THE FRAMINGHAM STUDY

An Epidemiological Investigation of Cardiovasculara Disease

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Section 36: Means at Each Examination and Inter-Examination Consistency of Specified Characteristics: Framingham Heart Study, 30-year Followup

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MEANS AT EACH EXAMINATION AND INTER-EXAMINATION CONSISTENCY OF SPECIFIED CHARACTERISTICS:

Framingham study, Exam 1 to Exam 16

Biennial examination of a sample of the adult population of Framingham, Massachusetts, aged 28 to 62, began in September 1948. Four years later, 5,209 persons had received their first examination. This sample continues to be studied on biennial examinations. This report presents data for fifteen subsequent biennial examinations (i.e., through Exam 16). considerable information has been collected about the characteristics of the participants. This report, like most previous sections of this series, presents characteristics measured on many of the successive biennial examinations.

Sections 1 and 2 of this monograph series described the design and execution of the Study. Section 29 reported mean values for some characteristics determined at examination for Exam 1 to Exam 10. This section is an update of Section 29. Mean values for most of the same characteristics, and for some additional ones, are extended through Exam 16, yielding a description of group mean changes over time. Also included is material showing for selected variables the extent to which an individual's values of a characteristic are related from one examination to another.

DESCRIPTION OF TABLES

The tables in this report present data for 21 characteristics. The characteristics and the index numbers employed henceforth to identify the variables are:

1A	Blood pressure, first examiner, systolic (mm Hg)
1B	As above, excluding subjects taking anti-hypertensive drugs at exam
2A	Blood pressure, first examiner, diastolic (mm Hg)
2B	As above, excluding subjects taking anti-hypertensive drugs at exam
3A	Elevated blood pressure, definite
3B	Hypertension, definite
4	Total serum cholesterol (mg/100 ml)
5	Hematocrit (percent)
6	Blood glucose (mg/100 ml)
7	Diabetes mellitus
a	Urine glucose, definite or trace
9	Glucose intolerance
10	Metropolitan relative weight (percent)
11	Vital capacity (deciliters)
12	Pulse rate (per minute)
13A	Smoking cigarettes
13B	Cigarettes smoked by cigarette smokers (number per day)
13c	smoking any kind of tobacco
14	Heart enlargement by X-ray, definite
15	Left ventricular, hypertrophy by electrocardiogram, definite
16	Nonspecific T-wave or ST-segment abnormality by electrocardiogram, definite

There are two types of tables, designated by the letters A and B. The A-tables give the mean values of the characteristic for all subjects attending that exam. The A-tables can be viewed as having two halves, upper and lower. In the upper half, data are given for five-year age groups based on age at initial examination. This is a cohort description of the study. The lower half contains analogous data for five-year age groups based on the age of the subjects at that particular exam. This is a cross-sectional

description of the data. The mean values 'presented are the sum of the observed values divided by the number of subjects supplying these values. For dichotomous variables, the percentage of subjects with the characteristic is presented. The number of subjects for which data 'were available are listed directly below the means or percentages. Asterisks appear where there were no subjects in a particular age category at an exam, or if data for that characteristic were not collected at that exam.

The B-tables summarize the relation of the values of a 'characteristic observed at each exam to the values observed at each subsequent exam. For the characteristics with continuous values, the relation for each distinct pair of exams is quantified by calculating a) the Pearson product-moment correlation coefficient (labelled CORR), b) the coefficients of a simple linear regression using the initial measure as a predictor of the subsequent measure (labelled INTERCEPT and SLOPE), and c) the standard error of estimate (the standard deviation of the residuals from the estimated regression, labelled SE EST). For the dichotomous characteristics, the relation is evaluated as a fourfold table:

		Characteristic at exam	
		Present	Absent
Characteristic at subsequent exam	Present	a	b
	Absent	c	d

The percent agreement (labelled % AGREE) is 100*a/(a+c) for characteristic present at prior exam, and 100*d/(b+d) for characteristic absent at prior exam.

Asterisks appear in a B-table when the characteristic of interest was not measured on both of the pair of exams. Only those subjects that attended both of the pair of exams are included in any computation.

Numbering scheme for tables

The numbering scheme for the tables puts the type of table first (A or B), then the index number of the characteristic, and finally an indication of whether the table is for males or females (M or F). For example, table A-13A-M displays the percent of males who smoke cigarettes over time.

