CLC Discussion Paper Number 1

Disablement in later life: moving beyond health determinants?

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December 2012

UNIVERSITY OF Southampton

EPSRC
Engineering and Physical Sciences Research Council

Abstract

The conceptual model developed by Verbrugge and Jette (1994) has identified an individual's health and the environment in which they live, as key determinants of their process of disablement. However, beyond health and environmental risk factors, and focusing on the latter part of the life course, there has been less emphasis in the literature on the influence of an older person's demographic and socio-economic characteristics on their risk of becoming disabled in later life. This paper uses data from the English Longitudinal Study of Ageing to show that although an older person's physical limitations are the strongest determinants of disability in later life, other characteristics relating to their social circumstances, psychological and mental well-being play a key role in determining disability and need for care.

Keywords

Disability; socio-demographic factors; English Longitudinal Study of Ageing (ELSA); logistic regression

Editorial Note

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The Care Life Cycle

The Care Life Cycle Project (CLC) is a multidisciplinary research project funded by the EPSRC (Engineering and Physical Sciences Research Council), grant number EP/H021698/1, under its 'Complexity Science in the Real World' initiative. The project is researching the supply and demand of health and social care within an ageing society, bringing together researchers from complexity science, gerontology, operational research and demography.

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Table of Contents

Introduction

People are living longer, however not all those years are expected to be spent in good health. In Britain, between 1981 and 2007 the number of years during which people aged 65 and over might experience limiting illness or disability rose from 5.4 to 7.1 years for men and from 8.4 to 8.9 years for women (Office for National Statistics 2010). In order to ensure that the demand for health and social care services in later life is adequately met, a better understanding of how disability is defined and the processes leading to disability is needed. This requires a model that recognises both the social and medical origins of disability (Barnes 2000; Brandt and Pope 1997). An important example of such a model is the disablement process model of Verbrugge and Jette (1994) which we explore in this paper using the English Longitudinal Study of Ageing (ELSA).

The disablement process

The conceptual model of the disablement process presented by Verbrugge and Jette (1994) has been regarded as all-encompassing of the factors associated with an individual's 'journey' towards a disabled state (Figure 1). In this model disability is conceptualised not only as a medical issue, but also as a social issue, relating to the way in which the environment can restrict an individual's capabilities, or compensate for their functional limitations. Such an inclusive conceptualisation places the subject of environmental design at the centre of the policy debate on appropriate housing for disabled individuals across the life course and particularly in later life (Imrie 2006). Of particular importance is the ability to complete tasks necessary for everyday living including activities of daily living (ADL), such as bathing and dressing (Katz et al. 1963) and instrumental activities of daily (IADL), such as shopping and cleaning the home (Lawton and Brody 1969). It is important to distinguish these from functional limitations because in a supportive environment, individuals with functional limitations may still be able to complete such tasks independently of other persons. Therefore it is more appropriate to consider health and functional limitations as proximal determinants of disability rather than synonymous to disability.

