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The Cost of Comorbidity to the Transport Accident Commission Compensation Scheme

ISCRR Development Grant (#GE-M-13-070)

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ABSTRACT

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Abstract

Pre-existing medical conditions are known to affect length of hospital stay and mortality after trauma. Existing evidence is based mainly on short-term outcomes derived from hospital records, but less is known about the impact of pre-injury health on the cost of recovery beyond the immediate post-accident care period. Because the population is ageing and the road user population is likely to age at an even higher pace, the prevalence of chronic disease among TAC clients can be expected to increase. The aim of this study was therefore to determine the impact of pre-existing health conditions on the cost of recovery after compensable road traffic injury. In the pre-injury year, the 738 study participants used a total of 15,625 Medicare and 9,846 PBS items. In total 14.3 million AU$ was paid by the TAC to the participants in the post-injury year. The modelling results showed that pre-injury health as identified by Medicare and PBS items had a relatively minor effect on the total TAC cost, with the exception of pre-injury mental health service use which was associated with increased total TAC cost. However, when considering individual TAC cost categories, several pre-injury health factors impacted recovery costs: particularly ambulance, hospital, medical and paramedical costs. Diabetes mellitus was associated with greater ambulance and hospital costs. Cardiovascular disease was associated with increased TAC medical costs and home services costs. Surgery in the year before the accident positively impacted post-injury hospital cost and home service costs. Back pain, indicated by pre-injury spinal X-rays and MRI, was associated with higher post-injury physiotherapy costs. And finally, mental health history, particularly pre-injury psychiatrist attendance and GP visits in relation to mental health, positively impacted total claim cost, administrative, income, hospital and paramedical expenses, especially when considered over the full post-injury year.

Keywords: Recovery, TAC, Comorbidity, Cost, Bayesian Model Averaging, MBS, PBS

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ACKNOWLEDGEMENTS

The authors wish to acknowledge the support of the Transport Accident Commission in the conduct of this research and Department of Human Services for provision of MBS and PBS data. We also thank the 738 study participants who consented to data linkage for making this project possible. We also appreciate the help received from David Attwood and the Client Research team at the TAC, and the Compensation Research Database Team at ISCRR.

EXECUTIVE SUMMARY

Pre-existing medical conditions are known to affect length of hospital stay and mortality after trauma. Existing evidence is based mainly on short-term outcomes derived from hospital records, but less is known about the impact of pre-injury health on the cost of recovery beyond the immediate post-accident care period. Because the population is ageing and the road user population is likely to age at an even higher pace, the prevalence of chronic disease among TAC clients can be expected to increase. The aim of this study was therefore to determine the impact of pre-existing health conditions on the cost of recovery after compensable road traffic injury.

The data source for this study was the Outcomes of Compensated Injury Study data (ISCRR project #031). The study sample consists of 738 TAC clients with accepted claims managed by the TAC's Recovery Branch (non-catastrophic injuries) that occurred between July 2010 and July 2012. Study participants gave informed consent to link their TAC claims and payments data to their Pharmaceutical Benefits Scheme (PBS) and Medicare records, provided by the Dept. of Human Services. Statistical modelling was used to determine the association between Medicare and PBS items used in the 12 months prior to the accident (as well as predetermined disease classifications) and the TAC cost in the post-accident year, in terms of total cost as well as specific cost categories.

In the pre-injury year, the 738 study participants used a total of 15,625 Medicare and 9,846 PBS items. In total 14.3 million AU$ was paid by the TAC to the participants in the post-injury year. The modelling results showed that pre-injury health as indicated by Medicare and PBS items had a relatively minor effect on the total TAC cost, with the exception of pre-injury mental health service use which was associated with increased total TAC cost. However, when considering individual TAC cost categories, several pre-injury health factors impacted recovery costs: particularly ambulance, hospital, medical and paramedical costs. Diabetes mellitus was associated with greater ambulance and hospital costs. Cardiovascular disease was associated with increased TAC medical costs and home services costs. Surgery in the year before the accident positively impacted post-injury hospital cost and home service costs. Back pain, indicated by pre-injury spinal X-rays and MRI, was associated with higher post-injury physiotherapy costs. And finally, mental health history, particularly pre-injury psychiatrist attendance and GP visits in relation to mental health, positively impacted total claim cost, administrative, income, hospital and paramedical expenses, especially when considered over the full post-injury year.

In conclusion, although pre-injury comorbidity did not have a large impact on the overall injury recovery cost, certain health conditions did have a significant impact on hospital, medical and paramedical expenses. These conditions are: mental disorders, diabetes, cardiovascular disease, recent surgery, and (suspected) back pain. The following questions could be asked to obtain client information regarding these key pre-injury health conditions and provide the TAC with opportunity of better claim management and the capability to better forecast the cost and duration of recovery:

1. Do you have diabetes?
2. Are you taking any prescription medication related to cardiovascular disease or have you had a vascular ultrasound?
3. Have you had surgery in the last twelve months?
4. Have you had an X-ray or MRI in relation to back pain in the last twelve months?
5. In the last twelve months, have you seen your general practitioner in relation to your mental health?
6. Have you attended a psychiatrist in the last twelve months?

This study is based on a relatively small and biased TAC client sample, which may limit the generalizability of the results. The overall study participation rate was only 7%, and among study participants older TAC clients were overrepresented. Furthermore it is likely that TAC clients with comorbidities are overrepresented as they may have self-selected into the study. Although this should not affect the internal validity of the findings, the results should be validated in a larger and unbiased TAC client sample. This could be achieved by including the recommended questions in the TAC longitudinal study or cross-sectional surveys and verifying the reported impact on TAC costs.

ABBREVIATIONS

ATC	Anatomical Therapeutic Chemical Classification System
BMA	Bayesian Model Averaging
CRD	Compensation Research Database
GCS	Glasgow Coma Scale
HPC	High Performance Computing
ISCRR	Institute for Safety, Compensation and Recovery Research
MBS	Medicare Benefits Schedule
MC	MBS Category
MG	MBS Group
MI	MBS Item
MUHREC	Monash University Human Research Ethics Committee
PBS	Pharmaceutical Benefits Scheme
SEIFA	Socio-Economic Indexes for Areas
TAC	Transport Accident Commission

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1. INTRODUCTION

This ISCRR Development Grant project is based on data collected as part of the ISCRR-funded Outcomes of Compensated Injury Study (ISCRR project #031). Of the Outcomes of Compensated Injury Study sample, Pharmaceutical Benefits Scheme (PBS) and Medicare records that occurred in the 12 months prior to the accident are linked to TAC records of payments that occurred in the 12 months following the accident date and analysed. Post-injury linked PBS and Medicare data are outside the scope of this analysis. TAC claim and payment data are linked via, and limited to, the ISCRR Compensation Research Database (CRD). Because this Development Grant economic evaluation of the linked dataset can be considered a substudy of the Outcomes of Compensated Injury Study, the introduction and methods section of this report will cover the general background, study design and methodology of the data linkage study before detailing the Development Grant cost analysis.

1-1- BACKGROUND

Pre-existing medical conditions are strong determinants of mortality after trauma. This has been demonstrated in adult trauma patients in the acute care setting (Sacco, Copes et al. 1993) (Milzman, Boulanger et al. 1992) (Morris, MacKenzie et al. 1990) (Wardle 1999), as well as among adults aged 65 years or older admitted to emergency departments for home or road injury (Camilloni, Farchi et al. 2008). Length of hospital stay among trauma patients is also impacted by pre-existing medical conditions: length of stay is increased with increase in the number of co-morbid conditions (MacKenzie, Morris et al. 1989, Wardle 1999). This has implications for hospital triaging, treatment of patients with comorbidity, and costing models in a clinical setting.

Research on the impact of comorbidity on trauma outcomes has mainly been conducted from a clinical perspective, in a clinical setting. This does not provide insight into the effect of chronic disease on the post-clinical injury recovery process, health service needs, return to work, and the overall cost of recovery. Furthermore, minor injury that does not require hospitalisation is not captured in trauma-centre based research: in Victoria, approximately 70% of road traffic injury claims are for injuries that do not require hospitalisation.

The population is ageing as the baby boom generation (birth years 1946-1965) is reaching retirement age. Table 1 gives an overview of licence holders per age group over the past 20 years: the prevalence of drivers' licences among Australians aged over 55 years is steadily increasing. The baby boom generation is more likely to drive a car than the generations before them, and baby boomers are more likely to continue driving as they age.

Table 1: Percentage of Persons with Full Driver's Licence across Four Age Groups in Sydney Greater Metropolitan Area; Source (Raimond and Milthrope, 2010).

Age Group	Year 1991/92	2001/02	2008/09
35-44	89%	92%	91%
45-54	86%	91%	92%
55-64	74%	85%	89%
65+	55%	63%	68%

The road user population can therefore be expected to age more rapidly than the general population. This is already reflected in the shift in TAC client age distribution: clients aged 65 years and over constitute a growing proportion of the client base (Figure 1).

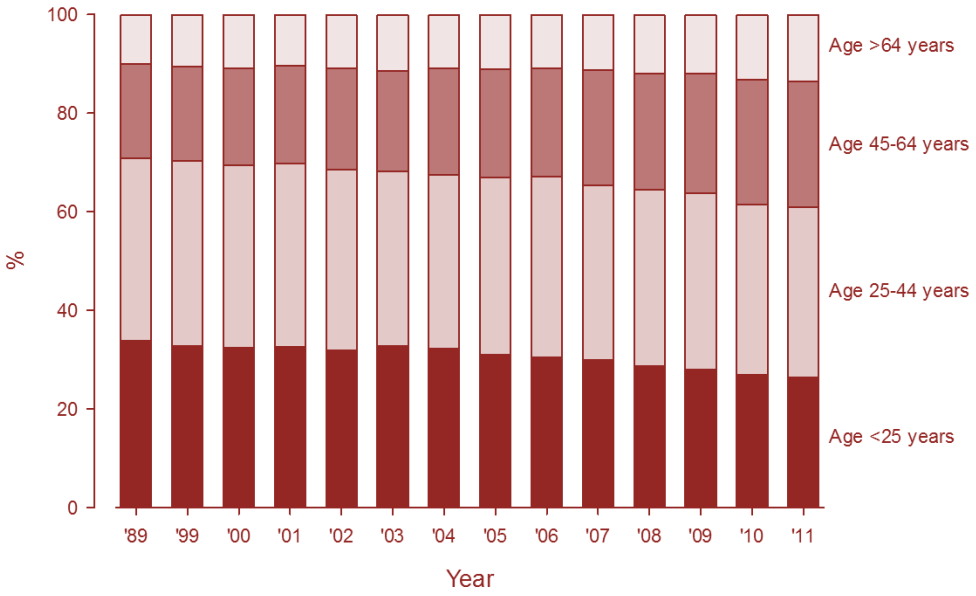

Figure 1: The age-at-accident distribution of TAC clients starting a claim between 1989 and 2011. The proportion of clients aged ≥65 years increased from 10.1% to 13.5% over this time period. Graph based on TAC claims data from the Compensation Research Database at ISCRR.

Chronic disease is more common with (older) age, and therefore the prevalence of chronic disease among road users, and among those with road traffic injury, can be expected to increase. Chronic health conditions can complicate and delay recovery from personal injury. Conditions such as diabetes, cardiovascular disease, asthma, arthritis and osteoporosis, as well as depression and anxiety, are common but their impact on the direct cost of compensable injury in Australia is not known. For the Transport Accident Commission (TAC) and other injury compensation schemes to anticipate this trend, insight into the effect of pre-existing chronic disease on injury recovery, and the cost of recovery, is essential.

1-2- AIMS

The aim of this study is to provide an economic evaluation of the cost of pre-existing conditions to the injury compensation scheme. Pre-existing treated conditions, health service use and prescription drug use will be determined from Medical (MBS) and Pharmaceutical Benefits Scheme (PBS) records that occurred in the 12 months prior to the injury, and the cost of injury to the compensation scheme will be determined from 12 months' post-injury Transport Accident Commission payment records (linked data).

The study will provide insight into which types of pre-injury conditions (indicated by service items and pharmaceuticals) have greatest impact on injury costs, and which costs to the TAC (health services, legal, income compensation) are most affected by pre-injury health conditions. The findings will contribute to the knowledge base for early identification of clients at risk of adverse outcomes: potentially, the study will generate key questions about pre-injury health.

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2. STUDY DESIGN

This is an opt-in, fully consented data linkage study. TAC clients were only included in the study if they gave informed consent and took action to ensure their inclusion in the study ('opt-in'); i.e., if they signed and posted a consent form.