DESCRIPTION OF CHARACTERISTICS

For each of the sixteen examinations, every subject taking that exam had a blood pressure measurement taken by the first physician. Hence the tables for blood pressure (characteristics 1A and 2A) account for all subjects attending the exam. Diabetes mellitus is the only other characteristic available for all subjects taking each exam.

For some of the characteristics, determinations were omitted at some examinations. Even when the measurement was intended to be made, missing values sometimes occurred. The extent of missing values is indicated in Table 1, and additional details may be found in the description of specific characteristics. Missing values here refer to the number missing out of the total number attending the exam.

Table 1 Missing values

Males

Exam Char. #	1	2	3	4	5	6	7	a	9	10	11	12	13	14	15	16
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3A	0	0	0	0	0	0	0	0	0	0	0	0	8	8	9	a
3B	0	0	0	0	0	98	0	0	0	0	414	4	10	a	7	12
4	a34	53	60	46	34	39	24	23	37	111	*	*	32	16	18	*
5	*	*	*	131	68	94	72	94	94	83	622	59	35	24	35	36
6	49.2	89	181	167	*	142	*	233	92	385	*	42	86	19	17	39
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	46	23	18	23	17	49	74	74	74	62	619	*	*	18	44	*
9	0	0	0	0	0	0	0	0	0	0	*	*	64	2	15	*
10	2	4	7	3	2	2	6	5	3	7	3	1	6	9	10	9
11	29	28	14	12	5	8	20	31	30	28	600	10	13	16	21	16
12	0	*	*	1	5	0	1	0	0		0.0	0	1	0	3	0
13A	19	*	*	51	3	*	9	0	2	4	577	4	1	2	2	*
13B	1	*	*	0	2	*	7	0	2	3	1	4	1	1	1	*
13C	18	*	*	51	1	*	2	0	0	1	576	0	0	1	1	*
14	12	7	14	5	3	2	3	9	22	22	603	*	*	239	391	*
15	0	1	0	0	1	0	0	0	0	0	0	1	1	4	5	3
16	0	1	0	0	1	0	0	0	0	0	0	0	2	2	3	1

Females

Exam Char. #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3A	0	0	0	0	0	0	0	0	0	0	0	0	11	28	45	27
3B	0	0	0	0	0	127	0	0	0	0	530	7	16	20	24	24
4	1203	156	201	179	156	158	133	115	98	190	*	*	90	50	64	*
5	*	*	*	294	201	236	230	230	199	153	794	155	97	63	84	94
6	720	178	319	341	*	299	*	386	163	519	*	133	143	59	66	90
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
a	44	50	72	47	41	58	83	71	71	77	791	*	*	45	121	*
9	0	0	0	0	0	0	0	0	0	0	*	*	103	50	94	*
10	4	la	9	8	12	7	10	10	5	8	19	2	4	28	47	30
11	23	45	24	25	18	9	32	36	35	38	762	6	10	51	a5	47
12	0	*	*	3	1	2	2	2	2	1	10	0	0	2	5	3
13A	17	*	*	15	19	*	12	0	1	2	740	3	1	3	3	*
13B	2	*	*	0	12	*	a	0	12		3	3	0	0	1	*
13C	15	*	*	15	7	*	4	0	0	0	737	0	1	3	2	*
14	19	9	14	11	13	11	10	16	30	38	772	*	*	330	640	*
15	0	1	0	1	0	0	1	2	2	1	10	3	2	3	a	7
16	0	1	0	1	0	0	1	2	2	1	11	3	2	4	7	5

***** - Characteristic not measured at exam

Missing values are the number missing out of the total number attending the exam.

How the characteristics were determined is described in detail in the following.

1 Blood pressure, first examiner, systolic (mm Hg)

2 Blood pressure, first examiner, diastolic (mm Hg)

systolic and diastolic readings in the left arm of the subject were taken with a mercurial sphygmomanometer and a 14-cm cuff long enough to fit the most obese arm. The recommendations of the American and British Heart Associations were followed for reading the pressure (see Standardization of Blood Pressure Readings, *American Heart Journal,* July 1939, 18:95). Palpatory method was used to check auscultatory systolic readings. Measurement was expressed in millimeters of mercury on the scale of the manometer. Although the original protocol did not specify the accuracy of the measurement to be employed, most readings were made to the nearest even number. After Exam 5 this became the standard practice.

