

Module 21: χ^2 For Contingency Tables

This module presents the χ^2 test for contingency tables, which can be used for tests of association and for differences between proportions

Contingency Tables

Contingency tables are very common types of tables used to present data. The cells of these tables include numbers that are integers and thus represent counts of something and/or percentages. For our purposes, we can use only those tables that have integers that are counts. If you are interested in analyzing data in a contingency table that includes only percentages in the cells, then you must convert these percentages into counts in order to proceed.

Appointment-Keeping Behavior Re-Evaluated

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Abstract: Many of the traditional approaches to the problem of appointment-keeping behavior have ignored the organizational factors that may be implicated in differentially high broken appointment rates leading to an implicit assumption that low-income and ethnic minority patients will be more likely to break appointments. A case study at a Model Clinic Health Center which maintains a kept appointment rate of 85

per cent examined the relationship of broken appointments to age, sex, ethnic background, and payment mechanisms. The results suggest alternative explanations for differentially high broken appointments centering on the role of the institution in reinforcing appointment-keeping behavior. (*Am. J. Public Health* 67: 1033-1036, 1977)

Broken appointment rates in ambulatory care facilities range from 15 per cent to 48 per cent. It is important to decrease the broken appointment rate as much as possible in order to provide for the best utilization of the direct care staff members. Explanations of broken appointment rates have concentrated primarily upon factors related to the patients, with emphasis placed upon demographic characteristics, such as socioeconomic status, race, age, sex, and educational levels, with other factors such as attitudes toward health care and personality factors also cited. Occasionally, additional factors have also been investigated, including the effect of weather and distance, and variables associated with the organization itself such as the appointment system, visiting patterns, and information flow in the organization. Most studies have concluded with acceptance of a primary myth which is that low-income patients do not keep appointments as well as people in middle-class socioeconomic groups. This has been consistently reported by several investigators over the last ten years.¹⁻⁵ The conclusion of the relationship between low income and high broken appointments has been proposed for ambulatory care in fee-for-service settings,⁶ psychiatric care,⁷ and ambulatory care in a pre-paid setting.⁸ The magnitude of the differences vary, but in one of the better designed studies, Greenlick contrasted appointment-keeping rates of a pre-paid group and an ORO⁹ Comparison-

Site Neighborhood Health Care Program that was part of the same medical system. The broken appointment rate for the pre-paid health plan sample was 8 per cent and for the ORO health plan sample 25 per cent.⁸

Confounding variables with low social class include age, ethnic identification, and educational levels. In general, the conclusion of most studies is that the older the patient the more likely they are to keep an appointment,¹⁻³ and that members of ethnic minorities, especially Blacks and Spanish-speaking are more likely to break appointments.^{1-3, 7, 10} Patients with lower educational levels are generally concluded to be poorer keepers of appointments,¹¹ although Adler's study did not confirm this relationship for psychiatric patients.⁷ Social disorganization of urban families, especially lower-income families, has also been related to poor appointment-keeping behavior.¹²

All of these studies have in common the emphasis upon the failure of the patient to keep an appointment, without analyzing the organizational factors which might be responsible for reinforcing poor appointment-keeping behavior. In those studies where efforts were made to increase the kept appointment rate, some interesting observations have been made with respect to the role of the health facility in broken appointments. Three major factors can be identified as being related to appointment-keeping behavior: physician continuity, communication systems, and type of appointment system. Becker found that physician continuity, i.e., seeing the same physician each time, was positively correlated to appointment-keeping among a group of low-income, mostly Black patients.¹³ Increased efforts at communication, including various reminders for missed appointments, also seems to be effective in reducing the broken appointment

¹Office of Economic Opportunity.

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patients to see specific requested physicians has been used for some time. Forward reminders are mailed five days prior to the appointment. In some cases, when the staff doctor is necessary, home visits are made to those who break their appointments. Home visits are utilized on many of the patients who had home telephone.

Methodology and Data Collection

Data were collected for the adult medical clinic for a 12-month period of time between April 1, 1974 and March 31, 1975, on number of appointments kept and broken, sex, age, ethnic group, and payment mechanism. Chi-square was utilized at a significance level of 5 per cent to test for the existence of relationships between these variables.

The monthly data for each variable were analyzed. Additionally, a chi-square test on the combined 12 months was calculated. There were a total of 3,172 visits recorded in the adult medical clinic during this time period.

Results

The overall kept appointment rate in the adult medical clinic during the study period was 85 per cent.

One of the 3,172 adult patient visits, 34 per cent were male and 66 per cent were female. As can be seen from Table 1, there were no significant differences in appointment-keeping behavior between males and females.

The age distribution of the population was broken into two categories using age 44 as the cut-off point. As with other studies,^{1, 2, 3} the data in Table 1 reveal a tendency for older patients to keep appointments better than younger patients. It should be noted that the differences with respect

to age are significant for only three months (June, October, and November), but these differences are more readily attributable to a statistical difference over the entire 12-month period of time.

The majority of the clinic's adult patients are Puerto Rican (69 per cent), with 27 per cent of the patients classified as White and 4 per cent classified as Black. Table 1 also demonstrates that there is a statistical relationship between ethnic group membership and appointment-keeping behavior, with Puerto Ricans having a higher broken appointment rate than either the Whites or Blacks. When these data are analyzed by months, May, June, August, November, February, and March show significant differences. During the months of June and August, neither the appointments secretary nor a bilingual health assistant were present in the Health Center. Both of these persons play key roles in scheduling Spanish-speaking patients. In November, February, and March the adult clinics were changed from their regular night to other evenings and some appointments in order to accommodate some of the schedules of the physicians. These changes were not adequately conveyed to the non-English speaking patients. The 18.5 per cent broken appointment rate among this group is compared to the 8.5 per cent broken appointment rate among Whites and the 7 per cent broken appointment rate among Blacks appears to be closely associated with these two events. The clinic's failure to fully communicate with the non-English speaking patient population, the erratic staffing of medical clinics, and the changes in the clinic schedules may well have contributed to the higher rates of broken appointments for the Spanish-speaking population. As can be seen from Table 1, these factors did not affect the English-speaking Black and White populations.

