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The longitudinal effect of depression on functional limitations and disability in older adults: an eight-wave prospective community-based study

S. W. GEERLINGS,[1] A. T. F. BEEKMAN, D. J. H. DEEG, J. W. R. TWISK AND W. VAN TILBURG

From the Department of Psychiatry and the Institute for Research in Extramural Medicine (EMGO), Free University, Amsterdam, The Netherlands

ABSTRACT

Background. The temporal relationship between depression and adverse functional outcomes in older adults is ambiguous. In the present eight-wave prospective community-based study, the longitudinal effect of depression on functional limitations and disability (in terms of disability days and bed days) was studied, thereby taking into account the role of chronic physical diseases.

Methods. The study is based on a sample which at the outset consisted of 325 non-depressed and 327 depressed persons (55–85 years) drawn from a larger random community based sample in the Netherlands. Generalized estimating equations time-lag models were used to examine the longitudinal relation between depression and both functional limitations and disability.

Results. Functional limitations were very persistent over time, whereas disability days and bed days were more fluctuating functional outcomes. Only in the presence of chronic physical diseases, there was a significant longitudinal association between depression at the previous measurement and functional limitations, disability days and bed days at the next measurement. The effect on functional limitations was small, which was probably partly due to their persistent nature.

Conclusions. The finding of a longitudinal relationship between depression and functional outcomes in older adults with a compromised health status provides a rationale for treatment of chronic physical diseases as well as depression in depressed chronically ill elderly, in order to prevent a spiralling decline in psychological and physical health.

INTRODUCTION

Depression in the older population is a major health problem, both because of its high prevalence (Blazer, 1994; Beekman *et al.* 1995) and its adverse consequences. Mortality has been shown to be one of the long-term consequences of depression (Bruce & Leaf, 1989; Pulska *et al.* 1998; Penninx *et al.* 1999), while both social and physical disability were found to be shorter-term functional outcomes of depression (Bruce *et al.* 1994; Beekman *et al.* 1997*a*; Armenian *et al.* 1998; Penninx *et al.* 1998; Ormel *et al.* 1998; Ormel, 2000). The impact of depression on disability seems to be similar or even stronger compared to that of chronic physical illness (Wells *et al.* 1989), and is partly explained by decreased physical activity and social interaction in depressed persons (Penninx *et al.* 1999). However, the temporal association between depression and functional outcomes is less than straightforward. In older populations with high prevalences of chronic physical disease, disability has also been found to predict the onset and the persistence of depression (Kennedy *et al.* 1990; Prince *et al.* 1998). Consequently, the association between depression and functional outcomes may be due to bi-directional effects (Ormel, 2000).

Functional outcomes may be studied in several ways. The well-known scheme of the World

[1] Address for correspondence: Dr S. W. Geerlings, Longitudinal Aging Study Amsterdam, Van der Boechorststraat 7, 1081 BT Amsterdam, The Netherlands.

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FIG. 1. The disablement process.

Health Organization (WHO, 1980) has been adapted for epidemiological studies by Verbrugge & Jette (1994) (Fig. 1). In their model of the disablement process, they distinguish functional limitation and disability. Functional limitation includes restrictions in performing basic mental and physical functions, such as limited mobility, while disability refers to difficulties experienced in performing necessary activities of daily living due to physical or mental health problems. While functional limitation refers to personal capabilities, disability refers to actual behaviour, evaluated relative to environmental demands. Employing the scheme of the disablement process makes it possible to study the impact of depression on functional outcomes, thereby taking into account the role of physical illness. This is important, since in older adults depression has been shown to be closely related to the presence of chronic physical diseases (Berkman *et al*. 1986; Kennedy *et al*. 1989; Beekman *et al*. 1997*a*).

