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Adaptation to life after surgical removal of the bladder—an application of graphical Markov models for analysing longitudinal data

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SUMMARY

Graphical Markov models have been developed particularly for the analysis of observational data. They allow the control of various background variables when analysing theoretically relevant associations. This paper demonstrates the application and some advantages of graphical Markov models in comparison to conventional statistical analyses. The aim of the study was to identify patients at risk for developing decreased health-related quality of life (QoL) after cystectomy and to explore the influence of coping on QoL in this situation. Therefore, the method was applied to analyse the data of a prospective study, in which 81 patients with bladder cancer were interviewed pre-operatively and in a 1-year follow-up. QoL was assessed both times, and two basic coping strategies (active and depressive) were measured preoperatively. The explanatory variables of theoretical interest were active and depressive coping strategies. As a result of the analysis, relevant proportions of variance in the development of QoL could be explained by the suggested model (60 per cent in mental component, 40 per cent in physical component of QoL). Active coping was positively related to QoL, depressive coping negatively. These effects were linear in the physical component of QoL, moderated by working status and the type of urinary diversion in the mental component of QoL. Copyright © 2004 John Wiley & Sons, Ltd.

KEY WORDS: graphical Markov model; quality of life; coping; bladder cancer; urinary diversion; longitudinal study

INTRODUCTION

Graphical Markov models represent a statistical method to describe and summarize associations between variables [1]. They enable the graphical representation of the structure among a relatively large number of variables and therefore can be used for analyses of complex association structures. In the formulation of the model, assumptions derived from the theoretical

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disciplines can be integrated in the statistical model. Like path analysis, graphical Markov models enable a hierarchical *a priori* ordering of variables. However, the models go beyond path analysis, mainly in two ways. First, they permit the inclusion of continuous as well as discrete explanatory variables and responses (but not rank variables); secondly, they allow for the testing of non-linear associations. Graphical Markov models were developed for the analysis of observational data, when a variety of background variables cannot be controlled for by design, but by the statistical analysis. They are particularly useful for the analysis of longitudinal data, in which case the *a priori* ordering of variables can be supported by the time sequence of their observation. They are also applicable in the analysis of cross-sectional data.

The variables under examination are divided into response variables and explanatory variables. Multiple responses can be formulated. In addition, mediating variables can be added; that means that the mediating variables are explanatory variables for one set of variables and response variables for a different set. Associations between each pair of variables in the model are directional. The associations can be either missing, linear, quadratic or interactive. This constitutes one big advantage of graphical Markov models compared to structural equation models, which imply linear relationships. Because the variables are ordered in a model, indirect paths can be obtained in addition to the direct associations. Technically, graphical Markov models consist of a set of multiple regression and multiple logistic regression analyses. In the present paper, an example of a complex statistical analysis of non-experimental data based on a graphical Markov model is presented in the context of the changes in quality of life (QoL) in patients who have bladder cancer. A more technical illustration of the method using categorical data was given by Klein *et al.* [2]. Some theoretical considerations and a short example are presented by Cox *et al.* [3], while Wermuth [4] gives an overview.

Ghoneim *et al.* [5] estimated 5-year survival rates at about 50 per cent after radical surgery. Radical surgery of the bladder means the complete removal of the bladder and the construction of an artificial urinary diversion. Furthermore, having to live with an artificial urinary diversion presents an additional extraordinary stress that must be coped with. Besides giving short-term psychological assistance, it is important for health-care practitioners to examine factors that contribute to the long-term outcome and to try to develop interventions to help patients cope with their disability and with the disease. On the other hand, those patients who survive do not, on average, exhibit a drastic decrease in their health-related QoL [6–9][‡]. Some patients were able to lead a life very similar to the one they had before the surgery, i.e. they returned to work, reporting only minor restrictions concerning food intolerance, bowel function or dressing. Others were not able to perform so well.

From the clinical and human viewpoint, this raises the question of whether, in addition to the urological treatment, patients should get professional psychological support on a regular basis to help them cope with their situation. In psycho-oncology, the judgements on how many patients should receive such support differ. Patients themselves reported at a rate of about 12–20 per cent that they were interested in psychosocial support, but when the psycho-oncologists were asked, the rate was about 40–60 per cent [10–12]. Psychosocial interventions in patients with cancer generally have been seen to have positive effects on QoL or other

[‡]Only health-related aspects of QoL are discussed here, so the term QoL stands for health-related QoL throughout the paper.

measures of adaptation, for a summary, see References [13, 14]. But some detailed explorations of psychological interventions reported none or even negative results for subgroups of patients, e.g. a structured peer discussion group had no positive effect in patients having high emotional support from their partners [15, 16]. In the same study, a similar interaction was found for oncologists' informational support. Hence, an observational study examining how patients perform without psychological intervention and who is at risk to develop low QoL may help supply the background information necessary for assessing the need for interventions.

From a theoretical viewpoint, the present study makes it possible to examine the role of coping in an existentially threatening situation. The currently prevalent view of stress and coping as a transactional process implies that the perceived stress is confounded with the coping options, because the threat of the situation is reappraised after examining the possibilities of coping with it in a circular model [17]. Longitudinal designs are one way of dealing with this confounding, as they enable us to see a long-term outcome of the transactional model [18]. According to Folkman and Lazarus [19]. Two basic dimensions in coping strategies have been examined in depth in various situations: problem- and emotion-focused coping. Although this dualism has been found to be too simplistic, e.g. asking a doctor about the disease may serve problem- and emotion-focused coping simultaneously [20]. The concept has brought up numerous research and interesting results.

In research on coping with a disease, some initial studies (some of them analysing patients with various diseases simultaneously) had found that active coping strategies had no effect on adaptation, and emotion-focused coping strategies were negatively related to adaptation [21]. These results have been criticized, partly because most questionnaires designed to assess emotion-focused coping contained items confounding with negative adaptation [22]. When the confounding items were avoided and a homogeneous group with respect to the disease was examined (breast cancer), associations between the emotion-focused coping strategy 'emotional expression' and various indicators of adaptation were observed. All of these associations indicated that emotional expression is associated with better adaptation, but none of them was found to be strong. In Stanton *et al.*'s study, which considered various coping strategies and other explanatory variables simultaneously, active coping again showed no relation to indicators of adaptation in a multiple regression analysis [23].

