providing the patient did not object. Check boxes were included for registering the willingness or unwillingness of the patient or a close relative, and a return envelope was supplied. The hospital did insist, however, that nonresponse even after two mailings could not be taken as indication of willingness of the patient to have his records included.

The results of this little experiment were as follows:

Cases in the sample	75
Returned with "Yes" checked	27
Returned with "No" checked	3
Not heard from after 2 mailings	45

It is clear from this experience that relying on the hospital to secure a release, no matter how trouble-free it is made, can result in considerable non-response unless the study is permitted to include the cases where no reply is received.

The listing of IN cases in the 19 participating hospitals for the period 1971 through 1974 yielded a total of 2046 different persons. From these a sample of 485 was drawn in the central office. The sampling rates varied from 100 percent in the hospitals with less than 50 on the list to 7.5 percent in the hospital listing the most cases, but all results presented hereafter are unweighted.

When it came to the abstracting of information from the hospital files for these 485 persons, some turned out on further inspection to be out of scope for the study but 87 percent of the remainder were successfully completed. The following table summarizes this experience:

Medical Abstracting

Cases sampled for abstracting	485
Found to be out of scope	60
Not released because no patient release form received	45
Record unavailable in files	12
Completed abstracts within scope	368

In the recording of charges data there was found to have been some overoptimism about the amount of detail that could practicably be extracted from the records of the hospital business office, particularly detail about charges for special diagnostic and therapeutic procedures performed. However, the total charges and the part devoted to room and board were not a problem. The charges abstracting yielded the following results:

Abstracting of Charges Records

Cases sampled for abstracting	485
Cases not hospitalized in 1973-74	125
Other cases out of scope	54
No charges (cases in VA hospital)	16
No permission received from patient	45
Unavailable in the files	31
Completed abstracts	203
Still in process	11

The following up of these cases to the attending specialist was to be preceded, it will be recalled, by preliminary contacts with all of the specialists in neurological disorders having practices in the PSU's. Surveying the specialists was to be a special feature of the pilot survey with the particular objective of finding NRH (not recently hospitalized) cases. This additional step was carried out only in the Richmond and Topeka PSU's. There were 56 specialists in these two PSU's of whom one refused to having anything to do with the study. Questionnaires were completed during interviews with 52 of them and the remainder were never contacted after repeated trials.

These 52 physicians reported 19 additional IN cases, whom they thought had not been hospitalized in the period 1971-1974. This figure can be roughly compared with the 2032 cases identified in the files of the hospitals in these same two areas.

The reasons why this cannot be an exact comparison are first, that not all the specialists were contacted, (though 93 percent were contacted), and, second, that the hospital may well have been drawing its cases from a considerably larger area than the physicians practicing within the boundaries of the same PSU's.

As we have indicated, a postcard query was also sent to all other physicians who might conceivably have been NRH patients. There were 1009 such physicians in the three PSU's, but this report will be confined to the 885 located in the same two PSU's for which the specialists were completely covered. Of these 404 (46 percent) responded to the mail query.

Twenty-two reported that they had seen one or more IN patient who they thought had neither been hospitalized for the condition nor treated by a neurologist or neurosurgeon in the 1971-1974 period.

This proportion, 22 out of 404 responding, seemed surprisingly high in view of the findings in the specialists' offices. Hence, a recheck by telephone was initiated to verify the cases. The final yield in cases that would not have been reported by the other two sources was only three. Apparently the original inquiry had been widely misunderstood.

However, since 54 percent of the original list of nonspecialist physicians had not responded to the mail query, it was decided to attempt to contact a sample of the remainder by telephone.

For this purpose 102 (about one in five) nonresponding physicians were sampled, and the field workers tried to reach them by telephone with the following results:

Total in Sample	102
No contact after repeated tries	54
Contact made but refused information	6
Contact made and supplied data	42
Number reporting 1 + NRH cases	8
Re-check yield in No. of NRH cases	1
Not a true case	7

Hence, making many assumptions about the nonrespondents, it appears that the non-specialists in these two PSU's had treated no more than perhaps 5-15 cases that would not have been known to the specialists or to the hospitals.