At the beginning of the Study two readings were taken on each subject: 1) admission blood pressure taken by the nurse and 2) final blood pressure taken by the examining physician. Beginning in April 1950 three readings were taken on each subject: 1) admission blood pressure taken by the nurse, *2)* blood pressure taken by the first examining physician at the start of his interview, and 3) another blood pressure taken at the end of the examination by a second physician after drawing blood. All of these pressures were taken on the left arm with the subject seated and the arm at

heart level. In coding blood pressure at Exam 1 for subjects through record number 2938, the nurse's blood pressure is used as the reading by the first examining physician.

3A Elevated blood pressure, definite

3B Hypertension, definite

At examination, a subject had two blood pressure readings taken by the examining physician(s). A blood pressure reading was "abnormal" if either the systolic or the diastolic component was "abnormal". The reading was "normal" if both systolic and diastolic parts were "normal". A systolic pressure was called "normal" when under 140 mm Hg, "abnormal" when 160 or greater. A diastolic pressure was called "normal" when under 90 mm Hg, "abnormal" when 95 or greater. If both readings were "abnormal" the subject had definite elevated blood pressure, i.e. if both of the following conditions held:

1. the first systolic pressure was 160 or greater or the first diastolic pressure was 95 or greater

and

2. the second systolic pressure was 160 or greater or the second diastolic pressure was 95 or greater.

Definite hypertension is defined to include all those with definite elevated blood pressure as well as anyone on anti-hypertensive treatment.

When on rare occasion a subject had only one blood pressure reading taken by the examining physician, hypertensive status was determined on the basis of this one reading.

4 Total serum cholesterol (mg/100 ml)

At the beginning of the Study, serum cholesterol concentrations were determined by the colorimetric method of Sperry (Schoenheimer and Sperry: *J Biol Chem* 106, 745, 1934. Sperry: Am *J Clin Path & Tech Supplement 2, 91,* 1938). On December 12, 1952 after the start of Exam 2, the method of Abell-Kendall was adopted (Abell, Levy, Brodie, and Kendall, *J Biol Chem* 195, 357-366, 1952). Serum cholesterol was not measured on Exams 11, 12, and 16.

5 Hematocrit (percent)

Blood was collected in a balanced oxalate tube and spun at 5000 rpm for 20 minutes. Hematocrit was read in the tube against a special scale constructed for this purpose. This method proved more reliable than the standard capillary method. On exams 1 to 3, hemoglobin was measured instead of hematocrit. Section 4 of this monograph series contains mean values of hemoglobin for the initial examinations.

6 Blood glucose (mg/100 ml)

The amount of glucose present in a casual specimen of the subject's whole blood (collected in a solution of potassium oxalate and sodium fluoride) was determined using the method of Nelson (Nelson, *J Biol Chem* 153, 375, 1944; Somogyi, *J Biol Chem* 160, 61, 1945). Blood glucose was not measured on Exams 5, 7 and 11.

7 Diabetes mellitus

A subject was diagnosed as having diabetes if he or she was under treatment by a private physician for diabetes or

the subject had a record of an abnormal glucose tolerance. test or had on at least two exams a casual blood glucose determination of 150 mg/100 ml or more.

Treatment by private physician meant that the subject was taking insulin or oral hypoglycemic agents. In addition, if the subject was taking oral agents, the diagnosis of diabetes was made only if records from the Framingham Study, private physician, or hospital showed several elevated blood glucose determinations before treatment started. For this purpose an elevated blood glucose meant a value of 150 mg/100 ml or higher.

The study did not give subjects glucose tolerance tests: therefore the record of such tests had to be obtained from a private physician or hospital. The standard glucose tolerance test was taken as the ingestion of 100 grams of glucose after a 12-hour fast. The test was considered abnormal if the blood glucose concentration was 160 mg/100 ml or more at one hour after challenge, 140 or more at two hours, and was still higher at three hours than when the test began.

Any subject that does not meet the above criteria is considered not diabetic. Once a subject is diagnosed as a diabetic, it is assumed that the person is diabetic at all subsequent exams attended. Thus there are no missing values for this characteristic at any exam.

8 Urine glucose, definite or trace

Procedure for testing the presence of glucose in a subject's freshly voided urine was as follows:

To five drops of urine in test tube add 10 drops of water and one Clinitest tablet. Allow to stand 15 seconds after boiling has ceased and then read promptly. Compare color to chart provided with tablets. Read as: negative, 1+, 2+, 3+, or 4+.

