B Data and variables

The data used in this study are from the first five waves of the Household, Income and Labour Dynamics in Australia (HILDA) survey. Section B.1 describes the HILDA dataset. Section B.2 discusses the relationship between the target health conditions and the indexes of physical and mental health that are derived from HILDA data.

B.1 Data used in the analysis

The HILDA survey provides a valuable opportunity to examine the returns to health and education in Australia. HILDA is a nationally representative household panel survey containing respondents' information regarding education, health, labour force status and experience, and demographic background. Five waves of data were used for this analysis, covering the period from 2001 to 2005.

Te National Health Survey (NHS) and the Survey of Disability, Ageing and Carers (SDAC) were considered as alternative datasets for this analysis. While the NHS and SDAC have the advantage of more detailed data on the health conditions of interest, HILDA was preferred because it:

- contains detailed wages data — SDAC and NHS only include data about income, an unreliable proxy for wages;
- contains more variables relevant to employment (such as work experience and industry) than are available from SDAC and NHS; and
- is based on a representative sample, in contrast to SDAC, which has relatively few observations from healthy people.

Documentation of the sample design, data collection and derivation of variables for the HILDA survey can be found in Goode and Watson (2006).

Estimation subsample

To maximise the number of observations available, the five waves of HILDA data were combined to form a pooled, cross-sectional dataset.[1] The panel data characteristics of the HILDA dataset were not exploited in this study because it was not feasible to use a Heckman approach to correct for sample selection bias using panel data. People eligible for the aged pension (assets permitting), self-employed workers, those employed by their own business, unpaid family workers and those aged under 18 and still at school were excluded from the dataset. Observations with incomplete responses were also dropped — failure to report a wage and failure to return the self-completion questionnaire component of the survey constituted the majority of incomplete responses.[2] After these adjustments, around 30 000 observations remained.

Problems of non-response and sample attrition also need to be considered when using a panel survey. If attrition is influenced by unobservable factors, then there is little that can be done to ensure unbiased estimators. If attrition can be attributed to observable characteristics — as shown by Watson and Wooden (2004) — then the bias can be adjusted by using weights, thereby ensuring that estimates reflect the population being surveyed (Henstridge 2001). For this project observations were weighted to produce unbiased estimators and to present results that are broadly representative of the Australian population.

Variables used in the estimation

Variables used in the wage and participation equations are defined in table B.1. A brief description of most of these variables follows. More detail is provided for the variables of interest — education and health.

The natural logarithm of hourly wages is the dependent variable in the wage equation, and is derived from gross weekly wage or salary and total weekly hours worked. The dependent variable in the participation equation is a binary indicator of

[1] This approach requires the assumption that coefficient estimates are constant over the five waves. For example, returns to having a degree (in terms of percentage effect on wages) are assumed to remain the same between 2001 and 2005. Also, the pooled data include up to five responses from the same person, so the assumption of error independence between observations from the same person was relaxed, as per Baum and Ford (2004).

[2] Respondents completing a personal interview are also given a self-completion questionnaire, either to be collected at a later date, or to be submitted by mail. Over the five waves of HILDA, an average of 92 per cent of interviewed respondents returned the self-completion questionnaire (Watson and Wooden 2006).

employment, with individuals designated as being employed if they report having a full- or part-time job, and they report a wage.

Table B.1 **Variables used in wage and participation equations**

Variable	*Definition*
Dependent variables	
Log wage[a]	Natural log of the hourly wage, multiplied by 100. (Hourly wage is calculated as the weekly gross wage or salary divided by hours usually worked per week.)
Employment[b]	1 if employed, 0 if not employed
Independent variables	
Employment history	
Experience	Years in paid work
Unemployment history	Proportion of time since leaving school spent unemployed and looking for work.
Demographic variables	
Age	Binary variables indicating whether aged 15–24, 25–44 or 45–64
State	Binary variables indicating state of residence
Region	1 if not resident in a major city
Indigenous	1 if Aboriginal or Torres Strait Islander
Married	1 if married or de facto
Non-English speaking background (NESB)	1 if born in a non-English-speaking country
Studying	1 if currently studying full time
Part time[a]	1 if working less than 35 hours per week
Children 0–4[b]	Number of resident children aged 0–4 years
Children 5–14[b]	Number of resident children aged 5–14 years
Children 15–24[b]	Number of resident children aged 15–24 years
Highest level of educational attainment	
Degree or higher	1 if Bachelor degree or higher
Diploma or certificate	1 if Advanced Diploma, Diploma, Certificate IV or Certificate III
Year 12	1 if completed Year 12
Year 11 or below[c]	1 if Year 11 or below
Health	
Physical component summary	Score ranging from 0 to 100 indicating level of physical health
Mental component summary	Score ranging from 0 to 100 indicating level of mental health
Other	
Wave identifiers	Binary variables indicating HILDA wave for each observation

[a] Used in wage equation only. [b] Used in participation equation only. [c] Includes those who have completed Certificate I or II, but not Year 12.

Source: HILDA release 5.1, waves 1–5.

Both equations contain other labour market and demographic control variables including experience; unemployment history; part-time status; age; geographic

location; indigenous status; language background; and marital status. Number of children was also included in the participation equation. Dummy variables indicating the wave from which observations were drawn were also included in both equations to control for changes in labour market conditions and wage inflation over time.

Education variables

Four categories of educational attainment are included in the analysis: degree or higher; diploma or certificate; year 12; and year 11 or below. These categories are derived from the ten categories of highest educational attainment used by HILDA, as shown in table B.2. In the wage model, year 11 and below is used as the default category for education.

Table B.2 Aggregation of education variables indicating highest level of education

HILDA survey response	*Aggregated education level used in wage model*
Postgraduate degree (Masters or doctorate)	Degree or higher
Graduate diploma, graduate certificate	Degree or higher
Bachelor degree	Degree or higher
Advanced diploma, diploma	Diploma or certificate
Certificate III or IV	Diploma or certificate
Certificate I or II	Year 11 or below
Certificate not defined	Year 11 or below
Year 12	Year 12
Year 11 and below	Year 11 or below
Undetermined	Observation dropped[a]

[a] Observations were also dropped if the question was not completed.

Source: Laplagne et al. (2007), based on HILDA survey, release 4.1.