On the basis of these findings about NRH cases Westat has recommended to NINCDS that the original plan for finding of cases for the prevalence count be adhered to, but that this estimate be supplemented by a second estimate of prevalence that will be based on the assumption, true only under certain circumstances, that the following relationship holds true: $P = I \times D$ where P is the average prevalence; I is the average incidence per year; and D is the average duration of the case expressed in years. If a new case is considered to exist until death, then D is equivalent to the average survival time in years. Statistics on D for IN cases can be secured from several sources, none of them, however, based on national samples and all of them based on truncated distributions of survival. That is, cases may have been followed for, say, 15 years at a maximum but the survival of those still alive after 15 years must be estimated.

In regard to the pilot survey it remains only to report briefly on the degree of success in abstracting data from the specialists' files about the hospitalized cases, and on the experience in securing information from the patients or relatives of patients. For these two steps a subsample of 208 cases was selected. The subsample is not cleanly representative of the 485 in the original hospital sample, however,

because work on previous steps had not been completed at the time these steps was initiated. The following table accounts for the 485 persons in the original sample:

Specialist Follow-up

Total number of cases	485
Subsample for specialist follow-up	208
Specialist data not obtained	57
VA cases handled separately	16
MD couldn't locate record	12
MD wouldn't allow access to record	10
Secured patient information from family and dropped efforts to reach M.D.	19
MD patient report completed	151

It is obvious from the above that we face considerable difficulty in securing information from the attending specialist. Furthermore, the abstractors were universally of the opinion that the data available in the specialists' files added relatively little to the total picture of the case. Nevertheless, there are certain items of great importance to the statistical design having to do with other hospitalizations, present status, and date of death if deceased which must be learned from this source, if possible. We plan to trim this part of the patient abstract to the bare minimum and concentrate on getting only those items of greatest importance. Furthermore, we may limit the inquiry to those cases in which we fail to obtain the information from the family.

The final step in the data collection was the completion of a questionnaire about the patient by interview or through the mails, the respondent being the patient, if able to respond, or a close relative, if not. The table below shows the results of this effort:

Family Follow-up

Subsample for family follow-up	208		
Not assigned to field staff	44		
MD refused permission	28		
Handled by VA	16		
Assigned to field staff	164		
		Mail	Interview
		94	70
Patient refusals	8	3	5
Unable to locate family	10	4	6
Incomplete (as of 9/8)	44	37	7
Satisfactory response	102	50	52

It can be seen from these results that the work of locating and interviewing the patient or a relative was not complete at the time this paper was written. However, the interviewing is going reasonably well, and we are optimistic that, given the names and addresses, we can secure the needed information from a satisfactory proportion of the respondents.

At this time the coding and processing of the pilot survey results are under way, but we feel that the basic methodological results are all in. As far as information needed for preparing a final plan for the national survey is concerned, we have learned most of what we are going to learn. The drafting of that plan would have been impossible without the pilot survey experience.

5. Special Features and Issues in the Sampling Plan

We have presented the broad framework of a Basic Plan survey, and have declared that the conceptual structure of the associated sampling design is fairly straightforward. The target is a sample of persons who have had one or more discharges, with an IN diagnosis, from a U.S. short-stay hospital in the four-year period 1971-74. We propose to reach this target through a national probability, essentially three-stage sample of geographically defined primary sampling units (PSU's), of hospitals within sample PSU's, and of persons within hospitals. The primary counts or measurements are to be (1) incidence, or number of persons with onset in 1973-74; (2) point prevalence, or average number of persons alive in 1973-74 possessing a diagnosis of IN measured two different ways; and (3) charges to these persons for services or care ascribed to those two years.

Filling in the important details of this conceptual structure has required resolution of quite a number of troublesome issues. We cannot in the present paper by any means deal with all these problems, but can only describe several of the more interesting or difficult ones. A full technical account of methodology will be included in the final report on the main survey.

