Indirect Economic Impacts of Comorbidities on People With Heart Disease

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Background: Few studies have assessed the effect of multiple health conditions among patients with heart disease, particularly the economic implications of having multiple conditions.

Methods and Results: This study used a microsimulation model, Health&WealthMOD, to assess the effect of comorbidities on the labor force participation of 45–64-year-old Australians with heart disease, and the indirect economic costs to these individuals and government. For most comorbid conditions, there is a significant increase in the chance of an individual being out of the labor force, relative to those with heart disease alone. For example, individuals with heart disease and arthritis have more than 6-fold the odds of being out of the labor force relative to those with heart disease alone (OR 6.64, 95% CI: 2.46–17.95). People with heart disease and ≥1 comorbidities also receive a significantly lower income, pay less in taxation and receive more in government transfer payments than those with heart disease alone.

Conclusions: It is important to consider whether an individual with heart disease also has other health conditions, as individuals with comorbidities have inferior financial situations and are a greater burden on government finances than those with only heart disease. (Circ J 2014; 78: 644–648)

Key Words: Comorbidities; Employment; Heart disease; Income

For most comorbid conditions there is a significant increase in the chance of an individual being out of the labor force, relative to those with heart disease alone. People with heart disease and ≥1 comorbidities also receive a significantly lower income, pay less in taxation and receive more in government transfer payments than those with heart disease alone.

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Around the world, diseases of the cardiovascular system contribute to more deaths than any other group of diseases, with half of these estimated to be in Asia.1,2 Consistent with international findings, within Australia most individuals with a cardiovascular disease have at least 1 other health condition.3,4 Despite a growing recognition of the importance of taking a holistic view of an individual’s health, including acknowledging their multiple health afflictions,4,5 the majority of studies that assess the effect of diseases of the cardiovascular system consider the conditions in isolation. The studies that have been conducted on comorbidity and cardiovascular diseases have only sought to determine the common clusters of comorbidities or have looked at a cardiovascular disease and only 1 other condition.8–11 Diseases of the cardiovascular system are significantly associated with lower levels of labor force participation,12–19 especially among older working-age people. For example, 45–64-year-old Australians with heart disease have been found to be more than 4-fold more likely to be out of the labor force than those of the same age and sex without a chronic health condition.10 Furthermore, it is known that being out of the labor force with a cardiovascular disease can produce large, indirect economic costs to both the individual and governments.17–19 However, no studies have considered either the effect of having multiple health conditions on labor force participation, or the indirect economic effects, on those with cardiovascular diseases. This study examined this important area, adding to previous work by using nationally representative Australian data of the 45–64-year-old population. It focused on people with 1 type of cardiovascular disease (ie, heart disease) and explored the relationship between having multiple health conditions and labor force attachment, an individual’s income, the amount of tax paid and the amount of transfer income received. Its aim was to show
the additional economic burden experienced by those with co-
morbidities relative to those with heart disease alone.

**Methods**

This study was conducted using Health&WealthMOD, a micro-
simulation model of the 45–64-year-old Australian popula-
tion. The model contains detailed information, at the individ-
ual level, of health, labor force participation, and economic sta-

tus. It has been successfully used in the past to document the
economic effects of various individual health conditions.\(^{16-22}\)

Health&WealthMOD was built using individual record data
from the 2003 Survey of disability, ageing and carers (SDAC), a
nationally representative survey of health and disability con-
ducted by the Australian Bureau of Statistics (ABS),\(^3^,^{23}\) and
STINMOD, a microsimulation model of income tax and gov-

erment support payments (Static Income Model),\(^{24,25}\) which is
maintained and developed for the Australian Government by
the National Centre for Social and Economic Modelling at the
University of Canberra.

The base population of Health&WealthMOD was unit record
data extracted from the SDAC. From this dataset, individual
records were extracted for those aged 45–64 years. The details
extracted for each individual in the base population included
demographic variables (eg, age, sex, family type, and state of
residence), socioeconomic variables (level and field of educa-
tion, income, benefits received), labor force variables (labor
force participation, employment restrictions, retirement), and
health and disability variables (main chronic conditions, number
of chronic health conditions, general health status, type and
extent of disability, support and care required).