2-1- APPROVAL PROCESSES

The study was first approved by the Monash University Human Research Ethics Committee (MUHREC): Project number CF12/0875 – 2012000398 'Outcomes of compensated injury in Victoria: a longitudinal approach'; Chief Investigator Dr Janneke Berecki-Gisolf, approved from 12 June 2012 to 12 June 2017. Amendments were approved by means of Request for Amendment forms to MUHREC. After MUHREC approval, the study was also evaluated by the External Request Evaluation Committee at the Dept. of Human Services in Canberra. Approval was dated 10 July 2012. Approval was based on the approved MUHREC study proposal, including the explanatory statement for participants as well as the Medicare consent forms.

The Outcomes of Compensated Injury Study design and implementation was discussed with, and carried out in collaboration with the Client Research Team at the TAC.

2-2- RECRUITMENT PROCEDURE

The study design was developed to ensure that the study would be large-scale, i.e. include a sufficient number of participants to allow for meaningful analysis of administrative linked data, and of minimal burden to clients. Existing data only is utilised: no new data is generated via surveys or interviews. Clients are therefore approached only to provide consent for us to use their existing records. By approaching clients with claims aged one year or older (instead of approaching new clients), interference with other in-house as well as external research is reduced.

The procedure is shown in Figure 2. The claims were selected by the Client Research team at the TAC: clients who had recently participated in the TAC in-house survey or who were selected for inclusion in the longitudinal study were omitted. The following inclusion and exclusion criteria applied:

Inclusion criteria:

- Claims for accident dating between 17-JUL-2010 and 22-JUL-2012
- Recovery division only
- Approved claims only
- Age 18 years and above

Exclusion criteria:

- The injured person has an acquired brain injury and the Glasgow Coma Scale (GCS) is less than 9 or the length of Post Traumatic Amnesia is greater than 6 days.
- The injured person has one or more of the following injuries: paraplegia, quadriplegia, amputation above elbow or above knee, severe burns (full thickness, approximately > 30% whole body) and blindness due to nerve severance.
- The injured person (or another family member) has opted out of all Transport Accident Commission (TAC) related client research or has been identified as a risk, e.g. history of challenging behaviours or if it relates to a current TAC staff member.
- The injured person was involved in an accident where there is a fatality

Contact details, date of birth and claim dates of the selected sample as well as the approved mail-out letter templates (including consent forms) were made available for the TAC mail-house. Reply paid Monash envelopes addressed to Dr Janneke Berecki were provided by the researchers at the Monash Injury Research Institute (MIRI). Study invitations were printed and posted by the TAC mail-house: name, address, date of birth and study linkage dates (based on the claim date) were pre-filled on the Medicare consent form. The mail-out forms are shown in the Appendix (N.B. 'Medicare and PBS' box was pre-ticked on the forms sent to participants). The researchers at MIRI were not provided with contact details of the selected sample; they only received the signed and posted consent forms. Therefore, only clients giving informed consent to participate in the study were known to the researchers. Furthermore, the TAC was not informed about participation of individual clients. This maintains privacy in two ways: (1) contact details of TAC clients not wishing to participate in the research are not shared with external parties (i.e. researchers at Monash University) and (2) TAC clients can decide about study participation knowing that the TAC claim will not be affected by the outcome of this decision.

Signed consent forms were collected at MIRI and stored in a locked filing cabinet. The contact details of consenting participants were entered in a contact database. The database and consent forms were posted to the Dept. of Human Services in Canberra for checking of the forms. When this was completed, researchers at MIRI were provided with the Medicare and Pharmaceutical Benefits Scheme records starting 12 months prior to, through to 18 months after the claim onset. This dataset was merged with a 'linkage key' file (study ID matched with CRD ID) provided by the TAC: after this merge, the study ID was removed and only the CRD ID was kept. Using the CRD ID, the MBS and PBS data were linked to the Compensation Research Database (CRD) claims and payments records; only payments that occurred in the 12 months following the injury were included. The CRD is held at the Institute for Safety, Compensation and Recovery Research (ISCRR). After removal of the study ID, the final linked dataset can no longer be linked back to the

database containing client names and contact details. All data were stored encrypted and password protected.

2-3- MAIL-OUT

An overview of study mail-out to clients is given in Table 2. Mail-out was divided over three batches: a pilot mail-out to test the study logistics, followed by two main mail-outs. After the first main mail-out, response rates proved to be unacceptably low at 5%. For the final (and largest) mail-out, the initial study invitation was followed by a reminder package including a reminder letter, a new set of forms (explanatory statement and consent form) and another Monash reply paid envelope. This resulted in a somewhat better response rate of 8%.

Table 2: Mail-out to clients: details of the three mail-out batches (pilot, first, second).

	Number of clients	Claim dates	Mail-out dates	Number of replies with signed consent form
Pilot	670	Jan 2012	23 Oct 2012	
First main	3718	Feb-Jul 2012	20 Nov 2012	237 (5%)
Second main				
Initial	6610	Jul 2011-Jul 2012	8 Apr 2013	
Reminder			8 May 2013	501 (8%)

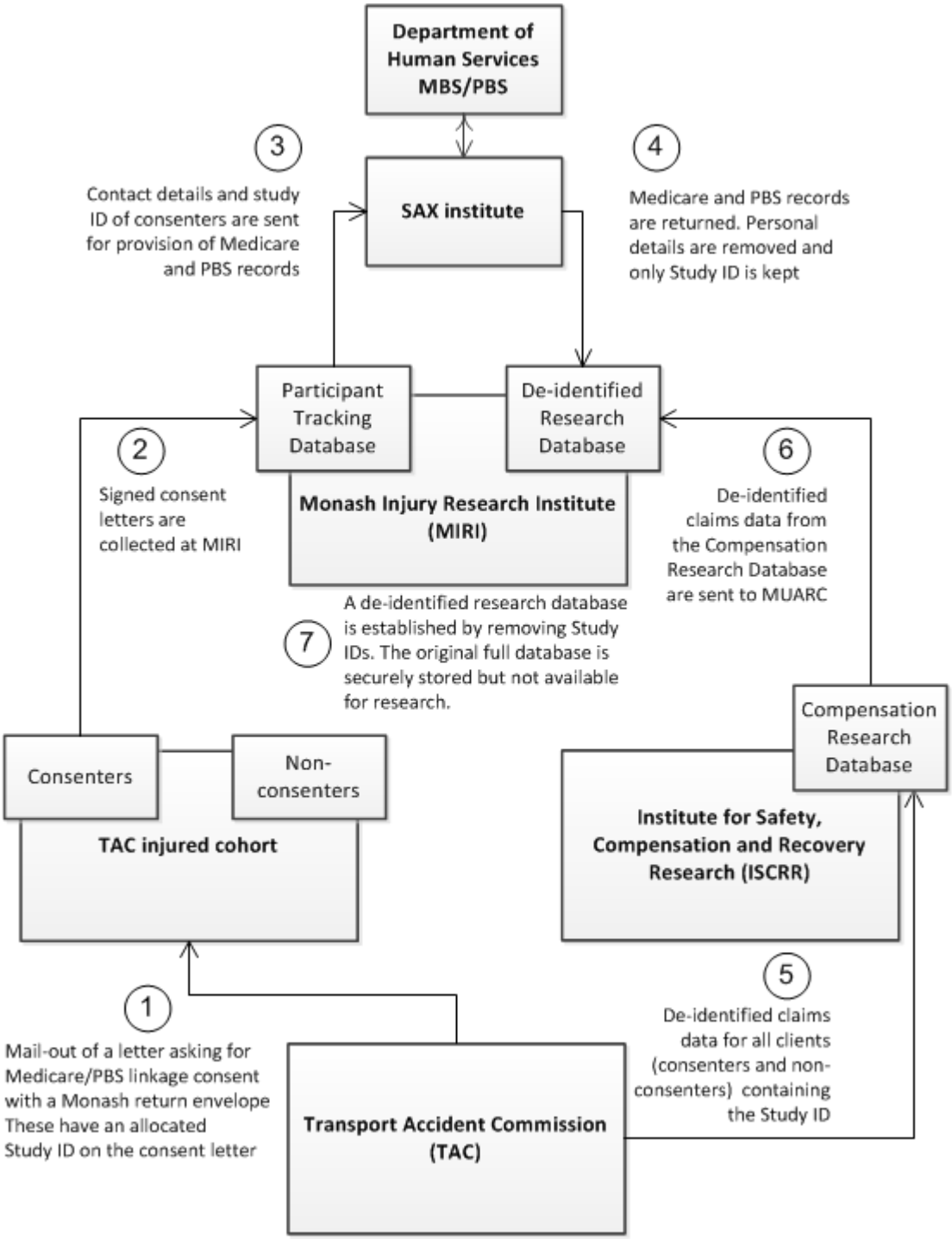

Figure 2: Diagram of the study design. The sequencing of events is labelled 1 through to 7: see text for section 3.2 for recruitment details.

3. SAMPLE

3-1- CLIENT RESPONSE

In total, 738 TAC clients gave informed consent for MBS and PBS data linkage. Following the mail-out, 63 clients phoned MIRI with questions about the study. Of these, 36 (57%) were women. Of the TAC clients who phoned MIRI, 17 (27%) indicated that they were interested in participating; 26 (41%) clearly did not want to participate; 11 (17%) were unsure and for 9 (14%) clients participation was not relevant. The main reasons for calling were:

1. 'I don't want to participate'
2. 'What does the research involve?'
3. 'I did not claim anything' (minor claim only)
4. Frail or elderly parent received the invitation but can't/doesn't want to participate
5. Passed away
6. Language barrier ('please explain study over the phone –this is easier than reading the forms'

Other than the signed forms sent to MIRI, there were 177 return-to-senders (sent back to the TAC) and 10 reported deaths. The deaths appeared to be unrelated to the injury (recorded fatalities were excluded from the mail-out sample) and were mostly among elderly TAC clients. Of the forms returned to MIRI, 11 forms could not be matched by the Dept. of Human Services.

3-2- SELECTION BIAS

Using the mail-out linkage key, the study participants were compared to the mail-out sample (return-to-senders excluded) in terms of demographic, injury characteristics and study logistics. To account for reminder letters, which were present in the second mail-out but not in the first; time since the claim onset; time since the accident etc.; a multivariable model was constructed. The selection bias overview is given in Table 3. Study participation was clearly associated with older age: median age [p25-p75] of study participants was 50 [35-63] years; this was 39 [26-54] years in the mail-out sample overall. The difference in age distribution of the participants and the mail-out sample overall is shown in Figure 3.

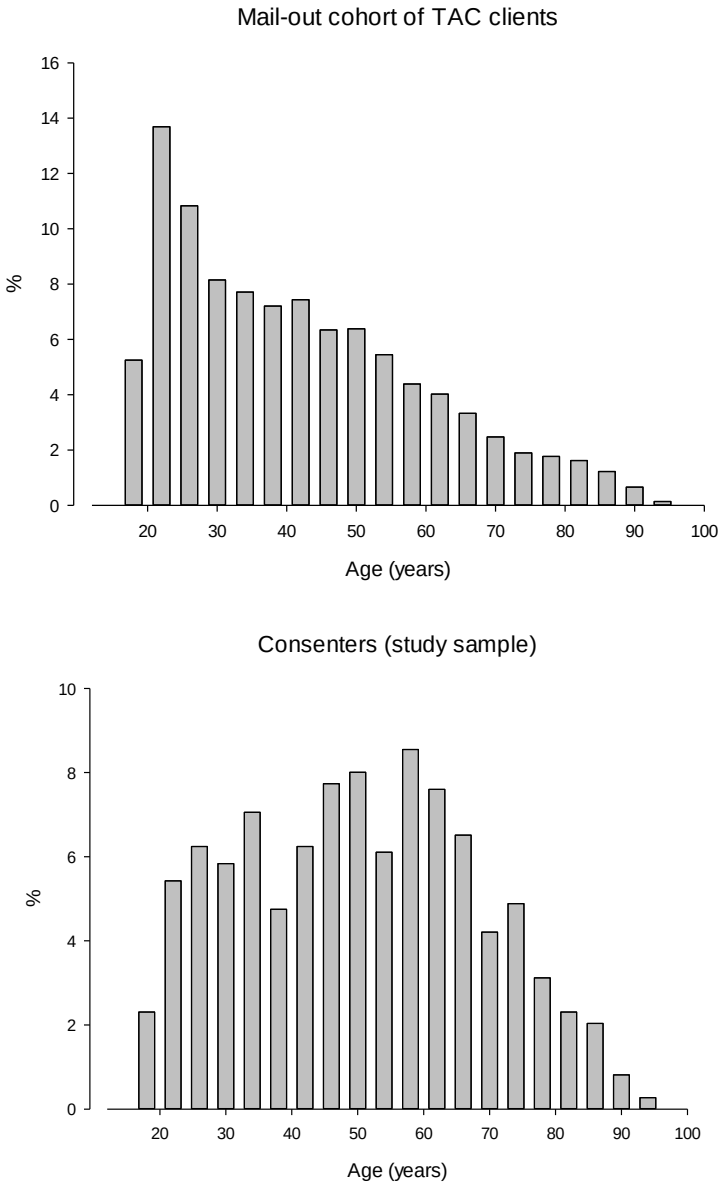

Figure 3: The age distribution of clients who were approached for the study (top) and the clients who chose to participate.

