A LONGITUDINAL MULTIDISCIPLINARY STUDY OF HUMAN AGING: SELECTED METHODOLOGICAL ISSUES George L. Maddox, Duke University

The Department of Psychiatry at the Duke University Medical Center is conducting an exploratory study of human aging focused on selected physical, psychological, and social correlates of the aging process. In this study a number of the aging processes have been studied simultaneously by persons representing various disciplines. The intention has been to maximize the number of variables which might be introduced in the study of any single process of change as well as to explore the interrelationship of various processes.

Aspects of the design for this research will be described, and some of their consequences for the interpretation of data will be assessed. Two characteristics of the research design are of special relevance for this discussion:

- The subjects of the investigation are volunteers from among persons 60 years of age and over who were living in a community at the time they indicated a willingness to come to the medical center for two days of interviews and clinical evaluations.
- 2. The focus of the research is on the <u>processes</u> of change as well as on the changes commonly observed among elderly subjects. Continued observation of the same subjects over an extended period of time has been considered basic.

Sampling procedure and panel maintenance in longitudinal studies are not novel methodological issues. They are, however, persistent issues, and the method of handling them is fundamentally related to the analysis, interpretation, and generalization of research data. The purpose of this paper is to illustrate this relationship within the context of a specific research enterprise. In order to place decisions about research design in context, it will be helpful to describe briefly the development of this particular research project. The consequences of these decisions for data analysis will then be assessed. No attempt will be made to summarize substantive findings.

Origins of the Research Project

The research under consideration is generically related to an investigation of senile patients begun more than a decade ago at the University of Colorado School of Medicine by Dr. E. W. Busse and his associates. Initially this research was focused on changes in the aging central nervous system as revealed by electroencephalographic records. In order to develop standards for evaluating the clinical records of senile elderly persons, volunteer subjects with a wide range of socioeconomic characteristics were used as <u>normal controls</u>. The volunteers included the old and the young, indigents and professional persons, the employed and the unemployed, the sick and the well. The initial findings suggested differences between the EEG records of institutionalized and noninstitutionalized subjects; moreover, among noninstitutionalized subjects, differences were related to variations in health and in socioeconomic circumstances.

The Colorado experience demonstrated the importance of extending the use of normal controls in developing standards for the interpretation of EEG records in elderly subjects. It also suggested the need to investigate interrelationships among the physical, psychological, and social correlates of these differences, and changes in their relationships through time.

The research was subsequently continued at Duke, and by 1957 electroencephalographic research was being conducted simultaneously among elderly persons in a private home for the aged, senile patients in a state mental institution, and non-institutionalized subjects living in and around Durham, North Carolina. These last subjects, recruited individually and through various community organizations serving older persons, included retired professionals and executives as well as persons from lower socioeconomic strata.

Other medical specialists and social scientists joined the psychiatrists in making plans for extending the scope of the research to explore the correlates of central nervous system change. In this planning, understanding differences in the changes experienced by the same elderly person through time emerged as the central issue. Initial interest in the noninstitutionalized subject developed as a reaction against the obvious inadequacy of applying observations made on institutionalized elderly subjects to elderly persons in general. This interest was given a decided boost by increasing national concern about the problems of non-institutionalized elderly persons. Consequently, it was decided to undertake a longitudinal, multidisciplinary investigation of the aging central nervous system and its correlates among non-institutionalized elderly subjects.

Selection of Subjects

The issue of sampling appropriate for the proposed research posed a basic problem. A review of the minutes of the seminar within which the research design was developed indicates that the discussion went something like this:

Persons engaged in a scientific enterprise can concern themselves with generalizations about the distribution of some characteristic or variable within a population; the epidemiologist,

for example, is preoccupied with this type of generalization. But a scientist may also be interested in the relationship between or among characteristics or variables independent of their distribution in a population. The scientific experiment that seeks to relate variables X and Y under given conditions is a case in point. Generalizations of the first type require the investigation of some universe or of samples representative of that universe. Generalizations of the second type require, as a minimum, control of variables presumed to be relevant. While optimum research design should provide for both types of generalizations, practical considerations frequently make it necessary to choose one or the other type as an immediate goal.

With appropriate misgivings, the research group at Duke decided to continue the practice of recruiting volunteers rather than attempting to involve a randomly drawn sample of elderly non-institutionalized subjects in research that would require intensive clinical evaluation. In recruiting more volunteers from the community, however, an attempt was to be made to develop a panel of subjects 60 years of age and older whose age, sex, ethnic, and socioeconomic characteristics would reflect the range of these characteristics found among older persons in the locale. It was not the purpose of this procedure to provide the appearance of random sampling without its substance, but rather to maximize the variety of controls which could be introduced subsequently. In time, 250 subjects who met these criteria indicated a willingness to participate in the research and completed the initial two-day series of interviews and clinical examinations. The only inducements offered these volunteers were a free annual medical examination, a subscription to a magazine for elderly persons, and whatever satisfaction the subjects derived from their participation.

