International Journal of Epidemiology, 2018, 829–840
doi: 10.1093/ije/dyx277
Advance Access Publication Date: 29 January 2018
Original article

Social Inequality

Do material, psychosocial and behavioural factors mediate the relationship between disability acquisition and mental health? A sequential causal mediation analysis

Zoe Aitken,[1]* Julie Anne Simpson,[2] Lyle Gurrin,[2] Rebecca Bentley,[1,2] and Anne Marie Kavanagh[1]

[1]Centre for Health Equity, Melbourne School of Population and Global Health, The University of Melbourne, Carlton VIC 3010, Australia and [2]Centre for Epidemiology and Biostatistics, Melbourne School of Population and Global Health, The University of Melbourne, Carlton VIC 3010, Australia

*Corresponding author. Centre for Health Equity, Melbourne School of Population and Global Health, The University of Melbourne, 207 Bouverie Street, Carlton, VIC 3010, Australia. E-mail: zoe.aitken@unimelb.edu.au

Editorial decision 3 December 2017; Accepted 15 December 2017

Abstract

Background: There is evidence of a causal relationship between disability acquisition and poor mental health; however, the mechanism by which disability affects mental health is poorly understood. This gap in understanding limits the development of effective interventions to improve the mental health of people with disabilities.

Methods: We used four waves of data from the Household, Income and Labour Dynamics in Australia Survey (2011–14) to compare self-reported mental health between individuals who acquired any disability (n=387) and those who remained disability-free (n=7936). We tested three possible pathways from disability acquisition to mental health, examining the effect of material, psychosocial and behavioural mediators. The effect was partitioned into natural direct and indirect effects through the mediators using a sequential causal mediation analysis approach. Multiple imputation using chained equations was used to assess the impact of missing data.

Results: Disability acquisition was estimated to cause a five-point decline in mental health [estimated mean difference: –5.3, 95% confidence interval (CI) –6.8, –3.7]. The indirect effect through material factors was estimated to be a 1.7-point difference (–1.7, 95% CI –2.8, –0.6), explaining 32% of the total effect, with a negligible proportion of the effect explained by the addition of psychosocial characteristics (material and psychosocial: –1.7, 95% CI –3.0, –0.5) and a further 5% by behavioural factors (material-psychosocial-behavioural: –2.0, 95% CI –3.4, –0.6).

Conclusions: The finding that the effect of disability acquisition on mental health operates predominantly through material rather than psychosocial and behavioural factors has important implications. The results highlight the need for better social protection,

including income support, employment and education opportunities, and affordable housing for people who acquire a disability.

Key words: disability, mental health, health inequalities, social epidemiology, causal mediation analysis

Key Messages

- This paper investigated the mechanistic pathways linking disability acquisition and mental health using sequential causal mediation analysis to examining the effect of material, psychosocial and behavioural factors as mediators of the association.
- The total causal effect of disability acquisition on mental health was estimated to be a five-point decline in Mental Health Inventory (MHI) score.
- The effect was partially explained by the three sets of mediators, with 32% of the total effect mediated by material factors, a negligible proportion mediated by the addition of psychosocial factors and a further 5% by behavioural factors.
- The effect of disability acquisition on mental health operates predominantly through material factors, highlighting the need for better social protection, including income support, employment and education opportunities, and affordable housing for people who acquire a disability.

Introduction

Currently, more than a billion people, approximately 15% of the world's population, live with a disability.[1] People with disabilities experience substantial health inequalities and are at high risk of poor mental health.[2,3] A causal relationship between disability and poor mental health has been suggested from analyses of prospective cohort studies.[2–9] However, the mechanism by which disability leads to deterioration in mental helath is poorly understood.

There are a number of different potential explanations for a causal link between disability and poor mental health. Supported by theoretical and empirical studies of the mechanisms underlying income-related health inqualities, three frameworks have become well established in explaining how social determinants influence health: material, psychosocial and behavioural pathways.[10–13] First, the material pathway, by which differential exposure to structural and material living conditions leads to health inequalities, which posits that material conditions such as poverty and economic deprivation affect health directly, but also have indirect effects by enabling access to better living circumstances such as access to health care.[14] Second, the psychosocial perspective emphasizes the importance of psychosocial and stress-related risk factors on health, with inequalities arising from the unequal distribution of psychosocial factors such as social support, home–work balance and personal control.[15] Third, differences in health-related behaviour are thought to contribute to health inequalities, e.g. smoking, physical activity and diet.[16] There has been considerable debate regarding the relative importance of these factors in explaining social inequalities in health.[11] Most empirical studies have argued for the significance of material pathways,[11,17] postulated to have a greater relative contribution because they exert both a direct effect on health as well as an indirect effect through psychosocial and behavioural pathways.[12,18]

With regard to the mechanisms driving disability-related mental health inequalities, disability acquisition may lead to changes in material, psychosocial and behavioural factors, which could explain, or mediate, the observed mental health deterioration. At present, it is not clear to what extent the effect of disability on mental health operates through these proposed pathways or through other mechanisms. Evidence regarding the importance of different pathways between disability and mental health is sparse; the research has mainly been conducted in cross-sectional studies of people with chronic illness, has only examined psychosocial pathways and no study has examined multiple pathways simultaneously. Three studies examined mediation of the effect through psychosocial resources and found evidence that some of the effect of disability acquisition on depressive symptoms[6] and depression was operating through this pathway.[6,19,20] Understanding the mechanisms underpinning these mental health inequalities is an important public health question because socioeconomic intermediary variables are potential modifiable