Using STINMOD, additional economic information such as
individual income, government support payments and tax li-
ability was imputed onto the base data. This imputation was
done by identifying persons with similar characteristics on
STINMOD and “donating” their income and wealth informa-
tion to Health&WealthMOD using a process commonly used
in microsimulation modelling called “synthetic matching”.\(^26\)
A total of 9 variables [sex (2 groups), income unit type (4 groups),
type of government pension/support (3 groups), income quintile
(5 groups), age group (4 groups), labor force status (4 groups),
hours worked per week (5 groups), highest educational qualifi-
cation (2 groups) and home ownership (2 groups)] that were
common to both datasets and strongly related to income were
chosen as matching variables for synthetic matching.

The data were then aged to reflect the 2009 Australian 45–
64-year-old population. The aging was used to account for the
disability and illness, demographic, labor force, earnings growth
and other changes that had occurred between 2003 and 2009.

Respondents’ health conditions were classified in the SDAC
2003 by the ABS using ICD10 codes. People who reported their
main long-term health condition as heart disease (ICD10 code:
I00-152), angina (ICD10 code: I20), myocardial infarction
(ICD10 code: I21-22), and other heart diseases (ICD10 code:
I23-52) were considered to have heart disease in this study.

Because of the low record numbers in the survey for condi-
tions comorbid with heart disease, the following conditions from
the 2003 SDAC were grouped together to form an ‘other’ condi-
tions group: certain infectious and parasitic diseases, diseases of
the blood and blood-forming organs, Alzheimer’s disease, dis-
eases of the skin and subcutaneous tissue, certain conditions
originating in the perinatal period, congenital malformations,
deformations and chromosomal abnormalities, signs/symptoms
and abnormal clinical and laboratory finding not elsewhere clas-
sified, other injury/poisoning and certain other consequences
of external causes, diseases of the genitourinary system, and a
group that the ABS originally called ‘other conditions’.

The SDAC recorded all long-term health conditions (ie, con-
ditions that had lasted, or were likely to last, for ≥6 months) re-
gardless of their severity and effect on functional capacity. As
this study was concerned with measuring the effect of the num-
ber of chronic conditions on the labor force participation of
people with heart disease, we only wanted to capture the effect
of conditions that were severe enough to effect normal func-
tioning. As such, a limited number of conditions (high choles-
terol, hypertension, deafness and noise induced hearing loss,
and diseases of the ear and mastoid process) were excluded from
the analysis because of the limited effect they are known to have
on the labor force participation of individuals.\(^5^,6\) Excluding these
conditions may underestimate the number of comorbidities an
individual had, but, given the limited influence these conditions
have on the capacity of individuals to engage in the labor force,
to include them may have masked some of the influence of hav-
ing more debilitating comorbidities on labor force participation.

The variables used for private income, taxation payments, and
transfer payments came from STINMOD. Private income is the
sum of a person’s income derived from employment and any
income generated from investments such as cash deposits, shares
or property, but excludes any government benefits payments.

All individual’s labor force status was classified as employed,
unemployed or not in the labor force. Those employed were
classified as “persons who reported that they had worked in a
job, business or farm during the reference week (the full week
prior to the date of interview); or that they had a job in the refer-
ence week but were not at work”; those who were unemployed
were “not employed during the reference week, and had actively
looked for full-time or part-time work at any time in the 4 weeks
up to the end of the reference week and were available for work
in the reference week; those who were not in the labor force
were “persons who, during the reference period, were neither
employed nor unemployed”.\(^27\)

**Statistical Analysis**

Initial descriptive analysis was undertaken on the number and
proportion of individuals with no chronic health conditions;
heart disease only; heart disease and 1 other chronic health con-
dition; heart disease and 2 other chronic health conditions; and
heart disease and ≥3 chronic health conditions.