In coding the result of the color comparison, definite urine glucose is 2+, 3+, or 4+; trace urine glucose is 1+.

This measurement was not made on Exams 12, 13, and 16. After Exam 11, the Ames Combustix (Labstix) method was employed.

9 Glucose intolerance

A subject was said to demonstrate glucose intolerance at examination if any one of the following conditions obtained: a) a diagnosis of diabetes mellitus at that examination or any preceding examination: b) a determination. of glucose in the urine sample, either definite or trace by Clinitest or Combustix, at that examination: c) a measurement of the amount of glucose present in a casual specimen of whole blood equal to 120 milligrams or more per 100 milliliters at that examination.

10 Metropolitan relative weight (percent)

This relative weight at exam was computed for a subject by forming the ratio of body weight at that exam to the desirable weight for the particular sex-height group,

according to standards set by the Metropolitan Life Insurance company. The ratio is expressed as a whole number in percent. The reference weight, for a given sex-height group, is the midpoint of the range for medium frame shown in the table of desirable weights on page 12 of "Four Steps to Weight Control" (1969), distributed by the Metropolitan Life Insurance Company. By linear extrapolation, reference weights were assigned to those sex-height groups not covered by the Metropolitan table, women 55 inches and men 60 inches tall. since the desirable weights are shown for persons with their clothes and shoes on, adjustments are made to apply the reference weight to the subjects in the Framingham Study, who were weighed without clothes and measured for height without shoes: five pounds are subtracted from the weight for men, four pounds for women; one inch was subtracted from the height for men, two inches for women. The resulting set of reference weights is shown in Table 2.

11 Vital capacity (deciliters)

A nurse or technician instructed the subject to take the deepest breath possible and exhale to the fullest extent into the tube of a water-sealed spirometer (Collins Vitalometer). Three trials were made for each subject: the highest reading was recorded. This measurement of vital capacity was read to the next lower 0.1 liter on the scale of the spirometer.

Table, 2

Reference weight for calculation
of Metropolitan Relative Weight

Height (inches)	Weight (pounds) Males	Females
55		94
56		97
57		100
58		103
59		106
60	116	109
61	119	112
62	122	116
63	125	120
64	128	124
65	131	128
66	135	132
67	140	136
68	144	140
69	148	
70	152	
7 1	157	
72	161	
73	166	
74	170	

12 Pulse rate (per minute)

The pulse rate is the ventricular rate as determined by the physician from the electrocardiogram made with the subject in the recumbent position. Electrocardiograms were made at each exam and the ventricular rate was coded for all exams except 2 and 3.

13A smoking cigarettes

13B cigarettes smoked by cigarette smokers (number per day)

13C Smoking any kind of tobacco

Histories of smoking were obtained on every exam except Exam 6. However, information from the first three exams was coded to represent usage at Exam 1, leaving Exams 2 and 3 **uncoded.** On the initial examinations there was no fixed rule for deciding whether a person was an ex-smoker, but persons who had only recently stopped were always considered still smoking. On later examinations anyone smoking within a year was considered a current smoker. For current smokers, the number of cigarettes usually smoked each day was recorded. Additional details are given in Sections 3 and 26 of this series.

14 Heart enlargement by X-ray, definite

Roentgenograms were taken at each exam with a Westinghouse **Autoflex** 300-milliampere X-ray unit and with a **Machlett** superdynamax tube. The subject was positioned erect in max-respiration phase with full anterior chest against the film cassette. The X-ray tube was placed at level of seventh thoracic vertebra, a distance of two meters from anode to

film. The film size was 14 x 17 inches. Beginning in Exam 4 the machine was actuated by a device attached to the subject through electrodes applied to the left and right axillary margin at level of the seventh rib, to take the X-ray at the moment of full systole. (Peak of R wave plus 0.008 seconds to termination of exposure insured the shadow of the cardiac silhouette in full systole.) The transthoracic Lead I electrocardiographic tracing showing the point of X-ray exposure was printed at the top of the exposed X-ray film before development.

All films were interpreted by a roentgenology consultant who did not have access to clinical data on the subject before viewing the films. Beginning in early 1952 one consultant, Dr. Lloyd E. Hawes, viewed all films taken at the Framingham Heart Clinic and made the X-ray interpretations.

