Measuring multimorbidity in Australia

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Statement of authentication

This thesis is submitted to the University of Sydney in fulfilment of the requirements for the degree of Doctor of Philosophy. The work presented in this thesis is, to the best of my knowledge and belief, original except as acknowledged in the text. I hereby declare that I have not submitted this material, either in full or in part, for a degree at this or any other institution.

Signed:

Date: 29/3/2017

Abstract

The ageing of the population is expected to lead to increases in the prevalence of chronic conditions, multimorbidity, and raised demand for primary care services. To enable health systems to respond to these increases, the prevalence of chronic conditions and multimorbidity need to be measured in an accurate and timely manner. However, prevalence estimates of multimorbidity vary widely due to inconsistent definitions and measurement methods used in research. The aim of this thesis is to develop a reliable and practical method of measuring multimorbidity in Australia.

The research reported in this thesis is based on two sets of sub-studies of the Bettering the Evaluation and Care of Health (BEACH) program, a continuous national survey of Australian general practice activity.

The first survey was conducted between August 2008 and May 2009, and involved 290 randomly selected general practitioners (GPs) who recorded all diagnosed chronic conditions in 8,707 patients at their encounters.

Having GPs record patients' diagnosed chronic conditions avoids the limitations of self-reported data used in most large population prevalence studies. However, patients sampled at GP encounters are not representative of the population as only about 87% of people visit a GP in any year and because older people are more likely to attend and to attend more often. To estimate population prevalence, I weighted each age-sex group to match the distribution of the population. I then weighted the outcome by the proportion in each age-sex group who visited a GP at least once in the survey year, assuming those who did not see a GP did not have a diagnosed chronic condition.

I estimated that two-thirds (66.3%) of patients at GP encounters had at least one diagnosed chronic condition as did half (50.8%) of the Australian population. Hypertension was the most prevalent condition, 26.6% of patients at GP encounters and 17.4% of the population having this diagnosed condition.

While multimorbidity has been most often defined as 2+ chronic conditions, there have been recent moves towards using 3+. There have been calls for standardisation of multimorbidity research, inconsistent definitions and methods having led to large variance in estimated prevalence between studies. I examined the independent effects on prevalence estimates of:

1.   how 'morbidity' is defined either as a single chronic condition or a 'group' of conditions using the chapter/domain structure of the International Classification of Primary Care (Version 2) (ICPC-2), the International Classification of Disease (10th revision)(ICD-10), or the Cumulative Illness Rating Scale (CIRS);

2.   the number of 'morbidities' required in the definition of multimorbidity;

3.   the number of diagnosed chronic conditions included in the study.

I found that data grouped by ICPC-2 chapters, ICD-10 chapters or CIRS domains produced similar multimorbidity prevalence estimates. Multimorbidity defined as 2+ morbidities provided similar estimates whether individual conditions or groups of conditions were counted and whether as few as 12 prevalent chronic conditions were studied or all chronic conditions, but it lacked the specificity to be useful, especially among older people. Multimorbidity, defined as 3+ morbidities, required more measurement conformity and inclusion of all chronic conditions, but provided greater specificity than the 2+ definition.

These results led to a set of guidelines for multimorbidity researchers, which if followed, will produce results that can be compared with results from other studies adhering to the same guidelines. I also proposed the concept of 'complex multimorbidity', the co-occurrence of three or more chronic conditions classified in three or more different body systems within one person, without defining an index chronic condition. Using 'complex multimorbidity' may identify high-need individuals.

I estimated that: 47.4% of patients at GP encounters and one-third (32.6%) of the population had multimorbidity (2+); further, that 27.4% of patients at GP encounters and 17.0% of the Australian population had complex multimorbidity. The most prevalent pattern of three conditions was hypertension + hyperlipidaemia + osteoarthritis (5.5% of patient at encounters and 3.3% of the population).

In my second, larger, survey, conducted between November 2012 and March 2016, 1,449 randomly selected GPs recorded all diagnosed chronic conditions for 43,501 patients. They also recorded the number of times each patient had seen a GP in the previous 12 months. Data collected in Survey 1 had not allowed adjustment for high and low attenders within each age-sex group. The individual attendance data in survey 2 allowed me to adjust for each patient's chance of being in the survey sample.

My prevalence estimates for patients at encounters were similar to those from Survey 1, with 26.5% of patients at encounters having diagnosed hypertension, 51.6% multimorbidity and 30.4% having complex multimorbidity. However, the population prevalence estimates produced with the new method were significantly lower than those from the previous method, an estimated 12.4% of the population having diagnosed hypertension, 25.7% multimorbidity and 12.1% complex multimorbidity. This suggests that patients with more chronic conditions attend more often than others in their age-sex group. Adjusting for individual patient attendance is therefore required to produce reliable population estimates from data collected from patients sampled at GP encounters.

My final task was to develop a parsimonious model to predict patient GP-visit rate, testing the assumption that the number of chronic conditions is driving GP service use. In Survey 2, the number of diagnosed chronic conditions alone accounted for a significant proportion of the variance (25.5%) in patient GP-visit rate. The number of body systems involved also explained a significant proportion of variance (23.9%). Including patient age, sex and Commonwealth concession health care card status only marginally increased the predictive value of the model to 27.9%.

In summary, this thesis demonstrates a practical method of measuring multimorbidity in Australia, using GPs as expert interviewers and adjusting for each patient's individual attendance. I have shown that to produce robust results that can be compared with other studies, multimorbidity researchers should ideally define multimorbidity as 3+ conditions and include as many chronic conditions as possible in their study. Finally the measure has practical application as the number of diagnosed chronic conditions in an individual is the most significant driver of general practice service use. The results of this research will help inform health policy makers in their response to the challenges posed by continued growth in the prevalence of multimorbidity.

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Publications related to thesis

Publications in peer reviewed journals contained in this thesis

Harrison C, Britt H, Miller G, Henderson J. *Prevalence of chronic conditions in Australia*. PLOS ONE. 2013;8(7):e67494.

Harrison C, Britt H, Miller G, Henderson J. *Examining different measures of multimorbidity, using a large prospective cross-sectional study in Australian general practice*. BMJ Open. 2014;4(7):e004694.

Harrison C, Henderson J, Miller G, Britt H. *The prevalence of complex multimorbidity in Australia*. Aust N Z J Public Health. 2016;40(3):239-44.

Harrison C, Henderson J, Miller G, Britt H. The prevalence of diagnosed chronic conditions and multimorbidity in Australia: A method for estimating population prevalence from general practice patient encounter data. PLOS ONE 2017;12(3):e0172935.

Papers currently under peer review contained in this thesis

Harrison C, Henderson J, Miller G, Britt H. *Predicting patient use of general practice services in Australia* (Currently under review at the Australian and New Zealand Journal of Public Health).

Publications in peer reviewed journals related to, but not contained in, this thesis

Stewart M, Fortin M, Britt HC, **Harrison CM**, Maddocks HL. *Comparisons of multi-morbidity in family practice—issues and biases*. Fam Prac 2013;30(4):473-80.

Wong C, **Harrison C**, Bayram C, Miller G. *Assessing patients' and GPs' ability to recognise overweight and obesity*. Aust N Z J Public Health. 2016;40(6):513-7.

Commissioned publications in peer reviewed journals related to, but not contained in, this thesis

Harrison C, Britt H, Miller G, Henderson J. *Multimorbidity*. Aust Fam Physician. 2013;42(12):845.

Oral presentations related to this thesis

(Presenter underlined)

International

Stewart M, Fortin M, <u>Britt H</u>, **Harrison C**, Maddocks H *Comparison of multimorbidity prevalence estimates in Canadian and Australian Family Practice – issues and biases*. North American Primary Care Research Group annual conference 2011 Banff, Alberta, Canada

<u>Harrison C</u>, Britt H. *Measuring family practice utilisation by patients with chronic conditions*. North American Primary Care Research Group annual conference 2012 Seattle, Washington, United States of America

<u>Harrison C</u>, Britt H, Miller G, Henderson J. *Measuring the effect of different measures of multimorbidity*. North American Primary Care Research Group annual conference 2013. Ottawa, Ontario, Canada

<u>Harrison C</u>, Henderson J, Miller G, Britt H. *Comparing the effectiveness of two measures of multimorbidity in predicting health resource use, severity of illness and complexity of care*. North American Primary Care Research Group annual conference 2015. Cancun, Mexico

In Australia

<u>Harrison C</u>, Britt H, Miller G, Henderson J. *Examining different measures of multimorbidity*. Primary Health Care Research and Information Service Conference 2013 Sydney, NSW

<u>Harrison C</u>, Britt H, Miller G, Henderson J. *Measuring the prevalence and patterns of multimorbidity in Australia*. 12th National Conference of Emerging Researchers in Ageing 2013 Sydney, NSW

<u>Harrison C</u>, Britt H, Miller G, Henderson J. *Is the concept of "complex multimorbidity" useful in health resource planning?* Primary Health Care Research and Information Service Conference 2014 Canberra, ACT

<u>Harrison C</u>, Henderson J, Miller G, Britt H. *The effectiveness of multimorbidity in predicting health resource use, severity of illness and complexity of care*. Sydney School of Public Health presentation day 2015. Sydney, NSW

Invited presentations related to this thesis

Harrison C. *The Australian BEACH study: Selected results from 17 years of continuous data collection*. 2014 Invited to talk by Professor Martin Fortin to speak at the University of Sherbrooke, Quebec, Canada

Harrison C. *Multimorbidity and Primary Care in Australia: Reflections on 10+ Years of Research and an Exploration of International Collaborative Opportunities*. 2016 Invited to speak as part of the WORC group series of presentations at the Oregon Health & Science University, Portland, Oregon, United States of America

Awards related to this thesis

Best presentation – 12th National Conference of Emerging Researchers in Ageing 2013 Sydney, NSW

Table of contents

Abbreviations

ABS – *Australian Bureau of Statistics*

ASGS – *Australian Statistical Geography Standard*

AusDiab – *Australian Diabetes, Obesity and Lifestyle Study*

BEACH – *Bettering the Evaluation and Care of Health*

BMI – *Body mass index*

CCHCC – *Commonwealth Concession Health Care Card*

CHF – Congestive heart Failure

CI – *Confidence Interval*

CIRS – *Cumulative Illness Rating Scale*

COPD – *Chronic obstructive pulmonary disease*

DVA – *Department of Veteran Affairs*

EDC – *Expanded diagnostic clusters*

EGPRN – *European General Practice Research Network*

EHR – *Electronic health record*

GORD – *Gastro-oesophageal reflux disease*

GP – *General practitioner*

ICD-10 – *International Classification of Disease (10th revision)*

ICPC-2 – *International Classification of Primary Care (Version 2)*

IHD – *Ischaemic heart disease*

IRSAD – *Index of Relative Socio-Economic Advantage and Disadvantage*

MBS – *Medicare Benefits Schedule*

MCCs – *Multiple chronic conditions*

NHS – *National Health Survey*

NICE – *National Institute of Health and Care Excellence*

OECD – *Organisation for Economic Co-operation and Development*

PACE in MM – *Patient-Centred Innovations for Persons with Multimorbidity*

PBS – *Pharmaceutical Benefits Scheme*

RCT – *Randomised control trial*

UK – *United Kingdom*

US – *United States of America*

WHO – *World Health Organisation*

Glossary

Throughout this thesis terms that are defined in the glossary are marked with the symbol 'ᵀ' where possible. Terms are only marked the first time they are used in the text.

Active patient: A patient who has seen a GP at least once in the previous 12 months.

Chronic condition: A medical condition that: has a duration that has lasted, or is expected to last, at least 6 months; has a pattern of recurrence, or deterioration; has a poor prognosis; and produces consequences, or sequelae that impact on the individual's quality of life as defined by O'Halloran et al.

CIRS domains: The main division within CIRS. There are 14 domains which represent different body systems.

Commonwealth concession health care card: Patients holding a Health care/benefit card which entitles the holder to a higher level of Government subsidy for health services (for example, reduced-cost medicines under the Pharmaceutical Benefits Scheme). Examples of patients who may be eligible include pensioners, unemployed, low-income earners.

Concessional patient: A patient who holds a Commonwealth concession health care card – see above.

Comorbidity: Any distinct additional entity that has existed or may occur during the clinical course of a patient who has the index disease under study as defined by Feinstein.

Complex multimorbidity: co-occurrence of three or more chronic conditions affecting three or more different body systems within one person without defining an index chronic condition.

Encounter: Any professional interchange between a patient and a GP.

General practitioner (GP): A medical practitioner who provides primary, comprehensive and continuing care to patients and their families within the community.

Health Care Homes: A model similar to the 'Patient Centred Medical Home'. Current Health Care Homes in Australia is a trial of voluntarily enrolment of patients with multiple diagnosed chronic conditions with a single practice which will receive capitation payments for the management of the enrolled patient's chronic conditions (but not their non-chronic issues).

ICD-10 chapters: The main divisions within ICD-10. There are 22 chapters primarily representing the body systems.

ICPC-2 chapters: The main divisions within ICPC-2. There are 17 chapters primarily representing the body systems.

Indexation: A technique to adjust payments by means of a price index, usually in attempt to maintain the payment's relative value after inflation.

Medicare: Australia's publicly funded, universal health care system, established to provide affordable medical, optometrical and hospital treatment. Contributions to the Medicare system are based on income and made through taxes.

Medicare Benefits Schedule (MBS) item: Each item number identifies a service funded through Medicare. The MBS lists all the Medicare services subsidised by the Australian Government, their claimable amount and conditions for use.

Morbidity: The distinct entities that are counted when measuring comorbidity or multimorbidity. Most commonly they are chronic conditions or groups of chronic conditions.

Multimorbidity: While there is no clear definition, in this thesis it refers to someone with multiple morbidities, without an index morbidity.

National Health Survey (NHS): A large population based study of Australia's health conducted by the Australian Bureau of Statistics every three to six years since 1977-78. The measurement of chronic condition prevalence is based on respondent self-report via personal interview.

Pharmaceutical Benefits Scheme (PBS): Australian Government program that subsidises the cost of necessary and lifesaving medicines for Australian residents.

Significant: A statistically significant result. In this thesis, statistical significance between point estimates is determined by non-overlapping 95% confidence intervals.

Structure of thesis

Chapter 1: Introduction

This chapter describes the need to measure the prevalence of chronic conditions and multimorbidity. It discusses the current challenges in measuring multimorbidity and the need for standards in definitions and methods multimorbidity research.

Chapter 2: The aims of this thesis and the candidate's contribution

This chapter outlines the six aims of the thesis and describes the candidate's contribution to its conception, design, conduct and creation.

Chapter 3: Prevalence of chronic conditions in Australia (Published in PLOS ONE 2013)

This published paper describes the first survey used in this thesis and introduces a new method to estimate population prevalence of chronic conditions from GP-patient encounter data.

Chapter 4: Examining different measures of multimorbidity, using a large prospective cross-sectional study in Australian general practice (Published in BMJ Open 2014)

This published paper uses the data and methods described in Chapter 3, to explore the independent effect of changing study parameters on multimorbidity prevalence estimates. Parameters investigated include: the number of conditions studied; the minimum number of 'morbidities' required to have multimorbidity; and counting groups of conditions versus individual conditions.

Data grouped by ICPC-2 chapters, ICD-10 chapters or CIRS domains produces similar multimorbidity prevalence estimates. Multimorbidity defined as 2+ morbidities provides similar estimates whether individual conditions or groups of conditions are counted or whether as few as 12 prevalent chronic conditions or all chronic conditions are studied, but it lacks the specificity to be useful, especially among older people. Multimorbidity, defined as 3+ morbidities, requires more measurement conformity and inclusion of all chronic conditions, but provides greater specificity than the 2+ definition. The concept of complex multimorbidity is put forward as having at least one chronic condition classified to each of 3+ body systems.

Chapter 5: The prevalence of complex multimorbidity in Australia (Published in ANZJPH 2016)

This published paper is the third and final paper using data from survey 1. It examines the patterns and prevalence of multimorbidity and complex multimorbidity (as defined in Chapter 4) among patients at GP encounters. It estimates the prevalence of multimorbidity and complex multimorbidity in the population using the methods from Chapter 3.

Chapter 6: The prevalence of diagnosed chronic conditions and multimorbidity in Australia: A method for estimating population prevalence from general practice patient encounter (Published in PLOS ONE 2017)

This published paper uses data from survey 2, which also surveyed the number of times the patient had seen a GP in the previous 12 months. This additional improves the method first described in Chapter 3, as it allows adjustments for individual patient visit rate. This adjustment method provides more reliable estimates and allows estimation of population prevalence within age-sex specific groups. This improved method is used to estimate prevalence of chronic conditions, multimorbidity and complex multimorbidity among people in the population.

Chapter 7: Predicting patient use of general practice services in Australia (Under review at ANZJPH)

This paper uses the data from survey 2 to create a predictive model explaining patient GP-visit rate. It shows that the number of diagnosed chronic conditions is the strongest single predictor of patient GP-visit rate. The final parsimonious model includes the patient's: number of diagnosed chronic conditions; age, sex; and Commonwealth concessional health care card status. This chapter also reports early results from the next study which show the strongest predictor of patient complexity of care is also the number of diagnosed chronic conditions.

Chapter 8: Discussion and conclusions

This chapter discusses the results from all five papers in relation to the six aims of the thesis and draws final conclusions.

Chapter 1: Introduction

The rise of chronic conditions

Globally in 2015, chronic conditions[Ŧ] (also known as non-communicable diseases) were the leading cause of death, with 71.3% of deaths attributed to them. Between 2005 and 2015, the total number of deaths attributed to chronic diseases rose by 14.3%, while the number of deaths from communicable, maternal, neonatal and nutritional diseases decreased by 19.7%. Cardiovascular diseases caused the highest mortality (17.9 million deaths), followed by cancers (8.8 million deaths) and chronic respiratory diseases (3.8 million deaths).[1] The proportion of mortality attributed to chronic conditions is higher in developed countries. In 2014, chronic conditions accounted for 91% of deaths in Australia, 89% in the Netherlands, in New Zealand and in the United Kingdom(UK) and 88% in the United States (US) and Canada.[2]

The prevalence of chronic conditions is increasing worldwide. From 2005 to 2015, while the world's population increased by 12.7%,[3] the total number of people with: peripheral vascular disease increased by 34.4%; osteoarthritis increased by 32.9%; diabetes increased by 30.6%; chronic kidney disease increased by 26.8%; ischaemic heart disease increased by 25.9%; major depressive disorder by 17.8%; chronic obstructive pulmonary disease by 17.0%; and anxiety disorders increased by 14.9%.[4]

In Australia, the National Health Survey[Ŧ] found that the proportion of people with at least one self-reported "long-term" condition increased from 77.9% in 2001 to 79.7% in 2014–15, the prevalence of diabetes (Type 1 or 2) rose from 3.3% to 5.1%, while prevalence of osteoporosis more than doubled from 1.6% to 3.5%.[5] In 2011, chronic conditions accounted for the majority of the total burden of disease in Australia.[6]

The increase in chronic conditions has been reflected in general practitioner[Ŧ] (GP) workload. In 2000–01, 48.2 (95% CIs: 46.6–49.8) chronic conditions were managed per 100 GP-patient encounters and they accounted for 33.2% (95% CIs: 32.4–34.1) of all problems managed.[7] By 2015–16, 53.3 (95% CIs: 51.4–55.3) chronic conditions were managed per 100 encounters and they accounted for 34.6% (33.6–35.5)[A] of all problems managed.[8] In

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[A] 95% confidence intervals were calculated separately as they were not published in the annual report referenced

the same year, 47.3% (95% CIs 46.0–48.6) of all medications prescribed in general practice were for the management of chronic conditions.[B]

The increase in the prevalence of diagnosed chronic conditions is being driven by three factors – the ageing of the population,[9] earlier detection of chronic conditions through enhanced screening[10] and the increase in prevalence of obesity.[11,12]

The ageing of the population

The world's population is ageing, with increases in both the absolute number and the proportion of people who are aged 60 years or older (60+). From 2000 to 2015, the number of people aged 60+ increased by 48% to 901 million. In 2015, people aged 60+ accounted for 12.3% of the world's population. The increase is expected to accelerate, with the projected number of people aged 60+ being 1.4 billion in 2030, a 56% increase over the number in 2015.[13]

The ageing phenomenon is currently more pronounced among the populations of developed countries. In 2015, 33% of Japan's population was aged 60+, while in Germany and Italy people aged 60+ accounted for 28% of their populations. However from 2015 to 2030, the number of people aged 60+ in developing countries is expected to increase at a faster rate than in developed countries. While the global increase in the number of people aged 60+ is expected to be 56% over this period, Latin America & the Caribbean are projected to have a 71% increase, Asia a 66% increase and Africa a 64% increase in the number of people aged 60+.[13]

While many of the reports on ageing focus on the number of people aged 60+, the number of people aged 80 years and over is increasing at a faster rate, by 77% from 2000 to 2015, and is expected to increase a further 61% by 2030.[13]

Australia is no exception to the ageing population phenomenon. From June 2000 to June 2015, the proportion of people who were aged 60+ increased from 16.6% to 20.4%, while the proportion aged 80+ increased from 2.9% to 3.9%. From 2015 to 2030, the proportion aged 60+ is projected to increase from 20.4% to 23.8%, while the proportion aged 80+ is projected to increase from 3.9% to 5.4%.[14]

The two main reasons for global population ageing are a reduction in the fertility rate, and increased life expectancy.

[B] Unpublished data from the Bettering the Evaluation and Care of Health project

Reduction in fertility rate

The global fertility rate fell from 4.96 in 1950–55 to 2.51 in 2010–15.3 Over this period the fertility rate in many developed and high income countries dropped below that required to replace the mother and her partner in the population.[3] This reduction has meant that the proportion of children in the population is decreasing, while the proportion of older people is increasing.

Australia's fertility rate has been below its replacement rate of 2.1 children per woman since the mid-1970s.[15] In 2015, the fertility rate was approximately 1.81 children per woman.[15]

Increased life expectancy

The global average life expectancy at birth in 1950–55 was 46.8 years. By 2010–15 it had increased to 70.5 years.[13] Therefore over this period, average life expectancy at birth increased by nearly 5 months for every year that passed.

The increase in life expectancy has been driven by reduced mortality in younger people in lower income countries and by improved survival of those aged 60+ in higher income countries.[13,16] A large study examining death registration data from higher income countries found that between 1980 and 2011, the risk of dying between the ages of 60 and 80 years decreased by 1.5% per year for men and 1.7% per year for women in these countries.[17] These gains were attributed to reduced tobacco use in men and improved cardiovascular disease and diabetes health outcomes for both sexes. Other research has found that about half the reduction in mortality from cardiovascular disease came from new treatments for these conditions while the remainder was the result of better management of risk factors of cardiovascular disease (e.g. hypertension, hyperlipidaemia and tobacco smoking).[18]

The ageing of the population is driving an increase in the prevalence of diagnosed chronic conditions since older people are more likely to be diagnosed with a range of chronic conditions than younger people.[19] As the proportion of older people in the population increases, the prevalence of chronic conditions common among older people will also rise. This is being compounded by the improved management of chronic conditions, such as cardiovascular disease.[18] As a result people are living longer with diagnosed chronic conditions.

Earlier diagnosis of chronic conditions

Part of the improved management of chronic conditions is the drive to diagnose chronic conditions earlier. For many chronic conditions, early diagnosis improves patient outcomes and helps prevent further deterioration of health.[20] In Australia, the drive for early detection of chronic conditions has come from both Government initiatives and community based non-profit organisations.

Government initiatives include large screening programs such as the National Bowel Cancer Screening Program[21] and the provision of funds through specific health insurance rebates for GPs to screen patients at risk of chronic conditions. These items include health assessments for patients at different stages of life, starting with the 'healthy kids checks' for children (now retracted), Type 2 diabetes risk evaluation for a patient aged 40–49 years, health checks for patients aged 45–49 years who are at risk of developing chronic conditions, annual health checks for permanent residents of a residential aged care facility, and for patients aged 75 years and over.[22] Recognising the disparity in health outcomes among Australia's Indigenous community, the Government provides funding for health assessments of Indigenous patients at all stages of their lives. The Australian Government Department of Health (DoH) states that the aim of this funding is *"to help ensure that Aboriginal and Torres Strait Islander people receive primary health care matched to their needs, by encouraging early detection, diagnosis and intervention for common and treatable conditions that cause morbidity and early mortality."*[23]

Community based non-profit organisations often seek to raise awareness of a condition and encourage people who are at risk of a condition to be checked by their GP. For example: the Cancer Council of Australia provides information on how a person can lower their risk of cancer, and about the signs and symptoms that people should have checked by a GP;[24] Beyondblue, seeks to raise awareness of mental health issues, but also tries to lower the barriers to diagnosis by attempting to destigmatise mental health conditions.[25]

Earlier diagnosis increases the length of time a patient is diagnosed with the condition over their life time, further increasing the overall prevalence of diagnosed chronic conditions in the community. The diagnosis of chronic conditions earlier in life alters the relationship between age and the prevalence of a chronic condition so that it is not constant over time. We therefore cannot use the historical age-sex prevalence of a condition to predict its future prevalence based on population projection alone.

The 'obesity epidemic'

An additional influence on the increasing prevalence of chronic conditions, independent of the ageing population, is the increasing prevalence of obesity. Defined as having a Body Mass Index (BMI) of 30 or greater, obesity has been increasing globally, from 3.4% of adult (aged 18+ years) men and 6.4% of adult women in 1975 to 10.8% for men and 14.9% for women in 2014.[26]

The prevalence of obesity in Australia is one of the highest in the world, 27.6% of adult men and 27.9% of adult women being considered obese in 2014.[26] The rise in prevalence of obesity has been reflected among patients at GP encounters[ƒ]. In 2000–01, 20.2% of adult patients sampled at GP-patient encounters were classed as obese.[7] By 2015–16, this figure had increased to 28.8%.[8]

This is a concern because obesity has been associated with higher prevalence of a wide range of chronic conditions including, but not limited to: Type 2 diabetes;[11,27] arthritis;[27] asthma;[27,28] cancer;[11,29] high blood pressure or hypertension;[11,27] high cholesterol;[27] chronic renal failure;[30] and heart disease.[11,12] A report by the Organisation for Economic Co-operation and Development (OECD) suggested that since obesity is related to preventable chronic conditions, it should be treated as a public health priority in Australia.[31]

The fact that obesity has an independent effect on the prevalence of many chronic conditions is another reason it would be inappropriate to use historical age-sex prevalence of a condition to estimate its future prevalence based on population projections alone.

Concern about rising prevalence of chronic conditions

With the ageing of the population, improvements in the management and detection of chronic conditions and the increasing prevalence of obesity, it is expected that the prevalence of chronic conditions will also continue to rise.[10] There are concerns that this will overwhelm the Australian healthcare system and make our current model unsustainable.[32]

GPs are usually the first port of call in the Australian healthcare system and they act as gatekeepers to secondary and tertiary care. Patients are free to visit any GP, in any practice at any time. The cost of visiting a GP in Australia is covered (all or at least in part) through a universal Government funded medical insurance scheme (called Medicare [ƒ])[33] and many medications are subsidised through the Government's Pharmaceutical Benefits Scheme [ƒ] (PBS).[34]

In 2015–16, 87% of Australians visited a GP at least once.[8] Currently, GPs are reimbursed for their patient consultations on a fee-for-service basis. Due to concern that healthcare costs will be unsustainable under the current funding model, since 2014 the Australian Federal Government has proposed several changes to Medicare funding of general practice.[35] These have included: a freeze on indexation of the amount paid for GP services claimed through Medicare, from July 2014 to June 2020;[36] proposed patient co-payments for general practice services[37] (currently withdrawn); proposed minimum consultation length of 10 minutes to claim 'standard' service items[37] (currently withdrawn); a proposed $5 reduction in the rebate for commonly claimed items of service[37] (currently withdrawn); and increased patient co-payments (above indexation) for medications subsidised through the PBS ($0.80 for concessional patients and $5 for non-concessional patients)[35] (awaiting ratification by Parliament). Primary Health Care reform is still underway with the most recent proposal being 'Health Care Homes' [ǂ], a trial of voluntarily enrolment of patients with multiple diagnosed chronic conditions with a single practice which will receive capitation payments for the management of the enrolled patient's chronic conditions (but not their non-chronic issues).[38,39]

Initiatives such as the trial of capitation payments for the management of chronic conditions among eligible patients require accurate prevalence estimates of chronic conditions to appropriately plan and fund them. However, due to the confluence of an ageing population, improved detection and an increasing prevalence of obesity, the prevalence of diagnosed chronic conditions needs to be measured regularly and in a timely manner.

Measuring the prevalence of chronic conditions

Large population surveys using respondent self-report

The most common way governments measure the prevalence of diagnosed chronic conditions among their citizens is to use large population health surveys that rely on respondent self-report. For example, the US has the "National Health Interview Survey", conducted by the Center for Disease Control,[40] Canada the "Canadian Community Health Survey", conducted by Statistic Canada;[41] and the UK has the "Health Survey of England", conducted by the UK National Health Service.[42]

In Australia, every three to six years since 1977-78, the Australian Bureau of Statistics has conducted the National Health Survey (NHS) (previously known as the Australian Health

Survey). The 2014–15 the NHS surveyed 19,259 people from 14,723 households. While some data elements were measured (the respondent's blood pressure, waist circumference, height and weight) respondent self-report was used for estimation of the prevalence of chronic conditions.[5]

The advantage of these large population health surveys is that they are usually quite representative of the entire population compared to smaller or localised studies. However, respondent self-report has its disadvantages, mainly the questionable validity and reliability of patient recall. A study comparing patient-reported and GP reported reasons for encounter and diagnoses found that there was disagreement in at least 30% of paired comparisons within individual encounters. They suggested *"that diagnoses recalled by patients at later household interview are at best only a rough approximation of the diagnoses recorded by the doctor"*.[43] Other studies have found similar phenomena where patients have reported having asthma or chronic obstructive pulmonary disease (COPD) when the GP has recorded another type of respiratory illness.[44] Research suggests that patient-recall is better for well-defined conditions,[45] worse for other conditions,[46-49] and worse among patients with lower levels of education.[50] Some suggest that medical record data may be needed in conjunction with patient self-report to increase accuracy,[47] while others suggest that clinical ascertainment of patient self-reported morbidity would improve accuracy.[46]

Health record review

Due to the issues surrounding the reliability and validity of patient self-report, patient health records (paper and/or electronic) to estimate the prevalence of chronic conditions have regularly been used as the 'gold standard' for comparisons with self-reported data.[48,51] However, the quality of information in health records is often compromised through inaccurate[52,53] or incomplete records.[47,49,52-55]

While large reviews of electronic health records (EHRs) can be performed in countries like the UK[56,57] and the Netherlands,[58] the same cannot be done in Australia. This is because of differences in the structure of the Australian healthcare system and our current infrastructure. In Australia, patients are not registered to a practice and are free to visit as many different GPs at as many different practices as they choose. Further there is currently no reliable linkage of data across practices and other sections of the health system (i.e. hospitals). Combined, these two issues mean that any review will not provide a full picture of the patient's medical history if they have visited more than one practice.

Finally, the biggest issue with extracting data from patient EHRs in Australia is the lack of standards across the many software providers.[59-61] As stated simply by Britt et al. *"we still have no mandated standards for EHR structure, data elements, definitions, terminologies and classification systems, and no minimum data set required about the patient, their past history, family history and their encounter."*[61]All these factors combined make it extremely difficult to extract reliable data from EHRs in Australia.

A recent Deeble Institute issues brief by Gordon et al examined the issues with Australia's current EHR system, and outlined a set of recommendations to solve them. They recommended: the implementation of an EHR data model, which would standardise the structure of GP EHRs; standardising data element labels and definitions; the use of standardised clinical terminology sets for each data element; standardised mapping of terminologies to classifications for data extraction and data analytics; GP EHR software accreditation, to ensure that software vendors adhere to the above standards; and the involvement of all relevant stakeholders (including but not limited to medical professional associations, software vendors and Australian Government Departments of Health).[62]

Administrative data review

Some researchers have used the prescribing of a certain type of medication as a proxy for the patient having a certain diagnosis, such as assuming someone who is prescribed an antidepressant also has diagnosed depression.[63] This has special appeal to researchers in Australia as all prescribed medications subsidised through the PBS are recorded and kept by the Government. However, there are several issues with using medication as a proxy for a diagnosis in Australia. Using depression as an example, it has been shown that only about 70% of antidepressants prescribed by Australian GPs were for the management of depression.[64,65] Further, not all patients with diagnosed depression have it managed with anti-depressants.[66] Further, while the PBS records all medications that it subsidises, not all antidepressants are subsidised through the PBS. Medications that fall below the rebate threshold are not counted and since patients without a health concession card have a higher cost threshold, they are less likely to have their medication covered by the PBS. Also the PBS does not record medications that are fully paid for privately. Finally, the PBS only records medications that have been dispensed. Some patients may have a script written for them by a clinician, but never fill the prescription. The PBS would have no record of those prescriptions.

Population screening studies

Studies that screen the population, such as the Australian Diabetes, Obesity and Lifestyle Study (AusDiab),[67] avoid most of the issues of patient self-report and chart review by measuring the clinical indications for conditions. They have the added advantage of being able to measure the prevalence of undiagnosed chronic conditions in the population.

However, these studies have their own disadvantages. They are usually limited to a specific disease or group of diseases and are relatively expensive—the most recent AusDiab study cost over $2.5 million.[68]

The use of clinicians as expert participants/interviewers

Another method researchers have used to avoid the problems associated with respondent self-report and with chart review is to recruit clinicians to actively collect data as a participant and/or interviewer. Clinicians are more likely than patients (through self-report) to label the chronic condition correctly. They may use the patient's health record, but unlike simple chart review by a third party, they also have their own knowledge of the patient, and if the patient is present, patient report of their own diagnosed conditions.

The largest study in Australia to employ such a method was the Bettering the Evaluation and Care of Health (BEACH) study.[8]

The BEACH study

The BEACH program was a continuous, national, cross-sectional study of general practice activity in Australia which operated from April 1998 to March 2016 inclusive. While the BEACH program began in April 1998, it was the culmination of about 20 years of research and development work.[8] The aims of BEACH were to provide a valid and reliable general practice data source that was responsive to the ever-changing needs of information users, and provide insight into the evolving nature of general practice in Australia.[8]

BEACH methods

The BEACH methods have been described in great detail elsewhere.[8] In summary, each year a new random sample of about 1,000 GPs took part in the project. The Australian Government Department of Health drew the random samples of eligible GPs from those with at least 375 Medicare items claimed for their services in the previous three months. This ensured that full-time and part-time GPs were included, but not those who were only working occasionally (e.g. academic GPs who do clinical work half a day per week and may not give a true reflection of GP clinical activity), nor those registered GPs who were

currently not practising, retired, or on leave. Twenty-five GPs were recruited for each of 50 weeks of each year, with a two week break over Christmas and New Year. Of the 25 GPs recruited each week, we expected 20 to complete the project for an average 80% completion rate, giving a total sample of about 1,000 GPs per year.

After agreeing to participate, each GP was mailed a recording pack which included:

- a set of instructions on how to complete the survey (see Appendix A)

- a patient information card, that described the survey and its purpose to the patient including the option for the patient to opt out if they wish (see Appendix B)

- a short questionnaire about the GP and their practice (see Appendix C)

- a pad of patient encounter recording forms (see Appendix D)

Each GP was asked to record all the details of 100 consecutive encounters with consenting, unidentified patients on the structured paper encounter recording forms. Patients provided the GP with oral consent to take part in the study. We intentionally collected no information that identified the patient, and therefore written patient consent was not required. The BEACH program and all sub-studies were approved by the Human Research Ethics Committee of the University of Sydney (Reference number 2012/130).

Details collected about the encounter included patient characteristics, the problems or diagnoses that were managed at the encounter and how each of these problems was managed.

With approximately 1,000 GPs each recording 100 consecutive encounters in each year, the BEACH study collected information on about 100,000 GP-patient encounters annually. The representativeness of the data was tested each year against Medicare claims data and published in the annual GP activity book.[8] Since the data were representative of patients at Medicare-claimed GP-encounters, the results could be extrapolated to the total GP-patient visits each year, which are published by the Department of Health on the web.[69]

The BEACH project was intentionally paper based, rather than electronic, for several reasons. Firstly, not all GPs have a computer at their desk, let alone use it to store the patient's health record.[70] Not all GPs have access to a reliable internet connection to allow transfer of data extracted from the patient's health record. To participate in BEACH, a GP only required a pen, a postal address and access to postal services to return the recording

form. This more inclusive approach ensured that the GPs who completed BEACH represented all active GPs, irrespective of their level of use (if any) of EHRs for clinical purposes. The BEACH encounter forms only allowed for recording of information about what happened at each encounter. For instance, if a patient had Type-2 diabetes, but did not have it managed at that encounter, it was not recorded on the encounter form. There is obvious value in collecting data about the patient that are not necessarily related to the current GP-encounter. To collect this additional information sub-studies were devised. The sub-studies were positioned along the bottom of the patient encounter form (Appendix D). Over the years of the BEACH program, in over 100 such sub-studies the topic of interest was the prevalence of a specific chronic condition or multiple chronic conditions.[71]

The BEACH sub-studies provided chronic condition prevalence data that was nationally representative of patients at GP-encounters and avoided the issues surrounding self-report and chart review. The prevalence of chronic conditions among patients at GP encounters is valuable in itself, as it reflects the prevalence of conditions across the GP workload. However, the results could not be generalised to the wider Australian population because patients at GP encounters are more likely to be older and more likely to be female than people in the population, and not all of the population visit a GP in any given year.[19]

Earlier research estimating the prevalence of chronic conditions using BEACH data

Prior to the start of this thesis, I was the analyst on a paper (Knox et al[19]) for which I developed a method to convert GP-encounter prevalence estimates to national population prevalence estimates. We ran a series of BEACH sub-studies in late 2005 where we asked the GP *"Does this patient have any of the following conditions which require ongoing management?"*. There were 23 common chronic conditions listed, each with a tick box for ease of response. The conditions covered were those in the Australian Government's National Health Priority Areas at the time, with the exception of injuries which were not included due to their largely acute nature. We also included other chronic conditions demonstrated to be frequently managed in general practice.[19]

Calculating the GP-encounter prevalence was a simple matter of measuring the unweighted proportion of patients in the sample that had the condition of interest. Calculating population prevalence estimates was more involved. The likelihood of a patient being sampled in our study was dependent on their visit frequency, with frequent attenders (who were generally older and may have more chronic conditions) being more likely to be

sampled than infrequent attenders. We therefore weighted each patient age-sex group to match the age-sex distribution of patients who attended general practice at least once from April 2005 to March 2006. In effect this meant that young adults (particularly men) were weighted up, and older patients were weighted down. We made an assumption that if a patient had not seen a GP in the previous 12 months, then that patient did not have a diagnosed chronic condition requiring ongoing management. To adjust for those who did not see a GP in that year, we weighted the outcome data by the proportion of people in the population who had made a claim for at least one a GP Medicare item of service in the previous 12 months (88% in 2005–06) to produce population prevalence estimates.[19]

This method gave us prevalence estimates that were significantly different to our GP encounter prevalence estimates and similar to the 2004–05 National Health Survey prevalence estimates. However it was a crude method, as it assumed there was no difference between each age-sex group in the proportion of people who saw a GP at least once. In reality, older people were far more likely to see a GP at least once in a year (based on Medicare claims data supplied the Australian Government Department of Health and Ageing). This meant that using this earlier method we were weighting older patient results down more than was appropriate.

The healthcare system's single disease focus and the complexity of patients with multiple chronic conditions

Health care delivery has been criticised for being single disease focussed.[72] Clinical care guidelines are usually single disease focussed[73-79] and patients are referred to medical specialists for the management of specific conditions. While this structure of healthcare may work well for patients with a single chronic condition, complexities in care arise when a patient has multiple diagnosed chronic conditions (MCCs).

Clinical trials

Ideally the management of patient health should follow clear guidelines based on sound scientific evidence, largely from clinical trials.[74] However, clinical trials of medications and other treatments usually exclude patients with MCCs as the additional chronic conditions are seen as confounding variables,[80,81] even though the majority of patients eligible for clinical trials have MCCs.[81] A recent study showed of all the registered randomised control

trials (RCTs) that assessed an intervention targeting adults with one of 10 selected common chronic diseases conducted 1st January 2014–31st January 2015, 79% excluded patients with MCCs. In an extreme example, the study found that even though 97% of patients with heart failure had other chronic conditions, 83% of trials targeting patients with heart failure excluded those with any other chronic condition.[80] Therefore the outcomes of these clinical trials cannot be generalised to patients with MCCs,[82] even though having MCCs is very common among patients with a chronic condition.[80]

Clinical guidelines

The dearth of evidence from clinical trials on how to manage patients with MCCs has led to deficiencies in current guidelines for the management of chronic conditions, because they do not account for the presence of other diagnosed chronic conditions.[73,74,83] Following all the guidelines for the management of each chronic condition in a patient with MCCs, may have unintended negative outcomes,[83] from interventions that will likely cause more harm than benefit,[75] or lead to excessive polypharmacy,[84,85] which in turn increases the risk of adverse drug events.[85-87] Simple adherence to all the recommended guidelines for the care of all the conditions in a patient with MCCs can lead to harmful combinations of medications.[88] Potentially serious drug interactions were found to be relatively common if GPs applied the UK's National Institute of Health and Care Excellence (NICE) clinical guidelines to patients with MCCs.[79,88] One US study showed that 22.6% of patients with MCCs had received at least one medication that may worsen a coexisting condition.[89]

Probably the most famous demonstration of the shortcomings of adhering to all clinical practice guidelines for a patient with MCC was provided by Boyd et al.[83] In their study, they applied all the relevant clinical practice guidelines to a hypothetical 79 year old woman with diagnosed osteoarthritis, osteoporosis, Type 2 diabetes, hypertension and chronic obstructive pulmonary disease. They found that this hypothetical patient would be prescribed 12 separate medications which required 19 doses per day between them, being taken over 5 periods during a typical day with one medication being taken weekly. There were 14 recommended nonpharmacological activities including daily monitoring of some conditions. Adherence to all the guidelines not only resulted in possible interactions between medications, but included conflicting nonpharmacological recommendations (such as whether the patient should undertake load bearing exercise). While some have argued that this example may overstate the scale of the problem,[88] it does highlight the complexity and treatment burden of managing MCCs within patients.