Women were more likely to participate than men. Clients with claims for musculoskeletal injuries were least likely; those with orthopaedic or other severe injuries were most likely to participate. There was a trend for clients with emergency expense only claims (EEO) to have a lower participation rate, but this was not statistically significant after adjusting for all other factors. Elapsed time between the accident date and the claim start date, calculated as 'claim delay' was strongly associated with study participation: those with minimal delay (<3 months) were more likely to participate. Reminder letters had a strong positive impact on study participation. And finally, the lag between the accident date and the study mail-out was not statistically significantly associated with study participation, although there was a trend towards lower participation among those with a lag of greater than 10 months.

Table 3: Modelling of response bias. Patient demographics, injury type, claim information and study logistics are analysed in relation to study participation in a logistic regression model (dependent variable is study participation). Univariate and full model results are given:

	Mail-out sample		Study participants		Univariate			Full model		
	N	%	N	%	OR	[95% CI]		OR	[95% CI]	
Age at accident										
≤20	963	(9)	28	(4)	0.94	[0.58 -	1.53]	0.97	[0.60 -	1.59]
21-24	1323	(12)	41	(6)	1	REF		1	REF	
25-34	2397	(22)	115	(16)	1.58	[1.10 -	2.27]	1.63	[1.13 -	2.35]
35-44	1992	(18)	109	(15)	1.81	[1.26 -	2.62]	1.83	[1.27 -	2.64]
45-54	1675	(15)	128	(17)	2.57	[1.80 -	3.68]	2.55	[1.78 -	3.66]
55-64	1230	(11)	150	(20)	4.32	[3.03 -	6.16]	4.19	[2.93 -	5.98]
≥65	1418	(13)	166	(23)	4.11	[2.90 -	5.84]	3.84	[2.70 -	5.47]
Sex										
Female	5308	(48)	401	(54)	1.30	[1.12 -	1.51]	1.36	[1.17 -	1.59]
Male	5690	(52)	336	(46)	1	REF		1	REF	
Injury Type										
Musculoskeletal	3922	(36)	202	(27)	1	REF		1	REF	
Orthopaedic	2046	(19)	181	(25)	1.79	[1.45 -	2.20]	1.59	[1.27 -	1.98]
Other injuries	3455	(31)	221	(30)	1.26	[1.04 -	1.53]	1.28	[1.04 -	1.57]
Other Severe	1575	(14)	133	(18)	1.71	[1.36 -	2.15]	1.57	[1.24 -	1.98]
Claim Subtype										
EEO	3414	(31)	182	(25)	0.71	[0.60 -	0.85]	0.87	[0.72 -	1.05]
Standard	7580	(69)	555	(75)	1	REF		1	REF	
Unknown	4	(0)	0	(0)						
Claim delay										
≤3 months	8920	(81)	663	(90)	1	REF		1	REF	
4-6 months	1249	(11)	45	(6)	0.47	[0.34 -	0.63]	0.64	[0.46 -	0.88]
7-12 months	829	(8)	29	(4)	0.46	[0.31 -	0.66]	0.62	[0.41 -	0.94]
Reminder letter										
No	4380	(40)	238	(32)	1	REF		1	REF	
Yes	6617	(60)	499	(68)	1.46	[1.25 -	1.72]	1.65	[1.18 -	2.30]
Study delay										
5-10 mths (1st QNTL)	2731	(25)	181	(25)	1	REF		1	REF	
11-16 mths (2nd QNTL)	2464	(22)	128	(17)	0.78	[0.62 -	0.98]	0.71	[0.53 -	0.96]
17-20 mths (3rd QNTL)	3096	(28)	261	(35)	1.33	[1.09 -	1.62]	0.88	[0.60 -	1.27]
21-50 mths (4th QNTL)	2706	(25)	167	(23)	0.96	[0.77 -	1.20]	0.75	[0.50 -	1.13]

Lessons learnt about recruitment

1. General willingness to participate in a data linkage study is low.

2. An upper age limit for the sample may have prevented mail-out to clients who passed away due to non-injury related causes. Linkage to the National Death Index is another way to prevent this. Mail-out to clients who are too old and frail to be interested in study participation is also prevented by using an upper age limit.

3. Potential participants make their own decisions about whether their participation makes a valuable contribution. Participation rates may increase by selecting only the most relevant group (e.g. high health service use post-injury) or by explaining the value of non-selective participation.

4. Clients with more severe injuries were more likely to participate. This may be because they were more engaged with the TAC; because they had more interaction with health services and therefore felt that the study was relevant to them; or because they were motivated to contribute to injury research.

5. 'Retrospective recruitment' (i.e. approaching clients with a TAC claim started 1-2 years prior) does work: time since the accident was significantly associated with study participation.

4. DATA AND METHODOLOGY

For this study, three types of data are used: 1) Pre-Injury Medicare and PBS linked data (which provides information regarding the health conditions of the patient in the year before accident; for instance, if the patient has used services for chronic disease or mental illness); 2) TAC claims data (which presents the information relating to the accident such as the injury type or the role of patient in the accident); and finally 3) Post-Injury TAC payment records (which provide the items and cost of compensated services received during the recovery). Each dataset and the methodology to analyse the data is explained in this section.

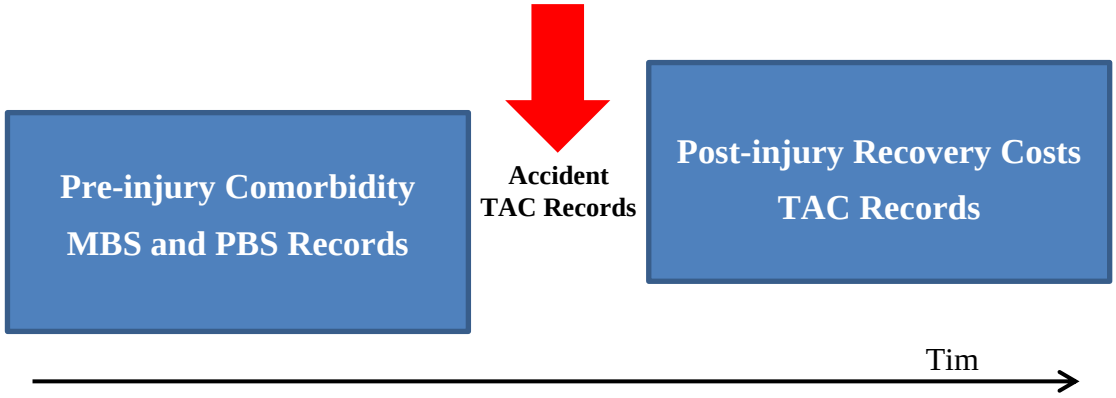

Figure 4: Diagram of data sources used in the analysis

4-1- PRE-INJURY LINKED DATA

The pre-injury data is collected from two main sources, namely: Medicare Benefit Scheme (MBS) and Pharmaceutical Benefit Schedule (PBS). The processes of data collection for these sources are explained in detail in Sections 2 and 3 of this report.

4-1-1- MBS Data

Out of the 738 study participants, 688 used at least one Medicare item in the year prior to their accident. The total number of service items for our sample is 15,625, distributed between 29/09/2009 and 10/06/2013.

The most commonly provided service in our sample was MBS Item 23 (Summarized as MI: MBS Item) which is Short [<20mins] Attendances by General Practitioners, comprising about 25 per cent of the total number of services, followed by other general and widely-used pathological and attendance services such as initiation of a patient episode by collection of a specimen for one or more tests, professional attendance at consulting rooms, and quantitation in serum, plasma, urine or other body fluid.

Following MBS categorisation, all medical services in Australia can be grouped under eight main categories (Summarized as MC: MBS Category). Overall, about 85 per cent of the services in our sample are categorized as Attendance and Pathology; further details about the rest of the groups are presented in Table 4. While as expected the highest share of cost belongs to the attendances due to their high usage, the most expensive services are surgeries, operations and organ replacements. The table also presents the comparison data across the state of Victoria and Australia. As can be seen, our sample very well represents the medical service use at the population-level when compared across the categories presented in the table[1].

Table 4: Distribution across service categories in the studied sample along with the similar values in Victoria and Australia. All Medicare by MBS category processed from July 2013 to March 2014

	Service Category	Count	Percentage	Avg. Vic	Avg. Aus
A	Professional Attendances	6927	48%	48%	47%
D	Diagnostic Procedures and Investigations	290	2%	2%	2%
T	Therapeutic Procedures	770	5%	6%	6%
O	Oral and Maxillofacial Services	2	~0%	0%	0%
I	Diagnostic Imaging Services	950	7%	6%	6%
P	Pathology Services	5394	37%	35%	36%
C	Cleft, Lip and Cleft Palate Services	0	0%	0%	0%
M	Miscellaneous	184	1%	3%	3%
	Total	14,517			

Overall, patients paid 977,634 dollars for the services (on average 62.5 dollars per service, 1324.7 per person across the total sample and 1420.9 across who have used at least one service) of which 781,938 was compensated by the MBS (79 per cent). According to the data provided by Australian Bureau Statistics, compared to an average Australian, our sample used 50 per cent more in number of services (14 national vs. 21 our sample) and have cost 80 per cent more (1324 our sample vs. 722 national). This can be attributed to the age distribution of our (relatively old) sample. Table 5 shows the Victorian population average annual benefits received from Medicare, stratified by age group and gender. The Medicare benefits per person per year for the TAC study cohort are generally similar to that of the Victorian population.

[1] Source for the state and national averages: http://www.medicareaustralia.gov.au/statistics/mbs_item.shtml

Table 5: The average benefits (AU$) for Medicare services per person per year, in the Victorian population ('Victoria') and in the pre-injury year of the TAC study cohort ('TAC sample').

	Women		Men	
Age	Victoria*	TAC sample	Victoria*	TAC sample
15 to 19	474	382	303	249
20 to 24	535	991	261	342
25 to 34	797	745	322	696
35 to 44	952	1371	468	318
45 to 54	958	1094	658	535
55 to 64	1221	1296	1020	835
65 to 74	1641	1589	1606	1709
75 to 84	2028	1763	2307	2065
85+	1744	1755	1655	1637

* The Annual Medicare Statistics contain data relating to Medicare for Financial year 2011-12[2].

From close to 6000 services covered by the MBS, our sample has only used 751, across the eight categories presented in Table 6. This provides us with 758 different variables (751 items + 7 categories) representing the medical history of the patient, which may have affected his or her cost of recovery.

We face three main challenges using this dataset:

First, for many of these services, the number of patients who have used the service is not large enough to provide us with enough evidence to make a robust decision regarding the associations between the pre- and post-accident conditions. As a result, some of the variables with less than enough uptake are removed, which consequently decreases the explanatory power of the model.

Second, there are many services with usage patterns and trends that are highly correlated. For instance, a skin biopsy is always followed by a pathology service. Although these are listed as separate items, they are both indicative of the same procedure (diagnostic procedure by means of biopsy).

[2]http://www.health.gov.au/internet/main/publishing.nsf/Content/34A89144DB4185EDCA257BF0001AFE29/$File/Medstat%20revised%20Financial%20Year%202012-13%20external%2020130823.pdf

Finally, while the eight categories introduced by the MBS are helpful in presenting a macro-level overview of service provision and hence pre-accident health status, they are generic when it comes to interpretation and understanding of health conditions, especially the severity of a health problem as well as the stage of recovery.

To address the above issues, we use service subcategories and groups provided by the MBS. MBS has four levels of categorization including Category, Group, Sub-Group and Item; the first and the last were introduced before. For instance, item 55113 which is "M-Mode and Two-Dimensional Real-Time Echocardiographic Examination" is located in sub-group *Cardiac* of group *Ultrasound* in category *Diagnostic Imaging Services*. In our analysis, we also include both the Group and Sub-Group levels whenever this information is available and the inclusion does not lead to collinear factors. MBS Groups and Subgroups are collectively summarized as MG: MBS Group.

Overall, out of eight categories, 249 groups/subgroups and 751 items in our dataset, after removing the factors with low number of observations, three categories (MC), 52 groups/subgroups (MG) and 66 items (MI) are included in the final MBS dataset (Table 6). It should be noted that some of the categories are removed since only one item inside a group is used and so the values for the group and item are identical leading to rank deficiency in the model[3].

Table 6 presents the list of categories, subcategories, groups and items included in the model.

