Epidemiology of Stroke in an Elderly Welfare Population

A. M. OSTFELD, MD
R. B. SHEKELLE, PhD
H. KLAWANS, MD
H. M. TUFO, MD

A prospective epidemiological study on a large population of elderly persons was carried out to investigate the incidence of cerebrovascular attack (stroke) and its relationship to other variables, particularly preexisting cardiovascular disease.

Introduction

Vascular lesions affecting the brain are the third leading cause of death in the United States and are a major cause of disability in middle-aged and elderly persons. The evidence implicating arterial hypertension in the etiology of stroke appears strong.[1-6] However, currently available data are less adequate for firmly relating other variables to risk of stroke and for planning programs aimed at stroke prevention.

In October, 1965, a cohort study of the epidemiology and natural history of cerebrovascular attacks (CVA) was begun in Cook County, Illinois, in an elderly poor urban population. The principal objective of that research has been to identify variables associated with the incidence of stroke. The basic hypothesis is that factors associated with risk of coronary heart disease (CHD) during middle age are also related to risk of CVA in old age. The prospective method of epidemiology was used to investigate this hypothesis in order to make possible direct assessments of the relationship between risk of stroke and the independent variables. Also, the prospective method was employed to avoid two problems which often diminish the value of data obtained by the retrospective method; namely, the possibility of bias arising from selective elimination of cases before sampling and of bias arising from systematic changes in the independent variables occurring after the clinical appearance of the disease.

Two considerations led to selecting an elderly population for this study. First, the incidence of stroke in younger persons in very low and a very large sample of persons observed for a long period of time would be required in order to detect enough new cases. Second, current prospective studies of coronary heart disease will eventually generate data on the relationship between variables measured in middle age and risk of stroke in later years. The data from studies of CHD will be useful for planning long term programs of primary prevention beginning in youth and middle age. However, we still need to determine whether effective programs of prevention can be instituted among persons who are now elderly, and a first step is to identify elderly persons with exceptionally high risk of stroke. Data from the present study should illuminate this purpose.

This report investigates the following major question. What is the incidence of CVA in this population and how is this incidence related to race, sex, age, blood pressure, serum lipids, glucose tolerance, smoking habits, electrocardiogram (ECG) patterns, transient ischemic attacks, and other cardiovascular disease?

The authors are from the Department of Epidemiology and Public Health, Yale University School of Medicine, New Haven, Connecticut, and the Department of Preventive Medicine and Community Health, University of Illinois College of Medicine, Chicago, Illinois.

Method

Sampling

Three probability samples were selected over a period of 14 months from the population of noninstitutionalized Negro and caucasian persons who were 65 to 74 years of age and receiving Old Age Assistance (OAA) in Cook County, Illinois. The samples were selected in September, 1965, January, 1966, and November, 1966. At that time, eligibility for OAA required a person to be at least 65 years of age, to have been a resident of Illinois for at least 1 year, and to meet certain financial criteria which, in effect, stated that the person must be destitute and unable to obtain support from relatives. Persons residing in public institutions for the treatment of tuberculosis or mental illness and inmates of penal or correctional institutions are not eligible for OAA.

The samples were selected from lists which included the name, sex, race, date of birth, and mailing address of each person who received OAA in Cook County during a particular month. Persons on these lists were included in the population to be sampled if they had also received OAA 3 months previously, were 65 to 74 years of age, caucasian or Negro, and not receiving aid through Nursing Home Service. Eligible persons were classified by sex and race into four groups. Sampling fractions were selected so that equal numbers of white men, black men, white women, and black women would be included in the sample. The first sample comprised 880 persons selected from a population of 7629. The second and third samples comprised 2200 and 1700 persons, respectively, from populations numbering 5813 and 5320.

Initial Interview

Subjects were clustered geographically by postal zone and, within clusters, put into groups of 8 to 12 persons living in close proximity to one another. These groups were assigned to trained interviewers using random permutations in order to randomize effects of systematic differences among interviewers.

A letter of introduction was mailed to each subject just before assignment to an interviewer. The project was described as a study of the health of older persons with the purpose of learning how to prevent illness and promote good health during old age. Cooperation of the subjects was solicited at the initial interview. The interviewers emphasized that cooperation was entirely voluntary and in no way would affect, positively or negatively, a subject's status with the Department of Public Aid.

If the person agreed, the interviewer completed a standard questionnaire schedule which covered demographic, social, and medical topics and made an appointment for the subject to be examined at the central office.

Initial Examination

Transportation between home and central office was provided by this project for almost all subjects and ad hoc translators (usually a relative or friend) were obtained for subjects who could not speak English.