Health variables

Two types of health variables are available in HILDA — measures of physical and mental health and binary indicators of target illnesses. Both were considered in this analysis, with the measures of general health being preferred.

The physical and mental health measures are continuous variables indicating a level of physical and mental health for each individual in each wave. While these health measures do not provide information about specific target conditions, there is a body of literature describing the relationship between these measures and the target

conditions, so it is possible to infer the effect of target conditions on wages. This relationship is discussed in section B.2.

Physical and mental health measures

The measures of physical and mental health — known as physical (PCS) and mental (MCS) component summaries — range from 0 to 100, with a population mean of 50 and standard deviation of 10. A higher score indicates better physical or mental health.

The PCS and MCS measures are both derived from the Short Form 36 (SF-36) questionnaire, a widely used self-reported measure of physical and mental health designed for comparing functional health and wellbeing and the relative burden of diseases, across diverse populations (Ware 2000).[3] The SF-36 has been included in each wave of HILDA. While the SF-36 questionnaire does not include references to symptoms of specific diseases, the measures derived from it have been shown to be highly correlated with the frequency and severity of many health problems (see for example, Alonso et al. 2004; Surtees et al. 2003; Ware and Kosinski 2001).

The SF-36 questionnaire comprises 36 questions relating to different aspects of an individual's health-related quality of life. The 36 questions are used to derive eight subscales of health, each ranging from 0 to 100, and measuring different elements of health: physical functioning; limitations in carrying out usual role due to physical problems; bodily pain; perception of general health; vitality; social functioning; limitations in carrying out usual role due to emotional problems; and mental health. The physical and mental health summary measures are produced by aggregating the most correlated of the subscales.

Use of the PCS and MCS as indicators of health-related quality of life and disease burden is widespread (see Ware and Kosinski 2001), as the aggregated information in the summary measures simplifies analyses while maintaining the bulk of the information gathered in the questionnaire (Schmitz and Kruse 2007). Confidence intervals around the summary indexes have also been shown to be smaller than for the eight subscales (Ware 2000).[4]

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[3] Documentation of the Short Form 36 questionnaire, including scoring procedures and applications of the PCS and MCS, is found in Ware and Kosinski (2001).

[4] For the subpopulation used in this analysis, estimates of the subscale means had a confidence interval of ± 0.36–0.62 points, whereas means of the PCS and MCS had a confidence interval of around ± 0.18 points.

Calculating the PCS and MCS

The PCS and MCS were calculated using the method described in Ware et al. (2004).

The PCS and MCS are not included in the HILDA data, but can be generated from the eight scales that are provided and parameters estimated using HILDA (table B.3). Only the first wave was used to estimate these parameters — because survey attrition might be correlated with one or more of the scales, using later waves to derive parameters could bias the summary measures (Dockery 2006).

The scales are standardised via a z-score transformation, using sample means and standard deviations. The standardised scales are then aggregated into physical and mental components using 'factor loadings' calculated using principal components analysis.[5] The aggregated scales are multiplied by 10 and the product is added to 50 to produce the final PCS and MCS measures. After dropping observations, PCS and MCS means were 51.3 and 49.4, respectively.[6]

Table B.3 **Parameters for calculating PCS and MCS measures[a]**

SF-36 scales	*Mean*	*Standard deviation*	*Physical factor loading*	*Mental factor loading*	*Variance explained[b]*
Physical functioning	82.54	23.68	0.4494	-0.2352	0.72
Role limitations — physical	78.74	35.85	0.3683	-0.1244	0.73
Bodily pain	73.84	25.50	0.3379	-0.0953	0.69
General health	69.72	21.32	0.1958	0.0513	0.62
Vitality	60.63	19.88	-0.0527	0.2992	0.68
Social functioning	81.45	23.92	0.0194	0.2429	0.72
Role limitations — emotional	81.93	33.27	-0.1093	0.3232	0.57
Mental health	73.72	17.48	-0.2707	0.4881	0.82

a The means, standard deviations and factor loadings used to produce the PCS and MCS were obtained using the unweighted first wave of HILDA. This is the same approach used in producing previous population norms (ABS 1995). **b** The proportion of variance of each scale explained by the physical and mental factors.

Source: Wave 1 of HILDA.

5 Principal components analysis is conducted with a varimax rotation, and then scored using the regression method in version 9 of Stata. The factor loadings calculated match those reported in Dockery (2006), and are consistent with the unscored loadings presented in Butterworth and Crosier (2006).

6 When averaged across the entire first wave, mean PCS and MCS scores were 50.1 and 50.0.

Interpreting the PCS and MCS

Individually, the PCS and MCS measures indicate 'physical and mental function and wellbeing, the extent of social and role disability, and personal evaluation of health status' (Ware and Kosinski 2001, p. 57). As a way of understanding what the measures mean in terms of health, a guide to interpreting values at the extremes of both measures is reproduced from Ware and Kosinski (2004) in table B.4. The relationship between individual health and the PCS and MCS measures is discussed further in section B.2.

Table B.4 **Health status of people with very low and very high PCS and MCS measures[a]**

Summary measure	*Very low*	*Very high*
Physical component summary	Substantial limitation in self-care, physical, social and role activities; severe bodily pain; frequent tiredness; health rated 'poor'	No physical limitations, disabilities or decrements in wellbeing; high energy level; health rated 'excellent'
Mental component summary	Frequent psychological distress; substantial emotional and role disability due to emotional problems; health in general rated 'poor'	Frequent positive affect; absence of psychological distress and limitations in usual social/role activities due to emotional problems; health rated 'excellent'

a 'Role' refers to activities that are carried out in an individual's 'usual role'.