The Longitudinal Aging Study Amsterdam (LASA) provides a unique resource for investigating the longitudinal relationship between depression and functional outcomes in the elderly. Both depression and functional outcomes were measured repeatedly at 5-monthly intervals in a community-based sample of older adults. So far, studies on depression and functional outcomes have relied on cross-sectional or longitudinal data using only one follow-up measurement of depression. However, late life depression often runs a fluctuating course (Geerlings *et al*. 2000), and depression should be measured frequently over time in order to obtain a better understanding of the temporal relationship between depression and functional outcomes. The study design offers the opportunity to analyse the data in a time-lag model; as in most earlier studies, in the main analyses, depression was studied in relation to subsequent functional outcomes. Another advantage of the present study is that different aspects of the disablement process were addressed: both functional limitations and disability were studied as functional outcomes, which may lead to a greater understanding of the way depression acts on the disablement process. Furthermore, the effect of chronic physical diseases on the complex interplay between depression and functional outcomes was examined. This study expands on our previous study in which functional status was considered only at baseline (Geerlings *et al*. 2000). The principle aim of the present study was to examine the longitudinal effect of depression on subsequent functional limitations and disability in a multiple-wave prospective design, thereby taking into account the role of chronic physical diseases.

METHOD

Sampling and procedures

The present study is part of the LASA study, which is a 10-year interdisciplinary study on predictors and consequences of changes in autonomy and well-being in the ageing population (Deeg & Westendorp-de Serière, 1994). Full details on sampling and response have been described elsewhere (Beekman *et al*. 1995; Geerlings *et al*. 1999). In short, a representative random sample of older adults (aged 55–85), stratified for age and sex, was drawn from the population registers of 11 municipalities in three regions of the Netherlands. The sample was used in two studies. Respondents were first interviewed for the NESTOR-LSN study (response 62·3%) (Broese van Groenou *et al*. 1995). About 10 months later, 3107 (81·7%) of the 3805 respondents to the NESTOR-LSN study took part in the LASA baseline interview. Non-response was related to age ($P < 0{\cdot}001$) but not to sex. The older old were more often found to be too ill or cognitively impaired to participate.

All 3107 participants to the baseline interview (t_0) were screened for depression, using the CES-D (Radloff, 1977, see measurements section below). Due to item non-response on the CES-D 51 subjects (1·6%) were lost, leaving a baseline sample of 3056 subjects. All subjects scoring $\geqslant$ 16 on the CES-D at baseline and a similarly sized random sample of those scoring < 16 were approached for a diagnostic interview, scheduled

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2 to 8 weeks after LASA baseline. Response was 86·0% relative to LASA baseline. Again non-response was related to age ($P < 0{\cdot}001$) but not to sex.

Respondents with a complete diagnostic interview were asked to participate in the present follow-up study concentrating on depression in older adults. The sample participating in the study consisted of a depressed cohort (CES-D $\geqslant 16$, $N = 327$) and a non-depressed cohort (CES-D < 16, $N = 325$). Follow-up data on depressive symptoms, functional limitations and disability were collected at 5-monthly intervals in seven successive waves (t_1 to t_7), covering a period of 3 years. At t_1 to t_6, data were collected by mail questionnaires, and at the final wave (t_7), the same face-to-face mode of interviewing was used as at t_0 (Geerlings *et al.* 1999, 2000). Response to follow-up is described in Table 1. At t_7, the numbers of disability days and bed days were asked for the last month only as against 5 months at previous waves. As a consequence, t_7 data on disability days and bed days were not used in the present study.

In order to study the longitudinal relation between depression and subsequent functional limitations and disability, a minimum of two pairs of consecutive measurements of depression and functional limitations ($N = 535$)/disability ($N = 503$) was considered necessary to contribute to the analyses in a meaningful way. Attrition to follow-up was therefore defined as having less than two pairs of consecutive measurements of depression and functional limitations/disability. The most important reason for loss to follow-up was death (47%).

Measurements

Dependent variables

Functional limitations were assessed by a questionnaire (van Sonsbeek, 1988; Kriegsman *et al.* 1997) including the following activities: climbing up and down a staircase of 15 steps without stopping, cutting one's own toenails, and using one's own or public transportation. Response categories were 'yes without difficulty', 'yes with difficulty', 'only with help', and 'no I cannot'. The number of functional limitations ranges from zero to three.

Disability was assessed in terms of general functioning (disability days and bed days), using questions derived from the Medical Outcomes Studies (Anderson *et al.* 1990). Disability days were addressed by the question 'How many days were you so sick that you were limited in your normal activities during the last 5 months'. Bed days were addressed by the question 'How many days were you so sick that you had to stay in bed during the last 5 months'.