One consequence of the decision to use volunteer subjects was obvious. Generalizations from the data would necessarily be limited to statements concerning the relationship among factors in the aging process <u>under</u> <u>specified conditions</u>. Statements about elderly persons in general would not be warranted.

The deliberate decision of a research group to use volunteers and to accept the consequences of its decision does not have to be defended. But an interesting question is posed: Was there in fact a feasible alternative to their decision? When the research project is one which necessarily involves clinical evaluations and which must be carried out among noninstitutionalized subjects, the answer seems to be <u>no</u>. Attempts to involve randomly selected non-institutionalized subjects in research requiring clinical evaluation have not proved rewarding. It is difficult to get subjects living in the community into a clinic for a single examination, much less for a series of different examinations; and the problem is intensified with the increasing age of the subjects.¹

The decision to use a panel of volunteers raises additional problems concerning subject selection which are not resolved by restraint in the generalization of findings. In addition to being a crucial condition of generalizing from a part to a whole, random selection procedure also has another function in research: It presumably minimizes the probability of introducing systematic bias from unrecognized or uncontrolled but potentially significant sources into the analysis of relationships among variables. For example, volunteers used as "normal controls" in clinical research may in fact neither be normal nor provide controls. In specific instances it has been demonstrated that volunteer subjects have introduced an uncontrolled but definitely biasing effect in clinical experiments.² The fact that an individual is not institutionalized and not a patient does not necessarily make him a normal control within any frame of reference.

Subtle as well as gross biasing effects introduced by self-selection may also have a bearing on the analysis of relationships among variables. The Duke research project, for example, was designed to explore selected physiological, psychological, and sociological correlates of central nervous system aging. Each type of factor implies a number of universes within which subjects may be ordered in some fashion -- say, in terms of relative health or illness, of higher or lower intelligence, of greater or lesser age, or of higher or lower socioeconomic status. Since a given individual is a member of each of these universes simultaneously, it is difficult to parcel out the effect of each factor in a given situation. If the subjects are volunteers, they may represent adequately the theoretically possible range of health and illness but include only those who are of higher intelligence and upper socioeconomic status; or they may run the gamut from high to low socioeconomic status but include only those who are relatively healthy and of high intelligence; or the subjects may be concentrated among those who are in good health, have high intelligence, and are in the upper range of status.

In the absence of probability sampling, the possibility of spurious relationships which are artifacts of the sampling procedure is increased. A cross sectional analysis of project data, for example, indicated that activity, but not morale, decreased with age among these elderly subjects. That this finding is probably an artifact of the age distribution of antecedent or intervening variables known to affect the relationship between activity and morale will be illustrated later. A number of studies involving non-institutionalized elderly subjects have employed random sampling procedure. The non-participation rates in such studies have been high, especially when clinical evaluation of subjects has been involved. It is entirely possible that a high refusal rate in such instances produces a sample which is essentially the equivalent of a collection of volunteers. To investigate this possibility, the Duke panelists have been compared with samples of elderly persons used in other research projects.

Three types of comparisons have been made: (1) a comparison in terms of selected physical and mental health characteristics between the Duke panelists and samples presumed to be representative of local, regional, or national populations of older persons; (2) a comparison of the panel with itself at two points in time, on the assumption that selective dropout of subjects through time might provide a rough indication of the characteristics of subjects initially attracted to participate in the research; and (3) a comparison, in terms of selected characteristics, between some of the panelists and a probability sample of elderly white subjects drawn from the same community by another research group for a survey of community involvement and participation.

<u>Selected comparisons with randomly drawn, nonlocal elderly subjects</u>

Physical health and associated degrees of disability are principal variables in any investigation of the aging central nervous system. The Duke research excluded the minority of elderly persons totally confined to their home by physical disability. Whether, among the majority of mobile persons 60 years of age and over, those in poor or good health would be more likely to participate is problematical. A partial answer to this question is provided by a limited comparison with certain findings of the National Health Survey.³

The comparison is limited by the fact that the National Health Survey utilized the reports of respondents as the basis for assessing degrees of disability, while the comparable health evaluation of the Duke panelists was based on clinical examinations. Moreover, pathological conditions appear characteristically to be under-reported in surveys.⁴ One comparison which does seem warranted, however, involves the category of persons in each study rated as severely disabled. The probability of coincidence between self-reports and clinical evaluations should be maximum in the extreme cases. Thirty-three per cent of the persons 65 years of age and older who were interviewed in the National Health Survey reported that they were either restricted in major life activities or totally confined to the home as a result of poor health. On the initial clinical examinations, 26 per cent of the Duke panelists were

assessed to be at least 60 per cent disabled in carrying out normal life activities; and, when the panelists were re-evaluated approximately three years later, 33 per cent were so disabled.