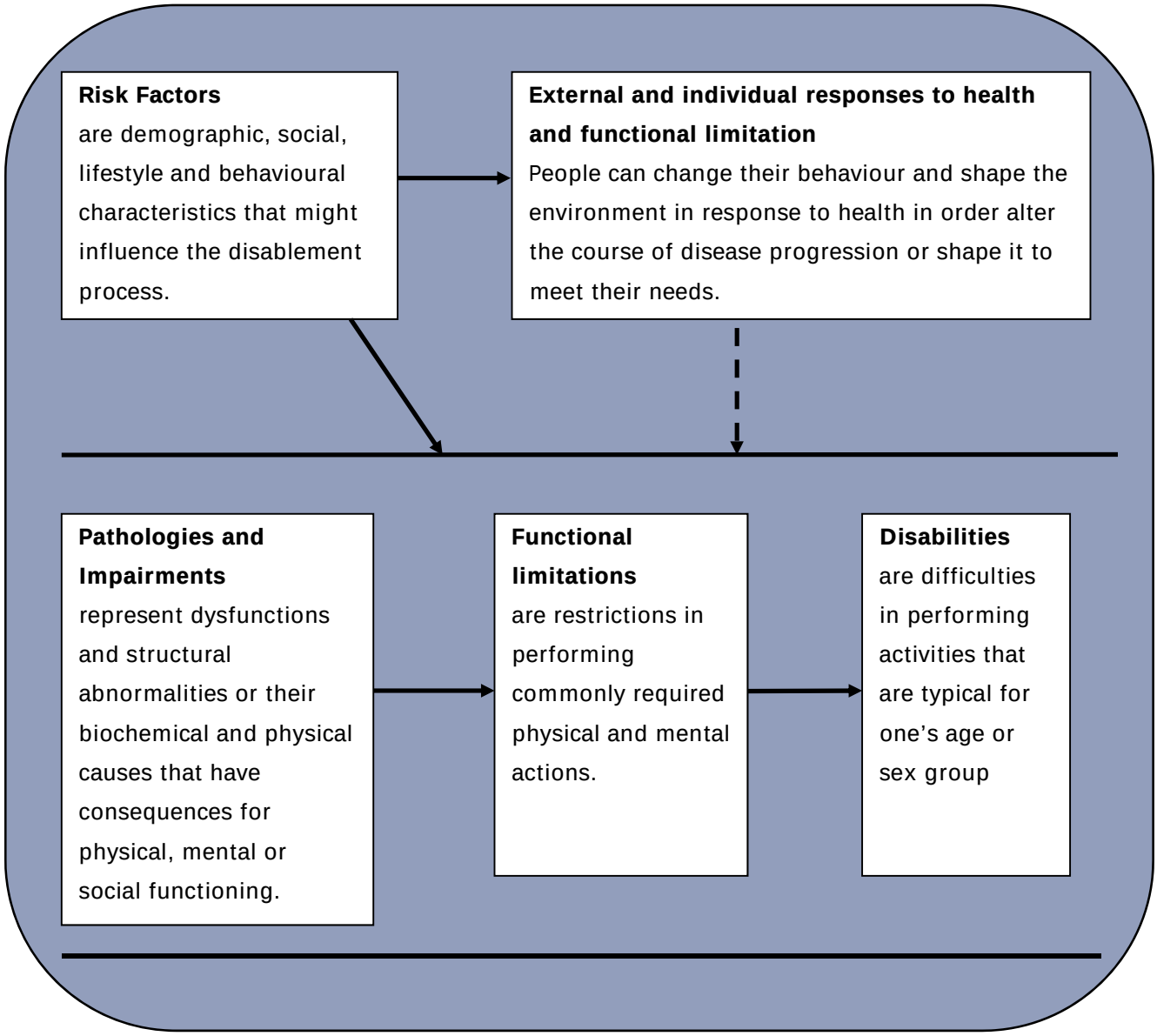


Figure 1: An adaptation of Verbrugge and Jette's (1994) disablement process model

Within the disablement process model, health is not considered as a static state but as part of a dynamic process consisting of pathologies, impairments and functional limitations (Verbrugge and Jette 1994). Progression along the sequence cannot be assumed to be steady or irreversible, as some pathologies, such as strokes, may lead to instantaneous impairments and functional limitations, while other pathologies such as dementia, represent a more prolonged and steadier decline in functional ability. At the same time, an individual's perception of their own

progression through the disablement process can have a significant impact on their experience of disability and their quality of life (Sapey, Stewart and Donaldson 2005).

The literature on functional limitations, which can take many forms, has shown consistent and strong links with disability. For example, mobility problems are strong determinants of disability (Stuck et al. 1999), and sometimes physical limitations are conceptualised as difficulties in performing ADLs (Gjonca, Tabassum and Breeze 2009). Other forms of functioning, such as one's eyesight, hearing, cognitive performance and emotional functioning have also been shown to be associated with an individual's day-to-day functioning (Freedman et al. 2008; Spiers et al. 2005; Stuck et al. 1999). The diverse nature of functional limitations may also relate to a range of pathologies and impairments, which affect an individual's disablement process. Pathologies refer to physiological and biological abnormalities that can be medically detected and labelled as a disease or injury, while impairments are defined as dysfunctions and structural abnormalities that can have consequences for physical, mental or social functioning (Verbrugge and Jette 1994). Whilst theoretically pathologies and impairments can be distinguished, operationalizing the concepts empirically is more problematic as the diagnosis and detection of pathologies is commonly dependent on the existence of impairments. As such it may be more effective to investigate pathologies and impairments in the context of the systems within which they coexist rather than as separate entities.

The evidence on the link between pathologies and disability is strong. Most but not all studies of cardiovascular disease and other diseases related to the metabolic syndrome, including strokes, hypertension and heart attacks are related to disability *independent* of an individual's socio-economic status and other health factors (Bowen 2009; Freedman et al. 2008). In contrast, in the same circumstances, angina may be associated with a reduced risk of disability (Spiers et al. 2005), emphasising the importance of understanding the influence of pathologies and impairments in other systems. A range of other impairments and pathologies are determinants of functional limitations and disability, such as impairments of the musculoskeletal system such as arthritis (Bowen 2009; Freedman et al. 2008; Spiers et al. 2005), sensory impairments such as macular degeneration and glaucoma (Ramulu 2009), respiratory problems such as chronic lung disease (Bowen 2009; Freedman et al. 2008; Spiers et al. 2005), and psychiatric disorders such as depression and dementia (Spiers et al. 2005; Stuck et al. 1999).

Risk factors in the disablement process model are standard epidemiological factors including demographic and socio-economic factors, and health behaviours (Verbrugge and Jette 1994). Risk factors may be associated with disability for at least three reasons. Firstly, risk factors may represent an individual's predisposition to developing a pathology or impairment. Secondly,

such factors may alter an individual's progression along the disablement process, for example in terms of their ability to access health or social care. Thirdly, risk factors may indicate the degree to which the environment can be shaped in order to fit a person's specific capabilities and functional limitations (Fox and Kim 2004).

Demographic risk factors including age, gender and marital status are important determinants of disability (Bowen 2009; Freedman et al. 2008; Matthews et al. 2005). The physical effects of age are well established; however older persons' self-perceptions may also influence their health (Sapey, Stewart and Donaldson 2005; Demakakos, Gjonca and Nazroo 2007). Age may also reflect one's marital status, with older persons being more likely to have experienced the stresses of bereavement (Perrin and Swerissen 2008). Married persons tend to have a lower risk of disability than those who are single, divorced or widowed (Warner and Brown 2011), and the health benefits of marriage are greater for men than for women (Lund, Nilsson and Avlund 2010). In general, women tend to have higher rates of disability than men before adjusting for their socio-economic circumstances and health (Freedman et al. 2008; Matthews et al. 2005; Warner and Brown 2011), which may be a result of women having higher rates of disabling chronic diseases and men having higher rates of fatal diseases (Doblhammer et al. 2009). However, studies adjusting for health and socio-economic conditions have shown that the gender 'advantage' of a lower risk of disability may work in either men's (Grundy and Glaser 2000) or women's direction (Spiers et al. 2005).