Upon arrival at the office, a subject was shown to an individual examination room where street clothes were removed and an examination gown put on. The following procedures or measurements were carried out at the initial examination:

- A 12-lead electrocardiogram recorded on a Sanborn direct-writing instrument;
- Response of the arterial pressure to sitting and standing after being supine while the ECG was recorded;
- Oral administration of 50 gm of glucose in a lemon-lime-flavored solution to subjects denying a history of diabetes mellitus;
- Height recorded to the nearest centimeter with the subject stretched to greatest height while standing against a flat surface;
- Weight recorded to the nearest hectogram on balance scales;
- Systolic and diastolic pressures in the left and right arms measured after 5 min of quiet sitting;

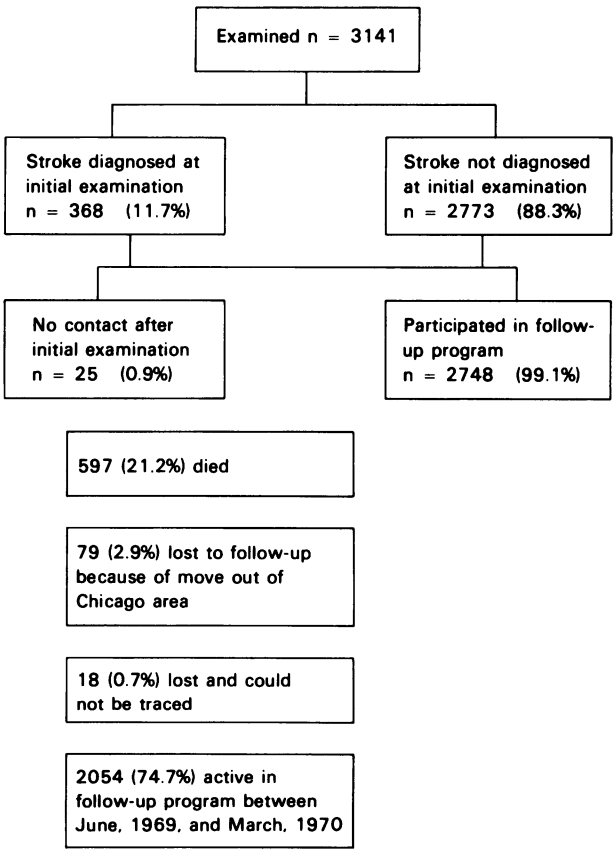

FIGURE 1 Disposition of subjects initially examined, Chicago Stroke Study, September, 1965, to March, 1970

- Specimens of venous and capillary blood drawn 1 hr after administration of the glucose;
- Vital capacity and 1-sec forced expiratory volume recorded on a 9-liter Collins respirometer;
- A detailed history, and physical examination with emphasis on the cardiovascular and central nervous systems.

TABLE 1—Distribution of Subjects in the Follow-up Program by Sex and Race, Chicago Stroke Study, 1965–1967

Categories	All Subjects	Population A	Population B*
White men	582	324	258
Black men	729	430	299
White women	619	367	252
Black women	818	526	292
Total	2748	1647	1101

* Subjects are included in population A if any one of the following conditions was present and in population B if none of the following conditions were present at the initial examination: (1) clinical heart disease; (2) clinical cerebrovascular disease, including transient ischemic attacks; (3) peripheral atherosclerosis; (4) intermittent claudication; (5) definite ECG abnormalities; (6) diabetes mellitus by history; (7) blood urea nitrogen 30 mg per dl; (8) health status rated as gravely ill.

TABLE 2—Months of Follow-up, Chicago Stroke Study, September, 1965, to March, 1970

Months of Follow-up*	Frequency	Cumulative Frequency	Cumulative Rate/1000
48–54	82	82	3.0
42–47	372	454	16.5
36–41	667	1121	40.8
30–35	741	1862	67.8
24–29	450	2312	84.1
18–23	131	2443	88.9
12–17	111	2554	92.9
6–11	122	2676	97.4
0–5	72	2748	100.0

* Median = 32.1 months.

TABLE 3—Distribution of Cases by Presumed Clinical Diagnosis, Chicago Stroke Study, September, 1965, to March, 1970

Diagnostic Category	Frequency	%
All strokes		
Nonembolic infarction	158	79.8
Hemorrhage	23	11.6
Embolus	2	1.0
Unknown	15	7.6
Total	198	100.0
Class I stokes only		
Nonembolic infarction	114	83.8
Hemorrhage	15	11.0
Embolus	2	1.5
Unknown	5	3.7
Total	136	100.0

TABLE 4—Distribution of Cases by Vascular System Involved in First Stroke, Chicago Stroke Study, September, 1965, to March, 1970

Vascular System*	Frequency	%
All strokes		
Right hemisphere	71	35.8
Left hemisphere	75	37.9
Brain stem	16	8.1
Not localizable	36	18.2
Total	198	100.0
Class I strokes only		
Right hemisphere	60	44.1
Left hemisphere	60	44.1
Brain stem	10	7.4
Not localized	6	4.4
Total	136	100.0

* In most instances the vascular system involved was determined solely on the basis of clinical evidence. Postmortem examination of the brain was obtainable in only six cases.