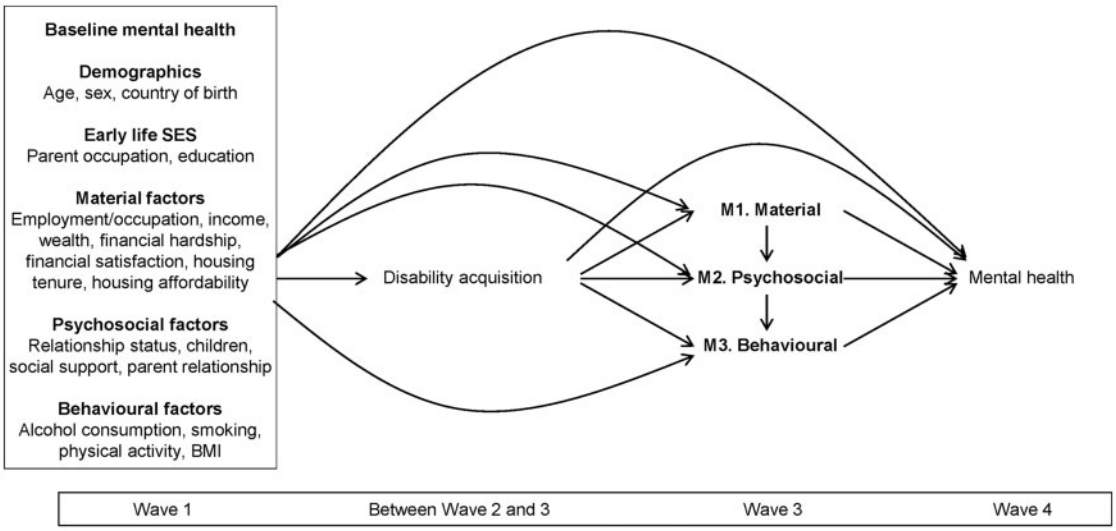

Figure 1. Casual diagram illustrating postulated causal relationships between disability acquisition and mental health.

targets for interventions to mitigate the adverse effects of disability on people's mental health.[21]

In this study, we use data from four waves of a longitudinal study of Australian adults and apply recently developed methods—sequential causal mediation analysis—to estimate the relative importance of three distinct mechanistic pathways leading from disability acquisition to poor mental health, quantifying the indirect effects through material, psychosocial and behavioural factors (Figure 1). Material factors are likely to affect mental health directly as well as indirectly through psychosocial factors such as latent consequences of employment (e.g. purposeful time use, self-esteem)[22] and behavioural factors. Similarly, psychosocial factors are thought to exert a direct effect on mental health, and an indirect effect through behavioural factors.

Methods

Data source

The Household, Income and Labour Dynamics in Australia (HILDA) Survey is a longitudinal study of Australian households, conducted annually since 2001.[23] The survey collects information on demographic, social, economic and health characteristics of individuals using a combination of interviews and self-completed questionnaires. The original sample included 13 969 participants from 7682 households, randomly sampled using a national probability sample of private dwellings. A top-up sample was added in 2011 to maintain representativeness, leading to a sample size after 14 waves of 28 794 people. On average, for all waves of the survey, response proportions were 80% (ranging from 70% to 92%) and attrition was 5.7% between waves, ranging from 3.5% in 2014 to 13.2% in 2002. The analysis used four waves of the survey (2011 to 2014) to establish a temporal sequence between disability acquisition, the mediators and mental health.

Disability acquisition

Information on disability was collected in every wave, using a single question defining disability as 'an impairment, disability or long-term health condition, which restricts everyday activities that had lasted for six months or more'. Disability acquisition was defined as two waves reporting no disability, followed immediately by two consecutive waves reporting a disability. We used two consecutive waves of disability so as to exclude people with transient disability and to reduce the potential for measurement error—a definition used in previous studies examining disability acquisition.[24–27] Participants who acquired a disability were compared with those who reported no disability in any of the four waves. People who reported other patterns of exposure, such as a single wave of disability, were excluded. Eligibility for inclusion required participation and response to the disability question at all four waves.

Mental health

Mental health was assessed in the final wave (2014) using the Mental Health Inventory (MHI), a subscale of the Short Form 36 (SF-36, a widely used general health questionnaire that has been validated in the Australian population using data from the HILDA Survey).[28] The MHI is a well-validated and reliable measure of mental health

Table 1. Description of mediator variables

Variables	Type	Definition/categorization
Material factors		
Occupation	Categorical	High skill; medium skill; low skill job; unemployed/not in labour force
Weekly income	Continuous	Equivalized household disposable income, $AUD
Financial hardship	Categorical	Prosperous/very comfortable; reasonably comfortable; just getting along/poor/very poor
Financial satisfaction	Continuous	Satisfaction with financial circumstances, ranked using an 11-point Likert scale ranging from 'totally dissatisfied' to 'totally satisfied'
Housing tenure	Categorical	Outright owner; mortgager; renter
Housing affordability	Binary	Unaffordable defined as households in the lowest 40% of the income distribution with housing costs exceeding 30% of their gross income
Psychosocial factors		
Relationship status	Binary	Yes; no
Children	Binary	Yes; no
Social support	Continuous	Constructed using the average of 10 questions addressing aspects of emotional support, each rated on a seven-point Likert scale[25]
Socializing	Continuous	Frequency of socializing with friends or relatives, rated on a seven-point Likert scale ranging from daily to less than once every 3 months
Parent relationship	Continuous	Satisfaction with relationship with parents, rated on an 11-point Likert scale ranging from 'completely dissatisfied' to 'completely satisfied'
Behavioural factors		
Smoking	Categorical	Never; ex-smoker; current
Alcohol consumption	Categorical	Never; rarely; 1–2 days per week; >2 days per week
Physical activity	Categorical	>3 times per week; one to three times per week; less than once a week
Body mass index	Continuous	Self-reported, kg/m^2
Healthy diet index	Continuous	Ranging from 0 'unhealthiest' to 4 'healthiest', derived from four binary questions: eating fruit every day; eating vegetables every day; eating fatty foods less than once a month; drinking low fat milk[26]
Quality of sleep	Continuous	Rated on a four-point Likert scale ranging from 1 'very good' to 4 'very bad'