The diagnosis of left ventricular hypertrophy signified that this chamber was enlarged as shown by an extension of the left apex of the heart towards the left, an elevation of the apex and a squaring of the apex. The transverse diameter of the heart was usually more than half the transverse width of the chest. However, in a subject with a large chest the square prominent shape of the left apex of the heart may have signified left ventricular hypertrophy even with transverse diameter of the heart less than half the width of the chest. The diagnosis of left ventricular hypertrophy could be made with normal measurement of the transverse diameter of the heart.

The diagnosis of generalized cardiac enlargement was made when the heart shadow was rounded and expanded both to the right and the left, giving an appearance not of left ventricular hypertrophy alone but of either a dilatation of all chambers or a dilatation of the atria and right ventricle as in mitral heart disease.

A diagnosis of generalized cardiac enlargement and left ventricular hypertrophy was made if the heart was rounded overall and enlarged, and the apex projected further out and was square and prominent.

A subject with heart enlargement had either generalized cardiac enlargement or left ventricular hypertrophy or both.

1s Left ventricular hypertrophy by electrocardiogram, definite or possible

Electrocardiograms were taken at each exam with a Sanborn visocardiette. The subject was in the recumbent position. Thirteen leads were used, three standard, three augmented unipolar limb leads, and seven precordial leads of Wilson. (see description of technique in Katz, *Electrocardiography,* Lee and Febiger, Philadelphia, 1947, pp 31-44.)

Left ventricular hypertrophy consisted of a tracing exhibiting a slight prolongation of "ventricular activation time" (at least 0.05 seconds on the left) associated with *R-wave* potentials of at least 20 mm in standard leads, at least 11 mm in augmented unipolar leads, at least 25 mm in any deflection in precordial leads or at least 35 mm combining any V (1), V (2) S-wave deflection with R-wave deflections from V (5) or V (6). This had to be accompanied by

depressed S-T segments or flattened to inverted T waves reflecting potentials from left precordial leads.

A category of possible left ventricular hypertrophy was designated when tracings exhibited characteristics similar to those above except in less striking degree or when not all were present. Increased R-wave potential without associated S-T and T-wave abnormality was included in this category.

16 **Nonspecific** T-wave or ST-segment abnormality by **elec-**trocardiogram, definite

Nonspecific abnormality was designated in the absence of a prominent R wave when there was ST-segment depression (exceeding one millimeter below the base line) and/or primary T-wave **inversion** or flattening. This diagnosis was not made if a more specific explanation could be made for these changes (such **as** intraventricular block, myocardial infarction, or left ventricular hypertrophy) or if the changes occurred in those leads where such variation is acceptable.

TRENDS BY AGE - THE A-TABLES AND FIGURES

The A-tables given in this report contain mean values **by** age, sex, and exam. They may be used to assess sex differences, age differences, and the effects of aging. Affecting these values are changes in measurement techniques, generation differences, and secular trends. The effects of all these latter forces are so intermingled that there is no completely satisfactory method for disentangling them.

In order to portray the information in the tables in graphic form, two methods of summarizing the data have been used. These methods were influenced by, but are different from, the techniques used to generate the graphs in Section 29.

One of the methods employed to illustrate the relation with increasing age was a cross-sectional approach. This method uses data from the lower half of the A-tables. The mean values obtained at each exam for a particular age group (e.g., 40-44) are themselves averaged across exams, weighted by the sample size from which they were determined. This procedure produces an average of all the observations in a particular age group, regardless of the exam on which they were measured. This procedure is followed for each five-year age group, producing one mean value per age group. Equivalently, one could view this process as a weighted average of the cross-sectional distributions obtained at each exam. These means are then plotted against the midpoint of the five-year age range in the figures labelled "Figure CS-##" (where ## stands for the characteristic numbers described previously). It should be noted that due to the aging of the population, mean values for young ages tend to come from earlier exams, while mean values for the older ages come from later exams. Thus, where there have been secular trends in these factors in the more than thirty years of the study, these averaged cross-sections may not represent what would be observed in a similar cross-section at present.