The presence or absence of physical pathology is related to an individual's assessment of his health status, but is not synonymous with it. Self-assessment of health status thus provides another basis for comparing the Duke panelists with a probability sample. Schnore and Cowhig⁵ have reported the distribution of self-assessment of health status among a randomly drawn sample of persons living in several metropolitan centers. Among their respondents 60 years of age and over, 46 per cent assessed their health as "excellent" or "good"; among Duke panelists, 52 per cent made this assessment.

Neither of the foregoing comparisons shows a striking difference between the volunteer panelists and randomly selected subjects who were willing to participate in other studies.

A serious objection advanced against the use of volunteers in clinical research is the large proportion of persons with diagnosed or diagnosable psychiatric illness who tend to be attracted.⁶ Among the panelists at Duke, however, 40 per cent were found to be without significant signs or symptoms of psychiatric illness, and only 6 per cent were classified as psychotic. This distribution between the extremes of mental health and illness is similar to comparable data based on mental health surveys utilizing random sampling techniques.

An example is Gruenberg's epidemiological study of mental illness among elderly subjects in selected census tracts in Syracuse. Approximately 4 per cent of the respondents were classified by him as dangerous to themselves or unable to care for themselves. While the home survey sample of Srole and his associates in their study of mental illness in a metropolis⁸ does not include persons beyond the age of 59, only 38 per cent of the subjects between 50 and 59 years of age were considered to be either "well" (unimpaired) or to exhibit only "mild" symptoms. Dr. Leighton, in an epidemiological survey of mental health in a small town in Nova Scotia, also found that 14 per cent of the respondents aged 18 and over were "asymptomatic" and another 21 per cent were borderline "normals."⁹ Although she did not analyze her findings in terms of specific age categories, the Duke panelists obviously compare faborably.

Selected comparisons of the physical and psychiatric characteristics of the Duke volunteers with subjects selected by random procedures do not indicate striking differences. On the whole, the physical and mental health of the Duke subjects appears to be slightly better than that of the samples of elderly persons with whom they are compared. These similarities do not prove that the Duke subjects provide the equivalent of a randomly drawn sample of elderly subjects; rather, they indicate that the relatively high refusal rate among older persons asked to participate in surveys tends to make the participating respondents essentially the equivalent of volunteers.

Selective dropout among panelists

Of the 250 subjects for whom there was relatively complete information at the end of the first phase of the study, 182 (73 per cent) repeated the two days of interviews and examinations approximately three years later. Of the 68 who failed to return, 65 per cent had died in the interim or had been immobilized by illness, 11 per cent had moved away, and the remaining 24 per cent indicated in various ways a reluctance to continue participation.

Three characteristics were observed with significantly greater frequency in the subjects who refused to return for the second phase of the research than in those lost because of death or immobility. Refusals were concentrated among (1) females, (2) subjects with IQ (WAIS) scores below the median of the panel, and (3) those clinically assessed to be in relatively good health (less than 20 per cent disability). In the case of this last factor, the voluntary dropouts were concentrated among subjects who were medically assessed to be in good health, but who assessed their own health status as poor. Subjects who refused to return also tended to be of lower socioeconomic status and relatively inactive socially, although these tendencies were not statistically significant.

When the 182 panelists who returned for the second evaluation are compared with the 250 original members of the panel, a significant increase is found in the proportion of subjects characterized as (1) active, (2) married and living with the spouse, (3) the head of a household, (4) in good health, (5) exhibiting high morale, and (6) intelligent (above median WAIS scores). The proportion of Negroes, females, and persons of higher social status among the panelists also increased, although these increases were not statistically significant.

Over the three years under consideration, the panelists as a group tended to become increasingly a physiological, psychological, and social elite. While part of this change reflects the effect of selective mortality, it is the impression of various members of the Duke research group that the volunteers initially represented a relatively elite category of elderly subjects, and only became more so through time. Supporting this impression are (1) the comparisons of the panelists, in terms of physical and mental health, with randomly drawn samples of elderly subjects who have "volunteered" by not refusing to cooperate in other studies; and (2) the observation that cooperation in a strenuous two-day sequence of interviews and examinations tends to exclude the physically disabled, the psychologically deteriorated, and the most socially deprived elderly persons in the community.