status.[29] It measures symptoms of depression, anxiety and psychological wellbeing and has been shown to be an effective screening tool for mood and anxiety disorders and severe depressive symptomatology in comparisons with established mental health, wellbeing and depression scales[30–33] as well as studies comparing against clinical diagnoses.[34–37] The MHI has been shown to be psychometrically sound, with high internal consistency, discriminant validity and high test–retest reliability.[38] It includes five items relating to mental health over the previous 4 weeks, each scored using five response categories. Total scores were transformed into a scale with a mean score of 74 (range: 0–100), as per standard practice, with higher scores reflecting better mental health. Previous research has suggested that a difference of four to five points on the MHI scale is likely to reflect a minimally important clinical difference in mental health.[39,40]

Mediators

Mediator variables, described in Table 1, were measured in the third wave (2013). The choice of variables and their classification into three broad categories were motivated by reviewing empirical studies examining different explanations for socio-economic inequalities in health[11,41–43] and selecting similar variables available in the HILDA Survey where possible.

Baseline covariates

Baseline covariates were measured in the first wave (2011), as a measure of people's circumstances prior to disability acquisition. It is well documented in the literature that the incidence of disability is socially patterned, with people who experience socio-economic disadvantage being more likely to acquire a disability.[25,44,45] Furthermore, according to the International Classification of Functioning, Disability and Health (ICF) framework, disability results from the interaction between health conditions, personal attributes and environmental factors.[46,47] Conceived in this way, personal attributes such as the experience of financial strain, or characteristics of people's social environment, such as their ability to access social support, are key determinants of disability as they influence the impact of people's impairments on activity limitations and restriction to participation.

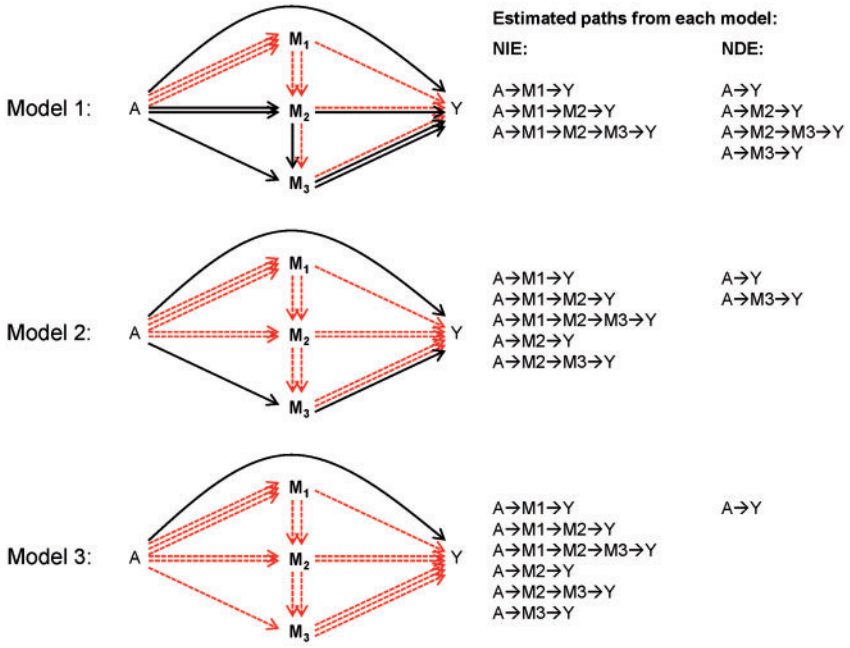

Figure 2. Simplified causal diagrams illustrating estimated paths in Models 1–3, the NDE illustrated by the black lines (-) and the NIE by the dashed lines (- -) (A, disability acquisition (exposure of interest); Y, mental health (outcome); Mediators—M1, material factors; M2, psychosocial factors; M3, behavioural factors).

Demographic characteristics included age, sex and country of birth (Australia; other) and socio-economic characteristics included education (bachelor's degree and above; completion of secondary education; did not complete secondary) and parental occupation (high skill; medium skill; low skill or not in the labour force). Baseline levels of material, psychosocial and behavioural variables were recorded, categorized as described above, except for diet index and sleep quality, which were not measured in 2011. Mental health at baseline was measured using the MHI.

Sequential causal mediation approach

Mediation analysis aims to determine the extent to which an association between an exposure (here, incident disability) and an outcome (mental health) is due to the effect of the exposure on an intermediate variable (the mediator) which then influences the outcome. It aims to partition the total (causal) effect (TCE) of the exposure on the outcome into the effect that acts through the mediator, the *indirect effect* and the effect of exposure on outcome through mechanisms other than those that involve the mediator, the *direct effect* ('direct' in the sense that it by-passes the putative mediator). We sought to decompose the effect of disability acquisition on mental health into natural direct effects (NDE) and natural indirect effects (NIE) through material, psychosocial and behavioural factors using a sequential approach to causal mediation analysis (further details in Supplementary File 1, available as Supplementary Data at *IJE* online).[48] This approach allows for mediation analysis through multiple causally related mediators and accommodates exposure–mediator interactions, one of the main sources of potential bias of the traditional approach to mediation. Based on our assumptions about the causal ordering of the mediators, this approach enabled us to estimate, in Model 1, the NIE through material factors (including paths that act through causal descendants of material factors but excluding paths that act only through psychosocial and/or behavioural factors), in Model 2, the NIE through both material and psychosocial factors (and through their causal descendants but excluding the path that acts only through behavioural factors) and, in Model 3, the NIE through material, psychosocial and behavioural factors, consisting of all possible paths except for the 'direct' path from exposure to outcome (Figure 2).