Sixty-five per cent of the Health Center's patient population is non-Mexican. As can be seen from Table 1, there is no relationship between Mexican status and appointment-keeping behavior.

In order to further clarify the relationship of ethnic status and payment mechanism, the three ethnic groups were classified by their payment mechanisms. Table 2 shows that there is an association between ethnic group and kept appointments, but this is stronger among those not on Medicaid. This group possesses the same characteristics as the total clinic sample, and thus reflects the same organizational problems that have been previously cited with respect to language problems.

Summary and Conclusions

The data presented suggest that the difference in the kept appointment rates of different ethnic groups does not reflect a true ethnic difference in health behavior. For the months when there was no significant difference in appointment-keeping behavior between the White and Puerto Rican populations, the appointment staff was present, and there were no changes in clinic days or medical staff. During five of the six months when such differences occurred, it was because of the absence of the bilingual appointment staff, the changes made in clinic days, and the physician

TABLE 1—Distribution of Percentage of Kept and Broken Appointments According to Selected Patient Characteristics

Patient Characteristics	N	% Kept (N = 2,693)	% Not Kept (N = 479)
Sex			
Male	1,100	85.39	14.61
Female	2,072	84.15	15.85
Age ^a			
≤ 44	2,560	84.00	16.00
> 44	612	90.37	9.63
Ethnicity ^b			
Puerto Rican	2,206	81.46	18.54
White	817	91.67	8.33
Black	149	93.96	6.04
Payment Mechanism ^c			
Medicare	2,220	83.40	16.60
Non-Medicaid	952	97.50	2.50
TOTAL	3,172	84.93	15.07

NS = not significant; * = 1.0% < .05

NS = not significant; ** = 1.0% < .01

NS = not significant; *** = 1.0% < .001

NS = not significant; **** = 1.0% < .0001

TABLE 1—Distribution of Percentage of Kept and Broken Appointments According to Selected Patient Characteristics

Patient Characteristic	N	% Kept (N = 2,603)	% Not Kept (N = 489)
Sex¹			
Male	1,109	85.39	14.61
Female	2,063	84.15	15.88
Age²			
< 45	2,603	83.00	17.00
45+	489	90.37	9.63
Ethnicity³			
Puerto Rican	2,206	81.46	18.54
White	837	91.52	8.48
Black	129	93.02	6.98
Payment Mechanism⁴			
Welfare	2,229	83.40	16.60
Non-Welfare	943	87.38	12.62
TOTAL	3,172	84.58	15.42

¹X² = 8.54; df = 1; p > .05

²X² = 24.22; df = 1; p < .05

³X² = 53.94; df = 2; p < .05

⁴X² = 8.05; df = 1; p > .05

H_0 : There is no association between the classification of the numbers of patients who kept their appointments and the classification of the sex of the patients, vs

H_1 : There is association between the classification of the numbers of patients who kept their appointments and the classification of the sex of the patients.

Or $H_0: P_M = P_F$ vs $H_1: P_M \neq P_F$

Where P_M = Proportion of males in population who “kept their appointments,”

P_F = Proportion of females in population who “kept their appointments.”

Contingency Tables

Contingency tables have:

r = number of rows, not counting any totals

c = number of columns, not counting any totals

$r \times c$ = number of cells

Approach is to compare observed number in each cell with the number expected under the assumption that the null hypothesis of no association is true.

Calculating Expected Numbers

Calculating the number expected in each contingency table cell under the assumption that the null hypothesis is true is, in practice, quite simple. This number is equal to the total for the row the cell is in times the total for the column the cell is in divided by the overall total for the table. You may be interested in working out why this is true; however, it really isn't worth the effort.

The algebraic expression is:

$$E = \text{Expected} = \frac{(\text{Row Total})(\text{Column Total})}{\text{Overall Total}}$$

Calculating χ^2

The value of the test statistic χ^2 calculated by comparing the observed number (O) to the expected number (E) in each cell according to the following formula:

$$\chi^2 = \sum_{\text{all cells}} \frac{(O - E)^2}{E}$$

The result of this calculation is then compared to the appropriate value in the tables for the χ^2 distribution. These are in the Table Module 3: The χ^2 Distribution.

Note that you need to look up $\chi^2_{0.95}(df)$ for a test with the α level at $\alpha = 0.05$.

So, for a 2x2 table,

$$df = (2-1)(2-1) = 1 \times 1 = 1$$

Reject H_0 : if $\chi^2 \geq \chi^2_{0.95}(1) = 3.84$

Sex	Kept appt		Didn't keep		Total
	n	%	n	%	
Male	947	85.39	162	14.61	1,109
Female	1,736	84.15	327	15.88	2,063
Total	2,683		489		3,172

Cell	O	E	(O-E)	(O-E) ²	(O-E) ² /E
1	947	938.03	8.97	80.46	0.09
2	162	170.97	-8.97	80.46	0.47
3	1,736	1,744.97	-8.97	80.46	0.05
4	327	318.03	8.97	80.46	0.25
Total	3,172	3,172.00	0		$\chi^2 = 0.86$

1. The Hypothesis

H_0 : There is no association between the classification of the numbers of patients who kept their appointments and the classification of the sex of the patients,

versus

H_1 : There is association between the classification of the numbers of patients who kept their appointments and the classification of the sex of the patients.