TABLE 5—Three-Year Incidence of Stroke, by Sex, Race, and Age, Chicago Stroke Study, September, 1965, to March, 1970*

Category	Number of Subjects	Number of Strokes	3-Year Rate/1000	Standard Error
Age 65–69				
White men	269	7	30	11
Black men	374	25	78	15
White women	218	8	44	15
Black women	309	21	75	16
All (adjusted)	1170	61	41	9
Age 70–74				
White men	313	19	76	17
Black men	355	26	89	17
White women	401	29	85	15
Black women	509	52	122	16
All (adjusted)	1578	126	83	10
Age 65–74 (adjusted)				
White men	528	26	50	10
Black men	729	51	82	11
White women	619	37	62	11
Black women	818	73	94	12
All (adjusted)	2748	187	59	7

* Incidence rates and their standard errors have been completed by life table procedure. Where indicated, these estimates have been adjusted for sex, race, and age to the 1960 U.S. population.

The medical histories and examinations were performed by three physicians, two of whom stayed with this phase of the project from beginning to end. One physician was an ophthalmologist; the other two were internists. One

TABLE 6—Three-Year Incidence of Stroke, by History of Diabetes Mellitus and Reported Mode of Treatment, Chicago Stroke Study, September, 1965, to March, 1970*

Categories	Subjects	All Strokes			Class I Strokes Only		
		Strokes	Rate/1000	S.E.	Strokes	Rate/1000	S.E.
History +, no Rx	278	32	119	20	19	73	16
History +, diet only	65	7	69	25	5	44	20
History +, oral med.	128	12	70	22	10	63	21
History +, insulin	53	5	123	50	4	98	47
All history +	524	56	111	15	38	75	13
All history −	2223	131	67	6	88	47	5
All	2747	187	75	6	126	52	5

* One subject (no stroke) omitted because of missing data.

internist and the ophthalmologist had received 6 weeks of special training in neurology under the supervision of a consulting neurologist. The other procedures were performed by medical technicians who had been specially trained in these techniques.

Laboratory Procedures

Hemoglobin, hematocrit, blood urea nitrogen, and plasma glucose were measured on all subjects. Protein-bound iodine, total protein, and albumin were measured on subjects in the first two samples, and protein electrophoretic patterns were measured on subjects in the first sample only.

At least two 2-ml samples of serum from each subject were placed in sealed vials and stored at −40° C. After the initial examinations were completed, these samples were used to measure total cholesterol and triglycerides on approximately three-fourths of the subjects. (Funds ran out before analyses on the remaining fourth were completed.) Except for the electrophoretic patterns, hemoglobin and hematocrit, all analyses were performed using standard AutoAnalyzer procedures. Pooled samples, blind split samples, and commercial controls were used continuously to monitor quality of the laboratory determinations.*

Diagnostic Categories

"Definite" myocardial infarction (MI) was diagnosed if there was a "definite" history of MI and/or if the ECG presented clear evidence of MI. A definite history of MI was defined as (1) the sudden—less often gradual—onset of chest pain or discomfort, (2) hospitalization for a period of weeks, and (3) a physician's statement that the subject had had a "heart attack." The electrocardiograms were read by one of the staff internists according to criteria used by the National Health Survey.[7]

"Possible" MI was diagnosed in the absence of clear ECG evidence if there was a history containing any two of the three criteria outlined above for a "definite" history.

"Definite" angina pectoris was diagnosed if there was a clear history of two or more attacks of discomfort or pain across both sides of the anterior chest wall, in the precordium or centrally under the sternum, which may have then radiated to the arms, shoulders, neck, or jaw. The discomfort or pain must have been precipitated by effort—e.g., exercise, emotion, or exposure to cold and wind—lasted for 30 sec to half an hour, been relieved within minutes after cessation of effort, and spontaneously described as "pressing," "tight," "heavy," "constricting," "crushing," "numbing," or "burning."

"Possible" angina pectoris was diagnosed (1) if there was only one attack meeting all criteria listed above, (2) if the pain or discomfort was described in terms other than those listed above except that lancinating, pleuritic, or throbbing pain was excluded, (3) if there was pain or discomfort as in definite angina but it began in any of the sites of radiation mentioned or in the right anterior chest or epigastrium, or (4) if the discomfort or pain subsided despite continued effort.