Statistical analysis

We used a weighting approach to estimate the marginal TCE, NDE and NIE for each set of mediators (further details in Supplementary File 1, available as Supplementary Data at *IJE* online). Inverse probability weighting was used to achieve exchangeability between the comparison groups and thus to account for possible confounding of the exposure–mediator and exposure–outcome associations by measured covariates.[48–50] The MHI was modelled as a continuously valued outcome using linear regression models with and without the mediators, including all baseline

variables as covariates. Interactions were included between the exposure and mediator variable if removal of an interaction term substantially changed the estimates of the NDE and NIE,[51] measured as a change in the estimate of greater than half a standard error. Bootstrapping with 200 replications was used to calculate 95% confidence intervals (CIs).

Missing data

There were missing observations for the outcome, as well as several baseline covariates and mediators (Table S2.1, Supplementary File 2, available as Supplementary Data at *IJE* online). The distribution of baseline covariates was compared between participants with and without missing observations to determine whether missingness was associated with the values of measured variables. Participants with missing data had poorer mental health and greater socio-economic disadvantage across all measures compared with those with complete data (Table S2.2, Supplementary File 2, available as Supplementary Data at *IJE* online), suggesting that the data were not missing completely at random. Multiple imputation (MI) using chained equations with 50 imputations was performed to optimize the validity of the findings. The imputation models included all variables in the target analysis as well as additional auxiliary variables (Table S2.3, Supplementary File 2, available as Supplementary Data at *IJE* online).

The sequential mediation analysis was conducted on each of the 50 imputed datasets and the mean of the estimates from each imputed dataset was calculated to give an overall MI estimate of the NDE and NIE. Standard errors were derived using Rubin rules for combining the between-imputation and within-imputation variance (obtained by bootstrapping the NDE and NIE estimates).[52]

Sensitivity analyses

Three sensitivity analyses were conducted to test the robustness of findings. First, we performed a bias analysis for unmeasured confounding, which assessed the sensitivity of the results to unmeasured confounding of the mediator–outcome association, positing a range of plausible values for the strength of association of the potential confounder with mental health and the difference in prevalence of this confounder between those with and without disability (further details in Supplementary File 3, available as Supplementary Data at *IJE* online).[53] Second, we removed participants with psychological impairments, defined as nervous or emotional conditions that require treatment, or any mental illness that requires help or supervision, as the effect of acquiring a psychological impairment on a general mental health score is likely to be different to other types of impairments. Third, we conducted a complete case analysis.

Results

Of the 28 794 people who participated in at least one wave of HILDA between 2001 and 2014, 14 534 participated in all four waves 2011 to 2014 and 14 518 of these (99.9%) responded to the disability question in all four waves. A total of 8323 individuals satisfied the definition of disability acquisition or reported no disability in any of the four waves, making them eligible for inclusion in the analysis (Figure S2.1, Supplementary File 2, available as Supplementary Data at *IJE* online). Complete data for all baseline covariates, mediators and mental health score were available for 4305 individuals (52% of the eligible sample).

Baseline characteristics

At baseline, people who went on to acquire a disability were older than those without disability (mean age of 53 vs 41 years, Table 2). They had poorer education, with 33.6% not completing secondary education compared with 24.9% of those without disability, were more likely to be unemployed or not in the labour force (38.8 vs 22.7%), had a lower mean weekly income (AU$834 vs AU$987) and experienced greater financial hardship (34.1 vs 25.1% reported being very poor or just getting by). People with disabilities were more likely to be in a relationship (71.3 vs 65.3%) and have children (72.9 vs 59.4%), more likely to be current (21.2 vs 17.2%) or ex-smokers (31.8 vs 23.7%), less likely to exercise regularly (34.2 vs 37.0%) and had higher mean BMI (27.4 vs 25.8 kg/m^2). At baseline, they also reported poorer mental health than those without disability (mean MHI score of 73.3 vs 77.6).

Sequential causal mediation analysis

Interactions between the exposure and the following mediator variables were included in the regression models: material factors including occupation, housing affordability, housing tenure and satisfaction with financial circumstances; psychosocial factors including social support, frequency of socializing and relationship status; and behavioural factors including smoking, alcohol consumption, physical activity, BMI and diet.

The TCE of disability acquisition was estimated to be a 5.3-point reduction in MHI score (95% CI –6.8, –3.7) (Table 3). In the sequential approach, we first considered the mediated effect through material factors and estimated a mean 1.7-point decline (95% CI –2.8, –0.6) in MHI was occurring through material factors, which corresponds to

Table 2. Distribution of baseline characteristics for people who acquired a disability and the control sample (*n*=8323)

