

RESEARCH REPORT

Effects on mortality of alcohol consumption, smoking, physical activity, and close personal relationships

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Abstract

The study analyses the risks of mortality associated with alcohol consumption and smoking, as well as possible counteracting effects of physical activity and social support through close personal relationships. Data are based on the Upper Bavarian Study, a longitudinal epidemiological study of a representative community sample (n = 1668) in a rural area. Extensive semistructural psychiatric interviews by research physicians were conducted between 1975 and 1977 (n = 1536). Thirteen years after psychiatric assessment, information was obtained from the community register concerning death in the interval, date of death and cause of death according to ICD 9. This information could be ascertained for 93.1% (n = 1430) of those who had been interviewed, thus providing a good basis for generalizing the findings. Results indicate that alcohol intake and cigarette smoking increased mortality while physical activity and the availability of a steady partner had protective effects. There were no interactive effects between the four variables studied, except for a dramatically increased risk for women drinking more than 20 ml of pure alcohol a day and reporting no physical exercise at wave one assessment. The relative risks of alcohol intake and smoking, and the counteracting effects of physical activity and partnership, are exemplified in the cases of a 40-year-old female and a 40-year-old male. Specific analyses of the relationship between alcohol consumption, smoking, physical exercise and personal relationships, on the one hand, and, on the other, different causes of death, are presented.

Introduction

The influences of such lifestyle factors as alcohol consumption and physical activity on mortality rates have been increasingly recognized (e.g. Rose, 1985, on cardiovascular diseases; Doll & Peto, 1981, or Saracci, 1985, on malignant

neoplasms). The present study, based on a longitudinal community study, analysed the mortality risk associated with alcohol consumption and cigarette smoking, and the effects of two potentially protective factors: physical activity, and social support from living in a close personal relationship. This paper presents the risks and health benefits associated with each lifestyle factor (following the practice of Rothman, 1986,

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pp. 7ff.), as well as an overall picture of the joint effects of all the factors.

Sample and method

In the years 1975–77 the first wave of the Upper Bavarian Study was conducted by Dilling & Weyerer (1984a). The sample consisted of 1668 community residents aged ≥ 15 years. It was drawn randomly from the community registers of two towns, Traunstein and Traunreut, and the village of Palling, in Upper Bavaria. During 1980–86 this sample was re-interviewed by psychiatrically trained physicians (second wave; see Fichter & Witzke, 1990, for a detailed description of the sample and methods). The Upper Bavarian Study focused on the assessment of prevalence and incidence of psychiatric disorders in the general population, and on the analysis of factors affecting the course of illness. The results have been reported (Dilling & Weyerer, 1984b; Fichter, Weyerer & Dilling, 1989; Fichter, 1990a).

In the first wave, psychiatrically trained physicians administered a standardized psychiatric interview developed by Goldberg *et al.* (1970) to 1536 members of the sample (92.1%). The interviewers also recorded socio-demographic variables, alcohol intake and smoking, use of psychiatric and other medical facilities, partnership status, recreational activities, and somatic illness.

Thirteen years after the first wave a second assessment was performed to determine the number of deaths that had occurred in the sample. In addition, the date of death, the disease or condition directly leading to death, and antecedent causes were recorded from the death certificates (Bundesminster für Jugend, Familie und Gesundheit, 1979). For 1430 of the 1536 persons, interviewed in the first wave (93.1% of the interviewed), information on vital status could be obtained. This amounts to 87.5% of the original sample drawn randomly in the mid-1970s. Thus, a high percentage of the sample was successfully followed up, which gives a good basis for generalization from the study findings.

The present study focuses on the analysis of the following four lifestyle factors and their impact on mortality.

1. *Alcohol intake* (in ml pure alcohol a day); Each subject was asked about quantity, frequency and variability of consumed alcoholic

beverages. After the interview this information was converted into the average daily intake of alcohol, grouped into four categories: (a) up to 20 ml; (b) 21 to 80 ml; (c) 81 to 120 ml; and (d) more than 120 ml. Only this transformed variable on alcohol intake was part of the present database.

2. *The number of cigarettes* smoked daily: This was assessed on the basis of subjects' self-reports. The data were classified into five categories: (a) nonsmoker; (b) 1–5 cigarettes; (c) 6 cigarettes to a pack (= 20 cigarettes); (d) one to two packs (= 21–40 cigarettes); (e) more than two packs (= more than 40 cigarettes).

3. *The amount of physical activity* was also assessed from subjects' self-reports. It was classified in the following categories: (a) no or almost no physical activities; (b) occasional physical activities; (c) regular physical activities. Physical activity has been shown to reduce mortality (Multiple Risk Factor Intervention Trial Research Group, 1990).

4. *Existence of a close personal relationship*: the interviewer assessed whether the subject was living in a steady partnership. This variable was chosen for analysis on the assumption that living in a partnership provides social support for coping with critical life-events and chronic difficulties (cf. Fichter, Rehm & Witzke, 1990, p. 302). Originally, the probe on partnership had the three categories: (a) no partner; (b) married partner; (c) steady partner but not married. Since the analysis was concerned with psychological function and not the legal status of a close personal relationship, the two latter categories were collapsed for purposes of analysis.