Angina pectoris was excluded (1) if the discomfort or pain occurred after the cessation of effort or only in

TABLE 7—Three-Year Incidence of Stroke, by Diagnostic Categories of Clinical Heart Disease at Initial Examination, Chicago Stroke Study, September, 1965, to March, 1970

Category*	Subjects	All Strokes			Class I Strokes Only		
		Strokes	Rate/1000	S.E.	Strokes	Rate/1000	S.E.
AP+, HHD −	175	4	33	17	1	11	11
MI +, HHD −	112	6	82	33	3	45	25
HHD +	600	77	147	20	54	115	19
Other HD	217	10	53	18	8	39	15
HD absent	1644	90	62	6	60	42	5
All	2748	187	75	6	126	52	5

* AP, angina pectoris; HHD, hypertensive heart disease; MI, myocardial infarction; HD, heart disease.

TABLE 8—Three-Year Incidence of Stroke, by Diagnosis of Peripheral Atherosclerosis at Initial Examination, Chicago Stroke Study, September, 1965, to March, 1970

Categories*	Subjects	All Strokes			Class I Strokes Only		
		Strokes	Rate/1000	S.E.	Strokes	Rate/1000	S.E.
PA present	245	24	125	25	18	94	22
PA absent	2503	163	72	6	108	49	5
All	2748	187	75	6	126	52	5

* PA, peripheral atherosclerosis.

* Distributions and intercorrelations of all variables measured and results of assessments of reliability of procedures will be mailed on request to interested readers.

TABLE 9—Three-Year Incidence of Stroke, by History of Cigarette Smoking at Initial Examination, Chicago Stroke Study, September, 1965, to March, 1970*

Categories	Sub-jects	All Strokes			Class I Strokes Only		
		Strokes	Rate/ 1000	S.E.	Strokes	Rate/ 1000	S.E.
All subjects							
Never smoked	1455	108	78	8	71	53	7
Former cigarette smoker	399	23	71	17	19	55	14
Current, <1/2 pk/day	357	28	101	19	16	61	15
Current, 1 pk/day	498	27	66	14	19	45	12
Current, 2+ pk/day	30	1	63	44	1	63	44
All	2739	187	75	6	126	52	5
Population A only							
Never smoked	900	86	98	12	58	68	11
Former cigarette smoker	241	16	91	28	12	64	24
Current, <1/2 pk/day	194	17	99	24	9	50	17
Current, 1 pk/day	288	18	76	19	12	51	16
Current, 2+ pk/day	17	0	–	–	0	–	–
All	1640	137	90	8	91	62	7
Population B only							
Never smoked	555	22	48	11	13	32	10
Former cigarette smoker	158	7	45	17	7	45	17
Current, <1/2 pk/day	163	11	89	25	7	63	22
Current, 1 pk/day	210	9	48	17	7	33	13
Current, 2+ pk/day	13	1	–	–	1	–	–
All	1099	50	54	8	35	39	7

* Nine subjects (no strokes) omitted because of missing data.

relation to meals, posture, or special movements of the body, (2) if the pain was described as stabbing or lancinating in the region of the left breast, or (3) if there was localized or general chest and/or arm pain due to thoracic outlet or hyperabduction syndrome.

Congestive heart failure was diagnosed if there was dyspnea with exertion or at night, if rales were present in the lung bases, and if there was cardiac enlargement.

Peripheral arterial disease was diagnosed if any of the following were present at examination: (1) history of intermittent claudication, (2) abnormal changes in skin color with changes in position of the extremity, (3) persistent redness or cyanosis of painful ulceration or gangrene in the absence of other disease of the extremity, (4) abnormally slow return of color after blanching, (5) excessive coldness of an extremity when accompanied by atrophic changes in the skin, or (6) evidence of collateral circulation at the femoral artery.

Hypertensive heart disease was diagnosed if (1) the systolic pressure was 160 and/or the diastolic pressure was 100 mm Hg, (2) there was at least grade 1 retinopathy, and (3) there was cardiac enlargement as evidenced by the ECG or physical examination.

Stroke was diagnosed if there was a clear history of cerebral dysfunction (1) compatible with occlusive or hemorrhagic involvement of one or more neck or intracranial arteries, (2) occurring suddenly, (3) lasting for at least 24 hr, and (4) showing some improvement after the time of maximum involvement unless death occurred early.