A range of socio-economic indicators are associated with disability including occupational social class (Matthews et al. 2005), the nature of one's retirement from the labour market (Denton, Plenderleith and Chowhan 2012), education (Bowen 2009; Jagger et al. 2007; Warner and Brown 2011), household income (Freedman et al. 2008; Matthews et al. 2005) and assets and wealth (Freedman et al. 2008; Warner and Brown 2011). The influence of socio-economic circumstances on disability may be *direct* in terms of affecting their health, but also *indirect* in terms of their ability to adapt to changes in their health and functional capabilites. Measures of one's socio-economic position may indicate material, psychosocial or educational resources that promote resilience in the face of functional limitations (Hildon et al. 2010). In particular, low levels of income and wealth, which are associated with disability even after other health and socio-economic conditions (Bowen 2009; Freedman et al. 2008), may indicate limited resources and options for individuals to complete everyday tasks (Morris et al. 2007). As a result, variations in socio-economic position are likely to indicate variations in resource that in turn affect people's ability to utilise health and social services and adapt their health behaviours in the face of ageing and disease (Verbrugge and Jette 1994).

Health behaviours are also likely to influence disability, for instance smoking is associated with disability (Bowen 2009; Freedman et al. 2008; Spiers et al. 2005; Stuck et al. 1999; Warner and Brown 2011). Ex-smokers who quit smoking during the previous 3 months are at an increased risk of being disabled and this may be due to smokers quitting in response to chronic disease (Doblhammer et al. 2009). Alcohol use is also associated with increased risk of functional limitations, and relative to moderate drinkers, both heavy drinkers (Warner and Brown 2011) and abstainers are at an increased risk of disability (Stuck et al. 1999).

In this paper we explore the ways in which risk factors influence progression through the disablement process using empirical date from the ELSA. In addition, we investigate whether measures of socio-economic position also influence the extent to which individuals are able to adapt and respond to their environment.

Design and Methods

The ELSA is a prospective cohort study of people aged 50 and over in England. The initial sample was drawn from the years 1998, 1999 and 2001 of the Health Survey for England (HSE), which is a random population sample of the English population living in private households. The design, sampling and response rates are presented in Taylor et al. (2003). The wave 1 of the ELSA sample, which has been used in this paper, included 11,392 core sample members, while the analytic sample comprises 10,375 individuals (4,764 men and 5,611 women) for whom there is complete data for all variables of interest.

Disability

The participants were classified as being disabled if they reported having any difficulties with at least one of 6 ADLs such as dressing, bathing, or using a toilet (Katz et al. 1963), or 7 IADLs such as preparing a hot meal, shopping, or making telephone calls (Lawton and Brody 1969).

Functional limitations

Physical capabilities were indicated by the degree of difficulty in walking a quarter of a mile or the report of a long-standing limiting illness (Netuveli et al. 2005), and mobility limitations were indicated by a 10-item scale of tasks which a person has difficulty completing, such as climbing stairs, or getting up from a chair. Sensory limitations were indicated by having difficulty with following a conversation in the presence of background noise, self-reported eyesight and the use of glasses or corrective lenses. Finally, cognitive ability was indicated by

the number of errors made in terms of orientation time (Guerrero-Berroa et al. 2009), and executive functioning was indicated by the number of letters correctly identified in a visual search (Richards et al. 1999).

Pathologies and Impairments

Pathologies were identified using a self-reported measure of past medical diagnosis of a number of conditions such as high blood pressure or hypertension; angina; heart attack, including myocardial infarction and thrombosis; congestive heart failure; diabetes or high blood sugar; stroke; arthritis, including osteoarthritis and rheumatic arthritis; osteoporosis; macular degeneration; cataracts; chronic lung disease; asthma; emotional; nervous or psychiatric problems; Alzheimer's or dementia; Parkinson's disease and cancer. In addition, there was a self-reported measure of the severity of experienced pain, and depression was assessed using 8 items from the Centre for Epidemiological Studies Depression Scale (CES-D) (Radloff 1977).

Risk factors

Health behaviours were represented by one's current smoking status and the frequency of their alcohol consumption. Demographic factors included gender, legal marital status and age group. Socio-economic position was assessed using the National Statistics Socio-Economic Classification (NS-SEC), education was indicated by the respondent's highest academic or national vocational qualification, and housing tenure. Income and non-pension wealth were measured in deciles at the level of the benefit unit (eg. household of one person or more), and were equivalised using the OECD equivalence scale (Hagenars, De Vos and Zaidi 1994).

The disablement process was modelled using logistic regression. The model building process started with bivariate analysis between each predictor separately with disability as an outcome (model 1). We then employed blocks of variables, associated to categories indicated in the conceptual framework, in order to investigate the association of variables with disability independently of other variables in the same category. The blocks were investigated as follows; risk factors (model 2), impairments and pathologies (model 3) and functional limitations (model 4). Those variables within a block which did not significantly improve model fit, using a log likelihood ratio test, were excluded. Variables excluded at this stage were living arrangements, household size, access to a car, diabetic eye disease, self-rated hearing, numeracy and prospective memory. We proceeded with a sequential model building process, which investigated the association of risk factors with disability, independent of pathologies and impairments in model 5, and then independently of functional limitations in model 6.

