AUSTRALIAN INSTITUTE
OF HEALTH INNOVATION
Faculty of Medicine, Health and Human Sciences

MACQUARIE University

Enhancing patient outcomes through evaluation of the appropriateness and quality use of pathology in general practice

A report to the Department of Health Quality Use of Pathology Program

Rae-Anne Hardie[1], Gorkem Sezgin[1], Chrissy Imai[1], Guilherme Saffi Franco[1], Ling Li[1], Chris Pearce[2], Adam McLeod[2], Tony Badrick[3], Johanna Westbrook[1], Andrew Georgiou[1]

[1]Centre for Health Systems and Safety Research, Australian Institute of Health Innovation, Macquarie University, Sydney, NSW, Australia

[2]Outcome Health, Melbourne, VIC, Australia

[3]Royal College of Pathologists of Australasia Quality Assurance Programs, St Leonards, NSW, Australia

This project was funded by the Department of Health Quality Use of Pathology Program

Suggested citation:

Hardie R-A, Sezgin G, Imai C, Franco GS, Li L, Pearce C, McLeod A, Badrick T, Westbrook J, Georgiou A. Enhancing patient outcomes through evaluation of the appropriateness and quality use of pathology in general practice. A report to the Department of Health Quality Use of Pathology Program. Australian Institute of Health Innovation, Macquarie University, Sydney. February 2020.

© Centre for Health Systems and Safety Research

Published 2020

Centre for Health Systems and Safety Research

Australian Institute of Health Innovation

Macquarie University

ISBN paperback: 978-0-85837-004-3

ISBN e-book: 978-1-86408-830-4

Research partners:

Outcome Health, GPHN, SEMPHN, EMPHN, RCPAQAP

RCPAQAP

The Royal College of Pathologists of Australasia
Quality Assurance Programs

Table of contents

1. CHSSR overview 10

2. Preamble 11

3. Executive summary 14

3.1 Project aim 14

3.2 Project setting 15

3.3 Review of guidelines and evidence 15

3.4 Key findings 15

4. Glossary 19

5. Introduction 20

5.1 Overview 20

5.2 Project aims 21

6. Methods 22

6.1 Study setting 22

6.2 Ethics approval 22

6.3 Data sources 22

6.4 Data selection for analysis 23

6.5 Active patients 24

6.6 Study period 24

6.7 Data analysis and statistical methods 24

7. Overview and descriptive statistics 25

7.1 Overview of GP activities 25

7.2 Patients 25

7.3 GP visit frequency 28

7.4 Health conditions/ diagnoses for general pratice visits 29

7.5 Pathology tests 31

8. Engagement with Primary Health Networks (PHNs) 35

9. Glycated haemoglobin A1c (HbA1c) and kidney function test for monitoring Type 2 diabetes 36

9.1 Introduction 36

9.2 Methods 36

9.3 Results 36

9.4 Limitations 42

9.5 Implications 42

10. INR Testing for patients taking warfarin 43

10.1 Introduction 43

10.2 Methods 43

10.3 Results 43

10.4 Limitations 46

10.5 Implications 46

11. Kidney function test for non-vitamin K antagonist oral anticoagulants (NOACs) ... 47

11.1 Introduction 47

11.2 Methods 47

11.3 Results 48

11.4 Limitations 50

11.5 Implications 50

12. Ferritin testing for iron deficiency 51

12.1 Introduction 51

12.2 Methods 51

12.3 Results 52

12.4 Limitations 53

12.5 Implications 53

13. Variation and trends in vitamin D testing 55

13.1 Introduction 55

13.2 Methods 55

13.3 Trends in vitamin D testing 56

13.4 Variation in vitamin D testing 56

13.5 Limitations 59

13.6 Implications 59

14. Use of thyroid function tests (TFTs) in the initial assessment for thyroid dysfunction **60**

14.1 Introduction 60

14.2 Methods 60

14.3 Results 60

14.4 Limitations 62

14.5 Implications 62

15. Vitamin B12 testing **64**

15.1 Introduction 64

15.2 Methods 64

15.3 Results 64

15.4 Limitations 67

15.5 Implications 67

16. Prostate-specific antigen (PSA) testing **68**

16.1 Introduction 68

16.2 Methods 68

16.3 Results 68

16.4 Limitations 71

16.5 Implications 71

17. Bowel cancer screening and colonoscopy referral **72**

17.1 Introduction 72

17.2 Methods 72

17.3 Results 72

17.4 Limitations 76

17.5 Implications 77

18. Monitoring patients on clozapine medication 78

18.1 Introduction 78

18.2 Methods 78

18.3 Results 79

18.4 Limitations 81

18.5 Implications 81

19. Folate testing 82

19.1 Introduction 82

19.2 Methods 82

19.3 Results 82

19.4 Limitations 85

19.5 Implications 85

20. Monitoring for aminoglycoside antibiotics (gentamicin, amikacin and tobramycin) 86

21. Discussion and implications 87

21.1 Future study 88

21.2 Limitations 88

21.3 Conclusion 89

22. References 91

23. Appendix tables and figures 94

List of tables

Table 6.1. Provider, practice, and patient key data elements. 23
Table 7.1. Active patients and selected general practices from 2008-09 to 2017-18 25
Table 7.2. Number and proportion of active patients by socio-demographic characteristics in 2017-18. 27
Table 7.3. Most common health conditions and recorded diagnosis for visit in 2017-18. 30
Table 7.4. 10 most common health conditions and recorded diagnosis for visits by age in 2017-18 (N (%)). 30
Table 7.5. Time (day) required between haemoglobin test request to sample collection in 2017-2018 34
Table 9.1. Number of type 2 diabetes and proportion of patients who had HbA1c testing ≤ 6 monthly. 38
Table 9.2. Median time intervals between HbA1c tests when the previous blood glucose level was within the target range. 39
Table 9.3. Median time intervals of HbA1c testing when the previous blood glucose level was outside the target range. 40
Table 9.4. Socio-demographic characteristics of patients with annual kidney function test. 42
Table 10.1. Socio-demographic characteristics of patients with INR testing ≤6 weekly. 46
Table 11.1. Sociodemographic characteristics of patients with annual kidney function test. 50
Table 12.1. Descriptive profile of ferritin tests. 52
Table 15.1. Frequency of vitamin B12 testing. 67
Table 16.1. Proportion of PSA test results and median testing interval (months) among patients aged 50 – 69 years with repeated tests. 70
Table 18.1. Interval between prescriptions. 79
Table 18.2. Assessment of clozapine monitoring protocol. 80
Table 19.1. Frequency of folate testing. 84
Table 20.1. Patients with aminoglycoside antibiotics prescription and kidney function test. 86
Appendix Table 1. Active patients and selected GP clinics by PHN from 2008-09 to 2017-18. 94
Appendix Table 2. Most common issues and reasons for GP visits in 2017-18. 97
Appendix Table 3. The number of pathology requests per 100 visits by PHN from 2008-09 to 2017-18. 98
Appendix Table 4. Time (day) required between pathology test order and sample collection in 2017-2018. 102
Appendix Table 5. The total number of prescriptions from 2008-09 to 2016-17 by PHN. 103