In most studies, only linear relations between coping and adaptation have been examined; however, linearity is not always the case. In a few studies, interactional effects have been tested and some interesting results emerged. For example, in patients with an inflammatory bowel disease, active coping was negatively related to adaptation for patients who were in an active phase of the disease, and no relation was seen for those in remission [24]; for another example, see Reference [25]. Another possible type of relation, which has seldom been explored, is that moderate use of a coping strategy might be more beneficial for adaptation than either extreme or very little use. In this case, a quadratic curve would fit the relation. In patients with bladder cancer, Mansson *et al.* observed such an effect indirectly. In a 1-year follow-up, patients with low defensive coping frequently recalled their first post-operative month to have been either extremely stressful or not stressful at all—whereas patients with good coping strategies scored mostly in the middle. A similar relation was found in a 5-year follow-up. The retrospective assessment of the first month itself was associated with several indicators of adaptation. A moderate degree of defensive coping seems to be optimal for a good adaptation at follow-up. In patients with chronic pain, Hardt [26] observed this kind of non-linear relation between

the coping strategy 'diverting attention' and treatment success. In the present study coping was assessed shortly before surgery, and a quadratic relation can be assumed for depressive coping. Perhaps a medium amount of depressive coping is better in this situation than a very little or extreme amount, and therefore may be related to a good long-term adaptation.

Given the background of (1) the extreme stress that patients with cancer may have to cope with, (2) the partly inconsistent results concerning the relationships between coping and adaptation and (3) the fact that most analyses were performed within a linear context, it seemed worthwhile to undertake an examination of these relationships using a graphical Markov model on a homogeneous sample with several background variables of interest. The aim of the study was to answer two questions: Which patients undergoing surgical treatment for bladder cancer are particularly at risk for developing decreased QoL? What is the influence of coping on QoL in patients experiencing such an extremely stressful and life-changing situation?

METHODS

Patients

After a pilot phase in January 1996, patients undergoing cystectomy (removal of the bladder) were consecutively recruited in the Urological Department of the University of Mainz from February 1996 to June 1998. Only patients whose surgery had occurred because of an actual or previously malignant disease are considered here. Exclusion criteria were the inability to speak and write German or severe mental disorders such as major depression or dementia. A total of 152 patients were eligible for the study; 107 patients (70 per cent) were interviewed preoperatively (21 refused to participate, 19 did not fill out the questionnaires, five could not be asked preoperatively). Out of the 107, 81 (76 per cent) could be re-interviewed at a 1-year follow-up. During that year, 21 patients died as a result of their disease, three were too ill due to tumour progression to be re-interviewed, and two more refused to participate, i.e. did not answer the letters and phone-calls at follow-up. Bivariate comparisons between the 81 patients who were re-interviewed and the 26 others revealed p-values >0.20 in all preoperative measures, except that the re-interviewed patients showed higher education ($p=0.10$), higher psychological distress ($p=0.13$), more continent diversions ($p=0.15$), and lower tumour stage ($p=0.15$). The patients' educational status was high: 20 per cent had a university degree, an additional 35 per cent had received between 10 and 12 years of formal education, and only 46 per cent had nine or fewer years of formal education. Other relevant patient characteristics are summarized in Table I.

Design and instruments

The design of the study was prospective and observational. After providing written informed consent, patients were interviewed three times by a psychologist (JH): 2–5 days preoperatively (time 1), 2 weeks post-operatively (time 2), and at a 1-year follow-up (time 3). After each interview, they filled out the questionnaires. As neither coping nor QoL was assessed at time 2, results presented here focus solely on time 1 and time 3. The time interval was set to 1 year to focus on long-term rather than short-term adaptation. To avoid a bias of social desirability, it was made clear to every patient that participation in the study was absolutely

Table I. Sample description.

Continuous variables	n	$\bar{x}$	SD	Quantiles				
				Min.	10 per cent	Median	90 per cent	Max.
QoL (z values)								
Mental preop.	81	−0.63	0.98	−2.52	−2.10	−0.61	0.68	1.21
Mental follow-up	81	−0.46	0.95	−2.77	−1.86	−0.37	0.72	0.92
Physical preop.	81	−0.33	0.83	−2.99	−1.36	−0.21	0.65	1.24
Physical follow-up	81	−0.47	0.87	−2.71	−1.63	−0.48	0.76	1.04
Active coping	80	3.49	0.89	1.00	2.25	3.50	4.66	5.00
Depressive coping	80	1.85	0.65	1.00	1.00	1.80	2.80	3.20
Psychological distress	81	37.95	9.40	23.00	27.00	36.50	49.50	68.00
Bodily complaints	81	9.88	9.32	0.00	0.00	7.00	25.00	37.00
Tumour-stage	81	1.77	1.24	0.00	0.00	2.00	3.00	4.00
Tumour-grading	81	2.31	1.07	0.00	0.00	2.00	3.00	4.00
Number of prev. diseases	81	2.65	1.71	0.00	1.00	2.00	5.00	8.00
Age (years)	81	63.61	9.05	44.00	51.00	63.00	75.00	82.00

Discrete variables	per cent	n
Chemotherapy postoperative	16	13/80
Surgical complications	27	22/81
Type of diversion (per cent continent)	47	38/81
Sex (per cent female)	25	20/81
Working status (per cent employed)	48	39/81

Note: All variables were scored according to the wording of their labels, i.e. high values mean good QoL, much coping, many complaints and high distress. A maximum of one missing case per variable was substituted by the sample mean (in che was set to zero).

voluntary and in no way related to the urological treatment they would receive, and that all answers would be kept anonymous before the members of the Urological Department [27].