Prioritisation of care

An additional complexity of managing patients with MCCs is the competing demands for treatment between the multiple chronic conditions.[90] Due to the management burden and the risks posed by managing all conditions in strict adherence to guidelines, clinicians will often have to prioritise the management of some of the patient's conditions over others.[79,90] This can mean that in competing for care, some conditions can go under-treated due to the management of another condition.[91]

Another layer of complexity is that a patient's outcome priorities for their care may differ from those of their clinician.[92] Fried et al found that 76% of elderly patients ranked their independence as their most important health outcome,[93] while only 11% ranked 'staying alive' as top priority. The most common ranking of priorities (29% of patients) was independence, followed by 'pain relief', 'symptom relief' and finally 'staying alive'.[93] A mismatch between patient and clinician priorities, may lead to poor treatment compliance by the patient.[92]

Higher health utilisation

Having MCCs has been repeatedly shown to increase patient use of health services[94-99] which increases overall health spending on these patients.[95] Patients with MCCs also visit a wider variety of healthcare professionals. They have increased: visits to general practice,[94-98] medical specialists,[96] and hospital outpatients,[95] more hospital admissions,[95] and avoidable hospitalisations.[99]

Barbara Starfield had concerns about over-reliance on medical specialists in the care of patients with MCCs, especially in the US. [100] She found that the number of different specialists a patient saw was positively related to the number of diagnosed chronic conditions in the patient.[101] This was of concern as she had shown that the high use of specialists is very costly, potentially dangerous and ultimately unnecessary.[102] Even after adjusting for other confounders (including the number of chronic conditions) patients who had seen a higher number of different specialists had higher costs, more procedures and medications prescribed.[103]

People with MCCs see a variety of healthcare professionals for the care of their various conditions and this can lead to fragmentation of their care. There is evidence that patients with multiple chronic conditions are less likely to receive continuity of care, even though

they would probably benefit from it most.[94] Other research suggests that continuity of care in primary care lowers the number of specialists seen by patients with MCCs.[103]

Patient treatment burden

As shown by the examples given by Boyd et al.[83] and again by Hughes et al.[79], the adherence to each clinical guideline for the management of each chronic condition in patients with MCCs can create a complex and heavy treatment burden for the patient. Islam et al found that the time patients spent on health care increased with the number of diagnosed chronic condtions.[104] Due to this increased burden, patients with MCCs have more trouble with self-care than those with only a single chronic condition,[105] including managing their medication,[105] and self-management of risk factors.[105] Further, the presence of multiple conditions can mask the early warning signs of exacerbation.[105] Fortunately, patients with multiple chronic conditions seem to be more willing to learn self-management skills than patients with a single condition.[106]

Overall, patients with MCCs also have a decreased quality of life[107] and health-related quality of life,[108] are at increased risk of avoidable complications when in hospital,[99] and have increased risk of mortality.[109,110]

How can the healthcare system adapt?

Most researchers agree that the single disease focus of modern medicine is lacking when it comes to the care of patients with MMCs.[72,79,85,101,105,111-113] Some believe that improving our clinical guidelines to account for patients with MCCs would improve their care.[73-79]

It has been argued that there needs to be a shift from disease-specific care to patient-centred care[72,74,111] and that this should be complimented by strengthening and supporting primary care.[72,99,101] Primary care physicians by their very definition are patient (not single disease) oriented[85,114] and research has shown that patients with MCCs have better outcomes in countries with strong primary care systems.[115,116] Patients with MCCs are more willing to accept team-based primary care than patients without MCCs.[106] Improved coordination of care between the different arms of the healthcare system is another popular suggestion. [72,99,101] The OECD health policy overview of Australia suggested that to meet the challenge of rising chronic disease, our healthcare system needs to move from its current fragmented state to better co-ordination of patient care.[31]

As Barbara Starfield stated *"Those who make their living by focusing on disease resist understanding that health is a pattern. Without grasping the pattern, management is at best an approximation of adequate care."*[85]

Issues with research on patients with multiple chronic conditions

There is clearly a growing body of evidence that patients with MCCs have a range of negative outcomes and that there are deficiencies in how the healthcare system manages their care. However, there has also been concern with the different ways that patients with MCCs have been defined and measured in these studies.[117-119] If there is too much variation in the way patients with MCCs are studied, the generalisability and comparability of the findings is limited. For instance, prevalence estimates of patients with MCCs among studies has ranged from 3.5%[82] to 98.5%.[120] It is clear that different types of patients in these studies are being identified as having MCCs. For results of studies measuring MCCs to be truly comparable and generalisable, they require standards. The first is a standard definition for the terms used to describe these patients.

Comorbidity

In studies of patients with MCCs, the first term used to describe the phenomenon was "comorbidity"[‡]. In 1970, Feinstein first coined the term "comorbidity" to describe *"Any distinct additional entity that has existed or may occur during the clinical course of a patient who has the index disease under study"*. He believed this term would highlight the issue that patients with additional disease entities (beyond the index disease being treated), had worse outcomes than patients who had only the index disease being managed.[121]

As the study of patients with multiple conditions progressed, the term 'comorbidity' was applied in various ways that did not align with Feinstein's definition. One of the most famous examples is the Charlson comorbidity index. Charlson et al. developed a method to predict the likelihood of one year mortality of a patient, based on the presence/absence of each of 22 diagnosed chronic conditions. Each condition is assigned a value based on the risk of the patient dying from the condition. The total value of these scores is used to predict the patient's likelihood of mortality over the next 12 months.[109] While it is called a 'comorbidity index', there is no index disease in the Charlson tool, making its use of the term fundamentally different to that of defined by Feinstein. A recent bibliometric analysis

by Amirall & Fortin found that 17% of papers that used the term 'comorbidity', did not have an index disease or medical condition under study.[119]

Multimorbidity

From 1976,[122,123] the term multimorbidity[Ŧ] was increasingly used by health researchers to describe patients with multiple chronic conditions, particularly in Germany. However, the term was used in different ways, to refer to: patients with an index disease under study who had other chronic conditions;[124,125] patients with multiple chronic conditions without defining an index disease;[126-129] and to describe both.[130]

Due to the growing ambiguity around the use of the terms comorbidity and multimorbidity, in 1996 Van Den Akker et al suggested clear definitions for both terms.[131] They suggested that comorbidity be defined according to Feinstein - *"Any distinct additional entity that has existed or may occur during the clinical course of a patient who has the index disease under study"* and that multimorbidity be defined as *"the co-occurrence of multiple chronic or acute diseases and medical conditions within one person"*.[131]

In 2010 Boyd & Fortin provided a simpler definition of multimorbidity: *"the co-existence of two or more chronic conditions, where one is not necessarily more central than the others"*.[111]

The distinction of whether a patient with multiple conditions has an index disease under study may seem trivial. However, it is important because it reflects the way different arms of the healthcare system view patients with multiple chronic conditions. The concept of comorbidity is more useful in secondary and tertiary care settings while the concept of multimorbidity is more useful in a primary care setting. For example, a patient with diagnosed chronic kidney disease, Type 2 Diabetes and hypertension, when seeing their nephrologist is considered by the specialist to have chronic kidney disease with comorbidities of Type 2 Diabetes and hypertension. When seeing their endocrinologist they are considered to have Type 2 diabetes with chronic kidney disease and hypertension being comorbid conditions. However, at visits to the GP, the patient has multimorbidity, as a GP's focus is not one particular condition, but on the holistic care of the patient.

While the concept of comorbidity may be useful to specialists, its disease-centric focus helps cement the health care system's single disease structure. Multimorbidity is a more helpful way to view patients with MCCS because its focus is on the patient as a whole, aligning with the concept of patient-centred care.[132] The exception to this may be patients

who have a condition that dominates their care and wellbeing, for whom the concept of comorbidity may be more appropriate.[83,112,133]

Research on multimorbidity

Since the turn of the century, the use of the term multimorbidity in research has dramatically increased. A simple search in Google scholar for the term 'multimorbidity' returns 86 related articles published in the year 2000. In the year 2011, when I was preparing to start this thesis, 1,050 articles relating to multimorbidity were published. Just five years later, the number had increased almost five-fold to 5,050 articles published in the year 2016.

This rapid increase in research on multimorbidity has come with a similar increase in the number of ways that it has been defined and measured. Concerningly, an analysis in 2013 found that only 49% of published papers that used the term multimorbidity described how they defined it.[119] In the same year a systematic review by Le Reste et al found 132 definitions of multimorbidity involving 1,631 different criteria.[134] This number has no doubt grown since then, due to the exponential increase in research and publications on this topic. Multimorbidity is most often measured through a simple count of chronic conditions,[135] however it is frequently also measured using indices such as the Charlson comorbidity index[109] or the Cumulative Illness Rating Scale (CIRS).[136] The lack of standards has led to multimorbidity prevalence estimates that range from 3.5%[82] to 98.5%.[120]

Over the years there have been many calls for guidelines and standards for multimorbidity research.[112,117,118,131] When Van Den Akker et al put forward their definition of multimorbidity in 1996, they already had concerns about the variety of ways multimorbidity had been studied. They argued that *"attention should be paid to the choices made in multimorbidity research regarding the inclusion of patients, the type of conditions studied and the measurement used. Choices made have consequences with respect to comparability to other studies and generalisability."[131]*

What conditions should be included in the study?

While most studies on multimorbidity only consider chronic conditions,[119] some also include acute conditions.[137,138] Indeed, Van Den Akker et al's definition of multimorbidity *"the co-occurrence of multiple chronic or acute diseases and medical conditions within one person"[131]* explicitly includes acute diseases and medical conditions. The European General Practice Research Network not only includes acute conditions in their definition, but

biopsychosocial and somatic risk factors, defining multimorbidity as *"any combination of chronic disease with at least one other disease (acute or chronic) or biopsychosocial factor (associated or not) or somatic risk factor."[134]* Some have made the distinction by using only chronic conditions in 'multimorbidity' and referring to patients as having 'acute multimorbidity' when they have an acute condition along with chronic conditions.[137]

The addition of an acute condition to a patient with chronic conditions may indeed make the management of the patient more complex in a way similar to an additional chronic condition.[137] This would mean that counting acute conditions may well be important in situations involving acute care. However, due to the temporary nature of acute conditions, if acute conditions were included in all measures of multimorbidity, the patients who were identified with multimorbidity would change over time. Because this measure would not identify the same group of patients over time, it would limit the application of using multimorbidity to predict outcomes such as patient health care use and need over time. This thesis will not focus on the issues of acute care, but the broader applications of a measure of multimorbidity. For this broader application, multimorbidity should be based on the number of chronic conditions within patients.

That leads to the question of what is a chronic condition? There is no clear agreement in the literature on the definition of a chronic condition.[139] The long-term duration of chronic conditions has been one of the most common traits used to define them, however, there is no agreement on the definition of 'long term'. Some suggest a minimum of 3 months is optimal with a minimum of 12 months being too long.[140] Others suggest 12 months should be the minimum with 3 months being too short a period as it may capture acute conditions with long recovery periods.[141] Some have also wondered whether risk factors, such as hyperlipidaemia, should be considered chronic conditions when measuring multimorbidity.[142]

The clearest definition of a chronic condition was developed by O'Halloran et al[139] after a thorough review of the literature. They defined chronic conditions as having four major characteristics:

- "have a duration that has lasted, or is expected to last, at least 6 months

- have a pattern of recurrence, or deterioration

- have a poor prognosis

- produce consequences, or sequelae that impact on the individual's quality of life."[135]

O'Halloran et al. [139] applied these criteria to all the International Classification of Primary Care (version 2) (ICPC-2) rubrics and ICPC-2 PLUS terms. The list of terms and rubrics were published alongside their paper. They considered long-term risk factors such as hypertension, hyperlipidaemia and obesity to be chronic conditions. In 2016, O'Halloran reviewed the current inclusions and found that they did not need to be updated (personal communication).

How many disease entities should be studied?

The number of conditions considered in multimorbidity studies varies widely and this is suspected of causing the biggest difference between prevalence estimates.[117,118] Diederichs et al[118] and Fortin et al[117] both suggested that studies considering only a few conditions produced lower prevalence estimates than those examining many conditions. In their respective systematic reviews Fortin et al[117] found that the number of conditions included in different studies of multimorbidity ranged from five conditions to all conditions, while Diederichs et al[118] reported a range of 4–102 conditions (mean 18.5 and median 14). The latter hypothesised that conditions included in each study may often have been chosen for pragmatic reasons (i.e. data availability), as most authors did not give reasons for their selection of included conditions. When authors did provide reasons for selecting conditions, a high prevalence or high impact on patients were the most common reasons given.[118]

Both Fortin and Diederichs suggested that multimorbidity researchers should include a specified minimum number of chronic conditions in order to reduce the variance in prevalence estimates. Fortin et al[117] suggested that any 12 prevalent conditions should suffice to measure multimorbidity accurately. Diederichs et al[118] suggested a minimum of 11 specified chronic conditions that are prevalent in elderly people (cancer, diabetes mellitus, depression, hypertension, myocardial infarction, chronic ischaemic heart disease, heart arrhythmias, heart insufficiency, stroke, chronic obstructive pulmonary disease and arthritis).

What is the 'morbidity' that is to be counted?

Ideally, morbidities[‡] being counted should be distinct. However, in practice this distinction is not always clear. Most multimorbidity studies count the number of individual diagnosed chronic conditions in a patient. Issues can arise with measuring the number of individual

conditions when a condition such as hypertension, that over time develops into complicated hypertension, might then receive a slightly different label or code in the medical record. Even though it is a continuum of the same condition it may be counted twice due to the different labels recorded. Another issue would be two inter-related conditions (e.g. transient ischaemic attacks and stroke) that may be considered as two separate conditions by one clinician while another may record them as a single condition in their notes. As Salisbury et al. summarised *"One problem with operationalising multimorbidity based on a count of chronic diseases entered in routine medical records is that the same disease may be coded in different ways and therefore counted twice in the same individual."[94]*

Researchers have tried to overcome this problem in some multimorbidity studies, by only counting groups of related chronic conditions once, even if the patient has multiple similar conditions, to ensure that the count was of distinct morbidities. Examples of this are studies that use the Cumulative Illness Rating Scale's (CIRS) 14 domains to group chronic conditions by body system.[143,144] Fortin et al[117] suggested that this approach may simplify coding and data collection. A similar example is counting the number of disease groups/body systems of the International Classification of Disease (10th revision; ICD-10)[145] in which at least one condition had been classified.[138] Salisbury et al.[94] used the "expanded diagnostic clusters" (EDCs) of the Johns Hopkins University Adjusted Clinical Groups Case-mix system.[146]

How are the data collected?

Since studies of multimorbidity first need to identify the diagnosed chronic conditions within study subjects, these studies face the same issues around data collection methods as studies of prevalence of a single chronic condition. The issues of participant self-report data, chart review and clinical screening studies have been discussed.

What minimum number of disease entities is required?

Multimorbidity is most commonly defined as two or more (2+) diagnosed disease entities present in the patient, but recently there has been debate about whether three or more (3+) may be a better measure. Fortin et al[117] argue that using 2+ disease entities identifies such a high proportion of patients as having multimorbidity that the measure lacks specificity, especially among older patients. When multimorbidity was defined as 2+ disease entities, the age-specific prevalence of multimorbidity was an 'S' shaped curve with a flat plateau for older ages. When multimorbidity was defined as 3+ disease entities, there was a more linear increase in prevalence by age, providing greater differentiation among older

patients. The authors further argued that using 3+ disease entities is likely to identify patients with greater health needs and is therefore more useful to clinicians.[117]

Severity

While most studies of multimorbidity simply count the number of chronic conditions, there are some that also measure the severity of each of the conditions being counted[120,144,147]. In one of his earliest papers on the topic, Fortin et al argued that *"Although a conceptual framework for measuring multimorbidity has yet to be proposed, it seems obvious that such a measure should include a means of evaluating the severity of the medical conditions."*[120] In this study, Fortin et al used CIRS scores to judge whether a patient had multimorbidity (5+ and 10+).

What population is being studied?

The validity and generalisability of multimorbidity studies can also be affected by the population under study. Often multimorbidity studies will only include older patients,[46,95,148-155] and the results from these studies may not be applicable to younger people with multimorbidity. Certainly, older people are more likely to have a higher number of chronic conditions and multimorbidity.[143]

The setting in which the data are collected can also effect the generalisability. People who are sitting in a GP waiting room are not representative of people in the wider population/community.[156] They are more likely to be female, older and have a higher prevalence of multimorbidity.[19,143] The same applies to patients admitted to hospital.[157,158]

First national study of multimorbidity in Australia

I was fortunate to be the analyst and a co-author on the first national study of multimorbidity in Australia. Britt et al[143] used the same data as the Knox et al[19] study of prevalence of individual conditions, described earlier in this chapter. In the study of multimorbidity we collapsed the 23 individual chronic conditions studied into the domains of the CIRS. The list of chronic conditions was limited, only representing 8 of the 14 CIRS domains[‡]. The surveyed chronic condition 'malignant neoplasm' was too broad to be allocated to a single domain, so a separate domain was created for it, giving us nine morbidity domains in total.[143]

Multimorbidity was defined as 2+ domains, though the prevalence of 3+ and 4+ domains was also reported. The patterns of the domains in patients with multimorbidity were examined. Prevalence was reported at both the GP-encounter level and for the Australian

population. The Australian population prevalence estimates were based on the same crude method I used in Knox et al.[19]

The Britt et al study[143] had the advantages of: being a large national study; using the GP as an expert interviewer/participant; and using the validated grouping structure of the CIRS. However, this study had two major limitations. Firstly, we did not collect all diagnosed chronic conditions. It has been suggested using a limited number of chronic conditions in a study leads to lower prevalence estimates. Secondly (as mentioned above), the weighting of the data to estimate the Australian population prevalence was the same crude method used in Knox et al.[19]

The opportunity provided by the BEACH study

The BEACH program provided an ideal opportunity to further investigate the issues raised above around the study and measurement of multimorbidity. BEACH provided access to a large, nationally representative, ever changing sample of GP participants and the patients they managed at encounters. The sub-studies of BEACH could be adapted quickly to meet the changing needs for different types of information about the patients.

By undertaking a large, national prospective study of multimorbidity using the BEACH project, I could improve on the earlier methods of Britt et al.[143] and Knox et al.,[19] and also investigate the effect on prevalence estimates of using different measures of multimorbidity, which is not possible by systematic review alone. The results from such a study would provide valuable information for Australia's health policy planners, and for multimorbidity researchers globally.

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Chapter 2: The aims of this thesis and the candidate's contribution

Aims

1) To improve on earlier methods of measuring the population prevalence of chronic conditions in using general practice data.

2) To measure the prevalence of chronic conditions among patients at GP encounters and in the Australian population, applying these methods.

3) To investigate the effect of different methods of measuring multimorbidity on who is identified as having multimorbidity.

4) To develop a method to measure multimorbidity in Australia that is valid, reliable, generalizable, and useful.

5) To investigate the relationship between multimorbidity and utilisation of general practice services.

6) To measure the patterns and prevalence of multimorbidity among patients at GP encounters, and the wider Australian population.

The candidate's contribution

The research in this thesis was performed using the data and resources of the BEACH program at the Family Medicine Research Centre (FMRC), University of Sydney. The candidate began working with FMRC in January 2002 as a research assistant on the BEACH team. In the first few years, he was tasked with cleaning and maintaining the BEACH data as a junior analyst. During this time, he developed and produced individual GP reports for each GP who took part in BEACH. He was also involved in the analysis of results for the BEACH annual reports. In 2006, he was promoted to the position of Senior Research Analyst to reflect the more advanced data analyses he was performing. He became deeply involved with promoting and disseminating the BEACH data to not only the wider research community, but to Government and Industry groups to help maintain funding. He was employed with the FMRC up until its closure in August 2016 due to withdrawal of funding (due to no fault of the candidate). He was given the honour of becoming the data custodian

of the BEACH data when it was moved to the Menzies Centre for Health Policy at the University of Sydney, where he is currently still employed.

The candidate has been involved in the publication of numerous peer reviewed publication and books that were based on BEACH data. Over the decade between 2007 and 2016, he amassed a *h*-index of 16 according to Scopus. He especially proud to have led numerous studies, including examining: gaps in the predicted Australian GP workforce;[1] differences between male and female GPs in their management style;[2] and the effect of the roll-out of the HPV vaccination in Australia.[3] The common theme of these papers was their focus on relevance to policy at a National level.

In 2007, the candidate became interested in the effect would be in the future, of the ageing of the Australian population on the healthcare system. Around this time he was asked to be the analyst on a study examining the prevalence of chronic conditions and multimorbidity among patients at GP encounters. His collaborators on these projects were the Director of the FMRC, Professor Helena Britt, the centre's principal analyst Ms Stephanie Knox, the Deputy Director, Dr Joan Henderson and the Medical Director, Associate Professor Graeme Miller. The candidate helped write both these papers associated with this study. While undertaking the literature review for multimorbidity paper, the candidate came to learn of the importance of multimorbidity and the challenges it was creating for the healthcare system. Seeing the value in population prevalence estimates, it was the candidate's idea to attempt to convert the GP encounter level results to estimates the prevalence among people in the Australian population.

After the papers were published, the candidate could already see ways in which his adjustment method could be improved. He also believed that the concept of multimorbidity would be incredibly important for primary healthcare research in the coming decades. Following discussions with, and encouragement from, the Director of the BEACH program (Professor Health Britt), the candidate decided to further investigate better ways to measures multimorbidity in Australia. This investigation forms the basis of the following thesis.

The candidate was fully involved in all aspects of this thesis. This included conceptualising the topic and developing the aims. He planned, designed and conducted the research and performed all the analyses.

This thesis was based on a series of BEACH sub-studies which the candidate designed with advice from several senior members of the BEACH research tem (Dr Joan Henderson, Deputy Director and Dr Clare Bayram BEACH program Manager).The candidate oversaw the design of the databases for data entry which was created by the centre's IT manager, Mr Tim Chambers. The candidate assisted Dr Clare Bayram in her normal role of supervising data entry, with the candidate resolving all data entry issues on the sub-studies. The candidate performed all the data cleaning for these sub-studies, with Associate Professor Graeme Miller advising on questions of a clinical nature that arose.

The candidate planned and performed all the analysis of data for the studies reported in the thesis. The candidate occasionally sought statistical advice from a fellow BEACH analyst (Dr Allan Pollack) and sought specific statistical advice for Chapter 7 from Dr Kevin McGeechan (Senior Lecturer, specialising in biostatistics, Sydney School of Public Health).

The preparation of this manuscript was entirely the work of the candidate. This includes the introduction, the literature review, the presentation and interpretation of results, and the conclusions drawn from the results. This thesis contains five papers that the candidate led with the help of his three supervisors (Professor Helena Britt, Associate Professor Graeme Miller and Dr Joan Henderson) who are co-authors on all five papers. Author contribution statements and permission from co-authors to reprint them in this thesis have been signed by all authors for each paper. (See Appendix F)

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Chapter 3: Prevalence of chronic conditions in Australia

Prevalence of Chronic Conditions in Australia

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Abstract

Objectives: To estimate prevalence of chronic conditions among patients seeing a general practitioner (GP), patients attending general practice at least once in a year, and the Australian population.

Design, setting and participants: A sub-study of the BEACH (Bettering the Evaluation and Care of Health) program, a continuous national study of general practice activity conducted between July 2008 and May 2009. Each of 290 GPs provided data for about 30 consecutive patients (total 8,707) indicating diagnosed chronic conditions, using their knowledge of the patient, patient self-report, and patient's health record.

Main outcome measures: Estimates of prevalence of chronic conditions among patients surveyed, adjusted prevalence in patients who attended general practice at least once that year, and national population prevalence.

Results: Two-thirds (66.3%) of patients surveyed had at least one chronic condition: most prevalent being hypertension (26.6%), hyperlipidaemia (18.5%), osteoarthritis (17.8%), depression (13.7%), gastro-oesophageal reflux disease (11.6%), asthma (9.5%) and Type 2 diabetes (8.3%). For patients who attended general practice at least once, we estimated 58.8% had at least one chronic condition. After further adjustment we estimated 50.8% of the Australian population had at least one chronic condition: hypertension (17.4%), hyperlipidaemia (12.7%), osteoarthritis (11.1%), depression (10.5%) and asthma (8.0%) being most prevalent.

Conclusions: This study used GPs to gather information from their knowledge, the patient, and health records, to provide prevalence estimates that overcome weaknesses of studies using patient self-report or health record audit alone. Our results facilitate examination of primary care resource use in management of chronic conditions and measurement of prevalence of multimorbidity in Australia.

Introduction

The ageing of the population [1] is expected to lead to increases in prevalence of chronic conditions, multimorbidity [2], and the demand on primary care [3]. To enable the health systems to respond to these increases, the prevalence of chronic conditions needs to be measured in an accurate and timely manner. There are three major methods by which prevalence is usually measured: respondent self-report; health record audit; and screening.

Many governments use large population health surveys that rely on respondent self-report to measure the prevalence of chronic conditions [4–6]. One such study is the National Health Survey [7] (NHS), one of Australia's largest studies of chronic conditions, which relies primarily on respondent self-report despite well documented concerns about the validity and reliability of self-reported health information [8–12].

Using health records (paper and/or electronic) to estimate prevalence is often seen as superior to patient self-report [13–15]. However, the quality of information in health records can be compromised through inaccurate [16–18] or incomplete records [9,15], and there are often issues in obtaining patient consent. Studies that screen the population, such as the Australian Diabetes, Obesity and Lifestyle Study (AusDiab) [19], avoid these issues, but are usually limited to a specific disease or groups of diseases and are relatively expensive - the most recent AusDiab study costing over $2.5 million [20].

Australia has a universal medical insurance scheme called Medicare which (fully or partially) covers the individuals cost of visits to general practitioners (GPs). GPs provide the bulk of primary care and act as gate keepers to government-subsidised health care from other medical specialists. The BEACH (Bettering the Evaluation And Care of Health) program is a study of general

practice activity in Australia. Sub-studies of the BEACH program can provide national prevalence estimates for chronic conditions, free of the limitations of health record audits and patient self-report. Our earlier research [21] showed that by embedding sub-studies within the national BEACH program [22], we could gain timely, accurate prevalence estimates of common chronic conditions. Accuracy was achieved by using the GP as an expert interviewer and informant, drawing on their knowledge of the patient, the patient's knowledge and the patient's health record.

This paper builds on our earlier methods by expanding the study's scope to include all chronic conditions (rather than a selection of common chronic conditions) and by improving the method of dealing with non-attenders when estimating population prevalence. This paper will show that by utilising the GP as an expert interviewer within the existing BEACH infrastructure, we can overcome the limitations of patient self-report, or patient health record review alone, to estimate prevalence of chronic conditions in Australia, at a marginal cost to the overall BEACH program.

Methods

In this study, patients attending a subsample of GPs participating in the BEACH program were surveyed. BEACH is a continuous, national cross-sectional study of general practice activity in Australia. Its methods are described in detail elsewhere [22]. In summary, an ever-changing, random sample of about 1,000 GPs per year each records information about encounters with 100 consecutive consenting patients, on structured paper forms [22].

In sub-studies of BEACH, the GP records information additional to the encounter data, in discussion with the patient. The full methods for sub-studies are reported elsewhere [22]. In this sub-study, 375 participating GPs were each asked to record diagnosed chronic conditions for each of 30 consecutive patients within their 100 BEACH records over three five week recording periods between 15th July 2008 and 4th May 2009.

Questions were brief, reducing the response burden on GPs and patients. GPs were asked, "Does the patient have any of the following chronic diseases/problems?" Common chronic conditions were listed (tick boxes) with additional blank spaces allowing free text descriptions of other unlisted chronic conditions (Figure 1). A "no chronic conditions" option was also provided. GPs were instructed to "Use your own knowledge, patient knowledge and health records as you see fit, in order to answer these questions". Chronic conditions listed were primarily those most frequently managed among Australian general practice [22]. Other less frequently managed conditions (such as chronic kidney disease and obesity) were included where previous research had indicated they were prevalent in general practice patients [22]. All current National Health Priority area conditions were included [23]. Free text conditions were classified according to the International Classification of Primary Care (Version 2) (ICPC-2) [24].

Data analysis

To ensure as many patients as possible were kept in the denominator, we examined GPs' response patterns for missing data. Where GPs ticked one or more conditions for some patients and did not tick any option (including "No chronic problems") for other patients, the patients with no responses were compared with the total sample and the "No chronic problems" group. If patients with missing data resembled patients in the "No chronic problems in this patient" group in terms of age, sex and problems managed at encounter, we assumed the patients with no options ticked had none of the listed conditions, and they were counted as such. Patients with no options ticked but with any chronic condition (as defined by O'Halloran et al [25]) managed at encounter were also included in the sample, with the recorded chronic condition(s) counted in the sub-study.

BEACH sub-studies have a single-stage cluster design, with each GP having 30 patients clustered around them. The cluster effect was accounted for using SAS 9.2.

Sample prevalence estimates were the proportion of patients with the morbidity in the total sample and can be interpreted as prevalence among patients found in GP waiting rooms.

As patients were sampled at GP consultations, the likelihood of being sampled is dependent on visit frequency. Therefore frequent attenders (such as older patients who may have more health problems) were more likely to be sampled than infrequent attenders. Sample prevalence estimates were adjusted for this likelihood by weighting the sub-study sample against the age–sex distribution of the people who visited a GP at least once in 2008–09 (supplied by the Australian Government Department of Health and Ageing from Medicare claims data). We used 10 year age groups through to 90 years and over. Worked examples of all our weightings are in table 1. Applying these weights resulted in prevalence estimates for the general practice patient population (ie. those who saw a GP at least once that year).

To estimate national prevalence, we first weighted the sub-study sample against the age–sex distribution of the Australian population in June 2008–09 [26]. We assumed that people who did not attend a GP that year had no diagnosed chronic conditions. After the above weighting we multiplied the outcome (condition count) for each patient, by the proportion of their age-sex group who saw a GP at least once that year. This accounted for those who did not see a GP. This approach differs from our previous method where the general practice patient population prevalence was multiplied by the proportion of the whole population that attended at least once [18]. This new method will be more accurate if a higher proportion of older patients (than younger) attend at least once and if older patients are more likely to have a chronic condition.

We compared our national population prevalence with estimates from our previous paper [21] and from the NHS [7]. Significant differences with our earlier paper were determined by non-overlapping 95% confidence intervals (CIs). As CIs for the NHS [7] were not publicly available, we assumed that NHS

Figure 1. BEACH sub-study questionnaire on prevalence of chronic conditions.
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Table 1. Worked examples of weighting method.

Formulas	Worked example: 80–89 year old female patient with condition X	Worked example: 10–19 year old male patient with condition X
A = Proportion of population that saw a GP at least once that year that was selected age–sex group	2.03%	5.83%
B = Proportion of the sample that was in the selected age–sex group	4.83%	3.03%
C = A/B (GP attenders weight)	0.42	1.92
D = Proportion of the total Australian population	1.87%	6.52%
E = D/B (National weight)	0.38	2.15
F = Number that saw a GP at least once that year (MBS GP item claims*)	362,815	1,040,270
G = Number in population (Australia Bureau of Statistics)	401,097	1,476,395
H = F/G (Proportion of age–sex group that saw a GP at least once that year)	90.46%	70.46%
Adjustment of outcome (or numerator) to estimate national prevalence = E*H	Condition X count = 0.34	Condition X count = 1.51
Denominator for national estimate (for both patients with and without condition) = E	0.38	2.15

*data supplied by the Australian Government Department of Health and Ageing.
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estimates not within the 95% CIs of our population estimate were significantly different.

Ethics statement

During the data collection period for this study the BEACH program was approved by the Human Research Ethics Committee of the University of Sydney and the Ethics Committee of the Australian Institute of Health and Welfare. Our method involves the collection of data from unidentifiable, consenting patients. A patient information card is supplied in the research kit, which GPs are instructed to show to patients in order to obtain informed consent (an example shown in Britt et al [22]). If the patient chooses not to participate their encounter details are not recorded. GPs are instructed to note the patient's consent in the patient's record, but are asked not to provide written consent to the research body, as this prevents patients remaining anonymous. These methods comply with the Ethics requirements for the BEACH program.

Results

Completed research packs were returned by 290 GPs (77.3%) who responded for 8,333 (95.7%) patients out of a total 8,707. "No chronic problems in this patient" was ticked for 2,620 (31.4%) patients and 5,713 (68.6%) had at least one chronic condition recorded. Only 374 patients (4.3% of 8,707 patients sampled) had no response recorded. These were similar to patients with "No chronic problems"–with both groups being younger on average than the total sample and the majority of problems managed at their encounters were acute, whereas in the total sample these were mainly chronic problems. Sixty-four 'no response' patients had one or more chronic conditions managed at the encounter and were included as having these conditions while the remaining 310 'no response' patients were added to the "No chronic problems" group. In total there were 8,707 patients in our sample with 5,777 (66.3%) having at least one chronic condition indicated and 2,930 (33.7%) with none.

The age-sex distribution of the final patient sample did not significantly differ from that of patients at all GP encounters claimed (as items of service) through Medicare in 2008–09 and was older than the population that attended a GP at least once that year (Table 2). The likelihood of at least one chronic condition

increased significantly with patient age but did not differ among males and females.

Sample prevalence

Cardiovascular problems were the most common, 31.3% having at least one, most prevalent being hypertension (26.6%) and ischaemic heart disease (8.7%) (Table 3). One or more endocrine/nutritional/metabolic diseases were present in 30.8% of patients, most commonly hyperlipidaemia (18.5%) and Type 2 diabetes (8.3%). Musculoskeletal conditions were present in 26.4% of patients, 19.7% having at least one type of arthritis (largely osteoarthritis 17.8%). One or more psychological problems were present in 22.1% of patients (13.7% depression and 8.3% anxiety). Asthma was indicated for 9.5% of patients and chronic obstructive airways/pulmonary disease (COAD/COPD) in 4.1%.

General practice patient population

After adjustment, estimates for the general practice patient population were generally lower than sample estimates (Table 3) with 58.8% having at least one chronic condition. In particular, cardiovascular disease, arthritis and diabetes, (conditions common in older age), were significantly less prevalent after adjustment. Estimated prevalence of asthma and of psychological problems were largely unaffected by adjustment suggesting more similar prevalence of each across attending population age groups.

Population prevalence

In 2008–09, 83% of the Australian population visited a GP at least once. After adjusting for non-attenders in each age-sex group, we estimated that 49.6% of the Australian population had at least one chronic condition, most commonly: endocrine problems (21.3%); cardiovascular problems (19.6%) and musculoskeletal problems (16.7%). Arthritis (any type) was present in 11.9%, asthma in 7.8% and gastro-oesophageal reflux disease (GORD) in 7.5% of the population. No estimate was made for obesity since it did not meet the assumption that it would not be present in non-attenders.

This study's estimate of the proportion of the population with at least one chronic condition was not significantly different to the 2005 study's estimate. For individual chronic problems there were

Table 2. Age/sex distribution of sampled patients compared with all patients at GP service items claimed through Medicare and with the Australian general practice attending population.

Patient Age/Sex	Number in sample	Percent of sample (95% CIs)	Percent of Australian general practice service claims*	Percent of Australian general practice population†	Proportion of the sample with at least one chronic condition (95% CIs)
Male					
<15 years	595	6.9% (6.2–7.6)	7.3%	9.6%	19.8% (16.4–23.3)
15–24 years	272	3.2% (2.8–3.6)	3.3%	5.8%	32.7% (27.4–38.1)
25–44 years	735	8.5% (7.7–9.4)	8.6%	12.2%	56.3% (51.9–60.7)
45–64 years	1,020	11.8% (10.9–12.8)	11.8%	12.5%	82.1% (79.2–85.1)
65–74 years	487	5.7% (5.0–6.3)	5.8%	3.9%	96.1% (94.4–97.8)
75+ years	486	5.6% (5.0–6.3)	5.5%	2.8%	97.9% (96.7–99.2)
Female					
<15 years	565	6.6% (5.9–7.2)	6.5%	9.1%	16.8% (13.6–20.0)
15–24 years	497	5.8% (5.2–6.4)	6.0%	6.8%	39.4% (34.6–44.3)
25–44 years	1,297	15.1% (14.0–16.1)	14.5%	15.2%	52.1% (49.1–55.2)
45–64 years	1,405	16.3% (15.3–17.3)	15.6%	13.9%	81.0% (78.6–83.4)
65–74 years	550	6.4% (5.8–7.0)	6.7%	4.2%	94.2% (92.1–96.2)
75+ years	703	8.2% (7.1–9.2)	8.5%	4.1%	98.2% (97.1–99.2)

95 patients had either/both age or sex missing.
*Total MBS GP service items claimed during the 2008–09 BEACH year.
†Distribution of all patients that had at least one GP service item claimed in 2008–09.
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few differences found between the two studies: our estimates for osteoarthritis, back pain and anxiety were significantly lower than our earlier study and the malignant neoplasm estimate significantly higher. Compared with the NHS, our population prevalence estimates were significantly higher for most cardiovascular conditions, hyperlipidaemia, osteoarthritis, diabetes mellitus, depression, anxiety and malignant neoplasms and significantly lower for rheumatoid arthritis, back pain, osteoporosis and asthma. There was agreement between the two estimates for congestive heart failure, COAD/COPD and alcohol and drug problems. No comparative results were available from NHS for GORD, sleep disorders, and the endocrine, gastrointestinal, and respiratory problem groups.

Discussion

Despite differences in both the range of conditions surveyed and the data weighting methods, our prevalence estimates are consistent with our earlier study [21]. This study has shown that nearly two-thirds of patients sitting in front of the GP and half of the Australian population had at least one chronic condition. These sample prevalence estimates provide a measure of underlying health needs of patients attending general practice, distinct from demand for health care measured by general practice morbidity management rates. However, not surprisingly, the most prevalent problems in our sample were similar to those most often managed in general practice [22].

Inclusion criteria may explain some of the differences between NHS estimates and our estimates. For example, our definition of "back pain" was limited to chronic back pain whereas the NHS, included all types of back issues. Another possible cause for differences is the NHS's reliance on respondent self-report, e.g. confusion between terms "arthritis" and "rheumatism" may explain why the NHS produced a far higher estimate of the prevalence of "rheumatoid arthritis".

While our prevalence estimate of psychological problems (16.6%) was about 50% higher than the NHS estimate it was closer to the 2007 National Mental Health and Wellbeing Survey estimate, that one-in-five Australians had experienced a psychological problem during the previous year [27]. Our prevalence estimate for hypertension (16.6%) lay between that of the NHS (9.4%) and 2005 AusDiab [28](31.1%) estimates. However, one would expect AusDiab's result to be higher for two reasons. Firstly, they measured blood pressure only once as per WHO guidelines for field testing [29] whereas a GP will use repeated measures before diagnosis [30]. Secondly, they included patients whose blood pressure was normal, but were taking antihypertensives. This would have included those without diagnosed hypertension prescribed antihypertensives to lower their cardiovascular risk from another condition such as diabetes [30].

The largest difference in estimates was for obesity. Our study suggested that only 8.0% of patients sitting in front of the GP are obese. This is far lower estimate than the 25.0% of adult patients found in the NHS [7] and 26.7% in other large BEACH substudies where patients self-report height and weight [22]. Many may find the low prevalence found in our study of concern, especially when one considers that obesity is infrequently managed in general practice as a condition in its own right [22]. However, while obesity is not frequently managed as an identified condition, in the management of other problems counselling about diet and exercise is one of the most frequent treatments given by GPs in Australian general practice [22]. When obesity is managed in general practice, the majority of the time the patient has raised it as an issue they want managed [31]. This suggests that patients' desire for treatment plays a strong role in whether a GP manages obesity as a condition in its own right. Our prevalence estimate of 8.0% does however match the 8.1% of patients with morbid obesity (BMI of 35+) found in previous research [32]. This may suggest that GPs in our study are identifying patients who have a more extreme "chronic" level of obesity.

Table 3. Prevalence of selected chronic conditions in sample, attending population and Australian population.

Condition	Sample prevalence	Prevalence in those who attend at least once	Population prevalence	Knox et al. population estimates (2005) [21]	NHS estimates (2007) [7]
At least one chronic condition	66.3 (64.4–68.3)	58.8 (56.7–60.8)	49.6 (47.8–51.4)	46.8+ (45.0–48.5)	N/A
Cardiovascular	31.3 (29.4–33.1)	22.7 (21.2–24.2)	19.6 (18.3–20.9)	19.7 (18.4–21.0)	16.4
Hypertension	26.6 (24.9–28.4)	19.2 (17.8–20.6)	16.6 (15.4–17.8)	15.5 (14.4–16.6)	9.4
Ischaemic heart diseases	8.7 (7.7–9.8)	5.7 (5.0–6.4)	5.0 (4.4–5.6)	5.7 (5.0–6.3)	3.8[1]
Cerebrovascular accident	2.9 (2.3–3.5)	1.8 (1.4–2.1)	1.5 (1.2–1.8)	2.1 (1.7–2.6)	1.2[2]
Congestive heart failure	2.9 (2.4–3.4)	1.7 (1.4–2.1)	1.5 (1.2–1.8)	1.8 (1.5–2.1)	1.3[3]
Endocrine, nutritional and metabolic diseases	30.8 (29.0–32.6)	24.7 (23.2–26.3)	21.3 (19.9–22.6)	N/A	**
Hyperlipidaemia	18.5 (17.0–20.0)	14.1 (12.9–15.3)	12.3 (11.3–13.4)	11.2 (10.2–12.1)	5.7[4]
Diabetes mellitus	9.2 (8.3–10.1)	7.0 (6.3–7.7)	6.1 (5.5–6.7)	5.8 (5.3–6.4)	4.0
Type 1	0.9 (0.6–1.2)	0.8 (0.6–1.0)	0.7 (0.5–0.9)	0.5 (0.3–0.7)	0.4
Type 2	8.3 (7.5–9.1)	6.2 (5.6–6.9)	5.5 (4.9–6.0)	5.0 (4.5–5.5)	3.5
Obesity (BMI>30)	8.0 (7.0–8.9)	7.1 (6.2–7.9)	***	N/A	25.0[5]
Musculoskeletal system and connective tissue	26.4 (24.6–28.2)	19.6 (18.1–21.1)	16.7 (15.5–18.0)	N/A	30.7
Arthritis	19.7 (18.1–21.4)	13.8 (12.6–15.0)	11.9 (10.8–12.9)	14.8 (13.6–16.0)	15.2
Rheumatoid	1.0 (0.7–1.2)	0.7 (0.5–0.9)	0.6 (0.4–0.7)	0.7 (0.5–0.8)	2.1
Osteoarthritis	17.8 (16.2–19.4)	12.2 (11.0–13.3)	10.4 (9.4–11.4)	12.6 (11.5–13.7)	7.8
Other and unknown	2.0 (1.7–2.4)	1.6 (1.4–1.9)	1.5 (1.2–1.7)	N/A	6.1
Back pain	6.4 (5.5–7.2)	5.1 (4.4–5.8)	4.4 (3.8–5.0)	7.4 (6.5–8.2)	13.8[6]
Osteoporosis	4.8 (4.2–5.5)	3.0 (2.6–3.4)	2.4 (2.1–2.8)	N/A	3.4
Psychological problems	22.1 (20.6–23.7)	20.0 (18.5–21.5)	16.6 (15.3–17.8)	19.4 (18.1–20.8)	11.2
Depression	13.7 (12.6–14.7)	12.1 (11.1–13.1)	10.0 (9.2–10.8)	11.3 (10.3–12.4)	7.4[7]
Anxiety	8.3 (7.3–9.4)	7.6 (6.6–8.5)	6.2 (5.4–7.0)	8.4 (7.4–9.3)	3.3
Sleep disorder	3.0 (2.5–3.6)	2.6 (2.1–3.2)	2.2 (1.8–2.6)	N/A	N/A
Alcohol & drug problems	1.0 (0.6–1.4)	1.1 (0.7–1.5)	1.0 (0.6–1.3)	N/A	0.8
Gastrointestinal	14.6 (13.4–15.8)	11.3 (10.3–12.2)	9.6 (8.8–10.4)	N/A	**
GORD	11.6 (10.5–12.6)	8.8 (8.0–9.6)	7.5 (6.8–8.2)	9.2 (8.2–10.1)	N/A
Respiratory disease	13.7 (12.6–14.7)	12.5 (11.5–13.5)	10.5 (9.7–11.4)	N/A	**
Asthma	9.5 (8.7–10.3)	9.4 (8.6–10.3)	7.8 (7.1–8.5)	9.3 (8.5–10.2)	9.9
COAD/COPD	4.1 (3.4–4.7)	2.8 (2.3–3.3)	2.5 (2.1–2.9)	2.3 (1.9–2.6)	2.4[8]
Malignant neoplasms	5.0 (4.4–5.7)	3.6 (3.1–4.1)	3.1 (2.7–3.6)	2.0 (1.7–2.3)	1.6

N/A – Not available;
**Groups not comparable due to different inclusions;
***Did not meet management assumption; GORD = gastro-oesophageal reflux disease; COAD/COPD = chronic obstructive airways disease/chronic obstructive pulmonary disease; +95% Confidence intervals were not reported in the earlier paper, they have been calculated for this paper;
NHS groups 1: Angina+other ischemic disease; 2: Cerebrovascular disease; 3: Odema+heart failure; 4: High cholesterol; 5: proportion of adults 18 years and older; 6: Back pain/problems, disc disorders; 7: Mood disorders; 8: Long term bronchitis+emphysema.
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Our slightly higher prevalence estimate of at least one chronic condition compared with our previous study is probably due to our inclusion of all chronic conditions rather than only a selection. However, the ageing population or increases in diagnoses could also have contributed to this difference.