Results

The results section is divided into four parts: the prevalence of the postulated influencing factors, followed by an overview of mortality in different sex-strata; the relationship of these factors to mortality rates, proceeding from Mantel-Haenszel estimates for $k \times 2 \times 2$ tables (Mantel & Haenszel, 1959) separately for all lifestyle factors stratified for three age-groups to a simultaneous modelling of all influences and their interactions; the significance of the determined risk-factor profile for a 40-year-old woman and a 40-year-old man; and influences of the factors examined on selected causes of death.

Table 1. Prevalence of alcohol intake, smoking, physical activities and close personal relationships. Sample of the Upper Bavarian follow-up study (30–69 years old)

	Total sample (n = 908)			Females (n = 489)			Males (n = 419)		
	N	%	(%)	N	%	(%)	N	%	(%)
1. Consumption of alcohol per day									
Less than 20 ml	637	70.2	(73.1)	444	90.8	(91.3)	193	46.1	(51.4)
20–80 ml	220	24.2	(22.0)	44	9.0	(8.6)	176	42.0	(38.0)
80–120 ml	47	5.2	(4.5)	1	0.2	(0.1)	46	11.0	(9.7)
More than 120 ml	4	0.4	(0.4)	0	0.0	(0.0)	4	1.0	(0.9)
2. Cigarette smoking per day									
Nonsmoker	627	69.1	(69.2)	405	82.8	(79.2)	222	53.0	(57.4)
1–5 cigarettes	77	8.5	(9.4)	29	5.9	(7.2)	48	11.5	(12.1)
6–20	147	16.2	(16.1)	48	9.8	(12.2)	99	23.6	(20.7)
21–40	54	5.9	(4.8)	7	1.4	(1.4)	47	11.2	(8.9)
More than 40	3	0.3	(0.4)	0	0.0	(0.0)	3	0.7	(0.9)
3. Physical activity									
None	436	48.0	(45.9)	254	51.9	(53.1)	182	43.4	(37.4)
Sometimes	247	27.2	(26.3)	140	28.6	(26.6)	107	25.5	(25.9)
Regular	225	24.8	(27.8)	95	19.4	(20.3)	130	31.0	(36.7)
4. Close personal relationship									
No	163	18.0	(27.6)	128	26.2	(33.3)	35	8.4	(20.7)
Yes	745	82.0	(72.4)	361	73.8	(66.7)	384	91.6	(79.3)

Numbers in parentheses refer to the percentages in the total longitudinal sample of the Upper Bavarian follow-up study (15 years and older). The sample sizes for this sample were $n = 1430$: (total sample), $n = 778$ (females) and $n = 652$ (males).

Prevalence of alcohol consumption, cigarette smoking, physical activity, and living in a steady partnership

Table 1 shows the raw counts and percentages for alcohol consumption, cigarette smoking, physical activity and partnership status at the time of the first assessment (1975–1977) in a subsample of persons between 30–69 years of age (= age-restricted sample). The 30–69 age-group was selected because most of the mortality analyses presented later were conducted on this sample (for explanations see below).

Results indicate a considerable variation according to gender in the examined variables. The analysis of *alcohol intake* showed that only slightly more than 9% of the females, but 54% of the males, consumed more than 20 ml of pure alcohol a day. Moreover, about every tenth man between 30 and 69 years consumed more than 80 ml a day (statistical significance of interaction between gender and alcohol intake: Pearson $\chi^2 = 221.1$; $df = 3$; $p < 0.001$). The relatively high level of alcohol intake by men can be ex-

plained by the values and mores of rural Bavaria, where at the time of wave one the drinking of beer and distilled beverages was socially reinforced. There are indications that drinking patterns in men have been changing since the 1970s in rural Bavaria (cf. Fichter, 1990b, p. 78). The prevalence of drinking more than 80 mg/day decreased from more than 10% in the 1970s to less than 7% in the 1980s among male adults. Considerable gender differences were also found with respect to *cigarette smoking* (Pearson χ^2 : 103.6; $df = 4$; $p < 0.001$). The prevalence of smokers was higher among men than among women (47% vs. 17%) in the 1970s, and the men smoked more cigarettes than did the women (see Table 1 for details).

Gender differences concerning the amount of *physical activity* were comparatively small but statistically significant (Pearson χ^2 : 16.4; $df = 2$; $p < 0.001$). About 50% of the females were at least sometimes physically active, compared with 57% of the males. The gender difference concerning involvement in regular physical activities

Table 2. Number of deaths according to different age groups

	Total sample		Females		Males	
	(n = 1430)		(n = 778)		(n = 652)	
	n/n _{total} ¹	%	n/n _{total} ¹	%	n/n _{total} ¹	%
Up to 29 years old	2/353	0.57	0/182	0	2/171	1.17
30–44 years	10/370	2.70	7/179	3.91	3/191	1.57
45–59 years	36/328	10.98	9/190	4.74	27/138	19.57
60 years and older	178/379	46.97	102/227	44.93	76/152	50.00
Age-restricted sample						
30–69 years	117/908	12.89	53/489	10.63	65/419	15.51
Total sample	226/1430	15.80	118/778	15.17	108/652	16.56

¹n denotes the number of deaths; n_{total} the number of persons in that sample.

(31% of men and 19% of women) was more pronounced.