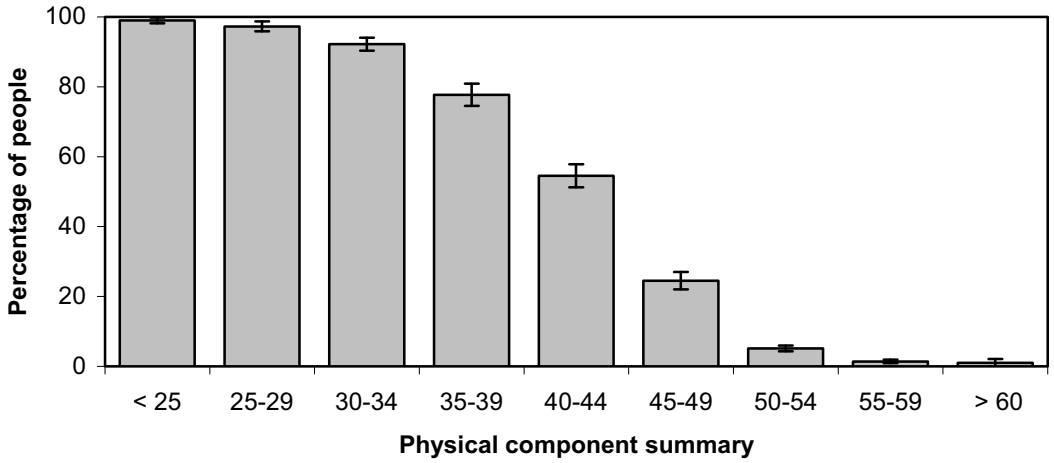
Source: Reproduced from Ware et al. (2001, p. 58).

People with lower PCS scores are significantly more likely to report difficulties in performing work and other activities (figure B.1) Overall, around 20 per cent of people reported some difficulty, but the overwhelming majority of these people have PCS scores below 50. Indeed, the percentage of those experiencing difficulties decreases substantially as PCS scores increase — for example, around 25 per cent of those with a PCS score between 45 and 49 compared to just 5 per cent of people with a PCS score between 50 and 54.

A similar negative relationship is observed between MCS scores and self-declared effects of emotional problems — such as feeling anxious or depressed (figure B.2). The percentage of people who 'didn't do work/other activities as carefully as usual' as a result of emotional problems again decreases substantially as MCS scores increase — 13.1 per cent of those scoring between 45 and 49 to 4.3 per cent of those with a score between 50 and 54.

Figure B.1 **People reporting difficulty performing work or other activities due to physical health, by PCS range[a]**

Percentage of people in each PCS range

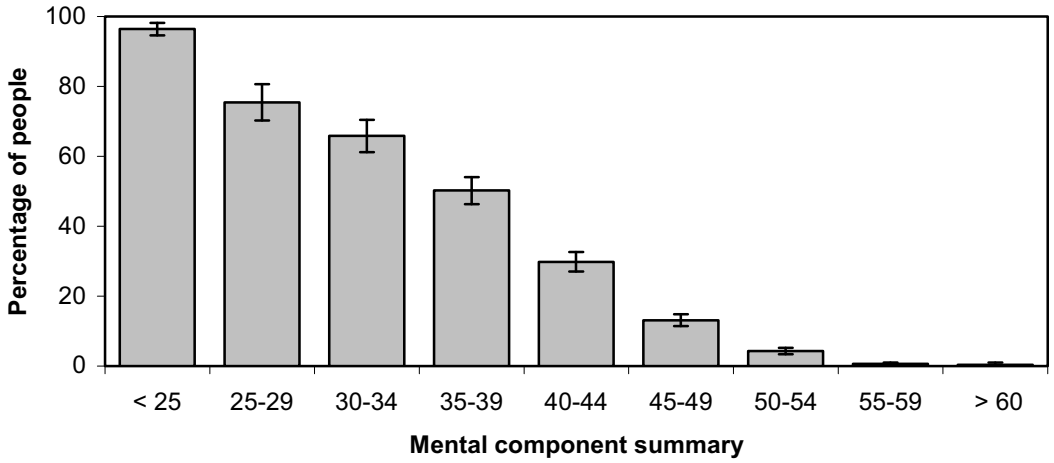


a Estimates are population-weighted. Error bars represent 95 per cent confidence intervals.

Data source: Productivity Commission estimates based on HILDA release 5.1, waves 1–5.

Figure B.2 **People who didn't do work or other activities as carefully as usual as a result of emotional problems, by MCS range[a]**

Percentage of people in each MCS range



a Estimates are population-weighted. Error bars represent 95 per cent confidence intervals.

Data source: Productivity Commission estimates based on HILDA release 5.1, waves 1–5.

Binary indicators of target health conditions

Because the focus of this project is on six specific 'target' health conditions, the most direct approach to the research question would be to use binary variables to indicate whether survey respondents suffer from each of the conditions. Attempts were made to construct binary variables from HILDA data.

Construction of the health condition variables involves combining information contained in waves 3 and 4 of HILDA to impute whether a respondent has a long-term, 'target' health condition across the five waves. Variable construction differs across target health conditions, and is described below.

Cardiovascular disease, diabetes, cancer and arthritis

Variables indicating if an individual has cardiovascular disease, diabetes, cancer or arthritis were constructed using the same approach. In wave 3, respondents were asked if they had been diagnosed with a number of conditions.

Respondents were designated as having cardiovascular disease in 2003 if they indicated in wave 3 that they had ever been 'told by a doctor or nurse' they had either 'heart or coronary disease', 'high blood pressure/hypertension' or 'any other serious circulatory condition (for example, stroke or hardening of the arteries)', and this condition had lasted or was likely to last for more than six months. Similarly, those told by a doctor or nurse that they had diabetes, cancer or arthritis were designated as having that condition for wave 3.

The way that the question was worded means that this approach may overstate the prevalence of the target conditions. The question asked if respondents had 'ever been told by a doctor or nurse' that they had a long-term health condition that had lasted or was likely to last for more than six months. Some of the conditions mentioned in the survey (such as high blood pressure) can be controlled and reversed. This means that somebody who had high blood pressure for six months or more prior to 2003 but got it under control would answer 'yes' to the HILDA question and would be erroneously designated by this process as having cardiovascular disease in 2003.

Respondents are also asked in each wave of HILDA if they have a long-term health condition and the year in which the condition developed.[7] Responses to this question were used to impute the presence of the condition in waves 1, 2, 4 and 5.

[7] This question does not refer to any specific conditions, and is used in this analysis to impute the continuation of conditions declared in wave 3.

For example, if a respondent declared that they developed a long-term condition in 2002 and they had cardiovascular disease in 2003, it was assumed that they had cardiovascular disease in 2002, but not in 2001. If the year they developed the condition was 2003, they were classified as not having the condition in either 2001 or 2002. In 2004, people were assigned a target condition if they declared a long-term health condition and had a target condition in wave 3.