Our study has limitations. We assumed that people who did not see their GP in the previous year did not currently have a diagnosed chronic condition. This assumption may not hold for conditions such as asthma, where it is mild and did not necessitate a GP attendance that year. This may explain our lower prevalence estimate for asthma compared with NHS.

An issue with measuring diagnosed chronic conditions is that, like most prevalence studies, we can only provide estimates for those conditions already diagnosed. As the Ausdiab study shows, a significant proportion of Australians have undiagnosed diabetes and hypertension [28].

Finally our sample was drawn from patients attending general practice, so we were more likely to sample people who attend more frequently. While we adjusted for higher attendance of female and older patients, our method could not adjust for high attenders within a specific ten year age-sex group. If patients with particular conditions consistently attend more often than the average for

their age and sex, this could lead us to overestimate prevalence of these conditions.

Conclusion

This study provides the only current prevalence data that uses the GP as an expert interviewer and informant to gather information from the patient, their knowledge of the patient, and the health record. For a marginal cost to the BEACH program, this investigation could be run on an annual basis and could be expanded to 30,000 patients per year if larger samples were required. Our estimates can be used to examine primary care resource use in management of these chronic conditions. Importantly, the increased scope of this study allows measurement of prevalence of all chronic conditions and can therefore be used to measure prevalence of multi-

morbidity in Australia. To further increase the accuracy of estimates, the next version of this study will include a question on the number of patient visits to any GP in the past year so we can adjust for intra age-sex group variation in visit frequency.

Author Contributions

Conceived and designed the experiments: CH HB GM JH. Performed the experiments: CH HB GM JH. Analyzed the data: CH. Contributed reagents/materials/analysis tools: CH JH. Wrote the paper: CH HB GM JH.

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Further examining the under-recognition of obesity

In this study I found that GPs only considered 8.0% of patients at encounters to have chronic obesity while the larger series of BEACH sub-studies had found that 26.7% of adults at GP-encounters were obese based on patient reported height and weight.[1] We hypothesised that GPs in our study were identifying patients who have a more extreme 'chronic' level of obesity. In collaboration with Mrs Carmen Wong, a colleague at the Family Medicine Research Centre (FMRC), we tested this hypothesis in a separate set of sub-studies in which we collected the patient's reported height and weight (to measure BMI) and examined whether GPs were able to identify if the patient was overweight or obese.[2] We found that GPs in this new study were twice as likely to identify patients as being obese (18.3%) as they were in the study reported in this chapter, correctly identifying 60% of obese patients. It was thought that the higher identification of obesity in the Wong et al. study was due to either prompting the GP to record the patient's height and weight, which may have helped them to identify obese patients, or that in our first survey, GPs judged some obesity not to be 'chronic'.[2] Wong et al. postulated that the "increasing prevalence and normalisation of overweight and obesity may be a contributing factor to under-recognition."[2]

Another colleague from the FMRC, Lisa Valenti, completed her Master's thesis on the topic of general practitioner management of overweight and obesity. She found that overweight/obesity was rarely managed as a problem in its own right (1.35 per 100 encounters) even though clinical advice/education for nutrition/weight, exercise and lifestyle were commonly provided by GPs at encounters (5.2 per 100 encounters) in the management of other conditions. She found that overweight or obesity was most frequently managed as a problem at encounters where the patient had raised it as a reason for the encounter. She hypothesised that *"GPs currently do not see overweight and obesity as a 'clinical entity' in its own right, in the way they perceive diabetes as a 'clinical entity' for example."* It might be that because GPs manage obesity as part of care for other conditions rather than in its own right, that they do not consider it to be a chronic condition.[3]

A reason GPs may not consider obesity to be a chronic condition is that there is still a debate around whether risk factors, such as obesity, should be considered chronic conditions or disease at all. In 2000, a report by WHO stated that *"Obesity is a chronic disease, prevalent in both developed and developing countries, and affecting children as well as adults."*[4] In 2004, O'Halloran et al classified obesity as a chronic condition in their

paper on defining chronic conditions.[5] In June 2009, the Australian House of Representatives Standing Committee on Health and Ageing tabled a report on its inquiry into obesity in Australia whereby they recommended that the MBS consider obesity a chronic disease and allow it to become eligible for chronic disease management plan items (which provide specific remuneration for the GP).[6] However, in their response in February 2013, the Government chose not to change the guidelines to include obesity as a chronic disease for these management plans.[7] In June 2013, the American Medical Association classified obesity as a chronic disease.[8] If it is true that some GPs do not consider obesity to be a chronic condition, multimorbidity prevalence estimates based on GP recognition of chronic conditions may slightly underestimate its true prevalence.

As discussed in the introduction, the rise in the prevalence of obesity in the population is one of the main independent drivers in the increased prevalence of many chronic conditions. If GPs are to help manage and curb this increase, they first must recognise obesity among their patients. Wong et al. suggested that increased awareness and documentation of obesity would increase its management by GPs.[2]

Comparisons of multimorbidity in family practice–issues and biases.

After the publication of the paper reproduced in this chapter and before I submitted the next paper in this thesis (basis of chapter 4), I collaborated with Professors Martin Fortin and Moira Stewart on a research highly relevant to this thesis.[9] In response to the wide variance in definitions and methods used by researchers measuring multimorbidity, this study compared prevalence estimates from three major studies based in general practice: the BEACH study from Australia led by Professor Britt; the DELPHI (Deliver Primary Health Care Information) project from South-western Ontario led by Professor Stewart, Canada; and the original Saguenay study from Quebec, Canada led by Professor Fortin.

We found that the estimated prevalence of multimorbidity varied significantly from 34% in the DELPHI study, 46% in the BEACH sub-study to 95% in the Saguenay study. A long list of variables that may affect the proportion of people identified with multimorbidity was agreed upon by all authors. They included the study: *"design"*; *"population and sampling"*; *"data and definition"*; and *"outcomes"*. These we called *"Method crystals for multimorbidity"*. We argued that researchers should report all these variables in their methods section to allow their results to be fully considered in comparison to other studies.

We hypothesised that the different definitions of multimorbidity used may have a large effect on multimorbidity prevalence estimates. Specifically, the number of chronic conditions studied, the minimum number of 'morbidities' required for someone to be considered as having multimorbidity, and how a morbidity was defined (individual chronic conditions or 'groups' of chronic conditions) were all thought to effect multimorbidity prevalence estimates. While we were not able to test this hypothesis in our comparative paper, the large prospective survey I undertook (see Chapter 3) provided an ideal setting for testing the effect of these variables independently. Chapter 4 will now describe the testing of these hypotheses.

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Chapter 4: Examining different measures of multimorbidity, using a large prospective cross-sectional study in Australian general practice

BMJ Open | Examining different measures of multimorbidity, using a large prospective cross-sectional study in Australian general practice

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ABSTRACT

Objectives: Prevalence estimates of multimorbidity vary widely due to inconsistent definitions and measurement methods. This study examines the independent effects on prevalence estimates of how 'disease entity' is defined —as a single chronic condition or chapters/domains in the International Classification of Primary Care (V.2; ICPC-2), International Classification of Disease (10th revision; ICD-10) or the Cumulative Illness Rating Scale (CIRS), the number of disease entities required for multimorbidity, and the number of chronic conditions studied.

Design: National prospective cross-sectional study.

Setting: Australian general practice.

Participants: 8707 random consenting deidentified patient encounters with 290 randomly selected general practitioners.

Main outcome measures: Prevalence estimates of multimorbidity using different definitions.

Results: Data classified to ICPC-2 chapters, ICD-10 chapters or CIRS domains produce similar multimorbidity prevalence estimates. When multimorbidity was defined as two or more (2+) disease entities: counting individual chronic conditions and groups of chronic conditions produced similar estimates; the 12 most prevalent chronic conditions identified about 80% of those identified using all chronic conditions. When multimorbidity was defined as 3+ disease entities: counting individual chronic conditions produced significantly higher estimates than counting groups of chronic conditions; the 12 most prevalent chronic conditions identified only two-thirds of patients identified using all chronic conditions.

Conclusions: Multimorbidity defined as 2+ disease entities can be measured using different definitions of disease entity with as few as 12 prevalent chronic conditions, but lacks specificity to be useful, especially in older people. Multimorbidity, defined as 3+, requires more measurement conformity and inclusion of all chronic conditions, but provides greater specificity than the 2+ definition. The proposed concept of "complex multimorbidity", the co-occurrence of three or more chronic conditions affecting three or more different body systems within one person without defining an index chronic condition, may be useful in identifying high-need individuals.

Strengths and limitations of the study

- A large, representative, prospective study of multimorbidity, involving 290 general practitioners and 8707 patients, allowed testing of the independent effect of variables on prevalence estimates, something not possible with systematic reviews.
- This study investigated all chronic conditions, not a selection of conditions.
- This study used the general practitioner as an 'expert interviewer', drawing on the patient's knowledge, the patient's health record and their own knowledge to indicate the patient's current chronic conditions. Most multimorbidity studies rely on only one of these sources of data.
- This study only considered chronic conditions, whereas some authors now include acute conditions when defining multimorbidity.

INTRODUCTION

Research into the coexistence of multiple chronic health conditions in an individual was initially concerned with comorbidity, defined as "the existence or occurrence of any distinct additional disease entity in a patient who has the index disease under study."[1] However, since the early 1990s, interest has progressed to 'multimorbidity', commonly defined as the "co-occurrence of two or more diseases within one person without defining an index disease."[2]

Interest in multimorbidity is growing due to its expected increase resulting from the ageing of the world's population.[3][4] Studies have shown that multimorbidity is associated with increased patient mortality, demand on health resources, complexity of care and reduced patient quality of life.[5][6] However, prevalence estimates of multimorbidity have ranged from 3.5%[7] to 98.5%,[8] the wide variance thought to be due to the lack of standards defining multimorbidity and how it is measured. A recent systematic review found

132 definitions involving 1631 different criteria.[9] There have been many calls for standards and guidelines for research into multimorbidity.[10–12] Recent systematic reviews have raised specific issues regarding the way multimorbidity is defined and/or measured.[11][12]

The first issue is the number of conditions studied. Fortin et al[11] found that this ranged from five to all conditions. Diederichs et al[12] reported a range of 4–102 conditions (mean 18.5 and median 14) and suggested that conditions may be chosen for pragmatic reasons (such as data availability), as the majority of authors did not give reasons for their selection. Where they did, the most common was those conditions with a high prevalence or high impact on patients.[12] Diederichs et al[12] and Fortin et al[11] suggested that studies considering only a few conditions produced lower prevalence estimates than those examining many conditions. Diederichs et al[12] suggested a list of 11 chronic conditions prevalent in the elderly as a minimum (cancer, diabetes mellitus, depression, hypertension, myocardial infarction, chronic ischaemic heart disease, heart arrhythmias, heart insufficiency, stroke, chronic obstructive pulmonary disease and arthritis). Fortin et al[11] suggested that any 12 prevalent conditions should suffice to measure multimorbidity accurately.

The second issue is how 'disease entity' was defined in multimorbidity studies. Ideally, morbidities being counted should be 'distinct' disease entities. However, disease entities used across studies varied from very specific conditions to groups of conditions. Even Diederichs et al's[12] suggested list (above) includes some disease entities that are groups of conditions (such as arthritis and cancer) and some very specific, closely related conditions (eg, myocardial infarction and chronic ischaemic heart disease). It is debatable whether myocardial infarction and chronic ischaemic heart disease should be considered as two separate disease entities in measuring multimorbidity. Some multimorbidity studies have tried to overcome this problem by only counting chronic conditions that affect different body systems, to ensure that the count was of distinct disease entities.[4][13] These studies used the Cumulative Illness Rating Scale (CIRS)[14] domains to group chronic conditions by body system.[4][13] Fortin et al[11] suggested that while the use of the CIRS needed further research, this approach may simplify coding and data collection. The impact of counting the different body systems affected by chronic conditions on multimorbidity prevalence estimates is not known.

Most primary care-based multimorbidity studies rely on a health record review.[11] A disadvantage of using CIRS in such reviews is that it requires additional mapping of diagnoses from the classification system in which the health records were coded. The two most commonly used disease classification systems are the International Classification of Primary Care (V.2; ICPC-2)[15] and the International Classification of Disease (10th revision; ICD-10).[16] ICPC-2 is used in primary care, and its chapters (with the exception of 'General and unspecified' and 'Social' chapters) are body system-

based, following the principle that localisation takes precedence over aetiology.[16] ICD-10 is primarily used in hospitals and its chapters axes include body systems, aetiology and 'others'.[16] ICD-10 lacks specificity for classification of undiagnosed problems or symptoms, both of which are commonly managed in primary care.[17] This has meant that data from primary healthcare records classified in the two systems have looked very different in the past. However, since most multimorbidity studies examine only chronic conditions, this problem may be avoided when conditions are grouped at the chapter level. It is not known whether counting disease entities from different CIRS domains, ICPC-2 or ICD-10 chapters produces comparable multimorbidity prevalence estimates.

The third issue is the number of disease entities required to define multimorbidity. Originally, multimorbidity was defined as two or more (2+) disease entities, but recently there has been debate about whether three or more (3+) may be a better measure. Fortin et al[11] argue that using 2+ disease entities identifies such a high proportion of patients as multimorbid that the measure lacks specificity. They found that age-specific prevalence of multimorbidity using the 2+ definition produced an 'S' shaped curve with a flat plateau for older ages. When using 3+, the increase in prevalence by age was more linear, with greater differentiation in older age groups. The authors further argued that using 3+ disease entities results in a lower prevalence estimate, is likely to identify patients with greater health needs and is therefore more useful to clinicians.[11] They recommended further research to test the 3+ definition of multimorbidity.[11]

The current study was conducted in Australian general practice. Australia's universal medical insurance scheme, Medicare, fully or partially covers the individual's cost of visits to general practitioners (GPs). GPs provide the bulk of primary medical care and act as gatekeepers to government-subsidised healthcare from other medical specialists. There are no patient lists and patients are free to visit multiple GPs and practices as they choose.

Our study examines how multimorbidity prevalence estimates are affected by: the number of chronic conditions studied; how a disease entity is defined; and the minimum number of disease entities required to define multimorbidity. We use a large Australian general practice-based prospective multimorbidity study, which allows us to examine the effect of each of these variables on multimorbidity prevalence estimates while controlling for other confounding variables, an approach not possible in systematic reviews.

METHOD

The BEACH (Bettering the Evaluation And Care of Health) programme is a continuous, national cross-sectional survey of general practice activity in Australia.[17]

Each year, an ever-changing sample of about 1000 GPs is randomly selected, and each GP records information about encounters with 100 consecutive consenting patients on structured paper forms.[17]

In substudies of BEACH, the GP records information additional to the encounter data, in discussion with the patient. The full methods for this substudy are reported elsewhere.[18] In brief, it measured the prevalence of diagnosed chronic conditions in patients attending general practice in Australia. Over three 5-week recording periods (August 2008–May 2009), 375 sampled GPs were asked to record all diagnosed chronic conditions for each of 30 consecutive patients on 30 bespoke forms within their 100 BEACH records. A sample of the instruction sheet and recording form can be found at www.http://sydney.edu.au/medicine/fmrc/publications/sand-abstracts/132-Multimorbidity.pdf

GPs were asked, "Does the patient have any of the following chronic diseases/problems?" Common chronic conditions were listed (tick boxes) with additional free text fields to record other unlisted chronic conditions. A 'no chronic conditions' option was also provided. Listed chronic conditions were primarily those most frequently managed in Australian general practice[17] and were inclusions in O'Halloran et al's[19] definition of chronic conditions. The free text options relied on GPs' judgement of whether a condition was chronic in this patient. GPs were instructed to "Use your own knowledge, patient knowledge and health records as you see fit, in order to answer these questions." Additional free text chronic conditions were coded using the ICPC-2 PLUS terminology,[20] which automatically classified them into ICPC-2.[15] All chronic conditions were classified to ICD-10 chapters[16] (n=20), ICPC-2 chapters[15] and CIRS domains[14] (table 1). There were some chronic conditions (eg, multisite cancer) that involved multiple systems. As these would usually be counted multiple times in different CIRS domains, we created an additional domain called 'Whole system', resulting in 15 CIRS domains instead of the usual 14. The ICPC-2 male and female genital system chapters (chapters Y and X) were combined as they referred to the same body system, resulting in 16 ICPC-2 chapters (rather than the usual 17). This sample was previously shown to be representative of the age–sex distribution of patients at all GP encounters claimed (as items of service) through Medicare in 2008–2009.[18]

Using this large prospective study, we examined the effect of three different dimensions of measuring multimorbidity while controlling for other confounding variables. This is achieved through the structure of the study, by only changing one of the three variables at a time.

Dimension 1: Does the way disease entities are defined affect multimorbidity prevalence estimates?

To test this dimension, we defined disease entity in four different ways. First, each recorded/ticked chronic condition was treated as a separate disease entity. For the other three methods, we considered a disease entity to be a chapter/domain that was affected by at least one chronic condition in each of the three classification systems. Comparing the resulting multimorbidity prevalence estimates, we were able to test two research questions. First, whether counting different body systems affected by chronic conditions produces prevalence estimates comparable to counting individual chronic conditions. Second, whether counting the number of different CIRS domains, ICPC-2 chapters or ICD-10 chapters affected produces comparable prevalence estimates.

Dimension 2: Does the minimum number of disease entities required to define multimorbidity affect multimorbidity prevalence estimates?

We compared prevalence of multimorbidity using 2+ through to 6+ disease entities. We also compared the age-specific prevalence of multimorbidity when it was defined as 2+ and 3+ disease entities, to see whether we could reproduce the 'S'-shaped curve when using the 2+ definition and test whether using 3+ provided greater differentiation among older patients, as found by Fortin et al.[11]

Dimension 3: Does the number of chronic conditions included in the study affect multimorbidity estimates?

We reduced the number of chronic conditions used, in order to simulate studies that were based on fewer chronic conditions. We used the 11 minimum chronic conditions as suggested by Diederichs et al),[12] the 12 most prevalent chronic conditions in our study (hypertension, hyperlipidaemia, ischaemic heart disease, type 2 diabetes, obesity, osteoarthritis, chronic back pain, asthma, depression, anxiety, gastro-oesophageal reflux disease and malignant neoplasms) as suggested by Fortin et al[11] and the 24 listed chronic conditions with a tick box. We then compared these results with those generated using all diagnosed chronic conditions.

BEACH substudies have a single stage cluster design, with each GP having 30 patients clustered around them. The cluster effect was accounted for using SAS V.9.3.

RESULTS

Completed research packs were returned by 290 GPs (77.3%) sampling 8707 patients. In total, 66.5% of patients (n=5777) had at least one chronic condition and 33.7% (n=2930) had none. The intracluster correlation coefficient was 0.121 for patients with at least one chronic condition.

Table 1 shows the proportion of patients with at least one chronic condition in each chapter/domain. For ICPC-2 and ICD-10, the 11 most prevalent chapters were body specific, with the non-body system-specific chapters being relatively uncommon. Prevalence estimates of patients with at least one chronic condition within a body system-specific ICD-10 and ICPC-2 chapter were remarkably similar, the top six chapters being in the same order, with no significant differences in the

Table 1 Proportion of patients in GP waiting rooms that have at least one condition in each CIRS domain, ICPC-2 chapter or ICD-10 chapter

CIRS domain	n	Proportion of patients in waiting room (%, 95% CIs)	ICPC-2 chapter	n	Proportion of patients in waiting room (%, 95% CI)	ICD-10 chapter	n	Proportion of patients in waiting room (%, 95% CI)
Vascular	2934	33.7 (31.7 to 35.7)	K (Circulatory)	2762	31.7 (29.8 to 33.6)	9 (Circulatory)	2748	31.6 (29.7 to 33.5)
Musculoskeletal*	2479	28.5 (26.6 to 30.4)	T (Endocrine†)	2694	30.9 (29.2 to 32.7)	4 (Endocrine‡)	2688	30.9 (29.1 to 32.7)
Psychiatric	1930	22.2 (20.6 to 23.7)	L (Musculoskeletal)	2293	26.3 (24.5 to 28.2)	13 (Musculoskeletal‡)	2268	26.0 (24.2 to 27.9)
Endocrine*	1840	21.1 (19.7 to 22.5)	P (Psychological)	1953	22.4 (20.8 to 24.0)	5 (Mental and behavioural disorders)	1910	21.9 (20.4 to 23.5)
Respiratory	1195	13.7 (12.7 to 14.8)	D (Digestive)	1387	15.9 (14.7 to 17.2)	11 (Digestive)	1296	14.9 (13.7 to 16.1)
Cardiac	1089	12.5 (11.3 to 13.7)	R (Respiratory)	1227	14.1 (13.0 to 15.2)	10 (Respiratory)	1211	13.9 (12.9 to 15.0)
Upper gastrointestinal	1052	12.1 (11.0 to 13.2)	X and Y (Genital)	353	4.1 (3.5 to 4.6)	2 (Neoplasms)	474	5.4 (4.7 to 6.1)
Neurological	542	6.2 (5.4 to 7.0)	U (Urology)	312	3.6 (3.0 to 4.2)	14 (Genitourinary)	389	4.5 (3.8 to 5.2)
Ophthalmological*	444	5.1 (4.4 to 5.8)	N (Neurological)	311	3.6 (3.1 to 4.1)	6 (Nervous system)	318	3.7 (3.1 to 4.2)
Lower gastrointestinal	377	4.3 (3.7 to 4.9)	F (Eye)	303	3.5 (2.9 to 4.1)	7 (Eye and adnexa)	292	3.4 (2.8 to 3.9)
Genitourinary	351	4.0 (3.4 to 4.6)	S (Skin)	294	3.4 (2.8 to 3.9)	12 (Skin and subcutaneous tissue)	179	2.1 (1.7 to 2.4)
Renal	232	2.7 (2.2 to 3.2)	A (General and unspecified)	134	1.5 (1.2 to 1.8)	18 (Symptoms‡)	105	1.2 (0.9 to 1.5)
Haematological	130	1.5 (1.0 to 2.0)	B (Blood†)	130	1.5 (1.0 to 2.0)	1 (Infectious and parasitic‡)	80	0.9 (0.7 to 1.2)
Hepatic and pancreatic	90	1.0 (0.8 to 1.3)	H (Ear†)	47	0.5 (0.4 to 0.7)	21 (Factors influencing health status‡)	68	0.8 (0.4 to 1.2)
Whole system	39	0.4 (0.3 to 0.6)	W (Pregnancy†)	8	0.1 (0.0 to 0.2)	3 (Blood‡)	58	0.7 (0.5 to 0.9)
			Z (Social problems)	2	0.0 (0.0 to 0.1)	19 (Injury, poisoning‡)	58	0.7 (0.5 to 0.8)
						8 (Ear and mastoid process)	47	0.5 (0.4 to 0.7)
						17 (Congenital‡)	23	0.3 (0.2 to 0.4)
						15 (Pregnancy‡)	3	0.0 (0.0 to 0.1)
						16 (Conditions—perinatal period‡)	2	0.0 (0.0 to 0.1)

*CIRS: musculoskeletal and tegumental; endocrine, metabolic, breast; ophthalmological and otorhinolaryngology.
†ICPC-2: endocrine, nutritional and metabolic; blood, blood forming organs and immune mechanism; ear and hearing; pregnancy, childbearing, family planning.
‡ICD-10: endocrine, nutritional and metabolic; musculoskeletal and connective tissue; symptoms, signs and abnormal clinical and laboratory findings; certain infectious and parasitic diseases; factors influencing health status and contact with health services; blood, blood forming organs and certain disorders involving the immune mechanism; injury, poisoning and certain other consequences of external causes; congenital malformations, deformations and chromosomal abnormalities; pregnancy, childbirth and the puerperium; certain conditions originating from the perinatal period.
CIRS, Cumulative Illness Rating Scale; ICD, International Classification of Disease; ICPC, International Classification of Primary Care; GP, general practitioner.

prevalence estimates for these six chapters. There were larger differences between estimates using CIRS and those from ICPC-2 and ICD-10. The major differences were due to CIRS splitting cardiovascular into vascular and cardiac domains, classifying cerebrovascular disease as neurological and classifying hyperlipidaemia in the vascular domain. In all systems, the most frequent chapters/domains were those relating to the: cardiac/vascular/circulatory; endocrine; musculoskeletal; psychological; digestive and respiratory systems.

Figure 1 shows the prevalence of multimorbidity among patients in the sample (representing those in a GP's waiting room) using different definitions of multimorbidity. The estimated prevalence of multimorbidity ranged from 47.4% when using 2+ individual chronic conditions to 2.8% when using 6+ ICPC-2 chapters. For all definitions using 3+ disease entities or more, counting individual chronic conditions resulted in a significantly higher prevalence estimate than any of the grouped estimates. This difference increased proportionally as the minimum number of disease entities increased—the individual chronic conditions estimate was 23% higher than the ICPC-2 chapter estimate at 3+ disease entities, through to 268% higher at 6+ disease entities. Overall, there was no significant difference found between prevalence estimates using ICD-10, ICPC-2 and CIRS, from 2+ through to 6+ disease entities.

Using the ICD-10 and ICPC-2 estimates, when multimorbidity was defined as two or more disease entities,

about 44% of patients presenting to GPs were identified as multimorbid. This prevalence decreased with each increase in the number of disease entities required, with about 27% of patients being considered multimorbid for 3+, about 15% for 4+, 7% for 5+ and only 3% for 6+ disease entities. There was nearly perfect concordance between patients identified as having multimorbidity using the ICD-10 and ICPC-2 classification systems. For example, when using the minimum of three disease entities as the definition of multimorbidity, over 99% of patients identified using ICD-10 were also identified using ICPC-2 and vice versa (table 2). There was also high concordance between ICPC-2/ICD-10 and CIRS. For every 12 patients identified as having multimorbidity with CIRS, 11 were also identified using ICPC-2/ICD-10 and vice versa.

Figure 2 shows multimorbidity prevalence estimates using the 2+ and the 3+ definitions across the different number of chronic conditions included. For all classification groups, the prevalence estimates derived when using Diederichs et al's 11 chronic conditions were significantly lower than those using the 12 most prevalent chronic conditions, which in turn were significantly lower than the estimates based on all chronic conditions. Prevalence estimates based on the 12 most prevalent chronic conditions and on the 24 common chronic conditions (tick boxes) did not significantly differ, except that the 24 chronic conditions produced higher estimates when using 3+ individual chronic conditions or 3+ CIRS domains.

	Two +	Three +	Four +	Five +	Six +
Individual conditions	47.4	33.8	23.7	16.0	10.3
ICPC 2 Chapters	43.7	27.4	14.7	6.7	2.8
ICD 10 Chapters	43.7	27.4	14.6	6.7	2.9
CIRS domains	43.8	27.9	16.0	8.4	4.0
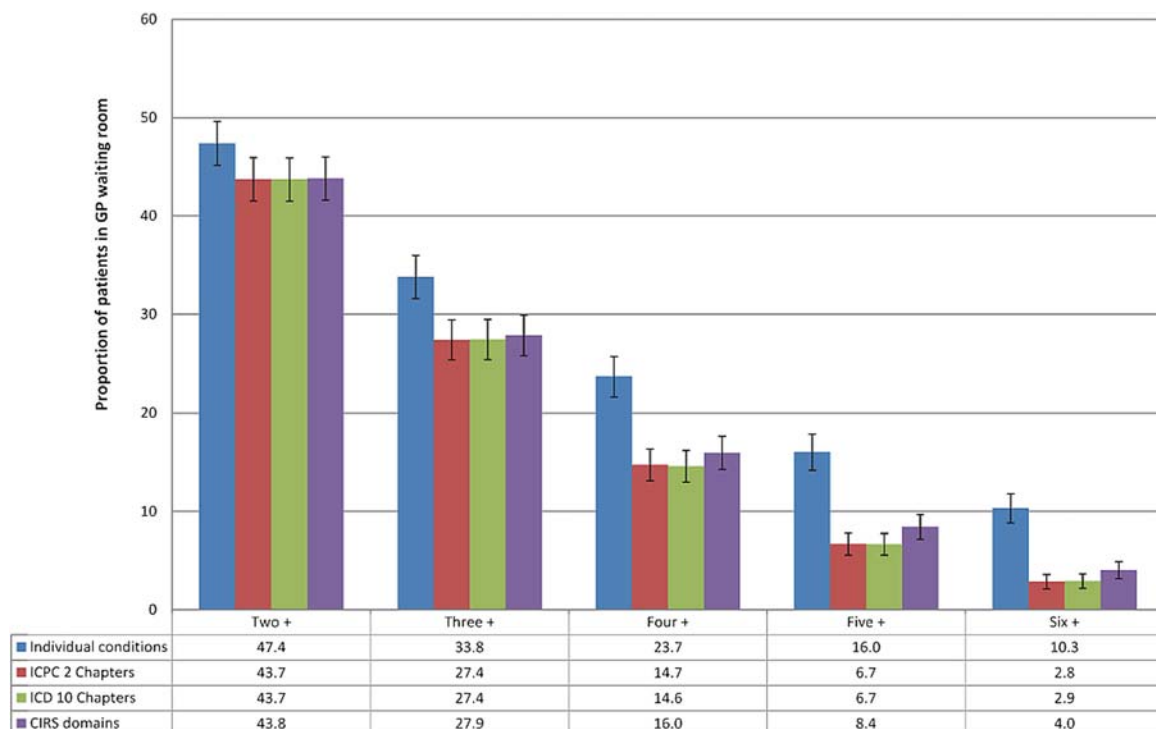
Figure 1 Multiple conditions within patients as defined by different classification systems (CIRS, Cumulative Illness Rating Scale; GP, general practitioners; ICD, International Classification of Disease; ICPC, International Classification of Primary Care).

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Table 2 Concordance of patients identified with multimorbidity (3+ definition) between ICPC-2, ICD-10 and CIRS

	Proportion of patients identified as having multimorbidity using each classification system (horizontal) that were also identified using other classification systems (vertical) (%, 95% CIs)		
	ICPC-2	ICD-10	CIRS
ICPC-2	100.0	99.1 (98.7 to 99.5)	92.1 (90.9 to 93.3)
ICD-10	99.3 (98.9 to 99.6)	100.0	91.9 (90.7 to 93.1)
CIRS	93.7 (92.6 to 94.7)	93.3 (92.2 to 94.4)	100.0

CIRS, Cumulative Illness Rating Scale; ICD-10, International Classification of Disease10th chapter; ICPC-2, International Classification of Primary Care second chapter.

When using a restricted number of chronic conditions (ie, Diederichs et al's list or Fortin et al's 12) rather than all chronic conditions, the proportion of patients identified as having multimorbidity was significantly less when multimorbidity was defined as 3+ than when defined as 2+. For example, applying the 2+ definition to ICPC-2 chapters, using the 12 most prevalent chronic conditions identified 79.4% of those identified as multimorbid using all chronic conditions. Using the 3+ ICPC-2 chapters definition, the 12 most prevalent conditions only identified 67.5%. Similarly, using Diederichs et al's list with the 2+ definition identified 54.5% and the 3+ definition identified only 32.8% of those identified using all chronic conditions.

Figure 3 shows the age-specific multimorbidity prevalence estimates using the 2+ and 3+ definitions by individual chronic conditions and ICPC-2 chapters. Only the ICPC-2 chapters are presented as we have demonstrated that there was no significant difference between estimates derived using ICPC-2 chapters, ICD-10 chapters or CIRS domains. The age-specific prevalence using 2+ individual

chronic conditions and 2+ ICPC-2 chapters increased rapidly up to the 70–79 years age group, and remained steady in the older age groups. Compared with 2+, the increase in prevalence started later for 3+ individual chronic conditions (between 20–29 and 30–39 years of age). For 3+ ICPC-2 chapters, this increase started even later (between 30–39 and 40–49 years of age). For both the 3+ measures, the prevalence did not plateau until 80–89 years of age, 10 years later than when using the 2+ definition.

DISCUSSION

This study has shown that multimorbidity prevalence estimates are independently affected by the number of chronic conditions collected in a study, how a disease entity is defined, and the minimum number of disease entities used to define multimorbidity. It has also demonstrated that health data classified to ICPC-2 chapters, ICD-10 chapters or CIRS domains produce similar multimorbidity prevalence estimates.

	2+ Diederichs	2+ Fortin	2+ 24 conditions	2+ All chronic conditions	3+ Diederichs	3+ Fortin	3+ 24 conditions	3+ All chronic conditions
Individual diseases	25.7	37.0	40.5	47.4	13.0	23.4	27.4	33.8
ICPC-2 Chapters	23.8	34.7	37.7	43.7	9.0	18.5	21.9	27.4
ICD-10 Chapters	23.8	34.7	37.7	43.7	8.8	18.5	21.9	27.5
CIRS Domains	25.7	33.8	37.2	43.8	12.7	18.1	22.1	27.9

Figure 2 Estimated prevalence of multimorbidity by different classification systems and by whether 2+ or 3+ minimum number of disease entities was used (CIRS, Cumulative Illness Rating Scale; GP, general practitioners; ICD, International Classification of Disease; ICPC, International Classification of Primary Care).

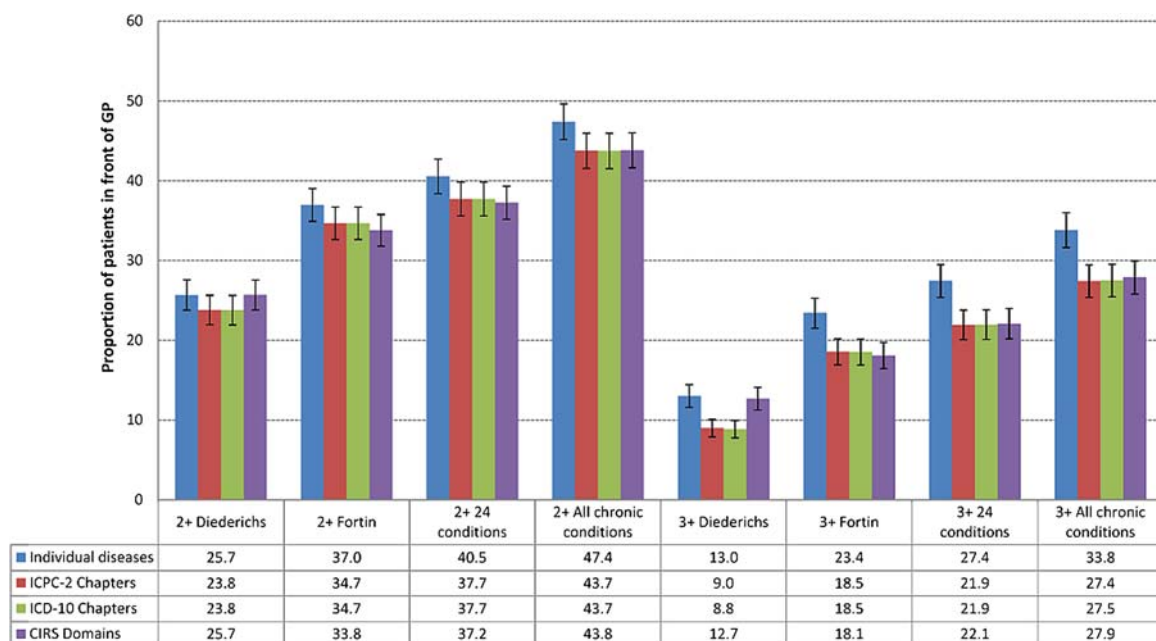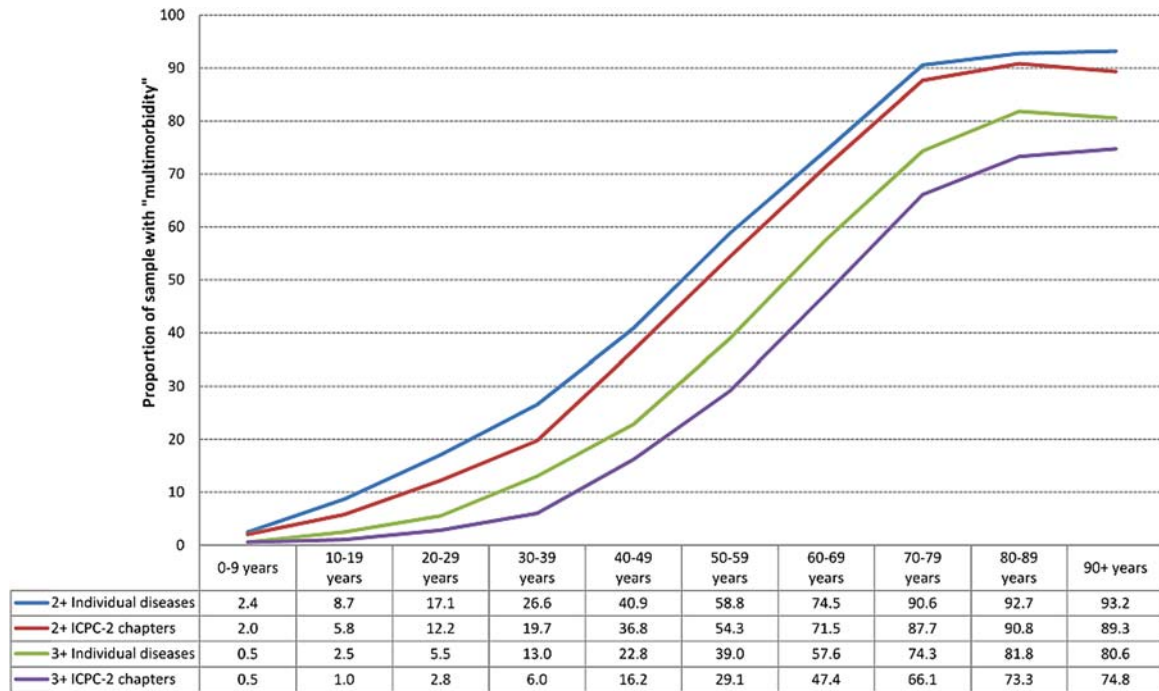|	0-9 years	10-19 years	20-29 years	30-39 years	40-49 years	50-59 years	60-69 years	70-79 years	80-89 years	90+ years
2+ Individual diseases	2.4	8.7	17.1	26.6	40.9	58.8	74.5	90.6	92.7	93.2
2+ ICPC-2 chapters	2.0	5.8	12.2	19.7	36.8	54.3	71.5	87.7	90.8	89.3
3+ Individual diseases	0.5	2.5	5.5	13.0	22.8	39.0	57.6	74.3	81.8	80.6
3+ ICPC-2 chapters	0.5	1.0	2.8	6.0	16.2	29.1	47.4	66.1	73.3	74.8

Figure 3 Patient age-specific prevalence of 'multimorbidity' (ICPC, International Classification of Primary Care).

Dimension 1: Does the way disease entities are defined affect multimorbidity prevalence estimates?

We found that when multimorbidity is defined as 2+ disease entities, prevalence estimates are similar no matter how a disease entity is defined, be it an individual chronic condition or an ICPC-2 chapter, ICD-10 chapter or CIRS domain involving one or more chronic conditions. This means that studies that define multimorbidity as 2+ can be compared even if the morbidity is classified differently. However, when multimorbidity is defined as 3+ disease entities, using individual chronic conditions produces higher prevalence estimates than counting the different domains/chapters affected. We conclude that researchers should not compare results from studies using the 3+ definition when one study has used grouped chronic conditions (classified) and the other individual chronic conditions.

Our finding that chronic conditions were predominantly classified to body system-specific chapters/domains for all three classifications suggests that chapters/domains could be used to represent the body systems affected. We also found no difference between the prevalence estimates produced with any of the three classification systems. Together, these results suggest that researchers may compare prevalence estimates from studies that count different ICPC-2 chapters, ICD-10 chapters or CIRS domains affected by chronic conditions. This allows researchers to draw data from primary care or hospital health records regardless of the classification system used (ICPC-2 or ICD-10) and know that results will be comparable to published studies that have used CIRS.[4 13]

Dimension 2: Does the minimum number of disease entities required to define multimorbidity affect multimorbidity prevalence estimates?