[3] http://www.mbsonline.gov.au/internet/mbsonline/publishing.nsf/Content/Downloads-201403

Table 6: List of MBS Items, Groups and Categories Included in the Analysis. Abbreviations are as give below.

Medicare Groups: MGA = Professional Attendances, MGD = Diagnostic Procedures and Investigations, MGT = Therapeutic Procedures, MGO = Oral and Maxillofacial Services, MGI = Diagnostic Imaging Services, MGP = Pathology Services, MGC = Cleft, Lip and Cleft Palate Services, MGM = Miscellaneous

Categories								
Attendances			Therapeutic Procedures			Diagnostic Imaging Services		
Groups and Sub-Groups								
MGA1	MGA10	MGA11	MGA14	MGA2	MGA20	MGA22L2	MGA22L3	MGA3
MGA4	MGA8	MGD1	MGD1L10	MGD1L4	MGD1L6	MGI1L1	MGI1L2	MGI1L3
MGI1L5	MGI1L6	MGI2	MGI3	MGI3L1	MGI3L2	MGI3L3	MGI3L4	MGI3L6
MGI4	MGI5	MGM1	MGM15	MGM3	MGM6	MGM7	MGP101	MGP11
MGP2	MGP3	MGP4	MGP5	MGP6	MGP8	MGP9	MGT10	MGT10L6
MGT10L7	MGT6	MGT8	MGT8L1	MGT8L15	MGT8L2	MGT9		
Items								
MI3	MI104	MI105	MI110	MI132	MI10900	MI10914	MI10916	MI10918
MI10940	MI10962	MI10993	MI11700	MI17610	MI20810	MI30071	MI55036	MI55113
MI55731	MI55808	MI57509	MI57521	MI57703	MI57712	MI57715	MI57963	MI65070
MI65120	MI66500	MI66503	MI66506	MI66512	MI66536	MI66551	MI66560	MI66596
MI66602	MI66608	MI66655	MI66716	MI66719	MI69312	MI69316	MI69333	MI69478
MI72816	MI72823	MI73920	MI73922	MI73924	MI73926	MI73929	MI73930	MI73938
MI73939	MI2702	MI2710	MI2712	MI2713	MI302	MI304	MI306	MI324
MI326	MI80010	MI80110						

4-1-2- PBS Data

The PBS dataset has 9,846 records covering 427 patients out of the total 738 patients (57.9 per cent). Among more than 550 items that are listed, Rosuvastatin (a statin: lowers high levels of cholesterol and triglycerides (fats) in the blood) and Atenolol (a beta blocker: used to treat high blood pressure and angina) are the most frequently occurring items, which may well reflect the age distribution of our sample.

As the PBS data provides both the dates of prescription and supply, in the analysis the second one is applied since it better indicates when the pharmaceutical treatment started. Only 18% of the items have identical dates of prescription and supply; for at least 50% of items there is a gap of more than two months between the dates.

The total PBS cost is 510,187 dollars of which 428,520 is compensated (83 percent). Our sample is compensated, on average, 43.54 dollars, compared to the average national 38.99 dollars per item which the PBS has paid for each patient in 2012/13 (11% higher).

As applied for the MBS data, we have used groupings that were predefined by Medicare (Dept. of Health) to categorize the data. For the PBS dataset, we have used the World Health Organization Anatomical Therapeutic Chemical (ATC) classification system[4]. According to this classification, all the items are grouped under 13 categories "according to the organ or system on which they act and their therapeutic, pharmacological and chemical properties". Table 7 presents the distribution of supplied items in our dataset.

Similar to the MBS, when the PBS categorical item consumption is compared to the state and national level, no significant difference is observed. The largest difference is in Cardiovascular System which may well reflect that our sample is relatively older than the average population. Overall, in no category the difference exceeds 5 per cent[5]. As can be seen in Table 7, about 70 per cent of the items are located in three categories: Cardiovascular (37%), Nervous (20%) and Alimentary Tract and Metabolism (13%).

[4] http://www.whocc.no/atc/structure_and_principles/

[5] http://www.medicareaustralia.gov.au/statistics/pbs_group.shtml

Table 7: Distribution of Consumed Items across ATC Categories

	System/Organs	% of Total Patient Contribution	Avg. Vic	Avg. Aus	% of People	% of Total Items
A	Alimentary Tract and Metabolism	13.1%	14.52%	14.27%	22.9%	12.9%
B	Blood and Blood Forming Organs	4.8%	4.04%	4.24%	9.8%	5.1%
C	Cardiovascular System	36.6%	33.21%	32.80%	27.9%	36.8%
D	Dermatologicals	1.6%	1.61%	1.44%	8.5%	1.5%
G	Genito Urinary System and Sex Hormones	1.3%	1.39%	1.49%	6.5%	1.8%
H	Systemic Hormonal Preparations, excl. Sex Hormones	0.9%	1.57%	1.57%	8.1%	1.4%
J	General Anti-Infectives for Systemic Use	5.2%	6.77%	6.66%	24.7%	6.1%
L	Anti-Neoplastic and Immunomodulating Agents	3.0%	1.64%	1.60%	1.8%	1.2%
M	Musculo-Skeletal System	4.3%	3.79%	4.08%	12.7%	4.8%
N	Nervous System	20.4%	21.94%	22.08%	27.6%	20.4%
R	Respiratory System	6.3%	5.18%	5.42%	11.2%	4.6%
S	Sensory Organs	2.3%	3.91%	3.96%	8.1%	3.0%
V	Various	0.2%	0.30%	0.27%	0.8%	0.30%

ATC coding has five levels. For instance, the most frequently item in our sample, Rosuvastatin, is located in:

Level 1:	C	Cardiovascular System
Level 2:	C10	Lipid Modifying Agents
Level 3:	C10A	Lipid Modifying Agents
Level 4:	C10AA	HMG CoA Reductase Inhibitors
Level 5:	C10AA07	Rosuvastatin

ATC coding has five levels. Considering the level of data availability, we use the top two levels in the analysis.The most frequently occurring categories in the second level are C09: Agents acting on the renin-angiotensin system, C10: Lipid Modifying Agents, N02: Analgesics, N06: Psychoanaleptics, and finally A02: Drugs for Acid-related Disorders. The list of final PBS factors is summarized in Table 8.

Table 8: List of PBS Categories Included in the Analysis

First level	Second level
A Alimentary Tract and Metabolism	A02 Drugs for acid-related disorders
	A03 Drugs for functional GI disorders
	A10 Drugs used in diabetes
B Blood and Blood Forming Organs	
C Cardiovascular System	C01 Cardiac therapy
	C03 Diuretics
	C07 Beta blocking agents
	C08 Calcium channel blockers
	C09 Agents acting on the RA system
D Dermatologicals	
G Genito Urinary System and Sex Hormones	
H Systemic Hormonal Preparations, excl. Sex Hormones	H02 Corticosteroids for systemic use
	H03 Thyroid therapy
J General Anti-Infectives for Systemic Use	
L Anti-Neoplastic and Immunomodulating Agents	
M Musculo-Skeletal System	M01 Anti-inflammatory and anti-rheumatic products
	M05 Drugs for treatment of bone diseases
N Nervous System	N02 Analgesics
	N05 Psycholeptics (incl. hypnotics and anxiolytics)
	N06 Psychoanaleptics (incl. antidepressants)
R Respiratory System	
S Sensory Organs	

4-1-3- Disease Categories for particular conditions of interest

Beyond the items and categories introduced by MBS and PBS, some disease categories are added to the final dataset by combining MBS items into derived variables. These are listed in Table 9. Not all derived disease categories are kept in the final modelling, because some are highly correlated with individual MBS or PBS items. These variables only give an indication that a certain health condition might be present *or is suspected by the treating physician* (e.g. diagnostic procedure for a particular disease). There is generally a level of uncertainty regarding the actual presence of the disease given the derived variable, and the results have to be interpreted as such.

Table 9: Manually Generated Items

Derived variable	Origin: MBS items	Indicates diagnostic procedure (D) or treatment (T) of the condition	Included
Diabetes	10951, 10954, 66542, 66545, 66551	T or D	Yes
Thyriod disease	61473, 66716, 66719, 66722, 66725, 66728, 66731, 66734	D	Yes
Cardiovascular disease	38218, 38240, 38243, 38246, 38306, 55113, 55114, 55115, 55116, 55118, 59912, 59925, 61320	D, T	Yes
Cardiac arrhythmia	11721, 11727, 13400, 38212, 38287	T	No
Osteoporosis	12306, 12312, 12315, 12321, 12323	D	No
Sleep apnea	12203, 12250	D	No
Back pain	56220, 56223, 58100, 58103, 58106, 58112, 58121, 63173	D	Yes
Mental health, with or without bulk billing	296:299, 361, 291, 293, 359, 319, 353:370, 330, 342 2721:2727, 80000:80015, 80100:80115, 80125:80140, 80150:80165, 2700, 2701, 2712, 2713, 2715, 2717	T*	Yes

*All mental health items refer to medical attendance for a mental health service: these include psychiatrist, general practitioner providing a mental health treatment plan, occupational therapist providing psychological strategies etc. Please note that mental health diagnostics may be included in these services.

4-2- INJURY DATA

Injury claims and payments data are provided by the Transport Accident Commission of State of Victoria in Australia based on the procedure discussed previously in Section 2.2. The data includes the items presented in Table 10.

Table 10: Participant and Accident Data Item

Factor	Description
	Patient
Gender	400 females and 338 males
Age	Both age and squared value of age are included
SEIFA Decile	Socio-Economic Indexes for Areas
Role in the accident	Driver, Cyclist, Motor-cyclist, Pedestrian, and Passenger
	Accident
Number of Vehicles	Number of Vehicles in the accident
Location of Accident	Metropolitan (67%), Country (29%), Interstate (4%)
Type of Injury	Refer to TAC Data Dictionary for details
Severity of Injury	Measures using a proxy calculated based on more than one day of hospitalization

"Socio-Economic Indexes for Areas (SEIFA) is a product developed by the ABS that ranks areas in Australia according to relative socio-economic advantage and disadvantage.[6]" If the study sample were perfectly representative sample of the Victorian population in terms of socio-economic index, the sample would be distributed equally across the ten SEIFA declines (i.e. a flat line). This is not the case: Figure 4 presents the distribution of patients across ten SEIFA decile groups indicating the fact that a larger portion of our sample live in areas which are relatively advantaged socioeconomically.

[6] http://www.abs.gov.au/websitedbs/censushome.nsf/home/seifa

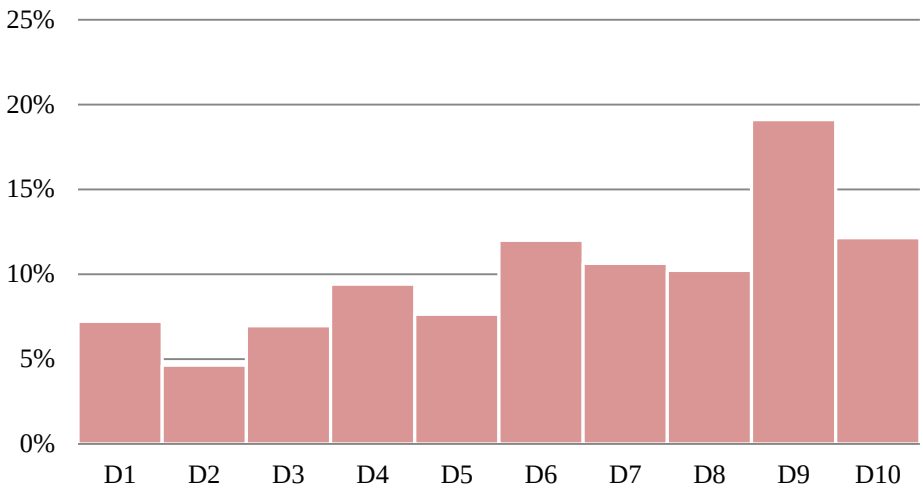

Figure 5: Distribution of Participants across SEIFA Deciles.

The role in the accident is divided to Driver (53%), Cyclist (12%), Motor-cyclist (12%), Pedestrian (11%), and Passenger (7%). Figure 5 presents the distribution of number of vehicles in each accident.