Another way of assessing what happens with increasing age is to examine the mean values for each five-year age cohort, defined by age at Exam 1, as it grows older. Instead of attempting to synthesize these curves, as was done in the previous monograph, the actual average values observed for each cohort are graphed, using the data that appears at the top of the A-tables. Thus in each graph labelled "COH-##" (where ## stands for the characteristic numbers described previously) there appears six curves plotting the observed means for each cohort at each exam, versus the median age of the cohort at, that time. Graphs for males and females appear side by side to allow comparisons between the sexes. The cohort aged 60-64 at exam one has been excluded from the graphs due to its small size.

systolic blood pressure

The interpretation of mean blood pressure values over time is complicated by the introduction and increasing use of anti-hypertensive treatment over the follow-up period. The percentages of men and women under treatment are shown in Table 3. It can be assumed that as each cohort grew older the observed mean level was being progressively pulled downward by treatment. In addition to including the mean values calculated on all subjects (Tables A-1A), results excluding those on treatment at that examination (Tables A-1B) have been presented. The mean pressures for untreated subjects are lower than for the overall group. This implies both that those with higher pressures are more likely to be treated,

Table 3 Percent on anti-hypertensive treatment

Males

Exam	4	5	6	7	8	9	10	11	12	13	14	15	16
Age at exam													
35-39	0.0	0.0	0.0										
40-44	0.9	1.5	2.0	1.3	0.0	0.0							
45-49	1.4	1.6	3.4	3.0	3.7	4.9	2.6	0.0					
50-54	0.0	0.5	1.9	5.2	4.9	6.3	6.6	7.2	9.5	9.1			
55-59	1.0	0.8	3.7	4.7	5.3	6.9	9.1	14.2	11.5	16.2	18.6	17.7	0.0
60-64	1.7	3.9	5.3	3.6	7.3	8.1	9.5	12.1	15.5	21.6	24.3	25.1	29.3
65-69		10.0	5.3	4.4	2.2	8.0	10.3	18.7	13.2	21.5	29.7	29.7	31.7
70-74				0.0	4.2	2.0	4.5	16.3	19.6	21.1	21.8	30.4	35.3
75-79							5.9	0.0	10.4	21.8	32.0	37.8	32.5
80-84									0.0	17.4	21.3	28.8	36.5
85-89											0.0	41.7	10.7

Females

Exam	4	5	6	7	8	9	10	11	12	13	14	15	16
Age at exam													
35-39	1.9	0.0	0.0										
40-44	1.3	1.4	1.8	4.3	2.0	0.0							
45-49	1.3	1.8	4.1	5.2	5.1	5.4	4.0	0.0					
50-54	2.4	5.9	6.5	7.9	10.5	9.3	8.2	8.5	9.7	12.9			
55-59	5.9	10.2	10.0	11.6	10.2	9.4	11.2	18.0	16.3	19.5	24.1	24.7	50.0
60-64	6.8	6.3	13.6	12.6	12.2	15.5	19.2	16.4	18.7	23.0	27.6	31.3	32.6
65-69	9.1	12.2	13.0	18.8	16.8	16.2	20.4	26.6	25.9	33.2	33.2	34.8	41.4
70-74			0.0	17.2	22.9	18.3	19.7	21.7	30.3	34.4	44.7	44.3	43.0
75-79						55.6	10.4	22.7	28.9	33.5	45.3	44.6	49.3
80-84									14.8	23.1	42.3	45.0	50.4
85-89											27.3	42.5	50.0

and that this treatment has not brought pressure down to the level of the rest of the population.

From Exam 1 to 3 the mean blood pressure values for each cohort decrease, after which they tend to increase until the later exams. This initial elevation has been felt to be caused by anxiety during the first few examinations, which tended to decrease once the subjects became familiar with the procedures. Due to this, graphs for both systolic and diastolic blood pressure have been constructed using data beginning at Exam 3 in order to reduce this potential source of variation. In the 9 exams (approximately 18 years) following Exam 3 the average systolic blood pressure rose steadily for each cohort (defined by age at Exam 1) with few exceptions. After Exam 12 there seems to be evidence of slight declines in pressure, both including and excluding subjects who are treated.

The cross-sectional curves for all subjects, treated and untreated, (Figure CS-1A) show a much steeper gradient for women than men. The pressures of both men and women look like they may be leveling off past age 70. The curves excluding those on treatment at exam would have much the same shape, with slightly lower levels for higher ages.

The cohort curves (Figures COH-1A) for systolic pressure in women show an interesting pattern. The values are displaced successively lower at comparable ages for each younger cohort. This could be taken as evidence of a secular

trend. Also of interest is that this pattern is not at all evident for men.