We found that the higher the minimum number of different disease entities used to define multimorbidity, the lower the prevalence estimate. If multimorbidity is defined as 2+ disease entities, nearly every second person sitting in front of the GP would have multimorbidity, whereas using 3+ decreased the estimate to nearly one in four. Like Fortin et al, we found that the 3+ definition provided greater differentiation in the older age groups than the 2+ definition. These results support their argument that using 2+ disease entities identifies such a large proportion of patients as having multimorbidity that it lacks the specificity to be useful, with a minimum of three disease entities arguably a better measure of multimorbidity.

Dimension 3: Does the number of chronic conditions included in the study affect multimorbidity estimates?

As previous research suggests,[11 12] the number of chronic conditions studied affects the multimorbidity prevalence estimates—estimates based on a low number of chronic conditions being a fraction of those based on all chronic conditions. In our study, Diederichs et al's list identified only half the patients identified with multimorbidity using all chronic conditions when using 2+, and only a third using 3+. Including the 12 most prevalent chronic conditions (suggested by Fortin et al), four of five multimorbid patients were identified using 2+ and two-thirds using 3+. While both used a similar number of chronic conditions, Diederichs et al's list

included the most prevalent chronic conditions in patients aged 65 years and over, whereas Fortin *et al* suggested the most prevalent overall conditions.

It is clear from these results that no matter how multimorbidity is defined, the list of chronic conditions suggested by Diederichs *et al* as a minimum is not sufficient to reliably measure multimorbidity prevalence. Using the 12 most prevalent chronic conditions, as suggested by Fortin *et al*, does provide prevalence estimates that are reasonably close to those gained with all chronic conditions when using the 2+ definition. However, when multimorbidity is defined as 3+, the 12 most prevalent chronic conditions are not sufficient to measure multimorbidity. For the 3+ definition, ideally researchers should include all chronic conditions in their study.

This study has some limitations. We only included chronic conditions, whereas some authors have recently included acute conditions in their definition of multimorbidity.[9][21] Including acute conditions is understandable in a clinical setting, as they will temporarily increase the patient's complexity of care. However, where the goal is to measure the prevalence of multimorbidity to inform planning to meet the health resource requirements of these high-need patients, the use of only chronic conditions is logical.

Fortin *et al*[8] suggest that when studying multimorbidity, one should also include a measure of severity. This study did not attempt to measure severity because of the limited space on the questionnaire and concerns that the additional burden on the GPs may reduce the response rate.

While our study was representative of patients at GP encounters, it should be remembered that patients are not representative of the population. Patients at GP encounters are generally older and therefore more likely to have a chronic condition.[18]

While our study was cross-sectional, the variables tested are relevant to all types of multimorbidity studies, be they cross-sectional, longitudinal, interview-based or based on a health record review.

Throughout this study, we have found that multimorbidity behaves quite differently when defined as 2+ or 3+ disease entities. With the 2+ definition, reasonable prevalence estimates could be obtained using only a dozen prevalent chronic conditions, regardless of how a disease entity was defined. With the 3+ definition, the way the disease entity was defined was important—counting individual chronic conditions produced significantly higher estimates than counting chapters/domains. The number of chronic conditions studied was also important as studying a restricted number of chronic conditions produced significantly lower estimates than studying all chronic conditions. However, the prevalence estimates gained using 2+ were so encompassing that they lacked specificity—especially in older patients—whereas 3+ provided greater specificity and more differentiation among the elderly patients.

These results suggest that the concepts of 2+ and 3+ multimorbidity are quite different. Rather than having both these concepts included under the same label, we propose adding the word 'complex' to those patients with 3+ chronic conditions from different body systems to clarify the meaning. 'Multimorbidity' would be defined as the "co-occurrence of two or more chronic conditions within one person without defining an index chronic condition." 'Complex multimorbidity' would be defined as the "co-occurrence of three or more chronic conditions affecting three or more different body systems within one person without defining an index chronic condition." In this way, we still have the more encompassing 2+ definition to compare with a previous work, while also being able to identify patients requiring additional care.

For consistency, we also propose a similar concept for comorbidity. We suggest that 'complex comorbidity' be defined as "the existence of two or more additional chronic conditions from two or more body systems different to that of the index chronic condition under study." This would mean that all patients with complex multimorbidity would also have complex comorbidity, the only difference being whether there is a chronic condition of interest.

There are advantages to using body systems affected (as represented by chapters/domains to which a chronic condition had been classified) rather than individual chronic conditions as 'disease entities'. Take, for example, two patients with three chronic conditions: patient A has peripheral vascular disease, hypertension and type 2 diabetes; patient B has depression, osteoarthritis and type 2 diabetes. The chronic conditions in patient A only affect two body systems while those in patient B affect three. According to our definitions, both would have multimorbidity, but patient B would also have complex multimorbidity. Patients identified with chronic conditions in 3+ body systems (complex multimorbidity) may be those whose care is more complex, as chronic conditions in different body systems are likely to compete for treatment, while the treatments of chronic conditions within the same system are more likely to be complementary. This is a similar concept to Piette and Kerr's[22] idea of concordant and discordant comorbidity.

Counting the body systems affected also provides an estimate of the specialist types that may be involved in the care of the patient. This is important for healthcare planning as it reduces double counting of chronic conditions that may be referred to the same specialist type; for example, a patient with depression and anxiety may be referred to one psychiatrist (not two). It also identifies patients who may need assistance with coordination of specialist care, as the healthcare of patients with multimorbidity is more likely to be poorly coordinated.[23][24]

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CONCLUSION

For the first time, a single large prospective study has been used to test the effect of the way multimorbidity is measured on prevalence estimates, while controlling for other variables, using the same data for all measures. This is not possible with systematic reviews. We have shown that multimorbidity behaves differently when defined as 2+ disease entities, as compared with when it is defined as 3+ disease entities. To address this, we recommend that

▶ 'Multimorbidity' be defined as the "co-occurrence of two or more chronic conditions within one person without defining an index chronic condition";
▶ 'Complex multimorbidity' be defined as the "co-occurrence of three or more chronic conditions affecting three or more different body systems within one person without defining an index chronic condition."

This study provides some evidence that complex multimorbidity is a more useful measure of multimorbidity as it results in a lower prevalence estimate and shows greater differentiation among older patients. However, further research is needed to assess whether 'complex multimorbidity' is indeed better than alternative measures of multimorbidity (such as counting individual chronic conditions, measures of severity, etc) in identifying patients with greater healthcare resource use, complexity of care, lower quality of life and overall severity of illness.

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In this chapter I have explored how changes in the method used to measure multimorbidity alters the proportion of people identified with multimorbidity. I have also proposed a new definition of 'complex multimorbidity' to help identify high need patients. Due to word limitations on a published paper, I did not report the prevalence and patterns of multimorbidity and 'complex multimorbidity' in this paper. The next chapter contains a paper that reports both of these among patients at encounters and in the Australian population, using the population adjustment method described in Chapter 3.

In the introduction of the current paper, I described 'multimorbidity', as commonly defined as the *"co-occurrence of two or more diseases within one person without defining an index disease."* with a reference to van den Akker et al's work. This definition was a paraphrasing of van den Akker's who made the distinction between 'comorbidity' and 'multimorbidity' based on whether or not there was an index condition. In reviewing this paper while collating my thesis, I realised that the current manuscript gives a false impression that I was directly quoting rather than paraphrasing van den Akker's work. I contacted BMJ Open and informed them of this issue. They have published a response online with my clarification.

A similar issue arose in the next chapter where I discuss researchers using a derivation of van den Akker's definition and using the above definition as an example of this derivation. I realise that the quotes around this definition once again give the impression that I am directly quoting van den Akker et al. I have also contacted ANZJPH and asked them to make a correction. While they have acknowledged this request, they are yet to act on it.

Chapter 5: The prevalence of complex multimorbidity in Australia

The prevalence of complex multimorbidity in Australia

Christopher Harrison,[1] Joan Henderson,[1] Graeme Miller,[1] Helena Britt[1]

Australia's health care system mainly focuses on single diseases. Payment structures support single disease management (e.g. diabetes mellitus and asthma cycle of care plans),[1] and guidelines for care usually take a single-morbidity approach.[2,3] This ignores the complexity in caring for the increasing number of patients with multiple chronic conditions, or 'multimorbidity'. It is argued that patients with multimorbidity are more than the sum of their individual conditions and that, using a single-morbidity model, we fail to grasp the pattern of the patient's disease, leading to inadequate management.[4] Multimorbidity has been shown to be associated with increased patient mortality, demand on health resources and complexity of care, and reduced patient quality of life.[5,6] If health systems are to meet the challenges raised by multimorbidity, we must first measure it.

Since we published the first comprehensive study on prevalence of multimorbidity in Australia,[7] several other Australian studies have investigated multimorbidity.[8-12] While valuable, they were often limited in scope (e.g. considering only a limited number of chronic conditions),[8-12] were not nationally representative[8-10] or only focussed on specific age groups.[11,12] Most importantly, there has been little consistency in the way multimorbidity has been defined. Most studies use a derivation of Van den Akker's definition: the "co-occurrence of two or more diseases within one person without defining an index disease".[13] Our earlier work suggested this definition may be so encompassing that it lacks sufficient specificity to be useful.[14]

We have proposed the concept of 'complex

multimorbidity', defined as the "co-occurrence of three or more chronic conditions affecting three or more different body systems within one person, without defining an index chronic condition".[14] It is more discriminating than 'traditional' multimorbidity and is likely to identify patients whose care is more complex. Chronic conditions in different body systems are likely to compete for treatment, while the treatments of chronic conditions within the same body system are more likely to be complementary, similar to Piette and Kerr's concept of concordant and discordant comorbidity.[15] Counting body systems affected by chronic conditions instead of individual chronic conditions has the added advantage of identifying the number and

types of specialised health services that may be involved with the patient's care. This will help guide resource planning by highlighting the common combinations of services required in the care of patients. It also identifies patients who may need assistance with coordination of specialist care, as the health-care of patients with multimorbidity is more likely to be poorly coordinated.[16,17]

In earlier research, we used the International Classification of Primary Care – Version 2 (ICPC-2),[18] the International Classification of Disease – 10th revision (ICD-10)[19] and the Cumulative Illness Rating Scale (CIRS)[20] to classify chronic conditions by body system. Each classification's chapters or domains were used to represent body systems. Defining

Abstract

Objective: To measure prevalence of multimorbidity and complex multimorbidity in the Australian population from a nationally representative prospective study and to identify the most prevalent patterns of chronic conditions and body systems affected.

Methods: A sub-study of the nationally representative BEACH program, using a random sample of 8,707 patients at encounters with 290 general practitioners. All diagnosed chronic conditions were recorded for each patient. Multimorbidity was defined as co-occurrence of 2+ chronic conditions, while complex multimorbidity was defined as 3+ body systems each affected by at least one chronic condition.

Results: We estimated: 47.4% of patients at GP encounters and one-third (32.6%) of the population had multimorbidity; and 27.4% of patients at GP encounters and 17.0% of the Australian population had complex multimorbidity. The most prevalent combination pattern of three conditions was hypertension+hyperlipidaemia+ osteoarthritis (5.5% of patient at encounters and 3.3% of the population). Most prevalent combination of three body systems affected was circulatory+musculoskeletal+endocrine / nutritional/metabolic systems (11.1% of patients at encounters and 7.0% of the population).

Conclusions and implications: A significant proportion of Australians have not only multimorbidity, but complex multimorbidity. To meet the challenge posed by complex multimorbidity, the single disease focus of our healthcare system needs to be re-evaluated.

Key words: multimorbidity, epidemiology, general practice

complex multimorbidity using each of these classification systems provided similar multimorbidity prevalence estimates. Patients identified as having complex multimorbidity with ICPC-2 were also identified using ICD-10 and visa versa.[14]

In our first study of multimorbidity, the prevalence of three or more CIRS domains with at least one chronic condition (which we would now define as complex multimorbidity) was estimated to be 10.6% among patients at general practitioner (GP) encounters and 7.0% among the Australian population. However, that study used a limited number of chronic conditions and CIRS domains.[7] A more recent localised Australian study of multimorbidity also using three or more CIRS domains as their definition, found that one-third (34.5%) of patients had complex multimorbidity. However, it was not nationally representative, including patients attending only two general practices in Perth (Western Australia).[8]

This study measures, for the first time, the prevalence of multimorbidity and of complex multimorbidity in the Australian population using all chronic conditions (not just a selected group) from a nationally representative prospective study. It also aims to identify the most prevalent patterns of chronic conditions and body systems affected among patients with multimorbidity.

Methods

The BEACH (Bettering the Evaluation and Care of Health) program is a continuous, representative, national cross-sectional survey of general practice activity in Australia. Each year an ever-changing random sample of about 1,000 GPs drawn by the Australian Department of Health participate, and each GP records information about encounters with 100 consecutive consenting patients, on structured paper forms.[21]

In sub-studies of BEACH, the GP records information additional to the encounter data, in discussion with the patient. The full methods for this sub-study are reported elsewhere.[22] In brief, we measured the prevalence of diagnosed chronic conditions in sampled patients seeing a GP in Australia. Between August 2008 and May 2009, each of 375 sampled GPs were asked to record all diagnosed chronic conditions/problems for each of 30 consecutive patients on 30 bespoke forms within their 100 BEACH

records. We used the term 'chronic conditions/problems' (referred to as chronic conditions in this paper) to encompass illnesses, diseases, diagnoses, syndromes and other health issues. A sample instruction sheet and recording form can be found at www.sydney.edu.au/medicine/fmrc/publications/sand-abstracts/132-Multimorbidity.pdf

GPs recorded all diagnosed chronic conditions in each sampled patient using their own knowledge of the patient, the patient's knowledge and the health record. Tick boxes were provided for 28 common chronic conditions for ease of recording, with spaces provided for additional chronic conditions to be recorded in free text. All chronic conditions recorded in free text were coded to ICPC-2 PLUS[23] and were secondarily classified to ICPC-2.[18] Whether a condition was chronic in an individual patient was left to the clinical opinion of the participating GP.

Multimorbidity was defined as the "co-occurrence of two or more chronic conditions within one person without defining an index chronic condition" and complex multimorbidity as the "co-occurrence of three or more chronic conditions affecting three or more different body systems within one person without defining an index chronic condition".[14] For the purposes of this paper, the chapters of ICPC-2 were used to represent the different body systems. The structure of ICPC-2 chapters can be found elsewhere.[24] A patient with complex multimorbidity had one or more chronic conditions within each of three or more different ICPC-2 chapters. Body systems were counted only once per patient, even if they had two or more chronic conditions classified to that body system.

BEACH sub-studies have a single stage cluster design, with each GP having 30 patients clustered around them. Survey procedures in SAS Version 9.3 (SAS Inc, Cary, NC, USA) were used to account for the effect of this clustering.

As patients were sampled at GP consultations, the likelihood of being sampled is dependent on visit frequency. Therefore, frequent attenders (such as older patients who may have more health problems) are more likely to be sampled than infrequent attenders. The method used to calculate national prevalence estimates has been described in detail elsewhere[22] but, in brief, we first weighted the sub-study sample against the age–sex distribution of the Australian population in June 2008–09.[25] We assumed that people who did not attend a GP that year had no

diagnosed chronic conditions. Therefore, after the above weighting we multiplied the numerator for each patient, by the proportion of their age–sex group who saw a GP at least once that year. This accounted for those who did not see a GP.

The prevalence of all patterns of multimorbidity was estimated. The most frequent observed combinations were compared with the expected prevalence of those combinations. The expected prevalence of the combinations of conditions/chapters was based on the assumption they were statistically independent of one another. It was calculated by multiplying the prevalence of condition A by the prevalence of condition B. The ratio of observed over expected prevalence was calculated to examine whether conditions were more or less likely than statistical chance to occur together.

Ethics committees of the University of Sydney and Australian Institute of Health and Welfare approved BEACH and this sub-study.

Results

Completed research packs were returned by 290 GPs (77.3%) sampling 8,707 patients. There were 18,792 chronic conditions recorded, 14,422 (76.7%) using the tick box options and 4,370 (23.3%) recorded in free text. Two-thirds (66.3%, n=5,777) of patients at encounters had at least one chronic condition (Figure 1). We estimated that about half the Australian population had at least one chronic condition (49.6%). Nearly half (47.4%) the patients at GP encounters and one-third of the population were estimated to have multimorbidity (32.6%). This means that about two-thirds (65.7%) of the patients with at least one chronic condition had two or more chronic conditions. We estimated that 27.4% of patients at GP encounters and 17.0% of the Australian population had complex multimorbidity (Figure 1).

Table 1 shows the prevalence of the most common combinations of two individual conditions and two ICPC-2 chapters. The 12 most prevalent combinations of individual chronic conditions were made up of eight prevalent conditions. The most common combination was hypertension+hyperlipidaemia (12.1% of patients at encounters and 8.3% of the Australian population). The most common combination of body systems affected

Figure 1: Prevalence of multiple chronic conditions and chapters affected by chornic problems within patients and the community.

	One or more	Two or more	Three or more	Four or more	Five or more	Six or more
Chronic conditions - at GP encounters	66.3	47.4	33.8	23.7	16.0	10.3
Chronic conditions - in population	49.6	32.6	21.8	14.6	9.5	5.9
ICPC-2 chapters - at GP encounters	66.3	43.7	27.4	14.7	6.7	2.8
ICPC-2 chapters - in population	49.6	29.5	17.0	8.8	3.8	1.5

Table 1: Most prevalent patterns of two chronic conditions or two chapters affected by chronic conditions.

	Most prevalent patterns of two chronic conditions					Most prevalent patterns of two ICPC-2 chapters with chronic conditions classified to them			
Chronic conditions	Observed prevalence among patients at encounters (95% CIs)	Expected prevalence among patients at encounters (Ratio)	Observed prevalence within Australian population (95% CIs)	Expected prevalence within Australian population (Ratio)	ICPC-2 chapters	Observed prevalence among patients at encounters (95% CIs)	Expected prevalence among patients at encounters (Ratio)	Observed prevalence within Australian population (95% CIs)	Expected prevalence within Australian population (Ratio)
Hypertension Hyperlipidaemia	12.1% (10.9-13.3)	4.9% (2.46)	8.3% (7.5-9.2)	2.0% (4.07)	Circulatory Endocrine*	19.8% (18.3-21.4)	9.8% (2.02)	13.8% (12.6-15.0)	4.3% (3.24)
Hypertension Osteoarthritis	10.9% (9.6-12.1)	4.7% (2.30)	6.4% (5.6-7.1)	1.7% (3.71)	Circulatory Musculoskeletal	16.6% (15.1-18.2)	8.3% (1.99)	10.2% (9.2-11.2)	3.3% (3.07)
Hyperlipidaemia Osteoarthritis	7.3% (6.4-8.3)	3.3% (2.22)	4.6% (4.0-5.2)	1.3% (3.60)	Musculoskeletal Endocrine*	14.6% (13.2-16.0)	8.1% (1.80)	9.9% (8.9-10.9)	3.6% (2.77)
Hypertension IHD	6.6% (5.7-7.5)	2.3% (2.85)	4.0% (3.4-4.6)	0.8% (4.82)	Circulatory Psychological	9.5% (8.4-10.7)	7.1% (1.34)	6.5% (5.8-7.3)	3.3% (1.94)
Hypertension GORD	6.2% (5.5-7.0)	3.1% (2.01)	3.9% (3.4-4.3)	1.2% (3.13)	Digestive Circulatory	9.4% (8.4-10.4)	5.0% (1.86)	5.9% (5.3-6.6)	2.1% (2.80)
Hypertension Type 2 Diabetes	5.9% (5.2-6.6)	2.2% (2.67)	4.1% (3.6-4.6)	0.9% (4.49)	Psychological Endocrine*	9.2% (8.2-10.2)	6.9% (1.33)	7.1% (6.3-7.9)	3.6% (1.97)
Osteoarthritis GORD	5.1% (4.4-5.8)	2.1% (2.47)	3.0% (2.6-3.5)	0.8% (3.85)	Musculoskeletal Psychological	9.1% (8.0-10.2)	5.9% (1.54)	6.4% (5.6-7.2)	2.8% (2.28)
Hypertension Depression	5.0% (4.3-5.6)	3.6% (1.37)	3.4% (2.9-3.9)	1.7% (2.05)	Digestive Endocrine*	8.5% (7.5-9.6)	4.9% (1.73)	6.0% (5.2-6.7)	2.3% (2.65)
IHD Hyperlipidaemia	5.0% (4.2-5.7)	1.6% (3.11)	3.1% (2.7-3.6)	0.6% (5.04)	Digestive Musculoskeletal	8.4% (7.4-9.4)	4.2% (2.01)	5.4% (4.7-6.0)	1.8% (3.05)
Hyperlipidaemia GORD	4.8% (4.1-5.5)	2.1% (2.24)	3.3% (2.8-3.8)	0.9% (3.58)	Circulatory Respiratory	6.1% (5.4-6.8)	4.5% (1.36)	3.9% (3.4-4.4)	2.2% (1.80)
IHD Osteoarthritis	4.5% (3.7-5.3)	1.5% (2.91)	2.4% (2.0-2.9)	0.5% (4.62)	Respiratory Endocrine*	5.9% (5.2-6.6)	4.4% (1.35)	4.2% (3.7-4.8)	2.3% (1.80)
Hypertension Obesity	4.5% (3.8-5.2)	2.1% (2.11)	3.5% (3.0-4.1)	N/A	Musculoskeletal Respiratory	5.7% (5.0-6.5)	3.7% (1.54)	3.8% (3.3-4.3)	1.8% (2.09)

Note: Patients could have more than two conditions/chapters, these are just the most common combinations of two (regardless of whether they had other conditions/chapters)

*Full name of chapter is Endocrine, nutritional & metabolic

was circulatory+endocrine/nutritional/ metabolic systems, with 19.8% of patients at GP encounters and 13.8% of the Australian population having at least one chronic condition in both systems.

For all the common combinations of chronic conditions/ICPC-2 chapters, the observed prevalence was significantly higher than the expected prevalence. For prevalence among patients at encounters, the combination of hypertension+IHD had the highest ratio of 3.11, while hypertension+depression had the lowest at 1.37. Combinations of chapters that included the psychological or respiratory chapter had comparatively lower observed-

to-expected ratios compared with the circulatory+endocrine/nutritional/metabolic systems (2.02) and digestive+musculoskeletal (2.01). The ratios for population prevalence were consistently higher than those for encounter prevalence.

Table 2 shows the prevalence of the most common combinations of three chronic conditions/ICPC-2 chapters. Once again, the most prevalent combinations of chronic conditions involved eight of the nine most prevalent conditions; the most common combination being hypertension+ hyperlipidaemia+osteoarthritis (5.5% of patients at GP encounters and 3.3% of people

in the population). The most prevalent combination of three body systems affected was circulatory+musculoskeletal+ endocrine/nutritional/metabolic systems (11.1% of patients at GP encounters and 7.0% of the Australian population). As with individual chronic conditions, the body systems that made up the most prevalent combinations were also the most prevalent chapters, with only six ICPC-2 chapters used. The observed-to-expected ratios were considerably higher for the combinations of three conditions/chapters than the combinations of two conditions/chapters.
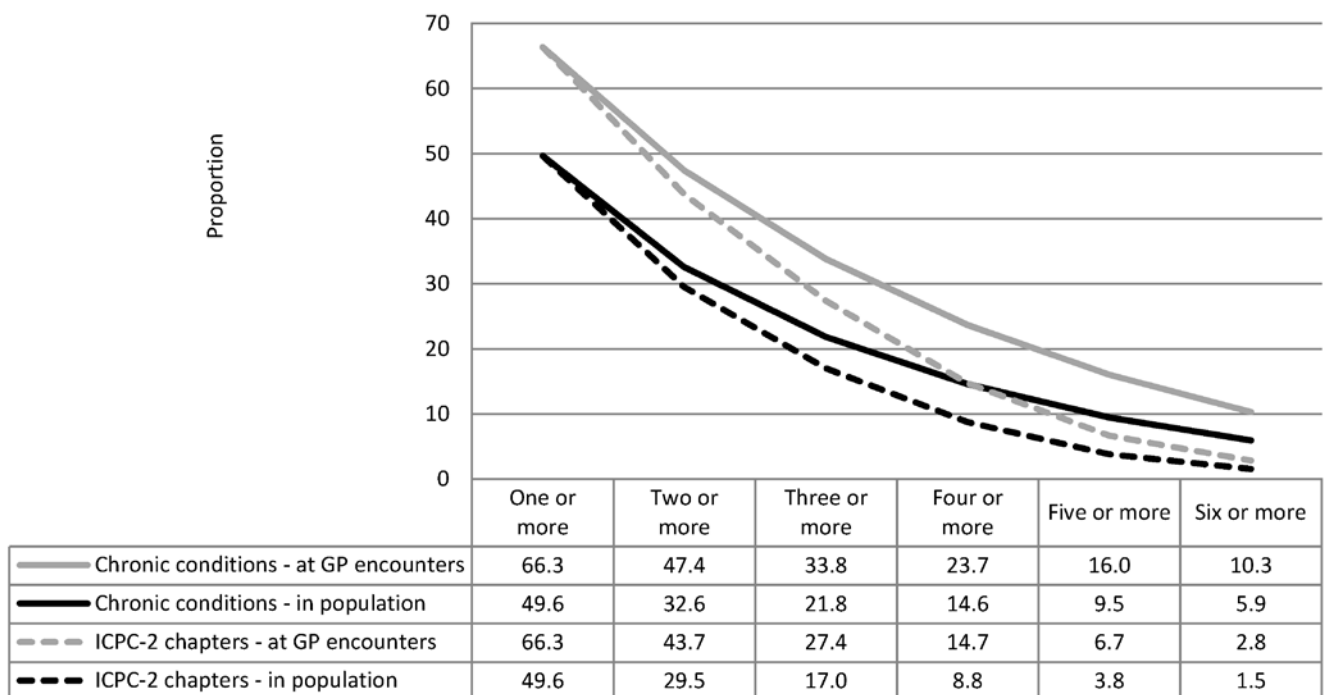
Table 2: Most prevalent patterns of three chronic conditions or three chapters affected by chronic conditions.

Chronic conditions	Most prevalent patterns of three chronic conditions				ICPC-2 chapters	Most prevalent patterns of three ICPC-2 chapters affected by chronic conditions			
	Observed prevalence among patients at encounters (95% CIs)	Expected prevalence among patients at encounters (Ratio)	Observed prevalence within Australian population (95% CIs)	Expected prevalence within Australian population (Ratio)		Observed prevalence among patients at encounters (95% CIs)	Expected prevalence among patients at encounters (Ratio)	Observed prevalence within Australian population (95% CIs)	Expected prevalence within Australian population (Ratio)
Hypertension Hyperlipidaemia Osteoarthritis	5.5% (4.7-6.4)	0.9% (6.28)	3.3% (2.81-3.80)	0.21% (15.5)	Circulatory Musculoskeletal Endocrine*	11.1% (9.9-12.4)	2.6% (4.31)	7.0% (6.2-7.8)	0.71% (9.84)
Hypertension IHD Hyperlipidaemia	4.1% (3.5-4.8)	0.4% (9.58)	2.6% (2.1-3.0)	0.10% (25.5)	Digestive Circulatory Endocrine*	6.3% (5.4-7.2)	1.6% (4.05)	4.1% (3.5-4.6)	0.45% (9.08)
Hypertension IHD Osteoarthritis	3.7% (3.0-4.4)	0.4% (8.98)	1.9% (1.6-2.3)	0.09% (22.0)	Digestive Circulatory Musculoskeletal	6.1% (5.2-7.0)	1.3% (4.60)	3.5% (3.0-4.1)	0.35% (9.94)
Hypertension Osteoarthritis GORD	3.5% (2.8-4.1)	0.5% (6.37)	1.9% (1.6-2.2)	0.13% (14.7)	Circulatory Musculoskeletal Psychological	6.0% (5.1-6.9)	1.9% (3.21)	3.7% (3.2-4.3)	0.56% (6.63)
Hypertension Hyperlipidaemia GORD	3.3% (2.8-3.9)	0.6% (5.78)	2.1% (1.8-2.5)	0.15% (13.7)	Circulatory Psychological Endocrine*	6.0% (5.1-6.8)	2.2% (2.73)	4.1% (3.5-4.7)	0.72% (5.73)
Hypertension Hyperlipidaemia Type 2 Diabetes	3.3% (2.8-3.7)	0.4% (8.08)	2.3% (2.0-2.7)	0.11% (20.5)	Digestive Musculoskeletal Endocrine*	5.3% (4.5-6.2)	1.3% (4.10)	3.4% (2.8-3.9)	0.38% (8.98)
IHD Hyperlipidaemia Osteoarthritis	2.7% (2.2-3.3)	0.3% (9.42)	1.5% (1.2-1.8)	0.06% (23.5)	Musculoskeletal Psychological Endocrine*	5.2% (4.4-6.0)	1.8% (2.86)	3.5% (3.0-4.1)	0.60% (5.83)
Hypertension Type 2 Diabetes Osteoarthritis	2.7% (2.3-3.2)	0.4% (6.87)	1.6% (1.3-1.9)	0.09% (16.9)	Circulatory Respiratory Endocrine*	4.3% (3.6-4.9)	1.4% (3.11)	2.7% (2.3-3.1)	0.46% (5.82)
Hyperlipidaemia Osteoarthritis GORD	2.6% (2.1-3.1)	0.4% (6.81)	1.6% (1.3-1.9)	0.10% (16.7)	Circulatory Musculoskeletal Respiratory	4.0% (3.4-4.6)	1.2% (3.40)	2.4% (2.1-2.8)	0.36% (6.63)
Hypertension Osteoarthritis Depression	2.4% (1.9-2.9)	0.6% (3.70)	1.4% (1.1-1.7)	0.17% (8.1)	Musculoskeletal Respiratory Endocrine*	3.7% (3.1-4.2)	1.1% (3.23)	2.4% (2.0-2.7)	0.39% (6.16)
Hypertension Hyperlipidaemia Obesity	2.2% (1.7-2.7)	0.4% (5.59)	1.7% (1.4-2.1)	NA	Digestive Circulatory Psychological	3.4% (2.8-4.0)	1.1% (3.01)	2.1% (1.8-2.6)	0.35% (5.93)
Hypertension Hyperlipidaemia Depression	2.2% (1.8-2.6)	0.7% (3.26)	1.6% (1.3-1.9)	0.20% (7.8)	Digestive Musculoskeletal Psychological	3.3% (2.7-3.9)	0.9% (3.52)	2.2% (1.8-2.6)	0.30% (7.40)

Note: Patients could have more than three conditions/chapters, these are just the most common combinations of three (regardless of whether they had other conditions/chapters)

* Full name of chapter is Endocrine, nutritional & metabolic

Discussion

For the first time in Australia, the patterns and prevalence of multimorbidity using all chronic conditions have been estimated from a nationally representative prospective study. We estimate that nearly half the patients at GP encounters and about one-third of the population have multimorbidity. Similar to previous studies,[7-9,14,26] we have shown that multimorbidity is an issue for a significant proportion of patients seen in general practice.

Our study has shown there are more patients at GP encounters with hypertension+ hyperlipdaemia+osteoarthritis than patients with many common individual conditions such as congestive heart failure (2.9%), rheumatoid arthritis (1.0%) or chronic obstructive pulmonary disease (4.1%).[22] It has also shown that about two-thirds of people with a chronic condition have two or more chronic conditions. This high proportion of patients with comorbidity suggests that we may need to re-examine the focus of our health care system on the management of single chronic conditions, particularly in regards to guidelines and clinical trials.

The prevalence observed for all common combinations of multimorbidity was higher than that expected by chance. This supports previous research that has shown that conditions, such as cardiovascular conditions, cluster together.[27,28] However, our results are unadjusted for patient age, which should account for some of this clustering as the prevalence of many chronic conditions increases with age. It is also possible that once a patient has been diagnosed with a chronic condition, their more frequent attendance to have it managed and monitored provides greater opportunity for other conditions to be diagnosed. Future studies will further investigate these relationships.

It has been suggested that multimorbidity defined as two or more chronic conditions identifies too high a proportion of patients with multimorbidity to be useful in resource planning and identifying patients with higher needs.[14,29] Our results support this conclusion, as nearly every second patient at encounters was identified as having multimorbidity using this definition. Complex multimorbidity appears to be a more discriminating measure, with our study identifying 27.4% of patients at encounters as having complex multimorbidity, similar to the 34.5% estimate among patients attending the two practices

in Perth.[8] Both these estimates are far higher than our first study where we estimated that only 10.6% of patients at encounters had complex multimorbidity. This is because the first study used a limited number of conditions covering only nine of the fourteen CIRS domains,[7] and limiting the number of conditions studied has been shown to reduce prevalence estimates of multimorbidity.[14]

Measuring the prevalence of complex multimorbidity is important as it is likely to identify higher-need patients, and this will help with allocation of health resources such as the number and types of health professionals required in an area. Reporting the patterns of body systems affected by chronic conditions may also help policy planners identify services that, if co-located, would be beneficial to the optimal care of these patients. The complex multimorbidity measure would also allow identification of patients who may need help in coordinating care between multiple health care providers.

While there is clearly value in measuring the patterns of body systems affected by chronic conditions, there is still great value in measuring the pattern of individual conditions. Knowledge of specific patterns of chronic conditions within an individual patient is crucial to their clinical care. Reporting the most prevalent patterns of individual chronic conditions in patients highlights the need for clinical guidelines for managing patients with common patterns of chronic conditions.

In an earlier study, we showed that when measuring the prevalence of complex multimorbidity it is vital to collect information on all chronic conditions – otherwise the estimate will be significantly less than the true prevalence.[14] However, the results of the current study suggest that when measuring the prevalence of the most common combinations of conditions, only the presence or absence of eight prevalent conditions needs to be collected. These conditions account for eight of the nine most prevalent conditions in Australia, with asthma being the other prevalent condition.[22]

Our study has limitations. We assumed that people who had not seen their GP in the previous year did not have a diagnosed chronic condition. This assumption may not hold for conditions such as asthma that, if mild, may not necessitate a GP attendance that year. Also, we can only provide estimates for those conditions already diagnosed,

and we know that not all cases of disease are diagnosed.[30] However, this limitation is shared with most prevalence studies.

Our study did not include a measure of the severity of the chronic conditions. This is important as, according to our definition, a patient with severe COPD and CHF would not be considered to have complex multimorbidity. In contrast, a patient with mild asthma, mild hypertension and controlled hyperlipidaemia would be considered to have complex multimorbidity. The first patient would, however, usually be more complex to manage and require more health services than the second. In our next study we will examine the relationship between the number of diagnosed chronic conditions/body systems affected and overall severity of illness, complexity of care and health resource utilisation.

Finally, our sample was drawn from patients attending general practice, so we were more likely to sample people who attend more frequently. While we adjusted for higher attendance of female and older patients, our method could not adjust for individual high attenders within a specific age–sex group. If patients with particular conditions consistently attend more often than the average for their age and sex, this could lead to an overestimate of the prevalence of these conditions in our study.

Conclusion

For the first time in Australia, the prevalence and patterns of multimorbidity using all chronic conditions have been estimated from a nationally representative prospective study. A significant number of Australians not only have multimorbidity, but have complex multimorbidity. Some patterns of complex multimorbidity are more prevalent than single conditions that receive a lot of individual attention. If we are to meet the challenge posed by the increasing prevalence of complex multimorbidity, we need to re-evaluate the single disease focus of our healthcare system. This will be particularly important for health service planning. In our next paper, we will examine how well complex multimorbidity predicts resource utilisation, complexity of care and overall severity of illness.

Acknowledgements

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The study in this chapter explored the prevalence and patterns of multimorbidity and complex multimorbidity among patients at encounters and people in the population, using the definitions I devised and described in Chapter 4. However, the adjustment of GP encounter prevalence estimates to those of the population, based on the method first described in Chapter 3, had the limitation of not being able to adjust for high and low attenders within each age-sex group. As I said in this paper, if within age-sex groups, patients with more chronic conditions attend GPs more often than those with fewer conditions, then our multimorbidity will be an overestimate. The next chapter is based on a new, larger survey in which I took steps to address this limitation.

Chapter 6: The prevalence of diagnosed chronic conditions and multimorbidity in Australia: A method for estimating population prevalence from general practice patient encounter data

The prevalence of diagnosed chronic conditions and multimorbidity in Australia: A method for estimating population prevalence from general practice patient encounter data

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Abstract

Objectives

To estimate the prevalence of common chronic conditions and multimorbidity among patients at GP encounters and among people in the Australian population. To assess the extent to which use of each individual patient's GP attendance over the previous year, instead of the average for their age-sex group, affects the precision of national population prevalence estimates of diagnosed chronic conditions.

Design, setting and participants

A sub-study (between November 2012 and March 2016) of the Bettering the Evaluation and Care of Health program, a continuous national study of GP activity. Each of 1,449 GPs provided data for about 30 consecutive patients (total 43,501) indicating for each, number of GP attendances in previous year and all diagnosed chronic conditions, using their knowledge of the patient, patient self-report, and patient's health record.

Results

Hypertension (26.5%) was the most prevalent diagnosed chronic condition among patients surveyed, followed by osteoarthritis (22.7%), hyperlipidaemia (16.6%), depression (16.3%), anxiety (11.9%), gastroesophageal reflux disease (GORD) (11.3%), chronic back pain (9.7%) and Type 2 diabetes (9.6%).

After adjustment, we estimated population prevalence of hypertension as 12.4%, 9.5% osteoarthritis, 8.2% hyperlipidaemia, 8.0% depression, 5.8% anxiety and 5.2% asthma. Estimates were significantly lower than those derived using the previous method.

About half (51.6%) the patients at GP encounters had two or more diagnosed chronic conditions and over one third (37.4%) had three or more. Population estimates were: 25.7% had two or more diagnosed chronic conditions and 15.8% had three or more.

Conclusions

Of the three approaches we have tested to date, this study provides the most accurate method for estimation of population prevalence of chronic conditions using the GP as an expert interviewer, by adjusting for each patient's reported attendance.

Introduction

Australia has a universal medical insurance scheme called Medicare which (fully or partially) covers the individuals cost of visits to general practitioners (GPs). GPs are paid on a fee-for-service basis. There is no patient registration, patients being free to visit any number practices and GPs as they choose. In any single year around 85% of Australians see a GP at least once[1] with GPs providing the bulk of primary care and acting as gate-keepers to government-subsidised health care from other health professionals.

Like all OECD countries, Australia's population is ageing[2,3]. It is expected this will increase the prevalence of diagnosed chronic conditions[4,5], of multimorbidity[6–8], and demand on the health care system[7,9,10]. In response, the Australian federal government recently announced a "Health Care Home" (Patient Centred Medical Home) initiative whereby patients with chronic and complex conditions voluntarily enrol at a general practice[11]. This plan will include a "bundled payment" (partial capitation) to the practice for each patient enrolled. While initial reports implied that patients with multiple chronic conditions would be targeted by the initiative, recent announcements suggest that patient eligibility will be determined by their risk of hospital admission[12]. However, hospital admission risk may not accurately predict use of general practice services, yet this will be required to calculate fair compensation to GPs under the partial capitation model of the initiative. Preliminary results have shown that multimorbidity is a strong predictor of primary care resource use[13]. Therefore to cost this initiative, the prevalence of chronic conditions and multimorbidity needs to be measured accurately.

Large population health surveys that rely on respondent self-report are commonly used to measure the prevalence of chronic conditions[14–16]. One such study is the National Health Survey (NHS)[17], one of Australia's largest health surveys, undertaken by the Australian Bureau of Statistics every three to six years since 1989. The most recent (2014–15) surveyed 19,259 people from 14,723 households, and while it used some measured data (such as respondent's blood pressure, height, weight and waist circumference) it still relied on respondent self-report for measurement of the prevalence of chronic conditions.[17] This is despite concerns about the accuracy of self-reported health information[18–22].

Due to these concerns, review of health records (paper and/or electronic) is often assumed to be a more accurate way of estimating prevalence of chronic conditions. However, this approach has its own issues with the stored information sometimes being inaccurate and often incomplete[23–25]. There are also concerns around obtaining patient consent to use their data, with many patients not being informed[26].

The BEACH (Bettering the Evaluation And Care of Health) program was a study of GP clinical activity in Australia[1]. Sub-studies of the BEACH program allowed us to investigate aspects of health and health care delivery, free of the limitations of health record audits and patient self-report. The sub-studies utilised the GP as an expert interviewer and informant, drawing on the patient's knowledge, their knowledge of the patient, and the patient's health record.

A study conducted in 2005 showed that sub-studies embedded within the national BEACH program could provide timely, accurate prevalence estimates of common chronic conditions in Australia[4].

In 2008–09, we conducted another sub-study which built on our earlier methods by expanding the study's scope to include all chronic conditions (rather than a selection of common chronic conditions) and by improving the methods of dealing with non-attenders when estimating population prevalence[5].

However, in the earlier studies we were not able to adjust for high and low attenders to general practice within each age-sex group of patients. This meant that our national estimates may have been inflated if, within a specific age-sex group, people with more diagnosed chronic conditions attend more often than people without chronic conditions. This may be true as our 2008–09 study estimated that 32.6% of the population had two or more diagnosed chronic conditions, a significantly higher proportion than that of the 2014–15 NHS (23.0%)[17].

Since the 2008–09 study, we introduced an additional question asking how many times the patient had seen a GP in previous 12 months (including today's visit). This will allow adjustment for attendance for each individual patient and overcomes the major limitation of the 2008–09 study.

If it is decided that the compensation paid to GPs for each patient enrolled in the health care home initiative is based on the patient's multimorbidity load, the way multimorbidity is measured will also need to be decided. The most common way of measuring multimorbidity is a simple count of the number of diagnosed chronic conditions within a patient[7,27]. Alternatively, it has been suggested that it is not the number of individual chronic conditions that is important, but the number of body systems affected by these chronic conditions[8,27].

The aims of this study were to:

1. estimate the prevalence of common chronic conditions among patients at GP encounters and among people in the Australian population.

2. assess the extent to which use of each individual patient's reported GP attendance over the previous year, instead of the average for their age-sex group, affects the precision of national population prevalence estimates of diagnosed chronic conditions.

3. estimate the prevalence of multimorbidity among patients at GP encounters and among people in the Australian population.

Method

This study was undertaken as a sub-study of the BEACH program. BEACH was a continuous, national cross-sectional study of general practice activity in Australia operating from April 1998–March 2016 inclusive. Its methods are described in detail elsewhere.[1] In summary, each year an ever-changing, random sample of about 1,000 GPs each recorded information about encounters with 100 consecutive consenting patients, on structured paper forms.

In BEACH sub-studies, the GP recorded information additional to the encounter data, in discussion with the patient. In this sub-study, 1,800 participating GPs were each asked to record all diagnosed chronic conditions present in each of 30 consecutive patients within their 100 BEACH encounter forms over twelve five-week recording periods between 27th November 2012 and 28th March 2016.