	Disability		No disability	
	n=387		*n*=7936	
	n	%	*N*	%
Age, years (mean (SD))	387	52.5 (18.1)	7936	41.2 (15.4)
Sex				
Men	193	49.9	3817	48.1
Women	194	50.1	4119	51.9
Country of birth				
Australia	297	76.7	6257	78.8
Other	90	23.3	1679	21.2
Parent occupation				
High skill	181	47.4	3988	51.1
Medium skill	129	33.8	2645	33.9
Low skill/never worked	72	18.9	1168	15.0
Missing	*n*=5		*n*=135	
Education				
Bachelor or higher	66	17.1	2184	27.5
Secondary, certificate, diploma	191	49.4	3777	47.6
Did not complete secondary	130	33.6	1975	24.9
Occupation				
High skill	75	19.4	2373	29.9
Medium skill	97	25.1	2395	30.2
Low skill	65	16.8	1364	17.2
Unemployed/not in the labour force	150	38.8	1799	22.7
Missing	*n*=0		*n*=5	
Income, weekly $AUD (mean (SD))	387	833.9 (476.8)	7936	986.9 (496.5)
Wealth				
High	138	35.7	2952	37.2
Medium	130	33.6	2616	33.0
Low	119	30.8	2368	29.8
Financial hardship				
Prosperous/very comfortable	42	12.0	1444	20.3
Reasonably comfortable	188	53.9	3874	54.6
Just getting by/very poor	119	34.1	1781	25.1
Missing	*n*=38		*n*=837	
Financial satisfaction [mean (SD)][a]	387	6.4 (2.3)	7931	6.7 (2.0)
Missing	*n*=0		*n*=5	
Housing tenure				
Outright owner	148	38.2	2107	26.6
Mortgager	126	32.6	3393	42.8
Other	113	29.2	2425	30.6
Missing	*n*=0		*n*=11	
Housing affordability				
Affordable	348	91.1	7263	92.4
Unaffordable	34	8.9	597	7.6
Missing	*n*=5		*n*=76	
Relationship				
Yes	276	71.3	5173	65.3
No	111	28.7	2755	34.8
Missing	*n*=0		*n*=8	
Children				
No	105	27.1	3224	40.6
Yes	282	72.9	4712	59.4

(continued)

Table 2. Continued

	Disability		No disability	
	n=387		*n*=7936	
	n	%	*N*	%
Social support [mean (SD)][b]	347	5.3 (1.1)	7017	5.6 (1.0)
Missing	*n*=40		*n*=919	
Frequency of socializing [mean (SD)][c]	347	3.8 (1.6)	7068	3.4 (1.4)
Missing	*n*=40		*n*=868	
Relationship with parents [mean (SD)][d]	197	7.9 (2.2)	5833	8.1 (2.0)
Missing	*n*=190		*n*=2103	
Alcohol consumption				
Never	59	16.9	1108	15.6
Rarely	129	36.9	2540	35.8
One or two times/week	62	17.7	1547	21.8
At least three times/week	100	28.6	1909	26.9
Missing	*n*=37		*n*=832	
Smoking				
Never smoked	164	47.0	4210	59.2
Ex-smoker	111	31.8	1684	23.7
Current	74	21.2	1222	17.2
Missing	*n*=38		*n*=820	
Physical activity				
At least four times/week	120	34.2	2638	37.0
One to three times/week	137	39.0	2998	42.1
Less than once/week	94	26.8	1493	20.9
Missing	*n*=36		*n*=807	
BMI, kg/m^2 [mean (SD)]	332	27.4 (5.3)	6855	25.8 (5.0)
Missing	*n*=55		*n*=1081	
Mental health inventory (MHI) [mean (SD)][e]	351	73.3 (18.9)	7125	77.6 (14.4)
Missing	*n*=36		*n*=811	

[a]Satisfaction with financial circumstances, ranked using an 11-point Likert scale ranging from 'totally dissatisfied' to 'totally satisfied'.
[b]Constructed using the average of 10 questions addressing aspects of emotional support, each rated on a seven-point Likert scale.
[c]Frequency of socializing with friends or relatives, rated on a seven-point Likert scale ranging from daily to less than once every 3 months.
[d]Satisfaction with relationship with parents, rated on an 11-point Likert scale ranging from 'completely dissatisfied' to 'completely satisfied'.
[e]Measured using five questions from the SF-36, each of which is scored using five response categories, and the total scores are transformed into a scale ranging from 0 to 100, with higher scores reflecting better mental health.

Table 3. Total causal effect (TCE), natural direct effect (NDE) and natural indirect effect (NIE) of disability acquisition on mental health, with mediation through material factors, psychosocial and behavioural factors

	Material factors Coef.[a] (95% CI)	+ psychosocial factors Coef.[a] (95% CI)	+ behavioural factors Coef.[a] (95% CI)
TCE	–5.3 (–6.8, –3.7)	–5.3 (–6.8, –3.7)	–5.3 (–6.8, –3.7)
NDE	–3.6 (–5.4, –1.8)	–3.5 (–5.3, –1.7)	–3.2 (–5.1, –1.4)
NIE	–1.7 (–2.8, –0.6)	–1.7 (–3.0, –0.5)	–2.0 (–3.4, –0.6)
Proportion of effect explained (%)	32.1 (10.1, 54.1)	33.2 (8.5, 58.0)	38.6 (11.4, 65.9)

[a]These primary analysis results were obtained using multiple imputation using chained equations with 50 imputed datasets.

32.1% of the total effect. We then considered the additional effect of psychosocial factors and found that 33.2% was explained by both material and psychosocial factors (NIE: –1.7, 95% CI –3.0, –0.5) and the additional effect of behavioural factors explained 38.6% of the decline (NIE: –2.0, 95% CI –3.4, –0.6).

Sensitivity analysis

The results were robust to the changes implied by the scenarios in the sensitivity analyses. The bias analysis demonstrated that the estimated indirect effects were unlikely to be explained by unmeasured confounding (Supplementary File 3, available as Supplementary Data at *IJE* online).