Independent variables

At all occasions, depressive symptoms were measured using the Center for Epidemiologic Studies Depression scale (CES-D) (Radloff, 1977). This is a 20-item self-report scale developed to measure depressive symptoms in the community. Subjects were asked how often they experienced each symptom during the previous week. Items were scored on a four-point scale, ranging from 0 (rarely or none of the time) to 3 (most of or all the time). The values of these response categories were reversed for the positive affect items. The total CES-D score ranges from zero to 60. A score of $\geqslant$ l6 has generally been used as indicative for clinically relevant depressive syndromes (Berkman *et al.* 1986). The psychometric properties of the scale were found to be good in older populations (Radloff & Teri, 1986; Beekman *et al.* 1994), and the overlap with symptoms of physical illness has been shown to be very limited in a number of studies (Berkman *et al.* 1986; Foelker & Shewchuk, 1992).

The presence of chronic physical diseases was measured using a detailed questionnaire; participants were asked whether they had any of the following diseases: cardiac disease; peripheral atherosclerosis of the abdominal aorta or the arteries of the lower limb; stroke; diabetes mellitus; lung disease (asthma or chronic obstructive pulmonary disease); malignant neoplasms; arthritis (rheumatoid arthritis or osteoarthritis); or any other major chronic diseases (Central Bureau of Statistics, 1989). The number of chronic diseases was calculated by summing up all specific diseases reported to be present. In a validation study, respondents' self-reports were compared to information obtained from their GPs, and proved to be sufficiently reliable (Kriegsman *et al.* 1996). For this study, the presence of chronic diseases was indicated as 0, no disease; and 1, one or more disease(s).

Covariates selected for this study have been shown to be related to depression and disability

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Table 1. *Response to follow-up (t_1 to t_7)*

Response	Functional limitations *N*(%)	Disability days *N*(%)	Bed days *N*(%)	Depression *N*(%)
t_1	517 (79·3)	391 (60·0)	404 (62·0)	486 (74·5)
t_2	527 (80·8)	446 (68·4)	471 (72·2)	510 (78·2)
t_3	513 (78·7)	454 (69·6)	470 (72·1)	494 (75·7)
t_4	491 (75·3)	434 (66·6)	429 (65·8)	479 (73·5)
t_5	381 (58·4)	357 (54·8)	358 (54·9)	378 (58·0)
t_6	441 (67·6)	415 (63·7)	421 (64·6)	434 (66·6)
t_7	484 (74·2)	—	—	470 (72·1)

in previous studies, and thus may act as confounders. Variables include sex, age, level of education, marital status, and cognitive impairment. Education was measured on an eight-point ordinal scale ranging from uncompleted primary school to completed university. For this study, education was dichotomised in the following way: low education (uncompleted or completed primary school) and middle to high education (secondary education up to and including university). Marital status was dichotomized as follows: married and not (or no longer) being married. Cognition was measured using the Mini-Mental State Examination (MMSE) (Folstein *et al.* 1975); respondents were divided into two categories: MMSE $\geqslant$ 24 (normal cognition); and, MMSE $<$ 24 (impaired cognition).

Data analysis

Data were analysed in three stages. First, attrition to follow-up (availability of <2 pairs of consecutive measurements of depression and functional limitations/disability days/bed days) was studied using chi² tests and logistic regression analysis. Secondly, the course of depression and functional limitations was described: the status of depression (no depression (CES-D $<$ 16)/depression (CES-D $\geqslant$ l6)) and functional limitations (no/yes) at baseline was compared to the last available simultaneous measurement of depression and functional limitations of the respondents; stability over time was measured by the kappa statistic. In the same way, both the course of depression and disability days (no/yes) and the course of depression and bed days (no/yes) was described. In the third analysis stage, the longitudinal relationship between depression at t_x and functional limitations, disability days and bed days at t_{x+1} was studied using Generalized Estimating Equations (GEE) (Zeger & Liang, 1986). GEE has the capacity to estimate regression models with correlated errors. Correlations between errors could occur because repeated measurements are performed on the same individual. In the analyses, an exchangeable correlation structure was employed. Unlike commonly used methods for analysing repeated measures data, GEE does not require a balanced design (i.e. observations at all occasions on each person).