In the very broadest sense "sample size" is set by the scale of the undertaking established by the NINCDS, expressed in terms of level of effort to be expended by the contractor. But at the start, unit costs for the various steps of the contemplated undertaking, for which there are no precedents, were almost totally unknown. A serious lack of information existed initially--and still does -- with respect to important characteristics of the universe, including such key features as even rough estimates of incidence, prevalence, or duration of major categories of IN. Using limited data available on brain tumors from a few sources, the opinions of advisory committee members, Westat experience on field costs, evidence from the pilot study, and theoretical analysis of relationships among incidence, duration and prevalence, we constructed crude estimates of the needed design parameters.

Because most of the survey operations require interviewers or abstractors on the spot, it was clear that the main sample should be concentrated in a limited number of geographic communities.

And for similar reasons and because of the substantial cost of persuading a hospital to participate, the number of hospitals should be only a small proportion of the 7000 in the universe.

Since a key decision had been made, as noted, earlier, to secure a sample of persons with one or more IN discharges in a four-year period, by sub-sampling cases in sample hospitals, it was essential to relate persons to hospitals in a manner that avoids duplication counts for persons that had discharges from more than one hospital in the universe. This could be done by use of some unique count rule that establishes a one-to-one relationship between a person (or an identifiable part of his experience) and a single hospital. Or it might be done in such a way that an appropriate part of the person's experience is associated with each hospital in the universe in which the person would have been discovered had a complete census been taken. As will be observed shortly, the intended estimating procedure will use one method for some variables, and another for different variables.

It is rarely feasible in sample designing to take all relevant factors simultaneously into consideration. That has been true in the present instance. Initially, in order to narrow the range of possibilities, an approach toward optimization was made using a very simple model in which the rel-variance of estimated incidence, x^1, was described by:

$$V_x^{2\,1} = \frac{B^2}{g} + \frac{W^2}{m} + \frac{\overline{ww}^2}{n}, \text{ where} \qquad (1)$$

B^2 = population rel-variance between PSU's

W^2 = population rel-variance between hospitals

$\overline{ww}^2$ = population rel-variance among persons within hospital

g = number of PSU's in sample

m = number of hospitals in sample

n = number of persons in sample, and

the cost equation is

$$C = C_1 g + C_2 m + C_3 n \qquad (2)$$

in which

C = available variable budget

C_1 = unit cost per PSU

C_2 = unit cost per hospital

C_3 = unit cost per person

We pass over the difficulties in estimating B^2, W^2, and $\overline{ww}^2$, except to observe that those estimates depend heavily on listings of numbers of beds in each hospital in the universe (from the 1972 Master Facility Inventory of the National Center for Health Statistics) and on a 1971 inventory of malignancies (with separate counts for brain tumors) conducted by the Regional Medical Program of the Public Health Service. The analysis yielded a general sample scale of approximately 50 PSU's, 200 hospitals, and 3000 persons.

The approximately 200 PSU's in the universe, each consisting of an SMSA or a county or a few adjacent counties, were classified into 50 strata of nearly equal 1970 population, principally on the basis of geography, number of inhabitants in 1970, population density, population changes between 1960 and 1970, and industrial characteristics. One sample PSU was selected from each statum with probability proportionate to size of 1970 population (PPS). The results were 10 self-representing SMSA's, 24 other SMSA's, and 16 non-SMSA's.

The hospital frame was the 1972 Master Facility Inventory of NCHS, cross-checked for completeness against a hospital list from the Food and Drug Administration (being used by Westat on another project), and also against the 1971 RMP inventory.

Efficiency in field work argued that extra effort should tend to be directed toward the larger hospitals, where there would be a greater concentration of IN cases. But of course the probabilities of selection of PSU's should be taken into account, and every hospital in the frame must be given a non-zero chance of inclusion in the sample.