Imputing health conditions in this way requires a number of assumptions that may distort the data. People reporting multiple conditions in 2003 and a long-term health condition in another year are assumed to have *all* the conditions they had in 2003 in that year, because the survey question relating to the year the condition developed does not refer to a specific condition. Around 25 per cent of those with cardiovascular disease, arthritis, cancer, or diabetes, are assumed to have more than one of these conditions in each wave.

The number of people with these four target conditions might have been underestimated in waves 1, 2, 4 and 5. It was not possible to assign a target condition to respondents that reported a long-term condition in these waves but did not report a target condition in wave 3, as there was no information about which condition they might have. For waves 1, 2, 4 and 5, around 40 per cent of those who say they have a long-term condition were assigned one of these four target conditions. This is in contrast to wave 3, where around 46 per cent of those with a long-term condition had at least one of these four conditions.

Mental illness

A binary indicator of mental illness was constructed using the mental health measure. Respondents were designated as being of 'poor mental health' if their MCS score was equal to or below 39. This approach is the same as that employed by Jofre-Bonet et al. (2005).[8] Sanderson and Andrews (2002) report that such a variable is likely to capture: 80 per cent of those with moderate depression; 92 per cent of those with severe depression; 75 per cent of those with any affective disorder; 58 per cent of those with anxiety disorder; and 60 per cent of those with psychosis.

Using this approach to construct an indicator of mental health was preferred over indicators based on diagnosis or use of health services, as not all people with mental illness seek treatment for their condition (Frank and Gertler 1991). Such 'utilisation' measures are likely to result in biased estimators if the selection of

[8] Ware (2000) considers a MCS cut-off point of 42 as an effective screen for psychiatric disorders.

treatment for mental illness is correlated with other determinants of wages, such as education.

Major injury

Information regarding major injury in the HILDA dataset is limited, but a variable can be constructed to gain some insight into the effect it might have on wages.

In waves 2, 3, 4 and 5, respondents were asked if they have suffered a 'serious personal injury or illness'. Those who had another target condition, or had declared a long-term health condition, were assumed not to have suffered a serious injury. For those in wave 1, the likelihood of major injury in wave 1 was conditionally imputed, as advised in Allison (2001). The probability of a person having a major injury in waves 2, 3, 4 and 5 was regressed using a probit model over other independent variables used in the wage equation. This estimated equation was used to generate predicted values of major injury for those in wave 1.[9]

The imputed binary variables were not considered reliable enough to use in this project

Accurate binary variables indicating the presence of the target health conditions would enable reliable estimation of the effects of the conditions on wages. Unfortunately, there are a number of problems with the imputed binary variables that make them unsuited for the current task. Problems include:

- There are only a small number of employed respondents suffering target conditions in the HILDA data.
- The method of imputing the target conditions means that the data are 'noisy'.
- Each year respondents were asked whether they had any long-term health condition. Because the survey question relating to the year the condition developed does not refer to a specific condition, people who reported in 2003 that they suffered from multiple conditions (for example, arthritis and cancer) and reported in another year that they suffered from a long-term health condition were assumed to have all the conditions they had in 2003 in that year. This may

[9] Use of conditional mean imputation is likely to lead to underestimated standard errors (Allison 2001), although bias introduced by this approach tends to be lower than that resulting from unconditional means (Liehr 2003). To examine the effect of imputing major injury on the standard errors for this variable, the wage equation was also estimated using waves 2, 3, 4 and 5 only. This produced standard errors for major injury of a similar magnitude to those resulting from all five waves.

have resulted in persons being assigned health conditions in years when they did not actually have them.

- It is not possible to say with certainty that every person who was imputed to have a certain health condition actually had it. Nor is it certain that the imputed variables have captured every occurrence of the health conditions in the sample.
- Preliminary estimation found — contrary to a priori expectations based on human capital theory — that the binary indicators of target conditions do not have a statistically significant effect on wages, positive or negative, after controlling for the likelihood of participation.[10]

Instead of using the imputed binary variables, an alternative approach was devised that uses the relationship between the target conditions and the PCS and MCS summary scores. This approach is described in section B.2.

It should be noted that these binary health status variables were used by Laplagne et al. (2007), who were aware that this approach could potentially lead to biased estimates of the effects of illness and injury. Sensitivity tests indicated that there was 'no consistent or large bias in the marginal effects of injury [on labour force participation]' (Laplagne et al. 2007, p. 59). Possible biases associated with the other conditions were not accounted for.

Data could be improved by including in the HILDA survey specific questions about whether respondents suffered from any chronic health condition, and when they had developed each condition.

Descriptive statistics

The survey-weighted means and standard errors of variables used in this analysis are shown in table B.5. This table includes means for variables used in all specifications of both the wage and participation equations. Many of these variables are binary (having a value of 1 or 0). The means of these variables represent the percentage of the population for which the variable takes the value of 1.

Differences in human capital and demographic characteristics between those who are employed and those who are not in paid employment are generally as expected. Those who are not employed tend to be older, and so have greater levels of experience. They have also spent a greater proportion of their working life

[10] Target conditions were found to have no significant effect on male wages. If the likelihood of participation is not controlled for — that is the wage equation is run as a simple OLS regression rather than using a two-stage Heckman procedure — then the effects of both mental illness and major injury on wages are both significant and negative at the 5 per cent level.

unemployed (unemployment history). Around 13 per cent of people who are employed are of a non-English speaking background (NESB), in contrast to about 20 per cent of those who are not employed.

The different labour market circumstances and experiences of men and women are captured in the descriptive statistics, giving support to the estimation of separate wage equations. For example, there are noticeable differences between men and women in the levels of part-time employment, wages paid and experience accrued. There are also substantial differences in the marital status and age distribution of men and women who are not employed. In terms of human capital, mean levels of education and physical and mental health measures are noticeably larger for those who are employed.