Throughout the model building process we used a conservative p value of 0.1 in order to avoid falsely excluding variables which may in fact be associated with disability.

Given that some IADLs may not be equally applicable to men and women (Lawton and Brody 1969), we tested for gender differences in the disablement process by exploring statistical interactions between gender and the variables in the final model. Finally, in order to investigate whether social and economic factors might influence one's ability to shape the environment and thus alter the relationship between functional limitations and disability, we tested for interactions between socio-economic measures and functioning limitations. For these analyses, functional limitations were indicated by the two measures of functional limitations which were the most strongly associated with disability, namely one's ability to walk a quarter mile and mobility limitations. In these analyses, those having four or more mobility limitations were collapsed into the same category. The socio-economic measures used to investigate interactions were housing tenure, benefit unit equivalised income in quintiles, benefit unit equivalised wealth in quintiles, highest educational qualification and access to car.

Results

Descriptive statistics for the risk factors used in the main models are presented in table 1. In the analytic sample there is a slight over-representation of people in the more advantaged deciles in terms of benefit unit income and wealth, for example only 9.4% of the analytic sample are in the lowest decile of income whilst 10.4% are in the highest. Almost half of the sample are ex-smokers (46.7%) and have no formal educational qualifications, reflecting the characteristics and experiences of this particular cohort earlier in life.

Table 1: Descriptive statistics and relationship with disability: Socio Economic Measures

Variables	N	%	Model 1	Model 2	Model 5	Model 6
Age in categories						
50 to 54	1,839	19.88	(ref)	(ref)	(ref)	(ref)
55 to 59	2,038	18.35	1.30**	1.30**	1.11	0.99
60 to 64	1,573	15.18	1.56***	1.49***	1.19+	0.93
65 to 69	1,585	13.88	1.75***	1.54***	1.31**	1.05
70 to 74	1,345	12.34	2.53***	2.10***	1.71***	1.24+
75 to 79	968	9.94	3.31***	2.79***	2.44***	1.50**
80 to 84	680	6.29	5.41***	4.32***	4.18***	2.22***
85 to 89	281	3.18	8.41***	6.53***	5.97***	2.01**
90+	66	0.95	11.86***	7.99***	11.54***	3.29***
Gender						
Male	4,764	46.89	(ref)	(ref)	(ref)	(ref)
Female	5,611	53.11	1.37***	1.13*	0.92	0.88+
Legal marital status						
Single, never married	564	5.62	(ref)	(ref)	-	-
First Marriage	5,837	55.96	0.75**	1.03	-	-
Remarried	1,139	10.99	0.89	1.21	-	-
Legally separated	133	1.30	1.07	1.16	-	-
Divorced	960	9.04	1.10	1.29*	-	-
Widowed	1,742	17.09	1.92***	1.10	-	-
NS-SEC						
Higher managerial and professionals	910	8.48	(ref)	(ref)	(ref)	(ref)
Lower managerial	2,130	19.92	1.83***	1.36*	1.22	-
Intermediate	1,381	13.08	2.54***	1.40*	1.39*	-
Small employers and own account	1,068	10.40	1.98***	1.30+	1.26+	-
Lower supervisory and technical	1,171	11.49	3.12***	1.46**	1.43**	-
Semi routine occupations	1,884	18.20	3.08***	1.36*	1.36*	-
Routine occupations	1,661	16.40	3.88***	1.51**	1.57**	-
Unclassified	170	2.03	5.36***	1.59*	1.48	-
Highest educational qualification						
NVQ4+	1,165	11.00	(ref)	(ref)	-	-
Higher education (Not degree)	1,157	11.04	1.38***	1.00	-	-
NVQ3	631	6.16	1.59***	1.15	-	-
NVQ 2	1,673	15.95	1.62***	1.06	-	-
NVQ 1	508	4.91	2.67***	1.27	-	-
Foreign other	905	8.60	2.28***	1.12	-	-
No qualification	4,336	42.36	3.57***	1.31*	-	-
Housing Tenure						
Own outright	5,801	54.84	(ref)			-
Mortgage or shared equity	2,565	25.42	0.62	0.95	-	-
Renting	1,896	18.62	2.34	1.16	-	-
Rent free or squatting	113	1.11	1.01	0.61*	-	-
Income (deciles)						
1st Lowest	968	9.44	(ref)	(ref)	(ref)	(ref)
2nd	1,012	9.90	0.93	0.64***	0.75**	0.78+
3rd	991	9.73	0.94	0.78*	0.78*	0.75*
4th	1,025	9.82	1.11	1.09	0.96	0.92
5th	1,034	9.88	0.99	1.14	1.06	0.92
6th	1,041	9.97	0.78*	1.01	0.95	0.85
7th	1,055	10.22	0.63***	1.08	1.08	1.05
8th	1,077	10.36	0.39***	0.77*	0.81	0.71*
9th	1,084	10.30	0.33***	0.72*	0.75*	0.74+
10th Highest	1,088	10.38	0.26***	0.72**	0.82	0.90
Wealth (deciles)						
1st Lowest	960	9.52	(ref)	(ref)	(ref)	-
2nd	962	9.47	0.85+	0.69***	0.80+	-
3rd	1,019	9.90	0.61***	0.70**	0.74*	-
4th	1,035	9.91	0.47***	0.61***	0.71**	-
5th	1,049	10.08	0.44***	0.57***	0.68**	-
6th	1,065	10.30	0.34***	0.49***	0.61***	-
7th	1,044	10.09	0.32***	0.47***	0.63***	-
8th	1,059	10.24	0.25***	0.39***	0.55***	-
9th	1,096	10.28	0.26***	0.44***	0.63***	-
10th Highest	1,086	10.21	0.19***	0.38***	0.61**	-
Smoking						
Non smoker	3,649	35.16	(ref)	(ref)	-	-
Ex smoker	4,860	46.71	1.24***	1.24***	-	-
Current Smoker	1,866	18.13	1.30***	1.24**	-	-
Alcohol consumption						
... twice a day or more	452	4.35	(ref)	(ref)	(ref)	(ref)
daily or almost daily	2,491	23.87	0.62***	0.76*	0.72*	0.73*
once or twice a week	3,181	30.65	0.65***	0.73*	0.73*	0.72+
once or twice a month	1,074	10.36	0.86	0.92	0.83	0.78
special occasions only	2,023	19.47	1.32**	1.04	0.88	0.83
not at all?	1,154	11.29	1.88***	1.37*	0.88	0.65*
Model likelihood			NA	-5436	-4294	-3304