Each hospital in the universe was assigned a size measure. For hospitals in the 1971 RMP inventory this was the number of IN discharges reported in that survey. For other hospitals the size measure was set at 0.01 times the number of beds. Because of their very large size and expected volume of IN cases, 7 hospitals were removed from the main frame, and will be included in the IN survey with certainty, even though they are not in any of the 50 sample PSU's.

The other hospitals were classified into five size-strata. For the sub-universe of all hospitals in the 50 sample PSU's, each hospital is given a "u-value" which is its original size-measure divided by the probability of selection of the PSU in which the hospital is located.

One of the difficult design decisions has been whether to control the numbers of persons sampled in each hospital and the number of hospitals in each PSU in order to retain close control over workload, or to adopt a selection procedure that allows these numbers to be more variable, but tends to produce a more nearly constant overall sampling rate of cases. The remainder of this account treats procedures which adopt the latter course.

For the sub-universe of sample PSU hospitals, a total of the u-values in each size-stratum is calculated. This is an estimate Z_i' of Z_i, the universe aggregate proxy value for IN cases in the i^{th} size class. Overall variable budget is allocated among the five size-classes in proportion to these Z_i values. Estimated optimum cluster

size of cases is calculated for each hospital size-class. Division of the hospital size-class budget by the expected average cost per cluster gives the number of clusters to be included in the sample in that size-class. Overlooking for this presentation minor modifications needed to distinguish between "clusters" and "hospitals," hospitals are then selected with probability proportionate to their u-values.

It may have been noticed in earlier parts of this paper that we sometimes speak of "persons" and sometimes of "cases." For clarity and the next steps, it will be useful to define "case" more carefully. A "case" is the person record of attributes or experiences of the person that are ascribed to the index hospital where the person turns up in the sample. A full person, contrastingly, is the complete consolidated record of all attributes and experiences of the person wherever they may have occurred in the universe. It is, then, cases that are sampled within sample hospitals, although in many instances, this third stage of sampling will be at a 100 percent rate. More generally the third-stage sampling rate will be $r\bar{q}_i/Z_{ij}$, where $\bar{q}_i$ is the average number of sample cases desired per hospital in the i^{th} hospital size class, r is a multiplier that relates expected number of cases to the Z-size-measure, and Z_{ij} is the size-measure for the j^{th} hospital in the i^{th} class. Estimation will include a ratio control by hospital size-class, using the Z_i' from the sample, and Z_i from the universe.

For a number of operational reasons, the weights will vary somewhat among cases, and a weight for each case must be calculated. But these weights will tend toward uniformity. The procedures outlined above should lead to a basic case weight in the i^{th} hospital size-class that hovers around $Z_i/rm_i\bar{q}_i$, where m_i is the number of sample hospitals in the i^{th} size class.

We have purposely in this paper avoided use of all but a minimum of algebra and equations -- possibly at the cost of some precision. At this point, we do include a formula that hopefully makes more explicit the estimation processes appropriate to the unique counting rule or other allocation procedures referred to earlier. The equation is somewhat simplified over the computational algorithm in order to better display the point of interest. Suppose, in one situation, the target is to estimate total charges in the nation, y, for a type of case, and that the charge for the k^{th} case is the j^{th} hospital is Y_{jk}. An unbiased estimate of Y is

$$Y = \sum_{j}^{M} \sum_{k}^{Q_j} \frac{Y_{jk}}{P_j P_{jk}} U_j U_{jk} \qquad (3)$$

in which:

P_j = the probability of selection of j^{th} hospital

P_{jk} = the probability of selection of k^{th} case, given selection of the j^{th} hospital

$U_j = 1$ if j^{th} hospital is in sample

$= 0$ otherwise

$U_{jk} = 1$ if k^{th} case is in sample, given $U_j = 1$

$= 0$ otherwise, and

the summations are over all cases and hospitals in the universe. (Computationally, of course, the summations need be taken over only sample cases.)

This estimator is typical of ordinary two-stage designs. It is needed in the present survey for some variables because measures for them can be revised only for the index hospital case, and cannot be obtained at reasonable cost for a person as a whole.