Table B.5 **Descriptive statistics, by gender and employment status[a]**

Survey-weighted means (standard errors in brackets for non-binary variables)

	Employed				*Not employed*			
	Male		*Female*		*Male*		*Female*	
Dependent variables								
Log wage[b]	297.49	(0.706)	285.01	(0.60)				
Wage[b]	21.91	(0.182)	18.97	(0.15)				
Independent variables								
Employment history								
Experience	18.70	(0.214)	15.76	(0.19)	21.35	(0.49)	12.23	(0.25)
Unemployment history	0.033	(0.002)	0.025	(0.00)	0.100	(0.01)	0.05	(0.00)
Demographic variables								
Age 15–24	16.94		18.48		17.68		12.11	
Age 25–44[c]	52.78		50.23		26.51		46.72	
Age 45–64	30.28		31.29		55.81		41.17	
NSW[c]	31.59		31.73		31.59		33.07	
Vic	25.55		25.22		25.00		23.78	
QLD	20.26		20.28		20.72		20.27	
SA	7.37		7.57		7.36		7.72	
WA	10.08		9.32		9.33		10.71	
NT	0.88		0.89		0.57		0.63	
ACT	2.04		2.15		0.98		1.38	
Tas	2.23		2.82		4.44		2.44	
Region	30.00		29.19		37.34		35.22	
Indigenous	1.28		1.40		2.64		3.07	
Married	64.36		63.63		53.77		70.83	
NESB	12.97		13.56		19.81		18.92	
Studying	4.50		5.83		10.25		6.23	
Part time[b]	12.83		46.29					
Children 0–4	19.58		12.98		8.37		37.49	
Children 5–14	33.99		40.03		17.43		51.94	
Children 15–24	20.63		28.72		14.03		24.58	
Highest level of education								
Degree or higher	22.89		27.07		10.58		12.35	
Diploma or certificate	36.18		22.93		33.34		18.92	
Year 12	17.09		20.39		16.48		17.53	
Year 11 or below[c]	23.83		29.60		39.61		51.20	
Health								
Physical component summary	52.97	(0.096)	53.01	(0.107)	45.24	(0.37)	48.52	(0.23)
Mental component summary	51.23	(0.131)	49.48	(0.143)	46.93	(0.34)	47.35	(0.23)
Wave identifiers								
Wave 1	19.16		19.39		21.04		19.10	
Wave 2	18.73		19.06		19.78		18.88	
Wave 3	20.71		20.30		20.45		20.72	
Wave 4	21.26		21.02		19.45		21.08	
Wave 5	20.14		20.22		19.28		20.22	
Number of observations	13451		13351		3634		7325	

a Means of binary variables represent the percentage of the population with the relevant characteristic. **b** Applicable only to those employed. **c** Default category in regression analyses.

Source: HILDA release 5.1, waves 1–5.

B.2 Target conditions and measures of physical and mental health

Because of the deficiencies in the imputed binary variables, an alternative approach was devised, that draws on the relationship between the target conditions and the measures of physical and mental health. The approach essentially involves:

- determining (based on a literature review and econometric analysis) the effects of the target conditions on the PCS and MCS scores. For example, the literature shows that the PCS score of a person suffering from diabetes is on average 3.5 points lower and the MCS 1 point lower than a similar person without diabetes.
- using the estimated effects of the conditions on PCS and MCS scores combined with the results of econometric estimation to estimate the marginal effect on wages of such a decline in the PCS and MCS scores.

The comparison of disease burden across conditions is a stated purpose of the SF-36 survey (Ware 2000). As patients with target conditions experience a burden of disease that negatively impacts their health-related quality of life, the PCS and MCS can be used to quantify the impact of these conditions on a person's health (Schlenk et al. 1998). This information has been used for the purposes of this study to infer the impact of target conditions on wages. The following sections set out:

- the assumptions about the relationship between the PCS and MCS and the target conditions; and
- estimates of the effects of the target conditions on the PCS and MCS scores, drawing on the literature and regression analysis using the 1998 Survey of Disability, Ageing and Carers (SDAC).

Assumptions about physical and mental health measures

In using the relationship between target conditions and the PCS and MCS to estimate the effect of the conditions on wages, it is necessary to make four key assumptions. These assumptions, and the justification for using the indirect approach, are set out below.

The PCS and MCS accurately reflect people's health

First, it is necessary to assume that the two measures of the relative burden of disease — the PCS and MCS — accurately reflect the effect of conditions on the health of the sufferer. The SF-36 survey — and the measures derived from it — are

designed to profile health and wellbeing and to enable comparison of disease burden. To the extent that they do not address impairments particular to specific conditions, the PCS and MCS are a limited reflection of an individuals' heath status (Sprangers et al. 2000).

Internationally, Ware and Kosinski (2001) show the PCS and MCS to be reliable indicators of the impact of chronic conditions. The validity of using the PCS and MCS as a measure of the relative burden of disease in an Australian context is demonstrated by Butterworth and Crosier (2004) and Sanson-Fisher and Perkins (1998). Both studies show that the physical and mental health measures are consistent, reliable and differentiate between individuals of differing health status. Importantly, Butterworth and Crosier conclude that 'results obtained using the SF-36 in the HILDA Survey can be interpreted by reference to published SF-36 normative data and comparison with previous research findings' (2004, p. 44).

Frijters and Ulker (2008) investigated the robustness of different survey-based measures of people's health, where 'robust' is taken to mean that one obtains the same research findings under different circumstances. If the survey-based measures are robust, it may be reasonable to generalise from one measure to another (such as from the PCS to specific health conditions).

Based on econometric estimation of the robustness of different measures of self-reported health, Frijters and Ulker (2008) concluded that:

> … our findings imply a lack of robustness in survey-based health research. Even when controlling for the same variables and using people from the same survey, we find large discrepancies in coefficients across different methodologies. The implication is that care should be taken not to generalise the findings of one health outcome to any other health outcome. (p. 22)

In this context, Frijters and Ulker's conclusions can be taken as a warning against generalising PCS and MCS scores to measure the impact of specific conditions. However, in personal communication, Paul Frijters stated that his 'gut reaction' was that 'as a policy piece, the approach you sketch is quite reasonable and will get you believable (low) estimates' (pers. comm. 19 January 2009). So while the indirect approach to estimating the effects of the target health conditions may not be entirely robust, it is likely to be a reasonable guide for the purposes of the analysis.