*** p<.001, ** p<.01, *p<.05,+ p<.10.

Table 1 shows that age is strongly associated with disability, and the association between age and disability remains strong and is independent of pathologies (model 5), but is greatly reduced when functional limitations are added in the final model (model 6). When marital status is included in the same model as age, gender and other risk factors, the association between disability and marital status and age is greatly diminished. This may suggest that the association between widowhood and disability is mostly due to women comprising the majority of those widowed rather than to the consequences of the stress of losing one's partner and to bereavement (Perrin and Swerissen 2008). The increased risk of experiencing disability by women is dramatically reduced and perhaps reversed when health and functional limitations are included in model.

In unadjusted analyses, there is a strong gradient for the association between disability and the measures of socio-economic position, although in the case of income there was little difference in the risk of disability between people in the first 5 deciles, and the gradient existed only from the sixth decile and above. However, the measures of socio-economic position are strongly associated with each other. The associations between education and housing tenure and disability are greatly reduced in model 2, suggesting that education and housing tenure are mediated by other risk factors, including income, wealth and occupational social class. In turn the associations between disability and income, wealth and occupational social class are reduced when pathologies and impairments are added (model 5), and these measures, with the exception of income, were entirely mediated by functional limitations in model 6. The only variable remaining in the final model (see model 6 in table 1) is income and, in contrast to the unadjusted results, the association suggests that the lowest incomes (bottom decile) are directly associated with disability, while the benefits of higher incomes are mediated by health and disease.

Once the other risk factors are accounted for (model 2 in table 1), the association between disability and being an ex-smoker and current smoker are similar and the exclusion of smoking in model 5 suggests that the effects of smoking are mediated by pathologies and impairments. In models 1 and 2 both frequent alcohol consumption and no consumption is associated with an increased risk of disability. However, once the effects of pathologies and impairments are accounted for, a lower frequency of alcohol consumption is associated with a reduced risk of disability, and the risk of non-drinkers having a disability is only two-thirds of the risk for frequent drinkers.

The distribution of pathologies and impairments is described in table 2. There was great variability in the prevalence and diagnosis of pathologies and impairments, for example only

0.38% of the population had a prior diagnosis of Alzheimer's or dementia, while 37% of the population had been diagnosed with blood pressure or hypertension. Functional limitations are described in table 3. Whilst nearly 60% of the population experienced some form of mobility limitation, only 16% experienced 4 or more limitations. Assessing functional limitations using the other measures was consistent with the majority of the sample not having any functional limitations. For example, less than 16% of the sample had a functional limitation related to their eyesight, while 33% of the sample had some form of limiting long-standing illness. Overall, only 27.33% of the sample (N=2,859) reported difficulties with at least one ADL or IADL.

Table 2: Descriptive statistics and relationship with disability: Impairments and pathologies