But for certain other variables or attributes, the measurement obtained is for the person and is only attributed to the case. The measure of onset or incidence is an example. For the jk^{th} case this is a 1-0 variate -- say $X_{jk} = 1$ if the person represented by the case had onset in the specified period, and $X_{jk} = 0$ if the person did not. Suppose this person had discharges in three hospitals. He would then generate three different cases somewhere in the universe. If equation (3) were used to estimate incidence, it is obvious that this person would have an expected contribution three times to the estimated incidence total. Several methods of correcting for this are possible. We intend to use the device of substituting $W_{.k} X_{jk}$ for Y_{jk} in equation (3), with X_{jk} being the person measure for the jk^{th} case, and $W_{.k}$ being the reciprocal of the number of hospitals in which the person would have been counted in a complete census of hospitals and cases. Clearly this requires knowledge of the person data for every sample case.

Theoretical exploration had identified several satisfactory techniques for estimating variances of the primary estimators, but a final choice has not yet been made.

We propose to supplement the main study -- or basic plan -- with a highly speculative secondary estimate of prevalence that is based on the model, mentioned earlier, that under stability assumptions, prevalence can be calculated as the product incidence times average duration. This supplementary estimate, for which we make no claims of precision, will feature three key assumptions and procedures:

a. Incidence will be estimated by the techniques described above, which are not affected by the restriction of case-finding to four years of hospitalization.

b. Average duration of IN cases will not come from the Westat survey, but from a subjective amalgamation of limited evidence from other sources and the opinions of experts.

c. Both incidence and duration are assumed to remain stable over the quite long period that embraces all the NRH cases.

The usefulness of this supplementary estimate of undeterminable quality is uncertain. Should it develop that the supplementary speculation and the main study agree fairly closely as to prevalence, there will be some evidence that the four-year hospitalization finding device did not seriously bias the overall main study. If the two schemes differ markedly, it may indicate that further effort is needed to quantify the additional prevalence of NRH cases.

6. Conclusions

Conclusions from the pilot study as it comes to a close have already been stated or implied in the earlier sections of this paper. To review, the principal determinations are these:

a. The Basic Plan, which samples all IN cases with one or more IN hospital discharges in a four-year period in a three-stage operation, and assembles data on those cases from hospital records and contact with case families and attending physicians, can produce adequate probability-based estimates of incidence, prevalence and costs for the universe of intracranial neoplasms, except for relatively small sectors of NRH cases.

b. The most serious hazard in the undertaking is the risk of non-cooperation of some hospitals and nonresponse from sources other than hospitals. We believe it will be possible to secure acceptable levels of response in the main survey, but it is clear that the prevailing climate of concern about invasion of privacy over the nation is going to make necessary very careful planning and execution if that goal is to be reached. The strategy for approaching the hospitals in the SIN project is not yet final, but it will contain the following elements:

    1. A more personal approach to the hospitals through co-operating specialists in the PSU's.

    2. Some options to the standard protocol in case the hospital insists on an advance release from patients in the sample, but rejection of the hospital letter to the patients requesting their approval, since that does not work.

    3. Less reliance on attending physicians for key information since they proved to be a disappointing source and more reliance on contacts with patients or relatives, except where it proves impossible to obtain permission to make contact with them in which case the effort will be to secure a few very basic items from the primary care physicians.

c. It appears the exclusions caused by limiting the final sample and case-finding to IN hospital discharges in a four-year period are a fairly small percentage of the total universe of surviving persons with intracranial tumors. But the pilot study suggests that there is a sufficient number of such exclusions that the supplementary prevalence estimate suggested in the paper should be attempted, even though it will have uncertain validity.

d. The low incidence and prevalence of this disease, coupled with the somewhat modest scale of the total effort, mean that principal findings of the survey -- other than important methodological evidence -- will be restricted to statistics for the more global categories of persons and diagnoses. Sampling errors, and possibly classification errors, for smaller domains will be large.