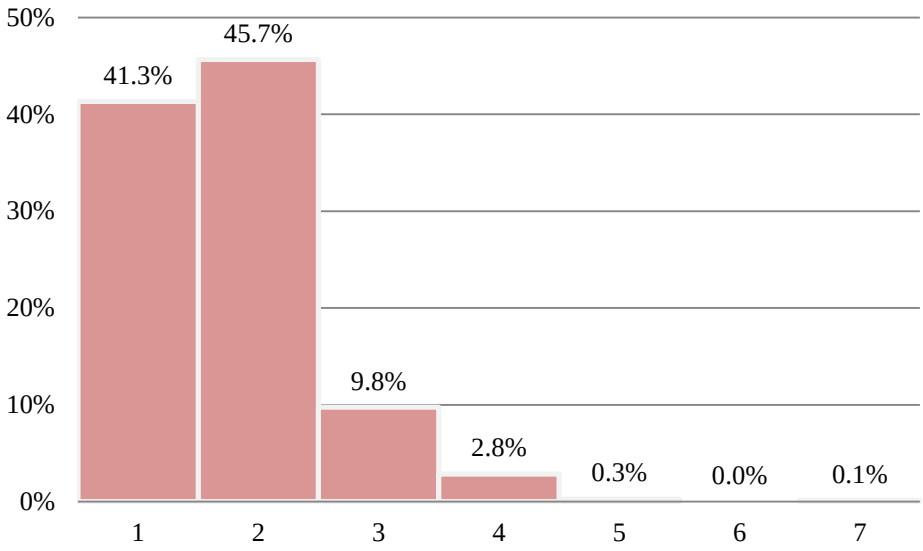

Figure 6: Distribution of Number of Vehicles in an Accident.

The type and severity of injury are measured using two main variables. The first one indicates the injury type categorized in the following groups: Musculoskeletal (such as contusion), Orthopaedic (such as fractures and dislocations), Brain Injury, and Internal Injury. The second is hospital stay, used as a proxy for injury severity (Newgard, Fleischman et al. 2010, Berecki-Gisolf, Collie et al. 2013) because the data does not include any other validated injury severity measure. We created a binary variable equal to one if the patient is hospitalized for at least one day, and zero in the absence of hospital stay.

4-3- POST-INJURY DATA

The inflation-adjusted cost of each service is used to measure the outcome variables. The first variable generated for each patient is the total cost of compensation for all the services received over one year after the accident. Figure 7 shows the distribution of the total cost for all the 738 patients with and without outliers in two boxplots. As can be seen, while in majority of cases the cost is distributed between zero and 36,000 dollars ($1167.89, $3776.68, $15290.44, and $36235.68 as quartiles), the plot on right presents the existence of outlier with very high compensation costs, at least three with more than 400,000 dollars.

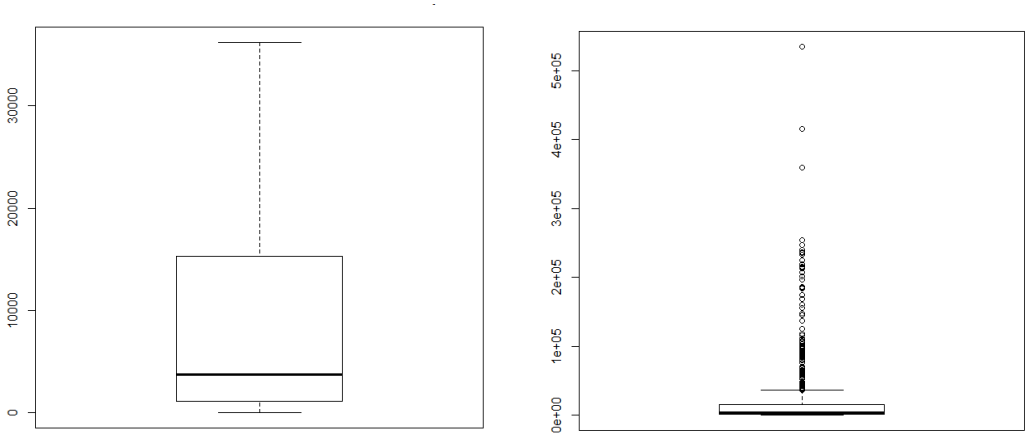

Figure 7: Distribution of Cost across the sample without (Left) and with (Right) the outliers.

Next, the total cost is broken down into cost categories. TAC has three level of categorization for service compensation costs, namely: Benefit Type, Benefit Category and Benefit Code. The details of these three levels are available in TAC Data Dictionary.

From the total of 14.3 million dollars paid by the TAC to our sample of participants in the first year after their accidents, more than 43 per cent is paid for hospital costs, 16 per cent for income compensation, and 18 per cent for medical costs (Table 11). The total cost of income compensation in our sample could be relatively low because of the overrepresentation of older (and possibly retired) TAC clients. Table 12 provides a time dimension into how the cost is accumulated over time. For instance, in categories such as income and legal benefits, the majority of the payments are disbursed long after the accident date, while in categories such as ambulance services, the biggest portion of cost occurs as early as the accident date. The colours present the share of cost in each category for each point in time.

Table 11: Distribution of Costs across Benefit Categories

Service Group	Sum of Cost	%	Count of Claimed Items	%	Avg. Cost of Claimed Item
Administration	$ 168,693.78	1.18%	1217	1.92%	$138.61
Ambulance/road accident rescue	$ 1,206,954.09	8.45%	848	1.34%	$1,423.29
Hospital	$ 6,281,771.28	43.96%	1287	2.03%	$4,880.94
Impairment lump sum	$ 113,124.10	0.79%	27	0.04%	$4,189.78
Income	$ 2,354,941.14	16.48%	8429	13.32%	$279.39
Legal	$ 2,477.47	0.02%	7	0.01%	$353.92
Long term care	$ 27,780.44	0.19%	85	0.13%	$326.83
Medical	$ 2,626,988.53	18.38%	21818	34.47%	$120.40
Paramedical	$ 1,506,442.16	10.54%	29543	46.68%	$50.99
Total	**$ 14,289,172.99**	100.0%	63261	100.0%	$255.88

Table 12: Accumulation of cost over time across cost categories

	Accident Day	First Week	First Month	First 3 Months	First 6 Months	First Year
Administration	559	7,550	18,181	56,102	84,757	169,700
Ambulance/RAR	993,903	1,056,328	1,112,910	1,195,078	1,204,098	1,209,016
Hospital	2,617,306	3,398,549	4,769,489	5,808,774	6,075,445	6,281,771
Impairment Lump Sum	-	-	-	-	7,013	113,124
Income	-	120,163	675,183	1,120,096	1,620,385	2,355,186
Legal	-	-	-	-	-	2,477
Long term Care	-	1,952	6,851	17,727	24,368	27,780
Medical	558,228	1,315,780	1,800,832	2,094,134	2,336,451	2,627,874
Paramedical	3,593	54,389	160,905	455,164	890,164	1,507,550

Considering the three levels of benefit categorization by the TAC and data availability, Figure 8 provides a tree presentation of cost categories investigated in this study. For each of these categories and subcategories, the data is divided into four time ranges: one month, three months, six months and one year. For some cost categories, one can expect the majority of expenses to be clustered in the first month post-accident (e.g. ambulance services) while other expenses are expected to continue beyond the first six months (e.g. income compensation and paramedical services). The cost outcomes are considered over four time ranges to determine which pre-injury health conditions are associated with expenditures beyond the immediate post-injury period.

All the generated variables are considered in four different forms including the original format as well as the log values. Overall, this leads to generation of more than 2000 outcome variables. Similar to what we experienced with the MBS and PBS datasets, some of the variables are removed as there were not enough participants who had used that service.

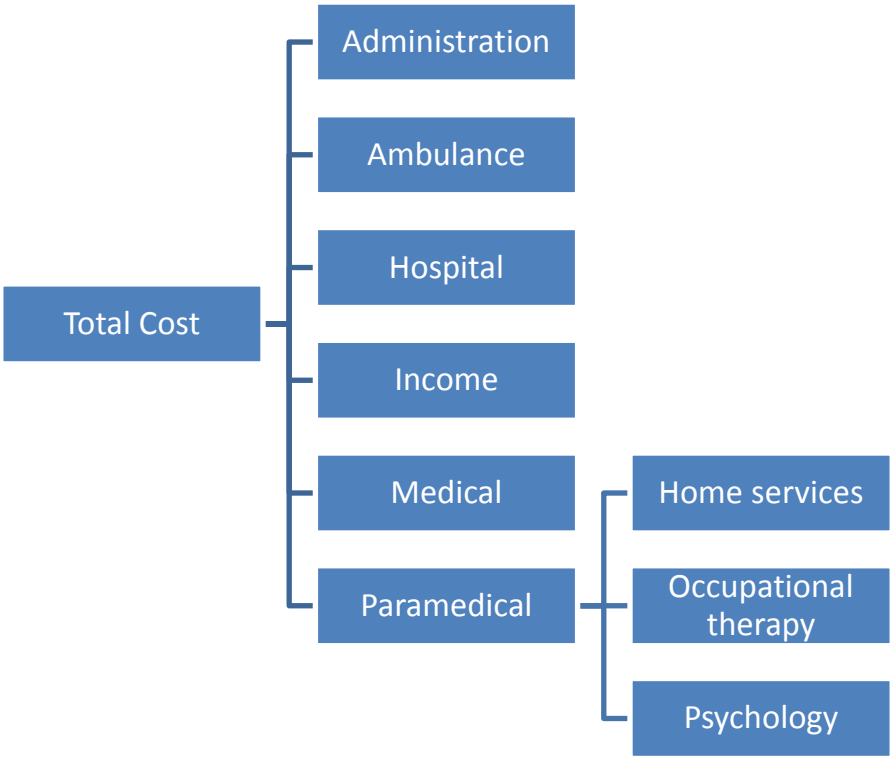

Figure 8: Benefit Categorization Structure used for measuring the Outcome Variables

4-4- METHODOLOGY

Bayesian Model Averaging (BMA) and Linear and Non-Linear Regression models are used to run semi-controlled data mining as well as testing for specific hypotheses that are introduced in the results section. BMA is applied mainly due to the uncertainty that exists in the model selection process. In other words, considering the large set of factors which affect the studied outcomes and the complexity of the data used in the analysis and also taking into account the limited literature that is available in this area, BMA is a powerful tool to provide robust results while correcting for possible collinearity between the factors. By using regression models along with the BMA approach, both model uncertainty and prediction uncertainty are addressed.

BMA is widely applied in a range of disciplines such as economics, ecology, biology and medicine (Röpnack, Hense et al. 2012, Baele, Li et al. 2013, Blattenberger, Fowles et al. 2013, Faust, Gilchrist et al. 2013, Parkinson and Liddle 2013, Punt, Hurtado-Ferro et al. 2014). It incorporates prior knowledge about a phenomenon into the model selection process which is vital in our study since limited evidence exists on the impacts of pre-injury comorbidity on post-injury recovery. R (Versions 2.15.2 and 3) and mainly "BMS" package is applied for the analysis. BMS is described as "Bayesian Model Averaging for linear models with a wide choice of (customizable) priors.[7]" This package has been extensively used recently in different areas and proven to be successful in running robust analysis (Böhmelt and Bove 2014, Feldkircher, Horvath et al. 2014, Price and Casler 2014, Pyron and Burbrink 2014, Weichenthal, Farrell et al. 2014).

As mentioned, more than 2000 outcome variables are analysed against more than 100 potentially contributing factors. The models are run so that in each simulation the results converge to a similar set of coefficients with statistically identical probabilities and magnitudes. For this purpose, each model is run at least for 5 million iterations. Considering the massive computational resources needed to perform this level of analysis, Monash Monash High Performance Computing (HPC) facilities are used for parallel running of millions of models[8].

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[7] Feldkircher, M. and S. Zeugner (2009): Benchmark Priors Revisited: On Adaptive Shrinkage and the Supermodel Effect in Bayesian Model Averaging; IMF Working Paper 09-202

[8] https://confluence-vre.its.monash.edu.au/display/mcgwiki/Monash+MCG

5. RESULTS

This section presents the results of the analyses for total and categorized costs.

5-1- ACCIDENT-RELATED FACTORS

Among the wide range of factors included in the model, as expected, injury type and severity can be considered as the most important drivers of compensation costs. Our analyses show that our manually-made variable of "more than one day of hospitalization" along with at least one type of injury, appear to be important in almost all the models reviewed. The results show that hospitalization is likely to increase the benefit costs by almost 2,000 dollars per person. Among different types of injury, Brain Injury, Fractures and Internal Injuries are considered to be the most costly types when it comes to compensation.

As for the role in the accident, motor cyclists have received the highest amount of benefits followed by the pedestrian and drivers. Women are expected to have lower costs than men although the evidence is not very strong (4,879 dollars less, p-value = 0.04602) and younger participants have lower costs (203 dollars per year of age) which can be due to lower levels of income compensation. This is clearer when the non-linear impacts of age are considered as in Figure 9. As the figure shows, the average benefits received increase when age increases until the participant reaches 41 years of age and then decreases for older participants.