Variables	N	%	Model 1	Model 3	Model 5	Model 6
High blood pressure or Hypertension						
No	6,458	62.65	(ref)	(ref)	(ref)	-
Yes	3,917	37.35	1.61***	1.14*	1.09	-
Angina						
No	9,358	90.35	(ref)	(ref)	(ref)	(ref)
Yes	1,017	9.65	3.09***	1.46***	1.22*	0.75**
Heart attack (including myocardial infarction and thrombosis						
No	9,768	94.24	(ref)	(ref)	(ref)	-
Yes	607	5.76	2.59****	1.35*	1.30*	-
Congestive Heart failure						
No	10,285	99.17	(ref)			
Yes	90	0.83	9.18***	3.91***	3.52***	2.04*
Diabetes						
No	9,631	92.99	(ref)	(ref)	(ref)	(ref)
Yes	744	7.01	2.33***	1.59***	1.50***	1.25+
Stroke						
No	9,963	96.07	(ref)	(ref)	(ref)	-
Yes	412	3.93	4.12****	2.62***	2.05***	-
Arthritis including osteoarthritis and rheumatism						
No	7,001	68.13	(ref)	(ref)	(ref)	-
Yes	3,374	31.87	4.60***	2.32***	2.11***	-
Osteoporosis						
No	9,875	95.27	(ref)	(ref)	(ref)	-
Yes	500	4.73	3.51***	1.84***	1.72*	-
Macular degeneration						
No	10,233	98.67	(ref)	(ref)	(ref)	-
Yes	142	1.33	2.92***	2.03***	1.72*	-
Cataracts						
No	9,005	8667	(ref)	(ref)	-	
Yes	1,370	13.32	2.71***	1.90***	-	
Chronic lung disease						
No	9,685	93.46	(ref)	(ref)	(ref)	-
yes	690	6.54	3.63***	2.11***	2.05***	-
Asthma						
No	9,173	88.63	(ref)	(ref)	(ref)	-
Yes	1,202	11.37	1.78***	1.21*	1.32***	-
Emotional Nervous or psychiatric problem						
No	9,612	92.78	(ref)	(ref)	(ref)	(ref)
Yes	763	7.22	1.87***	1.17	1.40***	1.36**
Alzheimer's or Dementia						
No	10,338	99.62	(ref)	(ref)	(ref)	(ref)
Yes	37	0.38	6.58***	7.27***	6.00***	6.28***
Parkinson's disease						
No	10,333	99.62	(ref)	(ref)	(ref)	(ref)
Yes	42	0.38	11.33***	14.00***	14.48***	5.96**
Cancer or Malignant tumour						
No	9,731	93.89	(ref)	(ref)	-	-
Yes	644	6.11	1.49***	1.22+	-	-
Pain						
No pain	6,442	62.72	(ref)	(ref)	(ref)	(ref)
Mild Pain	1,084	10.36	2.73***	1.90***	2.13***	1.18
Moderate Pain	1,923	18.14	6.34***	3.36***	3.73***	1.24**
Severe Pain	926	8.78	15.37***	6.29***	6.64***	1.66***
Depression in categories						
0 Symptoms	4,274	41.36	(ref)	(ref)	(ref)	(ref)
1 Symptoms	2,423	23.24	2.19***	1.56***	1.48***	1.18+
2 Symptoms	1,200	11.60	4.47***	2.72***	2.35***	1.51***
3 or more	2,478	23.81	7.11***	3.30***	2.84***	1.59***
Model likelihood			NA	-4500	-4294	-3304

*** p<.001, ** p<.01, *p<.05,+ p<.10.

The associations between disability, and pathologies and impairments of the musculoskeletal, visual and respiratory systems, are mostly independent of other risk factors, pathologies and impairments (model 5), but largely accounted for by functional limitations in model 6 (see table 2). In contrast, the associations between disability and pathologies and impairments of the cardiovascular system are more mixed. The association between hypertension and disability is modest and accounted for by other pathologies and risk factors. Prior experience of acute pathologies represented by stroke and heart attacks is independent of other pathologies and impairments, however the experience of stroke and heart attacks ceases to be associated with disability once functional limitations are added in model 6. More chronic conditions represented by congestive heart failure, diabetes and angina, do have associations with disability independent of the measured functional limitations. However, the interpretation of the association between angina and disability requires caution, as angina is associated with a reduced risk of disability. In contrast, pathologies and impairments relating to mental health, pain and Parkinson's disease are independently associated with disability in all models, while the association between dementia and disability remains unaltered by the inclusion of other variables in the model.

The associations between disability and functional limitations are shown in table 3. The strongest determinant of disability was mobility limitations, for example people with no mobility limitations had a 3.4% chance of experiencing disability, in contrast to those with eight or more mobility limitations who had a 95.3% chance of experiencing disability (see table 4). As a consequence, there are very high odds ratios in the models. Despite this there was evidence that disability was associated with other measures of functional limitations across different domains including the reports of limiting longstanding illness, orientation in time and hearing. However, not all the measures of individuals' capability were associated with disability, for example eyesight did not have an association with disability after adjusting for other functional limitations, while the same was true for accuracy, a measure of cognitive functioning.

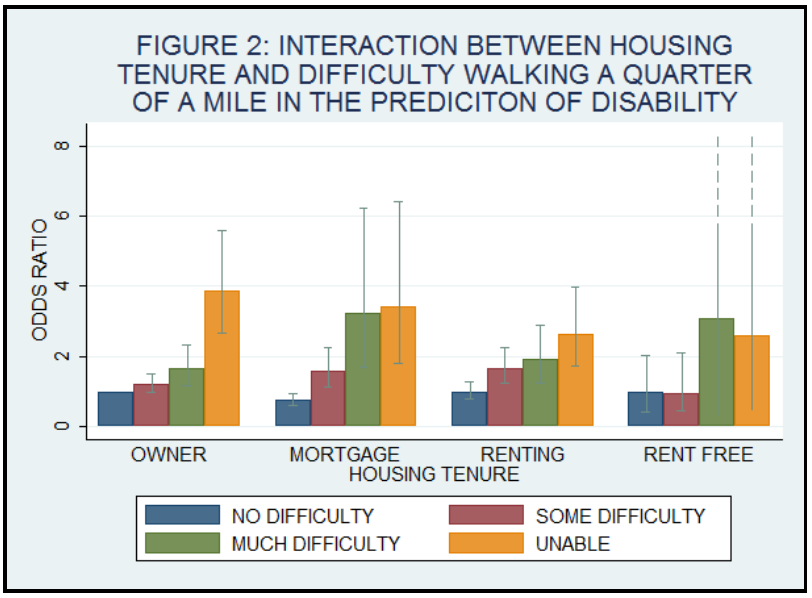
Table 3: Descriptive statistics and relationship with disability: Functional limitations