QoL was assessed by the SF-36 [28], a 36 item self-rating questionnaire designed in the U.S.A. The SF-36 contains eight domains: physical functioning, role limitations because of physical health, bodily pain, general health perceptions, vitality or energy, social functioning, role limitations because of emotional problems and mental health. Responses to each question were combined according to the eight dimensions defined by the manual [29]. Two further summary components, the mental component summary (MCS) and the physical component summary (PCS) have also been derived from factor analysis. The standard procedure to combine the eight subscores to form the MCS and PCS has recently been criticized, partly because both components were planned to be uncorrelated, which resulted in some negative scoring coefficients [30–32]. Various scoring alternatives have been suggested [33, 34]. Hays *et al.* [35], in the medical outcome study, developed alternative scoring coefficients that allow mental and physical components to correlate. These alternative scoring coefficients were used here to calculate the mental and physical components of QoL. Before doing so, the eight score values were compared to means and standard deviations (SD) of age- and gender-matched reference groups from the German general population (as presented in the manual), and the individual values were transformed into z values. This transformation was done for

two reasons. First, it is known that in some aspects QoL decreases differently with age for men and women. Second, reference values are at different levels for the different subscale scores. The SF-36 questionnaire was given to the patients twice, first preoperatively and again at the 1-year follow-up. Mental and physical QoL at follow-up were the primary response variables in the analyses. QoL was assessed preoperatively to obtain baseline values for every patient.

Chemotherapy and surgical complications have been added as possible mediators between the two assessments of QoL because they may contribute to lowering the QoL at follow-up. Chemotherapy was administered to all but one patient using the M-VAC scheme, a combination of methotrexat, vintblastin, adriamycin and cisplatin [36]. The regular sequence is six cycles; it was coded 'yes' if the patients had completed at least two cycles. Post-surgical complications were coded 'yes' if there were either complications directly related to surgery or major problems during the first weeks after surgery.

Preoperative coping strategies were the explanatory variables of primary interest. They were assessed by the Freiburger Fragebogen zur Krankheitsverarbeitung (FKV) [37], a 35-item questionnaire designed to measure five dimensions out of which two were utilized here: active and problem-oriented coping (four items), and depressive coping (five items). Considering the item contents, active coping can be regarded as largely congruent with problem-focused coping, and depressive coping with emotion-focused coping [38]. Active coping can be characterized by seeking information and behavioural action, depressive coping by showing negative emotions in thoughts and interpersonal reactions. Although high values in act seem to stand for a spirited and courageous mind, while high values in dep represent a temper of giving way to one's fears, both scales are far from being the two endpoints of a single dimension. The correlation between both is low ($r = 0.21$). A detailed analysis of the internal structure of the questionnaire in patients with various diseases is given elsewhere [39].

Predictors for the use of the coping strategies should be examined, too. Psychological distress and physical complaints have been added to the analysis because they may be related to both coping and QoL. A measure of psychological distress was added to exclude the possibility that there may be one factor responsible for a large, common part of variance in several measures of the analysis. A measure of physical complaints was added because the physical conditions of the patients varied strongly, i.e. some patients had multiple, severe comorbitities while others, except for their bladder tumours, were healthy. Attention was paid to selecting questionnaires that do not overlap in item formulation with the SF-36 and the FKV. Hence, we chose the trait dimension of State-Trait Anxiety Inventory (STAI) [40, 41] as a global indicator for psychological distress, and the global symptom score of the Giessener Beschwerdebogen GBB, [42] for bodily complaints.

The psychological distress and physical complaint questionnaires were added in the same step as the questionnaires on coping strategies, as coping may influence the report of complaints and distress, and *vice versa*. The type of diversion was also added in this step, as the patients were aware at this time of what type of diversion they were going to receive. Two different kinds of urinary diversions were considered: continent and incontinent [43]. An incontinent urinary diversion is a stoma on the anterior abdomen wall, covered by an adhesive stoma bag for urine collection. A continent urinary diversion is an interior reservoir created from segments of intestines, with an almost invisible stoma beyond the umbilicus. The obvious visible advantage of a continent diversion has some drawbacks; patients have to evacuate the urine every 4–5 h via self-catheterization. For the majority of the patients, this

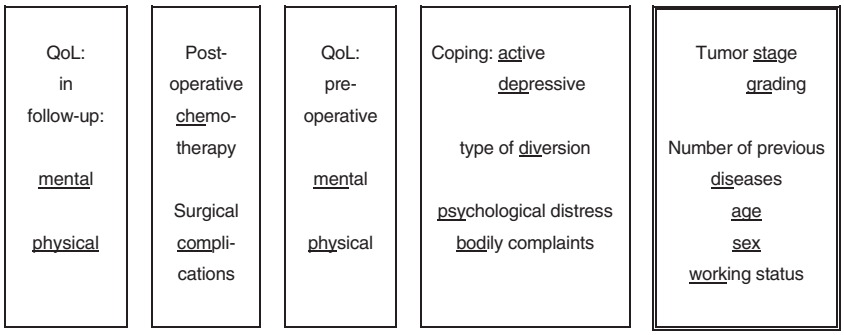


Figure 1. Order of variables determining the dependencies for the graphical chain model.

implies getting up once a night. Lengthening intervals or forgetting catheterization may cause serious harm such as dilation of the upper urinary tract. In contrast, an incontinent diversion may result in the worst-case in urinary leakage. Some patients cannot receive a continent diversion because of medical risk (comorbidity, age).

Additional predictors were considered: tumour stage and grading, previous diseases, age, sex and working status. Tumour stage and grading are coded following the TNM classification [44]. This yields ranking scores that each can take five values between 0 and 4. As there is no separate possibility to consider rank variables in graphical Markov models, they were treated as continuous variables here. The number of previous diseases was assessed by a list of 32 frequent diseases (heart attack, diabetes, etc.) and two open questions. No trivial diseases were counted. The score was successfully used in a similar analysis in chronic pain patients [26]. Age, gender and working status were assessed before surgery. These additional predictors were added to control for possible statistically important associations, which might bias the results. However, because they were not the targets of the analysis (and cannot be influenced by the variables under analysis), no relationships between these additional predictors were analysed.