The Follow-up

Each subject not diagnosed as having CVA at his initial examination was followed until a stroke or demise occurred or through March, 1970, when the follow-up phase of the study ended. The primary purpose of the follow-up was to identify those individuals who developed new strokes or transient ischemic attacks. Several procedures were used to achieve this purpose. All subjects were visited biannually by field workers trained to observe signs of CVA and to administer a standard questionnaire about symptoms of CVA and TIA. Data from these completed evaluations were mailed daily to the central office, where they were evaluated by the research supervisor who had been trained to compare current with past results and to apply consistently certain criteria for selecting subjects for follow-up examination by a neurologist. The supervisor's decisions were regularly checked by the neurological consultant (H.K.) to ensure that they agreed with his own. So long as the information was negative for the possibility of CVA or TIA, the participant was reevaluated at his next biannual examination. Data suggesting the possibility of CVA or TIA led to a follow-up physician's examination. Early in the study, these examinations were done in the subject's home. Later, subjects were examined in a special follow-up clinic at the University of Illinois Hospital where, as in the home, they were examined by a board-certified neurologist or a senior resident in neurology.

Another source of information about morbidity and

mortality in this cohort came from the Cook County Hospital, where the great majority of hospitalizations in this population occurred. Located directly across the street from the investigators, this hospital provided a daily list of all its admissions. Possible cases of CVA or TIA were brought to the attention of the neurologist for further workup. Diagnostic procedures such as angiography or lumbar puncture were suggested by the neurologist if they had not already been done, but no such procedures were performed on patients solely because of their participation in this study.

All diagnostic decisions were made by a neurologist according to criteria established at the beginning of the study. For living subjects, the decisions were based on examinations conducted by a neurologist or his senior resident. For deceased subjects, the diagnostic decisions were based upon the best available data—medical and hospital records, death certificates, or coroner's examinations. Whenever sufficient data were available, differentiation was made between brain infarction and hemorrhage.

Results

The disposition of subjects initially examined is shown in Figure 1. The total number of subjects examined, 3141, is 66 per cent of the target population. The reasons for nonparticipation are: could not be located, 9 per cent; refusal to participate, 19 per cent; and death between selection and initial contact, 6 per cent.

Information about the cohort's place of birth, years of education, marital status, and living arrangements have been published elsewhere, as have tabulations of the prevalence of major chronic illness at the initial examination.[8]

The distribution of subjects free of CVA at the initial examination and followed until new stroke, demise, or the end of the program is shown in Table 1. One of the major substantive questions of the research was whether potential risk factors for stroke, such as high blood pressure, operated to induce stroke in subjects without any evidence of cardiac or vascular disease. To evaluate this possibility, the total population at risk for stroke was divided into populations A and B. Population A consists of all persons with clinical heart disease, transient ischemic attacks, peripheral atherosclerosis, intermittent claudication, definite ECG abnormalities, histories of diabetes mellitus, blood urea nitrogen of 30 mg per dl, and health status rated as gravely ill. Population B consists of all persons without any one of these conditions.

Table 2 shows the cumulative frequency distribution of months of follow-up after the initial examination. The median length of follow-up is 32.1 months.

One hundred ninety-eight new strokes developed

TABLE 10—Three-Year Incidence of Stroke, by Level of Systolic Blood Pressure at Initial Examination, Chicago Stroke Study, September, 1965, to March, 1970*

		All Strokes			Class I Strokes Only		
Quintiles	Subjects	Strokes	Rate/ 1000	S.E.	Strokes	Rate/ 1000	S.E.
All subjects							
1	482	26	58	12	16	30	7
2	599	27	51	10	15	30	8
3	564	34	68	12	24	49	10
4	514	31	67	13	24	56	13
5	557	66	134	16	45	94	14
All	2716	184	75	6	124	52	5
Population A only							
1	245	15	63	16	10	38	12
2	326	16	56	14	8	29	11
3	327	22	74	16	14	51	14
4	320	23	86	21	18	73	20
5	407	58	158	20	39	110	18
All	1625	134	90	8	89	61	7
Population B only							
1	237	11	51	17	6	20	8
2	273	11	47	14	7	32	12
3	237	12	53	15	10	42	13
4	194	8	50	18	6	42	17
5	150	8	56	19	6	45	18
All	1091	50	54	8	35	39	7

* Thirty-two subjects (three strokes) omitted because of missing data.