$H_0: P_M = P_F$ vs $H_1: P_M \neq P_F$

2. *The assumption:* Contingency table
3. *The α - level:* $\alpha = 0.05$
4. *The test statistic:*
$$\chi^2 = \sum_{\text{all cells}} \frac{(O - E)^2}{E}$$
5. *The critical region:* Reject H_0 : if $\chi^2 \geq \chi^2_{0.95}(1) = 3.84$
6. *The result:* $\chi^2 = 0.86$
7. *The conclusion:* Accept H_0
Since $\chi^2 = 0.86 < 3.84$

TABLE 1—Distribution of Percentage of Kept and Broken Appointments According to Selected Patient Characteristics

Patient Characteristic	N	% Kept (N = 2,683)	% Not Kept (N = 489)
Sex¹			
Male	1,109	85.39	14.61
Female	2,063	64.15	15.86
Age²			
< 45	2,683	83.00	17.00
45+	489	90.37	9.63
Ethnicity³			
Puerto Rican	2,206	81.46	18.54
White	837	91.52	8.48
Black	129	93.02	6.98
Payment Mechanism⁴			
Welfare	2,229	63.40	16.60
Non-Welfare	943	87.38	12.62
TOTAL	3,172	84.58	15.42

¹ $\chi^2 = 0.54$; $df = 1$; $p > .05$

² $\chi^2 = 24.22$; $df = 1$; $p < .05$

³ $\chi^2 = 53.94$; $df = 2$; $p < .05$

⁴ $\chi^2 = 0.05$; $df = 1$; $p > .05$

Age	Kept Appt		Didn't keep		Total
	n	%	n	%	
<45	2,227	83.9%	456	17.00	2,683
45+	442	90.37	47	9.63	489
Total	2,669		503		3,172

In other tables  2,683

 489

Cell	O	E	(O-E)	(O-E) ²	(O-E) ² /E
1	2,227	2,257.54	-30.54	932.69	0.41
2	456	425.46	30.54	932.69	2.19
3	442	411.46	30.54	932.69	2.27
4	47	77.54	-30.54	932.69	12.03
Total	3,172	3,172	0		$\chi^2 = 16.90$

1. The Hypothesis

H_0 : There is no association between the classification of the number of patients who kept their appointments and the classification of the age of the patients,

versus

H_1 : There is association between the classification of the numbers of patients who kept their appointments and the classification of the age of the patients.

$H_0: P_Y = P_0$ vs $H_1: P_Y \neq P_0$

2. *The assumption:*

Contingency table

3. *The α - level:*

$\alpha = 0.05$

4. *The test statistic:*

$$\chi^2 = \sum_{\text{all cells}} \frac{(O - E)^2}{E}$$

5. *The critical region:*

Reject H_0 : if $\chi^2 \geq \chi^2_{0.95}(1) = 3.84$

6. *The result:*

$$\chi^2 = 16.90$$

7. *The conclusion:*

Reject H_0

Since $\chi^2 = 16.90 > 3.84$

TABLE 1—Distribution of Percentage of Kept and Broken Appointments According to Selected Patient Characteristics

Patient Characteristic	N	% Kept (N = 2,683)	% Not Kept (N = 489)
Sex ¹			
Male	1,109	85.39	14.61
Female	2,063	84.15	15.88
Age ²			
< 45	2,683	83.00	17.00
45+	489	90.37	9.63
Ethnicity ³			
Puerto Rican	2,206	81.45	18.54
White	837	91.52	8.48
Black	129	93.02	6.98
Payment Mechanism ⁴			
Welfare	2,229	83.40	16.60
Non-Welfare	943	87.38	12.62
TOTAL	3,172	84.58	15.42

¹X² = 8.54; df = 1; p > .05

²X² = 24.22; df = 1; p < .05

³X² = 53.94; df = 2; p < .05

⁴X² = 8.05; df = 1; p > .05

Ethnicity	Kept appt		Didn't keep		Total
	n	%	n	%	
Puerto Rican	1,797	81.46	409	18.54	2,206
White	766	91.52	71	8.48	837
Black	120	93.02	9	6.98	129
Total	2,683		489		3,172

Cell	O	E	(O-E)	(O-E) ²	(O-E) ² /E
1	1,797	1,865.92	-68.92	4,749.97	2.55
2	409	340.08	68.92	4,749.97	13.97
3	766	707.97	58.03	3,367.48	4.76
4	71	129.03	-58.03	3,367.48	26.10
5	120	109.11	10.89	118.59	1.09
6	9	19.89	-10.89	118.59	5.96
Total	3,172	3,172	0		$\chi^2 = 54.43$

1. The Hypothesis

H_0 : There is no association between the classification of the number of patients who kept their appointments and the classification of the ethnicity of the patients,

versus

H_1 : There is association between the classification of the numbers of patients who kept their appointments and the classification of the ethnicity of the patients.

2. *The assumption:* Contingency table
3. *The α – level:* $\alpha = 0.05$
4. *The test statistic:*
$$\chi^2 = \sum_{\text{all cells}} \frac{(O - E)^2}{E}$$
5. *The critical region:* Reject H_0 : if $\chi^2 \geq \chi^2_{0.95}(2) = 5.99$
6. *The result:* $\chi^2 = 54.43$
7. *The conclusion:* Reject H_0
Since $\chi^2 = 54.43 > 5.99$

A Cross-National Trial of Brief Interventions with Heavy Drinkers

ABSTRACT

Objective. The relative effects of simple advice and brief counseling were evaluated with heavy drinkers admitted to primary care and other health settings in eight countries.