Statistical analysis

A five-step ordering of the variables was chosen for analysis. Figure 1 gives an overview of the variables under analysis. The graphical Markov model [1] utilized for analysis is a set of multiple regression and multiple logistic regression equations, depending on the response variable being continuous (represented as a circle in the chain graph) or discrete (represented as a dot). In both forms of regression analyses, main-, quadratic- and 2-way interaction effects serve as possible explanatory variables. Two kinds of graphs illustrate the dependencies. The chain graph gives an overview by using arrows and edges to indicate significant associations and by using missing connections to show (conditional) independencies between variables (Figure 2). The type and strength of the association is shown by x–y graphs (Figure 3) and is underlined by the regression tables (Table II).

Variable selection in each regression analysis followed a step-by-step procedure. First, a backward selection of the main effects of all possible explanatory variables was performed. To the resulting model, all quadratic and interaction terms were offered. The term with the

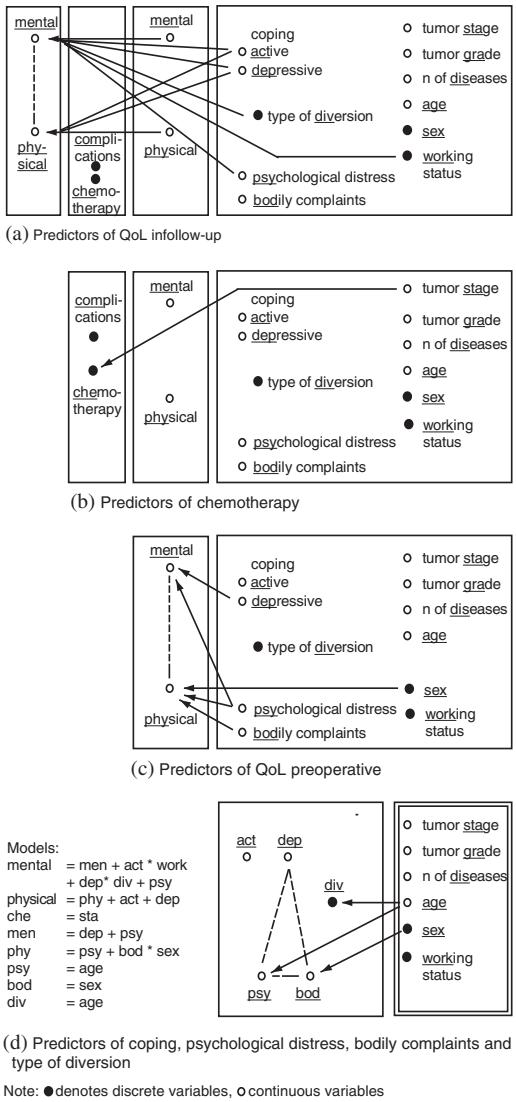
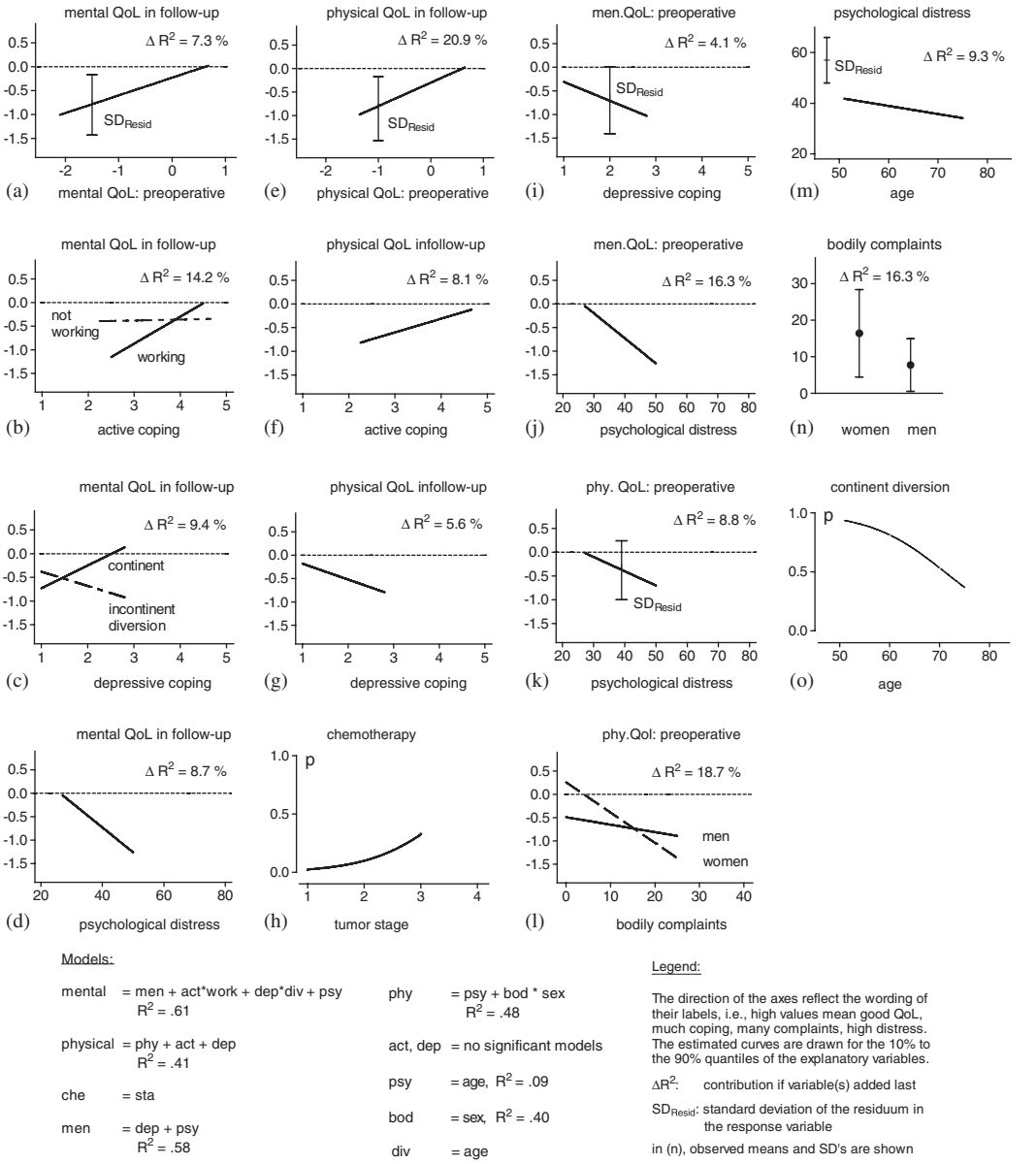