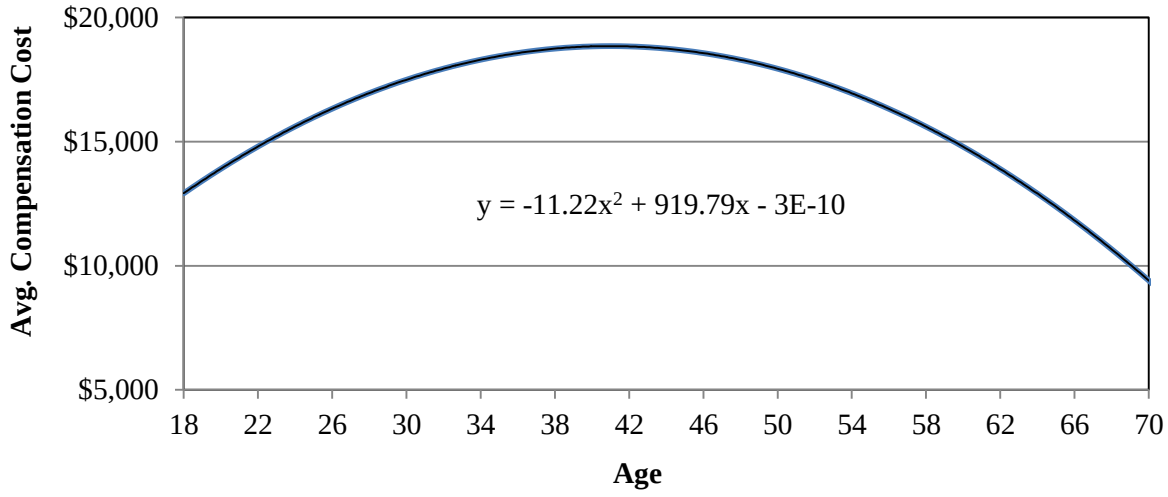

Figure 9: Non-linear impacts of age on costs of compensation

5-2- HEALTHY USER EFFECT

The purpose of this study is to examine the impact of pre-existing chronic disease on injury recovery and the cost of injury recovery. The linkage of pre-injury health service use records to injury claims data, however, only allows us to establish the relation between pre-injury diagnostics and treatment, and injury outcomes (Figure 10).

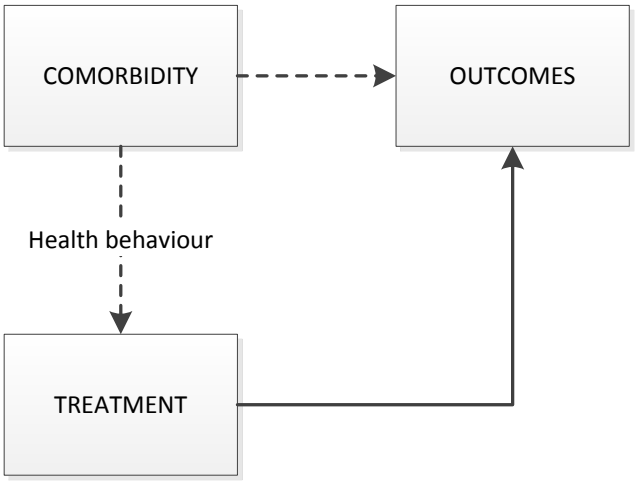

Figure 10: Health behaviour and its impact on the validity of treatment records as proxy for disease

Although specific treatments can be directly related to the presence of a diagnosed health condition, not all chronic disease is detected and treated. Furthermore, not all health service use records would reflect disease. Using health service use records as a proxy for health can impact our study findings in two ways:

1- Misclassification: Based on health service use data alone, undetected and untreated disease will be misclassified as no disease. This will weaken the detected associations between pre-injury disease and injury outcomes. In other words, the underlying associations between disease and injury outcomes are stronger than those reported based on health service records as proxy for disease.

2- Healthy user effect: Health service use is not only driven by 'need', but also by a range of other individual factors; factors relating to the resources and organisation of the health services system; and societal norms (Andersen and Newman 1973). Assuming a well organised and resourced health service system, and general affordability provided by Medicare and the PBS, individual factors are the main drivers of health service use. An important individual-level driver is 'healthy user behaviour', which is the tendency to seek medical care by healthy individuals (Shrank, Patrick et al. 2011). Healthy user behaviour is generally associated with other aspects of healthy behaviour such as following healthy lifestyle recommendations, uptake of flu vaccines, adherence to prescribed medication etc. Healthy user behaviour is also reflected in the use of primary and secondary preventive services such as cancer screening and cholesterol lowering medication, respectively.

When analysing health service records to determine pre-injury health, we are therefore mindful of services that do not reflect disease, but are indicative of healthy user behaviour. Although there are no set definitions of healthy user services, we identify screening services (PAP smears, PSA tests), flu vaccines, mammography, general blood tests (pathology) and in particular cholesterol testing as indicative of healthy user behaviour. Skin biopsy has also appeared in the data as a potentially 'healthy user driven' service, and can be interpreted as such. This is an approximation only, because in some cases these services may have been doctor-driven.

We expect the use of healthy user service to be negatively associated with cost of injury recovery: the healthy users are motivated to regain their health and proactive in their use of services that aid their recovery. We expect long term cost of recovery in this group to be lower, although short-term service use might be higher. In our study, the following items appeared most frequently with negative coefficients:

1- Pathology Item 66503: which is two test described in pathology Item 66500: "Quantitation in serum, plasma, urine or other body fluid (except amniotic fluid), by any method except reagent tablet or reagent strip (with or without reflectance meter) of: acid phosphatase, alanine aminotransferase, albumin, alkaline phosphatase, ammonia, amylase, aspartate aminotransferase, bicarbonate, bilirubin (total), bilirubin (any fractions), C-reactive protein, calcium (total or corrected for albumin), chloride, creatine kinase, creatinine, gamma glutamyl transferase, globulin, glucose, lactate dehydrogenase, lipase, magnesium, phosphate, potassium, sodium, total protein, total cholesterol, triglycerides, urate or urea - 1 test"

2- Pathology Item 66536: which is "Quantitation of HDL cholesterol"

3- Therapeutic Item 30071: which is Diagnostic Biopsy of Skin or Mucous Membrane, as an independent procedure, where the biopsy specimen is sent for pathological examination

4- Pathology Item 66608: which is Vitamin D or D fractions - 1 or more tests.

The conclusion regarding the healthy user effect is that an overall quantification of health service use cannot be interpreted as indicative of poor health: some services are indicative of proactive use of preventive and early detection services. Further research is needed to identify healthy users and use this information to inform outcome expectations. I.e. 'healthy users' are likely to have better outcomes, and TAC clients who make use of services that can speed up their recovery and return to work can potentially be identified at the intake.

5-3- TOTAL COST

One of the main challenges in measuring the effects of pre-injury comorbidity on the total cost is the outliers as discussed in Section 4-3. In order to respond to this challenge, total cost is converted to a ranked percentile value and then regressed against all the potential factors reviewed in Part 5 of this report using Bayesian Model Averaging.

The results show that in the short term, only accident and participant characteristics determine the total benefits received by a participant, and pre-accident comorbidities have no significant impact on the recovery. Among the factors included, the most significant one was *number of attendances*. Table 13 presents the drivers of one-year total benefits received by a participant. The only pre-injury comorbidity that affects the post-injury recovery is how many times a participant has used a service from MBS category A8. The category description is "Professional attendance by a consultant physician in the practice of his or her speciality of PSYCHIATRY where the patient is referred to him or her by a referring practitioner". In our data, the majority of participants used long consultations (usually more than 45 minutes) both at the consultation room and hospital.

Table 13: Drivers of Total Benefits received by a participant

Percentile	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	0.331	0.013	23.85	0.0000
Severity of Accident	0.313	0.019	16.05	0.0000
Country Area	0.081	0.016	4.99	0.0000
Musculoskeletal Injury	-0.051	0.019	-2.68	0.0075
Orthopaedic Injury	0.163	0.021	7.65	0.0000
Brain Injury	0.217	0.033	6.48	0.0000
Internal Injury	0.153	0.028	5.41	0.0000
MBS Category A8 (Psychiatry attendance)	0.007	0.003	2.45	0.0143

Beyond what is presented in the table, our simulations also showed that pre-injury Vascular Ultrasound (MBS category Imaging, Group Ultrasound and Sub-Group Vascular[9]) may have minor impacts on cost, which can be a topic for further investigations.

[9] http://www9.health.gov.au/mbs/search.cfm?cat1=89&cat2=90&cat3=93&adv=

5-4- OUTCOME CATEGORIES

This section presents the results for different benefit categories.

5-4-1- Administrative Costs

Administrative costs account for close to 1.2% of total costs in our data. The results show that the main pre-injury comorbidity that is significantly associated with this type of cost is history of mental illness, indicated by visiting a psychiatrist before the accident (i.e. MBS service category of A8). There is also suggestive evidence that participants who have been on 'psycholeptics' (N05 drug category) are likely to have higher administrative costs. Psycholeptics are a class of drugs that generally have a calming effect. Antipsychotics, anxiolytics and hypnotics and sedatives all fall into this category. Anxiolytics are drugs that decrease anxiety, and hypnotics are drugs used to induce sleep.

5-4-2- Ambulance Service Costs

Accounting for 8.5% of total cost over one year, 80% of ambulance costs occur on the day of accident. The results showed that participants who have used pharmaceuticals in the ATC category A10, "Drugs Used in Diabetes", are likely to have higher short-term ambulance costs: 108 dollars higher ambulance costs per each pre-injury A10 prescription (p-value = 0.001). To verify this finding, our manually generated Diabetes variables was included in the analysis, and it was also significant in the logged-outcome model (coefficient = 0.18, p-value = 0.0006). Further investigations show that the higher ambulance costs for this group are mainly driven by the participants who had one single expensive ambulance service costing in a range of five to ten thousand dollars. Moreover, slightly higher long-term ambulance costs are also observed for patients who had a vascular ultrasound in the year before the accident (p-value = 0.019).

5-4-3- Hospital Costs

Hospital costs are the highest cost component in our study. As presented in Figure 11, the hospital costs increase exponentially in the first month after the accident but then continues to grow at a slower pace.

Various pre-injury health service items/categories are identified as contributing to higher costs of hospital during the recovery period.

1- General Surgeries[10] [MBS Category: Therapeutic Procedures, Group: Surgical Operations]

Participants who have had general surgery in the year before their accident are more likely to be readmitted to a hospital after the accident. The most frequent items in this category in our sample include diagnostic

[10] http://www9.health.gov.au/mbs/search.cfm?cat1=32&cat2=62&cat3=63&adv=

biopsy of skin or mucous membrane, oesophagoscopy, treatment of premalignant skin lesions, and removal of tumour, ulcer or scar.

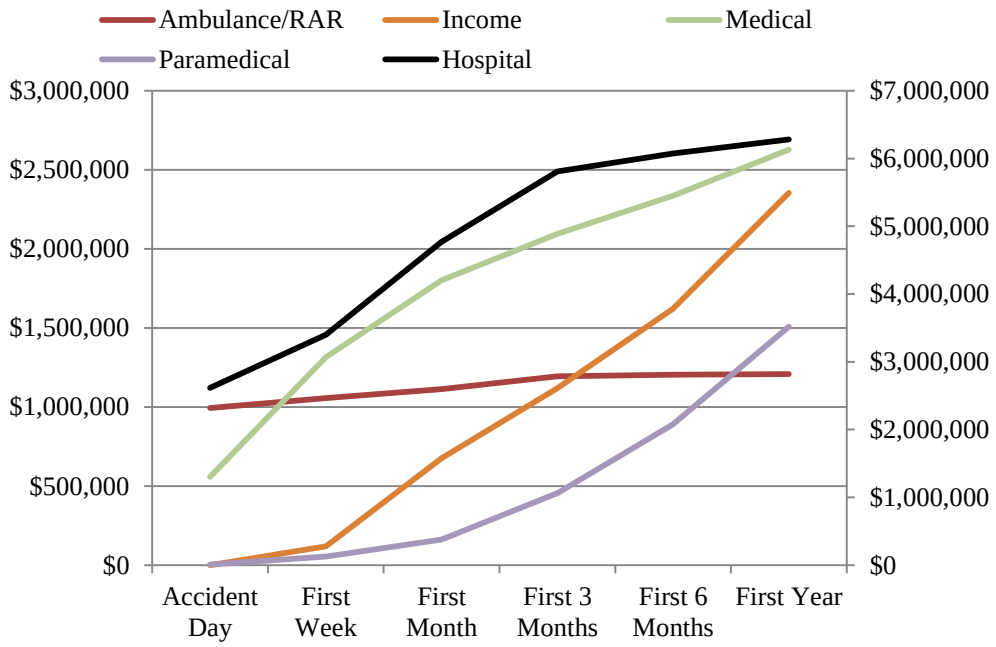

Figure 11: Cumulative cost over time after injury, in time categories ranging from the accident day to the entire first post-injury year. Main TAC cost categories (ambulance, income, medical, paramedical, hospital) are shown individually.