GPs were instructed to "Use your own knowledge, patient knowledge and health records as you see fit, in order to answer these questions". GPs were first asked, "Approx. how many times has this patient seen <u>any</u> GP in the past 12 months? (Including today)". They were then

asked "Does the patient have any chronic diseases/problems?". If 'No', the GP ended the questions for that patient. If 'Yes', the GP indicated all the diagnosed chronic conditions for that patient. Tick boxes were provided for common chronic conditions and additional blank spaces were provided to allow free text recording of other unlisted chronic condition.

Chronic conditions listed were primarily those that were included in the previous prevalence study[5] based on those most frequently managed in Australian general practice[1]. Chronic conditions were classified according to the International Classification of Primary Care (Version 2) (ICPC-2)[28].

Examples of the instruction sheet and the recording form provided to the GP are attached in S2 and S3 Files. The final question (which was not analysed for this paper) varied over the sub-studies, however the variables analysed in this paper were asked consistently across the sub-studies.

Data analysis

In previous studies[4,5] we found that patients for whom no response was recorded for the chronic condition question were similar in terms of age and problems managed at their encounters, to patients for whom the "no chronic conditions" option was recorded. Based on these similarities, we assumed that some GPs were leaving this question blank for patients who had no diagnosed chronic conditions. To account for this, patients with missing chronic condition data were counted as having "No chronic conditions" to ensure we did not overestimate the prevalence of chronic conditions. We then examined these same patient's encounter record to see whether any chronic conditions (as defined by O'Halloran et al[29]) were managed at their encounter. If chronic conditions were managed at the encounter, they were no longer considered to have "No chronic conditions" and those chronic conditions managed at their encounter were assigned to the patient in the sub-study. If in the current study we find that patients with missing chronic condition data were similar to those who had the "No chronic conditions" option ticked, we will follow the steps described above from previous studies.

When the number of GP visits in the previous year was not recorded (missing data), the average number of visits for a patient in the same 10 year age group, the same sex and the same number of diagnosed chronic conditions (0,1,2,3+ chronic conditions) was assigned.

Multimorbidity was defined as the "co-occurrence of two or more chronic conditions within one person without defining an index chronic condition" and complex multimorbidity as the "co-occurrence of three or more chronic conditions affecting three or more different body systems within one person without defining an index chronic condition"[27]. The chapters of ICPC-2 were used to represent the different body systems. A patient with complex multimorbidity had at least one diagnosed chronic condition in each of three or more different ICPC-2 chapters. Body systems were counted only once per patient, even if they had multiple chronic conditions classified to that body system.

The proportion of patients with morbidity X in the unweighted sample can be interpreted as the prevalence of that condition among patients found in GP waiting rooms or at GP encounters. We compared the prevalence of common chronic conditions at GP encounters with two earlier studies (Knox et al.[4] & Harrison et al.[5]) that used the same method. The only differences between the studies were that Knox et al. used a limited number of conditions and the conditions listed in Harrison et al[5] were listed in a different order.

As patients were sampled at GP consultations, the likelihood of being sampled is dependent on visit frequency. Therefore frequent attenders (such as older patients who may have more health problems) were more likely to be sampled than infrequent attenders.

In Harrison et al.[5], to estimate national prevalence, we weighted the data to match the age–sex distribution of the Australian population. We assumed that people who did not attend a GP that year had no diagnosed chronic conditions. After the above weighting we multiplied the outcome (condition count) for each patient, by the proportion of their age-sex group who saw a GP at least once that year (data supplied by the Australian Government Department of Health). This accounted for those who did not see a GP that year. However, this method did not account for high attenders within specific age-sex groups.

In the current study, we were able to adjust for high or low attenders by weighting each patient's data by the number of times they reported seeing a GP in the previous year, with high attenders being weighted down and low attenders being weighted up. We then followed the previous method using the weighted data instead of the raw data. Table 1 demonstrates how the weightings were calculated for each of the two methods using two example patients.

To test the effect of this new method on our estimates, we weighted the current data using both methods. We compared these national prevalence estimates with those of the previous study. If it is true that within an age-sex group, patients with chronic conditions attend more often than those without chronic conditions, then the prevalence estimates resulting from the new method should produce lower estimates than those produced by the previous method.

BEACH sub-studies have a single stage cluster design, with each GP having 30 patients clustered around them. Survey procedures (in SAS 9.3) were used to account for the effect of this clustering. Significant differences were determined by non-overlapping 95% confidence intervals (CIs). This is a more conservative estimate of difference than the usual p<0.05[30].

Ethics statement

During the data collection period for this study the BEACH program was approved by the Human Research Ethics Committee of the University of Sydney (Reference number 2012/130). Our method involved the collection of data from unidentifiable, consenting patients. In the research kit, a patient information card was supplied and GPs were instructed to show this to patients in order to obtain informed consent (an example shown in Britt et al.[1]). If the patient chose not to participate, their encounter details were not recorded. GPs were instructed to note the patient's consent in the patient's record, but were not asked to provide written consent to the research body, to preserve patient anonymity. These methods comply with the Ethics requirements for the BEACH program.

Table 1. New and previous methods to weight "encounter" data to reflect "population" prevalence.

	Example 1: Male patient aged 10–14 years		Example 2: Female patient aged 80–84 years	
	Old Method	New Method	Old Method	New Method
Reported number of GP visits in previous year (A)	—	8	—	6
Average number of GP visits for total sample(B)	—	4.54	—	4.54
C = B/A (Weight to adjust for attendance)	1	0.57	1	0.76
Proportion of the Australian population (D)	3.10%	3.10%	1.09%	1.09%
Proportion of sample that was in the selected age-sex group (after weighting in the New method) (E)	1.18%	2.03%	3.15	1.47%
F = D/E (National weight)	2.63	1.53	0.35	0.74
G = Proportion of age-sex group that saw a GP at least once that year	74.85%	74.85%	96.53%	96.53%
Final adjustment of outcome (or numerator) to estimate national prevalence = C*F*G	1.97	0.65	0.34	0.54
Denominator for national estimates (for both patients with and without condition) = C*F	2.63	0.87	0.35	0.56

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Results

Of the 1,800 GPs recruited, 1,449 GPs (80.5%) returned completed recording forms. Of the 43,501 patients in this sample, 41,722 (95.9%) reported the number of times they had seen a GP in the previous year and 42,185 (97.0%) responded to the chronic condition questions. The 1,316 patients with missing chronic condition data were examined and found to be similar to those patients with no chronic conditions, with both groups being younger on average than the total sample. Further, the most frequently managed problems at their encounters were acute, whereas in the total sample the most frequently managed conditions were chronic. Of these 1,316 patients, 323 (24.5%) had one or more chronic conditions managed at the encounter and were included as having these conditions while the remaining 993 (75.5%) were added to the no chronic conditions group (results not tabled).

On average, patients in the sample had seen a GP 9.66 times in the previous 12 months. After adjusting for this attendance, we estimated that all people who had seen a GP at least once in the previous 12 months, visited a GP 4.54 times on average.

Overall, the age-sex distribution of the sample was similar (range 0.80–1.14) to that of patients at all Medicare or Department of Veteran Affairs (DVA) claimed GP consultations, with the exception of patients aged less than 15 years (80–83% of expected) (Table 2). After

Table 2. Age-sex distribution of the sample.

Patient Age/Sex	Number in sample	Percent of sample (95% CI)	Percent of Australian general practice service claims*	Precision ratio	Percent of sample after adjusting for attendance	Percent of the Australian general practice population@	Precision ratio
Male							
<15 years	2,369	5.5% (5.2–5.8)	6.9%	0.80	8.1% (7.7–8.6)	9.4%	0.86
15–24 years	1,246	2.9% (2.7–3.1)	3.2%	0.91	5.0% (4.7–5.4)	5.5%	0.92
25–44 years	3,210	7.5% (7.1–7.9)	8.8%	0.85	11.0% (10.4–11.6)	12.3%	0.89
45–64 years	4,735	11.0% (10.6–11.4)	11.2%	0.99	11.6% (11.1–12.2)	12.3%	0.95
65–74 years	2,756	6.4% (6.1–6.7)	6.0%	1.07	4.8% (4.5–5.1)	4.5%	1.06
75+ years	3,011	7.0% (6.6–7.4)	6.8%	1.03	3.5% (3.3–3.8)	3.3%	1.09
Female							
<15 years	2,236	5.2% (4.9–5.5)	6.3%	0.83	7.7% (7.2–8.2)	8.9%	0.87
15–24 years	2,159	5.0% (4.7–5.3)	5.5%	0.91	6.6% (6.1–7.0)	6.3%	1.04
25–44 years	6,057	14.1% (13.6–14.6)	14.4%	0.98	15.7% (15.0–16.3)	14.8%	1.06
45–64 years	6,927	16.1% (15.7–16.6)	14.6%	1.10	15.0% (14.4–15.6)	13.6%	1.11
65–74 years	3,593	8.4% (8.0–8.7)	6.8%	1.22	5.7% (5.4–6.0)	4.9%	1.18
75+ years	4,605	10.7% (10.2–11.3)	9.4%	1.14	5.2% (4.9–5.5)	4.2%	1.23

There were 492 patients who had either/both age and/or sex missing.

*All general practice Medicare Benefits Schedule (MBS) items claimed GPs in 2014–15 and all Department of Veteran Affairs GP claims in 2012–13 (Most recent year available). MBS data supplied by the Medicare Information Analysis Section and Department of Veteran Affairs data was supplied by the Department of Veteran Affairs.

@Distribution of all patients who had at least one MBS GP service item claimed in 2014–15

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adjusting for each patient's attendance over the previous year, the age-sex distribution of the weighted sample was similar to that of all patients who had claimed at least one Medicare GP item of service within the previous year, with the exception of female patients aged 75 years and over (23% more than expected).

Sample prevalence of individual chronic conditions

The circulatory system was the body system most commonly affected by a chronic condition, with nearly a third (32.4%) of patients at GP encounters having at least one diagnosed circulatory chronic condition (Table 3). The musculoskeletal system and connective tissue (32.1%); and the endocrine, nutritional and metabolic disease system (30.7%) were also commonly affected by at least one diagnosed chronic condition. About one quarter (26.7%) of patients at GP encounters had a diagnosed psychological problem.

Table 3. Prevalence of common diagnosed chronic conditions among patients at GP encounters across three studies.

	Knox et al. estimates (2005, n = 9,156)	Harrison et al. (2008–09, n = 8,707)	Current estimates (2012–16, n = 43,501)
Circulatory	**30.0% (28.1–31.7)**	**31.3% (29.4–33.1)**	**32.4% (31.5–33.4)**
Hypertension	23.3% (21.8–24.9)	26.6% (24.9–33.1)	26.5% (25.6–27.3)
Ischaemic Heart Disease	9.5% (8.5–10.5)	8.7% (7.7–9.8)	7.8% (7.4–8.2)
Cerebrovascular Accident	3.7% (3.0–4.5)	2.9% (2.3–3.5)	2.6% (2.4–2.8)
Congestive Heart Failure	3.2% (2.7–3.7)	2.9% (2.4–3.4)	2.6% (2.4–2.8)
Peripheral Vascular Disease	2.0% (1.5–2.5)	N/A	1.8% (1.7–2.0)
Musculoskeletal system and connective tissue	**N/A**	**26.4 (24.6–28.2)**	**32.1% (31.1–33.0)**
Any Arthritis	22.8% (21.1–24.5)	19.7% (18.1–21.4)	25.0% (24.1–25.9)
Rheumatoid	1.0% (0.8–1.2)	1.0% (0.7–1.2)	1.3% (1.2–1.5)
Osteoarthritis	20.0% (18.3–21.6)	17.8% (16.2–19.4)	22.7% (21.8–23.6)
Other and unknown	N/A	2.0% (1.7–2.4)	2.0% (1.9–2.2)
Chronic Back Pain	10.1% (9.0–11.1)	6.4% (5.5–7.2)	9.7% (9.2–10.2)
Osteoporosis	N/A	4.8% (4.2–5.5)	5.8% (5.4–6.1)
Endocrine, nutritional and metabolic diseases	**N/A**	**30.8% (29.0–32.6)**	**30.7% (29.9–31.6)**
Hyperlipidaemia	15.9% (14.7–17.2)	18.5% (17.0–20.0)	16.6% (15.9–17.3)
Diabetes all	8.3% (7.5–9.0)	9.2% (8.3–10.1)	10.4% (10.0–10.8)
Type 1	0.6% (0.4–0.8)	0.9% (0.6–1.2)	0.9% (0.8–1.0)
Type 2	7.2% (6.5–7.9)	8.3% (7.5–9.1)	9.6% (9.2–10.0)
Psychological Problems	**24.8% (23.2–26.3)**	**22.1% (20.6–23.7)**	**26.7% (25.9–27.5)**
Depression	14.2% (13.0–15.4)	13.7% (12.6–14.7)	16.3% (15.8–16.9)
Anxiety	10.7% (9.6–11.8)	8.3% (7.3–9.4)	11.9% (11.4–12.4)
Insomnia	5.5% (4.6–6.4)	N/A	3.7% (3.4–4.0)
Digestive	**N/A**	**14.6% (13.4–15.8)**	**15.1% (14.5–15.7)**
GORD	13.1% (11.9–14.4)	11.6% (10.5–12.6)	11.3% (10.7–11.8)
Respiratory Disease	**N/A**	**13.7% (12.6–14.7)**	**14.6% (14.1–15.1)**
Asthma	10.7% (9.8–11.6)	9.5% (8.7–10.3)	8.3% (8.0–8.7)
COAD/COPD	3.6% (3.1–4.2)	4.1% (3.4–4.7)	4.5% (4.2–4.7)
Malignant Neoplasms	**3.1% (2.6–3.6)**	**5.0% (4.4–5.7)**	**6.2% (5.9–6.5)**

Note: GORD = gastro oesophageal reflux disease, COAD/COPD chronic obstructive airways disease/chronic obstructive pulmonary disease
N/A: Result not available due to chronic condition not being measured

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Hypertension (26.5%) was the most prevalent individual diagnosed chronic condition, followed by osteoarthritis (22.7%), hyperlipidaemia (16.6%), depression (16.3%), anxiety (11.9%), gastroesophageal reflux disease (GORD) (11.3%), chronic back pain (9.7%) and Type 2 diabetes (9.6%).

The prevalence estimates for diagnosed ischaemic heart disease, cerebrovascular accidents, GORD and asthma among patients at GP encounters were significantly lower than the 2005 study estimates. Conversely, the prevalence estimates of diagnosed hypertension, osteoarthritis, Type 2 diabetes, depression and malignant neoplasms were each significantly higher than in the 2005 study.

Population prevalence of individual conditions

After adjustment, we estimated that 16.0% of people in the population had at least one endocrine, nutritional and metabolic disease, 15.0% had at least one circulatory condition and 14.4% had at least one musculoskeletal system and connective tissue chronic condition (Table 4).

Hypertension was the most prevalent condition (12.4% of the population) followed by osteoarthritis (9.5%), hyperlipidaemia (8.2%), depression (8.0%), anxiety (5.8%), asthma (5.2%), GORD (4.9%), Type 2 diabetes (4.2%) and chronic back pain (4.1%).

Almost all the population prevalence estimates using the new 'revised' method were significantly lower than the 2008–09 prevalence estimates. However, when the current study's data were analysed using the older method (which adjusted for age-sex group attendance averages rather than individual patient's attendance) the prevalence estimates did not significantly differ from those found in the previous study. The population prevalence estimates produced using the new method were significantly lower (between 18% lower for dementia to 40% lower for insomnia) than those derived using the previous method when using the same data.

Compared with the 2014–15 NHS estimates, our prevalence estimates were significantly higher for circulatory conditions (including congestive heart failure), endocrine, nutritional and metabolic disease (including hyperlipidaemia), gastrointestinal conditions and malignant neoplasms. Our prevalence estimates were significantly lower for total arthritis, rheumatoid arthritis, other arthritis, osteoporosis, asthma and chronic obstructive pulmonary disease than the 2014–15 NHS estimates.

Prevalence of multimorbidity

About half (51.6%) the patients at GP encounters had two or more diagnosed chronic conditions and over one third (37.4%) had three or more. Nearly half (47.8%) had two or more body systems affected by chronic conditions and 30.4% had complex multimorbidity (Fig 1).

After adjustment we estimated that: 25.7% of the population had two or more diagnosed chronic conditions: 15.8% had three or more; 23.0% had two or more body systems affected by chronic conditions; and 12.1% of the population had complex multimorbidity (Fig 1).

Discussion

Adjusting for each individual patient's GP attendances over the previous 12 months provided prevalence estimates that were significantly lower than those generated by our previous method. This suggests that within an age-sex group, patients with diagnosed chronic conditions attend more often than those patients without. Adjusting for this variance will have made our population estimates more accurate than our previous estimates. We found that the clear majority of patients at GP encounters had at least one diagnosed chronic condition and about

Table 4. Population prevalence of common diagnosed chronic conditions and multimorbidity.

	Harrison et al. (2008–09, n = 8,707) (95% CIs)	Current using previous method (2012–15, n = 43,501) (95% CIs)	Current using revised method (2012–15, n = 43,501) (95% CIs)	National Health Survey (2014–15, n = 19,259) (95% CIs)
Circulatory	**19.6% (18.3–20.9)**	**18.5% (17.9–19.2)**	**15.0% (14.3–15.6)**	**18.3% (17.7–18.9)**
Hypertension	16.6% (15.4–17.8)	15.1% (14.5–15.7)	12.4% (11.8–12.9)	11.3% (10.8–11.8)
Ischaemic Heart Disease	5.0% (4.4–5.6)	4.0% (3.8–4.2)	2.9% (2.7–3.1)	**
Cerebrovascular Accident	1.5% (1.2–1.8)	1.3% (1.2–1.4)	0.9% (0.8–1.0)	0.8% (0.6–1.0)
Congestive Heart Failure	1.5% (1.2–1.8)	1.2% (1.1–1.3)	0.8% (0.7–0.8)	0.5% (0.4–0.6)
Peripheral Vascular Disease	N/A	0.9% (0.8–1.0)	0.6% (0.5–0.6)	**
Musculoskeletal system and connective tissue	**16.7% (15.5–18.0)**	**19.2% (18.5–19.9)**	**14.4% (13.8–15.1)**	**
Any Arthritis	11.9% (10.8–12.9)	13.9% (13.3–14.5)	10.7% (10.1–11.2)	15.3% (14.8–15.8)
Rheumatoid	0.6% (0.4–0.7)	0.8% (0.7–0.9)	0.6% (0.5–0.6)	1.8% (1.6–2.0)
Osteoarthritis	10.4% (9.4–11.4)	12.3% (11.7–12.8)	9.5% (9.0–10.0)	9.0% (8.6–9.4)
Other and unknown	1.5% (1.2–1.7)	1.4% (1.3–1.6)	1.0% (0.9–1.2)	5.3% (4.9–5.7)
Chronic Back Pain	4.4% (3.8–5.0)	6.5% (6.2–6.9)	4.1% (3.8–4.3)	**
Osteoporosis	2.4% (2.1–2.8)	2.6% (2.4–2.8)	2.1% (1.9–2.2)	3.5% (3.2–3.8)
Endocrine, nutritional and metabolic diseases	**21.3% (19.9–22.6)**	**20.0% (19.4–20.6)**	**16.0% (15.3–16.6)**	**13.8% (13.3–14.3)**
Hyperlipidaemia	12.3% (11.3–13.4)	10.0% (9.5–10.4)	8.2% (7.7–8.6)	7.1% (6.7–7.5)
Diabetes all	6.1% (5.5–6.7)	6.4% (6.2–6.7)	4.6% (4.4–4.9)	5.1% (4.8–5.4)
Type 1	0.7% (0.5–0.9)	0.7% (0.6–0.8)	0.5% (0.4–0.6)	0.7% (0.5–0.9)
Type 2	5.5% (4.9–6.0)	5.8% (5.5–6.0)	4.2% (3.9–4.4)	4.4% (4.1–4.7)
Psychological Problems	**16.6% (15.3–17.8)**	**20.5% (19.8–21.2)**	**13.7% (13.1–14.2)**	**17.5% (16.8–18.2)**
Depression	10.0% (9.2–10.8)	12.5% (12.0–13.0)	8.0% (7.6–8.4)	8.9% (8.4–9.4)
Anxiety	6.2% (5.4–7.0)	9.3% (8.9–9.8)	5.8% (5.5–6.2)	**
Insomnia	N/A	2.4% (2.2–2.6)	1.5% (1.3–1.6)	N/A
Digestive	**9.6% (8.8–10.4)**	**9.9% (9.4–10.3)**	**7.1% (6.7–7.5)**	**6.2% (5.8–6.6)**
GORD	7.5% (6.8–8.2)	6.9% (6.5–7.2)	4.9% (4.6–5.2)	N/A
Respiratory Disease	**10.5% (9.7–11.4)**	**11.1% (10.7–11.5)**	**7.9% (7.6–8.3)**	**
Asthma	7.8% (7.1–8.5)	7.1% (6.8–7.4)	5.2% (4.9–5.5)	10.8% (10.2–11.4)
COPD	2.5% (2.1–2.9)	2.4% (2.2–2.6)	1.6% (1.5–1.7)	2.6% (2.3–2.9)
Malignant Neoplasms	**3.1% (2.7–3.6)**	**3.4% (3.2–3.6)**	**2.8% (2.6–3.0)**	**1.6% (1.4–1.8)**

Note: GORD = gastro oesophageal reflux disease, COPD chronic obstructive pulmonary disease

** Inclusions used by NHS too different for reasonable comparison, N/A Results not available

half had two or more. The most prevalent conditions among both patients at GP encounters and among people in the population were hypertension, osteoarthritis and hyperlipidaemia.

In our earlier prevalence papers we suggested that some of the differences between our prevalence estimates and those of the NHS may be due to respondent self-report error[4,5]. For instance the relatively high NHS prevalence estimates for rheumatoid arthritis may be due to respondents confusing it with 'rheumatism'[5]. We found a similar difference in the current study. One of the great advantages of using the GP as an expert interviewer with access to the patient health record is that any such confusion from the patient can be clarified by the GP.

We estimated that about a quarter (25.7%) of the population had multimorbidity, two or more diagnosed chronic conditions, which is significantly smaller than the 32.6% estimated in our previous study(7). The lower estimates are due to using the new, more reliable method of
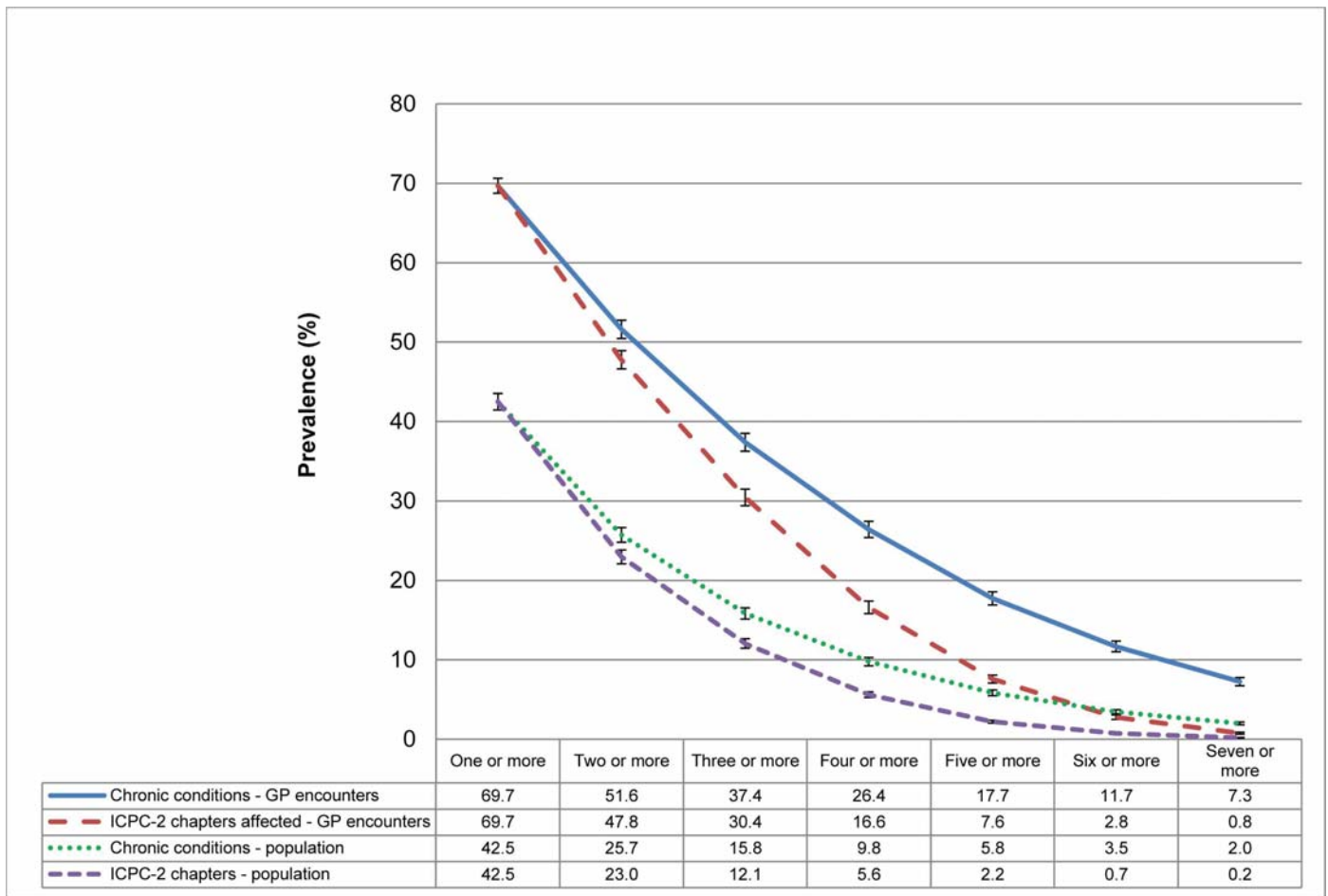
Fig 1. Prevalence of the number of chronic conditions among patients at encounters and people in the Australian population. (Note to go below Fig 1). Note: ICPC-2 chapters used as a proxy for body system.

	One or more	Two or more	Three or more	Four or more	Five or more	Six or more	Seven or more
Chronic conditions - GP encounters	69.7	51.6	37.4	26.4	17.7	11.7	7.3
ICPC-2 chapters affected - GP encounters	69.7	47.8	30.4	16.6	7.6	2.8	0.8
Chronic conditions - population	42.5	25.7	15.8	9.8	5.8	3.5	2.0
ICPC-2 chapters - population	42.5	23.0	12.1	5.6	2.2	0.7	0.2

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estimating population prevalence of chronic conditions. However this revised estimate of the population prevalence multimorbidity remains significantly higher than the 23.0% estimated by the 2014–15 NHS[17]. This difference is probably due to the NHS only counting a selected list of chronic conditions while our study counted all chronic conditions. Previous research has shown that counting all chronic conditions provides the most reliable estimates of multi-morbidity[27]. The issues of respondent accuracy noted above and the restricted list of chronic conditions used by the NHS, suggest that our estimates of multimorbidity may be more reliable than those of the NHS.

Our estimate of multimorbidity infers that 6.2 million patients would have been eligible to enrol in a Health Care Home' if eligibility was based on two or more diagnosed chronic conditions, as suggested from earlier Government statements. Our estimate of the proportion of patients at GP encounters with complex multimorbidity (30.4%) was higher than that found in our earlier study[7] (27.4%) and lower than that estimated by Brett et al (34.5%) among patients attending two GP practices in Perth[8].

Our study does have limitations. We have assumed that people who did not see a GP in the previous year, did not have a diagnosed chronic condition. This assumption may not hold for conditions such as mild asthma where a patient may not need to see a GP in a single chosen

year. This may explain why our prevalence estimate for asthma was lower than that of the NHS.

The apparent over-representation of older patients attending a GP at least once in our study is probably due to comparing our sample to only the Medicare data. Medicare data would not include patients who only claimed DVA services that year. However, since patients who are covered by the DVA can also claim through Medicare, we could not combine those who made at least one claim in both datasets for fear of double counting the same patients. The DVA data is heavily skewed towards older patients (veterans of World War Two and their partners). It is likely that our estimated distribution of patients who attend general practice at least once in the previous year is actually far closer to reality than is implied by our comparison with Medicare claims data alone.

Our estimate of the average number of GP visits (4.54) for patients who had seen a GP at least once, was significantly lower than the average number of Medicare GP consultation items claimed per person, by those who claimed at least once (6.8 in 2014–15[31]). This means that the patients and GPs were under-reporting the number of GP visits made in the previous 12 months. This may be because the patient had seen another GP but had forgotten the visit(s) and/or did not wish the current GP to know of it. This under-reporting could have affected our national prevalence estimates if there was a bias for high or low attenders to under-report more often, and this cannot be assessed from the data.

Conclusion

Of the three approaches we have tested to date, this study provides the most accurate method for estimation of population prevalence of chronic conditions using the GP as an expert interviewer, by adjusting for each patient's reported attendance. The results provide the groundwork for the Australian Federal Government to cost and plan the rollout of the 'health care homes' initiative. If this initiative results in GPs enrolling high-need patients with multiple chronic conditions, the GPs will need to be properly compensated for switching from full fee-for-service to partial capitation. Further research is underway, examining the extent to which measures of multimorbidity can provide a structure for scientific calculation of appropriate capitation payments.

Supporting information

S1 File. Data points for Fig 1.
(XLSX)

S2 File. Example of BEACH recording form.
(PDF)

S3 File. Example of information form provided to GPs for this particular sub-study.
(PDF)

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Conceptualization: CH HB JH GM.

Data curation: CH.

Formal analysis: CH.

Funding acquisition: CH HB JH GM.

Investigation: CH HB JH GM.

Methodology: CH HB JH GM.

Project administration: CH HB JH GM.

Resources: CH JH.

Software: CH.

Supervision: HB JH GM.

Validation: CH.

Visualization: CH.

Writing – original draft: CH.

Writing – review & editing: CH HB GM JH.

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The paper in this chapter introduced the second survey of my thesis, Australia's largest study of multimorbidity. This survey allowed me to improve my method for estimating population prevalence from general practice data by overcoming the limitation of not being able to adjust for high and low attenders in the earlier method. I estimated the prevalence of multimorbidity and complex multimorbidity including all the diagnosed chronic conditions among patients in the sample, as recommended by the guidelines outlined in chapter 4.

However, a practical measure of multimorbidity should predict a wide range of outcomes such as health resource utilisation, complexity of care, quality of life and mortality. As discussed in this chapter, the second survey included a question asking how often the patient had visited a GP in the previous 12 months. The second survey also added a changing set of questions about the patient, including patient complexity of care and severity of illness. The next study examines how well multimorbidity predicts patient GP-visit rate. The end of the next chapter also provides early results on how well it predicts patient complexity of care.

Chapter 7: Predicting patient use of general practice services in Australia

(Paper submitted March 2017, under review: Australian and New Zealand Journal of Public Health)

Abstract

Objective: To develop a parsimonious model that predicts patient visit rate to general practice.

Methods: In 2012 to 2016, 1,449 randomly selected general practitioners (GPs) recorded details for 43,501 patients in sub-studies of the Bettering the Evaluation and Care of Health (BEACH) program. Details included patient characteristics, all diagnosed chronic conditions and number of GP visits in previous 12 months. Models predicting patient GP visit rates were tested.

Results: Number of diagnosed chronic conditions alone accounted for 25.48% of variance (R-square) in number of visits in previous year. The final parsimonious model accounted for 27.58% of variance and estimated that each year: female patients had 0.52 more visits; Commonwealth Concessional Health Care Card holders had 1.06 more visits; for each chronic condition patients made 1.06 more visits; and visit rate initially decreased with age before increasing exponentially.

Conclusions: Number of diagnosed chronic conditions was the best individual predictor of the number of GP visits. Adding patient age, sex and concession card status explained significantly more variance.

Implications for public health: This model will assist health care planning by providing an accurate prediction of patient use of GP services.

Predicting patient use of general practice services in Australia

The ageing of the population and an increasing prevalence of multimorbidity, are expected to place greater demands on the Australian health system.[1-3] Being able to accurately predict patient use of general practice services is important for health workforce planning.

Traditionally, in Australia, a simple ratio of full time equivalent general practitioners (GPs) to population has been used to estimate adequacy of GP supply for a geographic area.[4] However this method fails to consider differing levels of health care demand by different types of patients. A patient's age and sex have been shown to influence the length of their GP encounters[5] and the number of times they see a GP in a year.[2] For example, on average, an 85 year old male patient will spend 291 minutes with a GP over a year while his 12 year old granddaughter will spend only 28 minutes.[2] This variance is important as inner regional areas of Australia have higher proportions of older residents than other areas and therefore have higher demand for GP services than an average GP:population ratio would estimate.[2] The ability to predict patient demand would improve the accuracy of policy planners' projections of required GP workforce.

Australian GPs are paid on a fee-for-service basis, covered (fully or in part) by a universal health insurance scheme called Medicare. GP remuneration is primarily based on the number of times they see patients. The Australian Federal Government is planning a trial of 'Health Care Homes' in which GPs will receive capitation payments for managing the chronic conditions (but not non-chronic conditions) of enrolled patients.[6] Ideally, the capitation payment should at least reflect the amount the GP would have earned through fee-for-service for managing that patient. Each patient will be assigned to one of three tiers of "complexity and need" with higher GP remuneration for care of those in higher tiers ($591 tier 1, $1,267 tier 2 and $1,795 tier 3).[6] However, there is concern that the planned tier assignment tools may not accurately reflect patient demand for GP care.[7] If it does not, GPs may choose not to enrol in the program, or those who do may only enrol patients with relatively low demand for services. An accurate measure of patient demand would provide a structure on which an appropriate reimbursement for GPs could be calculated.

In 2000, Knox et al found a range of patient characteristics were associated with the number of times a patient sampled at a GP encounter had seen a GP in the previous year.[8]

After adjustment for other factors, characteristics related to visit rate were: patient age (older patients visiting more often); holding a Commonwealth Concession Health Care Card (CCHCC) (attended more often) and number of chronic conditions (increase in visits for every additional chronic condition). Patient sex was not independently associated.

Since Knox's study, the population has aged considerably, with a corresponding increase in the number of GP consultations with patients aged 65 years or older.[9] To better identify future demand, geographic areas of need and appropriate capitation payments, a scientifically based tool is required to predict patient demand for GP services. We therefore examined known predictors of patient use of GP services with a particular focus on the number of diagnosed chronic conditions in an individual patient. For ease of reading, we will refer to 'diagnosed chronic conditions' simply as 'chronic conditions'.

Multimorbidity is the term commonly used to describe patients with multiple chronic conditions.[10] While multimorbidity has commonly been measured by counting the number of individual conditions, some researchers believe there are advantages in counting the number of 'groups' of similar conditions.[10] Examples of 'groups' of conditions are the domains of the Cumulative Illness Rating Scale (CIRS),[11] the chapters of the International Classification of Primary Care Version 2 (ICPC-2)[12] or those of the International Classification of Diseases Version 10 (ICD 10).[13] Previous research has shown that using CIRS domains, ICPC-2 or ICD-10 chapters, the same patients were identified as having three or more domains/chapters with at least one chronic condition in each.[10] Using groups of conditions may improve reliability of results. For instance, two inter-related conditions (e.g. chronic ischaemic heart disease and myocardial infarction) may be recorded as two separate conditions by one clinician while another may consider them to be a single entity. Only counting the body system of these conditions once would ameliorate labelling inconsistency. In another scenario, a condition such as hypertension, that over time develops into complicated hypertension, might then receive a slightly different label or code in the medical record. Once again, counting only the body system to which the conditions were classified would remove the double-count.

It has been argued that the diagnosis of a chronic condition in a body system previously free of any condition will have a greater impact on the patient's care than the diagnosis of an additional chronic condition in a body system.[10] This is because chronic conditions in different body systems are more likely to compete for treatment, while treatments for those in the same system are more likely to be complementary.[10] While the number of

chronic conditions has been shown to be a predictor of patient visits to GPs,[8] the predictive value of the number of different body systems has yet to be tested. In future we will refer to the concept of 'body systems with at least one chronic condition classified' simply as 'body systems'.

In a separate analysis Knox et al examined the effect of each of nine prevalent individual chronic conditions.[8] After accounting for other significant variables, including total number of chronic conditions, they found that patients attended more often if they had depression, anxiety or chronic back pain. Ideally, a wider range of chronic conditions should be tested for their independent effect on visit rate.

Some researchers believe that both the number of chronic conditions and the severity of illness are important.[14,15] The CIRS[11] is a widely used example that includes severity of illness in the measurement of multimorbidity. Without accounting for severity of illness, a patient with well controlled hypertension, hyperlipidaemia and mild asthma (and no others), and another patient with the same conditions, but severe and uncontrolled, would be considered to have the same level of multimorbidity. However, whether a patient severity of illness is an independent predictor of GP use has not yet been established.

The aim of this study is to develop a parsimonious model that predicts patient visit rate to GPs, by examining the predictive power of:

- the number of chronic conditions.

- the number of body systems. This is to test whether a count of body systems is as good a predictor as a count of individual conditions.

- patient age and sex

- the patient characteristics examined by Knox et al(8) with the addition of number of body systems

- the presence of specific chronic conditions. We will examine a wider range than Knox et al.[8]

- overall severity of patient illness.

Methods

These data were collected through a series of sub-studies of the BEACH program.[16] BEACH was a continuous, national cross-sectional study of Australian general practice activity running from April 1998 to March 2016. Full methods of the BEACH program are described in detail elsewhere.[16] In summary, each year an ever-changing, random sample of about 1,000 GPs participated, each recording information about the content of encounters with 100 consecutive consenting patients, on structured paper forms.

BEACH sub-studies allowed for collection of patient-based data not necessarily related to the encounter. The methods for this sub-study are described in greater detail elsewhere.[7] In brief, 1,800 participating GPs over twelve five-week recording periods between 27th November 2012 and 28th March 2016, collected information on each of a preordained 30 consecutive patients within their 100 BEACH encounter forms. GPs recorded the number of times the patient had seen any GP in the previous 12 months (including the recorded visit) and all diagnosed chronic conditions in that patient. For ease of completion, tick boxes were provided for 28 prevalent chronic conditions and additional blank spaces were supplied for free text recording of other chronic conditions. The order of listed chronic conditions was changed throughout the sub-studies to reduce any order effect bias. Examples of the instruction sheet and the recording form provided to the GPs have been published elsewhere.[16] The final question varied over the sub-studies. For two of the 18 sub-studies the GPs were also asked to rate the patient's overall severity of illness (based on their clinical opinion) using a 0-10 point Likert scale where '0' is least and '10' is most, severe.

The instructions given to the GP on how to measure patient's severity of illness were based on a modification of the Duke University Severity of illness (DUSOI) scale.[17] GPs were instructed to "Please mark the line with an X to indicate how you would rate this patient's overall severity of illness during the past week." For guidance GPs were told that "Lowest severity applies to someone whose total set of diagnoses results in the fewest symptoms and complications, the least disability and threat to life, the least need for treatment, and the best expected response to treatment if needed.

Highest severity applies to someone whose total set of diagnoses results in the most symptoms and complications, the most disability and greatest threat to life, the most need for treatment, and the worst expected response to treatment."

Data analysis

Where number of GP visits in previous year was not recorded, the patient was assigned the average number of visits for patients of the same sex, in the same 10 year age group, with the same number of chronic conditions (0,1,2,3+ chronic conditions).

The likelihood of a patient being sampled was directly related to how often they visited a GP. Frequent attenders were more likely to be sampled than infrequent attenders, since they account for more GP encounters. We adjusted for low or high attenders by weighting each patient's data by the number of times they were said to have seen a GP in the previous year, with low attenders being weighted up and high attenders being weighted down. The resulting weighted data set represents those patients who visited a GP at least once in the previous year, which we will call 'active patients'.

Patient Indigenous status included patients who self-identified as Aboriginal and/or Torres Strait Islander. A patient's relative level of advantage/disadvantage was determined using the Australian Bureau of Statistic's (ABS) Index of Relative Socio-Economic Advantage and Disadvantage (IRSAD),[18] patient residential postcodes in the lower 5 deciles being considered 'Disadvantaged' and postcodes in the upper 5 deciles considered 'Advantaged'. Patient rurality was defined using the ABS's Australian Statistical Geography Standard (ASGS),[19] their residential postcode being classified 'Major city' or 'Regional/remote'.

Different body systems were represented using ICPC-2 Chapters.[12] A body system was only counted once per patient, even if the patient had multiple chronic conditions classified to one body system.

Table S1 shows the models we tested and the initial explanatory variables for each model. The number of times patients saw a GP in the previous year was the outcome for all models. The R-square value was used to measure how well each model predicts GP attendance. An adjusted R-square was calculated for all models with more than one explanatory variable. Previous results on the relationship between age and patient GP visit rate showed that the rate decreased from very young patients to adolescents before increasing steadily with older age,[2] suggesting likelihood that the relationship was quadratic in nature. This was also tested (i.e. age^2).

Statistically insignificant variables were removed through backwards elimination. Due to the large sample size, we used $p<0.01$ rather than $p<0.05$ as our level of significance. Any variable removed that had a significance of $p<0.05$ will be reported in the text.

Table S1: Initial variables included in models tested

Model Number	Variables initially included in models as explanatory variables
Model 1	Number of chronic conditions
Model 2	Number of body systems (ICPC-2 chapters)
Model 3	Age, Age^2 and sex
Model 4	Number of chronic conditions Number of body systems Age Age^2 Sex Indigenous status (self-identified) Level of relative disadvantage/advantage (1-5 and 6-10 on IRSAD) Major city Vs regional/remote area (ASGC) Commonwealth Concession Health Care Card (CCHCC) holder
Model 4A	All variables from Model 4 with the addition of the presence/absence of each the following: Anxiety — Asthma Atrial fibrillation — Chronic back pain Chronic obstructive pulmonary disease — Chronic renal failure Congestive heart failure — Dementia Depression — Gastroesophageal reflux disease Glaucoma — Hyperlipidaemia Hypertension — Hyperthyroidism Hypothyroidism — Insomnia Ischaemic heart disease — Malignant neoplasm Obesity — Osteoarthritis Osteoporosis — Other arthritis Peripheral vascular disease — Rheumatoid arthritis Sleep apnoea — Stroke/cerebrovascular accident Type 1 diabetes — Type 2 diabetes
Model 4B	All variables from Model 4 with the addition of: Patient overall severity of illness

Models 4A and 4B were extensions of Model 4. In Model 4A, the presence/absence of each of the 28 common chronic conditions listed on the recording form was added. In Model 4B we added GP assessment of patient severity of illness from the sub-sample previously described. As the data for Model 4B is a subset of the data used in the original test of Model 4, we first retested Model 4 with only this subset to ensure that any changes in variables retained in Model 4B (compared with Model 4) were the result of inclusion of severity of overall illness.