Figure 2. Chain graph summarizing the observed dependencies and independencies.

highest absolute t-value was tested (including the underlying main effects if they had not already been in the model). A term was added if the model change and the t-value for the quadratic or interaction term were significant, i.e. $p < 0.01$. Otherwise, the next significant term was tested. When added, partial residual plots were inspected; the term would have been removed if significance had been only an effect of outliers. This was not the case in the present analysis. If the term remained in the equation, all remaining main-, quadratic- and interaction terms were offered to the resulting model again. The procedure was repeated until all p-values for variables not in the regression equation were > 0.01. The



Models:

mental = men + act*work + dep*div + psy
R^2 = .61

physical = phy + act + dep
R^2 = .41

che = sta

men = dep + psy
R^2 = .58

phy = psy + bod * sex
R^2 = .48

act, dep = no significant models

psy = age, R^2 = .09

bod = sex, R^2 = .40

div = age

Legend:

The direction of the axes reflect the wording of their labels, i.e., high values mean good QoL, much coping, many complaints, high distress. The estimated curves are drawn for the 10% to the 90% quantiles of the explanatory variables.

ΔR^2: contribution if variable(s) added last

SD_{Resid}: standard deviation of the residuum in the response variable

in (n), observed means and SD's are shown

Figure 3. X–Y Graph displaying directions and strengths of the estimated relations.

mixed backward and stepwise selection had to be used because some interactions should not appear in such an analysis without the main relevant explanatory variables having been partitioned out.

We chose this selection method because, to our knowledge, no automatic detection procedure is available for interaction terms. The method is conservative in the sense that not

Table II. Parameters of multiple regression analyses for continuous responses.

Response	Figure	Explanatory variables		Contribution when variable(s) added last			Estimated parameters		
			$r^{(*)}$	$\Delta R^{2(\dagger)}$	df	F	$\beta^{\ddagger}$	t	p
Mental	2(a), 3(a)	Men	0.57	7.3	1	13.45	0.37	3.67	<0.01
		Act	0.19				0.02	0.14	0.89
		Work[§]	−0.17				−2.14	−3.60	<0.01
	2(a), 3(b)	Act * work		14.2	3	8.75	0.55	3.30	<0.01
		Dep	−0.37				−0.30	−1.55	0.13
		Div[§]	0.03				−1.13	−2.56	0.01
	2(a), 3(c)	Dep * div		9.4	3	5.81	0.78	3.48	<0.01
	2(a), 3(d)	Psy	−0.59	8.7	1	16.24	−0.04	−4.03	<0.01
		Constant					1.84		
		Model $R^2=0.61$	df $=8;72$	$F=14.18$	$p<0.001$				
Physical	2(a), 3(e)	Phy	0.54	20.9	1	27.25	0.50	5.22	<0.01
	2(a), 3(f)	Act	0.20	8.1	1	10.63	0.29	3.26	<0.01
	2(a), 3(g)	Dep	−0.35	5.6	1	7.34	−0.34	−2.71	<0.01
		Constant					−0.67		
		Model $R^2=0.41$	df $=3;77$	$F=17.86$	$p<0.001$				
Men	2(c), 3(i)	Dep	−0.57	4.1	1	6.31	−0.39	−2.51	0.01
	2(c), 3(j)	Psy	−0.43	16.3	1	24.85	−0.05	−4.99	<0.01
		Constant					2.11		
		Model $R^2=0.61$	df $=2;78$	$F=37.00$	$p<0.001$				
Phy	2(c), 3(k)	Psy	−0.54	8.8	1	12.82	−0.03	−3.58	<0.01
		Bod	−0.56				−0.02	−1.35	0.18
		Sex[§]	−0.18				0.75	2.83	<0.01
	2(c), 3(l)	Bod * sex		18.7	3	9.09	−0.05	−3.02	<0.01
		Constant					0.97		
		Model $R^2=0.48$	df $=4;76$	$F=17.40$	$p<0.001$				
Psy	2(d), 3(m)	Age	0.31	9.3	1	8.15	−0.32	−2.85	<0.01
		Constant					58.15		
		Model $R^2=0.09$	df $=1;79$	$F=0.15$	$p<0.01$				
Bod	2(d), 3(n)	Sex	0.40	16.3	1	15.43	8.68	3.93	<0.01
		Constant					0.38		
		Model $R^2=0.16$	df $=1;79$	$F=15.43$	$p<0.01$				

[*] Bivariate correlation (Pearson).
[†] ΔR^2 is the percentage of variance explained by the respective variable (set of variables) when added last to the equation.
[‡] Unstandardized beta.
[§] Discrete variables are coded 1 if present and 0 if absent (div 1: continent, 0: incontinent; sex 1: female, 0: male).

all possible significant interaction terms could be detected by it. An interaction term that would become significant only if an underlying main effect was considered will not be added if the main effect is non-significant itself. On the other hand, all terms added are significant. Considering the large number of tests in a sample of medium size, it seemed preferable to use a conservative selection strategy. To increase precision of the analysis, the data

were entered twice into a special computer program that minimizes the possibility of typing errors.