TABLE 11—Three-Year Incidence of Stroke, by Level of Diastolic Blood Pressure at Initial Examination, Chicago Stroke Study, September, 1965, to March, 1970*

		All Strokes			Class I Strokes Only		
Quintiles	Subjects	Strokes	Rate/ 1000	S.E.	Strokes	Rate/ 1000	S.E.
All subjects							
1	534	28	57	11	12	28	8
2	529	32	65	13	22	45	11
3	646	43	75	11	31	57	10
4	444	30	91	17	21	67	16
5	563	51	95	14	38	73	12
All	2716	184	75	6	124	52	5
Population A only							
1	311	20	65	15	8	32	12
2	306	21	76	19	16	59	18
3	365	28	88	16	19	65	15
4	262	22	109	24	14	73	21
5	381	43	115	18	32	88	16
All	1625	134	90	8	89	61	7
Population B only							
1	223	8	49	19	4	20	10
2	223	11	67	22	6	39	17
3	281	15	60	15	12	50	14
4	182	8	66	24	7	61	23
5	182	8	44	15	6	34	14
All	1091	50	54	8	35	39	7

* Rates of incidence and their standard errors were computed by life table methods, and have been adjusted by giving equal weight to each of the eight sex-race-age-specific estimates. Thirty-two subjects (three strokes) omitted because of missing data.

TABLE 12—Three-Year Incidence of Stroke, by Level of Serum Cholesterol* at Initial Examination, Chicago Stroke Study, September, 1965, to March, 1970

Quintiles	Subjects	All Strokes: Strokes	All Strokes: Rate/1000	All Strokes: S.E.	Class I Strokes Only: Strokes	Class I Strokes Only: Rate/1000	Class I Strokes Only: S.E.
All subjects							
1	472	33	73	13	19	46	12
2	520	36	78	13	26	55	11
3	474	21	56	13	11	33	10
4	483	36	81	14	28	64	12
5	463	30	69	13	20	46	10
All	2412	156	72	6	104	49	5
Population A only							
1	282	21	75	19	12	46	16
2	300	26	99	19	19	69	16
3	281	14	57	15	7	33	13
4	275	28	105	19	23	89	18
5	290	24	88	18	14	52	15
All	1428	113	86	8	75	59	7
Population B only							
1	190	12	65	18	7	40	14
2	220	10	53	16	7	39	14
3	193	7	60	22	4	32	15
4	208	8	47	17	5	30	14
5	173	6	39	16	6	39	16
All	984	43	52	8	29	36	7

* Serum lipid determinations were not performed on all subjects. See text.

during the follow-up period. In 136 cases, there was a clear history with confirming signs, in six a clear history without confirming signs, in 16, a less than clear history with confirming signs at examination, in 11, signs only,* and in 29, a death certificate only. When the designation Class I strokes occurs in this paper, it refers to those strokes with both a clear history and confirming signs at follow-up examination.

Table 3 shows the distribution of cases of stroke by presumed clinical category and Table 4 shows the distribution of cases by vascular system involved in first stroke. In most instances the vascular system involved was determined solely on the basis of clinical evidence. Postmortem examination of the brain was obtained in only six cases.

Table 5 shows the 3-year incidence of stroke by sex, race, and age. Incidence rates and their standard errors have been computed by life table procedures. When indicated, these estimates have been adjusted for sex, race, and age to the 1960 U.S. population. The substantially higher incidence of strokes in blacks in each group is noteworthy. Stroke incidence was also higher at ages 70 to 74 for each race and sex category than at 65 to 69; for all categories, it rose from 41 per 1000 to 83 per 1000.

* Because the precise time of onset of these 11 strokes is not known, they have not been included in determinations of incidence.

Table 6 indicates the 3-year incidence of stroke by history of diabetes and reported mode of treatment. The incidence of stroke is significantly higher ($p < 0.05$) among those with a positive history of diabetes than those without a history of diabetes both for all strokes and Class I strokes only.

In Table 7, the 3-year incidence of stroke by diagnostic category of heart disease at initial examination is shown. Subjects with hypertensive heart disease, but not CHD or other heart disease, were at substantially and significantly higher risk of developing stroke ($p < 0.05$) than those free of heart disease. Table 8 depicts the 3-year stroke incidence by diagnosis of peripheral vascular disease. For both all strokes and Class I strokes, there was a significantly higher incidence ($p < 0.05$) among persons with peripheral atherosclerosis. Table 9 demonstrates the absence of association between reported cigarette smoking and stroke incidence. The lack of association holds for both all strokes and Class I strokes and for all subjects and those with and without major illness at the start of the study.