Functional limitations are 'counts' and therefore the longitudinal relationship between depression at time t_x and functional limitations at time t_{x+1} was studied using longitudinal Poisson regression, resulting in incidence density rates. For the longitudinal relationship between depression at time t_x and disability days and bed days at time t_{x+1} regression coefficients (linear regression) are reported. As the distributions of disability days and bed days were highly skewed to the right with a minimum of zero, the longitudinal analyses were performed using a logarithmic transformation of the number of disability days/bed days plus one. Since the study sample was stratified for depression, the percentage of respondents with a clinically relevant depressive syndrome at t_0 (50%) was much higher than the percentage depressed persons in the general older population (14·9%) (Beekman *et al.* 1995). To check whether and how stratification had an effect on the results, the interactions according to depression status at baseline were tested.

In multivariate models, the effect of depression (t_x) on functional limitations, disability days and bed days (t_{x+1}) was studied after adjustment for potential confounders which were identified in bivariate analyses. The variable 'time' was included in all models, in order to adjust for the influence of time. Depression was treated both as a continuous and a dichotomous variable (CES-D $<$ 16/CES-D $\geqslant$ 16). In separate analyses, the longitudinal relationship between depression (t_x) and disability days and bed days (t_{x+1}) was further adjusted for functional limitations over time.

Because of differences in both the prevalence of depression, functional limitations and disability between persons with and without chronic

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physical diseases, the longitudinal analyses were also performed in respondents with and without chronic physical diseases separately.

CES-D data were collected by two different modes: face-to-face interviews (t_0 and t_7) and mail questionnaires (t_1 to t_6). The latter mode yielded on average higher scores than the former one. In order to check whether this mode effect has affected the results, the longitudinal analyses were repeated adjusting for mode of data collection (Geerlings *et al*. 1999).

RESULTS

Characteristics of the sample and attrition analyses

In Table 2, the characteristics of the baseline sample are presented. From the baseline sample ($N = 652$) 117 respondents (17·9%) could not contribute to the analyses of the relationship between depression and functional limitations, leaving a sample of 535 respondents (82·1% of the total baseline sample). On average, the number of consecutive pairs of measurements was five. Since data on disability days and bed days at t_7 were not used in their relation to depression (see section sampling and procedures), an additional 32 respondents were lost, leaving a sample of 503 respondents (77·1% of the total baseline sample). Consequently, on average, the number of consecutive pairs of measurements was four. Attrition to follow-up (< 2 pairs of consecutive measurements) was bivariately associated with higher age ($P < 0{\cdot}01$), low education ($P < 0{\cdot}01$), not (or no longer) being married ($P < 0{\cdot}001$), impaired cognition (MMSE < 24) ($P < 0{\cdot}01$), being depressed (CES-D $\geqslant 16$) ($P < 0{\cdot}001$), having one or more chronic diseases ($P < 0{\cdot}05$), and having one or more functional limitations ($P < 0{\cdot}001$) at baseline but not with disability days, bed days and sex. In a multivariate model, only marital status ($P < 0{\cdot}01$) and functional limitations ($P < 0{\cdot}05$) predicted attrition.

The course of depression and functional limitations/disability

Table 3 shows the last assessment status of depression and functional limitations in relation to the status of depression and functional limitations at baseline. Stability was fair to moderate ($\kappa = 0{\cdot}40$). The percentage of respondents developing functional limitations was 27% (23 + 4%) among those free of depression at baseline, and 36% (16 + 20%) among those who were depressed at baseline. The high percentage of 46 (off the diagonal) of respondents with depression and no functional limitations at the first measurement, recovering from depression over time is noteworthy. Depression persisted in 39% (19 + 20%) of those free of functional limitations at baseline and in 57% (1 + 56%) of those with functional limitations at baseline. Functional limitations were highly persistent over time: 85% (68 + 17%) in

Table 2. *Baseline characteristics of sample* (N = 652)

Characteristic	%	Mean (S.D.)
Sex		
Female	57·7	
Age		70·5 (8·8)
Education		
Low	44·5	
Marital status		
Not (or no longer) married	46·5	
Cognition		
MMSE $\geqslant 24$	83·6	
MMSE < 24	15·8	
Unknown	0·6	
Chronic physical diseases		
0	20·7	
1	30·5	
> 1	48·5	
Unknown	0·3	
Depression		
CES-D < 16	49·8	
CES-D $\geqslant 16$	50·2	
Functional limitations		
0	50·9	
1	19·3	
2	13·2	
3	15·6	
Unknown	0·9	
Disability days*		
0 days	79·9	
1–3 days	6·7	
4–7 days	4·6	
1 week < 1month	4·4	
All the time	4·1	
Unknown	0·2	
Bed days*		
0 days	87·9	
1–3 days	4·9	
4–7 days	2·5	
1 week < 1 month	3·5	
All the time	1·1	
Unknown	0·2	

S.D., Standard deviation.
*Disability days/Bed days in the previous month.