The proportions of people in the labor force (ie, employed
full- or part-time, or unemployed but seeking full- or part-time
employment) and out of the labor force were then assessed for
people with heart disease and the different numbers of comor-
bidities. The odds ratio (OR) of being “not in the labor force”
was then calculated for those with heart disease only, heart dis-
ease and 1 comorbidity, heart disease and 2 comorbidities, and
heart disease and ≥3 comorbidities. Those with heart disease
only were used as the reference group and the results were ad-
justed for age, sex and education.

The OR of being “not in the labor force” was then calculated
for those with heart disease only, and heart disease and the vari-
able comorbidities to determine which comorbid conditions were
significantly related to workforce absence. Those with heart
disease only were used as the reference group and the results
were adjusted for age, sex and education.

Descriptive analysis was undertaken to assess the number of
comorbidities those with heart disease had, and the top 5 comor-
bid conditions associated with workforce absence.

Descriptive analysis was undertaken to determine the mean
and median weekly private income, taxation payments, and
transfer income attributable to individuals with no chronic health
condition, heart disease only, and heart disease and 1, 2 ≥3 comorbidities.

A multiple linear regression model of the log of weekly income was used to analyze the differences between weekly private incomes of these groups. Analyses were repeated for weekly transfer income and weekly tax liability. Those with heart disease only were used as the reference group. The covariates of age group, sex and highest education were adjusted for in the regression analysis, and regression diagnostics confirmed that the assumptions were reasonably satisfied.

Regression analysis was undertaken on log-transformed data in order to satisfy the assumptions of linear regression models. Regression analysis was undertaken on log-transformed data in order to satisfy the assumptions of linear regression models.

Table 1 shows the number of individuals with heart disease alone, and heart disease and the variable number of comorbidities. For those people who identified having heart disease, it also shows the proportion who only had heart disease (and no comorbidities), and heart disease and the variable number of comorbidities. Of the people with heart disease, 21% only had heart disease, with the remainder (79%) having at least 1 comorbidity. Those with heart disease and 2 comorbidities had 5.34-fold the odds of being out of the labor force compared to those with heart disease only (P=0.1995). Of those who had heart disease only, 32% were out of the labor force. Half of the people with heart disease and 1 comorbidity were not in the labor force. Of those who had heart disease only, 32% were out of the labor force. Half of the people with heart disease and 1 comorbidity were not in the labor force. The majority of individuals with heart disease and ≥3 comorbidities were not in the labor force (76%).

After adjusting for age, sex and education, it was found that there was no significant difference in the likelihood of being out of the labor force for those with heart disease and only 1 comorbidity compared to those with heart disease only (P=0.1995). Those with heart disease and 2 comorbidities had 5.34-fold the odds of being out of the labor force compared to those with heart disease only (95% confidence interval (CI): 1.78–16.01); and those with heart disease and ≥3 comorbidities had 8.72-fold the odds of being out of the labor force compared to those with heart disease only (95% CI: 3.37–22.60) (Table 1).

Table 2 shows the OR of being out of the labor force for people with heart disease and comorbidities compared to those

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**Table 1. Heart Disease and Comorbidities in 45–64-Year-Old Australians, 2009**

<table>
<thead>
<tr>
<th>No. of conditions</th>
<th>Number in population</th>
<th>% of population with heart disease</th>
<th>Not in the labor force (NILF)</th>
<th>OR of being NILF (95% CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No chronic health condition</td>
<td>3,780</td>
<td>2,290,000</td>
<td>–</td>
<td>17%</td>
<td>–</td>
</tr>
<tr>
<td>Heart disease only</td>
<td>69</td>
<td>35,000</td>
<td>21%</td>
<td>32%</td>
<td>–</td>
</tr>
<tr>
<td>Heart disease + 1 comorbidity</td>
<td>78</td>
<td>42,000</td>
<td>25%</td>
<td>50%</td>
<td>1.90 (0.71–5.04)</td>
</tr>
<tr>
<td>Heart disease + 2 comorbidities</td>
<td>48</td>
<td>26,000</td>
<td>15%</td>
<td>62%</td>
<td>5.34 (1.78–16.01)</td>
</tr>
<tr>
<td>Heart disease + ≥3 comorbidities</td>
<td>128</td>
<td>67,000</td>
<td>39%</td>
<td>76%</td>
<td>8.72 (3.37–22.60)</td>
</tr>
</tbody>
</table>

CI, confidence interval; OR, odds ratio.