Conditions have an additive effect

The second assumption is that the influence of any target condition on the PCS and MCS is independent of the impact of other conditions. That is, the combined effect

of two or more conditions is assumed to approximate the sum of the independent effect of each condition. Wee et al. (2005) find this to be the case in terms of the relationship between diabetes and a number of other chronic conditions (see also Ware and Kosinski 2001). However, Gaynes et al. (2002) find the combined effect to be greater than the sum of the individual effects. That is, they assert that co-morbidity has a multiplicative rather than additive effect.

An analysis of Australian data supports the assumption that multiple conditions have an additive effect. The PCS and MCS were regressed on the target conditions, individually and as a set of interaction terms, using the SDAC dataset.[11] The interaction terms were not significant — either individually or jointly — confirming the additive nature of the relationship between the target conditions and the physical and mental health measures.

The effects of the target conditions are similar across countries

Third, it is assumed that relationships between the target health conditions and the measures of physical and mental health are similar across countries. It is necessary to use results from different countries to estimate the relative burden of target conditions because of the lack of analysis of this issue for Australia.

The use of PCS and MCS scores from other countries is supported by Ware et al. (1998), who used principal component analysis to test whether results from the SF-36 could be generalised across countries. They concluded that the SF-36 and the summary measures derived from it (the PCS and MCS scores) are similar across cultures and that the scores can be compared internationally.

The use of estimates from international sources is also supported by comparing the impact of different conditions across countries. For example, Alonso et al. (2004) found that the impact of a range of chronic conditions — including four of the six target conditions — is 'fairly consistent' across the eight developed countries included in their study, despite differences in the incidence of these target conditions across countries (Alonso et al. 2004, p. 294). Effects of target conditions in Australia are also observed to be of a similar magnitude to those observed in other countries (table B.6).

[11] Annex B.1 contains details on estimating the effect of target conditions using SDAC. Estimations with the interactive terms are not included in this annex, but are available on request.

The SF-36 and SF-12 produce comparable results

Finally, it is assumed that PCS and MCS health measures derived from an abridged version of the SF-36 questionnaire — the SF-12 — capture the effects of target conditions to the same extent as those based on the longer version. Studies using the shorter questionnaire are included to provide more information on the relationship between target conditions and summary scores.

Inclusion of these studies is justified on the grounds that PCS and MCS scores drawn from the SF-12 survey explain at least 90 per cent of the variance in the measures derived from the SF-36 survey (see Ware et al. 1998; Müller-Nordhorn et al. 2004). The correlation between the PCS and MCS from the full and abridged questionnaires holds for both the general population (see, for example, Sanderson and Andrews 2002) and for patients with specific conditions such as arthritis (Hurst et al. 1998), stroke (Pickard et al. 1999) and coronary heart disease (Müller-Nordhorn et al. 2004).

Effects of target conditions on the PCS and MCS

The effects of each target condition on PCS and MCS scores were estimated based on a literature review and regression analysis using the SDAC. The literature review focused on studies that were based on large samples that compared the effects of multiple chronic conditions on both the PCS and MCS, and controlled for the effect of demographic characteristics on the health measures. Examining the literature identified three such studies:

- Alonso et al. (2004) examined the impact of multiple chronic conditions — including cardiovascular disease, diabetes and arthritis — using pooled, representative samples from Denmark, France, Germany, Italy, Japan, the Netherlands, Norway and the United States.
- Surtees et al. (2003) compared the effect of generalised anxiety disorder and major depressive disorder with the effect of cardiovascular disease, diabetes and cancer in a large sample (around 20 000) aged 40–74 in the United Kingdom.
- Ware and Kosinski (2001) reported the effects of a large range of chronic conditions as observed in two samples — a sample of patients with chronic medical and psychiatric conditions (Medical Outcomes Survey (MOS)) and a representative sample of the US General Population (USGP).

The effects of target conditions reported in these studies are detailed in table B.6. In addition to already published results, table B.6 includes the effects of target conditions on the PCS and MCS, estimated using the 1998 SDAC. Definitions of

variables, descriptive statistics and the results from these estimations are presented in Annex B.1.

Preferred estimates of the effects of target conditions

In order to quantify the effects of target conditions on wages, a preferred estimate of the effect of each target condition is drawn from the available literature, and is used to estimate the impact of each illness on individuals' general health.

As no single study includes estimates of the effects of all six target conditions, different sources are used to provide estimates for different conditions. Where available, multiple sources are sought to ensure that results are not extreme in nature. Preferred estimates, drawn from the summary (table B.6), are presented in table B.7.

Where possible, estimates of the effects of target illnesses are taken from Alonso et al. (2004), a large, recent study bringing together results from a number of countries. The results in Alonso et al. control for the influence of age, gender, marital status and education, which is important for this study.

Estimates from Alonso et al. are preferred to other estimates because they provide a general characterisation of the burden of these diseases, rather than one specific to a particular population. Effects of target conditions from this study are used for cardiovascular disease, diabetes and arthritis. These estimates are preferred to estimates obtained from SDAC because the subjects of the SDAC tend to have more severe conditions. For that reason, the SDAC is not considered a representative sample.

Table B.6 **Effects of target illnesses on measures of physical and mental health, selected sources**

	Denmark, France, Germany, Italy, Japan, Netherlands, Norway, and United States (Alonso et al. 2004)		*United Kingdom (Surtees et al. 2003)*		*United States, Medical Outcomes Survey (Ware and Kosinski 2001)*		*United States, General US Population (Ware and Kosinski 2001)*		*Australia (Survey of Disability, Ageing and Carers 1998)*	
	PCS	MCS	PCS	MCS	PCS	MCS	PCS	MCS	PCS	MCS
Cardiovascular disease[a]									-3.0 ***	-0.9 **
Myocardial infarction			-6.3 ***	-2.5 ***	-3.2 ***	-0.9	-2.8 **	-2.4		
Angina	-3.3 ***	-2.1 ***			-4.0 ***	-0.4	-3.7 ***	0.2		
Congestive heart failure	-4.4 ***	-1.6 ***			-5.4 ***	-1.0	-6.7 ***	-1.4		
Stroke			-6.6 ***	-3.2 ***						
Hypertension	-1.5 ***	-1.2 ***			-1.9 ***	0.6	-1.5 ***	-0.1		
Diabetes	-3.5 ***	-1.0 **	-4.9 ***	-2.5 ***	-3.5 ***	0.6	-3.4 ***	0.3	-3.5 ***	-0.6
Arthritis	-4.5 ***	-1.0 ***					-2.8 ***	-0.9	-9.3 ***	-0.5
Osteoarthritis					-5.2 ***					
Rheumatoid arthritis					-7.6 ***					
Cancer			-3.6 ***	-1.0					-7.3 ***	-4.3 ***
Mental illness			-3.9 ***	-13.9 ***			-0.4	-9.3 ***	-0.4	-11.0 ***
Major depressive disorder			-3.9 ***	-14.0 ***	-2.3 **	-12.7 ***				
Generalised anxiety disorder			-6.3 ***	-15.7 ***						
Major injury									-9.9 ***	-4.3 ***