Continuously distributed variables were divided into quintiles to evaluate the relationship between their levels and stroke incidence. The relationship between stroke incidence and systolic blood pressure quintiles is shown in Table 10; between stroke incidence and diastolic pressure in

TABLE 13—Three-Year Incidence of Stroke, by Level of Plasma Glucose at First Examination, Persons Denying History of Diabetes Mellitus, Chicago Stroke Study, September, 1965, to March, 1970*

Quintiles	Subjects	All Strokes: Strokes	All Strokes: Rate/1000	All Strokes: S.E.	Class I Strokes Only: Strokes	Class I Strokes Only: Rate/1000	Class I Strokes Only: S.E.
All subjects							
1	432	22	59	13	15	41	11
2	415	27	72	14	15	41	11
3	431	27	73	14	18	52	13
4	435	29	71	13	23	57	12
5	445	22	59	13	14	39	11
All	2158	127	67	6	85	47	5
Population A only							
1	199	11	61	18	6	35	15
2	205	17	81	19	11	54	16
3	216	16	94	25	11	72	23
4	240	16	64	16	13	54	15
5	231	17	85	22	9	52	19
All	1091	77	79	9	50	55	8
Population B only							
1	233	11	55	17	9	47	16
2	210	10	58	18	4	25	12
3	215	11	55	16	7	36	13
4	195	13	78	21	10	59	18
5	214	5	29	13	5	29	13
All	1067	50	56	8	35	40	7

* There were 590 subjects (60 strokes) omitted, 524 (50 strokes) because they had a history of diabetes mellitus at initial examination, and 66 (four strokes) because of missing data.

Table 11; between stroke incidence and serum cholesterol in Table 12; between stroke incidence and plasma glucose in Table 13; and between stroke incidence and ponderal index in Table 14. Table 15 depicts the results of testing for linear trends in incidence rates of stroke within the quintiles based on distributions of systolic and diastolic blood pressure, serum cholesterol, plasma glucose, cigarette smoking, and ponderal index. The procedure is described in Snedecor and Cochran's statistical methods.[9] Table 15 indicates that the slopes of the relationship between stroke incidence on the one hand and systolic pressure, diastolic pressure, and ponderal index on the other hand differ significantly from 0, both for all subjects and for population A (the ill group). No such relationship exists between stroke incidence and serum cholesterol, plasma glucose, and cigarette smoking for population A. No significant relationships of any kind exist among population B.

Discussion

These data make tenable several inferences about stroke incidence in this population. Stroke incidence was higher among blacks than whites and higher at ages 70 to 74 than at ages 65 to 69. Strokes occurred significantly more often in those with transient ischemic attacks,[10] peripheral vascular disease, and hypertensive heart disease than in those without these diagnoses. The risk of stroke increases significantly with increasing levels of systolic and diastolic pressure and decreases significantly with increasing ponderal increase. These relationships hold both for the

TABLE 14—Three-Year Incidence of Stroke, by Level of Ponderal Index at Initial Examination, Chicago Stroke Study, September, 1965, to March, 1970*

		All Strokes			Class I Strokes Only		
Quintiles	Subjects	Strokes	Rate/ 1000	S.E.	Strokes	Rate/ 1000	S.E.
All subjects							
1	508	35	72	12	25	53	11
2	502	39	95	15	30	74	14
3	493	35	74	12	23	51	11
4	498	32	69	12	22	47	10
5	508	23	45	10	16	33	10
All	2509	164	72	6	116	52	5
Population A only							
1	318	29	90	17	20	63	14
2	301	25	103	21	20	86	20
3	290	23	81	17	18	67	16
4	308	25	81	16	16	52	13
5	286	15	52	14	10	34	12
All	1503	117	83	8	84	61	7
Population B only							
1	190	6	40	17	5	35	16
2	201	14	85	22	10	61	19
3	203	12	73	21	5	33	16
4	190	7	45	16	6	36	14
5	222	8	39	14	6	32	13
All	1006	47	55	8	32	39	7

* There were 239 subjects (23 strokes) omitted because of missing data.

TABLE 15—Tests of Linear Trends in Incidence Rates of Stroke, Chicago Stroke Study, September, 1965, to March, 1970

	All Subjects		Population A Only		Population B Only	
Statistic*	All strokes	Class I only	All strokes	Class I only	All strokes	Class I only
Ponderal index						
Slope	−8.0	−6.7	−9.6	−8.9	−4.6	−3.2
Standard deviate	2.21	2.15	1.92	2.06	0.90	0.75
Plasma glucose						
Slope	−0.1	1.1	2.8	3.1	−3.3	−0.5
Standard deviate	0.03	0.36	0.49	0.69	0.68	0.13
Serum cholesterol						
Slope	−0.5	0.9	3.0	3.0	−5.7	−1.3
Standard deviate	0.14	0.28	0.58	0.68	1.09	0.30
Diastolic blood pressure						
Slope	10.1	11.1	13.1	12.6	−0.8	5.4
Standard deviate	2.78	3.61	2.64	2.99	0.16	1.23
Systolic blood pressure						
Slope	17.5	15.8	24.3	20.2	1.2	6.3
Standard deviate	4.81	5.17	4.87	4.80	0.24	1.49
Cigarette smoking						
Slope	−1.0	−1.3	−5.9	−6.3	4.2	3.4
Standard deviate	−.23	0.37	0.96	1.27	0.71	0.66

* Standard deviate 1.645 are associated with $p < 0.05$.

entire population and for the ill group only. It is essential, in this connection, to recall that ponderal index is inversely related to body ponderosity. No association between stroke incidence and serum cholesterol or cigarette smoking was demonstrated.