Analysis of changes in the composition of the panel through selective dropout does nothing more than suggest differences between the panelists and the population from which they came. The noted changes do, however, have important implications for data analysis in longitudinal research. These will be discussed later.

Comparison with a random sample of elderly subjects in the same locale

For a study of community participation among white persons of various ages, the Department of Sociology at Duke drew two area probability samples in Durham -- one including persons through the age of 64, and another including persons 65 years of age and older. If the original panelists who are 1) Negro, 2) under 65, and 3) living outside the city limits are excluded, it is possible to compare those remaining (N=108) with those persons 65 years of age and older in the probability sample (N=139) in terms of age, sex, marital status, activity, and self-estimate of health.

In terms of age and self-estimate of health, the probability sample of persons 65 years of age and older and the comparable panelists are similar. The average age of the sample subjects was 72, and that of the panelists, 71; 14 per cent of the former and 15 per cent of the latter were 80 years of age or older. Sixty-two per cent of the panelists being compared estimated their health to be good or excellent, while 56 per cent of the sample subjects made this estimate.

In terms of reported activity, sex distribution, and marital status, however, these two groups of elderly subjects showed striking differences. The mean Activity Inventory score¹⁰ originally of the Duke panelists was 27.4, as compared with 20.4 for the subjects in the probability sample. Moreover, 54 per cent (compare 36 per cent) of the panelists were male, and 65 per cent (compare 34 per cent) were married and living with the spouse. The high proportion of panelists who were married and living with their spouses can be explained by two factors: (1) the high propertion of males in the group, and (2) the fact that there were 13 married couples participating. That even one couple would be drawn in a random sample of individuals is extremely unlikely. Since "married and living with spouse" is a factor positively associated with physical and mental health, the high proportion of persons in the panel who fall into this category helps to explain the favorable showing, in terms of health, made by the panelists in comparison with other groups.

Summing up, this comparison with a random sample of elderly subjects in the same community tends to support the inference that the Duke panelists represent an elite among the elderly. It is all the more interesting, therefore, that the panelists are so nearly similar, in selected health characteristics, to randomly drawn samples of elderly subjects in the instances noted.

A Longitudinal Design

The initial conception of the Duke research project was to explore human aging as a complex process of interrelated changes. Selected physical, psychic, and social factors involved in this process were to be explored. A longitudinal design was proposed because it permitted intensive focus on individual subjects and also permitted each subject to be used as his own control.

Baselines for each subject were established in the first series of interviews and examinations. A cross-sectional analysis of the initial data explored the complex interrelationships among a wide range of variables and focused attention on those factors which would warrant the most attention in the longitudinal analysis. The second series of observations on the subjects who remained approximately three years later provided a basis for assessing individual changes and an additional check on the relationships initially observed.

The cross-sectional analysis proved to be a double temptation:

 In addition to providing information about the relationship between factors under specified conditions, such an analysis also provides information about the distribution of these factors among the panelists and, in some cases, measures of central tendency.

Even though the temptation to draw unwarranted inferences about elderly persons from such distributions and statistics might be avoided by an investigator, there is little control over the inferences which others draw. By a conscious focus on processes of aging and their correlates among selected older persons rather than on the description of the population of elderly persons, the Duke investigators have kept such errors to a minimum.

> 2. A panel statistic based on observations at two different points in time understandably invites comparison. That such comparisons must be made with great caution when there is a selective dropout of panelists is suggested by the

following illustration:

Both the initial and later cross-sectional analyses indicated a significant positive relationship between contact with the environment (activity) and morale among the panelists. It was hypothesized that, as activity tends to decrease with age, so should morale. When the age factor was controlled, however, both initial and later analyses showed an age-related decrease in activity, but not in morale. In the later analysis, moreover, the relationship between the activity and morale, while still significant, was less pronounced. A possible explanation for this observation is the "theory of disengagement" suggested by Cumming and Henry on the basis of their Kansas City data. 11 These au These authors hypothesize that, with age, activity and morale become increasingly independent of each other.

Analysis of the Duke data suggested an alternative interpretation. The initial crosssectional analysis disclosed three important factors in interpreting the relationship between activity and morale: (1) health, especially an individual's own assessment of his health status; (2) the presence or absence of clinical depression; and (3) the individual's reported sense of usefulness. Morale was likely to be higher in elderly panelists who were, or believed themselves to be, in good health, who were not depressed, and who felt useful than in those who reported an equal degree of activity, but did not have these other characteristics. Moreover, the panelists who showed these characteristics were more likely than the others to have high morale, even though they reported low activity.