BEACH sub-studies have a single stage cluster design, with each GP having 30 patients clustered around them. Survey procedures in SAS version 9.3 (SAS Inc, Cary, NC, USA)

were used to account for the effect of this clustering. The BEACH program and all sub-studies were approved by the Human Research Ethics Committee of the University of Sydney (Reference number 2012/130).

Results

Completed recording forms were returned by 1,449 GPs of the 1,800 (80.5%) recruited. There were 43,501 patients in this sample, of whom 41,722 (95.9%) had a reported number of GP visits in the previous year. These patients had an average 9.66 GP visits in that time, and after weighting, we estimated that active patients had an average 4.54 GP visits over the previous 12 months.

The age-sex distribution of the sample is reported elsewhere.[7] In summary it was similar to that of patients at all Medicare or Department of Veteran Affairs (DVA) claimed GP consultations (precision ratio range 0.80-1.14). After weighting for each patient's attendance over the previous year to create our 'active patients' sample, the age-sex distribution was similar to that of all patients who had claimed at least one Medicare GP service item in the previous year.

Figure 1: Number of GP visits in the previous 12 months by the number of individual diagnosed chronic conditions

	0	1	2	3	4	5	6	7	8	9	10+
- - - Patients at encounters	5.0	7.7	9.4	11.4	13.1	14.6	16.9	17.1	18.7	19.8	22.0
—— Active patients	2.9	4.4	5.6	6.9	8.3	9.3	10.9	11.7	13.3	13.9	15.1
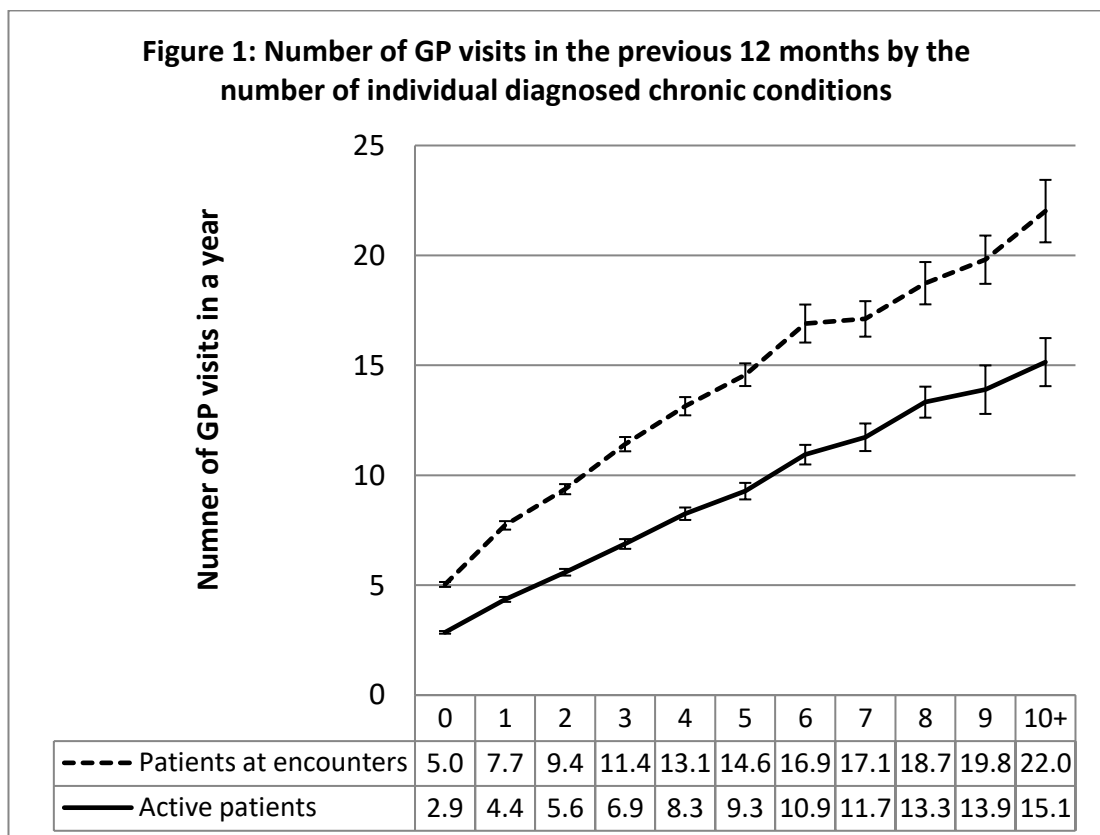
Patients at encounters R-square = 20.36% (p<.0001), Active patients R-square = 25.48% (p<0.0001)

Model 1

Among sampled patients the number of GP visits in the previous 12 months (visit rate) significantly increased with the number of chronic conditions, from 5.0 visits for sampled patients with no chronic conditions to 22 visits for those with 10 or more. For active patients, the average visit rate increased from 2.9 for those with no chronic conditions to 15.1 for those with 10 or more. A simple linear regression model found that the number of chronic conditions alone accounted for 20.36% of all the variance (R-square) in the visit rate of patients at encounters and 25.48% of the variance among active patients (Figure 1).

Model 2

The GP visit rate increased with the number of body systems, from 5.0 visits for sampled patients with no chronic conditions to 20.1 visits for those with at least one condition in eight or more different body systems. For active patients, the average visit rate increased from 2.9 for those with no chronic conditions to 15.2 for those with chronic conditions in eight or more different body systems. A simple linear regression model found that the number of body systems accounted for 18.77% of all the variance (R-square) in the GP visit rate of sampled patients and 23.91% of the variance among active patients (Figure 2).

Figure 2: Number of GP visits in the previous 12 months by the number of body systems affected by at least one diagnosed chronic condition

	0	1	2	3	4	5	6	7	8+
---- Patients at encounters	5.0	8.1	10.4	13.1	15.0	17.5	19.7	20.4	20.1
—— Active patients	2.9	4.5	6.1	8.0	9.7	11.8	13.5	14.0	15.2
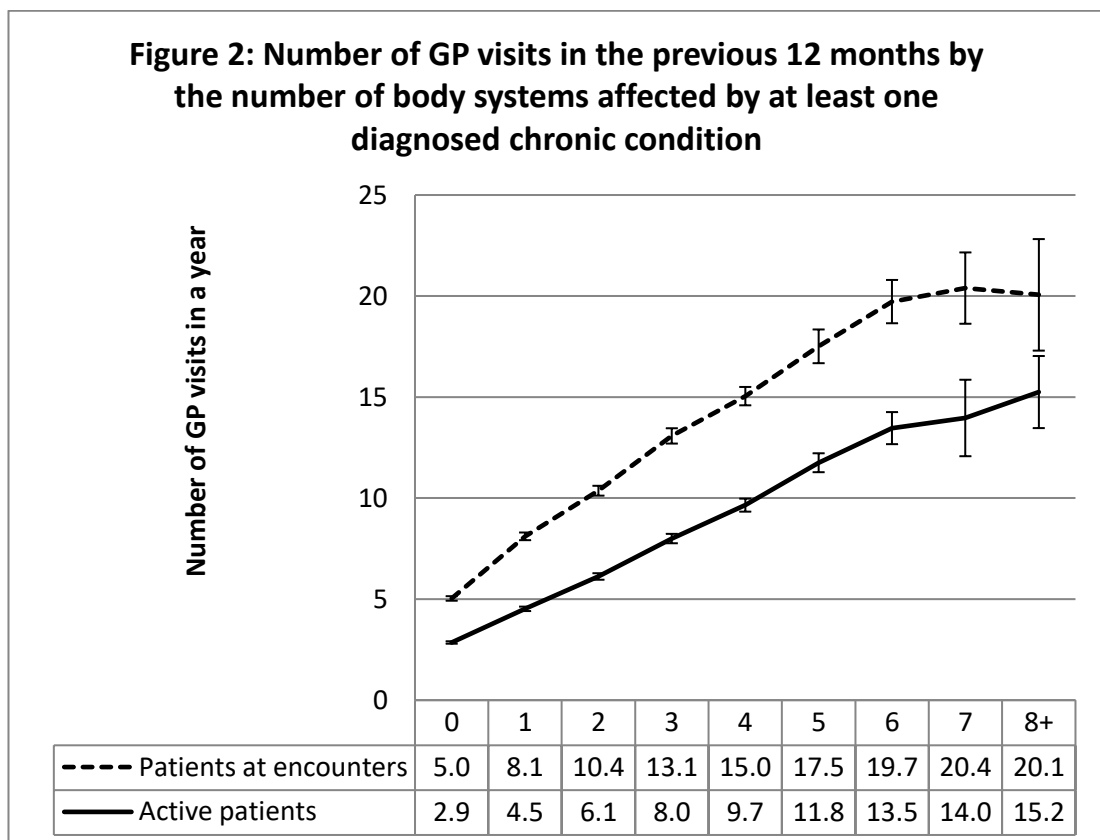
Patients at encounters R-square = 18.77% (p<.0001), Active patients R-square = 23.91% (p<0.0001)

Model 3

For each of the four decade age-groups from 10 to 49 years, sampled female patients had a significantly higher GP visit rate than male patients. Among females, the visit rate increased significantly with age, especially after the 60-69 years age group. Among male patients the visit rate decreased between the 0-9 and 10-19 years age groups, but then increased significantly with age. A regression model found that the sex of patient and the age of patient accounted for 9.24% of the variance in the visit rate of sampled patients. When age^2 was added to the model, the amount of variance explained increased to 10.15% (Figure 3).The pattern for active patients was similar. For the six decade age groups from 10 to 69 years, female active patients had significantly higher visit rates on average than active male patients (Figure 4). From the age group of 10-19 years, the GP visit rate increased significantly with age for female active patients. For active male patients the visit rate decreased between the age groups of 0-9 years and 10-19 years before increasing with older age. A regression model showed that the sex and the age of patients accounted for 11.23% of all the variance in GP visit rate for active patients. When age^2 was included in the model, the variance explained increased to 14.28%. The adjusted R-square of this model was very similar at 14.27% (Figure 4).

Figure 3: Number of GP visits in the previous 12 months among patients at encounters - by patient age and sex (95% CIs)

	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90+
Male	6.1	4.8	5.4	7.0	8.0	9.1	10.0	12.5	15.4	16.1
Female	5.8	5.8	7.3	8.1	9.2	9.6	10.6	13.0	15.5	17.4

Age group (years)
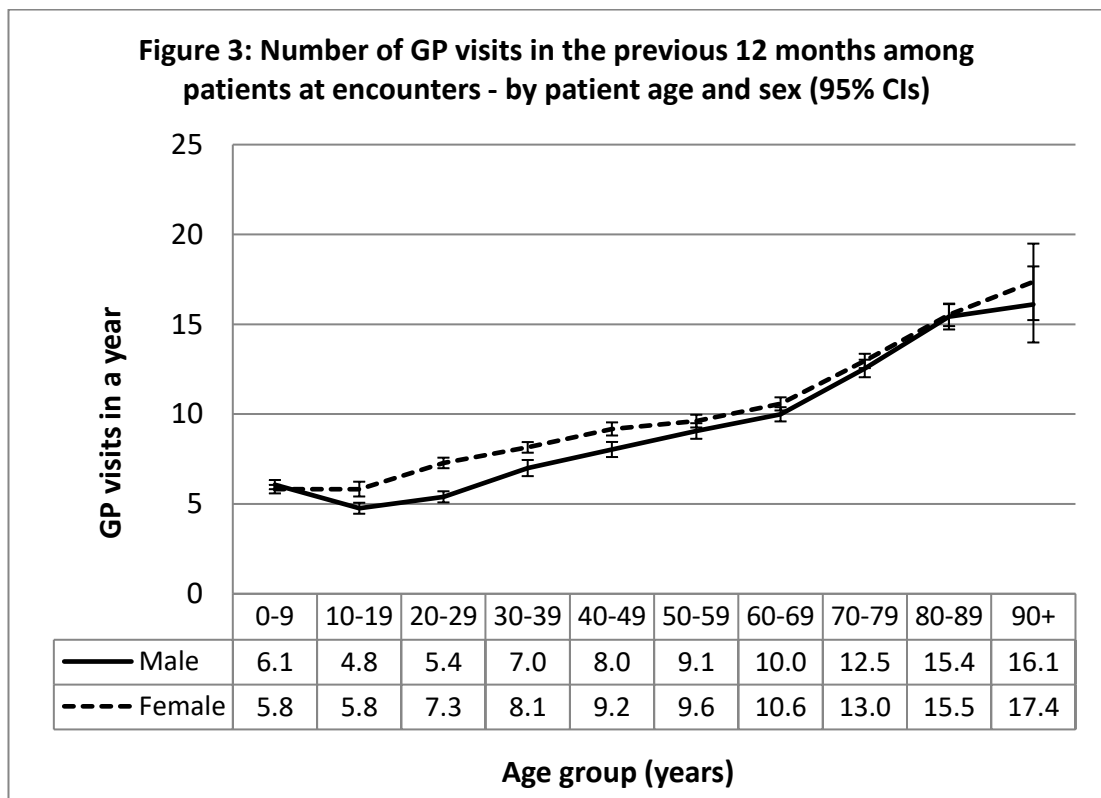
Patient age and sex: R-square = 9.24% (p<.0001) Adjusted R-square 9.23%
Patient sex, age, and age^2: R-square = 10.15% (p<.0001) Adjusted R-square 10.14%

Figure 4: Number of GP visits in the previous 12 months among active patients - by patient age and sex (95% CIs)

Age group (years)	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90+
Male	3.3	2.7	2.7	3.1	3.8	4.4	5.3	7.5	9.7	9.6
Female	3.3	3.0	3.8	4.2	4.6	5.0	5.9	8.0	9.8	11.2
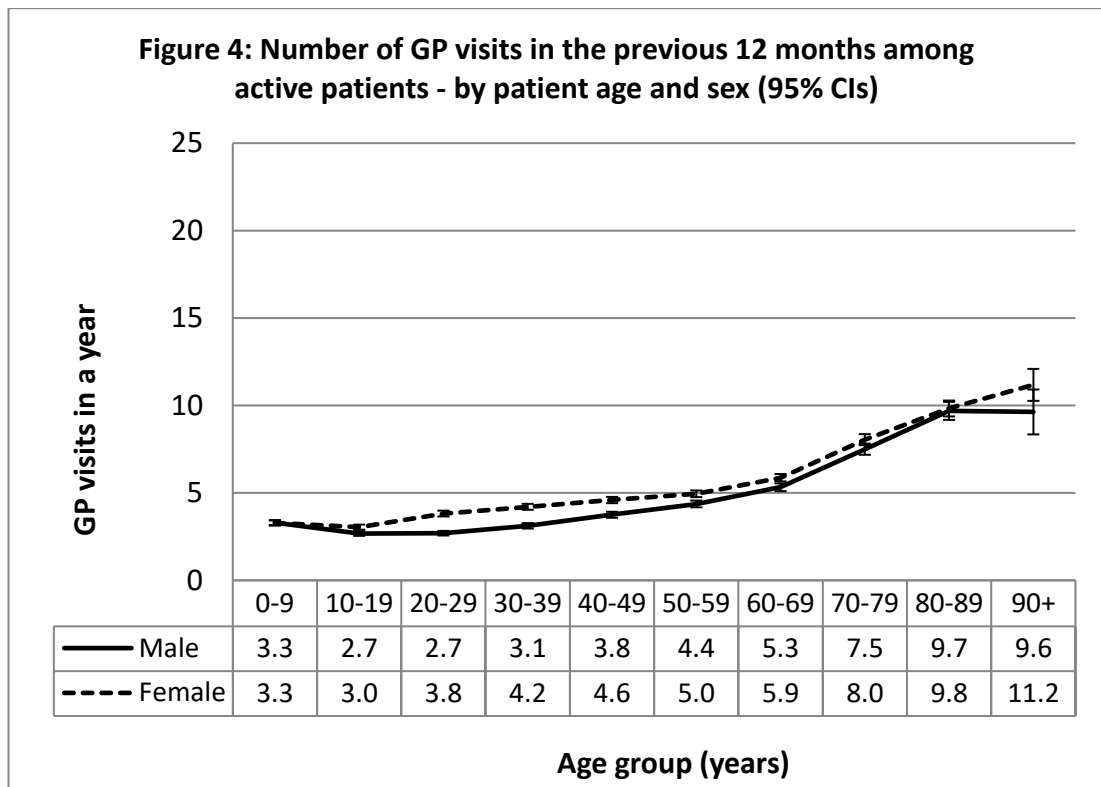
Patient age and sex = R-square: 11.23% (p<0.0001) Adjusted R-square 11.22%
Patient sex, age, and age^2: R-square = 14.28% (p<0.0001) Adjusted R-square 14.27%

Model 4

Through backward elimination, patient Indigenous status, patient relative advantage/ disadvantage, number of body systems, and patient rurality were removed. Patient rurality was the last to be removed, with a p-value of 0.0284 and an effect size of 0.334 more visits for major city patients. The final model accounted for 27.59% of the variance in GP visit rate. The adjusted R-square was very similar (27.58%). After adjusting for all other significant variables: female patients had about half a visit (0.52) more per year than male patients; those with a CCHCC had 1.06 more GP visits in the year than those without; the number of visits initially decreased with age before increasing exponentially; for each of their chronic conditions patients made 1.06 more visits in the year (Table 1).

Model 4A

After adding to the model each of the 28 individual listed chronic conditions (see Box 1), backwards elimination removed all bar seven: hyperlipidaemia; hypertension; peripheral vascular disease; glaucoma; asthma; obesity; and atrial fibrillation. The number of body systems remained significant in this model. Variables removed that had a significance of p<0.5 were: patient rurality (p=0.0328 and effect size of 0.322 extra visits for 'major city'

patients) and the presence of rheumatoid arthritis (p=0.0360 and effect size of -0.008). While statistically significant, the effect of each retained specific individual condition on the GP visit rate was small, ranging from 0.003 fewer visits for a patient with asthma, to 0.014 additional visits for one with atrial fibrillation. This model accounted for 28.40% of the variance in the number of times active patients saw a GP in the previous year, with an adjusted R-square of 28.37%.(Table 1).

Table 1: Final variables models 4, 4A and 4B

Parameter	Estimate (Visits)	t-Value	p-Value
Model 4 (p<0.0001) R-square = 27.59%, Adjusted R-square = 27.58%			
Intercept	2.789	40.63	<0.0001
Female (over male)	0.516	11.56	<0.0001
Age (years)	-0.032	-8.02	<0.0001
Age^2 (years)	0.00052	9.13	<0.0001
Commonwealth Concession Health Care Card	1.056	14.43	<0.0001
Number of chronic conditions	1.061	38.82	<0.0001
Model 4A (p<0.0001) R-square = 28.40%, Adjusted R-square = 28.37%			
Intercept	2.735	40.14	<0.0001
Female (over male)	0.495	11.04	<0.0001
Age (years)	-0.030	-7.52	<0.0001
Age^2 (years)	0.0005	8.59	<0.0001
Commonwealth Concession Health Care Card	1.031	14.06	<0.0001
Number of body systems	0.355	4.75	<0.0001
Number of chronic conditions	0.980	14.75	<0.0001
Atrial fibrillation	0.014	4.79	<0.0001
Peripheral vascular disease	0.009	2.65	0.0082
Hyperlipidaemia	-0.012	-9.59	<0.0001
Hypertension	-0.005	-5.56	<0.0001
Glaucoma	-0.008	-3.07	0.0022
Obesity	-0.006	-4.04	<0.0001
Asthma	-0.003	-2.85	0.0044
Model 4B (p<0.0001) R-square = 19.97%, Adjusted R-square = 19.88%			
Intercept	3.797	7.95	<0.0001
Age (years)	-0.065	-3.33	0.0010
Age^2 (years)	0.0009	3.97	<0.0001
Commonwealth Health Care Card	1.744	6.71	<0.0001
Indigenous	-2.310	-2.65	0.0088
Number of chronic conditions	0.817	9.49	<0.0001

Model 4B

Of the 250 GPs who were sent recording forms that included the severity of illness question, 211 (84.4%) completed the sub-study for 6,339 patients. Of these, 4,610 (72.7%) had at least one chronic condition, for whom a GP-estimated overall severity of illness had been requested. GPs reported severity for 4,461 patients (96.8% of those eligible). The average active patient with at least one chronic condition had an overall severity of illness score of 3.5/10.

After retesting the variables from Model 4 on this sub-sample, backwards elimination removed: patient sex; patient advantage/disadvantage; number of body systems; and patient rurality. This model accounted for 19.97% of the variance (R-square) in active patients' GP visit rate. The adjusted R-square was similar at 19.88%.

After adding severity of illness to the model, the same variables were removed by backwards elimination, as was severity of illness. Severity of illness was the last variable to be removed with a p-value of 0.0139 and an effect size of 0.172. The final model is presented in the lower third of Table 1.

Discussion

Number of chronic conditions was the best predictor of GP visit rate in the previous 12 months, far better than the age and sex of the patient combined. The number of chronic conditions alone accounted for 92.4% of the variance explained by a model including all other significant patient characteristics and 89.7% of a model including all significant patient characteristics and the presence or absence of individual chronic conditions.

The model explaining the most variance included significant patient characteristics, the number of chronic conditions, the number of body systems, and the presence/absence of seven specific chronic conditions. While statistically significant, the effects that the presence of specific chronic conditions had on patient visit rate were so small they are unlikely to be clinically significant. For example, atrial fibrillation had the largest effect size, but a patient would need to have had this condition for 70 years before it resulted in one extra GP visit. We therefore conclude that the most practical parsimonious model is Model 4, which includes patient age and sex, the number of chronic conditions and whether the patient held a CCHCC. This more practical model accounted for 97.1% of the variance explained by the larger model.

The number of body systems was almost as useful in predicting the GP visit rate as the number of chronic conditions (Model 2 c.f. Model 1). This suggests that body systems can be used in lieu of individual chronic conditions when they are not available or there is concern around the robustness of the data.

The number of body systems was removed from our final parsimonious model (Model 4) as it did not significantly explain any more variance than already explained by the count of individual chronic conditions. However, the number of body systems remained significant in the model that included adjustment for the presence/absence of specific conditions (Model 4A). Further investigation is required to assess why body systems were significant in Model 4A, especially since the effect size of the presence of specific individual conditions was so small.

Our results largely reflect those of Knox et al[8] which found that the number of chronic conditions, patient age and holding a CCHCC all increased the patient GP visit rate. However, unlike Knox et al we found in our much larger sample that, after adjusting for all other confounding variables, female patients attended more often than males. This is likely a reflection of higher attendance rates of younger women, often for reproductive issues,[20] many of which would not usually be classed as chronic conditions.

In Australia, the GP workforce is maldistributed, with fewer GPs in rural and remote than in metropolitan areas.[2] The Government currently funds several initiatives to attract GPs to rural/remote areas.[21] We did not find rurality to be a significant predictor of GP visits at our $p<0.01$ level. However, if we considered it significant at the $p<0.05$ level, it showed that patients in rural areas attended less often. Lower visit rates may reflect restricted access to care caused by the current GP shortages in rural areas.[2] Including rurality in any model to predict required GP workforce or to calculate capitation payment levels would exacerbate rural patient healthcare disadvantage and would be antithetical to Government initiatives currently in place. For similar reasons no model should pay less for the care provided to Indigenous patients even though Indigenous status was a significant predictor of fewer GP visits in Model 4B.

Severity of illness did not significantly add to our model at the $p<0.01$ level. However, if included at the $p<0.05$ level, its effect on GP visit rate was minimal, with a patient needing a 6 point increase in their overall severity of illness to generate one more GP visit in the year. Further, it may be difficult for a GP to objectively judge a patient's severity of illness knowing they will be reimbursed at a higher rate if the patient is classed as more severe.

The Health Care Homes model will probably result in the transfer of some services currently provided by GPs, to other health professionals in the team. While our model predicts the number of GP visits by a patient over a year, in the Health Care Homes model it is likely to represent overall patient demand for services from general practices.

This study does have a limitation. Our estimate of the average number of GP visits for active patients (4.54) was significantly lower than the average number of Medicare GP consultation items claimed by people who made at least one claim (6.8 in 2014–15).[9] As discussed in our earlier paper, this means that our GPs and patients were likely to have under-reported the number of GP visits in the previous 12 months.[7] This could be due to the patient seeing another GP that they had forgotten and/or did not wish to disclose to the current GP. If the under-reporting was evenly and proportionally spread among high and low attenders, it would be possible to weight the results of our model up to reflect the observed number of GP visits. However, if the under-reporting was skewed in some way, it is unlikely that reweighting the data would be accurate. The final model should be validated on another independent data source.

Conclusion

While there are multiple factors that influence the number of times a patient sees a GP in a year, our study found the most parsimonious model included patient age and sex, the number of chronic conditions, and whether the patient holds a Commonwealth Concession Health Care Card. The results of this study will assist with workforce planning and the proposed trial of capitation payments for GP care of diagnosed chronic conditions in enrolled patients. Further research is planned to test whether this model also predicts patient complexity of care.

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Further discussion – international comparisons

Due to a restricted word limit and the parochial nature of the Australian and New Zealand Journal of Public Health, in this paper I focussed my Introduction and Discussion on the Australian context. However, these results support similar research that was undertaken around the same time.

A study in Germany found a linear relationship between the number of diagnosed chronic conditions and the number of contacts the patient had with physicians in ambulatory care.[1] They did not find that age was an independent predictor, though this may be because they only examined patients aged 65 years and older.

A study of patients in the UK found that patient age, sex and the number of chronic conditions predicted patient consultation rate.[2] However, a study published two years later suggested that it was the number of prescribed medications (and not the number of morbidities) that predicted future consultations.[3] I was unable to test this new result with the data I collected through the BEACH sub-studies. Due to space restrictions on the form, one could either ask for all chronic conditions diagnosed for a patient, or for all the medications the patient was taking, but not both. When attempts to replicate our model using an independent data source are undertaken, efforts should be made to also include the number of medications the patient is taking.

Early results from complexity of care sub-studies

Two of the sub-studies used in survey 2 asked the GP to rate the patient's complexity of care on a 10 point Likert scale. Each form asked the GP to *"Mark the line with an X to indicate how complex you find the management of this patient"*. The instruction sheet that accompanied this set of sub-studies provided a more detailed explanation of what was meant by 'complexity of care'. (See Appendix E for full instruction sheet) The explanations for this particular question were:

"This question aims to assess, in your clinical opinion, the complexity of managing each patient who has at least one chronic condition.

Complexity could be influenced by many factors, including:

- the mix of conditions

- overall severity of illness

- contradictory clinical care guidelines

- interactions between medications

- access to other health services

- patient compliance

- patient expectations

- patient cultural background

- patient health literacy

- patient socio economic status

- contradictory advice to patient

- other environmental factors

- frailty of the patient

This list is not exhaustive and not all factors will relate to every patient."

I presented early results from this set of sub-studies at the North America Primary Care Research Group Conference in Cancun in 2015[4]. I will briefly describe these early results in this section.

Early results

250 GPs agreed to take part in the sub-studies conducted 6th May-14th July 2014. Of these 210 GPs returned completed recording packs for a completion rate of 84.0%. Of the 6,309 patients sampled at these sub-study encounters, 4,402 patients (69.8%) had at least one diagnosed chronic conditions and were eligible to answer the complexity of care question. GPs provided their judgement of complexity of care for 4,257 of the 4,402 eligible patients (96.7%).

GPs rated the complexity of care as 4.5 out of 10 (95% CIs: 4.3–4.7) for patients at encounters with at least one diagnosed chronic condition and (after adjustment) 3.9 (95% CIs: 3.7–4.1) for active patients with 1+ diagnosed chronic condition.

Patient complexity of care increased significantly with the number of diagnosed chronic conditions for both patients at GP encounters and for active patients (Figure 5). Number of diagnosed chronic conditions accounted for 19.98% of variance (R-Square) in the complexity of care of patients at GP encounters and 17.49% in active patients.

Complexity of care also increased significantly with the number of 'body systems' (Figure 6). Number of 'body systems' alone accounted for 15.72% of variance in the complexity of care for patients at encounters and 13.67% in active patients.

Figure 5: Patient complexity of care by number of diagnosed chronic conditions

	1	2	3	4	5	6	7	8	9	10+
Patients at encounters	3.2	4.0	4.6	4.9	5.4	5.8	6.0	6.6	6.9	7.3
Active patients	3.0	3.6	4.2	4.7	5.0	5.6	6.0	6.3	7.0	7.3
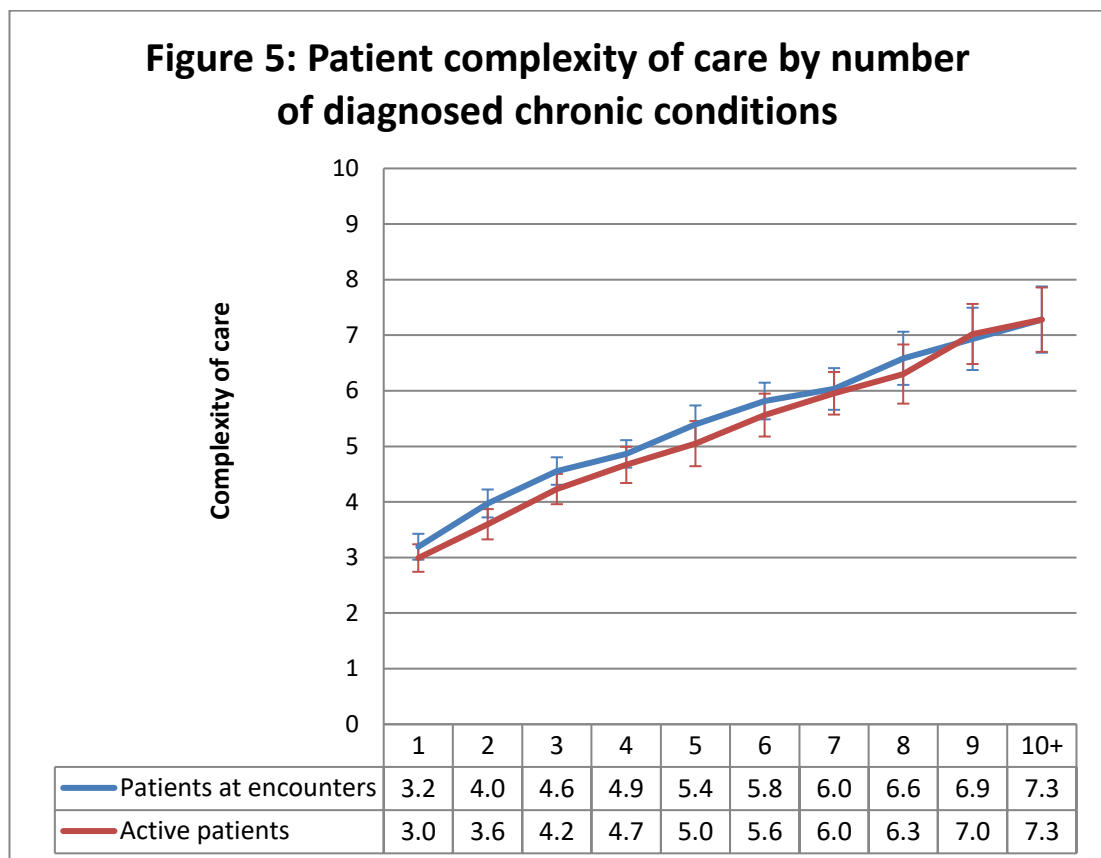
Figure 6: Patients complexity of care by number of body systems (ICPC-2 chapters)

	1	2	3	4	5	6	7+
Patients at encounters	3.4	4.2	5.0	5.4	6.0	6.6	7.3
Active patients	3.1	3.8	4.6	5.0	5.8	6.3	7.5
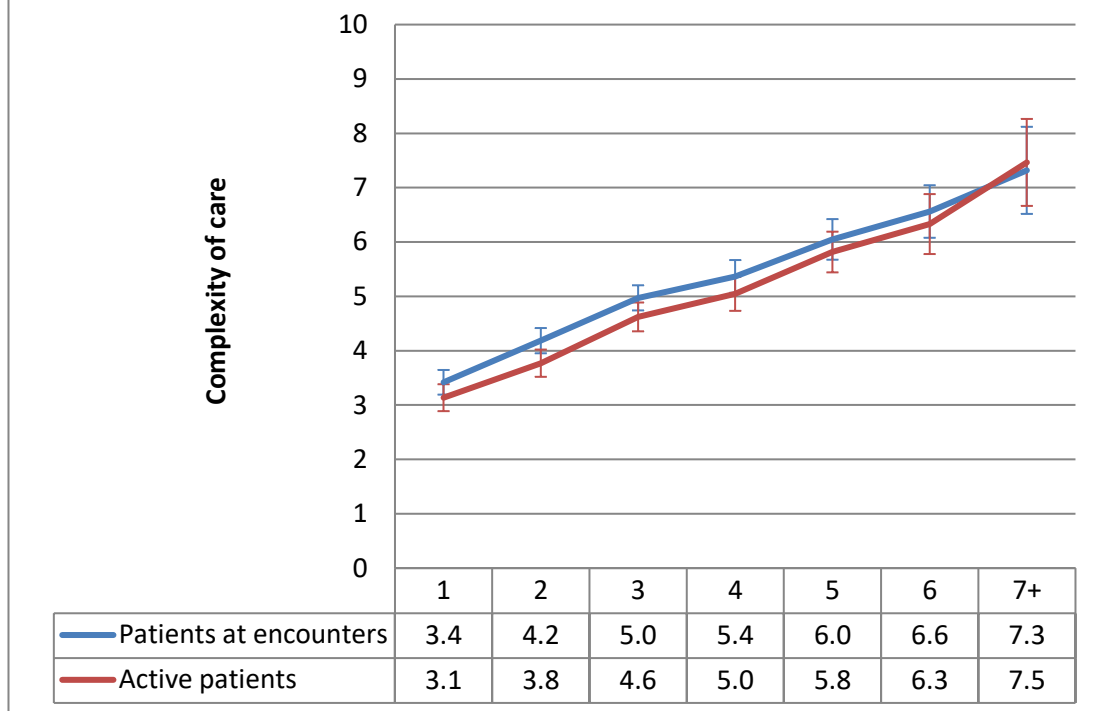
Multivariate modelling was performed including the same variables as listed in model 4 (Table S1) for 'active patients'. After backwards elimination, the only variable to remain in the model was the number of individual chronic conditions with patient complexity of care increasing 0.49 for every additional diagnosed chronic condition. Patient CHCC status was the last variable to be eliminated with a p value of 0.021 with patients holding a CHCC being slightly more complex to care for (0.32 extra).

Multivariate modelling was then performed including the same variables as listed in Model 4A (Table S1) for 'active patients'. After backwards elimination, the final model included the number of diagnosed chronic conditions, hypertension, hyperlipidaemia, GORD, asthma and chronic renal failure (Table 2). The final model accounted for 19.62% (R-Square) of the variance in patent complexity of care, while the adjusted R-Square was 19.50% for the final model. Anxiety (p = 0.0487, effect size = 0.0026), Type 1 diabetes (p = 0.0310, ES = 0.0080), osteoporosis (p = 0.0217, ES = -0.0046), and CHCC status (p = 0.0176, ES = 0.3173) were the last variables to be eliminated.

Table 2: Final model predicting patient complexity of care

Parameter	Estimate (Visits)	t-Value	p-Value
Intercept	2.651	19.69	<0.0001
Number of chronic conditions	0.590	18.56	<0.0001
GORD	-0.0060	-4.53	<0.0001
Asthma	-0.0050	-4.12	<0.0001
Hypertension	-0.0041	-3.75	0.0002
Hyperlipidaemia	-0.0042	-3.18	0.0017
Chronic renal failure	0.0075	2.98	0.0033

Discussion

The number of chronic conditions is the strongest predictor of GP-judged patient complexity of care. This parallels the results found for patient GP-visit rate. However, other patient characteristics (e.g. patient age and sex and CHCC status) were not found to significantly predict complexity of care, though they were for GP-visit rate. While the presence/absence of several individual chronic conditions added significantly to the statistical model, the effect size of each condition was negligible. In contrast, the presence of asthma, hypertension and hyperlipidaemia were significant negative predictors of GP-visit rate and patient complexity of care.

As discussed in the Introduction to this chapter, in the Australian Federal Government's planned trial of "Health Care Homes" participating practices will be given a capitation payment for the care of each enrolled patient's chronic conditions. This capitation payment will supposedly be based on the "complexity and need" of the patient's care.[5] This chapter has shown that the number of chronic conditions is the strongest driver of patient GP-service use and of patient complexity of care, so it would be the simplest measure by which each enrolled patient in the trial could be categorised in terms of 'complexity and need'.

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Chapter 8: Discussion

There is a fear that the projected increase in the number of people living with multiple chronic conditions will strain Australia's healthcare system, with its single disease structure unable to provide optimal healthcare for these patients. This has created an urgent need for research to assist in the development of evidence based health policy. The prevalence of multiple diagnosed chronic conditions, the patterns of coexisting conditions, and the wide variety of negative outcomes associated with care of these people need to be examined. However, researchers have not been using the same terms or the same metrics in their investigations, which limits the generalisability and application of their results. The metrics used need to balance the priorities of being: sufficiently specific to be easily replicable by other researchers; able to predict a wide array of outcomes; sufficiently adaptable to be applied in a range of settings; and pragmatic in terms of resources required.

In response, I have measured the patterns and prevalence of multimorbidity in the Australian population using unique methods that I developed. I did so by undertaking the largest prospective national study of multimorbidity in Australia using a series of sub-studies from the continuous BEACH project. I converted this GP encounter data to population prevalence data using a method I devised. These results will inform the Primary Health Care reform processes currently underway in Australia, and highlight the need for holistic care of these patients. They also show the need to improve clinical care guidelines so that they take into account the most common comorbidities and possibly create new guidelines for the total care of patients with the most common clusters of chronic conditions.

I have shown that the individuals identified with multimorbidity, and therefore the estimated prevalence of multimorbidity, changes significantly if researchers alter the: population under study; number of chronic conditions studied; definitions of 'morbidity'; and minimum numbers of morbidities required to have multimorbidity. These results will help other researchers decide which metrics they will use in their studies of multimorbidity.

This thesis has shown that multimorbidity is the strongest driver of patient utilisation of GP services. I have suggested a measure of complex multimorbidity that identifies people with high health care needs, and that could be deployed across various healthcare settings. These results will facilitate better targeting of funding based on patient healthcare need.

This thesis had six aims, each of which will now be address in detail.

Converting the prevalence of diagnosed chronic conditions among patients at GP-encounters to population prevalence (AIM 1)

While the use of a GP as an expert interviewer/respondent to record the presence of chronic conditions among patients avoids the issues of using respondent self-report[1-8] or chart review[5,7,9-12] alone, patients at GP encounters are not representative of people in the population. [13,14] This thesis describes the only series of studies that has attempted to convert GP-encounter prevalence estimates to reflect population prevalence.

In the earlier work by Britt et al,[15] the method that I employed to convert prevalence estimates was crude, making the statistical assumption that in all ages and sexes the same proportion of people saw a GP at least once in the year of measurement. The first paper of this thesis[16] (Chapter 3) outlined an improved adjustment method that took into account the difference in the proportion of people in each age-sex group that saw a GP at least once in a year. However, this new method did not take into account high or low attenders within age-sex group. Therefore this approach overestimated population prevalence of the chronic conditions under study (as shown in Chapter 6), because within age-sex groups people with more chronic conditions attended more often than people with fewer (Chapter 7). Also, this method could not provide a population prevalence estimate for any specific age-sex group because the method relied on weighting age-sex groups against each other, to create national prevalence estimates for the whole population.

In survey 2, I was able to adjust for each individual patient's chance of being in my sample by collecting the number of times the patient had seen a GP in the previous year (Chapter 6).[17] This allowed me to adjust for high or low attenders in each age-sex group, which provided more reliable population prevalence estimates. This method also had the advantage of being able to provide population prevalence estimates for a specific age-sex group, since the adjustment was done at an individual patient level rather than at the age-sex group level. For example, this final method will allow estimation of the prevalence of a specific diagnosed condition among a specific sex (e.g. population prevalence of cervical cancer among women) or among a specific age group (e.g. prevalence of diagnosed depression among people of working age).

While this adjustment method was initially developed so that the BEACH study could provide an alternative to the ABS National Health Survey,[18] the only source of national chronic condition prevalence, the method can be applied to any study that draws its sample from patients at general practice encounters or in waiting rooms. All that is required is that the number of GP-visits in the previous year be recorded for each patient. This method is not restricted to adjusting the prevalence of chronic conditions from a patient sample to 'active patients' or to the population— it can be used for a wide range of health-related topics. Examples might include the proportion of active patients who: are currently taking certain prescribed medication; have had a specific test ordered; have ever been referred to a certain type of specialist. To adjust the measure to the population level, one must be able to assume that whatever is being measured requires at least a yearly visit to a GP. This allows one to take the logical step that if a patient does not see a GP in a year; they do not have the variable of interest. Examples could include the proportion of people in the population who have had a medication review performed by a GP in the previous 12 months or the proportion of people are currently taking oxycodone that was prescribed by a GP. Finally, this method also requires the researcher to know the proportion of each age-sex group in the population that visit a GP in a 12-month period. Such information may be difficult to find in countries that do not have a single payer system.

Prevalence of chronic conditions (AIM 2)

There is a need to measure the prevalence of individual chronic conditions both among patients at GP encounters and among people in the Australian population. In Chapter 6, I estimated that over two-thirds of patients at GP-encounters had at least one diagnosed chronic condition. The extrapolated result suggested that, of the 143 million Medicare claimed GP-patient encounters in Australia in 2015–16: about 100 million were with patients with at least one chronic condition; about 38 million were with patients with hypertension; 32 million were with patients with osteoarthritis, and 24 million with those who had diagnosed hyperlipidaemia. While the BEACH annual GP activity books[19] report the management rate of specific conditions at GP encounters, patients with a diagnosed chronic condition may not have it managed at every GP encounter. Measuring the prevalence of conditions among patients at encounters highlights the fact that even though the GP may not be actively managing the condition at this particular encounter, they must take the presence of this condition into consideration when managing the patient. One can use the encounter prevalence estimates to

measure the proportion of GP encounters with patients who have the diagnosed condition, at which the condition is managed. I applied this method to people aged 65 years and over in Table 14.1 of the 2014–15 BEACH annual GP activity book.[20] Using Type 2 diabetes as an example, I estimated that 19.4% of patients aged 65 years and over at GP-encounters had diagnosed Type 2 diabetes. BEACH encounter data estimated that Type 2 diabetes was managed at 6.9% of encounters with patients aged 65+. Type 2 diabetes was therefore managed at 35.8% of the GP-encounters with patients aged 65+, who had diagnosed Type 2 diabetes. From my data, we also know that on average, 'active patients' aged 65+ with Type 2 diabetes visited their GP 9.3 times a year. This suggests that Type 2 diabetes was managed by a GP around 3.3 times a year on average for each of these patients.