List of figures

Figure 7.1. Active patients from 2008-09 to 2017-18 by PHN 26
Figure 7.2. Patients distribution between the report data and the national report. 28
Figure 7.3. GP visit frequency from 2008-09 to 2017-18. 28
Figure 7.4. GP visit frequency by socio-demographic characteristics in 2017-18. 29
Figure 7.5. Annual pathology requests per 100 visits from 2008-09 to 2017-18. 31
Figure 7.6. Total pathology requests per 100 visits by socio-demographic in 2017-18. 32
Figure 7.7. Proportion of patients completing all pathology requests by socio-demographic status in 2017-18. 33
Figure 7.8. Proportion of completed pathology requests by socio-demographic status in 2017-18. 33
Figure 9.1. A comparison of age and gender distribution of patients with type 2 diabetes between study data and AIHW report. 37
Figure 9.2. Proportions of patients by HbA1c testing frequency. 37
Figure 9.3. Proportions of patients by frequency of kidney function test. 41
Figure 10.1 The prevalence (%) of regular warfarin use by age and gender. 44
Figure 10.2. Proportions of patients on regular warfarin by frequency of INR testing. 45
Figure 11.1. The prevalence (%) of regular use of NOACs by age and gender. 48
Figure 11.2. Proportions of patients with regular use of NOACs by frequency of kidney function test. 49
Figure 12.1. Variation in the ratio of low ferritin test results by PHN and gender. 53
Figure 12.2. Variation in ferritin test results returning abnormal result, by PHN and gender. 54
Figure 13.1. Trends in vitamin D testing from 2007 to 2018. 56
Figure 13.2. Proportion of vitamin D tests returning with low results, with differences among PHNs and by gender shown. 57
Figure 13.1. Variation in vitamin D tests returning with abnormal results in by PHN and gender. 58
Figure 14.1. Cumulative proportion of ordering patterns of thyroid function tests by primary health network (PHN). ..... **Error! Bookmark not defined.**
Figure 14.2. Variation in ratio of abnormal TSH test results by PHN and gender. 61
Figure 14.3. Variation in TSH test results returning abnormal result, by PHN and gender. 63
Figure 15.1. Prevalence of B12 testing. 65
Figure 15.2. Usage of vitamin B12 tests by age and gender. 66
Figure 16.1. Prevalence of PSA testing by age group. 69
Figure 16.2. Frequency of PSA testing by age group. 70
Figure 17.1. Gender distribution of patients tested for iFOBT by age groups (n = 2,024). 73
Figure 17.2. Distribution of tested patients by remoteness and socioeconomic areas. 74
Figure 17.3. Gender distribution of patients tested positive for iFOBT by age groups (n = 107). 75
Figure 17.4. Distribution of patients tested positive for iFOBT by remoteness and socioeconomic areas. 76
Figure 18.1. Gender distribution by age groups of active patients on clozapine. 79
Figure 18.2. Clozapine blood count monitoring protocol. 80
Figure 19.1. Prevalence of folate. 83

Figure 19.2. Usage of folate tests by age and gender. 84
Figure 21.1. A model for engagement of PHNs. 87
Appendix Figure 1. Annual frequency of GP visit by PHN from 2008-09 to 2017-18..... 95
Appendix Figure 2. Socio-demographic characteristics of visit frequency by PHN in 2017-18..... 96
Appendix Figure 3. Socio-demographic characteristics of the number of pathology requests per 100 visits by PHN in 2017-18. 99
Appendix Figure 4. Socio-demographic characteristics of the proportions of completed pathology requests in 2017-18..... 100
Appendix Figure 5. The proportion of patients who carried out all requested tests in 2017-18..... 101

1. CHSSR OVERVIEW

The **Centre for Health Systems and Safety Research (CHSSR)** is one of three research centres forming the **Australian Institute of Health Innovation (AIHI)** at Macquarie University. The Centre conducts world-class research aimed at understanding and improving health care systems and patient outcomes through the effective use and exchange of information. CHSSR has a focus on translational research, aimed at turning research evidence into policy and practice, while also making fundamental contributions to international knowledge.

The Centre's research program has four central aims:

1. Produce research evidence of the impact of information and communication technologies (ICT) on the efficiency and effectiveness of health care delivery, on health professionals' work and on patient outcomes
2. Develop and test rigorous and innovative tools and approaches for health informatics evaluation
3. Design and apply innovative approaches to understand the complex nature of health care delivery systems and make assessments of health care safety
4. Disseminate evidence to inform policy, system design, practice change and the integration and safe and effective use of ICT in healthcare

2. PREAMBLE

This report is the product of the Centre of Health Systems and Safety Research (CHSSR) funded by the Australian Government Department of Health's Quality Use of Pathology Program (QUPP).

Acknowledgements

The following individuals provided feedback and assistance over the course of the project. We would like to thank Julie Li, Lisa Pont, Magda Raban, Cinny Dong, Denise Azar, Elisabeth Wearne, Kathy Tepper, Chris Wood, Brendon Wickham, Natalie Rinehart, Karina Gardner, Sheree Crick, and Kelly Smith for their contributions.

As required under Funding Agreement Schedule item E6, this Final Report details:

1. An evaluation of the performance, benefits and outcomes of the entire Activity including those outlined in Item B the Funding Agreement Schedule. These include the objectives and aims summarised below, which are further discussed in Chapter 3 (Executive summary), Chapter 5 (Introduction), and Chapter 21 (Discussion and implications).