*** significant at 1 per cent; ** significant at 5 per cent; * significant at 10 per cent.

[a] Alonso et al. (2004) do not control for mental illness in their published results, and note that the effect of congestive heart failure, hypertension and arthritis on the MCS may be overstated between 0.5 and 1 point. Accordingly, 0.5 has been subtracted from the effects stated above for these illnesses.

Sources: Alonso et al. (2004); Surtees et al. (2003); Ware and Kosinski (2001); Productivity Commission estimates.

Table B.7 **Preferred estimates of the effects of target conditions on physical and mental health summary measures[a]**

Target condition	*PCS*	*MCS*	*Source*
Cardiovascular disease	-3.3	-2.1	Alonso et al. (2004)
Diabetes	-3.5	-1.0	Alonso et al. (2004)
Cancer	-3.6	0	Surtees et al. (2003)
Arthritis	-4.5	-1.5	Alonso et al. (2004)
Mental illness	-3.9	-13.9	Surtees et al. (2003)
Major injury	-9.9	-4.3	Survey of Disability, Ageing and Carers (1998)

a Effects are considered to be 0 if they are not statistically significant in the studies from which they are sourced.

Sources: Alonso et al. (2004); Surtees et al. (2003); Productivity Commission estimates.

Cardiovascular disease and diabetes

There is a general consensus on the size of the effects of cardiovascular disease and diabetes. Although Alonso et al. (2004) reported effects of different types of cardiovascular disease that are of differing magnitudes, the effect of angina is in the middle of the range of effects and can be viewed as representative. This is supported by the fact that angina effects reported by Alonso et al. (2004) are similar to those observed in both the USGP and the MOS (Ware and Kosinski 2001) and the SDAC. Effects of diabetes reported by Alonso et al. (2004) are also consistent with results from those studies, and are adopted as the preferred estimate.

Cancer

The effect of cancer on the PCS and MCS is drawn from Surtees et al. (2003). Cancer is not considered in either Alonso et al. (2004) or Ware and Kosinski (2001). The preferred estimates from Surtees et al. (2003) are supported by Sprangers et al. (2000), who find similar sized effects for cancer in the Netherlands. The SDAC estimates are considerably larger than Surtees et al. (2003), and are viewed as extreme.

Athritis

The estimate from Alonso et al. (2004) is used as the preferred estimate of the effect of arthritis, as it is indicative of the effect arthritis is likely to have on those working, and is comparable to that found in the USGP sample. The impact of arthritis is considerably larger in both the MOS and SDAC samples, which both contain large numbers of people with chronic medical conditions.

Mental illness

Preferred estimates for the effect of mental illness are taken from Surtees et al. (2003), who identify subjects as having either major depressive disorder (MDD) or generalised anxiety disorder (GAD). These estimates are similar to, but slightly larger, than those observed in SDAC and MOS. It is important to note that Goldney et al. (2004) and Sanderson and Andrews (2002) both report Australian effects of depression comparable to those reported by Surtees et al. (2003).[12]

Major injury

The preferred estimate of the effect of major injury is drawn from SDAC, and relates to those who have suffered an injury and are profoundly or severely disabled. There is a limited literature with which to compare these effects, although Haran et al. (2005) report respective PCS and MCS scores of around 17 and 5 points less than the normative population for Australians with spinal cord injury.

12 Sanderson and Andrews (2002) only report the effects of mental illness on the MCS.

Annex B-1: Estimated effects of target conditions on measures of physical and mental health

The 1998 Survey of Disability, Ageing and Carers (SDAC) was used to estimate the impact of the target conditions on both the physical (PCS) and mental (MCS) component summaries.

SDAC is a national survey of people with disabilities, persons over the age of 60 and those who provide care for people with a disability. It can be used for estimating the effects of chronic illness on the component summaries because it contains detailed information on the health conditions and limitations of people with a range of conditions and disabilities, as well as the required physical and mental component summaries. SDAC also contains detailed demographic data. Individual data from survey respondents are accessed using a Confidentialised Unit Record File (CURF).

Only observations that have both a physical and mental component summary are included in the regressions. As most carers do not complete the SF-12 section of the survey, this means that about 90 per cent of the estimation sample report a disability.

Binary indicators of whether or not a respondent has a disease or disorder which has lasted, or is likely to last, for six months or more are included in the regressions.[13] Target conditions and key variables are described in table B.8 and descriptive statistics presented in table B.9.

To estimate the effect of an illness on each health index, the component summaries are regressed over age, sex and illnesses. It is assumed that the effect of an illness on an index is completely additive, with the occurrence of an illness reducing a person's index score by the same amount, regardless of whether or not they have other illnesses. Results from the two regressions are presented in table B.10.

The impact of target conditions is broadly in line with other international studies considered in Appendix B. Possible exceptions are the impact of cancer, which is noticeably larger.

[13] The disease classification system used in SDAC is based on the International Statistical Classification of Diseases and Related Health Problems-10th Revision (ICD-10), as presented in the SDAC Technical Paper (ABS, 1999). Disease classifications have been adjusted to the needs of the study in the case of diabetes and serious injury.