Gender differences in the *existence of a close personal relationship* were marked: 26% of the females but only 8% of the males, reported that they had no steady partner (significance of the interaction between partnership and gender: Pearson χ^2 : 48.7; df = 1; $p < 0.001$). Primarily the 50–69-years age-group accounted for this difference, with only 11.7% of the men but 45.7% of the women not living with a partner. This difference is most likely due to the lower life expectancy of men than of women, resulting in a higher rate of widows after a certain age. This explanation is supported by the fact that 69% of all subjects between 55 and 69 years of age without a steady partner were widowed.

The higher prevalence of persons living without a steady partner in the total sample (as compared with the restricted sample of between 30 and 69 years) was due to persons in the old-age strata, where the probability of having lost a partner was largely increased. Of the age-group 70 years and over, almost three fourths of those without a steady partner were widowed.

Interactions of lifestyle factors: How did the potential influencing factors interact? For *men*, two correlations exceeded an absolute value of 0.10 set to be the limit of a moderate effect for Spearman correlations.¹ The first concerned the relationship between drinking and smoking among males, found to be 0.185 for the age-

restricted (30–69 years of age) and 0.285 for the total sample. In other words, those men who tended to drink more also tended to smoke more. Secondly, there was a negative relationship between physical activity and smoking: those who engaged more in physical activities tended to smoke less and vice versa ($r = 0.146$ age-restricted sample; $r = -0.162$ total sample).

For *women*, again the relationship between smoking and drinking proved to yield the highest correlation among influencing factors ($r = 0.195$ for both samples). Otherwise, women who were not living in a partnership tended to engage less in physical activities ($r = 0.110$ for both samples).

Mortality in the examined sample

Table 2 gives an overview of the number of deaths according to gender and different age-groups. As expected, mortality increased with age and was higher for males than for females.

Association of lifestyle factors with total mortality

Mantel-Haenszel estimates for influences of each lifestyle factor on mortality: Association between, on the one hand, alcohol intake, smoking, physical activity and partnership status and, on the other, mortality was in the first step analysed for each lifestyle factor separately. Bases were 2*2 tables (lifestyle present/absent * dead/alive) for three different age strata, which were pooled by means of a Mantel-Haenszel estimator. This procedure can be considered as a weighted average of the stratum-specific estimates (see Mantel & Haenszel, 1959). Results are summarized in Table 3.

¹A correlation of 0.10 would correspond to a shared variance of 1% in the parametric case of the Pearson correlation. This limit also reflects significant correlations if adjustments are made for all correlations tested (Bonferroni adjustment). The interpretation of the significance of unadjusted correlation matrixes would be statistically problematic (see Salsberg, 1985).

Table 3. Influences of lifestyle variables on mortality—stratified and crude analysis

95% CL limits ³	Total sample			Females			Males		
	Odds ratio ¹			Odds ratio ²			Odds ratio ³		
	Lower	Upper		Lower	Upper		Lower	Upper	
1. Alcohol consumption									
0–20 ml vs. more than 20 ml									
30–44 years	0.30	1.52	7.70	0.17	1.52	13.38	0.14	1.51	16.99
	(0.21	0.82	3.21)						
45–59 years	0.65	1.37	2.90	1.11	4.82	21.05	0.44	1.03	2.39
	(1.36	2.74	5.54)						
60 years and older	0.65	1.14	2.02	0.30	1.02	3.45	0.62	1.18	2.25
	(0.75	1.24	2.07)						
Stratified for all age groups ⁴	1.02	1.52	2.24	0.69	1.66	3.96	0.69	1.13	1.87
(MH test for interaction: $\chi^2 = 4.10$, 2df, NS)									
2. Cigarette smoking									
Nonsmoker vs. smoker									
30–44 years	0.72	2.69	9.99	0.61	2.83	13.24	0.22	2.42	27.19
	(0.56	1.98	6.96)						
45–59 years	0.85	1.79	3.77	0.53	2.24	9.43	0.70	1.67	3.97
	(1.41	2.85	5.76)						
60 years and older	0.84	1.50	2.70	0.20	0.69	2.42	0.97	1.91	3.75
	(0.91	1.57	2.69)						
Stratified for all age groups ⁴	1.30	1.95	2.92	0.62	1.38	3.07	1.09	1.84	3.09
(MH test for interaction: $\chi^2 = 1.75$, 2df, NS)									
3. Physical activity									
None vs. sometimes or regular									
30–44 years	0.11	0.40	1.43	0.10	0.47	2.15	0.02	0.26	2.97
	(0.11	0.38	1.38)						
45–59 years	0.42	0.85	1.73	0.22	0.85	3.25	0.37	0.85	1.97
	(0.45	0.90	1.79)						
60 years and older	0.24	0.39	0.63	0.17	0.36	0.73	0.22	0.42	0.81
	(0.29	0.46	0.72)						
Stratified for all age groups ⁴	0.38	0.54	0.78	0.24	0.43	0.78	0.32	0.53	0.88
(MH test for interaction: $\chi^2 = 2.84$, 2df, NS)									
4. Close personal relationship									
Absent vs. present									
30–44 years	0.06	0.30	1.51	0.06	0.49	4.39	0.01	0.12	1.48
	(0.06	0.29	1.42)						
45–59 years	0.19	0.47	1.16	0.16	0.68	2.84	0.10	0.34	1.14
	(0.34	0.79	1.84)						
60 years and older	0.24	0.40	0.65	0.28	0.49	0.85	0.06	0.19	0.60
	(0.37	0.56	0.84)						
Stratified for all age groups ⁴	0.41	0.58	0.83	0.31	0.51	0.84	0.11	0.23	0.51
(MH test for interaction: $\chi^2 = 2.84$, 2df, NS)									

¹Odds ratios of the total sample refer to stratified Mantel-Haenszel analyses pooled over both sexes (first line), or to crude estimates over both sexes (second line in parentheses).