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Table 3. *Last assessment status of depression (Dep) and functional limitations (FL) in relation to baseline status* (N = 535)

	Last assessment (%)			
Baseline t_0	Dep−/FL−	Dep−/FL+	Dep+/FL−	Dep+/FL+
Dep−/FL− (*N* = 204)	70	23	3	4
Dep−/FL+ (*N* = 79)	15	68	0	17
Dep+/FL− (*N* = 92)	46	16	19	20
Dep+/FL+ (*N* = 155)	7	36	1	56

Percentages are based on transformed depression scores (Geerlings *et al.* 1990).
Five respondents are missing because of incompleteness of data.

the absence of depression and 92% (36+56%) in the presence of depression at baseline, respectively.

Table 4 shows the last assessment status of depression and disability days in relation to the status of depression and disability days at baseline. Stability was fair ($\kappa = 0{\cdot}27$). The percentage of respondents reporting 'new' disability days at the end of the study was 12% (10+2%) among those who initially were not depressed, and 24% (10+4%) among those who were depressed at the first measurement. Depression was persistent in 47% (33+14%) of the respondents in the absence and in 50% (23+27%) of the respondents in the presence of disability days at baseline. The reporting of disability days was persistent in 30% (10+20%) of the respondents in the absence and in 39% (12+27%) of the respondents in the presence of depression at baseline.

The course of depression and bed days resembled the course of depression and disability days (results not shown). Stability was fair ($\kappa = 0{\cdot}31$).

Longitudinal relationship depression and functional limitations/disability

There was a significant longitudinal association between depression at t_x (both measured as a continuous and a dichotomous measure) and functional limitations, disability days and bed days at t_{x+1} (Table 5). The (unadjusted) incidence density rates in Table 5 should be interpreted as follows: the risk of experiencing a change in functional limitations increases by 4% for every five points increase on the CES-D (results are presented per five points on the CES-D), and the risk of experiencing a change in functional limitations increases by 11% for a transition from no depression to depression. The (unadjusted) regression coefficients in Table 5 should be interpreted as follows: a change of five points on the CES-D is associated with a change of 15% ($e^B = e^{0{\cdot}14} = 1{\cdot}15$) in disability days, and a change from no depression to depression is associated with an increase of 57% ($e^B = e^{0{\cdot}45} = 1{\cdot}57$) in disability days. The coefficients for bed days should be interpreted correspondingly. Additional analyses showed that depression at baseline (CES-D $\geqslant$ 16) was also predictive for functional limitations (incidence density rate (IDR) = 2·48, 95% CI 1·89–3·27), disability days (B = 0·45, S.E. = 0·08, $P < 0{\cdot}001$), and bed days (B = 0·24, S.E. = 0·05, $P < 0{\cdot}001$) over time. The associations between depression and functional limitations, disability days and bed days were somewhat stronger in the non-depressed cohort than in the depressed cohort (results not shown); however, no significant interactions according to depression status at baseline were found ($P > 0{\cdot}10$).

Female sex (incidence density rate (IDR) = 1·35, 95% CI 1·15–1·59), higher age (IDR = 1·06 (1·05–1·06)), low educational level (IDR = 1·58 (1·35–1·84)), not (or no longer) being married (IDR = 1·77 (1·52–2·06)), impaired cognition (MMSE < 24) (IDR = 1·62 (1·35–1·95)) and the presence of one or more chronic physical diseases at baseline (IDR = 2·09 (1·78–2·45)) were all associated with relatively more functional limitations over time. Adjustments for these variables hardly influenced the incidence density rates for the longitudinal relationship between depression (t_x) and functional limi-

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Table 4. *Last assessment status of depression (Dep) and disability days in relation to baseline status* (N = 503)

Baseline t_0	Last assessment (%)			
	Dep−/Disability days−	Dep−/Disability days+	Dep+/Disability days−	Dep+/Disability days+
Dep−/Disability days− (*N* = 250)	81	10	7	2
Dep−/Disability days+ (*N* = 20)	65	10	5	20
Dep+/Disability days− (*N* = 158)	43	10	33	14
Dep+/Disability days+ (*N* = 74)	38	12	23	27

Percentages are based on transformed depression scores (Geerlings *et al.* 1999).
One respondent is missing because of incompleteness of data.