Diastolic blood pressure

The same comments made about the effect of anti-hypertensive treatment on systolic pressure would be appropriate here. The same sequence of tables, omitting those treated, is included. After the same initial decrease over the first few exams, mean values for the cohorts all seem to peak around the middle exams, followed by a rather pronounced decline. The cross-sectional curves for men and women (Figure CS-2A) show men's pressures increasing slightly to age 55, followed by a steep decline, while women's pressures begin much lower, increase steeply to age 60, after which they decline at about the same rate as the men. Again, the curves for untreated subjects would have essentially the same shape.

Cohort curves for diastolic pressure (Figures COH-2A) again show no discernible trend for men, while the curves for women are lower for the younger cohorts at comparable ages.

Elevated blood *pressure* and hypertension

Trends in the prevalence of elevated blood pressure (as defined previously) are related to the trends for systolic and diastolic blood pressure. Inspection of the percentages over time (Tables A-3A) show a marked decrease over the later exams. This is probably largely due to the decrease in diastolic pressure noted above.

Tables A-3B, which include as hypertensive all subjects on anti-hypertensive treatment regardless of their actual blood pressure, show a different pattern. Hypertension by this criteria increases consistently with age, with an indication of levelling off around age 70. The difference between the two sets of tables indicates that treatment is having a noticeable effect on pressure levels.

serum cholesterol

cross-sectional curves indicate that serum cholesterol levels rise gradually in men to age 50 and rise steeply in women to age 65, then decrease steadily at older ages in both sexes (Figure CS-4). Cohort curves (Figures COH-4) emphasize the tendency in the data for the mean values to increase to a peak at Exam 7, followed by a sharp decline. It is not possible to ascertain how much of this trend might be due to measurement bias and how much might be due to a real secular trend. If the large variations here are solely due to measurement error, it may make the averaging of the data into cross-sectional curves invalid.

Hematocrit

For cross-sectional data in men, hematocrit levels decrease irregularly with age. For women they increase until age 65 after which they may be stabilizing (Figure CS-5). Cohort curves show the same general trends with no obvious pattern of cohort differences (Figures COH-5).

Blood glucose

Blood glucose levels rise more or less uniformly with age for both men and women (Tables 6-A). There seems to have been a substantial shift in measurement technique beginning with Exam 10 which makes comparisons over time difficult.

Diabetes mellitus

cross-sectional data show a steadily increasing prevalence of diabetes mellitus with age in both sexes (Figure cs-7). Rates for men are almost uniformly higher than for women at all ages. Cohort **curves** show the same general pattern of increase with age (Figures COH-7). There are **no** obvious cohort trends among **women.** There may be a tendency for higher rates of diabetes among men in younger cohorts, but this is not clear-cut. .

'Urine glucose

The prevalence of urine glucose (Tables A-8) generally rises with age. The prevalence in men is consistently much higher than in women.

Glucose intolerance

The prevalence of glucose intolerance (Tables A-9) rises consistently with age at approximately the same rate for men as women. Again, rates are consistently higher in men.

Metropolitan relative weight

The average aging trends from cross-sectional data for **Metropolitan** relative weight show a distinctly different pattern for men and women (Figure CS-10). Men show **a** slight

increase until age 50, after which they steadily decrease. Women begin at a much lower level at younger ages, have a steady pronounced increase. to a peak around age 60, after which their weights also begin to decrease.

The cohort curves for the same data (Figures COH-10) are somewhat confused, but may be pointing towards a secular decrease in relative weights for women and a secular increase in relative weights for men.

Vital capacity

cross-sectional curves for vital capacity (Figure CS-11) show a remarkably consistent decline with age in both men and women, roughly 3.5 deciliters per decade. Males are consistently higher on average than females. Cohort curves show the same aging patterns and do not reveal any 'cohort differences (Figures COH-11). Data from Exam 16 have been excluded from the graphs due to the large difference in measurement levels from the previous exams.

Pulse rate

There is a slight suggestion for pulse rates to rise slightly with age (Figures CS-12 and COH-12), but no obvious aging or cohort patterns are apparent.

Smoking

For both cigarette smoking (Figures CS-13A and COH-13A) and smoking of all tobacco (Tables 13C) there is a dramatic decline in prevalence with age for men and women. The mean number of cigarettes smoked by cigarette smokers (Figures CS-13B and COH-13B) show male smokers smoking somewhat less

with age, while women decrease only slightly from a lower average level.