²Odds ratios for males and females refer to crude estimates derived from the respective 2 × 2 tables.

³CI = confidence interval.

⁴Mantel-Haenszel estimates of the odds ratio stratified for age.

The analysis shows significant overall effects for each of the four lifestyles in the hypothesized direction: alcohol consumption and cigarette smoking increased the risk of dying, whereas physical activity and existence of a close personal relationship reduced mortality. The degrees of

the risks were about twofold for cigarette smoking and a 50% rise for alcohol consumption, while both protective factors reduced the risk to about one half.

Although some variation can be seen between the odds ratios of one lifestyle for different age

strata, these differences do not reach significance (see Table 3). The same can be said of possible gender differences.

All in all, the selected lifestyles showed the postulated influences on mortality. If this result is taken as a screening procedure for possible inclusion of the factors in more sophisticated models (as Hosmer & Lemeshow, 1989, suggest), it can be concluded that all four factors should be included in such models.

Dose-response relationships and control for confounding of age and somatic status. In a second step, odds ratios were determined also for different levels of lifestyle. Additionally, adjustments for age and severity of somatic diseases were included in the models (for reasoning see below). Mantel-Haenszel analysis was no longer possible, since many cells would have displayed no entries, owing to the relatively numerous factors included. Consequently, logistic regression was chosen as the method of analyses (see Kahn & Sempos, 1989, for a comparison of the methods). Technically, the programs of SYSTAT LOGIT (Steinberg, 1985) and LOGISTIC (Dallal, 1988) were used to estimate the logistic regression models. Analyses were made separately for males and females, for two reasons. Firstly, a joint analysis revealed significant gender differences in the risks related to different levels of alcohol consumption and cigarette smoking (significant respective interaction terms in the logistic regression equation). Secondly, a joint analysis would have to restrict itself to levels of lifestyle factors shared by both genders, and thus exclude a category such as heavy drinking (more than 80 ml/day) as a separate category.

Analyses were performed primarily for the age range 30–69 years at time of first interview (age-restricted sample), mainly because of specified causes of death in very old people are affected by the problem of multimorbidity, resulting in difficulties in attributing a specific cause of death. However, for comparison, the results for the total sample have also been provided. The subjects under 30 years of age were excluded from the age-restricted sample since only two deaths occurred in this group during the period of study.

As already indicated, all influences were calculated with *adjustment for age and judged severity of somatic disorders* within the last year, as rated by the research physician on a five-point scale.

Since mortality is clearly related to age as well as to the influencing factors, this adjustment was necessary. The reasons for adjusting for severity of somatic disorders were the following: The amount of smoking, drinking and physical exercise can be influenced by the presence of a somatic disorder, and therefore doctors may advise patients with a somatic disorder to stop smoking or drinking alcohol. They may also forbid physical activity. Since somatic disorders also affect mortality quite strongly (an increased risk of about 1.7 is associated with each additional degree of judged severity on the five-point scale; see Table 4), they constitute a classical case of a potential confounder (see Rothman, 1986). Hence it was decided to control for somatic disorders in analysing the influences on mortality of all four lifestyle factors.

Table 4 gives an overview of the adjusted effects of the examined factors. It can be seen that the expected dose-response relationships are present with one exception: cigarette smoking for females. This anomaly is discussed below.

Men and women differed in the magnitude of the associated relative risks. The data indicate that alcohol intake of more than 20 ml is the largest risk for mortality in *women* (among the examined lifestyle variables), increasing the chances of death more than threefold. An effect of about this size is rather large, according to the literature (see Shaper, 1990, for an overview). However, in the present study somatic status could be controlled for, and this variable is often suspected of obscuring the relationship between alcohol consumption and mortality (e.g. Shaper, 1990). The relative risks of tobacco smoking for mortality in women are difficult to explain, because they did not conform to the otherwise well-established dose-response relationship (compare also the results for males, described below). It has to be taken into account that in the 1970s cigarette smoking was less common than now among females in our rural population (only 7 of 489 females (1.4%) reported smoking more than a pack of cigarettes a day), and that false-negative reports about smoking may be expected in females, since at the time of original assessment it was socially less acceptable for females to smoke. The analysis was therefore repeated with the dichotomous risk factor smoker vs. non-smoker, showing a non-significant risk of 1.79 (total sample 1.78) for female smokers, with a confidence interval

Table 4. Influences of lifestyle variables on mortality—logistic regression analyses