Table 5. *Results of GEE: longitudinal relation between depression at t_x and functional limitations, disability days and bed days at t_{x+1} in the total sample, in respondents without chronic physical diseases, and in respondents with chronic physical diseases*

Depression t_x (CES-D)	Functional limitations t_{x+1} IDR (95% CI)	Disability days t_{x+1}		Bed days t_{x+1}	
		B	S.E.	B	S.E.
Total sample	(*N* = 535)	(*N* = 503)		(*N* = 503)	
Continuous (per 5 points)	1·04 (1·02–1·06)***	0·14	0·02***	0·08	0·01***
After adjustments†	1·03 (1·01–1·05)***	0·12	0·02***	0·07	0·01***
Dichotomous (<16/ ⩾ 16)	1·11 (1·05–1·18)***	0·45	0·07***	0·28	0·05***
After adjustments†	1·09 (1·03–1·15)**	0·38	0·07***	0·25	0·05***
No chronic physical diseases	(*N* = 120)	(*N* = 114)		(*N* = 114)	
Continuous (per 5 points)†	0·97 (0·91–1·03) NS	0·04	0·03 NS	0·01	0·02 NS
Dichotomous (<16/ ⩾ 16)†	0·96 (0·78–1·18) NS	0·14	0·12 NS	0·03	0·09 NS
Chronic physical diseases	(*N* = 415)	(*N* = 389)		(*N* = 389)	
Continuous (per 5 points)†	1·04 (1·02–1·05)***	0·15	0·02***	0·08	0·02***
Dichotomous (<16/ ⩾ 16)†	1·10 (1·04–1·17)**	0·47	0·08***	0·29	0·06***

IDR, Incidence density rate; CI, confidence interval; B, regression coefficient; S.E., standard error.
†Adjustments were made for sex, age, marital status, chronic physical diseases (t_0), and time. The longitudinal association between depression and functional limitations were adjusted for education and cognition as well.
**$P < 0·01$; ***$P < 0·001$; NS, not significant.

tations (t_{x+1}) (Table 5). Relatively more disability days were predicted by not (or no longer) being married (B = 0·18, S.E. = 0·08, $P < 0·05$) and the presence of chronic physical diseases at baseline (B = 0·26, S.E. = 0·03, $P < 0·001$). Not (or no longer) being married (B = 0·17, S.E. = 0·06, $P < 0·01$) and the presence of chronic diseases at baseline (B = 0·35, S.E. = 0·04, $P < 0·001$) were also predictive for more bed days over time. Since the LASA sample was stratified for sex and age, the longitudinal associations between depression at t_x and disability days and bed days at t_{x+1} were adjusted for sex, age, marital status and the presence of chronic physical diseases at baseline. Table 5 shows that adjustments only slightly influenced the regression coefficients. In separate analyses, it was shown that adjusting for functional limitations over time slightly weakened the association between depression at t_x and disability days at t_{x+1} (continuous measure of depression: B = 0·11 as against 0·12; dichotomous measure of depression: B = 0·34 as against 0·38) and bed days at t_{x+1} (continuous measure of depression: B = 0·06 as against 0·07; dichotomous measure of depression: B = 0·21 as against 0·25). However, functional limitations did not explain a significant proportion of the depression–disability association. The adjusted regression coefficients were inside the confidence intervals of the coefficients before adjustment for functional limitations.