2- Anaesthesia Consultations[11] [MBS Category: Therapeutic Procedures, Group: Anaesthetics]

Patients who received a consultation for anaesthesia in the pre-injury year had higher injury-related hospital costs. The service which has a significant impact in our analysis is, according the definition from the MBS website, "a pre-anaesthesia consultation of a straightforward nature occurring prior to investigative procedures and other routine surgery. This item covers routine pre-anaesthesia consultation services including the taking of a brief history, a limited examination of the patient including the cardio-respiratory system and brief discussion of an anaesthesia plan with the patient[12]".

3- Optometrical Services and Items: [MBS Category Professional Attendances[13] and PBS Category S[14]]

[11] http://www9.health.gov.au/mbs/search.cfm?cat1=32&cat2=57&cat3=58&adv=

[12] http://www9.health.gov.au/mbs/fullDisplay.cfm?type=item&q=17610&qt=item&criteria=

[13] http://www9.health.gov.au/mbs/search.cfm?cat1=1&cat2=3&cat3=&adv=

[14] http://www.whocc.no/atc_ddd_index/?code=S01&showdescription=no

One of the main groups of participants with higher long-term hospital costs are clients who have used optometrical services in the year before the accident.

4- Pathological Services

While many of the pathological services are likely to be signs of healthy user effect, in some cases services such as Initiation of Patient Episode[15] (Group 10), Thyroid function test (MBS Item 66719)[16], and Quantitation of glycosylated haemoglobin performed in the management of established diabetes (MBS Item 66551[17]) are among the pathological services which have positive impacts on hospital costs. For instance, a patient who has had a glycosylated haemoglobin quantitation test (indicating monitoring of established diabetes or further testing of suspected diabetes) is likely to have 8000 dollars more hospital cost.

5- Mental Health History: [Consumers of Anxiolytics and Hypnotics]

Patients who have used Anxiolytic and Hypnotic medication at least once in the year before the accident are more likely to have higher hospital costs, especially when public hospital costs are taken into account.

5- Diabetes: [Manually generated group]

The public hospital cost of a patient with diabetes may be up to 50% higher than a patient without the disease.

5-4-4- Income Costs

As Table 14 presents, the only pre-injury comorbidity that affects income compensation cost is psychiatry services (MBS category A8). The table presents the results for log models which show that participants who have been suffering from mental illness have about 10 percentage points higher income claims than those who have not. The effects of psychiatry service use are similar when considering short term and long term income compensation costs.

[15] http://www9.health.gov.au/mbs/search.cfm?cat1=147&cat2=149&cat3=&adv=

[16] http://www9.health.gov.au/mbs/search.cfm?q=66719&sopt=S

[17] http://www9.health.gov.au/mbs/search.cfm?q=66551&sopt=S

Table 14: Drivers of short and long terms income compensation costs

	One Month	Three Months	Six Months	One Year
+1-Hospitalization*	1.966	2.332	2.460	2.586
Age	0.134	0.140	0.143	0.147
Age-Squared	-0.0017	-0.0018	-0.0018	-0.0019
Inj Musculoskeletal	-1.341	-1.441	-1.475	-1.524
Inj Contusion	-1.139	-1.246	-1.284	-1.280
Inj Dislocation	2.070	2.122	2.321	2.701
Inj Fracture Limb	1.078	1.156	1.155	1.180
MBS A8†	0.099	0.107	0.108	0.113

* At least one day hospitalisation after the accident. Binary variable created as proxy for injury severity
† Use of psychiatry consultation in the year pre-injury

5-4-5- Medical Cost

This benefit category highlights how health service use before the accident can affect injury-related medical costs after the accident. Among the wide range of studied factors, the following services are statistically significantly associated with the clients compensated injury-related medical expenses.

1- Vascular Ultrasounds[18]: [MBS category Imaging, Group Ultrasound]

The subgroup of vascular ultrasound includes a wide range of duplex scanning services. Table 15 presents the list of MBS items that are included in this subgroup.

2- Optometrical Services: [MBS Category Professional Attendances and PBS Category SS]

As for the hospital costs, pre-injury optometrical services can explain post-injury recovery costs. Artificial tears, Antiglaucoma Preparations and Miotics, Antiinfectives and Corticosteroids and Antiinfectives in Combination are among the most frequently appeared items on the list of prescribed drugs for our participants in the year before the accident.

[18] http://www9.health.gov.au/mbs/search.cfm?cat1=89&cat2=90&cat3=93&adv=

Table 15: List of MBS Vascular Ultrasound Services used by the Participants

MBS Item	Frequency	Description
55238	11	DUPLEX SCANNING, unilateral, involving B mode ultrasound imaging and integrated Doppler flow measurements by spectral analysis of arteries or bypass grafts in the lower limb OR of arteries and bypass grafts in the lower limb, below the inguinal ligament
55244	9	DUPLEX SCANNING, unilateral, involving B mode ultrasound imaging and integrated Doppler flow measurements by spectral analysis of veins in the lower limb, below the inguinal ligament, for acute venous thrombosis
55274	8	DUPLEX SCANNING, bilateral, involving B mode ultrasound imaging and integrated Doppler flow measurements by spectral analysis of extra-cranial bilateral carotid and vertebral vessels, with or without subclavian and innominate vessels, with or without oculoplethysmography or peri-orbital Doppler examination
55276	8	DUPLEX SCANNING involving B mode ultrasound imaging and integrated Doppler flow measurements by spectral analysis of intra-abdominal, aorta and iliac arteries or inferior vena cava and iliac veins OR of intra-abdominal, aorta and iliac arteries and inferior vena cava and iliac veins, excluding pregnancy related studies
55246	7	DUPLEX SCANNING, unilateral, involving B mode ultrasound imaging and integrated Doppler flow measurements by spectral analysis of veins in the lower limb, below the inguinal ligament, for chronic venous disease
55252	1	DUPLEX SCANNING, unilateral, involving B mode ultrasound imaging and integrated Doppler flow measurements by spectral analysis of veins in the upper limb
55278	1	DUPLEX SCANNING involving B mode ultrasound imaging and integrated Doppler flow measurements by spectral analysis of renal or visceral vessels OR of renal and visceral vessels, including aorta, inferior vena cava and iliac vessels as required excluding pregnancy related studies

3- Pathology Item 65120[19]: Prothrombin time.

The item is explained as: Prothrombin time (including INR where appropriate), activated partial thromboplastin time, thrombin time (including test for the presence of heparin), test for factor XIII deficiency (qualitative), Echis test, Stypven test, reptilase time, fibrinogen, or 1 of fibrinogen degradation products, fibrin monomer or D-dimer - 1 test.

Prothrombin time is generally indicative of a patient who is using warfarin. This could potentially complicate an injury because of prolonged bleeding. Figure 12 presents the trend of using the service per 100,000 population in Victoria.

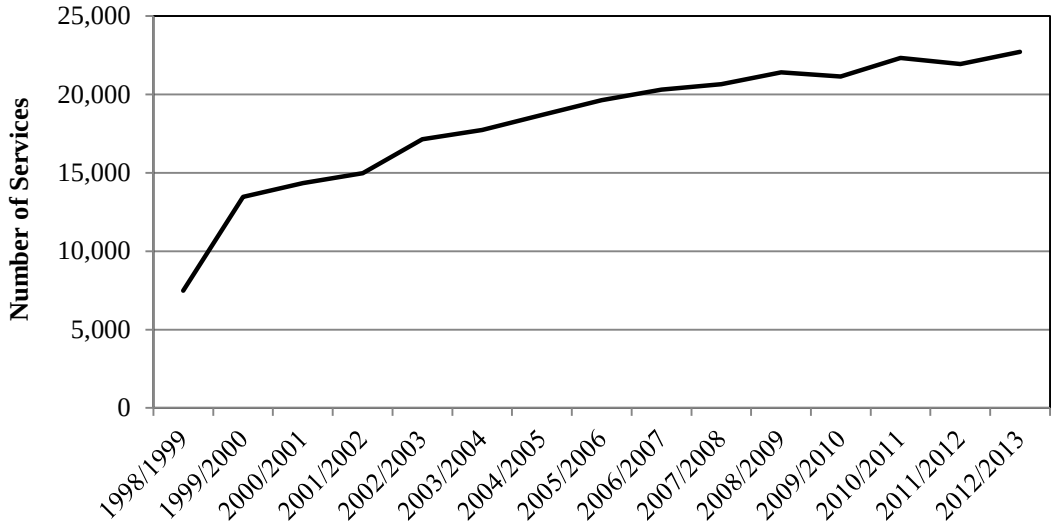

Figure 12: MBS Item 65120 [Prothrombin time] Services per 100,000 population

4- MBS Item 2712[20] [GP mental health treatment plan]

Since its introduction in 2006/07, this item has grown rapidly from only 237 services per 100,000 population to 1,759 in 2012/13. The details of the service is "Attendance by a medical practitioner (including a general practitioner, but not including a specialist or consultant physician) to REVIEW a GP MENTAL HEALTH TREATMENT PLAN prepared by that medical practitioner (or an associated medical practitioner) to which item 2700, 2701, 2715, 2717 or former items 2702 and 2710 applies or to REVIEW a PSYCHIATRIST ASSESSMENT AND MANAGEMENT PLAN to which item 291 applies (not being a service associated with a service to which items 2713 or 735 to 758 apply)".

[19] http://www9.health.gov.au/mbs/fullDisplay.cfm?type=item&q=65120&qt=item&criteria=65120

[20] http://www9.health.gov.au/mbs/fullDisplay.cfm?type=item&qt=ItemID&q=2712

5-4-6- Paramedical Costs

There were no specific pre-injury service items or pharmaceuticals that were statistically significantly associated with the overall post-injury paramedical costs. This can be mainly due to the fact that what TAC categorises as "paramedical" covers a wide range of services ranging from allied health to home and vocational services. As a result, the cost is further broken into more detailed groups as follows.

5-4-6-1 TAC Physiotherapy Services

Among the wide range of factors studied, pre-injury Spinal Radiology[21], Magnetic Resonance Imaging (MRI) and our manually derived variable of Mental Health have been the main contributors to the increasing costs of physiotherapy after the accident.

In the first two service groups, lumbosacral spine and cervical spine x-rays as well as MRI scans of head and musculoskeletal system are among the main driving factors. Spine X-ray and MRI are generally indicative of back and neck pain.

Beyond the mentioned items, participants who have used two or more from MBS item 69475[22] which is "One test for hepatitis antigen or antibodies to determine immune status or viral carriage following exposure or vaccination to Hepatitis A, Hepatitis B, Hepatitis C or Hepatitis D" have also had slightly higher costs of physiotherapy.

5-4-6-2 Psychology Services

The main driver of post-injury psychological services is the pre-injury psychology service use to an extent that clients with mental health history are expected to visit a psychologist four times more than the rest of participants. Beyond this non-surprising fact, participants who have had more attendances (which again include psychological attendances) are more likely to use this group of services.

5-4-6-3 Occupational Therapy Services

Two main factors are found to be significantly affecting the post-accident occupational therapy cost. First, participants who have on average used more medical services before the injury (i.e., Medicare items) are among the main users of this type of service. Secondly, patients with history of using Diagnostic Radiology services such as radiographic examination of shoulder, head or spine are also more likely to claim in this category.

[21] http://www9.health.gov.au/mbs/search.cfm?cat1=89&cat2=96&cat3=108&adv=

[22] http://www9.health.gov.au/mbs/fullDisplay.cfm?type=item&q=69475&qt=item&criteria=69475

5-4-6-4 TAC Home Services

One of the main drivers of receiving home services, as presented in Figure 13, is the age of participant. But after controlling for age, there is still a long list of pre-injury medical items which have significant impacts on post-injury cost of home services.

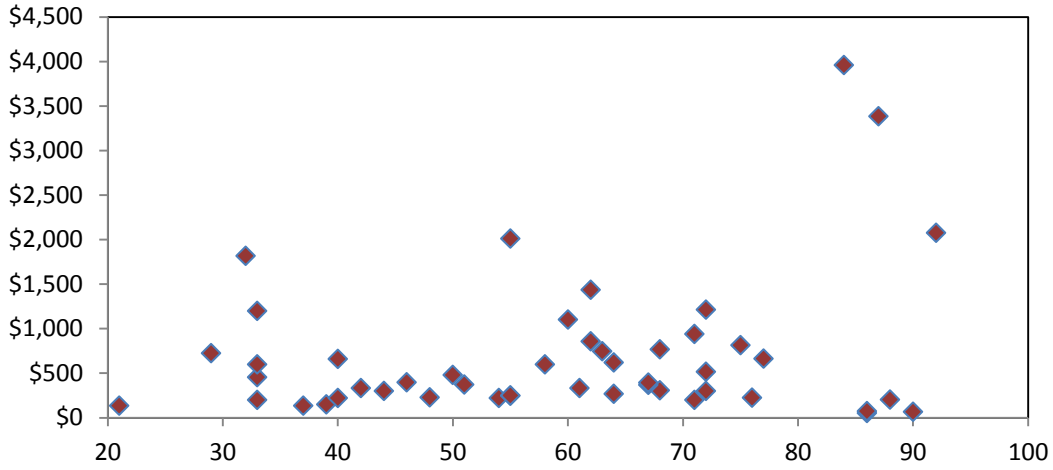

Figure 13: Cost of Home Services vs. Age

1- Count of Therapeutic Services

Participants who have received more therapeutic services before the accident, on average, have higher post-accident home services costs.