95% CI limits ³	Females			Males		
	Odds ratio ¹			Odds ratio ¹		
	Lower	Upper		Lower	Upper	
1. Alcohol consumption						
Females $G = 5.8$, $p < 0.05^2$						
Males $G = 3.4$, NS						
0–20 ml		1.0			1.0	
20–80 ml	1.30	3.42	8.78	0.44	0.86	1.67
	(0.97	2.45	6.20)	(0.58	1.02	1.80)
More than 80 ml	Not applicable since there was only 1 case (included in the above category)			0.84	2.00	4.81
				(0.84	1.87	4.13)
2. Cigarette smoking						
Females $G = 4.5$, NS						
Males $G = 10.6$, $p < 0.05$						
Nonsmoker		1.0			1.0	
1–5 cigarettes	1.21	4.02	13.28	0.47	1.22	3.20
	(1.14	3.74	12.25)	(0.73	1.60	3.49)
6–20	0.34	1.06	3.32	1.12	2.40	5.13
	(0.33	1.05	3.32)	(1.17	2.31	4.57)
More than 20	Not applicable since there were only 11 cases (included in the above category)			1.58	4.17	10.02
				(1.53	3.86	9.73)
3. Physical activity						
Females $G = 3.1$, NS						
Males $G = 4.2$, NS						
None		1.0			1.0	
Sometimes	0.27	0.60	1.35	0.28	0.61	1.32
	(0.33	0.69	1.46)	(0.33	0.65	1.26)
Regular	0.15	0.47	1.43	0.22	0.48	1.04
	(0.20	0.50	1.25)	(0.31	0.58	1.09)
4. Close personal relationship						
Females $G = 1.4$, NS						
Males $G = 6.1$, $p < 0.05$						
No		1.0			1.0	
Yes	0.35	0.67	1.30	0.13	0.32	0.77
	(0.42	0.72	1.22)	(0.14	0.30	0.66)

¹ Odds ratio refers to logistic regressions with adjustment for age and physicians' judgement of the severity of somatic disorders within the last year.

² P values refer to tests of significance in the change of the deviance statistic where the respective variables were included in or excluded from the model (e.g. "cigarette smoking" by males refers to the inclusion vs. exclusion of all three dummy variables related to cigarette smoking; see Hosmer & Lemeshow, 1989, pp. 14ff.).

³ CI = confidence interval.

Numbers in parentheses refer to total sample aged ≥ 15 years.

reaching from 0.77 (0.77) to 4.17 (4.13). As to the protective factors, regular physical activities appear to be more protective than occasional activities. The lack of a partner resulted in an increased relative risk of $1/0.67 = 1.5$.

For men cigarette smoking was the most important risk factor in the sample and it showed a clear dose-response relationship, reaching from a

relative risk of 1.22 for males smoking up to five cigarettes a day, to a risk of 4.17 for those men who smoked more than two packs. In men alcohol consumption resulted in an increase of mortality only when larger quantities had been consumed: the risk was more than doubled with a daily intake of more than 80 ml pure alcohol. As regards physical activities, the results were

Table 5. Logistic regression models estimating the simultaneous influence of all four lifestyle factors on mortality

95% CI limits ²	Females			Males		
	Lower	Odds ratio ¹		Lower	Odds ratio ¹	
		Upper			Upper	
Age in years	1.05	1.09	1.14	1.08	1.12	1.16
Severity of somatic diseases	1.19	1.65	2.27	1.18	1.55	2.04
Alcohol consumption						
20–80 ml	1.41	3.94	11.01	0.43	0.86	1.73
More than 80 ml				0.56	1.41	3.57
Cigarette smoking						
1–5 cigarettes	1.12	4.02	14.45	0.32	0.89	2.52
6–20	0.26	0.85	2.81	0.94	2.06	4.49
More than 20				1.20	3.34	9.29
Physical activity						
Sometimes	0.21	0.50	1.18	0.34	0.76	1.69
Regular	0.09	0.32	1.05	0.26	0.57	1.25
Close personal relationship						
Yes	0.30	0.60	1.20	0.13	0.34	0.88

With interaction of alcohol and physical activity

95% CI limits ²	Females		
	Lower	Odds ratio ¹	
		Upper	
Age in years	1.05	1.09	1.14
Severity of somatic diseases	1.29	1.79	2.49
Alcohol consumption			
More than 20 ml	0.07	0.60	5.20
Cigarette smoking			
Yes	0.62	1.55	3.90
Physical activity			
Sometimes	0.33	0.77	1.81
Regular	0.18	0.59	1.93
Partnership			
Yes	0.30	0.60	1.19
Interaction alcohol-sport			
Alcohol and no sport	1.77	21.63	264.05

¹For explanation see Table 4.

²For explanation see Table 4.

similar to those for women: regular physical activities were more protective than occasional activities, and the latter were more protective than none at all. As to close personal relationships, a significant protective effect of living with a steady partner was observed. In terms of relative risks, lacking a close personal relationship was associated with a more than threefold risk of dying in the course of the observation period.

Models including all four lifestyle variables simultaneously. The estimates of the logistic regression

models for all four lifestyle factors simultaneously, and again adjusted for age and somatic status, are summarized in Table 5.

For men none of the possible interactions between different lifestyle factors added significant information to a model including only the lifestyle factors (see Table 6). Also, since the relative risks remained about the same, it can be concluded that adjustment for, and interplay between, the different lifestyle factors did not change the separate estimates of influences for each lifestyle factor.