The absence of any statistically significant relations between levels of potential risk factors and stroke incidence in the initially well population is striking. The data suggest that by the time hypertensive people have reached age 65, those with some target organ damage are suceptible to more target organ damage, i.e., stroke, and those without it are less susceptible to stroke.

In one sense, such abnormalities as TIA and peripheral vascular disease are not risk factors for stroke. They are more properly evidence of atherosclerosis occurring concomitantly with CVA and implying that when fatty plaques are present in the legs they are also likely to be in the neck and head.

What implications do these data have for programs of stroke prevention in this age group? Clearly, little is to be gained by lowering serum cholesterol or reducing cigarette smoking, two procedures which are likely to reduce CHD incidence in younger persons. Would it do any good to reduce blood pressure and rigorously control diabetes? The data are not conclusive but suggest certain inferences. It may be desirable to lower blood pressure among those with higher pressures and other evidence of cardiovascular disease, but not in those without the latter. In this cohort, untreated diabetes and those receiving insulin had a higher stroke incidence than the diabetics receiving diet or oral agents. An obvious inference is that mild diabetics have fewer strokes than more severe ones, and that the underlying character of the disease, rather than success of treatment, influences stroke incidence. The evidence that ponderal index is inversely related to stroke incidence suggests that weight reduction may be helpful but provides no assurance that such action would be beneficial.

Even though no risk factors for stroke were discernible in population B, strokes still occurred in that group. The operation of unidentified risk factors comes to mind.

These findings suggest that hypertension in those with target organ damage is a risk factor for stroke and in those without such damage is not a risk factor. These observations may have implications for primary prevention of atherosclerotic disease and indicate the need for more knowledge about the natural history of hypertension.

Summary

The data signify that even in the elderly, the stroke-prone persons can be identified. In this cohort, risk of stroke is higher among blacks, the older, and those with preexisting cardiovascular disease manifested as TIA, peripheral vascular disease, diabetes, and hypertensive heart disease. Among those with preexisting cardiac and vascular disease, systolic and diastolic pressures and ponderal index were significantly related to risk of stroke. Among the group free of preexisting disease, no gradient of risk could be demonstrated with any variable measured.

References

1. Kurtzke, J. F. Epidemiology of Cerebrovascular Disease. Springer-Verlag, New York, 1969.
2. Kannel, W. B. Epidemiology of Stroke. PHS publication no. 1607. U.S. Government Printing Office, Washington, DC, 1967.
3. Kannel, W. B., Dawber, T. R., and McNamara, P. Epidemiologic Assessment of the Role of Blood Pressure in Stroke: The Framingham Study. J. A. M. A. 214: 301—310, 1970.
4. U.S. Veterans Administration Cooperative Study Group on Antihypertensive Agents: Effects of Treatment on Morbidity in Hypertension. Results in Patients with Diastolic Blood Pressures Averaging 115 through 129 mm Hg. J. A. M. A. 202:1028—1034, 1967.
5. U.S. Veterans Administration Cooperative Study Group on Antihypertensive Agents: Effects of Treatment on Morbidity in Hypertension. II. Results in Patients with Diastolic Blood Pressures Averaging 90 through 114 mg Hg. J. A. M. A. 213:1143—1152, 1970.
6. Kannel, W. B. Current Status of the Epidemiology of Brain Infarction Associated with Occlusive Arterial Disease. Stroke 2:295—318, 1971.
7. Gordon, T., and Garst, C. C. Coronary Heart Disease in Adults, United States, 1960—1962. PHS publication no. 1000, Ser. 11, No. 10. U.S. Government Printing Office, Washington, DC, 1965.
8. Ostfeld, A. M., Shekelle, R. B., Tufo, H. M., Wieland, A. M., Kilbridge, J. A., Drori, J., and Klawans, H. Cardiovascular and Cerebrovascular Disease in an Elderly Poor Urban Population. Am. J. Public Health 61:19—29, 1971.
9. Snedecor, G., and Cochran, W. Statistical Methods, Ed. 6. Iowa State University Press, Ames, 1967.
10. Ostfeld, A. M., Shekelle, R. B., and Klawans, H. Transient Ischemic Attacks and Risk of Stroke in an Elderly Poor Population. Stroke 4:980—986, 1973.