Table 4. Results of the sensitivity analyses showing total causal effect (TCE), natural direct effect (NDE) and natural indirect effect (NIE) of disability acquisition on mental health, with mediation through material, psychosocial and behavioural factors

	Material factors Coef. (95% CI)	+ psychosocial factors Coef. (95% CI)	+ behavioural factors Coef. (95% CI)
Psychological impairments removed[a]			
TCE	–4.3 (–5.9, –2.7)	–4.3 (–5.9, –2.7)	–4.3 (–5.9, –2.7)
NDE	–2.7 (–4.6, –0.8)	–2.6 (–4.4, –0.8)	–2.2 (–4.0, –0.3)
NIE	–1.6 (–2.7, –0.5)	–1.7 (–3.0, –0.5)	–2.1 (–3.5, –0.8)
Proportion of effect explained (%)	37.7 (7.0, 68.4)	40.2 (8.8, 71.6)	49.8 (14.6, 84.9)
Complete case analysis			
TCE	–5.1 (–7.7, –2.5)	–5.1 (–7.7, –2.5)	–5.1 (–7.7, –2.5)
NDE	–3.3 (–5.8, –0.8)	–3.2 (–5.7, –0.7)	–3.1 (–5.7, –0.5)
NIE	–1.7 (–3.6, 0.1)	–1.9 (–4.1, 0.3)	–2.0 (–4.5, 0.6)
Proportion of effect explained (%)	34.4 (0.2, 68.7)	36.9 (–4.4, 78.2)	38.9 (–10.0, 87.8)

[a]These sensitivity analysis results were obtained using multiple imputation using chained equations with 50 imputed datasets.

Removing disabled people with psychological impairments (41 of 387) attenuated the effect estimates; however, the proportion of the effect mediated increased slightly. For the complete case analysis, only small changes in the magnitude of individual coefficients were observed (Table 4).

Discussion

Interpretation of findings

In this analysis, we found that 32% of the effect of disability acquisition on mental health was mediated by material factors, with only a negligible proportion explained by the addition of psychosocial factors and 5% by behavioural factors. This is consistent with the majority of the literature explaining health inequalities, which found that health differences are predominantly attributable to material factors.[11,17] The results were not consistent with studies that had shown that psychosocial resources accounted for some of the effect of disability on depression;[6,19,20] however, these pathways are not mutually exclusive and it is possible that a large proportion of the effect through material factors is also operating through psychosocial pathways. Previous studies did not use a sequential causal mediation approach, which allows estimation of the additional contribution of psychosocial factors beyond the effect that is operating through material factors.[48]

The effect sizes estimated in this study were of clinical significance. Study participants who acquired a disability experienced on average a five-point decline in mental health, exceeding the four- to five-point difference considered to represent a clinically meaningful change.[29,39,40] The effect mediated through material factors was estimated to be 32.1%, which can be interpreted as the proportion of the mental health decline that could be avoided if people with disabilities experienced the same material socio-economic circumstances as those without disabilities. About two-fifths of the effect (38.6%) was explained by all three sets of mediators, leaving a large proportion of the effect unexplained—it seems unlikely that the remaining 61.4% of the total effect is not mediated by any other factors and is therefore a true 'direct' effect. This is perhaps not surprising as, despite measuring a broad range of socio-economic characteristics, these measures capture only a snapshot of people's socio-economic experiences at one point in time[54] and do not capture the broader structural, political and economic processes they experience.[11] Additionally, there were some factors that were not recorded in HILDA that could be important mediators, such as experience of discrimination, sense of personal control (asked only in 2011 and 2015), psychosocial working conditions and personal–work balance (asked only for those people who were employed). Therefore, the effect operating through psychosocial pathways may be underestimated.

Strengths and limitations

This study used data from a large longitudinal survey in Australia. The longitudinal nature of the data meant that we could characterize disability acquisition, based on a sample of people who reported no disability for two waves followed immediately by two waves of disability. Furthermore, we could measure disability acquisition, mediators and mental health at different time points, to establish a temporal sequence between them, and control for prior values of the mediator and mental health score so that the results can be interpreted as effects of changes in the mediators on the outcome. We used causal sequential mediation methods, which can address the limitations of traditional mediation methods, generating unbiased estimates of mediation through multiple causally ordered

mediators, given a set of clearly specified assumptions of no confounding.

There were also limitations with this study. The analysis rests on several strong assumptions about no confounding between disability acquisition, mediators and mental health. We used inverse probability weighting to account for (measured) confounding of the disability–mental health and the disability–mediator relationships. For the assumption relating to no uncontrolled confounding of the mediator–outcome relationship, we conducted a bias analysis which suggested that the NDE and NIE were unlikely to be explained by confounding by measured or unmeasured variables. The weighting approach is sensitive to outcome model misspecification, which can lead to biased estimates of natural direct and indirect effects; however, this approach was deemed most appropriate because of the large number of mediators.[48] Furthermore, to ensure best specification of the outcome model, interactions between the exposure and each mediator were considered and tested. There were strong assumptions about the causal ordering of the mediators. The direction of causality between these contributory factors is likely to be bi-directional, e.g. the relationship between employment and social support. This may have led to overestimation of the proportion of the effect operating through material factors if these are consequences of psychosocial and behavioural factors, rather than a cause of them. However, for most of the variables considered, the effect is likely to be causally ordered from material to psychosocial to behavioural factors. There was a large proportion of missing data and this was higher in participants with poorer mental health and greater socioeconomic disadvantage; however, the use of MI as the primary analysis should have reduced this selection bias.

The concepts of disability and mental health are related, which makes it difficult to isolate the causal effect of one on the other. To address this limitation, first we chose to use the mental health subscale of the SF-36 health questionnaire (MHI), rather than the summary mental health score (MCS), therefore selecting parts of the SF-36 questionnaire that were less likely to overlap with the definition of disability. Furthermore, we conducted a sensitivity analysis in which we excluded people with psychological impairments to further minimize overlap between the concepts, which did not change the interpretation of the results though the magnitude of effect estimates was slightly attenuated. When we excluded people with psychological impairments, the proportion of the effect mediated was slightly larger. It is plausible that the mechanisms are different for people with psychological impairments compared with other types of disability, though the relative proportion through each of the three pathways was similar. It would be interesting to look at differences in these effects according to types of impairments; however, we lacked power to examine differences by disability characteristics. Finally, people with severe disabilities are less likely to participate in HILDA; therefore, our results are likely to underestimate the population effect of disability acquisition on mental health.