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**Table 2. Odds Ratio of Being Not in the Labor Force (NILF) for Conditions Comorbid With Heart Disease Compared With Those With Heart Disease Only Among 45–64-Year-Old Australians in 2009, Adjusted for Age, Sex and Highest Education**

<table>
<thead>
<tr>
<th>Comorbid condition</th>
<th>Number in the population</th>
<th>Proportion NILF</th>
<th>OR of being NILF</th>
<th>95% CI</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart disease only</td>
<td>35,000</td>
<td>68%</td>
<td>Reference group</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Depression/mood affective disorders</td>
<td>14,000</td>
<td>90%</td>
<td>20.52</td>
<td>3.56–118.40</td>
<td>0.0007</td>
</tr>
<tr>
<td>Diseases of the respiratory system</td>
<td>6,000</td>
<td>82%</td>
<td>7.55</td>
<td>1.32–43.07</td>
<td>0.0228</td>
</tr>
<tr>
<td>Diseases of the digestive system</td>
<td>11,000</td>
<td>82%</td>
<td>9.47</td>
<td>2.56–35.00</td>
<td>0.0007</td>
</tr>
<tr>
<td>Mental health and related disorders</td>
<td>29,000</td>
<td>80%</td>
<td>8.16</td>
<td>3.10–21.46</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Diabetes</td>
<td>25,000</td>
<td>76%</td>
<td>7.40</td>
<td>2.91–18.74</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Asthma</td>
<td>24,000</td>
<td>75%</td>
<td>6.07</td>
<td>2.27–16.25</td>
<td>0.0003</td>
</tr>
<tr>
<td>Arthritis</td>
<td>52,000</td>
<td>74%</td>
<td>5.33</td>
<td>2.49–11.41</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Injury/accident</td>
<td>25,000</td>
<td>74%</td>
<td>6.03</td>
<td>2.40–15.16</td>
<td>0.0001</td>
</tr>
<tr>
<td>Other endocrine/nutritional and metabolic disorders</td>
<td>7,000</td>
<td>74%</td>
<td>7.25</td>
<td>1.51–34.71</td>
<td>0.0132</td>
</tr>
<tr>
<td>Back problems</td>
<td>42,000</td>
<td>73%</td>
<td>7.42</td>
<td>2.54–12.43</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Other diseases of the musculoskeletal system</td>
<td>16,000</td>
<td>72%</td>
<td>5.06</td>
<td>1.70–15.07</td>
<td>0.0036</td>
</tr>
<tr>
<td>Diseases of the nervous system</td>
<td>16,000</td>
<td>71%</td>
<td>5.51</td>
<td>1.84–16.48</td>
<td>0.0023</td>
</tr>
<tr>
<td>Other diseases of the circulatory system</td>
<td>20,000</td>
<td>69%</td>
<td>4.88</td>
<td>1.86–12.78</td>
<td>0.0013</td>
</tr>
<tr>
<td>Diseases of the eye and adnexa</td>
<td>4,000</td>
<td>58%</td>
<td>3.15</td>
<td>0.63–15.62</td>
<td>0.1608</td>
</tr>
<tr>
<td>Neoplasms</td>
<td>5,000</td>
<td>40%</td>
<td>1.37</td>
<td>0.31–6.03</td>
<td>0.6758</td>
</tr>
<tr>
<td>Other</td>
<td>7,000</td>
<td>70%</td>
<td>4.39</td>
<td>0.99–19.42</td>
<td>0.0514</td>
</tr>
</tbody>
</table>

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**Results**

There were 8,864 records of individuals aged 45–64 years, representing 4,673,000 individuals in the Australian population of 2009. Of this population, 50% were male and 50% were female; 29% were aged 45–64 years, 26% were aged 50–54 years, 23% were aged 55–59 and 21% were aged 60–64 years; 19% of the 45–64-year-old population had attended university, and 81% had not. Within the 45–64-year-old population, 4% identified as having heart disease.