Table 6. Likelihood ratio test statistic (*G*) and degree of freedom (*df*) for possible interaction of interest to be added to the main-effects-only model

Interaction added	Females			Males		
	G ¹	df	<i>p</i> -value	G	df	<i>p</i> -value
Alcohol drinking * cigarette smoking	0.4 (0.3)	1 1	NS ² (NS)	0.2 (1.3)	1 1	NS (NS)
Alcohol drinking * no physical activity	10.9 (12.9)	1 1	<i>p</i> < 0.001 <i>p</i> < 0.001)	0.0 (0.1)	1 1	NS (NS)
Cigarette smoking * no physical activity	0.1 (0.4)	1 1	NS (NS)	0.8 (0.9)	1 1	NS (NS)
Alcohol drinking * no partner	1.6 (0.6)	1 1	NS (NS)	0.5 (0.0)	1 1	NS (NS)
No partner * no physical activity	0.4 (0.7)	1 1	NS (NS)	0.0 (0.1)	1 1	NS (NS)
No partner * cigarette smoking	3.3 (2.6)	1 1	<i>p</i> < 0.10 (NS)	0.2 (1.1)	1 1	NS (NS)

For the main-effects-only model, the log likelihood for females was -126.4 (-190.3), for males -128.3 (-175.4).

¹For purposes of assessing the significance of an interaction term the value of the weighted log-likelihood (weighted by -2) of the model with and without the interaction term in the equation is compared (see Hosmer & Lemeshow, 1989, pp. 14ff. and pp. 82ff.). The *G* statistic follows a χ^2 distribution under certain assumptions (Hosmer & Lemeshow, 1989).

²NS means *p* > 0.10.

Numbers in parentheses refer to total sample aged ≥ 15 years.

For women a different picture emerged. Here the interaction of physical activity and alcohol intake had a striking effect (see Table 6). Women who drank more than 20 ml of pure alcohol a day *and* who engaged in no physical activity had a 20 times higher risk of dying during the 13-year observation period than those not belonging to this category. In comparison with this factor, all the other risks and protective factors lost importance.

Illustration of the implications of different risk profiles for mortality

The following example illustrates the implications of different risk profiles for individuals.

The mortality risks for healthy 40-year-old females and males were calculated under worst compared with best lifestyle conditions. The best conditions for a 40-year-old woman consisted in drinking less than 20 ml of alcohol a day, abstaining from smoking, having a steady partner, and doing regular physical exercise. The mortality risk of such a woman could be calculated by inserting the respective alpha and beta values in the logistic regression equation (see formula 1

below; for further details see Kahn & Sempos, 1989).

Formula 1

$$p(d = 1 | x) = 1 / \{ 1 + e^{[-(\beta_0 + \beta_1 x_1 + \dots + \beta_k x_k + \beta_m x_m + \beta_n x_n)]} \}$$

where

d is the risk of death (*d* = 1)

x is the vector of influencing factors and adjustment variables

$x_1 \dots x_i$ are the lifestyle variables (coded 0/1)

x_k is the interaction term of alcoholic intake* lacking physical activity (included in the model for females only)

x_m, x_n are variables used for adjustment ('age in years', and 'judged severity of somatic disorders' from a 5-point rating-scale).

The alpha and beta values constitute the logged values of the odds ratios presented in Table 5 (see Kahn & Sempos, 1989, p. 153, for further explanation.

The substitution resulted in a probability of 0.006, or 6 per 1000, of a healthy 40-year-old

woman dying within the 13 years after the interview if she showed the best lifestyle factor profile (as described above).

Inserting the values for the most negative combination of lifestyle factors (drinking more than 20 ml of alcohol a day, smoking more than a pack of cigarettes, no regular exercise, and lacking a close personal relationship) would result in a much higher chance of dying within the next 13 years: 0.260 or 260 per 1000. This risk is more than 40 times higher than the risk for women with the ideal risk profile. This risk difference due to lifestyle variables is considerable and depends largely on the interaction effect of alcohol consumption and exercise (see Table 5 above).

For a 40-year-old man, the same analyses were performed. The highest mortality risk was seen in a healthy 40-year-old man who drank more than 80 ml of pure alcohol a day, smoked more than a pack of cigarettes, did not engage in physical activities, and had no steady partnership. The resulting probabilities were 0.010 (10 per 1000) for men with protective lifestyles compared with 0.197 (197 per 1000) for men with unfavourable lifestyles.

Association with specific causes of death

An analysis of the factors that influence specific causes of death in the Upper Bavarian Study requires a choice between analysing the total sample or imposing an age restriction, with both alternatives having marked disadvantages. The use of the total sample could bring chance results, owing to problems of multimorbidity, or to covariance of lifestyles with illness from other causes, especially in older ages. For example many persons over 80 have to restrict their physical activities greatly during somatic illness. Therefore, the idea of analysing the total sample was discarded.

However, restricting the analysis to subjects of 30–69 years leads to small numbers in the different sub-categories of causes of death. For example, lung cancer as cause of death was entered on the death certificates of only four males of between 30 and 69 years. Since the pattern of results concerning the influence of lifestyle factors (present vs. absent) on mortality was largely similar for males and females (see Table 3 above), it was decided to keep the age restriction but to analyse males and females

together (with an appropriate term for gender in the regression equations).

The results of the logistic regression analyses are presented below, again controlled for age and somatic disorders during the year preceeding the interview. The relatively large confidence intervals require caution in interpretation. They result from the relatively small numbers in the different sub-categories of causes of death:² for cardiovascular disease (ICD9 390.0–459.9) 39 persons; for cancer (ICD9 140.0–239.9) 23; for lung cancer (ICD9 160.0–165.9) six; and for injuries and poisoning (ICD9 800.0–999.9) four. Nevertheless, the following conclusions seem to be justified:

(1) Age seems to be related more to mortality due to heart and circulatory diseases than to mortality from cancer. With each year, the risk of dying of cardiovascular diseases increases by 15% (Confidence interval—CI 10–21%), whereas the risk of dying of cancer increases by 5% (CI 1–10%).