The objectives of the study were to:

OBJECTIVES/AIMS	OUTCOME
Define characteristics and changes over time in patient/general practice/pathology laboratory interactions and services	Data presented in chapters 6 and 7 provides a description of the methodology and overview of the data, including a summary of pathology testing patterns in general practice over time.
Identify key areas to monitor compliance with evidence-based guidelines relating to the appropriate and quality use of pathology in general practice, and identify and measure variability using statistical process control methods	Chapters 9 through 20 provide a comprehensive overview of each of the 12 key indicators for pathology testing in conditions monitored in general practice. Guidelines for each condition or test were used to provide a baseline and variation for each test was analysed under several different conditions including sociodemographic features and by region.
Co-design and evaluate the effectiveness of Primary Health Network (PHN)-led quality improvements	Chapters 8 and 21 details the relationship between Macquarie University researchers and PHNs, which consisted of regular reports, meetings, and feedback about the results as well as ideas for targeted analysis specific to each PHN's needs. We have received positive responses and PHNs are currently working to schedule a research roadshow for us to showcase our findings to GPs as part of the regular GP education activities hosted by the PHNs, but also to provide GPs a forum in which to provide feedback. This roadshow will take place in early 2020.
The aim of the activity is to identify variation in pathology requests in general practice in the context of best practice guidelines, to improve the quality of pathology in general practice and patient outcomes	This aim was achieved through meeting the 3 key objectives and through ongoing partnership with PHNs.

2. An evaluation of the Activity against the Performance Indicators/Targets in Item B.3 of the Funding Agreement Schedule.

	PERFORMANCE INDICATOR DESCRIPTION	TARGET	OUTCOMES
1	Access and analyse General Practice data from Outcome Health's Data Warehouse, to generate benchmark data for the quality use of pathology	100% of available data	Data has been successfully transferred in extracts and analyses are presented in this report
2	Identify the key quality use of pathology in general practice areas to monitor compliance and report against	At least 10 areas	12 key indicators for quality use of pathology were identified, with analyses focused on showing variation across Primary Health Networks and comparisons against guidelines and recommendations
3	Publish results in peer-reviewed scientific journals	At least 2	This work has been published in BMJ Open: Sezgin G, Georgiou A, Hardie RA, Li L, Pont L, Badrick T, Franco G, Westbrook JI, Rinehart N, McLeod A, Pearce C, Shearer M, Whyte R, Deveny E. *Compliance with pathology testing guidelines in Australian general practice: protocol for a secondary analysis of electronic health record data.* BMJ Open. 2018. 8 (11), e024223 Two further manuscripts on the use of iron studies are in preparation, as well as one on usability of electronic general practice pathology data. Further publications are planned and will include vitamin D, diabetes, and prostate specific antigen testing, and others.
4	Present outcomes at conferences and industry forums	At least 5	This work has been presented at: Preventing Overdiagnosis Conference (Sydney, 5-7 December 2019) *Vitamin D test ordering practices of Australian general practitioners between 2007 and 2017: evidence from electronic health records* **and** *A snapshot of prostate-specific antigen testing in general practices across three Primary Health Networks in Victoria* Australian Academy of Science Lindau Nobel Alumni Event "Adults Only Science" (Questacon, Canberra, 2-3 September 2019) Aurora Research Showcase (Melbourne, 18 July 2019) *Enhancing patient outcomes through evaluation of the appropriateness and quality use of pathology in general practice* Royal College of Pathologists Quality Assurance Programs Lunch and Learn (RCPAQAP), 20th March 2019) *Enhancing patient outcomes through evaluation of the appropriateness and quality use of pathology in general practice* Lunch and Learn session (South Eastern Melbourne PHN (SEMPHN), 7th December 2018).

3. A discussion of any issues, problems or delays that we experienced in our performance of the Activity and an outline of how we dealt with those issues, problems or delays.