Table B.8 **Definition of variables used in regression analysis**

Variable label	*Description*
PCS and MCS	Physical and mental component summary indices, derived from SF-12 questions.
Age	Age of respondent, included as five-year cohorts.
Female	A dummy variable that takes a value of 1 if the respondent is female.
Mental illness	Mental and behavioural disorders. These include: psychoses and depression/mood affective disorders; neurotic, stress-related and somatoform disorders; intellectual and developmental disorders; and other mental and behavioural disorders.
Diabetes	All types of diabetes. Other endocrine, nutritional and metabolic disorders are included as a separate condition.
Serious injury	All injuries, poisoning and certain other consequences of external causes where respondent has a 'profound or severe disability'. Other injuries where the respondent does not have a profound or severe disability are included as a separate condition.
Cardiovascular	Diseases of the circulatory system. These include: heart disease; rheumatic fever/chorea with heart disease; hypertension; stroke; arterial or aortic aneurisms; hypotension; and other diseases of the circulatory system.
Cancer	All neoplasms (tumours/cancers).
Arthritis	Diseases of the musculoskeletal system and connective tissue. These include: arthritis and related disorders; back-related problems; repetitive strain injuries; synovitis/tenosynovitis; other soft tissue/muscle disorders; osteoporosis; and other disorders of the musculoskeletal system and connective tissues.
Other conditions	Other ABS broad categories of long-term health conditions.[a]

[a] The ABS coding of conditions is outlined in ABS (1999).

Source: ABS (1999).

Table B.9 **SDAC descriptive statistics**[a]

Population means (standard errors in brackets for non-binary variables)

	Mean	*SE*
Dependent variables		
Physical component summary	41.52	(0.81)
Mental component summary	47.86	(0.27)
Demographic variables		
Female	51.78	
Age 15–19	2.92	
Age 20–24	5.54	
Age 25–29	6.43	
Age 30–34	8.17	
Age 35–39	10.44	
Age 40–44[b]	11.88	
Age 45–49	12.90	
Age 50–54	15.02	
Age 55–59	13.32	
Age 60–64	13.37	
Target conditions		
Mental illness	21.80	
Cardiovascular	19.11	
Diabetes	4.96	
Serious injury[c]	4.49	
Cancer	2.31	
Arthritis	54.19	
Other conditions		
Infectious and parasitic diseases	1.53	
Blood diseases	0.61	
Endocrinal, nutritional and metabolic disorders (excluding diabetes)	4.31	
Diseases of the nervous system	9.09	
Diseases of the eye and adnexa	3.52	
Diseases of the ear and mastoid process	17.89	
Diseases of the respiratory system	14.27	
Diseases of the digestive system	5.40	
Diseases of the skin and subcutaneous tissue	2.37	
Diseases of the genitourinary system	2.56	
Congenital malformations, deformations and chromosomal abnormalities	2.08	
Symptoms, signs and abnormal clinical and laboratory findings	5.01	
Other injury[d]	13.11	
1998 codes with no ICD–10 equivalent	2.02	

[a] Means of binary variables represent the percentage of the population with the relevant characteristic. [b] Default category in regression. [c] Includes people reporting injury, poisoning and certain other consequences of external causes who are profoundly or severely restricted in their core activities. [d] Includes people reporting injury, poisoning and certain other consequences of external causes but who are not profoundly or severely restricted in their core activities.

Source: Productivity Commission estimates based on 1998 Survey of Disability, Ageing and Carers.

Table B.10 **Physical and mental component summary regressions**[a]

	Physical Component Summary		*Mental Component Summary*	
	Coefficient	*SE*	*Coefficient*	*SE*
Constant	49.628***	(0.566)	50.597***	(0.617)
Demographic variables				
Female	0.514	(0.336)	-1.197***	(0.363)
Age 15–19	3.768***	(0.917)	3.598***	(1.107)
Age 20–24	2.462***	(0.819)	2.709***	(0.932)
Age 25–29	0.775	(0.812)	-0.926	(0.896)
Age 30–34	1.270*	(0.744)	0.672	(0.817)
Age 35–39	0.937	(0.679)	-0.740	(0.768)
Age 45–49	-1.066	(0.667)	0.487	(0.714)
Age 50–54	-1.637**	(0.640)	1.326*	(0.694)
Age 55–59	-2.584***	(0.671)	2.883***	0.706)
Age 60–64	-1.566**	(0.682)	3.519***	(0.700)
Target conditions				
Mental illness	-0.376	(0.401)	-11.032***	(0.469)
Cardiovascular	-3.024***	(0.452)	-0.901*	(0.468)
Diabetes	-3.479***	(0.746)	-0.574	(0.859)
Serious injury[b]	-9.910***	(0.776)	-4.280***	(0.941)
Cancer	-7.329***	(1.247)	-4.253***	(1.413)
Arthritis	-9.274***	(0.337)	-0.486	(0.362)
Other conditions				
Infectious and parasitic diseases	-3.959**	(1.574)	-2.133	(1.641)
Blood diseases	-4.113**	(2.095)	0.119	(2.993)
Endocrinal, nutritional and metabolic disorders (excluding diabetes)	-0.730	(0.784)	1.014	(0.867)
Diseases of the nervous system	-4.484***	(0.629)	-0.733	(0.652)
Diseases of the eye and adnexa	0.642	(0.851)	0.237	(0.874)
Diseases of the ear and mastoid process	1.938***	(0.410)	0.165	(0.433)
Diseases of the respiratory system	-4.130***	(0.494)	-0.890*	(0.515)
Diseases of the digestive system	-2.794***	(0.719)	-1.951**	(0.790)
Diseases of the skin and subcutaneous tissue	-3.226**	(1.287)	-0.803	(1.144)
Diseases of the genitourinary system	-3.571***	(1.092)	-1.277	(1.155)
Congenital malformations, deformations and chromosomal abnormalities	-0.186	(1.226)	3.414***	(1.138)
Symptoms, signs and abnormal clinical and laboratory findings	-2.841***	(0.803)	-1.956**	(0.858)
Other injury[c]	-1.551***	(0.485)	0.886*	(0.499)
1998 codes with no ICD–10 equivalent	-2.611**	(1.261)	-1.581	(1.438)

*** significant at 1 per cent, ** significant at 5 per cent, * significant at 10 per cent.

[a] Regressions are survey-weighted. [b] Includes people reporting injury, poisoning and certain other consequences of external causes who are profoundly or severely restricted in their core activities. [c] Includes people reporting injury, poisoning and certain other consequences of external causes but are not profoundly or severely restricted in their core activities.

Source: Productivity Commission estimates based on 1998 Survey of Disability, Ageing and Carers.