Conclusions

The finding that the effect of disability acquisition on mental health operates predominantly through material factors has important policy implications. These results highlight that social policy reforms that reduce socio-economic disadvantage among people who acquire a disability will improve mental health. This could be achieved through better social protection, including income support, but also through improved educational and employment opportunities for people with disabilities and access to affordable housing. It is important to further disentangle the mechanisms involved in the material pathway, to better understand the relative importance of specific factors and which social determinants are driving the mental health inequalities. This will help to better target policy interventions to improved the mental health of people with disabilities.

Supplementary Data

Supplementary data are available at *IJE* online.

Funding

This work was supported by an Australian Government Research Training Program Scholarship and a National Health and Medical Research Council Postgraduate Scholarship (1093740 to Z.A.), a National Health and Medical Research Council Senior Research Fellowship (1104975 to J.A.S.) and an Australian Research Council Future Fellowship (FT150100131 to R.B.).

Conflict of interest: The authors have no conflicts of interest to declare.

References

1. World Health Organization and World Bank Group. *World Report on Disability*. Geneva: WHO, 2011.
2. Kavanagh AM, Aitken Z, Baker E *et al*. Housing tenure and affordability and mental health following disability acquisition in adulthood. *Soc Sci Med* 2016;**151**:225–32.
3. Kavanagh AM, Aitken Z, Krnjacki L, LaMontagne AD, Bentley R, Milner A. Mental health following acquisition of disability in adulthood: the impact of wealth. *PLoS One* 2015;**10**:e0139708.
4. Mandemakers JJ, Monden CWS. Does education buffer the impact of disability on psychological distress? *Soc Sci Med* 2010; **71**:288–97.

5. Smith DM, Langa KM, Kabeto MU, Ubel PA. Health, wealth, and happiness: financial resources buffer subjective well-being after the onset of a disability. *Psychol Sci* 2005;**16**:663–66.
6. Yang Y. How does functional disability affect depressive symptoms in late life? The role of perceived social support and psychological resources. *J Health Soc Behav* 2006;**47**:355–72.
7. Kariuki M, Honey A, Emerson E, Llewellyn G. Mental health trajectories of young people after disability onset. *Disabil Health J* 2011;**4**:91–101.
8. Emerson E, Kariuki M, Honey A, Llewellyn G. Becoming disabled: the association between disability onset in younger adults and subsequent changes in productive engagement, social support, financial hardship and subjective wellbeing. *Disabil Health J* 2014;**7**:448–56.
9. Yang Y, George LK. Functional disability, disability transitions, and depressive symptoms in late life. *J Aging Health* 2005;**17**: 263–92.
10. Lynch J. Income inequality and health: expanding the debate. *Soc Sci Med* 2000;**51**:1001–05.
11. Lynch JW, Smith GD, Kaplan GA, House JS. Income inequality and mortality: importance to health of individual income, psychosocial environment, or material conditions. *Brit Med J* 2000; **320**:1200–04.
12. Marmot M, Wilkinson R. *Social Determinants of Health*. Oxford: Oxford University Press, 1999.
13. Bartley M. *Health Inequality: An Introduction to Theories, Concepts and Methods*. Cambridge: Polity Press, 2004.
14. DHSS. *Inequalities in Health: Report of a Research Working Group*. London: DHSS, 1980.
15. Wilkinson RG. Socioeconomic determinants of health—health inequalities: relative or absolute material standards? *Brit Med J* 1997;**314**:591–95.
16. Pocock SJ, Cook DG, Shaper AG, Phillips AN, Walker M. Social-class differences in ischemic-heart-disease in British men. *Lancet* 1987;**2**:197–201.
17. Davey Smith G, Bartley M. Explanations for socio-economic differentials in mortality. *Eur J Public Health* 1994;**4**:131–44.
18. Power C, Matthews S. Origins of health inequalities in a national population sample. *Lancet* 1997;**350**:1584–89.
19. Kiviruusu O, Huurre T, Aro H. Psychosocial resources and depression among chronically ill young adults: are males more vulnerable? *Soc Sci Med* 2007;**65**:173–86.
20. Bisschop MI, Knegsman DMW, Beekman ATF, Deeg DJH. Chronic diseases and depression: the modifying role of psychosocial resources. *Soc Sci Med* 2004;**59**:721–33.
21. Hafeman DM, Schwartz S. Opening the Black Box: a motivation for the assessment of mediation. *Int J Epidemiol* 2009;**38**:838–45.
22. Jahoda M. *Employment and Unemployment: A Social-Psychological Analysis*. Cambridge: Cambridge University Press, 1982.
23. Summerfield M, Freidin S, Hahn M *et al. HILDA User Manual—Release 14*. Melbourne: Melbourne Institute of Applied Economic and Social Research, 2015.
24. Burchardt T. *Being and Becoming: Social Exclusion and the Onset of Disability*. London: The London School of Economics, 2003.
25. Jenkins SP, Rigg JA. Disability and disadvantage: selection, onset, and duration effects. *J Soc Policy* 2004;**33**:479–501.
26. Polidano C, Vu H. Differential labour market impacts from disability onset. *Health Econ* 2015;**24**:302–17.
27. Burkhauser R, Daly M. Employment and economic well-being following the onset of a disability: the role for public policy. In: Mashaw J, Reno V, Burkhauser R, Berkowitz M (eds). *Disability, Work, and Cash Benefits*. Kalamazoo MI: Upjohn Institute for Employment Research, 1996.
28. Butterworth P, Crosier T. The validity of the SF-36 in an Australian National Household Survey: demonstrating the applicability of the Household Income and Labour Dynamics in Australia (HILDA) Survey to examination of health inequalities. *BMC Public Health* 2004;**4**:44.
29. Ware JE, Jr, Kosinski M, Gandek B. *SF-36 Health Survey: Manual and Interpretation Guide*. Lincoln, RI: QualityMetric, 2000.
30. McCabe CJ, Thomas KJ, Brazier JE, Coleman P. Measuring the mental health status of a population: a comparison of the GHQ-12 and the SF-36 (MHI-5). *British Journal of Psychiatry: The Journal of Mental Science* 1996;**169**:516–21.
31. Strand BH, Dalgard OS, Tambs K, Rognerud M. Measuring the mental health status of the Norwegian population: a comparison of the instruments SCL-25, SCL-10, SCL-5 and MHI-5 (SF-36). *Nord J Psychiat* 2003;**57**:113–81.
32. Weinstein MC, Berwick DM, Goldman PA, Murphy JM, Barsky AJ. A comparison of three psychiatric screening tests using receiver operating characteristic (ROC) analysis. *Med Care* 1989; **27**:593–607.
33. Yamazaki S, Fukuhara S, Green J. Usefulness of five-item and three-item Mental Health Inventories to screen for depressive symptoms in the general population of Japan. *Health Qual Life Out* 2005;**3**:48.
34. Berwick DM, Murphy JM, Goldman PA, Ware JE, Jr, Barsky AJ, Weinstein MC. Performance of a five-item mental health screening test. *Med Care* 1991;**29**:169–76.
35. Cuijpers P, Smits N, Donker T, ten Have M, de Graaf R. Screening for mood and anxiety disorders with the five-item, the three-item, and the two-item Mental Health Inventory. *Psychiat Res* 2009;**168**:250–55.
36. Means-Christensen AJ, Arnau RC, Tonidandel AM, Bramson R, Meagher MW. An efficient method of identifying major depression and panic disorder in primary care. *J Behav Med* 2005;**28**: 565–72.
37. Rumpf HJ, Meyer C, Hapke U, John U. Screening for mental health: validity of the MHI-5 using DSM-IV Axis I psychiatric disorders as gold standard. *Psychiat Res* 2001;**105**:243–53.
38. Pirkis J, Burgess P, Kirk P, Dodson S, Coombs T. *Review of Standardised Measures Used in the National Outcomes and Casemix Collection (NOCC)*. Sydney: NSW Institute of Psychiatry, 2005.
39. Knox SA, King MT. Validation and calibration of the SF-36 health transition question against an external criterion of clinical change in health status. *Qual Life Res* 2009;**18**:637–45.
40. Mchorney CA, Ware JE, Raczek AE. The Mos 36-Item Short-Form Health Survey (Sf-36). 2. Psychometric and clinical-tests of validity in measuring physical and mental-health constructs. *Med Care* 1993;**31**:247–63.
41. Moor I, Spallek J, Richter M. Explaining socioeconomic inequalities in self-rated health: a systematic review of the relative