Knowing the proportion of people with a specific diagnosed chronic condition will improve health resource planning, by providing guidance for more accurate allocation of disease-specific resources (such as medications, specialists, and medical equipment). Using my final weighting method, I estimated that in 2015–16 about 4 out of 10 (i.e. about 10 million) people in the Australian population had at least one diagnosed chronic condition. Further, my results suggest that in that year, there were about 2.9 million people with diagnosed hypertension, 2.3 million with diagnosed osteoarthritis and 2.0 million with diagnosed hyperlipidaemia.

The effect different methods of measuring multimorbidity has on who is identified as having multimorbidity (AIM 3)

The way in which multimorbidity has been researched has varied widely between studies. The definition of multimorbidity has ranged from the extremely comprehensive European General Practice Research Network's definition,[21] through the common 2+ chronic conditions definition,[22,23] to my definition of complex multimorbidity.[24] The estimated prevalence of multimorbidity has ranged from 3.5%[25] to 98.5%[26] between studies. It had been hypothesised that it is the methods and definitions used in the measurement of multimorbidity that are greatly affecting which individuals are identified as having multimorbidity, and therefore the multimorbidity prevalence estimates.[27-29]

This thesis has shown that the proportion of people identified as having multimorbidity is independently affected by multiple factors. I was able to determine the effects of each of these variables by using a single large prospective study allowing me to control for all other variables, something that is not possible in systematic reviews.

The first issue to consider when measuring multimorbidity is the study population. I have shown that there are significant differences between patients at GP encounters, 'active patients' (and 'active patient' lists) and the population. Patients at GP-encounters have a significantly higher prevalence of individual chronic conditions and multimorbidity than people in the wider population.[17] Researchers need to be mindful of this when generalising their results from clinical samples.

All the other factors in how multimorbidity is defined and measured are interrelated, with the biggest differences in prevalence estimates being dependant on whether multimorbidity was defined as 2+, or 3+, morbidities. Overall, using the 2+ definition provides more statistical sensitivity and provides reliable results across methods, while the 3+ definition provides greater specificity and identifies patients with higher resource use and complexity of care.

My results show that the prevalence of people identified with multimorbidity defined as 2+ would be similar across studies, even if those studies had major methodological differences between them. For example, defining multimorbidity as 2+ morbidities identified a similar proportion of patients as having multimorbidity when the morbidities being counted were individual chronic conditions or groups of chronic conditions (such ICPC-2 chapters). Defining multimorbidity as 2+ also allows comparison between studies that include all diagnosed chronic conditions and those that only consider a limited number of chronic conditions. However, I also found that using 2+ as the definition of multimorbidity identifies too large a proportion of people to be useful, especially among older age groups.

Conversely, when multimorbidity is defined as 3+, the number of people identified with multimorbidity changes significantly depending on the methods used to measure it. For example, significantly more people were identified as having multimorbidity 3+ when individual chronic conditions were counted, than when the number of groups of conditions was counted. Using the 3+ definition also identified far fewer people with multimorbidity when the number of conditions considered was limited, than when all diagnosed chronic conditions were considered.

However, the 3+ definition has several advantages over the 2+ definition. The 3+ definition identifies patients with higher GP visit rates and provides far greater specificity than the 2+ definition, especially among older patients. Early results from my next study suggest that compared with the 2+ definition, the 3+ definition identifies patients whose care is more complex.[30]

Using a higher minimum number of morbidities than two when defining multimorbidity, may align more closely with how clinicians think of multimorbidity. While there have been no formal publications investigating this hypothesis, it was demonstrated by Professor Martin Fortin during a presentation on multimorbidity at the 2011 North America Primary Care Research Group Annual Meeting.[31] He asked the clinicians in the audience to stand up and to imagine a patient of theirs with multimorbidity. He then asked them to sit down if the patient had only 2 chronic conditions, and then asked those who were thinking of a patient with 3 chronic conditions to sit and so on. Very few clinicians were thinking of a patient with only 2 conditions, and most were thinking of patients with 5 or 6 chronic conditions. It makes sense that clinicians would imagine a patient with many chronic conditions, as my results suggest they would be regular visitors whose care is complex. A more rigorous scientific study is required to confirm or dismiss this hypothesis.

Due to these advantages, I believe researchers and policy makers should agree to use a higher minimum than two morbidities when defining multimorbidity. If it is agreed that a higher minimum, (e.g. 3+) must be used in defining multimorbidity, my results show that more stringent standards are going to be required across studies if results are to be comparable. Ideally as many chronic conditions as possible should be considered. The minimum number of conditions considered would need to be significantly higher than those suggested by either Fortin et al[28] or Diederichs et al,[29] as using their minimum suggested numbers identifies only a fraction of the number identified when all chronic conditions are considered.(Chapter 4)

A choice will also need to be made on whether the 'morbidities' counted are individual conditions or groups of conditions, as counting individual chronic conditions identifies far more people with multimorbidity than counting groups of chronic conditions when multimorbidity is defined as 3+.

A method to measure multimorbidity in Australia (AIM 4)

In this thesis I have suggested a definition of multimorbidity that counts groups of chronic conditions based on the body systems to which they are classified. I defined the concept of 'complex multimorbidity' (from Chapter 4), as the *"co-occurrence of three or more chronic conditions affecting three or more different body systems within one person without defining an index chronic condition."*[24] I believe this would be a simple metric for identification of high need patients. Counting the number of body systems: reduces the chance of double counting the same individual condition recorded under multiple labels; facilitates estimation of the number (and types) of specialists likely to be involved in the care of the patient or sub-population; and helps identify patients who may require assistance coordinating the care provided to them by a range of other health professionals.

While using the chapter structure of ICPC-2 or ICD-10 may seem a simplistic way of grouping chronic conditions, in this thesis I have shown that using either of these two classifications to group of conditions identifies the same individual patients as having multimorbidity. This is particularly useful as it will allow comparable identification of people with complex multimorbidity irrespective of whether the data are drawn from primary care (ICPC-2) or from hospital (ICD-10) health records. In Chapter 7, I showed that patients with diagnosed chronic conditions classified in 3 or more body systems had a significantly higher average GP-visit rate than those with 3 or more individual chronic conditions. Early results from my next study suggest this difference is also true of the patient's overall complexity of care.[30]

The relationship between multimorbidity and utilisation of GP services (AIM 5)

The ability to accurately predict patient utilisation of GP services will greatly assist policy makers with GP-workforce planning, future health care costing and implementation of policies such as the health care homes initiative. I found that multiple factors influence a patient's GP visit rate. The most parsimonious model includes patient age and sex, the number of diagnosed chronic conditions, and whether the patient holds a Commonwealth Concession Health Care Card. Going forward, this model should be validated independently on a comparable dataset.

The number of individual diagnosed chronic conditions and the number of 'body systems' were strongly positively associated with the patient's GP-visit rate (Chapter 7). This supports similar results found earlier in Australia[32] and around the same time internationally. [33,34]

While I have explored only patient utilisation as an outcome of multimorbidity in this thesis, early results from my next study suggest a similar pattern emerges when complexity of the patient's care is the outcome.[30] These results suggest that the number of diagnosed chronic conditions and the number of 'body systems' are both strongly positively associated with complexity of care, with the number of chronic conditions being a slightly better predictor.

The linear relationships between the number of chronic conditions/body systems with patient GP-visit rates and complexity of care suggest that multimorbidity is actually a continuum. If multimorbidity is really a continuum, as my results suggest, do we then need a minimum number of conditions? I would argue that the need for a minimum is dependent on the reason multimorbidity is being measured. Conceptualising multimorbidity as a continuum is useful when it is being applied in a model to predict outcomes (such as patient GP-visit rate). However, when its prevalence is being measured, a standard minimum number of morbidities is required so that comparisons can be made between studies and over time.

The prevalence and patterns of multimorbidity in Australia (AIM 6)

For the first time in Australia, this thesis has measured the patterns and prevalence of multimorbidity using all chronic conditions from a nationally representative prospective study. This study had a larger sample of respondents than any of the previous ABS National Health Surveys.[18] I estimated that about a quarter (25.7%) of the population had two or more diagnosed chronic conditions while about one in eight people had complex multimorbidity, equating to about 6.2 and 2.9 million people respectively.

This high proportion of patients with multimorbidity strengthens the argument that we need to re-examine the focus of our health care system on the management of single chronic conditions, particularly in regards to its structure, to guidelines, and to clinical trials. About half the patients at GP encounters had two or more chronic conditions while about 3 in 10 had complex multimorbidity. When these figures are compared with

the 26.5% of patients at encounters who had diagnosed hypertension, the most prevalent individual chronic condition, one understands Tinetti et al's quip that the *"most common chronic condition experienced by adults is multimorbidity"*. [35] There are combinations of chronic conditions that are more prevalent than some common individual conditions. For example, in Chapter 5, I showed that 5.5% of patients at GP encounters had diagnosed hypertension + hyperlipidaemia + osteoarthritis, while only 4.1% had COPD, 2.9% had congestive heart failure and 1.0% rheumatoid arthritis. I have also shown that it is uncommon for patients to have just one single chronic condition, with about two-thirds of people with at least one chronic condition having two or more. These results point to a clear need for clinical trials and guidelines for care to expand from their current single disease focus to incorporate patients with multiple chronic conditions. While creating a set of guidelines for every possible combination of chronic conditions would be impractical, my results could be used to prioritise the creation of guidelines for the care of patients who have the most common combinations of chronic conditions.

This thesis also reports the most common patterns of body systems with at least one chronic condition classified to them. These may also help policy planners identify services that, if co-located, would be beneficial for optimal care of these patients.

Within this thesis I have primarily focussed on the methodology associated with measuring multimorbidity in Australia. As such, I have prioritised the reliability and generalisability of the method over the clinical outcomes associated with multimorbidity. This is not because I believe that clinical outcomes and patient's experience with multimorbidity are any less important.

In contrast the European General Practice Research Network (EGPRN) prioritised measuring the clinical complexity of multimorbidity. They undertook a systematic review in consultation with experts to define multimorbidity, though it has been criticised because many leaders in the field of multimorbidity were not involved.[36] The EGPRN sought a "comprehensive" definition of multimorbidity which incorporated most of the characteristics of the definitions found during their review. Importantly they stressed that the health outcomes of a patient happen in a context wider than the number of diagnosed chronic conditions, and so they explicitly included other factors that impact a patient's health. Their full definition of multimorbidity is

> *"any combination of chronic disease with at least one other disease (acute or chronic) or biopsychosocial factor (associated or not) or somatic risk factor.*
>
> *Any biopsychosocial factor, any somatic risk factor, the social network, the burden of diseases, the health care consumption, and the patient's coping strategies may function as modifiers (of the effects of multimorbidity).*
>
> *Multimorbidity may modify the health outcomes and lead to an increased disability or a decreased quality of life or frailty"[21]*

My thesis suggests that the common definition of multimorbidity as 2+ chronic conditions would identify too high a proportion of people with multimorbidity to be useful in targeting high need patients. This conclusion is even more applicable to the EGPRN's comprehensive definition. Since this definition also includes acute conditions, biopsychosocial factors and somatic risk factors among the 'morbidities' being counted, people with at least one diagnosed chronic condition may be considered to have multimorbidity at some point in time (such as when the contract an acute illness). I*f I applied this definition to my data, it may identify the 18% of patients at GP encounters (and the 17% of the population) who have only one chronic condition as having multimorbidity at some time. This would provide multimorbidity prevalence estimates of up to 70% for patients at GP-encounters and 40% for people in the population. It would also no doubt identify almost all older people as having multimorbidity.*

The other issue with this definition is the sheer number of variables that would have to be collected by researchers, or recorded by clinicians, planning to apply it in their work. Further, there will be difficulties standardising which acute conditions, biopsychosocial factors and somatic risk factors are included across studies.

> *As one of my collaborators, Maxime Sasseville, said "This definition speaks to the conflict between providing a definition that is comprehensive enough to capture the clinical reality of multimorbidity and a definition that is specific enough for the development of functional measures or tools."(Personal communication)*

While my definition of complex multimorbidity has been shown to be a reliable measure of multimorbidity and to predict patient GP-visit rate and complexity of care, it has yet to be shown as a strong indicator of a wide variety of other outcomes. Further research on how well it predicts other outcomes, such as patient quality of life and mortality needs to be undertaken.

I also acknowledge that by proposing an additional measure of multimorbidity, no matter how useful and valid, I am contributing to the number of already existing definitions of multimorbidity and furthering the lack of standardisation. Ideally the leaders in the field of multimorbidity research need to agree on a set of guidelines that define multimorbidity and how it should be measured. If the guidelines advocated by these leaders provided a pragmatic method for measuring multimorbidity, then it is more likely that it will be widely adopted as the standard.

This thesis provides a clear basis for these guidelines. For reliability, distinct groups of conditions should be counted. Using groups of like conditions reduces the occurrence of double counting of the same condition due to it receiving a different label over time.[34] Grouping conditions also reduces the variance between clinicians where some decide to record two inter-related conditions as two separate conditions, while others record them as a single condition. In my definition, I suggested the use of the chapter structure of ICD-10[37] and ICPC-2[38] to group conditions. These chapter structures were created by committees of clinical classification experts, e.g. ICPC-2 is a product of the Classification Committee of the World Organization of Family Doctors.[38] The other option is to use data driven groups of chronic conditions, using methods such as factor analysis[39] or cluster analysis.[40,41] The issue with data driven groups of conditions is that the groups that are formed may not make clinical sense.

If groups of conditions are accepted as the standard, my results show that researchers should include as many chronic conditions as possible to produce reliable results. While it has been suggested that conditions should be chosen based on their impact on patient outcomes, my studies have found little evidence of any major difference between individual chronic conditions in their impact on patient GP-visit rates or the complexity of their care. This suggests that including as many chronic conditions as possible not only improves the reliability of prevalence estimates, but also the ability to predict outcomes.

For increased specificity in targeting higher need patients, the minimum number of chronic conditions defining multimorbidity should be at least three. This would rule out the common current definition of multimorbidity as 2+ chronic conditions and the EGPRN's comprehensive definition.

Whatever is agreed upon should not be restricted by propriety licensing (such as the Johns Hopkins Adjusted Clinical Groups),[42] but be accessible to all researchers so that it can be widely applied and critiqued. The method adopted should predict a wide variety of

outcomes instead of focusing on single outcomes (such as health service utilisation or mortality).

Apart from my definition of complex multimorbidity, there is also work being conducted by the Patient-Centred Innovations for Persons with Multimorbidity (PACE in MM) study.[43] Early publications suggest that researchers are planning to measure multimorbidity using 20 specified chronic disease categories (groups). These categories each correspond to a defined list of ICD-9 codes, which when combined, cover most chronic conditions managed in general practice.[44] It will be interesting to see how good this new measure of multimorbidity is as a predictor of a wide range of outcomes.

In an ideal world, the methods I have developed in this thesis to measure the prevalence of chronic conditions in the population from general practice data would soon be made redundant. In this world, Australia would have a system whereby all people had an electronic medical record (EHR). These EHRs would be linked, not just between general practices, but to all arms of the health care system (e.g. hospitals, medical specialists, allied health professionals) and would have a record of every contact the patient made with the healthcare system. The EHRs would have a minimum data set about the patient including elements describing their past history, family history and each of their encounters with the system. All EHRs would have a standardised structure, ideally a problem oriented structure similar to that described by Dr L Weed.[45] The data elements would have consistent definitions and labels and they would be stored using standardised clinical terminology and classifications. This system of EHRs would make it relatively simple to measure the prevalence of individual chronic conditions and multimorbidity in the population. In depth models examining patient utilisation of all healthcare resources could be undertaken across the whole population. Patients could be followed longitudinally, so that the progress of multimorbidity could be examined over time, allowing for statistical modelling to predict multimorbidity and its outcomes, which in turn may provide an evidence base for effective prevention.

However, as Gordon et al shows,[46] this ideal system is still a long way off in Australia with our current EHR systems lacking the required characteristics described above. Projects such as MedicineInsight (run by the National Prescribing Service MedicineWise heavily funded by the Australian Government) have been attempting to extract clinical data from general practice EHRs. However, the quality of their data is not only hampered by the lack of standardisation described above, but also by the quality of the data being entered (or not

entered) into the EHR. For example, they found that when an antibiotic prescription was recorded in the patient's EHR, the indication for the antibiotic was only recorded in about 30% of instances.[47]

The prevalence of chronic conditions and multimorbidity is expected to continue rising, due to the ageing of the population and increasing prevalence of obesity. This in turn creates a continued need to measure these prevalence and associated outcomes. In the environment of poor standardisation and linkage of electronic health data, collection of GP-encounter-based data is still highly valuable, suggesting that the methods described in my thesis will be relevant for years to come. While these methods were designed for the BEACH project which has now sadly been shut down, I am currently piloting another study examining the feasibility of having GPs record the same information about their patient encounters using an electronic data collection form. The structure of this form borrows heavily from lessons learnt from the BEACH project. A similar attempt a decade ago found that this type of data collection was too burdensome for GPs. However, since then a new generation of younger GPs have started practising who may be more computer savvy than those who have since retired. Also there have been improvements in user interface that may also make the process easier for GPs. If this new project is viable, the methods described in my thesis could be applied to the data from this new study.

Primary care, and general practice in particular, may provide an ideal home for the study of multimorbidity. As discussed previously, the use of GPs as expert interviewers/participants avoids the issues of collecting data through patient self-report[1-8] or chart review[5,7,9-12] alone. Data collected using my method is likely to be more reliable than that of respondent self-report used in the National Health Survey.[18] It has been commonly suggested that primary care holds our best hope of dealing with the complexity of caring for patients with multimorbidity.[48-50] It therefore follows that multimorbidity research should be based in primary care, with primary care informing research and the results from this research informing primary care. However for this to happen, there needs to be greater incentive for GPs to undertake research. An adaptation of the 'Health Care Homes' model may provide the structure, support and incentive for GPs to undertake this research. At the very least, there needs to be some incentive for GPs to improve their recording of data in patient EHRs.

Limitations

As I have discussed earlier, my first survey had the limitation of assuming no variance in the attendance patterns between patients in the same each age-sex group. Using this method overestimated the prevalence of chronic conditions (and multimorbidity) due to patients with more chronic conditions visiting GPs more often regardless of their age and sex. The final method applied to the second survey overcame this limitation by taking into account each individual patient's attendance when weighting their data.

However, this new adjustment method still has limitations. The newest method still assumes people who do not see a GP in a year do not have a diagnosed chronic condition. As I have mentioned in earlier chapters this may not apply to a chronic condition such as mild asthma (in an otherwise healthy person) that did not necessitate a GP visit in that year. It would also apply to a small number of people that are being managed solely by specialists (such as hospital outpatients). In the case of conditions such as asthma, the NHS is likely to be a more reliable source of prevalence data.

As with all studies of diagnosed chronic conditions, the GP must recognise that the patient has the chronic condition for it to be recorded. As the AusDiab study showed, there is a significant proportion of society with undiagnosed hypertension and/or with undiagnosed Type 2 Diabetes.[51]

While not a limitation of the new adjustment method, there was a limitation in the data collected in my second survey. The patient/GP reported number of GP-visits in the previous 12 months was under-reported when compared with Medicare claims statistics. This under-reporting is likely due to recall bias. This may be because the patient had seen another GP but had forgotten the visit(s) and/or did not wish the current GP to know of it or the current GP did not ask the patient whether they had seen another GP and had only recorded the visits at their practice. This under-reporting may have affected my national prevalence estimates if there was a bias for high or low attenders to more often under-report their visit rate. Whether this bias exists cannot be assessed from the current data. What is certain is that this under-reporting means that the models I built in Chapter 7 would underestimate the number of times a patient would see a GP in a year. While it is possible that weighting the effect size of the variables in the model could account for this under-reporting, it would only do so if there was no bias in the under-reporting for each of the variables in our model (i.e. patient age and sex, the number of diagnosed chronic conditions and whether the patient holds a CCHCC).

It has been suggested that any measure of multimorbidity should include some measure of the severity of the conditions.[26,52-54] In my research I was unable to include an individual measure of severity for each chronic condition due to space limitations on the research questionnaire and concern that the additional burden on GPs would lower their response rate. However in some of the sub-studies I did ask for the GP's opinion of the overall severity of illness of the patient.

As I showed in Chapter 7, overall severity of illness had little effect on GP-visit rates and we found it not to be a significant independent predictor. The fact that severity of illness was not an independent predictor of GP visit rate may be due to a strong relationship between the number of diagnosed chronic conditions and the overall severity of illness. It could also suggest that well controlled conditions require a similar amount of GP visits as conditions with a high severity.

While patient use of GP services is important, it is just one of many outcomes associated with multimorbidity. Further research into whether there is a relationship between severity of illness and these other outcomes needs to be undertaken.

Conclusion

I have taken the opportunity provided by the BEACH program to create and undertake Australia's largest national study of chronic conditions. I have measured the prevalence of chronic conditions not only among patients at GP encounters, but the prevalence in the Australian population, using methods I developed over the course of this thesis. For the first time, a single large prospective study has been used to test the effect of the way multimorbidity is measured on prevalence estimates, while controlling for other variables, using the same data for all measures. This has provided clear guidelines for other researchers to follow in their studies of multimorbidity. Using these same guidelines, I estimated the prevalence and patterns of multimorbidity in the Australian population. Finally, this thesis showed that multimorbidity was the largest driver of patient demand for GP services.

The results of this thesis could be used to inform the 'Primary Health Care' reform currently underway in Australia. The model predicting patient GP-visit rate will assist with future workforce planning and provide a scientific basis for calculation of suitable capitation payments for patients enrolled in the Health Care Homes trial. The high prevalence of

multimorbidity among patients at GP encounters and among people in the population, once again supports calls to change the healthcare system's single disease focus to a patient-centred focus. This is especially true of clinical trials and guidelines for care.

My concept of 'complex multimorbidity' may be useful in identification of high need patients. However, further testing of the extent to which it is associated with a wider array of outcomes is required. Further, the models I developed predicting patient GP-visit rate and complexity of care need to be independently validated using a comparable data source.

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Appendices

Appendix A: Instructions for the GP

A set of instructions for the GP on how to complete the survey

BEACH © - *Bettering the Evaluation And Care of Health*

NATIONAL MORBIDITY AND TREATMENT STUDY

INSTRUCTIONS FOR PARTICIPATING DOCTORS

USING THESE INSTRUCTIONS

Use these instructions as a resource to complete the forms. While they may look daunting, most of the form is self-explanatory. The instructions contain:

- ◆ an example consultation scenario
- ◆ a completed form for the example scenario
- ◆ detailed explanations for each question on the form.

Reading these instructions will:

- ◆ show you how to fill out the forms
- ◆ **ultimately save you time**
- ◆ decrease the variation among practitioners in their recording techniques.

When to complete the forms

Complete a form for each patient encounter. An encounter is defined as any professional interchange between a patient and a GP where the GP's clinical action results in entry of information into the patient's record.

Please complete the form during the course of the encounter as

- ◆ some information needs to be asked of the patient
- ◆ it will be faster and more accurate than going back to your records at the end of the day. **To show the full range of your clinical activity it is vital that you take the pad with you to all hospital, home and nursing home visits.**

Informing patients

In your research pack there are two copies of a gloss board notice which tells patients about the study and of their right to refuse to allow inclusion of their unidentified data. Please ask your reception staff to **ensure your patients read the notice.** Patients who consult with you in another language should be made aware of their options regarding the study. For patients not seen, nursing home visits and palliative care, please use your professional discretion in this matter. The Human Research Ethics Committee of the University requires that a mark be placed in the medical record of each patient who agrees to allow their data to be included in BEACH. Please record B ✓ or Beach Y (for yes) in the patient record. This action could be performed by any authorised staff member.

Patient information questions at the bottom of the form

These vary and are presented in blocks within the pad, so please read carefully the instructions relating to these questions. When the questions change in the pad, a green instruction sheet gives you instructions for the next block of forms.

EXAMPLE OF ONE TYPE OF RECORDED ENCOUNTER

This is a description of the data recorded on the sample recording form that follows.

On April 30th 2015, Mr A comes to the surgery. He has read the patient information card while in the waiting room and agrees to be included in the study. The consultation starts at 9.10 am. From the medical record you note Mr A's date of birth is 13/3/1953, his postcode is 2145 and that he carries a Health Care Card. You ask if he is from a Non English-Speaking Background or identifies himself as an Aboriginal or Torres Strait Islander and he answers no. You use the tick boxes to show his responses.

He is a regular patient suffering from hypertension and says he has almost run out of Coversyl and requests a script. After examination you feel Mr A is not responding to medication and you refer him to a cardiologist but also provide him with the required script for Coversyl 10mg tablets to be taken once a day with two repeats. You also recommend he try to lose weight (as you have on previous visits), advise a low-fat diet and send him for cholesterol screening. Since his last visit, you have spent time discussing Mr A's case with the practice dietitian. You advise him that she can help with a weight-loss program and to make an appointment to see her after the consultation.

Mr A then complains about his ribs. He says he slipped and bumped himself while gardening the day before and his ribs are hurting. You send him for an x-ray and advise him to take Panadol for the pain.

Finally, Mr A asks for a flu injection. You tell Mr A that you will arrange for the practice nurse to give him a FluVax injection from your practice supply. You tell him you have to ask him a couple of extra questions for the study. He says that he is 170 centimetres tall and weighs about 90 kilos. He has seen a GP 5 times in the past 12 months. He says he no longer smokes and has a drink most nights but never more than one or two. You show him the 'standard drinks' card and he confirms one or two standard drinks.

This has been a standard surgery consultation in the Item 23 category, which finishes at 9.28 am.

1

BEACH (Bettering the Evaluation And Care of Health) - Morbidity and Treatment Survey - National

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DOC ID

PATIENT SEEN BY GP	☑
PATIENT NOT SEEN BY GP	☐
Home visit (not RACF)	☐

Encounter Number

Date of encounter: 30 / 04 / 15

Date of Birth: 13 / 03 / 1953

Sex: M ☑ F ☐

Patient Postcode: 2145

START Time: 9 : 10 AM (circled) / PM (please circle)

Patient Reasons for Encounter
1. Script for hypertension tablets
2. Sore ribs
3. Flu shot

	Yes / No
New Patient	☐ ☑
Health Care/Benefits Card...	☑ ☐
Veterans Affairs Card....	☐ ☑
NESB........................	☐ ☑
Aboriginal.................	☐ ☑
Torres Strait Islander....	☐ ☑

Medicare
Item Nos: (if applicable)
1. _23_
2. _____
3. _____

New Patient ☐ Workers comp paid.... ☐
Other paid........................ ☐
No charge........................ ☐

Diagnosis/Problem ① : Hypertension

Problem Status: New ☐ Old ☑

Drug Name AND Form for this problem	Strength of product	Dose	Frequency	No. of Rpts	OTC	GP Supply	Drug status New	Cont.
1. Coversyl tablets	10mg	1 tab	1 daily	2		✓		✓
2.								
3.								
4.								

Procedures, other treatments, counselling this consult for this problem
1. Low fat diet advised   Prac Nurse? ☐
2.   Prac Nurse? ☐

Diagnosis/Problem ② : Injury - ribs

Problem Status: New ☑ Old ☐

Drug Name AND Form for this problem	Strength of product	Dose	Frequency	No. of Rpts	OTC	GP Supply	Drug status New	Cont.
1. Panadol tablets	500mg	2 tabs	qid		✓		✓	
2.								
3.								
4.								

Procedures, other treatments, counselling this consult for this problem
1.   Prac Nurse? ☐
2.   Prac Nurse? ☐

Diagnosis/Problem ③ : Immunisation

Problem Status: New ☑ Old ☐

Drug Name AND Form for this problem	Strength of product	Dose	Frequency	No. of Rpts	OTC	GP Supply	Drug status New	Cont.
1. FluVax injection	0.5 ml	1 inj	stat	0		✓	✓	
2.								
3.								
4.								

Procedures, other treatments, counselling this consult for this problem
1. Injection given   Prac Nurse? ☑
2.   Prac Nurse? ☐

Diagnosis/Problem ④ :

Problem Status: New ☐ Old ☐

Drug Name AND Form for this problem	Strength of product	Dose	Frequency	No. of Rpts	OTC	GP Supply	Drug status New	Cont.
1.								
2.								
3.								
4.								

Procedures, other treatments, counselling this consult for this problem
1.   Prac Nurse? ☐
2.   Prac Nurse? ☐

IMAGING/Other tests

		Body site	Problem(s)
1. X-ray	-	Ribs	① 2 3 4
2.	-		1 2 3 4
3.	-		1 2 3 4

PATHOLOGY

	Problem(s)
1. Lipid screen	① 2 3 4
2.	1 2 3 4
3.	1 2 3 4

PATHOLOGY (cont)
4.
5.

NEW REFERRALS, ADMISSIONS

	Problem(s)
1. Cardiologist	① 2 3 4
2. Dietitian	① 2 3 4

Patient reported
Height: 170 cm
Weight: 90 kg

Approx. how many times has this patient been any GP in the past 12 months (including today)? 5

To the patient if 18+:
Which best describes your tobacco smoking status?
Smoke daily .... ☐
Smoke occasionally ...... ☐
Previous smoker .... ☑
Never smoked............ ☐

To the patient if 18+:
How often do you have a drink containing alcohol?
Never .... ☐
Monthly or less.......... ☐
Once a week/fortnight.... ☐
2-3 times a week .... ☐
4+ times a week .... ☑

How many 'standard' drinks do you have on a typical day when you are drinking? 2

How often do you have 6 or more standard drinks on one occasion?
Never .... ☑
Less than monthly .... ☐
Monthly .... ☐
Weekly .... ☐
Daily or almost daily.... ☐

FINISH Time: 9 : 28 AM (circled) / PM (please circle)

BA18

BEACH (Bettering the Evaluation And Care of Health) - Morbidity and Treatment Survey - National

DOC ID

Encounter Number | **Date of encounter** | **Date of Birth** | **Sex** | **Patient Postcode**

Date of encounter: 30 / 04 / 15

Date of Birth: 13 / 03 / 1953

Sex: M ☑ F ☐

Patient Postcode: 2145

DATE: Enter day, month and year of encounter.

BIRTH: Enter day, month and FULL YEAR of patient's birth.

SEX: Tick box for sex of patient.

PATIENT POSTCODE: Postcode of patient's home address.

ENCOUNTER NUMBER:
Pre-stamped with consecutive encounter number 001-105. A few extra forms allow for error - please complete up to 102.

This is not a patient identification number.

If you see the same patient more than once during the recording period, complete a new form for each encounter. No linking of forms is required.

Ask the patient the following questions and tick either 'Yes' or 'No' for each item.

Yes / No

New Patient .... ☐ / ☑
Health Care/Benefits Card.... ☐ / ☑
Veterans Affairs Card........ ☐ / ☑
NESB......................... ☐ / ☑
Aboriginal................... ☐ / ☑
Torres Strait Islander .... ☐ / ☑

◆ **New Patient:** If this is the patient's first visit to your practice, tick the 'Yes' box. If the patient has been seen previously at this practice by you or one of your associates, tick the 'No' box.

◆ **Health Care / Benefits Card Holder:** eg unemployed, pensioner, low income earner.

◆ **Veterans' Affairs Card holder:** Indicate whether the patient has a Veterans' Card. Patients may hold both Veterans' and Health Care cards.

◆ **NESB:** Non-English Speaking Background i.e. primary language spoken at home is NOT English.

◆ **Aboriginal / Torres Strait Islander:** Ask the patient "Are you of Aboriginal or Torres Strait Islander origin?" The patient may answer "Yes" to either or both. If both, tick both 'Yes' boxes. Otherwise, tick 'Yes' to whichever option the patient nominates and 'No' to the other, or tick 'No' for both options if that is the patient's response.**

Medicare Item Nos:
(if applicable)
1. ___23___
2. _____
3. _____

PATIENT SEEN BY GP .... ☑
PATIENT NOT SEEN BY GP .... ☐
Home visit (not RACF) .... ☐

Workers comp paid............ ☐
Other paid .... ☐
No charge .... ☐

PATIENT SEEN / NOT SEEN / HOME VISIT.

Tick '**PATIENT SEEN**' if this is a face-to-face encounter

Tick '**PATIENT NOT SEEN**' if a service is provided where your clinical action results in entry of information into the patient's record but the patient is not seen e.g: referrals, renewals for prescription/certificates, case conferences/ EPC items, where the patient is not seen face-to-face. This includes any telehealth consultations between the GP and the patient.

Tick '**Home visit**' if the patient is seen in a place other than a residential aged care facility (RACF), consulting room, hospital or institution.

Note - Informed consent must be obtained from the patient or their carer prior to inclusion in the study, either by telephone or in person.

These items ask about the type of renumeration claimable for the encounter.

Medicare Encounters (including Department of Veterans Affairs (DVA))

Item No:

◆ Write the item number/s when there is a charge through Medicare, **bulk-billed or otherwise.**

◆ When multiple item numbers are involved, record the **consultation item**, e.g. 23 **and up to 2 others.**

◆ If unsure of item number, please provide type and level of consultation e.g. NHV-B (nursing home visit - level B) or health assessment.

◆ Include item numbers (when applicable) for services when the patient is not seen e.g. case conferences.

Non-Medicare (non-DVA) Encounters

◆ *Workers Compensation paid:* For consultations claimable through workers compensation.

◆ *Other paid:* For encounters being paid for by a state government (e.g. prisons, hospital (HMO) or other state agency); an insurance company; an employer; by 'cash only' patients (e.g. overseas visitors) or any patient not eligilble for Medicare; or other source. DOES NOT include additional cash payments made by patients charged through Medicare.

◆ *No charge:* For services you provide free - with no payment from **ANY** source.

** This question was formally adopted in 1995 by the Australian Bureau of Statistics as the standard for measuring membership of the Indigenous population.

McLennan, W. & Madden, R. (1999) The health and welfare of Australia's Aboriginal and Torres Strait Islander Peoples ABS 4704.0 p.149

3

PATIENT REASON FOR ENCOUNTER (RFE):

Record at least 1 and up to 3 patient reasons for the encounter.

♦ The reason for encounter is the patient's view of the reasons he/she is consulting you. The **patient's own words** should be used. May include:

   ◆ symptoms e.g. "runny nose",

   ◆ diagnoses e.g. "diabetes",

   ◆ requests for service e.g. "script for BP", "referral".

   ◆ other examples – "Worried about…", "follow-up", "check-up circulatory"

♦ Specify the body system even when this is not stated between you.

PROBLEM STATUS:

Tick '**New**' if:

   ◆ this is a new problem to the patient, or

   ◆ this is a new episode of a recurrent problem (e.g. URTI), AND

   ◆ the patient has not been treated for that problem or episode by any medical practitioner before.

Tick '**Old**' if the patient has been seen before by ANY medical practitioner for this chronic problem or this episode of an acute problem.

PROCEDURES, OTHER TREATMENTS, COUNSELLING:

For each problem:

♦ Record up to two procedures, other treatments or counselling.

♦ Only include those ACTUALLY PROVIDED at the encounter.

♦ **Include in this section actions such as**

   ◆ pap smears, injections, excisions, ear syringe

   ◆ psychosocial counselling

   ◆ diet and exercise advice

   ◆ medical certificates

♦ **Do NOT include in this section:**

   ◆ history

   ◆ routine physical examinations e.g. blood pressure checks

   ◆ discussion

   ◆ referrals, imaging, or pathology ordered (there are sections for these).

NB - If a **practice nurse performs the procedure**, please **tick the box** marked 'Prac Nurse?'

START TIME

9 : 10   (AM) PM
(please circle)

Date of encounter	Date of Birth	Sex	Patient Postcode
30 / 04 / 15	13 / 03 / 1953	M ☑ F ☐	2145

Patient Reasons for Encounter	1.	*Script for hypertension tablets*
	2.	*Sore ribs*
	3.	*Flu shot*

Diagnosis/ Problem ① : *Hypertension*

Problem Status
New ☐ Old ☑

Drug Name AND Form for this problem	Strength of product	Dose	Frequency	No. of Rpts	OTC	GP Supply	Drug status New	Drug status Cont.
1. *Coversyl tablets*	*10mg*	*1 tab*	*1 daily*	*2*				✓
2.								
3.								
4.								

Procedures, other treatments, counselling this consult for this problem   Prac Nurse? ☐   2.

1. *Low fat diet advised*   Prac Nurse? ☐   Prac Nurse? ☐

START TIME

Record the time the consultation STARTED in hours and mins and circle whether the time was AM or PM.

eg.   9 : 10
(AM) PM

DIAGNOSIS/PROBLEM:
Record at least one and up to four problems.

♦ Use one Diagnosis/problem box for each diagnosis/problem

♦ Only record problems actually dealt with at this encounter

♦ Include ill-defined conditions (e.g. "cough"), preventive care (e.g. "pap smear", "contraception", "immunisation" or "checkup"), and social problems (e.g. "problems with spouse").

♦ Diagnose at the highest level possible with the information available (e.g. for diabetes, differentiate between IDDM/NIDDM/Type 1/Type 2 etc.)

♦ The order in which you record the problems is not significant - they do not have to match the order of the RFEs.

♦ If more than four problems are managed at the consultation, record the four problems that best describe the breadth of the consultation.

4

MEDICATIONS: **NB - ONLY** record medications that were prescribed / advised / supplied **at this encounter**

Record medications when

- a prescription is written at this encounter,
- you recommend that the patient take an "over the counter" (OTC) medication.
- you administer or supply a medication/vaccine. eg. If 'Immunisation' is the problem managed, please enter drugs administered at this encounter, (e.g. IPV, DTP) or any drug samples you provide.

Diagnosis/ Problem ① : _Hypertension_   **Problem Status** New ☐ Old ☑

Drug Name AND Form for this problem	Strength of product	Dose	Frequency	No. of Rpts	OTC	GP Supply	Drug status New	Cont.

Procedures, other treatments, counselling this consult for this problem

1.

Prac Nurse? ☐

Diagnosis/ Problem ② : _Injury - ribs_   **Problem Status** New ☐ Old ☑

Drug Name AND Form for this problem	Strength of product	Dose	Frequency	No. of Rpts	OTC	GP Supply	Drug status New	Cont.
1. _Panadol tablets_	_500mg_	_2 tabs_	_qid_		✓			✓
2.								
3.								
4.								

Procedures, other treatments, counselling this consult for this problem

1.   2.

Prac Nurse? ☐

Drug name and Form: the brand or generic name of the medication **and its form** eg Cardizem CD tablets; Panadol syrup; Ventolin nebules etc.

Strength of product: Please specify the **strength** of the product you are prescribing/ supplying/advising. We are attempting to differentiate between product strengths, e.g. 250mg or 500mg of the same product.

Dose: the **quantity** of medication to be taken e.g. 2 tabs; 25 mls; 1 inj; 2 puffs etc.

Frequency:
- **how often** the dose is to be taken.
- record in accepted abbreviations e.g. "bd", "tds", etc.
- if drug is to be taken "as required", write PRN.

OTC: tick if the medication advised is to be bought **Over The Counter** i.e. an S2 or S3 product. **Otherwise leave blank.**

No. of Rpts: for all prescriptions please specify the **number of repeats** ordered. If no repeats are given, please write '0' or ' - '. **Please do not leave blank.**

Drug status: If the medication is being used for the management of this problem for the **first time** then tick the '**New**' box. If it is a **continuation** or repeat of previous therapy then tick the '**Cont.**' box.

GP supply: tick box if medication is from the **practice supplies** eg drug sample or vaccine. **Otherwise, leave blank.**

DO NOT TICK IF YOU HAVE PROVIDED A PRESCRIPTION, ONLY IF YOU HAVE PROVIDED A MEDICATION.

PLEASE RECORD INFORMATION IN AS MUCH DETAIL AS YOU WOULD WRITE ON A PRESCRIPTION.

For OTCs, provide as much detail as the patient would need to buy the medication over the counter.

5

OTHER MEDICATION EXAMPLES

ALWAYS SPECIFY
NAME and FORM,
STRENGTH,
DOSE and
FREQUENCY

Syrups
Dose may be written in "mg" or "ml" but strength must be specified.

Drug Name AND Form for this problem	Strength of product	Dose	Frequency	No. of Rpts	OTC	GP Supply	Drug status New	Cont.
1. Amoxil syrup	250mg/5ml	2.5ml	tds	0			✓	
2. Panadol syrup	120mg/5ml	10ml	4 hrly		✓			✓

Creams
Specify the name, form, strength and no. of applications per day. There is no need to specify pack size.

Drug Name AND Form for this problem	Strength of product	Dose	Frequency	No. of Rpts	OTC	GP Supply	Drug status New	Cont.
1. Aristocort cream	0.02%		tds	-				✓

Multiple strengths of same drug
If prescribing multiple strengths of the same drug to achieve a particular dose, specify both.

Drug Name AND Form for this problem	Strength of product	Dose	Frequency	No. of Rpts	OTC	GP Supply	Drug status New	Cont.
1. Warfarin tablets	1mg	1 tab	mane	2				✓
2. Warfarin tablets	2mg	1 tab	mane	2				✓

Injections
Tick GP supply only if you have provided the vaccine / medication yourself.
NB Please write '**injection given**' in the "Procedures, other treatments ..." section if you have given the injection at this encounter.

Drug Name AND Form for this problem	Strength of product	Dose	Frequency	No. of Rpts	OTC	GP Supply	Drug status New	Cont.
1. Fluvax inject	0.5ml	1 inj	stat	0			✓	
2. Engerix B Adult inject	20mcg/ml	1 inj	stat	0		✓	✓	

Insulin
Specify the number of units prescribed.

Drug Name AND Form for this problem	Strength of product	Dose	Frequency	No. of Rpts	OTC	GP Supply	Drug status New	Cont.
1. Mixtard 30/70 injection	100iu/ml	20units	mane	1				✓
2. Mixtard 30/70 injection	100iu/ml	12units	nocte	1				✓

Inhaled medications
Specify the mode of delivery, e.g. inhaler, turbuhaler, nebules, etc. and the strength.