Methods. Subjects (11,081 men, 799 women) with no prior history of alcohol dependence were screened if they responded affirmatively to self-rated frequency or interests in the consumption of one of alcohol-related problems. Subjects were randomly assigned to a control group, a simple advice group, or a group receiving brief counseling. Ninety-five percent of subjects were evaluated 6 months later.

Results. Male patients exposed to the interventions reported approximately 17% lower average daily alcohol consumption than those in the control group. Reductions in the quantity of drinking were approximately 40%. Few women, significant reductions were observed in both the control and the intervention groups. Few instances of simple advice were as effective as 30 minutes of brief counseling.

Conclusions. Brief interventions are consistently better across health care settings and countries at groups and can make a significant contribution to the secondary prevention of alcohol-related problems if they are widely used in primary care. (*J Gen Intern Med*. 1998;13:211-218).

HEALTH BEHAVIOR CHANGE STUDY GROUP

Introduction

Alcohol-related conditions have become a major source of concern in both developed and developing countries. The limited approaches to the management of alcoholism have focused largely on either medical and social rehabilitation rather than early identification and/or primary prevention. In 1988, a World Health Organization expert committee stressed the need for efficient methods to detect persons with harmful and hazardous alcohol consumption before health and social consequences become pronounced and called for the development of strategies that could be applied in primary health care settings with a minimum of time and resources.¹ Harmful alcohol consumption is defined as a maladaptive pattern of drinking that is causing physical or psychological harm. Hazardous alcohol use refers to drinking patterns (e.g., frequent intoxication) that have a high probability of causing harm.

Within this context, the World Health Organization Collaborative Project on Identification and Treatment of Persons with Harmful Alcohol Consumption was initiated in 1991 to develop a scientific basis for screening and brief interventions in primary care settings. The purpose of this project was twofold: (1) to define, in collaboration with various participating health centers of cultural groups worldwide, the development of a simple instrument to screen for persons at high risk of alcohol problems in both developed and developing countries;²

(2) the second phase of the project was initiated in 1992 to test the usefulness of alcohol screening when it is linked to methods of brief intervention. The aim was to study the relative effects of simple advice and brief counseling on short-term changes in hazardous drinking behavior

and to investigate the mediating role of reduced consumption on the resolution of alcohol-related problems.

It was hypothesized that the inclusion of alcohol consumption rates in a screen instrument for progression to the primary of the intervention with increased benefits for comparison with those for control patients resulting from simple advice and brief counseling. Although several studies have demonstrated that groups exposed to brief interventions drink less and experience fewer health problems than those receiving no advice,³⁻¹⁰ other studies have called for more data on the importance of specific types of elements of brief interventions.¹¹⁻¹⁵ The relatively small samples available to most of these studies could have obscured small effects that may nevertheless be meaningful in terms of large-scale public health programs.

On the basis of research indicating that reduced drinking is associated with improved liver function, lower risk of stroke, less risk of the hospital, fewer social problems, and lower mortality rates,¹⁶⁻¹⁸ we further hypothesized that persons who reduce their drinking will also experience fewer alcohol-related problems.¹⁹⁻²¹

A third aim of this research was to investigate the process-related generalizability of brief interventions. We assumed that brief interventions are thought of as social behavioral principles are derived

The members of the WHO Health Organization Study Group are listed in the Acknowledgments section.

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The paper was prepared by James J. Coakley, MD, and Robert J. Giblin, MD, for the Health Organization Study Group, and all had contributed to the review of the World Health Organization.

TABLE 1.—Subjected Means and Analysis of Covariance Results for Primary Nutrients Measured from Eight Sites Following Spring Closures, with 2002 Interim Data and 2003 October Data

	Control Concentration Mean	Spring Closure Concentration Mean	Fall Closures Concentration Mean	F		p-Value (LSD)
				Exposition	Number	
Male nutrients						
Average total phosphorus	1.33	0.18	0.19	11.2277	2.0777	1.05
Standard deviation	0.23	0.07	0.08			
Female nutrients						
Average total phosphorus	0.83	0.37	0.38	7.72	1.33	0.01
Standard deviation	0.21	0.11	0.12			

Note: Sample sizes were as follows: control group, 487 observations; spring closure group, 297 observations; fall closures group, 222 observations. Degrees of freedom were 112, 112, and 111, respectively.

TABLE 2.—Percentages of Male and Female Subjects Who Increased, Decreased, or Remained at the Same Level of Altered Consumption

	Average Daily Consumption			Intensity of Activity		
	Control	Spring Closure	Fall Closures	Control	Spring Closure	Winter Closures
Male subjects						
Increased	29.0	40.8	40.0	39.0	43.8	49.0
Decreased	31.0	22.7	22.0	28.0	24.0	17.0
Remained	39.0	36.5	38.0	33.0	32.2	34.0
Female subjects						
Increased	25.7	43.0	40.0	38.0	40.0	41.0
Decreased	35.0	28.0	28.0	22.0	24.0	23.0
Remained	40.0	29.0	32.0	40.0	36.0	36.0

Note: Sample sizes were as follows: control group, 487 observations; spring closure group, 297 observations; fall closures group, 222 observations. Degrees of freedom were 112, 112, and 111, respectively.

The subjects of various procedures with different combinations of subjects were used to examine the direct effects of the two subjects, consumption and activity intensity, on a typical adult population.

Subjects completed the first control day and recorded consumption amounts were considered to take full advantage of the data collected. There were several reasons for this strategy. First, three of the eight control subjects (Female 3, Female 4, and Female 5) did not drink the opened packaged drinking conditions in their study design. Second, several of the days in the first three days recorded consumption indicated no difference between the control and the first consuming month day. Finally, several control subjects (Male 1, Male 2, Male 3, Male 4, Male 5, and Male 6) did not record consumption with the system used to record the packaged drinking, thereby allowing no consumption observations.