Table 5 also shows the results of the longi-

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tudinal analyses between depression at t_x and functional limitations, disability days and bed days at t_{x+1} for respondents with and without chronic physical diseases separately. The percentage of respondents with one or more chronic physical diseases was relatively high. The incidence density rates of the longitudinal association between depression (t_x) and functional limitations (t_{x+1}) were higher in respondents with one or more chronic physical diseases than in those without a chronic physical disease. Contrary to the latter group, the longitudinal association was significant in respondents with one or more chronic physical diseases. However, this difference between groups was not statistically significant: the interaction term between depression and chronic physical diseases was not significant ($P = 0{\cdot}14$ for the continuous measure of depression and $P = 0{\cdot}35$ for the dichotomous measure of depression). With respect to the longitudinal relationship between depression (t_x) and disability days (t_{x+1}), there was also a difference between respondents without a chronic physical disease and those with one or more chronic physical diseases: the regression coefficients were higher in the latter group. Only in the latter group, the longitudinal relationship was statistically significant. The interaction term between depression and chronic physical diseases was statistically significant ($P = 0{\cdot}001$ for the continuous measure of depression and $P = 0{\cdot}01$ for the dichotomous measure of depression). The analyses of the relationship between depression and bed days yielded essentially the same results: the regression coefficients were higher in respondents with one or more chronic physical diseases. The interaction term between depression and chronic physical diseases was statistically significant ($P = 0{\cdot}01$ for the continuous measure of depression and $P = 0{\cdot}01$ for the dichotomous measure of depression).

Additional analyses showed that the longitudinal relationship between depression at t_x and functional limitations, disability days and bed days at t_{x+1} was the same in respondents with one and in respondents with more than one chronic physical disease (results not shown). In respondents with newly occurring diseases during the follow-up, there was no statistically significant longitudinal relationship between depression at t_x and functional limitations, disability days and bed days at t_{x+1} (results not shown).

Adjusting for mode of data collection (face-to-face interviews *versus* mail questionnaires) (Geerlings *et al.* 1999) in the longitudinal analyses did not affect the results (results not shown).

DISCUSSION

Depression has been shown to have a wide range of adverse outcomes (Bruce & Leaf, 1989; Bruce *et al.* 1994; Beekman *et al.* 1997*a*; Armenian *et al.* 1998; Penninx *et al.* 1998, 1999; Pulska *et al.* 1998; Ormel *et al.* 1998; Ormel, 2000). However, the temporal relationship between depression and functional outcomes is ambiguous. The present study is, to our knowledge, the first one in which both depression and functional outcomes were measured frequently over time in a community-based sample of older adults. Functional outcomes were operationally defined according to the disablement process model described by Verbrugge & Jette (1994): both functional limitations and disability (disability days and bed days) were studied. The principle aim of this study was to examine the longitudinal effect of depression on subsequent functional limitations, disability days and bed days, thereby taking into account the role of chronic physical diseases.

With respect to the findings, functional limitations were shown to be a clearly different outcome of depression than disability days and bed days. Functional limitations were very persistent over time ($\geqslant 85\%$) whereas both disability days and bed days were less prevalent, less persistent and more fluctuating outcomes. Furthermore, sociodemographic variables associated with functional status in earlier studies such as female sex and higher age (Stuck *et al.* 1999) were associated with functional limitations but not with disability days and bed days.

In longitudinal analyses, a statistically significant association was found between depression at one point in time and both functional limitations, the number of disability days and the number of bed days 5 months later. The associations held up whether depression was analysed at the level of severity of symptoms or at the clinical syndrome level. Moreover, the

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associations were similar in the non-depressed cohort and the depressed cohort. The longitudinal unique short-term effect of depression on subsequent functional limitations was very small; functional limitations were much better predicted by depression at baseline. Several explanations can be put forward. First, functional limitations may be a long-term outcome of depression and the time frame of 5 months may be too short to observe an effect of depression. Similar associations were observed when longer time-lags (10 months and 15 months) were incorporated in the analyses (results not shown); however, since the number of respondents as well as the number of consecutive measurements were smaller in the latter analyses, the results are not completely comparable. Secondly, the strong association between baseline depression and functional limitations may be partly explained by the method of cross-sectional case finding; respondents with a long episode of depression are more likely to be identified at the time of the case finding. Due to the overrepresentation of respondents with persistent depression in the baseline sample, a relatively strong association between baseline depression and an adverse outcome in terms of functional limitations may have been found. This probably explains the relatively strong associations found in earlier studies relying on less frequent measurements and longer intervals. With respect to the longitudinal association between depression and disability, depression was found to be directly associated with disability days and bed days 5 months later; functional limitations did not explain a significant proportion of this depression–disability relationship.

In line with most earlier studies, in the main analyses, depression was studied in relation to subsequent functional outcomes. However, disability has been found to predict depression too (Kennedy *et al*. 1990; Prince *et al*. 1998; Geerlings *et al*. 2000). Separate analyses showed that there was a longitudinal association between functional limitations and disability and subsequent depression as well. Moreover, longitudinal associations remained when models without a time-lag were employed (results not shown), the latter indicating synchrony of change in depression and functional status (Ormel, 2000).