contribution of material, psychosocial and behavioural factors. *J Epidemiol Commun H* 2017;**71**:565–75.
42. Skalicka V, van Lenthe F, Bambra C, Krokstad S, Mackenbach J. Material, psychosocial, behavioural and biomedical factors in the explanation of relative socio-economic inequalities in mortality: evidence from the HUNT study. *Int J Epidemiol* 2009;**38**: 1272–84.
43. van Oort FVA, van Lenthe FJ, Mackenbach JP. Material, psychosocial, and behavioural factors in the explanation of educational inequalities in mortality in the Netherlands. *J Epidemiol Commun H* 2005;**59**:214–20.
44. McMunn A, Nazroo J, Breeze E. Inequalities in health at older ages: a longitudinal investigation of the onset of illness and survival effects in England. *Age Ageing* 2009;**38**:181–87.
45. Emerson E, Madden R, Robertson J, Graham H, Hatton C, Llewellyn G. *Intellectual and Physical Disability, Social Mobility, Social Inclusion and Health: Background Paper for the Marmot Review*. Lancaster: Centre for Disability Research, Lancaster University, 2009.
46. World Health Organisation. *The International Classification of Functioning, Disability and Health*. Geneva: WHO, 2001.
47. World Health Organization. *Towards a Common Language for Functioning, Disability and Health: ICF the International Classification of Functioning, Disability and Health*. Geneva: WHO, 2002.
48. VanderWeele TJ, Vansteelandt S. Mediation analysis with multiple mediators. *Epidemiologic Methods* 2014;**2**:95–115.
49. Vansteelandt S, Bekaert M, Lange T. Imputation strategies for the estimation of natural direct and indirect effects. *Epidemiologic Methods* 2012;**1**:131–58.
50. Hernan MA, Robins JM. Estimating causal effects from epidemiological data. *J Epidemiol Commun H* 2006;**60**:578–86.
51. VanderWeele TJ. *Explanation in Causal Inference: Methods for Mediation and Interaction*. New York: Oxford University Press, 2015.
52. Rubin D. *Multiple Imputation for Nonresponse in Surveys*. New York: Wiley, 1987.
53. VanderWeele TJ. Bias formulas for sensitivity analysis for direct and indirect effects. *Epidemiology* 2010;**21**:540–51.
54. De Stavola BL, Daniel RM. Commentary: Incorporating concepts and methods from causal inference into life course epidemiology. *Int J Epidemiol* 2016;**45**:1006–10.