Table 1 shows the number of individuals with heart disease
Indirect Economic Costs of CVD Comorbidities

Table 3. Proportion of Individuals With 1, 2, or ≥3 Comorbidities Among Those With Heart Disease

<table>
<thead>
<tr>
<th>Comorbid conditions</th>
<th>Distribution by number of total comorbidities and % not in the labor force</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart disease comorbid with depression</td>
<td>0% 18% 82%</td>
</tr>
<tr>
<td>Heart disease comorbid with diseases of the digestive system</td>
<td>9% 19% 72%</td>
</tr>
<tr>
<td>Heart disease comorbid with mental health and behavioral condition</td>
<td>11% 9% 80%</td>
</tr>
<tr>
<td>Heart disease comorbid with diseases of the respiratory system</td>
<td>0% 32% 68%</td>
</tr>
<tr>
<td>Heart disease comorbid with diabetes</td>
<td>12% 15% 73%</td>
</tr>
</tbody>
</table>

Table 4. Average and Median* Weekly Private Income, Transfer Payments and Tax Liability by Number of Comorbidities for the Australian Population Aged 45–64 Years in 2009

<table>
<thead>
<tr>
<th>Labor force status</th>
<th>Weekly private income (A$) received by individuals</th>
<th>Weekly tax (includes Medicare levy) (A$) paid by individuals</th>
<th>Weekly transfer income (A$) received by individuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>No health conditions</td>
<td>Mean 1,327 SD 35,891 Median 1,049</td>
<td>Mean 246 SD 10,281 Median 138</td>
<td>Mean 32 SD 2,142 Median 0</td>
</tr>
<tr>
<td>Heart disease only</td>
<td>Mean 1,270 SD 32,293 Median 976</td>
<td>Mean 209 SD 9,327 Median 86</td>
<td>Mean 54 SD 2,744 Median 0</td>
</tr>
<tr>
<td>Heart disease + 1 comorbidity</td>
<td>Mean 1,046 SD 28,926 Median 826</td>
<td>Mean 144 SD 8,249 Median 11</td>
<td>Mean 95 SD 3,418 Median 0</td>
</tr>
<tr>
<td>Heart disease + 2 comorbidities</td>
<td>Mean 791 SD 25,640 Median 635</td>
<td>Mean 74 SD 4,004 Median 0</td>
<td>Mean 150 SD 3,905 Median 129</td>
</tr>
<tr>
<td>Heart disease + ≥3 comorbidities</td>
<td>Mean 689 SD 26,972 Median 328</td>
<td>Mean 56 SD 4,806 Median 0</td>
<td>Mean 195 SD 3,416 Median 254</td>
</tr>
</tbody>
</table>

*All results given in 2009 Australian dollars (A$).

Table 5. Differences in Average Weekly Private Income, Transfer Payments and Tax Liability for Labor Force Status, Adjusted for Age Group, Sex and Education, Among the Australian Population Aged 45–64 Years in 2009

<table>
<thead>
<tr>
<th>Labor force status</th>
<th>Income</th>
<th>Tax liability (includes Medicare levy)</th>
<th>Transfer income</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart disease only</td>
<td>% difference</td>
<td>95% CI</td>
<td>P value</td>
</tr>
<tr>
<td>Heart disease + 1 comorbidity</td>
<td>-37.5</td>
<td>-47.3 –25.8</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Heart disease + 2 comorbidities</td>
<td>-57.9</td>
<td>-69.5 –41.9</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Heart disease + ≥3 comorbidities</td>
<td>-76.3</td>
<td>-82.9 –67.3</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

Abbreviation as in Table 1.