The effect of chronic physical diseases on the interplay between depression and both functional limitations and disability was examined. Stratified analyses showed that the association between depression and subsequent functional limitations and disability was statistically significant only among respondents with one or more chronic physical diseases. This effect of chronic physical diseases was most apparent with respect to the relation between depression and disability days and bed days. In respondents without chronic physical diseases at baseline and in respondents with newly occurring diseases during the follow-up, no association was found. This is inconsistent with previous longitudinal studies, in which depression was found to be associated with functional outcomes in (younger/middle-aged) samples with a low prevalence of medical morbidity as well (Ormel *et al*. 1993, 1999; Armenian *et al*. 1998; Judd *et al*. 2000). However, some of the earlier studies are not comparable with respect to the measurement of depression (major depression instead of depressive symptoms/syndromes), the measurement of functional outcomes (often defined as (psycho)social disability in terms of occupational and social role dysfunction), the number of measurements and the length of the time-intervals.

Some limitations of the present study have to be acknowledged. A first concern is the loss of subjects before and during the present follow-up study. Oversampling in the more vulnerable strata has resulted in considerable non-response. Through mortality and a higher attrition rate in the subjects with more compromised health status, the more frail elderly were underrepresented. Loss to follow-up is probably an inevitable consequence of measuring depression repeatedly over a relatively long period of time. The longitudinal relationship between depression and functional outcomes was most apparent in those subjects with chronic physical diseases; consequently attrition in the most frail elderly has presumably resulted in an underestimation of the effects. Furthermore, bias was probably limited, since the results of the multivariate longitudinal models were essentially the same after adjusting for the number of responses (results not shown). Secondly, functional limitations and disability were measured by self-report, which is likely to be influenced by mood.

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However, since other studies suggest that similar relations would have been observed if measures relatively independent of psychological state were used (Von Korff *et al*. 1992; Ormel *et al*. 1993), bias was probably limited. Nevertheless, future assessments should include independent sources (e.g. family members) or performance-based data. A third concern is that depression was measured using a symptom rating scale, and the results pertain to depressive symptoms experienced and clinically relevant depressive syndromes but not to depressive disorders as defined in the DSM classification. However, it has been shown that depressive syndromes not fulfilling rigorous diagnostic criteria are highly prevalent in older adults, while their consequences are similar to those of major depressive illness (Wells *et al*. 1989; Beekman *et al*. 1997*b*).

Although depression is common in the older population, it is not a necessary component of normal ageing, but rather a treatable condition with severe consequences if not attended to. Unfortunately, depression often goes unrecognized by clinicians and family members (Ormel *et al*. 1991; Freeling, 1993). In the present study, depression was shown to have marked long-term and short-term consequences with respect to functional limitations, disability days and bed days, respectively. Depression at one measurement was directly associated with disability days and bed days 5 months later, whereas the 'incubation' of functional limitations did seem to take more time. Contrary to the former, functional limitations were highly persistent over time. Chronically ill older persons were found to represent a high-risk group for both an adverse long-term effect of depression on functional limitations and an adverse short-term effect of depression on disability. The differential effect of depression on functional limitations and disability may be (partly) conceptually explained in the context of the disablement process (Fig. 1) (Verbrugge & Jette, 1994). Functional limitations include restrictions in basic mental and physical actions, while disability is a concept including difficulty doing activities of daily life. Probably, functional limitations are in the first instance a direct consequence of physical illness, while disability (the last stage of the disablement process) reflects the way people cope with their limitations, thereby being influenced by other factors than the presence of physical illness alone. The direct, probably reciprocal, synchronous link between depression and disability offers opportunities for intervention and treatment of depression; effective treatment of depression has already been shown to improve functional outcomes in younger and clinical populations (Mintz *et al*. 1992; Katon *et al*. 1999). Furthermore, since disability is related to environmental demands (Verbrugge & Jette, 1994), environmental factors should also be taken into account and improved if possible. The finding of a longitudinal relation between depression and functional outcomes in older adults with a compromised health status provides a rationale for treatment of chronic diseases as well as depression in depressed chronically ill elderly, in order to prevent a spiralling decline in psychological and physical health.

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