2- M05 [Drugs for treatment of bone diseases]

Patients who used pharmaceuticals in the ATC category M05, drugs used for the treatment of bone diseases, are more likely to receive home services. This category includes items such as Alendronate and Risedronate at different dosages, and is generally indicative of treated osteoporosis.

3- Vascular Ultrasound [MBS category Imaging, Group Ultrasound]

Vascular ultrasound has again appeared to be a significant factor in this cost category. There is also some evidence that participants, who have had more CT Scans before the accident, are more likely to use post-accident services.

4- Mental Health

There is some less significant evidence that participants with mental health history are more likely to use this type of service when considered over the full post-accident year.

6. SUMMARY & CONCLUSIONS

Better understanding of the drivers of traffic accident compensation costs is a key step in: 1) providing a fairer and further optimised system of providing benefits to TAC clients through better allocation of financial resources, and 2) better internal management of claims and efficient allocation of physical and human resources and therefore greater client satisfaction. Researchers from different areas of medical and social sciences have tried to identify key factors that affect the recovery process and overall cost of compensation, including the role of pre-injury comorbidity. One of the main challenges they have faced is that the majority of data on pre-accident conditions of the patient is self-reported or reliant on doctor-reporting, which is prone to inaccuracies such as recall bias and underreporting, respectively.

This study, for the first time in Australia that we are aware of, used the Medicare and Pharmaceutical Benefits Scheme records of 738 participants to investigate the links between pre-accident health conditions and post-accident cost of recovery from compensable road traffic injury in Victoria, Australia. The main findings of this study can be summarised in the following five items:

1- Overall, the results showed that the pre-injury health service and pharmaceutical use was a relatively minor factor in explaining the cost of recovery. In other words, except in some specific categories of TAC cost, whether in short or long-term, total cost of recovery was mainly a factor of severity, accident features and client sociodemographics. The main findings of this study are on the impact of pre-existing health conditions on specific TAC cost categories rather than on the overall TAC cost.

2- Across the TAC cost categories that were studied, non-administrative categories such as Medical Benefits, Hospital Benefits, and certain Paramedical Benefits were more sensitive to the pre-injury health service and pharmaceutical factors while administrative categories such as Income Benefits and administration cost were less affected.

3- Across the wide range of studied factors, four main pre-injury factors had the greatest impact:

- First, chronic conditions: patients with history of diabetes or cardiovascular disease were expected to have higher recovery costs. Diabetes was associated with higher ambulance cost and hospital cost. Cardiovascular disease was also a dominant pre-injury health factor which increased the cost of injury, particularly in the category of TAC Medical costs and home services (TAC Paramedical costs).
- Receiving therapeutic services, particularly surgery-related services such as general surgeries or anaesthesia in the year before the accident were indicators of significant pre-injury complications that can lead to greater post-injury recovery costs. Particularly TAC Hospital costs and home services (TAC Paramedical costs) were increased by pre-injury surgery. Overall, pre-injury surgery was a better predictor of recovery cost and duration when compared to attendance, pathology or imaging services.
- Pre-injury health service items that are likely to be indicative of back pain, that is spinal X-rays and MRI services in the year before the injury, were associated with greater post-injury physiotherapy costs (TAC Paramedical services).
- Finally, one of the main findings of our study was the significant impact of mental health on the overall cost of recovery. Mental health history was the main factor affecting the total cost, administrative cost and income cost while also leading to higher expenses in areas such as hospital or paramedical costs, especially when studied over the long-term. Indicators of mental health problems were GP attendance related to mental health problems, psychiatry attendance, and use of pharmaceuticals in the category of antipsychotics, anxiolytics, hypnotics and sedatives.

4- The main limitation of this study was the relatively small sample size, and the biased sample which was reflected in an overrepresentation of older clients. Many of the potentially informative pre-injury health service items could not be included in the analysis because they were not frequent enough in the sample. A further investigation in this area with a larger sample size is recommended. The analysis can also improve if longer pre-injury and post-injury time periods are taken into account.

5- The findings of this project are actionable. The TAC can practically benefit from this study by collecting data on the highlighted comorbidities and then using them for managing the cases better. The following questions could be asked to obtain client information regarding the key pre-injury health conditions that impacted on TAC costs in our study sample:

- Do you have diabetes?

- Are you taking any prescription medication related to cardiovascular disease or have you had a vascular ultrasound?

- Have you had surgery in the last twelve months?

- Have you had an X-ray or MRI in relation to back pain in the last twelve months?

- In the last twelve months, have you seen your general practitioner in relation to your mental health?

- Have you attended a psychiatrist in the last twelve months?

Responses to these items will help the TAC to identify clients that are at risk for having a greater post-injury health service need.

The authors conclude by recommending the TAC to collect more data on the pre-injury comorbidity as well as supporting future research projects to further investigate the topic based on larger samples.

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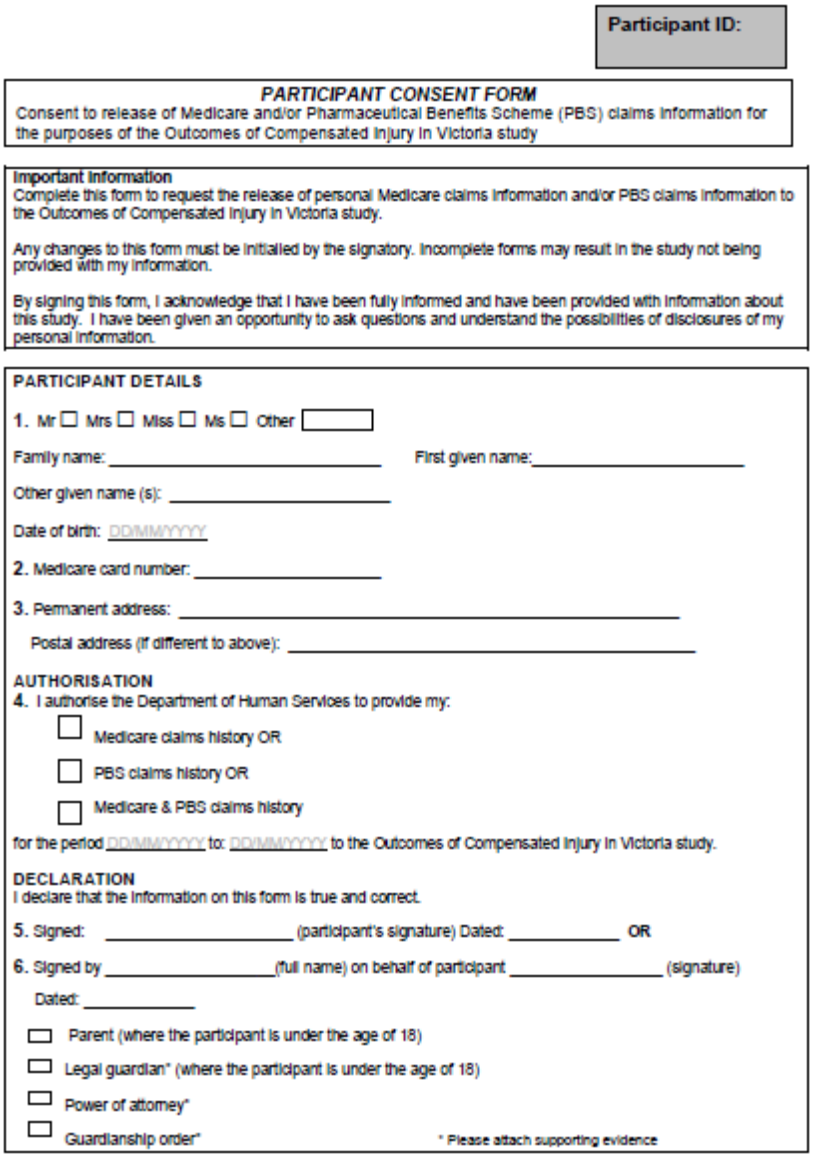
8. APPENDIX

Participant consent form. Participant ID, Mr/Mrs/Miss/Ms, Family name, Date of Birth, Address, and linkage dates were all pre-populated before mail-out. The box 'Medicare & PBS claims history' was pre-ticked.



Participant ID:

PARTICIPANT CONSENT FORM

Consent to release of Medicare and/or Pharmaceutical Benefits Scheme (PBS) claims information for the purposes of the Outcomes of Compensated Injury in Victoria study

Important information

Complete this form to request the release of personal Medicare claims information and/or PBS claims information to the Outcomes of Compensated Injury in Victoria study.

Any changes to this form must be initialled by the signatory. Incomplete forms may result in the study not being provided with my information.

By signing this form, I acknowledge that I have been fully informed and have been provided with information about this study. I have been given an opportunity to ask questions and understand the possibilities of disclosures of my personal information.

PARTICIPANT DETAILS

1. Mr ☐ Mrs ☐ Miss ☐ Ms ☐ Other ☐

Family name: _____ First given name: _____

Other given name (s): _____

Date of birth: DD/MM/YYYY

2. Medicare card number: _____

3. Permanent address: _____

Postal address (if different to above): _____

AUTHORISATION

4. I authorise the Department of Human Services to provide my:

☐ Medicare claims history OR

☐ PBS claims history OR

☐ Medicare & PBS claims history

for the period DD/MM/YYYY to: DD/MM/YYYY to the Outcomes of Compensated Injury in Victoria study.

DECLARATION

I declare that the information on this form is true and correct.

5. Signed: _____ (participant's signature) Dated: _____ **OR**

6. Signed by _____(full name) on behalf of participant _____ (signature)

Dated: _____

☐ Parent (where the participant is under the age of 18)

☐ Legal guardian* (where the participant is under the age of 18)

☐ Power of attorney*

☐ Guardianship order*

* Please attach supporting evidence

Power of attorney – A power of attorney is a document that appoints a person to act on behalf of another person who grants that power. In particular, an enduring power of attorney allows the appointed person to act on behalf of another person even when that person has become mentally incapacitated. The powers under a power of attorney may be unlimited or limited to specific acts.

Guardianship order – A Guardianship order is an order made by a Guardianship Board/Tribunal that appoints a guardian to make decisions for another person. A Guardianship order may be expressed broadly or limited to particular aspects of the care of another person.

A sample of the information that may be included in your Medicare claims history:

Date of service	Date of Processing	Item number	Item description	Provider charge	Schedule Fee	Benefit paid	Patient out of pocket	Bill type
20/04/09	03/05/09	00023	Level B consultation	$38.30	$34.30	$34.30	$4.00	Cash
22/06/09	23/06/09	11700	ECG	$29.50	$29.50	$29.50		Bulk Bill

Scrambled ordering Provider number*	Scrambled rendering Provider number*	Date of referral	Rendering Provider postcode	Ordering Provider postcode	Hospital Indicator	Provider derived major speciality	Item category
	999999A		2300		N	General Practitioner	1
999999A	999999A	20/04/09	2300	2302	N	Cardiologist	2

* Scrambled Provider number refers to a unique scrambled provider number identifying the doctor who provided/referred the service. Generally, each individual provider number will be scrambled and the identity of that provider will not be disclosed.

A sample of the information that may be included in your PBS claims history:

Date of supply	Date of prescribing	PBS Item code	Item description	Patient category	Patient contribution	Net Benefit	Scrambled Prescriber number*	Pharmacy postcode	Form Category
06/03/09	01/03/09	03133K	Oxazepham Tablet 30 mg	Concessional Ordinary	$5.30	$25.55	9999999	2560	Original
04/07/09	28/05/09	03161J	Diazepam Tablet 2 mg	General Ordinary	$30.85		9999999	2530	Repeat

ATC Code	ATC Name	Prescriber derived major speciality
N05 B A 04	Oxazepam	General Practitioner
N05 B A 01	Diazepam	Psychiatrist

* Scrambled Prescriber number refers to a unique scrambled prescriber number identifying the doctor who prescribed the prescription. Generally, each individual prescriber number will be scrambled and the identity of that prescriber will not be disclosed.