The primary dependent variables were following decreases of both the

total daily amount of alcohol consumed by subjects in alcohol tolerance and the amount of drinking on typical drinking days. The amount of typical daily consumption included the total amount that existed in the previous 4 months and the daily amount of daily consumption of alcohol the prior 4 months on a particular day. The primary results indicated that there was a significant effect on drinking days by increasing the days it may be used to take that 1 or more 1.0L of alcohol. When subjects were in the intervention group the intervention on alcohol consumption was significant in drinking behavior, alcohol tolerance, and persistence on measures of alcohol-related problems.

Subjects had no follow-up (2011) of the control group consumption with those who participated in the follow-up control of consumption system and drinking behavior subjects had no follow-up with participants from the intervention group and higher in indicators of alcohol con-

sumption activity. In a series of analyses for the subjects that recorded their consumption amount of alcohol on typical drinking days, their control of change in alcohol consumption from baseline to their follow-up on the follow-up days was not statistically significant.

Results

Table 1 presents selected results for the primary nutrients measured in spring closure consumption and intensity of drinking (alcohol) for the control group. The mean total alcohol for the fall is consistent. The results for male subjects indicate differences in the control and fall consumption between the control and fall groups. Female subjects were significantly different in the control and fall groups. The results for female subjects indicate differences in the control and fall groups. The results for the male subjects indicate differences in the control and fall groups.

TABLE 1—Adjusted Means and Analysis of Covariance Results for Primary Outcome Measures from Eight Cross-National Study Centers, WHO Brief Interventions with Heavy Drinkers Trial

	Control Condition, Mean	Simple Advice Condition, Mean	Brief Counseling Condition, Mean	F		
				Condition	Center	Condition × Center
Male patients						
Average daily consumption	6.29	5.18	5.29	11.12***	5.29***	1.31
Intensity	11.23	10.01	10.16	5.36**	4.01***	1.23
Female patients						
Average daily consumption	5.85	3.39	2.99	0.72	1.71	2.74*
Intensity	6.63	6.27	5.90	1.14	3.64*	2.13

Note. Sample sizes were as follows: control group, 404 men and 64 women; simple advice group, 360 men and 111 women; and brief counseling group, 452 men and 100 women.
*P < .05, **P < .01, ***P < .001.

TABLE 2—Percentages of Male and Female Patients Who Increased, Decreased, or Remained at the Same Level of Alcohol Consumption

	Average Daily Consumption			Intensity of Drinking		
	Control	Simple Advice	Brief Counseling	Control	Simple Advice	Brief Counseling
Male patients						
Decreased	29.0	43.6	40.3	32.9	43.5	46.4
No change	54.5	53.1	50.3	48.6	47.8	42.1
Increased	16.5	3.1	9.3	18.4	8.7	11.5
Female patients						
Decreased	35.7	45.2	45.1	29.6	43.3	51.0
No change	58.3	48.6	50.0	58.5	43.2	41.2
Increased	6.0	6.1	4.9	10.7	14.4	7.8

Note. Sample sizes were as follows: control group, 407 men and 64 women; simple advice group, 360 men and 111 women; and brief counseling group, 451 men and 100 women.

Table 2. JGIM July 1996, Vol 11(5) 351. Counseling levels for males

	% of patients			Number of Patients			
	Control	Simple Advice	Brief Counseling	Control	Simple Advice	Counseling	Total
Decreased	29.0	40.8	40.3	118	160	166	464
No Change	54.5	59.1	50.3	202	208	202	662
Increased	16.5	6.1	9.3	67	24	43	134
Total	100	100	99.9	407	392	461	1260

Cell	O	E	O - E	$(O - E)^2 / E$	χ^2
1	118	149.88	-31.88	1016.28	6.78
2	160	144.36	15.64	244.75	1.70
3	166	169.77	-16.23	263.59	1.55
4	202	213.84	-8.16	66.64	0.31
5	208	205.96	2.04	4.16	0.02
6	202	242.21	-10.21	104.20	0.43
7	67	43.28	23.72	562.44	12.98
8	24	41.69	-17.69	312.50	7.51
9	43	49.03	-6.03	36.32	0.74
Total	1260	1260	0.00	1778	32.03

1. The Hypothesis

H_0 : There is no association between the classification of the number of patients according to their change in alcohol consumption and the treatment they received

versus

H_1 : There is association between the classification of the numbers of patients according to their change in alcohol consumption and the treatment they received.

2. *The assumption:* Contingency table
3. *The α - level:* $\alpha = 0.05$
4. *The test statistic:*
$$\chi^2 = \sum_{\text{all cells}} \frac{(O - E)^2}{E}$$
5. *The critical region:* Reject H_0 : if $\chi^2 \geq \chi^2_{0.95}(4) = 9.49$
6. *The result:* $\chi^2 = 32.03$
7. *The conclusion:* Reject H_0
Since $\chi^2 = 32.03 > 9.49$

Table 2. — Percentages of Men Who Are Reporting Abstinence, Inadequate Intake, and Daily Drinking Habits in a Mixed Group of Individuals and Following Exposure to Their Study Conditions

	Control Group (n = 200)	Control Group (n = 200)	Study Group (n = 271)	P ^a
Abstinence (abstinent)				
Men	30	30	30	ns
Women	3	3	4	
Study or semi-daily drinking^b				
Men	19	19	19	ns
Women	25	26	14	
Abstinence (abstinent) or inadequate intake^c				
Men	49	49	49	ns
Women	28	27	17	
Inadequate (study) or abstinent^d				
Men	67	66	66	0.001
Women	36	34	27	
At least one failed attempt^e				
Men	55	54	56	ns
Women	36	34	22	
At least one failed attempt^f				
Men	33	32	33	ns
Women	37	36	25	

ns = Not significant; P values were not determined for significant differences between treatment groups and between groups for each variable. P values for between treatment and control groups were determined by chi-square test for categorical or Fisher's exact test for small cell frequencies.