Heart enlargement by X-ray, definite

The prevalence of heart enlargement increases with age in both sexes (Tables A-14). Measurements at early and later exams (Exams 1 & 2 and 13 & 14) are not directly comparable with the other exams due to different X-ray reading methods.

Left ventricular hypertrophy by electrocardiogram, definite or possible

Cross-sectional data (Tables A-15) show a steady rise with age of prevalence of left ventricular hypertrophy in both sexes.

Nonspecific T-wave or' ST-segment abnormality by electrocardiogram, definite

Prevalence of abnormal electrocardiographic findings rises steeply with age (Tables A-16), and is in general more in evidence for men than women.

INTERCORRELATION OF VARIABLES OVER TIME - THE B-TABLES

The B-tables provide data regarding the relationship over time of the same major characteristics. In order to illustrate some of the features of these tables, we will review the information in Table B-1A-M, systolic blood pressure among male subjects, which resembles many of the other continuous characteristics.

The first line of the left-hand column of the table shows that the correlation between values at Exams 1 and 2 is .750, and the estimated regression equation for predict-

ing Exam 2 systolic pressure from Exam 1 pressure is: Estimated Exam 2 pressure=29.619+.755*(Exam 1 pressure).

Notice that the correlations decrease as the time between measurement increases. This is not unexpected. It is also evident that the estimate of the intercept increases, and the estimate of the slope decreases, as the time between measurements increases. Table 4 demonstrates the predicted values obtained from a few of the estimated regression equations. The well-known phenomenon of "regression towards the mean" is obvious here. The last of the pieces of information we find in the first line of Table B-1A-M is the standard error of estimate (i.e., the standard deviation of the residuals). (Dixon and Massey, ***Introduction to Statistical Analysis,*** McGraw Hill, New York, 1983, pp 211-214.) Like all standard errors, this value tells us the limits within which two-thirds of the actual values lie. In this case it indicates the amount of dispersion expected about the predictions made from given values of the earlier measure. This also increases as the time between measurements increases. The rate of increase in this measure, however, seems to decrease with time.

For the dichotomous variables, instead of correlation and regression coefficients, the percent agreement among those with and without the characteristic at the earlier exam are displayed. Conclusions from these tabulations should be made cautiously.

Table 4 Examples of predicted values obtained from regression equations for systolic blood pressure (from Table B-1A-M)

Value used in equation	Exams (predicting from -> to)				
	1->2	1->9	1->16	3->9	3->16
110	112.7	124.2	131.7	125.6	133.3
115	116.4	127.1	133.6	128.9	135.5
120	120.2	130.0	135.6	132.3	137.7
125	124.0	133.0	137.6	135.7	139.9
130	127.8	135.9	139.5	139.0	142.1
135	131.5	138.8	141.5	142.4	144.3
140	135.3	141.8	143.5	145.7	146.5
145	139.1	144.7	145.4	149.1	148.7
150	142.9	147.7	147.4	152.5	150.9
155	146.6	150.6	149.4	155.8	153.1
160	150.4	153.5	151.4	159.2	155.3
165	154.2	156.5	153.3	162.5	157.5
170	158.0	159.4	155.3	165.9	159.7
175	161.7	162.3	157.3	169.3	161.9
180	165.5	165.3	159.2	172.6	164.1
185	169.3	168.2	161.2	176.0	166.3
190	173.1	171.1	163.2	179.3	168.5
195	176.8	174.1	165.1	182.1	170.6
200	180.6	177.0	167.1	186.1	172.8
Intercept	29.619	59.602	88.319	51.658	8'5.040
Slope	0.755	0.587	0.394	0.672	0.439

For some, the prevalence of positive findings is so low that the percentages are difficult to interpret. For others, the definitions must be carefully considered if these summaries are to be interpreted sensibly. For example, for diabetes mellitus (Tables B-7), by definition a person remains a diabetic once they have been diagnosed. Consequently, the data under the heading "characteristic present" show 100% agreement for all exam combinations, while the percentages shown under @'characteristic absent" are the complement of the incidence rate in this cohort. Furthermore, technical shifts in measurement will also influence these comparisons. A review of Tables A-14 shows that the finding of heart enlargement on X-ray was substantially more frequent on Exam 1 than on Exam 4. Hence percent agreement for exams subsequent to Exam 1 are likely to be lower then those subsequent to Exam 4.