When the distribution of these modifying characteristics was checked against age, it was found that the proportion of subjects with one or more of these characteristics was slightly higher in the older age categories than among the younger panelists. This difference was even more noticeable when the later series of observations were made. In this instance, the finding that morale became increasingly independent of activity with age appears to have been an artifact of the particular characteristics of the subjects in the various age categories. The slight decrease in the mean activity score of the panel over approximately three years, concomitant with an increase in the mean morale score, can be explained in the same way. When individual subjects are used as their own controls, changes in activity scores tended to be related positively to changes in morale except in the presence of one or more of the factors known to modify the relationship.¹²

This illustration re-emphasizes the soundness of the initial orientation of the research group to use each individual as his own control and, when comparisons of panelists in terms of group statistics seemed appropriate, to match the comparison groups with care. It also serves as a reminder that, when summarizing measures are used in longitudinal studies, an observed relationship may be an artifact of changes in the composition of the panel resulting from selective dropout.

Summary

Selected aspects of a research design have been described, and some consequences of this design for data interpretation have been discussed. The research project involved a longitudinal multidisciplinary investigation of the aging process and its correlates among selected non-institutionalized subjects 60 years of age and older. Two hundred and fifty elderly subjects volunteered to participate initially in a two-day series of interviews and clinical examinations. Approximately three years later, 182 of them returned to complete a second series of investigations.

Two methodological issues discussed on the basis of experience in this investigation are: (1) the use of volunteer subjects and (2) selective dropout of panelists in a longitudinal study. Regarding the first, it is argued that, in spite of the limitations incurred, there is at present no feasible alternative to the use of volunteers in research requiring clinical examinations. Selective dropout of subjects imposes still further limitations on the use of group statistics in the analysis of longitudinal observations. Because of the changes in the characteristics of groups under investigation over a period of years, such statistics are dependable only if there is control for the effects of selective dropout of subjects.

FOOTNOTES

 See, for example, S. Cobb <u>et al</u>, "Diff= erences between Respondents and Nonrespondents in a Morbidity Survey Involving Clinical Examination," Journal of Chronic <u>Disease</u>, 6 (1957), 95-108; Tava Gordon <u>et al</u>, "Some Methodological Problems in the long-term Study of Cardiovascular Disease: Observations on the Framingham Study," Journal of Chronic Disease, 10 (1959), 186-206; P. Borsky and E. White, "Factors Affecting the Decision to Volunteer for a Physical Examination," <u>Public Opinion Quarterly</u>, 23 (Fall, 1959), 445-446; "Cooperation in Health Examination Surveys," United States National Health Survey (Publication D-2), June, 1960; and D. E. Krueger, "Measurement of Prevalence of Chronic Disease by Household Interviews and Clinical Evaluation," <u>American Journal of Public Health</u>, 47 (August, 1957), 953-960.

- 2. H. Esecover <u>et al.</u>, "Clinical Profiles of Paid Normal Subjects Volunteering for Hallucinogen Drug Studies," <u>American</u> <u>Journal of Psychiatry</u>, 117 (1961), 910-915, presents a case in point and a convenient bibliography. It is pertinent that most discussions of volunteer "normal controls" concern only younger subjects. Experience in the research reported here suggests that the usual characterization of the young volunteer as "not normal" cannot be extended uncritically to apply to elderly subjects.
- U. S. National Health Survey, "Preliminary Report on Disability, United States, July-September, 1957" (Series B-4).
- 4. Krueger, op. cit.
- "Some Correlates of Reported Health in Metropolitan Areas," <u>Social Problems</u> 7 (Winter, 1959-60), 218-225.
- 6. Esecover et al., op. cit.
- 7. "A Mental Health Survey of Older Persons," in Hoch and Zubin (Eds.), <u>Comparative</u> <u>Epidemiology of Mental Disorders</u> (Grune and Stratton, 1961).
- 8. <u>Mental Health in Metropolis</u>, I (McGraw-Hill, 1962).
- "The Distribution of Psychiatric Symptoms in a Small Town," <u>American Journal of</u> <u>Psychiatry</u>, 112 (1956).
- See R. S. Cavan <u>et al</u>., Personal Adjustment in Old Age (Chicago: Science Research Associates, Inc., 1949).
- 11. Growing Old (Basic Books, 1961).
- 12. For a more detailed discussion of this point, see the author's "Activity and Morale: A Longitudinal Study of Selected Elderly Subjects," a paper presented at the annual meeting of the American Sociological Association, Washington, D. C., September, 1962.