^ans = Not significant; P values were not determined for significant differences between treatment groups and between groups for each variable. P values for between treatment and control groups were determined by chi-square test for categorical or Fisher's exact test for small cell frequencies.

Completion of the baseline and follow-up survey on the present study is complete, and we conclude that all groups achieved their drinking or abstinence goals. The intervention group participants had significantly ($P < .05$) less failed attempts at abstinence than the control group. For example, whereas the control group is shown to report daily consumption by approximately 75% of men in the control study, only 19% of men in the control group reported 27% and 21% less drinking respectively.

The differences between the control and intervention groups in the amount and intensity of drinking were accompanied by similar reductions in the number of drinking days that men in the treatment or abstinent group reported by 25%.

The results for women (Table 2) show that 30% of the 2 control for treatment condition differences attained

abstinence (abstinent). Although these results indicate that there were no differences among conditions at the time of the follow-up evaluation, repeated measures analysis of covariance indicated significant main effects for time (drinking or abstinence) and study (drinking or abstinence) from baseline to follow-up. The results for men and women are shown in Table 2. The results for men and women are shown in Table 2. The results for men and women are shown in Table 2.

Table 2 shows the percentages of men and women who drinking at the time of the follow-up evaluation relative to baseline levels. The percentage of men and women who reported no drinking were increased in both conditions in the study. With one exception, drinking abstinence was increased 1.5 or 2.0 times in the control for treatment condition differences attained

average daily drinking at follow-up relative to baseline. In contrast, the changes for the study group were 20% (men) and 47% (women) and the total percentage was 24% (men) and 37% (women) respectively. The results for men and women are shown in Table 2. The results for men and women are shown in Table 2. The results for men and women are shown in Table 2.

The results for women show a similar trend toward decreased consumption in the intervention group. Although the treatment group did not report significantly less or more daily consumption than the control group, the results for men and women are shown in Table 2. The results for men and women are shown in Table 2. The results for men and women are shown in Table 2.

Table 2 and 3 show percentages of study and control women who reported abstinence, semi-daily drinking, and daily drinking. The results for men and women are shown in Table 2. The results for men and women are shown in Table 2. The results for men and women are shown in Table 2.

TABLE 3—Percentages of Male Patients Reporting Abstinence, Hazardous Drinking, and Alcohol-Related Problems in 6-Month Period prior to Intervention and following Exposure to Three Study Conditions

	Control (n = 403), %	Simple Advice (n = 387), %	Brief Counseling (n = 471), %	χ^2
Completely abstinent^a				
Pretest	0	0	0	.. ^b
Posttest	2	5	8	
Daily or almost daily drinking^c				
Pretest	19	18	19	6.7*
Posttest	23	16	14	
Above recommended weekly limit^d				
Pretest	77	78	74	7.2*
Posttest	65	57	57	
"Hazardous" daily consumption^e				
Pretest	67	69	68	11.0**
Posttest	58	49	47	
At least one recent complaint				
Pretest	50	54	56	1.5
Posttest	39	35	40	
At least one recent problem				
Pretest	30	37	38	3.6
Posttest	37	28	35	

Note. Chi-square analyses were used to test for significant associations between treatment group and outcome status for each variable. Outcome was defined dichotomously, with posttest status as a criterion. Chi-square tests were performed on the posttest frequencies for each dichotomous outcome variable.

^aPatient reported no drinking during previous 6-month period.

^bNot calculated because of small cell sizes.

^cPatient reported drinking 28 to 31 days per month.

^dFor men, no more than 3-4 standard drinks per day, no more than 4-5 days per week (approximately 24 oz ethanol per week or 3.4 oz ethanol per day).

^e40 g (4.30 oz) average daily consumption.

*P < .05; **P < .01.

Table 3, AJPH July 1996, Vol 86 p952 Hazardous daily consumption, Males Posttest

Posttest	%			Number			Total
	Control	Simple Advice	Brief Counseling	Control	Simple Advice	Brief Counseling	
Yes	58	49	47	234	190	221	645
No	42	51	53	169	197	250	616
Total	100	100	100	403	387	471	1261

Cell	O	E	O-E	$(O-E)^2$	$(O-E)^2/E$
1	234	206.13	27.87	776.51	3.77
2	190	197.95	-7.95	63.20	0.32
3	221	240.92	-19.92	396.64	1.65
4	169	196.87	-27.87	776.51	3.94
5	197	189.05	7.95	63.20	0.33
6	250	230.08	19.92	396.64	1.72
Total	1261	1261.00	0.00		11.74

1. The Hypothesis

H_0 : There is no association between the classification of the number of patients according to their posttest hazardous alcohol consumption and the treatment they received.

versus

H_1 : There is association between the classification of the numbers of patients according to their posttest hazardous alcohol consumption and the treatment they received.