Variables	N	%	Model 1	Model 4	Model 6
Mobility limitations					
Zero	4,456	43.61	(ref)	(ref)	(ref)
One	1,766	16.90	4.61***	3.74***	3.50***
Two	1,022	9.58	11.10***	7.36***	6.61***
Three	1,405	13.47	27.79***	13.80***	11.68***
Four to seven	1,150	10.96	125.20***	36.17***	30.81***
Eight or more	576	5.49	574.93***	100.04***	82.78***
Limit' longstanding illness					
No limiting illness	6,854	66.66	(ref)	(ref)	(ref)
Limiting illness	3,521	33.34	11.05***	1.91***	1.86***
Walk a quarter of a mile					
No difficulty	7,442	71.89	(ref)	(ref)	(ref)
Some Difficulty	1,383	13.16	7.76***	1.62***	1.45***
Much difficulty	613	5.79	24.59***	2.37***	2.01***
or unable to do this	937	9.17	57.70***	4.22***	3.43***
Difficulty holding a conversation					
No difficulty	6,826	65.81	(ref)	(ref)	(ref)
Some difficulty	3,549	34.19	2.03***	1.29***	1.22**
Orientation in time					
No errors	8,126	78.26	(ref)	(ref)	(ref)
one error	1,946	18.78	1.61***	1.30***	1.27*
Two or more	303	2.97	2.67***	1.71**	1.54+
Eye sight					
Excellent	1,583	15.28	(ref)	(ref)	-
Very good	3,208	30.89	1.38***	1.06	-
Good	4,051	39.01	2.00***	1.07	-
Fair	1,232	11.86	4.35***	1.32*	-
Poor or Blind	301	2.96	8.23***	1.61*	-
	Mean	SD			
Cognitive functioning: accuracy	18.5	5.9			
One unit Change from 0 to 20	NA	NA	0.91***	0.97***	-
One unit Change from 20 to +	NA	NA	0.98*	0.99	-
Model Likelihood			NA	-3391	-3304

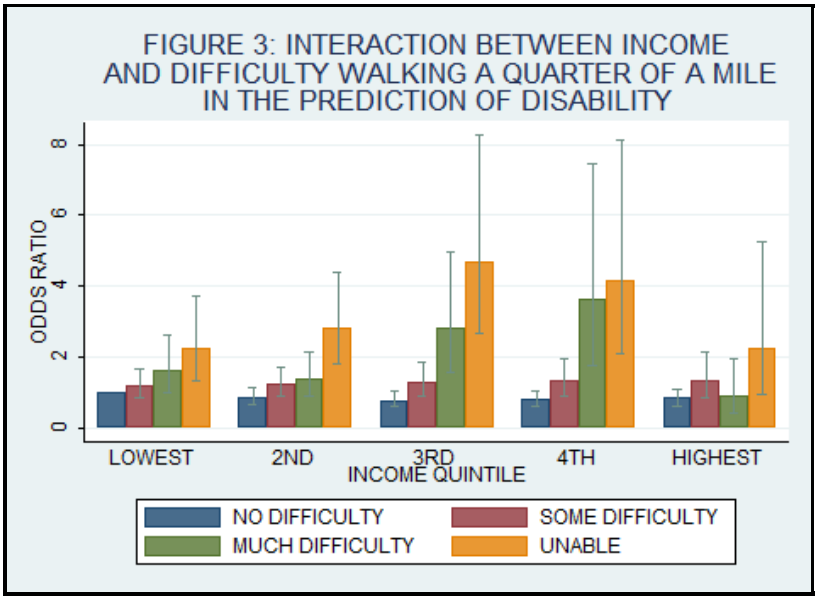
*** p<.001, ** p<.01, *p<.05,+ p<.10.

In order to test for gender differences in the disablement process, we tested for interactions between gender and all variables included in model 6, however none were significant. In addition, in order to assess whether individuals with a more advantaged socio-economic status were less vulnerable to disability, we tested for interactions between socio-economic measures and selected functional limitations. In these analyses the measures used to operationalise one's socio-economic position were housing tenure, benefit unit income (in quintiles), benefit unit wealth (in quintiles), highest educational qualification, occupational social class and access to a car, while the measures used to operational functional limitations were mobility limitations and the ability to walk a quarter of a mile. In the prediction of disability there were no significant interactions between mobility limitations and the socio-economic measures. However, there were two significant interactions between the socio-economic measures and the ability to walk a quarter of a mile. The first significant interaction p=0.0369 was with housing tenure (see figure 2), and owner-occupiers who had much difficulty walking a quarter mile were much less

likely to experience a disability than those who had a comparable difficulty with walking but lived in a home with a mortgage or shared equity scheme.



The second interaction was between income and being unable to walk, which was significant at $p < .05$ (see figure 3). The key driver of the interaction would appear to be that the association between disability and having much difficulty to walk a quarter of a mile is much greater for individuals in the 3rd and 4th quintiles than for those in the highest and lowest income quintiles.



Discussion

The aim of this paper was to empirically examine the determinants of disability as conceptualised by Vebrugge and Jette (1994), in order to better understand the disablement process and how it is influenced by a range of risk factors. In the final model (6), we found that physical functioning as indicated by mobility limitations was the single most important predictor of disability. However, despite the dominance of mobility limitations, other measures of functional limitations, including cognitive ability and the ability to hold conversations were in the final model, as were certain pathologies and impairments relating to one's cardiovascular system and mental health. In addition, three of the risk factors, namely age group, gender and benefit unit equivalised income, were included in the final model.