For continuous variables, the x co-ordinates in the graphs represent the full theoretical range of the questionnaires for which they stand. The z values, age and number of previous diseases were an exception; here an arbitrary range was chosen. Lines in the graphs range from the 10th to the 90th percentile of the explanatory variables as observed in the present sample (Table I). Regression analysis often gives no precise estimates at the ends of distributions, because there are few observations in these areas. In combination with the use of quadratic and interactional terms, drawing lines from minimum to maximum may lead to vague interpretations.

The method of analysis is illustrated in detail by the results of the two primary responses, mental and physical QoL, in the 1-year follow-up. Statistical analyses were performed by Simstat V1.4 and SPSS V6.3. All significance tests were two tailed at a significance level $\alpha = 0.01$. In a sample of the given size, an effect has to explain about 5 per cent of the variance in a continuous response variable to reach the chosen significance level. By setting alpha at that level, we also have avoided detecting clinically non-relevant but statistically significant relationships.

RESULTS

Primary responses: QoL at the 1-year follow-up

The *mental* component of QoL at follow-up has a mean value of $z = -0.46$ (Table I) and is explained by two main effects (men, psy) and two interactions (act * work and dep * div; Figure 2 and Table II). The *physical* component of QoL at follow-up has a mean value of $z = -0.47$ and is explained by three main effects (phy, act, dep, Figure 2 and Tables I, II). The proportion of variance explained by the respective model is 61 per cent in mental QoL, and 41 per cent in physical QoL. Both models are highly significant ($F_{8;72} = 14.18; F_{3;77} = 17.86, p < 0.001$, Table II). The dashed line between mental and physical QoL indicates that after partitioning out all significant explanatory variables there is still a significant correlation (partial $r = 0.60$, bivariate $r = 0.75$) between them.

The relationship between mental QoL at follow-up and the mental QoL preoperative is estimated to be linearly positive (Figure 3(a)). The curve is drawn for all other variables set at the sample means. The observed proportions were taken for discrete variables. This means that the estimated curve would be moved up or down parallel if the estimates of the other variables differed from the means. To show the precision of the estimate, one standard deviation (SD) of the residuum is displayed for each response variable. The bivariate correlation between mental QoL at follow-up and preoperatively is $r = 0.57$, which indicates that mental QoL is a relatively stable measure from preoperative to follow-up.

Active coping has a positive relation to mental QoL at follow-up among patients who were still working before surgery. No relationship could be observed for those patients who were retired or did not work for other reasons (Figure 3(b)). The estimated mental QoL at follow-up for patients not working is at $z \approx -0.40$, regardless of their amount of active coping. The estimated mental QoL at follow-up for patients still working is $z \approx -1.00$ for very low-active copers, and about the population mean for very high-active copers. This interaction adds 14.2 per cent of variance to the explanation of mental QoL at follow-up. No bivariate correlation

can be computed for the interaction term, and no separate variance estimations were performed for the underlying main effects of such an interaction (Table II).

Depressive coping and type of diversion also show an interactive effect on mental QoL at follow-up (Figure 3(c), $\Delta R^2 = 9.4$ per cent). At first glance, the relationship between depressive coping and mental QoL at follow-up seems to be positive for patients who received a continent diversion and negative for those with an incontinent one. This means that those who give way to fears, tended to have worse QoL than those who did not give way to fears, insofar as the patients belong to the incontinent diversion group. In the continent diversion group, however, the opposite pattern was observed: those who give way to fears tended to have better QoL than those who did not give way to fears. Both curves have almost equal gradients, but with a different sign. To understand this interaction, one has to consider that these relationships were estimated by partitioning out all other significant explanatory variables, including the mental QoL preoperative. Besides the direct interactional effect there is an indirect effect on mental QoL at follow-up: depressive coping was negatively associated with mental QoL preoperative, and QoL showed some stability over time (Figure 3(a), 3(i)). So what we see here is the change in mental QoL from the preoperative time to the 1-year follow-up. In sum, the analysis shows that the negative effect of depressive coping on mental QoL is buffered by the continent diversion. The bivariate correlations between depressive coping and mental health at follow-up were $r = -0.24$ in the group of patients who received a continent diversion and $r = -0.52$ in the group of patients who received an incontinent one.

Preoperative psychological distress has an additional linear negative effect on mental QoL at follow-up (Figure 3(d), $\Delta R^2 = 8.7$ per cent). The higher the psychological distress, the worse the mental QoL at follow-up.

The *physical* component of QoL at follow-up is explained by three variables: physical QoL pre-operative, active coping and depressive coping. All relationships were linear and explain all together a total amount of 41 per cent of the variance in physical QoL pre-operative (Table II, Figure 3). Physical QoL pre-operative turned out to be the strongest predictor, accounting for 20.9 per cent of the variance (Figure 3(e), Table II). Active coping is positively associated with physical QoL at follow-up, while depressive coping is negatively associated. They explain 8.1 and 5.6 per cent of the variance, respectively (Figure 3(f) and (g), Table II).

Secondary and tertiary responses: complications, chemotherapy, preoperative QoL, coping, psychological distress and bodily complaints

Post-surgical complications could not be predicted by any of the variables under analysis. Chemotherapy could be predicted by tumour stage. The probability of receiving post-operative chemotherapy is almost zero for tumour stage 1, and about $p = 0.33$ for stage 3 (Figure 2(b) and 3(h), Table III). As a rank variable was treated like an interval-scaled one here, this result is only a rough estimate.

Mental QoL pre-operative is predicted by two linear negative relationships, depressive coping (Figure 2(c), 3(i), Table II, $\Delta R^2 = 4.1$ per cent) and psychological distress (Figure 3(j), $\Delta R^2 = 16.3$ per cent). The higher is the psychological distress or the depressive coping, the lower is the mental QoL pre-operative. Together, both variables explain 58 per cent of the variance, which is considerably more than the sum of the contributions, if each variable is added last. This means that there is a part of common variance for both predictors of about

Table III. Parameters of logistic regression analyses for discrete responses.