2. *The assumption:* Contingency table
3. *The α - level:* $\alpha = 0.05$
4. *The test statistic:*
$$\chi^2 = \sum_{\text{all cells}} \frac{(O - E)^2}{E}$$
5. *The critical region:* Reject H_0 : if $\chi^2 \geq \chi^2_{0.95}(2) = 5.99$
6. *The result:* $\chi^2 = 11.74$
7. *The conclusion:* Reject H_0
Since $\chi^2 = 11.74 > 5.99$

Heart Rate as a Predictor of Mortality: The MATISS Project

Fabrizio Ceronegrosso, MD, Fabio Panzavolta, MD, Francesco Di Cori, Anna Minguzzi, MD, Antonia Marchetti, MD, Ugo La Rovere, and Roberto Cappucci, MD

A direct association of elevated heart rate with hypertension, hypercholesterolemia, and hyperglycemia and an inverse relationship with physical activity and pulmonary function have been found in several epidemiologic studies.¹⁻⁷ Independent predictors hypertension, increased risk of arrhythmias, and left-left heart failure development of atherosclerotic plaques.^{8,9}

All-cause mortality seems to be higher in individuals with elevated heart rates. In the Framingham Study, death rates increased with increasing levels of heart rate; the association was stronger in men and not related to age, and there was no indication of a threshold value that could be defined as hazardous.¹⁰ Among individuals with hypertension, a positive association between heart rate and cardiovascular disease, particularly coronary heart disease and sudden death, has also been shown even after adjustment of early disease, confirming that heart rate is an independent predictor of fatal events and not only an indicator of progressing disease.¹¹ The National Health and Nutrition Examination Survey, the Paris Prospective Study, the Spanish Health Test, and the 3 Chicago epidemiologic studies have also revealed a positive association between heart rate and cardiovascular and noncardiovascular mortality.¹²⁻¹⁵ These findings represent evidence that heart rate can be considered a determinant of health status and a predictor of poor outcomes in the general population.

Despite the amount of international evidence, mostly from Northern European and US studies, that heart rate is a health determinant, the prognostic role of heart rate in mortality has not been assessed in Mediterranean populations. Among these groups, other risk factors, such as dietary intake, serum cholesterol, and body mass index, have been shown to have unique relations to total mortality and fatal coronary events.¹⁶⁻¹⁸ In the present study, we evaluated the association of heart rate with all-cause, cardiovascular, and non-

Objectives. This study sought to verify the independent role of heart rate in the prediction of all-cause, cardiovascular, and noncardiovascular mortality in a low-risk male population.

Methods. In an Italian population-based observational study, heart rate was measured in 2533 men, aged 40 to 60 years, between 1984 and 1993. Data on cardiovascular risk factors were collected according to standardized procedures, that status was updated in December 1997.

Results. Of 2533 men followed up (representing 74487 person-years), 393 men died. Age-adjusted death rates for 5 heart rate levels showed increasing trends. The adjusted hazard rate ratios for each heart rate interval were 1.52 (95% confidence interval [CI] = 1.29, 1.79) for all-cause mortality, 1.62 (95% CI = 1.29, 2.10) for cardiovascular mortality, and 1.47 (95% CI = 1.19, 1.80) for noncardiovascular mortality. Relative risks between extreme levels were more than 2-fold for all endpoints considered.

Conclusions. Heart rate is an independent predictor of cardiovascular, noncardiovascular, and total mortality in the Italian middle-aged male population. (*J Gen Intern Med*. 2003;18:1258-1263.)

cardiovascular mortality among a sample of middle-aged men residing in central Italy.

METHODS

Between 1984 and 1993, the Malattie Cardiovascolari Neurodegenerative, Istituto Nazionale di Studi (MATISS Project) were used 2533 men aged 40 to 60 years who resided in 4 municipalities of central Italy approximately 100 km southeast of Rome (Figure 1). Participants represented 90% of a random sample, stratified by age and sex, selected from the electoral rolls. Data on cardiovascular risk factors were collected according to procedures and methodologies described in detail elsewhere.¹⁹

Resting electrocardiograms (ECG) were read according to the Minnesota code to standard ECG reading procedure that provides a framework for uniform reporting as being normally and previously defined channels. Heart rate was calculated as mean number of beats per minute.

Total serum cholesterol (mg/dL) was centrally tested by the Laboratory of Clinical Biochemistry, Istituto Nazionale di Studi, via an automated enzymatic colorimetric method (Boehringer Mannheim GmbH Diagnostica, Monza, Italy). Fasting cholesterol values (Boehringer Mannheim GmbH Diagnostica, Monza, Italy) were used as reference, and a

calibration curve was established for each run. As a means of providing internal quality control, commercial controls were analyzed in each run.

During the screening period, the laboratory performing serum lipid level analysis was assessed in regard to quality control by the World Health Organization Lipid Reference Center in Perugia. For each control sample, bias was estimated as the difference between



FIGURE 1. Map of Italy delineating the area covered by the MATISS Project.

TABLE 1.—Person-Years and Number of Deaths, by Heart Rate Class and Outcome: MRFIT Project, 1984-1997

Heart Rate Class (beats per minute)	Person-Years	Cause of Death		
		All Causes (No.)	Cardiovascular (No.)	Noncardiovascular (No.)
<60	1 074	36	18	18
60-69	9 337	339	161	178
70-79	9 043	395	200	195
80-89	4 026	131	63	68
≥90	967	36	17	19
Total	24 447	897	459	438

Multivariate heart rate coefficients were 0.0209 (α_{100}) = 5.1% for all-cause mortality, 0.043 (α_{100}) = 3.7% for cardiovascular disease mortality, and 0.0179 (α_{100}) = 5.4% for noncardiovascular mortality (Figure 2). Corresponding multivariate heart rate rates compared for each heart rate increment of 10 beats per minute were 1.02 (95% CI = 1.01,

1.03), 1.03 (95% CI = 1.01, 1.05), and 1.07 (95% CI = 1.05, 1.09).