Drug Name AND Form for this problem	Strength of product	Dose	Frequency	No. of Rpts	OTC	GP Supply	Drug status New	Cont.
1. Pulmicort turbuhaler	400mcg	2 puffs	bd	1			✓	
2. Prednisone tablets	25mg	½ tab	1 daily	0			✓	
3. Ventolin inhaler	100mcg	2 puffs	4/24 prn		✓			✓

NEW REFERRALS / ADMISSIONS:

◆ Specify the type of specialist(s) or allied health professional(s) to whom the referral has been made, e.g. dermatologist, physiotherapist, hospital emergency department etc.

◆ Record NEW referrals only. Do not include continuation referrals.

◆ Indicate the problem or problems for which the referral was made by circling the appropriate problem number.

◆ Include referrals for clinical measurements such as spirometry and ECG

IMAGING/Other tests (+ Body site):

Imaging

◆ write the name of the imaging (e.g. x-ray) and body site

◆ circle the number(s) of the Diagnosis/problem which is being investigated

Other tests

◆ specify the type of test

◆ circle the relevant Diagnosis/problem number(s)

Lateralization is not required.

PATHOLOGY:

◆ Give details of up to five pathology tests/batteries of tests ordered at the encounter. Document one test per line.

◆ Circle the associated Diagnosis/problem number(s).

◆ For single tests, write the test name (e.g. *HBA1C, pap smear*). If ordering a set of tests such as a FBC or LFT or lipids or thyroid function, record them in this grouped form. You don't need to list each of the individual tests incorporated in the set.

◆ Do not record simple urine dip stick tests.

NEW REFERRALS, ADMISSIONS

	Problem(s)
1. *Cardiologist*	① 2 3 4
2. *Dietitian*	① 2 3 4

IMAGING/Other tests

	Body site	Problem(s)
1. *X-ray*	- *Ribs*	1 ② 3 4
2.	-	1 2 3 4
3.	-	1 2 3 4

PATHOLOGY

	Problem(s)
1. *Lipid screen*	① 2 3 4
2.	1 2 3 4
3.	1 2 3 4

PATHOLOGY (cont)

	Problem(s)
4.	1 2 3 4
5.	1 2 3 4

Appendix B: Patient information card

A patient information card, that described the survey and its purpose to the patient

including the option for the patient to opt out if they wish

INFORMATION FOR PATIENTS

The *BEACH* © Project

Today your doctor is taking part in a National Survey of general practice called *BEACH*© *(Bettering the Evaluation and Care of Health).* This study is being done by the Family Medicine Research Centre, University of Sydney.

Your Doctor will be recording information about each patient he/she sees (age, gender etc), the problems that you see the Doctor about and the treatments given to you. **There are no names on the forms so you cannot be identified.** The information about today's visit to the doctor will be one record in a set of 100,000 records collected in general practices across Australia every year.

This information will be used by researchers to describe what happens in general practice and to look at different aspects of health care; by government departments to help them plan for our future health; and by pharmaceutical companies to gain a picture of the problems being treated with the drugs they produce.

Remember: your name will not be on the form and no information will ever be released which could possibly let anyone know who you are. However, if you do not wish your doctor to record any unidentified information about you or your visit **please tell your Doctor as soon as you go in**. Such a decision will not affect the consultation with your doctor in any way.

SEE OVER FOR PROJECT DETAILS

(page 1 / 2)

BEACH © Program details

This program has been approved by the Ethics Committee of the University of Sydney. The data are being collected in accordance with the Privacy Act 1988 as amended.

Organisations contributing financially to the conduct of this study in 2015–2016 are:

✦ The Australian Government Department of Health

✦ AstraZeneca Pty Ltd (Australia)

✦ bioCSL (Australia) Pty Ltd

✦ Novartis Pharmaceuticals Australia Pty Ltd

BEACH is endorsed
by
the Royal Australian College
of General Practitioners

BEACH is endorsed
by
the Australian Medical Association

AMA

FURTHER INFORMATION

Family Medicine Research Centre

The University of Sydney

Acacia House, Westmead Hospital

Westmead 2145

Phone: (02) 9845 8151

Fax: (02) 9845 8155

Email: clare.bayram@sydney.edu.au

Web: sydney.edu.au/medicine/fmrc/

Any person with concerns or complaints about the conduct of this research study can contact The Manager, Research Integrity and Ethics Administration, University of Sydney on +61 2 8627 8176 (Telephone); +61 2 8627 8177 (Facsimile); ro.humanethics@sydney.edu.au (Email).

Appendix C: GP questionnaire

A short questionnaire about the GP and their practice

GP profile

THE UNIVERSITY OF SYDNEY

Family Medicine Research Centre

Doctor Identification Number

Please answer the following questions ABOUT YOU

1. Sex .... **Male / Female** *(Please circle)*

2. Age ....

3. How many years have you spent in general practice? ....

4. Country of graduation *(primary medical degree)*:

☐ Australia   ☐ Other: *(specify)* _____

5. How many direct patient care hours do you work per week?
(Include hours of direct patient care, instructions, counselling etc and other services such as referrals, prescriptions, phone calls etc.) ....

6. Are you a GP Registrar *(i.e. in training)*? ....**Yes / No**

7. Do you hold FRACGP? ....**Yes / No**

8. Do you hold FACRRM? ....**Yes / No**

9. Do **YOU** use a computer at your major practice? .... **Yes / No**
If '**yes**', which clinical software is used? *(specify)* _____

10. Over the past four weeks have you provided any patient care...
(a) in a residential aged care facility? ....**Yes / No**
(b) as a salaried/sessional hospital medical officer? ....**Yes / No**

11. At how many practice locations do you usually work, in a regular week ....

12. Did any of your BEACH consultations take place in an Aboriginal Community Controlled Health Service?
(Circle <u>one</u> option)
No...1
Yes - all 2
Yes - some (which dates?)_____3

· ·

Please answer the following questions ABOUT YOUR <u>MAJOR</u> PRACTICE

13. Is your major practice a teaching practice?
(Circle all that apply):
For undergraduates...1
For junior doctors...2
For GP registrars 3
No 4

14. Postcode of major practice?.................

15. Which Primary Health Network?_____

16. What was your Medicare Local? _____

17. Is the practice accredited?.....................**Yes / No**

18. How many individuals (ie. headcount) and how many full-time equivalents (FTE*) for each type of professional listed below?
*Each FTE is defined as working 35-45 hours per week e.g. 2 GPs each working 20 hours/wk is recorded as 2 individual GPs and 1 FTE; 1 practice nurse working 20 hours/wk is recorded as 1 individual and 0.5 FTE.

	No. individuals	No. FTEs
(a) GPs (including yourself)		
(b) Practice nurses		

19. Health services located or available (on a daily or regular basis) at the practice site?

(Tick all that apply)	In the practice	Not in the practice, but in the building or within 50 metres
Physiotherapist.........................	☐	☐
Psychologist	☐	☐
Dietitian....................................	☐	☐
Podiatrist	☐	☐
Pathology collection centre/lab ..	☐	☐
Imaging	☐	☐
Diabetes educator.....................	☐	☐
Specialist(s) *(specify)*: _____	☐	☐
_____	☐	☐
Other *(specify)*: _____	☐	☐
NONE	☐	☐

20. Normal after-hours arrangements?
(Circle all that apply)
Practice does its own..1
Co-operative with other practices 2
Deputising service...3
Other *(specify)*_____4
None 5

*Thank you for participating in the **BEACH PROGRAM**.*
Please return this form with the completed BEACH pad.

Appendix D: Patient encounter recording form

A patient encounter recording form. These came in a pad of 100.

BEACH (Bettering the Evaluation And Care of Health) - Morbidity and Treatment Survey - National

© **BEACH** The University of Sydney 1996

DOC ID

Encounter Number | Date of encounter | Date of Birth | Sex | Patient Postcode

Sex: M ☐ F ☐

START Time : ☐ AM / PM (please circle)

Patient Reasons for Encounter
1.
2.
3.

PATIENT SEEN BY GP .... ☐
PATIENT NOT SEEN BY GP .... ☐
Home visit (not RACF) .... ☐

Medicare Item Nos: (if applicable)
1.
2.
3.

Workers comp paid ..... ☐
Other paid .... ☐
No charge .... ☐

Yes / No
New Patient .... ☐ ☐
Health Care/Benefits Card... ☐ ☐
Veterans Affairs Card........ ☐ ☐
NESB................ ☐ ☐
Aboriginal................ ☐ ☐
Torres Strait Islander .... ☐ ☐

Diagnosis/Problem ① :

Problem Status New ☐ Old ☐

Drug Name AND Form for this problem	Strength of product	Dose	Frequency	No. of Rpts	OTC	GP Supply	Drug status New	Cont.
1.								
2.								
3.								
4.								

Procedures, other treatments, counselling this consult for this problem
1. Prac Nurse? ☐
2. Prac Nurse? ☐

Diagnosis/Problem ② :

Problem Status New ☐ Old ☐

Drug Name AND Form for this problem	Strength of product	Dose	Frequency	No. of Rpts	OTC	GP Supply	Drug status New	Cont.
1.								
2.								
3.								
4.								

Procedures, other treatments, counselling this consult for this problem
1. Prac Nurse? ☐
2. Prac Nurse? ☐

Diagnosis/Problem ③ :

Problem Status New ☐ Old ☐

Drug Name AND Form for this problem	Strength of product	Dose	Frequency	No. of Rpts	OTC	GP Supply	Drug status New	Cont.
1.								
2.								
3.								
4.								

Procedures, other treatments, counselling this consult for this problem
1. Prac Nurse? ☐
2. Prac Nurse? ☐

Diagnosis/Problem ④ :

Problem Status New ☐ Old ☐

Drug Name AND Form for this problem	Strength of product	Dose	Frequency	No. of Rpts	OTC	GP Supply	Drug status New	Cont.
1.								
2.								
3.								
4.								

Procedures, other treatments, counselling this consult for this problem
1. Prac Nurse? ☐
2. Prac Nurse? ☐

NEW REFERRALS, ADMISSIONS

Problem(s)
1.   1 2 3 4
  1 2 3 4

IMAGING/Other tests

Body site   Problem(s)
1. -   1 2 3 4
2. -   1 2 3 4
3. -   1 2 3 4

PATHOLOGY

Problem(s)
1.   1 2 3 4
2.   1 2 3 4
3.   1 2 3 4

PATHOLOGY (cont)

Problem(s)
4.   1 2 3 4
5.   1 2 3 4

Approx. how many times has this patient seen any GP in the past 12 months (including today)? ☐

To the patient if 18+: Which best describes your tobacco smoking status?
Smoke daily .... ☐
Smoke occasionally......... ☐
Previous smoker.......... ☐
Never smoked.............. ☐

To the patient if 18+: How often do you have a drink containing alcohol?
Never .... ☐
Monthly or less .... ☐
Once a week/fortnight..... ☐
2-3 times a week .... ☐
4+ times a week .... ☐

How many 'standard' drinks do you have on a typical day when you are drinking? ☐

How often do you have 6 or more standard drinks on one occasion?
Never.............. ☐
Less than monthly .... ☐
Monthly................ ☐
Weekly............ ☐
Daily or almost daily .... ☐

Patient reported
Height: ☐ cm
Weight: ☐ kg

FINISH Time : ☐ AM / PM (please circle)

BA18

Appendix E: Instructions for sub-studies used in this thesis

Presented in order

Instructions for survey 1

Instructions for survey 2 – part 1: Consultation length

Instructions for survey 2 – part 2: Severity of illness

Instructions for survey 2 – part 3: Complexity of care

Instructions for survey 2 – part 4: Health resource utilisation #1

Instructions for survey 2 – part 5: Health resource utilisation #2

Instructions for survey 2 – part 6: Health resource utilisation #3

PLEASE READ CAREFULLY

The shaded section of the following forms asks questions about **PATIENT'S CHRONIC DISEASES / PROBLEMS.**
You may tear out this page as a guide to completing the following section of forms.

INSTRUCTIONS

Answer these questions for **ALL** of the **next 30 PATIENTS in the order in which the patients are seen.**

Please **DO NOT select patients** to suit the topic being investigated.

Use your own knowledge, patient knowledge and medical records as you see fit, in order to answer these questions.

Abbreviations

IHD = ischaemic heart disease

CHF = congestive heart failure

Periph Vasc Dis = peripheral vascular disease

CVA = cerebrovascular accident

COAD = chronic obstructive airways disease

GORD = gastro-oesophageal reflux disease

Patient chronic diseases/problems

The aim of these questions is to allow us to estimate the **prevalence** and **patterns** of **multimorbidity** in general practice patients. This may assist in the planning for future health service needs.

Please use the tick boxes to indicate whether the patient has **ANY** of the **listed chronic diseases or problems** even if you have managed this problem today. Tick as many as apply.

Most of the conditions listed below require continual management or surveillance and may need consideration in future care.

If the patient has **chronic diseases/problems** that are **not listed**, please tick the box labelled **'other' in the relevant group** and **specify the problem(s)** in the space provided.

Malignant neoplasms are dealt with separately. In the far right hand column please **specify the primary site** of the neoplasm.

If the patient has any **other chronic problems or diseases** that **cannot be grouped by the listed body systems** please specify these in the **other chronic problems group.**

If the patient has **NO chronic problems** please tick the box labelled '**no chronic problems in this patient**', leaving everything else blank.

Does the patient have any of the following chronic diseases/ problems? (Tick as many as apply)	Cardiovascular	Endocrine / nutritional	Musculoskeletal	Respiratory	Psychological	Gastrointestinal	Genitourinary	Other chronic problems
	☐ Hypertension	☐ Hyperlipidaemia	☐ Osteoarthritis	☐ Asthma	☐ Depression	☐ GORD	☐ Chronic renal failure	☐ **Malignant neoplasm**
	☐ IHD	☐ Diabetes Type 1	☐ Rheumatoid arthritis	☐ COAD	☐ Anxiety	☐ Inflammatory bowel disease	☐ Other _____ *(please specify)*	Site: _____ *(please specify)*
	☐ CHF	☐ Diabetes Type 2	☐ Other arthritis	☐ Other _____ *(please specify)*	☐ Sleep disorder	☐ Other _____ *(please specify)*	**Eye**	**Other diseases:**
	☐ Periph.Vasc. Dis	☐ Obesity (BMI ≥30)	☐ Osteoporosis		☐ Other _____ *(please specify)*		☐ Glaucoma	_____
	☐ CVA/stroke	☐ Other _____ *(please specify)*	☐ Chronic back pain				☐ Other _____ *(please specify)*	_____ *(please specify)*
	☐ Other _____ *(please specify)*		☐ Other _____ *(please specify)*					

☐ **No chronic problems in this patient**

BL104B

PLEASE READ CAREFULLY

The shaded section of the following forms asks questions about **PATIENT'S CHRONIC CONDITIONS / PROBLEMS.**
You may tear out this page as a guide to completing the following section of forms.

START Time

:

AM / PM
(please circle)

Start time

Record the time the consultation STARTED in hours and minutes and circle whether the time was AM or PM.

For example: 9 : 10

(AM)/ PM
(please circle)

INSTRUCTIONS

Answer these questions for **EACH** of the **next 30 PATIENTS in the order in which the patients are seen.**

Please **DO NOT select patients** to suit the topic being investigated.

Use your own knowledge, patient knowledge and your records as you see fit, in order to answer these questions.

Finish time

Record the time the consultation FINISHED in hours and minutes and circle whether the time was AM or PM.

For example: 9 : 28

(AM)/ PM
(please circle)

FINISH Time

:

AM / PM
(please circle)

BL148B

Frequency of GP visits

Please write the approximate **number of times (including today's visit)** the patient has **seen any GP for any reason** in the **past 12 months.** Use patient recall, and/or your notes or knowledge, to give the best estimate.

Abbreviations

BMI = body mass index
IHD = ischaemic heart disease
CHF = congestive heart failure
Periph Vasc Dis = peripheral vascular disease
CVA = cerebrovascular accident
COPD = chronic obstructive pulmonary disease (including emphysema)
GORD = gastro-oesophageal reflux disease

Patient chronic conditions/problems

The aim of these questions is to estimate the **prevalence** and **patterns** of **multimorbidity** in general practice patients. With an ageing population, the prevalence of multimorbidity is expected to increase and much of the care will fall on general practice. This study will highlight the complexity of multimorbidity and assist in planning for future health service needs.

If the patient has **NO chronic problems** please tick the box labelled '**NO chronic problems in this patient**', and go to the 'finish time' question.

If the patient **DOES** have chronic conditions or problems, please **use the tick boxes to indicate which ones** they have (irrespective of whether you have managed them today). Tick as many as apply.

If the patient has a **malignant neoplasm(s)** please **specify the primary site** of the neoplasm.

If the patient has any **other chronic problems or conditions** that are **not listed** please specify these in the '**Other chronic problems not listed**' section.

| Approx. how many times has this patient seen any GP in the past 12 months (including today)?

No: _____

☐ Don't know | Does the patient have any chronic conditions/ problems?

(Tick all that apply)

☐ **NO chronic problems in this patient → Go to last question** | Musculoskeletal
☐ Osteoarthritis
☐ Rheumatoid arthritis
☐ Other arthritis
☐ Osteoporosis
☐ Chronic back pain | Psychological
☐ Depression
☐ Anxiety
☐ Insomnia
☐ Dementia (incl Alzheimer's) | Endocrine / nutritional
☐ Hyperlipidaemia
☐ Diabetes Type 1
☐ Diabetes Type 2
☐ Obesity (BMI ≥30)
☐ Hypothyroidism
☐ Hyperthyroidism | Cardiovascular
☐ Hypertension
☐ IHD
☐ CHF
☐ Periph.Vasc. Dis
☐ CVA/stroke
☐ Atrial fibrillation | Other chronic problems
☐ Asthma
☐ COPD
☐ Sleep apnoea
☐ Chronic renal failure
☐ GORD
☐ Glaucoma
☐ Malignant neoplasm→Site: | Other chronic problems not listed: *(please specify)*
_____
_____ |

PLEASE READ CAREFULLY

The shaded section of the following forms asks questions about **PATIENT'S CHRONIC CONDITIONS / PROBLEMS.**
You may tear out this page as a guide to completing the following set of forms.

INSTRUCTIONS

Answer these questions for **EACH** of the **next 30 PATIENTS** in the **order in which the patients are seen.**

Please **DO NOT select patients** to suit the topic being investigated.

Use your own knowledge, patient knowledge and your records as you see fit, in order to answer these questions.

Frequency of GP visits

Using patient recall, and/or your notes or knowledge, please write the approximate **number of times (including today's visit)** the patient has **seen any GP for any reason** in the **past 12 months.**

Severity of illness

Please mark the line with an X to indicate how you would rate this **patient's overall severity of illness during the past week.**

Lowest severity applies to someone whose total set of diagnoses results in the fewest symptoms and complications, the least disability and threat to life, the least need for treatment, and the best expected response to treatment if needed.

Highest severity applies to someone whose total set of diagnoses results in the most symptoms and complications, the most disability and greatest threat to life, the most need for treatment, and the worst expected response to treatment.

Source: Department of Community and Family Medicine, Duke University Medical Center, Durham, NC, USA.

Abbreviations

BMI = body mass index
IHD = ischaemic heart disease
CHF = congestive heart failure
Periph Vasc Dis = peripheral vascular disease
CVA = cerebrovascular accident
COPD = chronic obstructive pulmonary disease (including emphysema)
GORD = gastro-oesophageal reflux disease

Patient chronic conditions/problems

The aim of these questions is to estimate the **prevalence** and **patterns** of **multimorbidity** in general practice patients. With an ageing population, the prevalence of multimorbidity is expected to increase and much of the care will fall on general practice. This study will highlight the complexity of multimorbidity and assist in planning for future health service needs.

If the patient has **NO chronic problems** please tick the box labelled **'NO chronic problems in this patient'**, you may end the questions here for this patient.

If the patient **DOES** have **chronic conditions or problems**, please **use the tick boxes to indicate which ones** they have (irrespective of whether you have managed them today). Tick as many as apply.

If the patient has a **malignant neoplasm(s)** please **specify the primary site** of the neoplasm.

If the patient has any **other chronic problems or conditions** that are **not listed** please specify these in the **'Other chronic problems not listed'** section.

Approx. how many times has this patient seen any GP in the past 12 months (including today)?	Does the patient have any chronic conditions/problems? *(Tick all that apply)*			*Other:*
	☐ NO chronic problems → **End questions**			
	Musculoskeletal	*Psychological*	*Endocrine / nutritional*	*Cardiovascular*
	☐ Osteoarthritis	☐ Depression	☐ Hyperlipidaemia	☐ Hypertension
	☐ Rheumatoid arthritis	☐ Anxiety	☐ Diabetes Type 1	☐ IHD
	☐ Other arthritis	☐ Insomnia	☐ Diabetes Type 2	☐ CHF
	☐ Osteoporosis	☐ Dementia (incl Alzheimer's)	☐ Obesity (BMI ≥30)	☐ Periph. Vasc. Dis
	☐ Chronic back pain		☐ Hypothyroidism	☐ CVA/stroke
			☐ Hyperthyroidisim	☐ Atrial fibrillation
BL159B				

Other:
☐ Asthma
☐ COPD
☐ Sleep apnoea
☐ GORD
☐ Chronic renal failure
☐ Glaucoma
☐ Malignant neoplasm
Site:

Other chronic problems not listed:
_____
_____
(please specify)

Mark the line with an X to indicate the patient's overall severity of illness in the past week:

LOWEST SEVERITY 0 1 2 3 4 5 6 7 8 9 10 *HIGHEST SEVERITY*

PLEASE READ CAREFULLY

The shaded section of the following forms asks questions about **PATIENT'S CHRONIC CONDITIONS / PROBLEMS.**
You may tear out this page as a guide to completing the following set of forms.

INSTRUCTIONS

Answer these questions for **EACH** of the **next 30 PATIENTS** in the **order in which the patients are seen.**
Please **DO NOT select patients** to suit the topic being investigated.

Use your own knowledge, patient knowledge and your records as you see fit, in order to answer these questions.

Frequency of GP visits

Using patient recall, and/or your notes or knowledge, please write the approximate **number of times (including today's visit)** the patient has **seen any GP for any reason** in the **past 12 months.**

Abbreviations

BMI = body mass index
IHD = ischaemic heart disease
CHF = congestive heart failure
Periph Vasc Dis = peripheral vascular disease
CVA = cerebrovascular accident
COPD = chronic obstructive pulmonary disease (including emphysema)
GORD = gastro-oesophageal reflux disease

Patient chronic conditions/problems

The aim of these questions is to estimate the **prevalence** and **patterns** of **multimorbidity** in general practice patients. With an ageing population, the prevalence of multimorbidity is expected to increase and much of the care will fall on general practice. This study will highlight the complexity of multimorbidity and assist in planning for future health service needs.

If the patient has **NO chronic problems** please tick the box labelled **'NO chronic problems in this patient'**, you may end the questions here for this patient.

If the patient **DOES** have **chronic conditions or problems**, please **use the tick boxes to indicate which ones** they have (irrespective of whether you have managed them today). Tick as many as apply.

If the patient has a **malignant neoplasm(s)** please **specify the primary site** of the neoplasm.
If the patient has any **other chronic problems or conditions** that are **not listed** please specify these in the **'Other chronic problems not listed'** section.

Complexity of management

This question aims to assess, in your clinical opinion, **the complexity of managing each patient who has at least one chronic condition.**

Complexity could be influenced by many factors, including:

- the mix of conditions
- overall severity of illness
- contradictory clinical care guidelines
- interactions between medications
- access to other health services
- patient compliance
- patient expectations
- patient cultural background
- patient health literacy
- patient socio economic status
- contradictory advice to patient
- other environmental factors
- frailty of the patient

This list is not exhaustive and not all factors will relate to every patient.

Please **mark the line with an X to indicate how complex it is for you to manage the patient**, with 1 being the lowest complexity and 10 being the highest.

Approx. how many times has this patient seen any GP in the past 12 months (including today)?	Does the patient have any chronic conditions/problems? *(Tick all that apply)*				Other:	Other chronic problems not listed: *(please specify)*
	☐ No chronic problems →**End questions**				☐ Asthma	
	Musculoskeletal	*Psychological*	*Endocrine / nutritional*	*Cardiovascular*	☐ COPD	
	☐ Osteoarthritis	☐ Depression	☐ Hyperlipidaemia	☐ Hypertension	☐ Sleep apnoea	
	☐ Rheumatoid arthritis	☐ Anxiety	☐ Diabetes Type 1	☐ IHD	☐ GORD	
	☐ Other arthritis	☐ Insomnia	☐ Diabetes Type 2	☐ CHF	☐ Chronic renal failure	
	☐ Osteoporosis	☐ Dementia (incl Alzheimer's)	☐ Obesity (BMI ≥30)	☐ Periph.Vasc. Dis	☐ Glaucoma	
	☐ Chronic back pain		☐ Hypothyroidism	☐ CVA/stroke	☐ Malignant neoplasm	
			☐ Hyperthyroidism	☐ Atrial fibrillation	Site:	

Mark the line with an X to indicate how complex you find the management of this patient:

LOWEST   0 1 2 3 4 5 6 7 8 9 10   HIGHEST

BL162C

The shaded section of the following forms asks questions about the **PATIENT'S CHRONIC CONDITIONS / PROBLEMS.**
You may tear out this page as a guide to completing the following set of forms.

INSTRUCTIONS

Answer these questions for **EACH** of the **next 30 PATIENTS** in the **order in which the patients are seen.**

Please **DO NOT select patients** to suit the topic being investigated.

Use your own knowledge, patient knowledge and your records as you see fit, in order to answer these questions.

Frequency of GP visits - *ASK THE PATIENT*

Using patient recall, and your notes and knowledge, please write the approximate **number of times (including today's visit)** the patient has **seen any GP** for **any reason** in the **past 12 months.**

Abbreviations

BMI = body mass index
IHD = ischaemic heart disease
CHF = congestive heart failure
CVA = cerebrovascular accident
COPD = chronic obstructive pulmonary disease (including emphysema)
GORD = gastro-oesophageal reflux disease

Co-ordination of care

This question aims to assess **the complexity of co-ordinating the care** of each patient who has **at least one chronic condition.**

Please advise **how many individual** health care providers have provided patient care over the **previous 12 months.** This may have included care provided by:

- any **GP** either in your practice or at another practice (ask the patient), for <u>any</u> problem
- any **medical or surgical specialist/s** (either private or hospital-based) who has provided healthcare to the patient for <u>any</u> problem (i.e. the deciding carer - not their registrar)
- any **allied health professional** (either private or hospital-based) who has/have provided healthcare to the patient for <u>any</u> problem

For example, if the patient has seen you and a partner at your practice, a cardiologist, a diabetes educator, and a physiotherapist, your response would be:

GPs	_2_
Medical specialists	_1_
Allied Health Profs	_2_

Ask the patient - *(Apart from me today),* how many different **GPs, Specialists or Allied Health professionals have you seen in the past 12 months?**

GPs	___
Medical specialists	___
Allied Health Profs	___

Patient diagnosed chronic conditions/problems

The aim of these questions is to estimate the **prevalence** and **patterns** of **multimorbidity** in general practice patients. With an ageing population, the prevalence of multimorbidity is expected to increase and much of the care will fall on general practice. This study will highlight the complexity of multimorbidity and assist in planning for future health service needs.

If the patient has **NO diagnosed chronic problems** please tick the box labelled '**NO**', and end the questions here for this patient.

If the patient **DOES** have **diagnosed chronic conditions or problems**, please **use the tick boxes to indicate which ones** (irrespective of whether you have managed them today). Tick as many as apply.

If the patient has a **malignant neoplasm(s)** please **specify the primary site** of the neoplasm.

If the patient has any **other diagnosed chronic problems or conditions** that are **not listed** please specify these in the '**Other chronic problems not listed**' section.

Approx. how many times has this patient seen any GP in the past 12 months? (including today)
___

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Does the patient have any chronic conditions/problems?

☐ Yes →
☐ No ↴
<u>**End questions**</u>

If 'yes' please tick all that apply:

Musculoskeletal
☐ Osteoarthritis
☐ Rheumatoid arthritis
☐ Other arthritis
☐ Osteoporosis
☐ Chronic back pain

Psychological
☐ Depression
☐ Anxiety
☐ Insomnia
☐ Dementia (including Alzheimer's)

Endocrine / nutritional
☐ Hyperlipidaemia
☐ Diabetes Type 1
☐ Diabetes Type 2
☐ Obesity (BMI ≥30)
☐ Hypothyroidism
☐ Hyperthyroidism

Cardiovascular
☐ Hypertension
☐ IHD
☐ CHF
☐ Peripheral Vascular Disease
☐ CVA/stroke
☐ Atrial fibrillation

Other:
☐ Asthma
☐ COPD
☐ Sleep apnoea
☐ GORD
☐ Chronic renal failure
☐ Glaucoma
☐ Malignant neoplasm → Site: ___

Other chronic problems not listed: (please specify)
___

PLEASE READ CAREFULLY

The shaded section of the following forms asks questions about the **PATIENT'S CHRONIC CONDITIONS / PROBLEMS.**
You may tear out this page as a guide to completing the following set of forms.

INSTRUCTIONS

Answer these questions for **EACH** of the **next 30 PATIENTS in the order in which the patients are seen.**

Please **DO NOT** **select patients** to suit the topic being investigated.

Use your own knowledge, patient knowledge and your records as you see fit, in order to answer these questions.

Frequency of GP visits - *ASK THE PATIENT*

Using patient recall, and your notes and knowledge, please write the approximate **number of times (including today's visit)** the patient has **seen any GP for any reason** in the **past 12 months.**

Abbreviations

BMI = body mass index
IHD = ischaemic heart disease
CHF = congestive heart failure
CVA = cerebrovascular accident
COPD = chronic obstructive pulmonary disease
(including emphysema)
GORD = gastro-oesophageal reflux disease

Patient's diagnosed chronic conditions/problems

The aim of these questions is to estimate the **prevalence** and **patterns** of **multimorbidity** in general practice patients. With an ageing population, the prevalence of multimorbidity is expected to increase and much of the care will fall on general practice. This study will highlight the complexity of multimorbidity and assist in planning for future health service needs.

If the patient has **NO diagnosed chronic problems** please tick the box labelled '**NO**', and end the questions here for this patient.

If the patient **DOES** have **diagnosed chronic conditions or problems**, please **use the tick boxes to indicate which ones** (irrespective of whether you have managed them today). Tick as many as apply.

If the patient has a **malignant neoplasm(s)** please **specify the primary site** of the neoplasm.

If the patient has any **other diagnosed chronic problems or conditions** that are **not listed** please specify these in the '**Other chronic problems not listed**' section.

Co-ordination of care

This question aims to assess **the complexity of co-ordinating the care** of each patient who has **at least one chronic condition.**

Please advise **how many individual** health care providers have provided patient care over the **previous 12 months.** This may have included care provided by:

- any **GP** either in your practice or at another practice (ask the patient), for **any** problem

- any **medical or surgical specialist/s** (either private or hospital-based) who has provided healthcare to the patient for **any** problem (i.e. the deciding carer - not their registrar)

- any **allied health professional** (either private or hospital-based) who has/have provided healthcare to the patient for **any** problem

For example, if the patient has seen you and a partner at your practice, a cardiologist, a diabetes educator, and a physiotherapist, your response would be:

GPs	2
Medical specialists	1
Allied Health Profs	2

Approx. how many times has this patient seen any GP in the past 12 months? (including today)	Does the patient have any chronic conditions/ problems?	If 'yes' please tick all that apply:				
		Musculoskeletal	*Psychological*	*Endocrine / nutritional*	*Cardiovascular*	*Other:*
	☐ Yes →	☐ Osteoarthritis	☐ Depression	☐ Hyperlipidaemia	☐ Hypertension	☐ Asthma
	☐ No ↴	☐ Rheumatoid arthritis	☐ Anxiety	☐ Diabetes Type 1	☐ IHD	☐ COPD
	End questions	☐ Other arthritis	☐ Insomnia	☐ Diabetes Type 2	☐ CHF	☐ Sleep apnoea
		☐ Osteoporosis	☐ Dementia (including Alzheimer's)	☐ Obesity (BMI ≥30)	☐ Peripheral Vascular Disease	☐ GORD
_____		☐ Chronic back pain		☐ Hypothyroidism	☐ CVA/stroke	☐ Chronic renal failure
BL168C				☐ Hyperthyroidism	☐ Atrial fibrillation	☐ Glaucoma
						☐ Malignant neoplasm → Site: _____

Other chronic problems not listed: *(please specify)*
_____
_____

Ask the patient - How many different GPs, Specialists or Allied Health professionals have you seen in the past 12 months?

GPs	_____
Medical specialists	_____
Allied Health Profs	_____

PLEASE READ CAREFULLY

The shaded section of the following forms asks questions about the **PATIENT'S CHRONIC CONDITIONS / PROBLEMS AND SERVICE USE.** Please complete these questions in addition to information about the encounter. *This page is a guide to completing the shaded section of the following forms.*

INSTRUCTIONS

Answer the questions in the shaded section for **EACH** of the **next 30 PATIENTS in the order in which the patients are seen.** Please **DO NOT select patients** to suit the topic being investigated.

Use your own knowledge, patient knowledge and your records as you see fit, in order to answer these questions.

Frequency of GP visits

Using patient recall, and your notes and knowledge, please write the approximate **number of times (including today's visit)** the patient has **seen any GP for any reason** in the **past 12 months.**

Co-ordination of care

This question aims to assess **the complexity of co-ordinating the care** of each patient.

Please advise **how many individual** health care providers have provided care to this patient over the **previous 12 months (including today).**

- The number of **GPs** either in your practice or at another practice (ask the patient), for **any** problem

- The number of **GP practices** (including your own) the patient has visited, for **any** problem

- any **medical or surgical specialist/s** (either private or hospital-based) who has provided healthcare to the patient for **any** problem (i.e. the responsible specialist)

- any **allied health professional** (either private or hospital-based) who has/have provided healthcare to the patient for **any** problem

For example, if the patient has seen you and a partner at your practice (and has gone to no other practice), a cardiologist, a diabetes educator, and a physiotherapist, your response would be:

Individual GPs	2
GP practices	1
Medical specialists	1
Allied Health Profs	2

Patient's diagnosed chronic conditions/problems

The aim of these questions is to estimate the **prevalence** and **patterns** of **multimorbidity** in general practice patients. With an ageing population, the prevalence of multimorbidity is expected to increase and much of the care will fall on general practice. This study will highlight the complexity of multimorbidity and assist in planning for future health service needs.

If the patient has **NO diagnosed chronic problems** please tick the box labelled '**NO**', and end the questions here for this patient.

If the patient **DOES** have **diagnosed chronic conditions or problems**, please **use the tick boxes to indicate which ones** (irrespective of whether you have managed them today). Tick as many as apply.

If the patient has a **malignant neoplasm(s)** please **specify the primary site** of the neoplasm.

If the patient has any **other diagnosed chronic problems or conditions** that are **not listed** please specify these in the '**Other chronic problems not listed**' section.

Approx. how many times has this patient seen any GP in the past 12 months? (including today)

_____

In the past 12 months (including today), how many of the following has the patient seen?

Individual GPs _____

GP practices _____

Medical specialists _____

Allied Health Profs _____

Does the patient have any chronic conditions/ problems?

☐ Yes →

☐ No ↴

End questions

If 'yes' please tick all that apply:

Cardiovascular
☐ Hypertension
☐ IHD
☐ CHF
☐ Peripheral Vascular Disease
☐ CVA/stroke
☐ Atrial fibrillation

Musculoskeletal
☐ Osteoarthritis
☐ Rheumatoid arthritis
☐ Other arthritis
☐ Osteoporosis
☐ Chronic back pain

Psychological
☐ Depression
☐ Anxiety
☐ Insomnia
☐ Dementia (including Alzheimer's)

Endocrine / nutritional
☐ Hyperlipidaemia
☐ Diabetes Type 1
☐ Diabetes Type 2
☐ Obesity (BMI ≥30)
☐ Hypothyroidism
☐ Hyperthyroidism

Other:
☐ Asthma
☐ COPD
☐ Sleep apnoea
☐ GORD
☐ Chronic renal failure
☐ Glaucoma
☐ Malignant neoplasm → Site: _____

Other chronic problems not listed:
(please specify)

_____

_____

_____

BL178B

Appendix F: Co-author contribution statements for each paper contained in thesis

Co-author contribution statement Chapter 3

Title: Prevalence of Chronic Conditions in Australia

Authors: Christopher Harrison, Helena Britt, Graeme Miller, Joan Henderson

Journal: PLOS one

Author contributions

CH conceptualised the study, designed the sub-study, supervised the data entry, performed the statistical analysis and wrote the first draft of the article and all redrafts. All authors contributed to the conception and design of the sub-study, collection of the data, interpretation of the data and critical revision of important intellectual content. HB, GM and JH were all involved in the revision of all drafts of the paper. All authors approved the final version.

Candidate signature		**Date**
Christopher Harrison		20/3/2017

As co-authors, we declare that the above author contribution statement is true and we confirm that Christopher Harrison's contribution to the paper is consistent with him being first author. We also provide permission for this paper to be reprinted within this thesis.

Co-author signatures		**Date**
Helena Britt		26/03/2017
Graeme Miller		26/3/2017
Joan Henderson		20/3/2017

Co-author contribution statement Chapter 4

Title: Examining different measures of multimorbidity, using a large prospective cross-sectional study in Australian general practice

Authors: Christopher Harrison, Helena Britt, Graeme Miller, Joan Henderson

Journal: BMJ open

Author contributions

CH conceptualised the study, designed the sub-study, supervised the data entry, performed the statistical analysis and wrote the first draft of the article and all redrafts. All authors contributed to the conception and design of the sub-study, collection of the data, interpretation of the data and critical revision of important intellectual content. HB, GM and JH were all involved in the revision of all drafts of the paper. All authors approved the final version. CH is the study guarantor.

Candidate signature		**Date**
Christopher Harrison		20/3/2017

As co-authors, we declare that the above author contribution statement is true and we confirm that Christopher Harrison's contribution to the paper is consistent with him being first author. We also provide permission for this paper to be reprinted within this thesis.
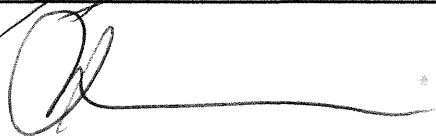
Co-author signatures		**Date**
Helena Britt		26/03/2017
Graeme Miller		26/5/2017
Joan Henderson		20/3/2017

Co-author contribution statement Chapter 5

Title: The prevalence of complex multimorbidity in Australia

Authors: Christopher Harrison, Joan Henderson, Graeme Miller, Helena Britt

Journal: Australian and New Zealand Journal for Public Health

Author contributions

CH conceptualised the study, designed the sub-study, supervised the data entry, performed the statistical analysis and wrote the first draft of the article and all redrafts. All authors contributed to the conception and design of the sub-study, collection of the data, interpretation of the data and critical revision of important intellectual content. HB, GM and JH were all involved in the revision of all drafts of the paper. All authors approved the final version.

Candidate signature   **Date**

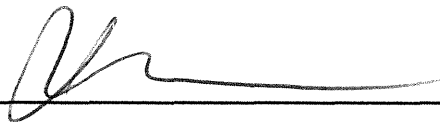Christopher Harrison   20/3/2017

As co-authors, we declare that the above author contribution statement is true and we confirm that Christopher Harrison's contribution to the paper is consistent with him being first author. We also provide permission for this paper to be reprinted within this thesis.

Co-author signatures   **Date**

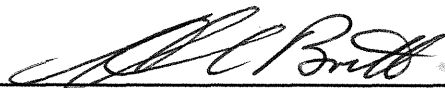Joan Henderson   20/3/2017

Graeme Miller   28/3/2017

Helena Britt   26/03/2017

Co-author contribution statement Chapter 6

Title: The prevalence of diagnosed chronic conditions and multimorbidity in Australia: A method for estimating population prevalence from general practice patient encounter data

Authors: Christopher Harrison, Joan Henderson, Graeme Miller, Helena Britt

Journal: PLOS one

Author contributions

CH conceptualised the study, designed the sub-study, supervised the data entry, performed the statistical analysis and wrote the first draft of the article and all redrafts. All authors contributed to the conception and design of the sub-study, collection of the data, interpretation of the data and critical revision of important intellectual content. HB, GM and JH were all involved in the revision of all drafts of the paper. All authors approved the final version.

Candidate signature		**Date**
Christopher Harrison	_CH.._	20/3/2017

As co-authors, we declare that the above author contribution statement is true and we confirm that Christopher Harrison's contribution to the paper is consistent with him being first author. We also provide permission for this paper to be reprinted within this thesis.

Co-author signatures		**Date**
Joan Henderson		20/3/2017
Graeme Miller		26/3/2017
Helena Britt		26/03/2017

Co-author contribution statement Chapter 7

Title: Predicting patient use of general practice services in Australia

Authors: Christopher Harrison, Joan Henderson, Graeme Miller, Helena Britt

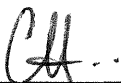**Journal:** (Under review) Australian and New Zealand Journal for Public Health

Author contributions

CH conceptualised the study, designed the sub-study, supervised the data entry, performed the statistical analysis and wrote the first draft of the article and all redrafts. All authors contributed to the conception and design of the sub-study, collection of the data, interpretation of the data and critical revision of important intellectual content. HB, GM and JH were all involved in the revision of all drafts of the paper. All authors approved the final version.

Candidate signature		**Date**
Christopher Harrison		20/3/2017

As co-authors, we declare that the above author contribution statement is true and we confirm that Christopher Harrison's contribution to the paper is consistent with him being first author. We also provide permission for this paper to be reprinted within this thesis.
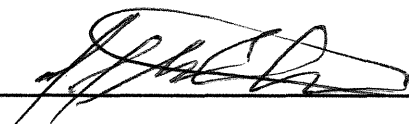
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Joan Henderson		20/3/2017
Graeme Miller		26/3/2017
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Appendix H: Ethics approval

Research Integrity
Human Research Ethics Committee

Tuesday, 16 February 2016

Prof Helena Britt
School of Public Health: Public Health; Sydney Medical School
Email: helena.britt@sydney.edu.au

Dear Helena

Your request to modify the above project submitted on 05 February 2016 was considered by the Chair of Executive of the Human Research Ethics Committee on 09 February 2016.

The Committee had no ethical objections to the modification/s and has approved the project to proceed.
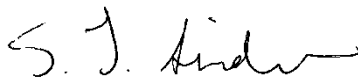
Details of the approval are as follows:

Project No.:   **2012/130**

Project Title: **BEACH (Bettering the Evaluation and Care of Health)**

Approved Documents:

Date Uploaded	Type	Document Name
05/02/2016	Questionnaires/Surveys	BEACH GP profile

Please do not hesitate to contact Research Integrity (Human Ethics) should you require further information or clarification.

Yours sincerely

Dr Stephen Assinder
Chair
Human Research Ethics Committee