Response	Figure	Explanatory variables	r^*	Estimated parameters		
				β	Wald†	p
Che‡	2(b), 3(h)	Sta	0.49	1.52	3.67	$<.01$
		Constant		−5.28		
		Model $Chi^{2*} = 22.67$	$p < 0.01$			
Div‡	2(d), 3(o)	Age	−0.47	−0.13	14.68	<0.01
		Constant		7.93		
		Model $Chi^{2*} = 19.53$	$p < 0.01$			

* bivariate correlation (point-biserial or phi-coefficient).
† Wald's statistic.
‡ Che 1: present, 0: absent; div 1: continent, 0: incontinent.

37.4 per cent. Both variables are highly correlated; after partitioning out the effects of age and sex, the association remains significant ($r_{part} = 0.58$, Figure 2(d) shows this association by a dashed line between these two variables).

Physical QoL pre-operative is predicted by a linear negative effect of psychological distress (Figure 2(c), 3(k), $\Delta R^2 = 8.8$ per cent). This effect is not as marked as the one on mental QoL pre-operative (Figure 3(j)) but points in the same direction. Additionally, there is an interactive effect of bodily complaints and gender. Women show a strong negative relation between physical QoL pre-operative and bodily complaints; a very weak relation for men is estimated (Figure 3(l), $\Delta R^2 = 18.7$ per cent). As at follow-up, there is still a significant relation between pre-operative mental and physical QoL after partitioning out all significant influences of other variables (dep, psy, bod, sex); this relationship is indicated by the dashed line between them in Figure 2(c) ($r_{part} = 0.64$, $r_{bivariat} = 0.70$).

Active and depressive coping could not be predicted by any variable under analysis (Figure 2(d)). There is an association between active coping and tumour grading, which narrowly failed to reach significance ($r = -0.27$, $p < 0.015$). For depressive coping, a similar result was found with age ($r = -0.27$, $p < 0.015$). Psychological distress is explained by age (Figure 2(d), 3(m)), accounting for 9.3 per cent of the variance. Younger patients report more psychological distress than older ones. Bodily complaints are predicted by gender (Figure 2(d), 3(n)); women report more complaints than men. Differing from the other figures, Figure 3(n) shows observed means and SDs for women and men. Finally, the type of diversion is explained by age (Figure 2(d), 3(d), Table III). Patients about the age of 50 were very likely to receive a continent diversion; for patients above 70, the likelihood decreased to less than 50 per cent . As the variables (act, dep, psy, bod and div) are placed in the same box, no *a priori* hypotheses of the direction of influences among them were made. The dashed lines in Figure 2(d) indicate that there are three significant relations among them, given the influences of age and sex. Depressive coping is correlated with psychological distress ($r_{part} = 0.58$) and bodily complaints ($r_{part} = 0.40$); the latter two also are correlated with each other ($r_{part} = 0.47$). No other significant relations could be found, since active coping is correlated with depressive coping with $r_{part} = 0.20$, which does not meet our significance criterion.

DISCUSSION

This is the second longitudinal study on how patients perform with a urinary diversion and on whether coping can be a predictor of QoL. The first one was conducted by Mansson *et al.* [45]. At first glance, the results of the two studies differ. Mansson *et al.* found no direct effects of coping on QoL at follow-up; we did. However, there were some conceptual and methodological differences between the two studies; an important distinction was that QoL and coping were defined differently. Mansson *et al.* measured QoL only at follow-up and examined defensive coping strategies in a series of tachistoscopic presentations of an angry, aggressive-looking face (MCT, Smith *et al.*, 1989). In the present study, QoL was assessed twice. Having a baseline makes it possible to detect a change in QoL, which may be a more sensitive measure than a single assessment of QoL. In addition, coping was measured by a questionnaire. Instead of defensive coping, which has an intra-psychic function derived from psychoanalytic theory, the strategies assessed here were strongly disease related and grounded in the cognitive theory of learning. Considering that in a tumour-based disease there are both ego-threatening and physically threatening aspects, it is possible that basic and disease-related coping strategies become more relevant for the patient's future condition than intra-psychic preferences in reacting only to ego-threatening stimuli.

In this study, mental QoL shows a slight increase and physical QoL a slight decrease from pre-operative measurement to follow-up. In addition, QoL showed high stability over time, a finding that is seen particularly in the bivariate correlations. This finding is even more remarkable, as serious changes to the patients and their bodies occurred between the two times of measuring QoL. This result may be interpreted as a consequence of two underlying traits. One part of the common variance may reflect stability in the QoL, another part stability in the answering behaviour to the specific questionnaire used. The non-common variance may be divided into measurement error and true change. The latter can be explained to some extent by the coping strategies. The slight average decrease in physical QoL is explained by the impairment of the artificial diversion and scar from surgery. For the average increase in mental QoL, there are two possible explanations: fear and worry from initial diagnosis and upcoming surgery generally decrease during the following year. Another possible explanation is that patients who survive such a dramatic situation sometimes experience a response shift in their judgement of QoL. That means that people are able to adapt to changes in health; even decreased or stable abilities can be evaluated more positively in light of different circumstances [46–48].

One of the most important findings of this study is the buffering effect of a continent diversion for depressive coping on mental QoL at follow-up. This effect, involving four different variables, would have been misinterpreted if only a multivariate regression analysis had been performed without the additional use of a graphical Markov model. But by looking at the direct and indirect effects on mental QoL at follow-up all at once, a buffering effect of the continent diversion can be detected clearly. The continent diversion is less physically disturbing than the incontinent one; maybe this is the mediating factor for the effect.

An additional interactional effect turned out to be significant in the prediction of mental QoL at follow-up. Patients who are still working are likely to develop a good QoL when they use active coping. A closer look at Figure 3(b) reveals that retirees are likely to develop a relatively good QoL anyway, regardless of their amount of active coping. It seems notable that a lack of problem-focusing attitude is particularly dangerous for people who are still at work, as most of them have to cope actively with problems in other domains of their lives.