(2) Alcohol consumption was established as a risk factor for all deaths (see above). The risk is especially high for injuries and poisoning (OR 3.5 with CI from 0.31 to 40.4; not significant because only four persons died from these causes). For cardiovascular diseases, however, the effect of drinking more than 20 ml of pure alcohol a day is slightly protective: OR = 0.70 with CI from 0.30 to 1.66. This confirms recent results of other cohort studies on cardiovascular mortality (Miller, 1992; Boffetta & Garfinkel, 1990) and morbidity (Stampfer *et al.*, 1988; Rimm *et al.*, 1991).

(3) Cigarette smoking increases the risk of cardiovascular diseases (OR 1.28; CI 0.58–2.81) as well as of cancer (OR 1.63; CI 0.63–4.19), although not significantly in the relatively small samples of this study. Here, the well-known relationship to lung cancer yields the highest OR 3.1; with CI between 0.51 and 18.6 ($n = 6$ cases of lung cancer). The relatively few persons with lung cancer in the sample, as well as the possibility of differential misclassification, may explain

²'Cause of death' did not include mode of dying, e.g. heart failure or asthenia. Moreover, if the condition directly leading to death was due to (or a consequence of) other specified antecedent causes, only those antecedent causes were classified as 'causes of death' in our analyses (see Bundesminister für Jugend, Familie und Gesundheit, 1979, pp. 779ff.). Otherwise, there would be a considerable overlapping of cases in which the condition leading to death was related to heart disease and the antecedent cause would be a cancer.

the relatively small risk found, which usually is more than 10 (e.g. Garfinkel & Silverberg, 1990).

(4) Sport has protective effects for cardiovascular diseases (OR 0.69; CI 0.38–1.23) and, surprisingly, even larger and statistically significant protective effects for cancer (OR 0.34; CI 0.12–0.96).

(5) Having a close personal relationship is protective for heart diseases (OR 0.82; CI 0.36–1.87), but seems to be inversely related to cancer (OR 1.64; CI 0.50–5.34). Again, the relationships are not statistically significant.

Discussion

The impact on mortality of alcohol intake, cigarette smoking, physical activity, and living in a steady relationship was analysed longitudinally in a representative community sample. In summary, the results confirmed that increased alcohol intake and smoking were risk factors, whereas physical activity and living in a close personal relationship should be regarded as protective factors.

Cigarette smoking appeared to be the principal risk factor for males, and alcohol intake for females. The protective effects of physical activity were about the same for both sexes. Regular activities were more protective than occasional, and occasional more protective than no or almost no activities. The effect of living in a partnership was more protective for men than for women.

As regards the significance of all analyses undertaken so far, it should be taken into account that statistical significance depends on the magnitude of the effect sizes (= relative risks) as well as on the sample size (cf. Rosenthal & Rosnow, 1984). If the sample sizes for males and females were doubled and the effects amounted to the same size, most effects would show statistical significance.

More important than mere statistical significance was the fact that the consumption of alcohol, cigarette smoking, and physical activity showed dose-response relationships for both sexes (except the already discussed case of cigarette smoking for women). Thus, abstaining from cigarettes, drinking less than 20 ml of pure alcohol a day, and regular involvement in physical activity clearly emerged as best behavioural alternatives with respect to mortality.

The examples of a 40-year-old male and a 40-year-old females showed that lifestyle can make a difference. For example, about every fifth man with an "unfavourable" lifestyle of that age would die within 13 years, but only every 100th man with a "favourable lifestyle". It should be noted that in this comparison the distinction between favourable and unfavourable refers to all four variables included in the analysis.

Such lifestyle profiles are not very unusual, however, since risky behaviours tend to correlate as well as protective behaviours. In other words, females who are already at risk from smoking are more likely to also drink alcohol, and those who lack social support are also less likely to engage in physical activity. Similarly, the same men tend to drink and smoke, as well as to refrain from physical activities. Thus, the extreme risk profiles occur not only in epidemiological 'worst case scenarios' but also in reality. For example, in the restricted sample of persons of 30–69 years of age, 5.3% of the females and 10.3% of the males showed risk-factor profiles in which at least three of four lifestyle variables had unfavourable values (as defined in the scenario above).