with heart disease alone (adjusting for age, sex and highest education), and the frequency of occurrence of various comorbidities. Only the people with heart disease and diseases of the eye and adnexa, neoplasms, and conditions classified into the “other” grouping did not have a significantly higher likelihood of being not in the labor force compared to those with heart disease only (Table 2), although this may be related to the small number of people in those groups. People with arthritis, which was the most common comorbid condition, were 5-fold more likely to be out of the labor force than people with heart disease and no comorbid conditions (OR 5.33, 95% CI: 2.49–11.41). People with depression as well as heart disease were 20-fold more likely to be out of the labor force than people with heart disease and no comorbid conditions (OR 20.52, 95% CI: 3.56–118.40). For the comorbid conditions that were most likely to be associated with being out of the labor force (compared to those with heart disease only), Table 3 shows the proportions of people with heart disease and just 1, 2 and ≥3 comorbidities. Of the people with the comorbid conditions shown in Table 3, the majority of people had ≥3 comorbidities in addition to heart disease. All people with heart disease and depression, and heart disease and diseases of the respiratory system had at least 1 additional condition. Only 9% of people with heart disease and diseases of the digestive system, 11% of people with heart disease and mental and behavioral disorders, and 12% of people with heart disease and diabetes had no further health conditions. Table 4 shows that as the number of comorbidities increases, the weekly private income received by individuals and the amount of taxation paid decreases; similarly the amount of transfer income received by individuals’ increases. The median amount of private income received, taxation paid and transfer income received by people with no health condition and people with heart disease and no other conditions is similar. Once adjusted for age, sex and education, those with comorbidities receive significantly less in weekly income, pay significantly less in taxation per week and receive significantly more in transfer income (Table 5). People with heart disease and only 1 comorbidity receive 38% less in weekly income than those with heart disease alone (−37.5%, 95% CI: −47.3 to −25.8). Similarly, those with heart disease and 1 other health condition pay 76% less in taxation per week (−76.3%, 95% CI: −83.3 to −66.4) and receive >200% more in transfer income than those with heart disease alone (227.6, 95% CI: 150.4–328.6).
Discussion

In this study, the majority of individuals who had heart disease also had at least 1 comorbidity. In general, having heart disease and at least 2 comorbidities is associated with increased rates of early retirement, compared to those with heart disease alone. Some comorbidities have a greater association with labor force participation than others; for example, those with heart disease and depression were 20-fold more likely to be out of the labor force than those with heart disease alone. Individuals with heart disease and comorbidities also had lower incomes than those with heart disease alone, that is, income decreases with increasing number of comorbidities.

Previous studies have emphasized the effect that heart disease has on labor force participation, and its indirect economic costs. However, the present study has shown that the outcomes are not uniform across all people with heart disease. Those with additional health conditions have much lower incomes, making them more financially vulnerable than those with heart disease alone. As such, these individuals should be targeted by any initiatives aiming to improve the welfare of people with heart disease. Similarly, such initiatives should not look at heart disease in isolation, but include the health conditions currently afflicting individuals.

Management of multiple chronic diseases is complex for both the individual and the clinicians caring for them. Current treatment guidelines tend to address individual diseases and rarely provide guidance on managing comorbid conditions or consider potential problems such as drug interactions. The Australian National Heart Foundation Guidelines for managing heart disease do recommend assessment for depression and provide guidance on treatment if present, but do not discuss arthritis, asthma or other diseases. Treatment that addresses the whole patient, not just the separate conditions, will be most appropriate, and likely produce the best results for workforce and economic outcomes in addition to the health outcomes.

Comorbidities should be a key concern for governments, given the lower rate of labor force participation and corresponding lower amounts of tax being paid and higher amounts of government transfer income received by those with heart disease and comorbidities. Population aging and increasing dependency ratios will result in lower numbers of workers to support increasing numbers of retirees, making labor force participation an increasingly important issue for governments. However, this study has shown that consideration of the comorbidities associated with heart disease is essential to a fuller understanding of how the condition interacts with labor force participation.

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References