The positive linear relationship between psychological distress and mental QoL at follow-up/pre-operative does not need to be interpreted. Although the questionnaires were chosen to have minimal overlap in item formulation, both constructs were closely related. Positive associations are trivial. However, it seems to be noteworthy that in spite of adding a psychological distress measure to the pre-operative explanatory variable set, there is still a considerable contribution of coping to the explanation of mental QoL at follow-up. This demonstrates that coping can be assessed differently from indicators of adaptation such as psychological well-being or distress. Altogether, ~ 60 per cent of the variance of mental QoL at follow-up could be explained by the variables in the model.

The outcome in terms of *physical* QoL at follow-up was explained less accurately ($R^2 \sim 40$ per cent), but the effects can be summarized relatively easily: physical QoL is mainly stable, it is likely to become better by active coping and worse by depressive coping (Figure 3(e)–(g)). Prediction of coping itself was not possible. This is an unfavourable result, as active coping is a significant predictor for physical QoL in all patients, and for mental QoL in patients who are still working. It should be noted that active coping had a high mean in this sample, and the majority of patients had values in the upper half of the possible theoretical scale range. For depressive coping, on the other hand, the majority of the distribution lies in the lower half. This is even more remarkable as, objectively, there is nothing active one can do in favour of forthcoming surgery. Perhaps the chosen assessment of coping measures relatively stable personality traits, which continue to work during the time between surgery and follow-up.

The estimated effects of pre-operative coping on QoL at follow-up were stronger than those of pre-operative coping on QoL pre-operative (Figure 3(b), 3(c), 3(f), 3(g) vs 3(i)). This result is unusual, as measures made at the same time often show higher associations than those performed at different times. For instance, the relation between psychological distress and QoL is stronger pre-operatively than at follow-up ($\Delta R^2 = 16.3$ per cent vs 8.7 per cent, Figure 3(j), 3(d)) and for another example, see Reference [49]. A possible interpretation of this effect would be that coping with an event as serious as that which the patients in this study experienced, takes some time to work. Interestingly, Stanton *et al.* [23] reported a similar pattern for emotional coping strategies and various indicators of well-being in patients with breast cancer.

Returning to our initial question: Who needs psychological care and who does not? The change in QoL from pre-operative to follow-up can be explained to a considerable degree by five risk factors: active and depressive coping, psychological distress, type of diversion and working status. These variables can be utilized for a pre-operative screening to determine to which patients a psychosocial intervention programme may be offered and/or which elements the programme may contain. Mansson *et al.* [50] reported only minor effects of a psychosocial intervention in patients after cystectomy. Those patients who had low scores in the psychosocial dimension of the sickness impact profile and received a continent cutaneous diversion seemed to benefit from the intervention. Rofé *et al.* [51] reported that cancer patients stated a preference for waiting alone or with healthy others rather than with other cancer patients, e.g. in the physician's waiting room. This is congruent with the experience we had during the data collection phase. A minority of patients appreciated the psychological interview very much, i.e. they were thankful to have an opportunity to talk to someone about their worries and fears. Other patients, however, gave the interview in order to support the research. Some patients even refused to participate. So there is some evidence that psychosocial interventions

can bring additional stress or relief for the patients. Screening for coping resources and actual adaptation may be helpful before offering to patients the opportunity to participate in a psychological programme that involves confrontation with the disease. If the results obtained here can be confirmed in other studies, primarily patients with low-active coping who are still working or with high-depressive coping who cannot receive a continent diversion should be offered a psychological programme to change their coping strategies. All the others possibly do not need such a programme.

Our second aim was to examine the role of coping in patients undergoing such an extraordinary, stressful situation. The main result is that coping is quite an important predictor for both mental and physical QoL at follow-up. Active coping turned out to be positively related to physical QoL in all patients, and even more strongly to mental QoL in those patients who were still working at the time before surgery. In contrast to most other studies, active coping was significantly related to adaptation here.

On the other hand, and consistent with most results reported in the literature, depressive coping is negatively associated with QoL, the association being stronger for the mental component than for the physical component. The items for depressive coping express an awareness of the experienced stress and the willingness to focus on it, even if that may strain social relations. In contrast to our expectations, it turned out to be not helpful to focus on the emotion in that way, even in the days before the surgery, when a positive effect would be expected. No curvilinear effects for depressive coping were observed, so that one cannot say: 'It's not bad to let oneself go a little bit in such a severe situation'. Again, it is plausible that the attitude to focus on the emotion or to let one go persists until past surgery and keeps on working in the future.

We concede several major limitations of this study: (1) Coping was assessed in a basic way utilizing only two dimensions. This was done to keep the number of possible explanatory factors small and to enable a differentiated analysis for the remaining variables. (2) Coping was assessed a few days before a life-threatening surgery. Often, the diagnosis of cancer was relatively new. Heim [52, 53] pointed out that the coping process runs through different phases. The first reaction to a stressor may require different coping strategies than long-term adaptation. Pre-operative coping may not comprise the aspects most relevant for long-term adaptation. (3) QoL was assessed by a generic and unspecific instrument. Using alternative instruments that contain specific modules for invasive bladder cancer, such as the EORTC-BLM30 [54] or the FACT-BL [55], probably would give different insight into the QoL of these patients. (4) The conclusions drawn here do not rely on an experimental study. If other explanatory variables or responses had been taken into account, the results may have been different. (5) Generalization is limited by the fact that the analysis was based only on those patients who gave a follow-up interview. Nothing was said about the 20 per cent who did not survive the first year. (6) A large number of tests have been performed in a sample of medium size. The results need to be replicated.

The use of a graphical Markov model has demonstrated that even a complex structure, as in the present data, can be broken down into subsets that make the associations understandable. Furthermore, it has shown some advantages in contrast to using a multiple regression analysis alone. For instance, using a multiple regression analysis would have led in the present case to the false conclusion that depressive coping is associated with an improvement of QoL in the case of a continent diversion. In addition, a non-trivial result was that the associations between coping and QoL were stronger with a 1-year time lag than in the cross-sectional

measure at time 1, a finding that was not likely to be detected by other forms of analysis, e.g. repeated measurement analysis of variance.

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