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References

- BOFFETTA, P. & GARFINKEL, L. (1990) Alcohol drinking and mortality among men enrolled in an American Cancer Society prospective, *Epidemiology*, 1, pp. 342–348.
- BUNDESMINISTER FÜR JUGEND, FAMILIE UND GESUNDHEIT (Ed.) (1979) *Handbuch der Internationalen Klassifikation der Krankheiten, Verletzungen und Todesursachen (ICD)*, 9, Revision, Vol. 1 & 2 (Wuppertal, Deutscher Consulting).
- DALLAL, G. E. (1988) LOGISTIC: a logistic regression program for the IBM PC, *The American Statistician*, 42, p. 272.
- DILLING, H. & WEYERER, S. (1984a) Psychische Erkrankungen in der Bevölkerung bei Erwachsenen und Jugendlichen, in: DILLING, H., WEYERER, S. & CASTELL, R. (Eds) *Psychische Erkrankungen in der Bevölkerung*, pp. 1–121 (Stuttgart, Enke).
- DILLING, H. & WEYERER, S. (1984b) Prevalence of mental disorders in the small town–rural region of

- Traunstein (Upper Bavaria), *Acta Psychiatrica Scandinavica*, 69, pp. 60-79.
- DILLING, H., WEYERER, S. & CASTELL, R. (1984) *Psychische Erkrankungen in der Bevölkerung* (Stuttgart, Enke).
- DOLL, R. & PETRO, R. (1981) *The Causes of Cancer* (Oxford, Oxford University Press).
- FICHTER, M. M. (1990a) *Verlauf psychischer Erkrankungen in der Bevölkerung* (Berlin, Springer). (English summary, pp. 313-316).
- FICHTER, M. M. (1990b) Prävalenz von Alkoholabusus und -abhängigkeit der Bevölkerung, in: FICHTER, M. M. (Ed.) *Verlauf psychischer Erkrankungen in der Bevölkerung*, pp. 72-83 (Berlin, Springer).
- FICHTER, M. M. & WITZKE, W. (1990) Methodik, in: FICHTER, M. M. (Eds) *Verlauf psychischer Erkrankungen in der Bevölkerung*, pp. 11-45 (Berlin, Springer).
- FICHTER, M. M., REHM, J. & WITZKE, W. (1990) Verlauf psychischer Erkrankungen in der Bevölkerung, in: FICHTER, M. M. (Ed.) *Verlauf Psychischer Erkrankungen in der Bevölkerung*, pp. 274-307 (Berlin, Springer).
- FICHTER, M. M., WEYERER, S. & DILLING, H. (1989) The 5-year follow-up study in Upper Bavaria, *Acta Psychiatrica Scandinavica*, 79, Suppl. 348, pp. 130-140.
- GARFINKEL, L. & SILVERBERG, E. (1990) Lung cancer and smoking trends in the United States over the past 25 years, in: DAVIS, D. L. & HOEL, D. (Eds) *Trends in Cancer Mortality in Industrial Countries*, pp. 146-158 (New York, Annals of the New York Academy of Sciences, 609).
- GOLDBERG, C. H., COOPER, P., EASTWOOD, R. R., KEDWARD, M. B. & SHEPHERD, M. (1970) A standardized psychiatric interview for use in community surveys, *British Journal of Preventive and Social Medicine*, 24, pp. 18-23.
- KAHN, H. A. & SEMPOS, C. T. (1989) *Statistical Methods in Epidemiology* (Oxford, Oxford University Press).
- HOSMER, D. W. & LEMESHOW, S. (1989) *Applied Logistic Regression* (New York, Wiley).
- MANTEL, N. & HAENSZEL, W. (1959) Statistical aspects of the analysis of data from retrospective studies of disease, *Journal National Cancer Institute*, 22, pp. 719-748.
- MILLER, G. J. (1992) Alcohol consumption: protection against coronary heart disease and risks to health, in: VEENSTRA, J. & VAN DER HEIJ, D. G. (Eds) *Alcohol and Cardiovascular Disease*, pp. 35-44 (Wageningen, Pudoc).
- THE MULTIPLE RISK FACTOR INTERVENTION TRIAL RESEARCH GROUP (1990) Mortality rates after 10.5 years for participants in the Multiple Risk Factor Intervention Trial. Findings related to *a priori* hypotheses of the trial, *Journal of the American Medical Association*, 263, pp. 1795-1801.
- RIMM, E. B., GIOVANUCCI, E. L., COLDITZ, G. A., ASCHERIO, A., ROSNER, D., WILLETT, W. C. & STAMPFER, M. J. (1991) A prospective study of alcohol consumption and the risk of coronary disease in men, *Lancet*, 338, pp. 464-468.
- ROSE, G. (1985) Cardiovascular diseases, in: HOLLAND, W., DETELS, R. & KNOX, G. (Eds) *Oxford Textbook of Public Health*, Vol. 4, pp. 133-144 (Oxford, Oxford University Press).
- ROSENTHAL, R. & ROSNOW, R. L. (1984) *Essentials of Behavioral Research* (New York, McGraw-Hill).
- ROTHMAN, K. J. (1986) *Modern Epidemiology* (Boston, Little Brown).
- SALSBURG, D. S. (1985) The religion of statistics as practiced in medical journals, *The American Statistician*, 39, pp. 220-223.
- SARACCI, R. (1985) Neoplasms, in: HOLLAND, W., DETELS, R. & KNOX, G. (Eds) *Oxford Textbook of Public Health*, Vol. 4, pp. 112-129 (Oxford, Oxford University Press).
- SHAPER, A. G. (1990) Alcohol and mortality: a review of prospective studies, *British Journal of Addiction*, 85, pp. 837-847.
- STAMPFER, M. J., COLDITZ, G. A., WILLETT, W. C., SPEIZER, F. E. & HENNEKENS, C. H. (1988) A prospective study of moderate alcohol consumption and the risk of coronary heart disease and stroke in women, *New England Journal of Medicine*, 319, pp. 267-273.
- STEINBERG, D. (1985) *LOGIT. Manual* (Evanston, IL, SYSTAT).

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