DISCUSSION

Like other researchers,^{1,2} we observed a strong association of heart rate with systolic blood pressure, number of cigarettes smoked

per day, serum cholesterol level, and other factors, an inverse relationship with pulmonary function, and an association with age. Although an association between heart rate and cardiovascular disease has not always been found,^{11,12,13} there is general agreement that heart rate is a strong determinant of overall mortality.^{14,15,16,17}

In the present study, multivariate analyses of all-cause, cardiovascular, and noncardiovascular mortality showed an increasing trend when moving from the lowest to the highest heart rate levels; relative risks for these outcome classes were 2.7 for all-cause mortality, 2.7 for cardiovascular mortality, and 2.5 for noncardiovascular mortality. Trends were adjusted for age, systolic blood pressure, number of cigarettes smoked per day, BMI, serum cholesterol, adjusted forced expiratory volume, cholesterol, and preceding cardiovascular disease. For the 3 outcomes, the risk functions obtained by applying the

TABLE 2.—Characteristics of Study Population, by Heart Rate Class: MRFIT Project, 1984-1997

	Heart Rate Class (per Minute)					F	P
	<60 (n = 482)	60-69 (n = 8,855)	70-79 (n = 8,061)	80-89 (n = 4,026)	≥90 (n = 967)		
Systolic blood pressure, mm Hg (mean ± SD)	106.2 ± 10.8	109.5 ± 11.4	113.5 ± 10.1	120.4 ± 11.0	128.5 ± 15.4	10.07	<.001
No. of cigarettes smoked per day (mean ± SD)	4.4 ± 11.2	7.6 ± 10.4	8.0 ± 10.0	8.4 ± 10.1	1.4 ± 10.4	1.47	<.001
Body mass index, kg/m ² (mean ± SD)	27.3 ± 3.4	27.3 ± 3.1	27.4 ± 3.0	27.2 ± 3.0	28.4 ± 4.1	1.40	<.001
Serum cholesterol level (mg/dL) (mean ± SD)	193.0 ± 40.2	192.5 ± 41.4	194.2 ± 41.0	193.1 ± 40.5	179.2 ± 40.4	4.05	<.001
Forced expiratory volume, mL (mean ± SD)	1,621 ± 300	1,602 ± 300	1,612 ± 300	1,611 ± 300	1,511 ± 307	13.14	<.001
Sex composition, % (mean ± SD)	51.5 ± 1.9	51.4 ± 1.4	51.2 ± 1.0	51.4 ± 1.1	51.2 ± 1.4	10.20	<.001
Prevalence of diabetes, %	0.2	1.4	1.8	2.8	6.2	17.08 ^a	<.001

^aFisher's χ^2 .

TABLE 3.—Age-Standardized Yearly Death Rates ($\times 100,000$), by Heart Rate Class: MRFIT Project, 1984-1997

Heart Rate Class (beats per minute)	No. Cigarettes	All Causes		Cardiovascular		Noncardiovascular	
		Rate	SE	Rate	SE	Rate	SE
<60	10.1	174.0	10.0	89.5	10.0	89.4	10.0
60-69	6.0	1,465	10.1	587	17.0	83.8	10.0
70-79	8.0	1,642	10.7	76.5	19.0	1,097	14.0
80-89	8.0	1,600	14.0	607	17.4	1,129	17.4
≥90	1.4	1,000	10.0	1,004	20.1	1,007	10.0
Test for trend, P		.0000		.0000		.0000	
Relative risk between extreme classes (95% confidence interval)		1.76 (1.71, 1.81)		1.76 (1.71, 1.81)		1.81 (1.69, 1.93)	

Table. Percent with and without diabetes within heart groups

Diabetes	Heart Rate (Beats/Min)				
	< 60	60 - 69	70 - 79	80 - 89	≥ 90
Yes	4.3	3.4	7.1	7.8	9.3
No	95.7	96.6	92.9	92.2	90.7
Total	100	100	100	100	100

Source: AJPH 2001, Vol 91, No. 8 page: 1260

Table. Number with and without diabetes within heart groups

Diabetes	Heart Rate (Beats/Min)					Total
	< 60	60 - 69	70 - 79	80 - 89	≥ 90	
Yes	28	29	34	14	9	114
No	614	807	443	167	88	2,119
Total	642	836	477	181	97	2,233

Chi-Square Worksheet

Cell	O	E	(O-E)	$(O-E)^2$	$(O-E)^2/E$
1	28	32.78	-4.78	22.848	0.70
2	29	42.68	-13.68	187.14	4.38
3	34	24.35	9.65	93.123	3.82
4	14	9.24	4.76	22.658	2.45
5	9	4.95	4.05	16.403	3.31
6	614	609.22	4.78	22.848	0.04
7	807	793.32	13.68	187.14	0.24
8	443	452.65	-9.65	93.122	0.20
9	167	171.76	-4.76	22.658	0.13
10	88	92.05	-4.05	16.403	0.18
Total	2,233	2,233	0		15.45

1. The Hypothesis

H_0 : There is no association between the classification of the number of patients according to their heart rate category and this classification of their diabetes status.
versus

H_1 : There is association between the classification of the numbers of patients according to their heart rate category and this classification of their diabetes status

2. *The assumption:* Contingency table
3. *The α - level:* $\alpha = 0.05$
4. *The test statistic:*
$$\chi^2 = \sum_{\text{all cells}} \frac{(O - E)^2}{E}$$
5. *The critical region:* Reject H_0 : if $\chi^2 \geq \chi^2_{0.95}(4) = 9.49$
6. *The result:* $\chi^2 = 15.45$
7. *The conclusion:* Reject H_0
Since $\chi^2 = 15.45 > 9.49$