In early models, consistent with the literature (Bowen 2009; Freedman et al. 2008; Spiers et al. 2005), there is a clear a link between the measures of socio-economic position and disability. Wealth, income and occupational social class have a stronger influence than education, and these associations appear to be largely mediated by pathologies, impairments and physical functioning. There is some evidence that being in the lowest income decile was associated independently with an increased risk of disability, a finding supported elsewhere (Morris et al. 2007). However, the relationship between income and functional capabilities may be more complex. We found interactions between the ability to walk a quarter of a mile and both income and housing tenure, however we are interpreting them cautiously, and more longitudinal analysis may be required in order to assess the causal direction of each association.

The association between alcohol consumption and disability in unadjusted analyses and in analyses adjusting for risk factors, is consistent with the literature showing that both those who drink frequently and those who do not drink at all are at an increased risk of disability (Stuck et al. 1999). However, in our final model, and once health has been accounted for, frequent drinkers were clearly the most at risk of reporting a disability, while non-drinkers were the least likely. This could suggest that frequent drinking is potentially debilitating and that any disadvantage in terms of disability and functional limitations for non-drinkers is driven by other risk factors and health problems. Our results indicate that once other risk factors are accounted for, ex-smokers are at just as much risk of disability as current smokers, and that this association appears to be mediated by pathologies and functional limitations possibly set in early life. The literature is unclear on the effects of smoking on disability in later life, with some studies suggesting that ex-smokers have a reduced risk of disability relative to current smokers (Stuck et al. 1999), and other studies suggesting that ex-smokers face an increased risk of disability (Bowen 2009).

In addition, our results demonstrate that any disadvantages with respect to disability that women may face relative to men, are accounted for by health and functional limitations, and this is consistent with the literature (Doblhammer et al. 2009; Freedman et al. 2008; Grundy and Glaser 2000; Lund et al. 2010; Matthews et al. 2005; Spiers et al. 2005; Warner and Brown 2011). Also consistent with the literature is the suggestion that there are protective associations between marriage and disability (Warner and Brown 2011), particularly for women, and such associations are mostly accounted for by other risk factors, notably age, with a weak association appearing between divorce and disability. This suggests that the stresses of divorce may have certain disabling effects, which are mediated by subsequent pathologies.

Our study also provides key insights into how we might define pathologies, impairments and functional limitations, which can have important methodological implications. Physical pathologies and impairments represented by cancer, and problems with the musculoskeletal, respiratory and visual functions, were accounted for by functional limitations, suggesting that the way in which such pathologies impact on disability is explained by other factors operationalized in the model. In contrast the pathways through which cardiovascular factors influence disability appear to be more mixed.

High blood pressure would appear to merely be a risk factor showing no association with disability once other risk factors, pathologies and impairments are accounted for, and any associations between disability, and stroke and heart attacks appear to be mediated by functional limitations. However, chronic conditions such as diabetes, congestive heart failure and angina, appear to have effects which are independent of the measured functional limitations, suggesting that such impairments may restrict an individual's functioning in ways which are not recognised by scales of physical functioning used in the ELSA. For example, diabetic neuropathy may mean that diabetics find it more difficult to identify problems associated with their feet, thus making self-care tasks harder (Perrin and Swerissen 2008). Similarly, pathologies and impairments relating to neurological problems and mental health are associated with disability independently of functional limitations, indicating that in these areas, it is difficult to separate the consequence of the pathology from the underlying disease.

Some of the variables that might be thought to contribute to the final model were excluded as they did not significantly improve the model fit. A key surprise was the exclusion of some of the measures of cognitive ability early in the modelling process. For example, numeracy could be considered as helpful with the management of certain IADLs such as managing one's finances, however, there was no association between numeracy and disability independent of other functional limitations. Similarly, one's eyesight was excluded from the model, despite the

central role of one's eyesight in recognising and identifying objects which are essential for the performance of ADLs or IADLs. This may indicate that limitations in one's visual system result directly in difficulties with physical functioning, and may partly explain the predominance of mobility limitations in indicating functional limitations.

A key issue in this paper was drawing the distinction between functional limitations and disability, which is due to the fact that disability is associated with measures of functional limitation from multiple domains, thereby suggesting that there are multiple routes to disability. However, the shear strength of the association between disability and different measures of mobility limitations suggests that the difference between people's physical health and disability can only partly be mitigated by technological solutions designed to help people adapt the environment to their needs. This may partly be due to the measure used to operationalize disability in the ELSA. More specifically, ADLs and IADLs are used to assess the extent of "difficulty" one faces with performing ADLs and IADLs. Nevertheless, ADLs and IADLs can also be operationalized using measures based on "dependence", which assess the extent to which one needs help in order to complete ADLs and IADls, and dependence measures have been shown to be more susceptible to environmental influences (Spiers et al. 2005). As a result, the measure used in the ELSA identifies individuals who would broadly benefit form extra support in relation to daily activities, but who may have a lower overall level of need, and this is supported by other analyses of this dataset (Vlachantoni et al. 2011).

Our study operationalizes the disablement process model of Vebrugge and Jette (1994), in doing so we shed light on the way in which epidemiological risk factors influences disability. Physical functioning and in particular mobility limitations show the strongest associations with disability demonstrating a need to greatly improve technological solutions to rehabilitate and support people with functional limitations. However, we also demonstrate that physical functioning is not synonymous with disability and that other aspects of functioning and the social environment that need to be considered.

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