As described in Performance Reports delivered throughout the Activity, there were delays in receiving the final data due to quality issues with early datasets, as summarised in the table below. Several data extracts have been provided, the first of which arrived in April 2018 but only contained pilot data collected using an earlier extraction tool. This dataset was mainly used for a preliminary investigation of feasibility of proposed indicators. A further four datasets were received between July 2018 and January 2019, each of which had data quality issues which were resolved, therefore each dataset had increasingly higher data quality resulting from our feedback to Outcome Health. A final dataset with all previous issues addressed was made available in February 2019, which was the final extract used in this report. Further, a greater number of records have been included in the recent dataset due to the data custodians (Outcome Health)

receiving ethical approval from more practices in the participating primary health networks (PHNs) since the unveiling of the new data collection period earlier last year.

DATE RECEIVED	ANALYSIS PERFORMED	DATA ISSUES/FEEDBACK TO OUTCOME HEALTH
April 2018	Our first data extract contained pilot data in the form of older GRHANITE data Mainly used to initiate the data link between ourselves and Outcome Health, and check whether we had the variables we needed Data Quality assessment: each dataset was analysed for accuracy, completeness, comparability, consistency and usability	No PHN listed for each patient Data quality issues flagged
July 2018	Our first data extract using the new extraction tool, Hummingbird Data Quality assessment: each dataset was analysed for accuracy, completeness, comparability, consistency and usability Investigation of feasibility of data to create relevant indicators for our project	Data quality issues flagged Linkage issues between datasets
August 2018	New data extract received following feedback to Outcome Health Data Quality assessment: each dataset was analysed for accuracy, completeness, comparability, consistency and usability Investigation of feasibility of data to create relevant indicators for our project	Data quality issues flagged Linkage issues between datasets
September 2018	New data extract received following feedback to Outcome Health Data Quality assessment: each dataset was analysed for accuracy, completeness, comparability, consistency and usability	Data quality issues flagged Linkage issues between datasets
January 2019	New data extract received following feedback to Outcome Health Data Quality assessment: each dataset was analysed for accuracy, completeness, comparability, consistency and usability	Test results dates were included Refreshed SNOMED diagnosis mapping Test units in pathology dataset missing
February 2019	New data extract received following feedback to Outcome Health Data Quality assessment: each dataset was analysed for accuracy, completeness, comparability, consistency and usability	No issues flagged

4. An overview of the extent to which the Activity achieved the Aim of the Activity and the Program's Objectives which is discussed throughout the report and in Chapter 21.

5. The benchmark results from the Activity, detailed findings (including of the impact of PHN-led interventions) related to the quality use of pathology referrals and interpretation in general practice, including statistical modelling and explanations of the clinical and organisational implications of these findings. These can be found throughout the report.

3. EXECUTIVE SUMMARY

General practitioners (GPs) are crucial in screening for chronic diseases, predisposition to disease development, and ongoing patient management. Appropriate and efficient utilisation of pathology testing by GPs forms a key part of clinical decision-making, including diagnosing, screening, treating, and monitoring diseases. Despite the benefits of screening and monitoring for patients, especially those with chronic conditions, we know little about how general practice testing compares to recommended disease screening. Despite the significant implications of pathology testing on patient diagnosis and outcomes in general practice, the limited availability of high quality and reliable data from general practice historically has made it difficult to assess the utilisation of pathology tests in depth. General practice activity data has previously only been reported as aggregated data in self-reported cross-sectional surveys. More recently, the now-widespread digitisation and use of health information technologies (HIT) by Australian GPs has prompted interest in the use of electronic health record (EHR) data as a research source for identifying variation in general practice activities. This data source includes pathology testing data and its impact on patient outcomes in general practice, which has been an overlooked area of research. The lack of studies published in this area is, at least partly owing to the lack of high-quality general practice datasets, due to access concerns as well as issues with lack of standardisation between clinical software across practices, resulting in difficulty combining datasets for research purposes.

This study, undertaken in collaboration with Outcome Health's POLAR Aurora Research Consortia and the associated Primary Health Networks (PHNs), has facilitated a comprehensive analyses of general practice activity and its relationship to pathology testing through EHR data, and is one of the first such studies in Australia to do so. The key aim of this study was to provide much-needed benchmark data on how specific pathology tests are used in general practice and investigate how test ordering practices align with evidence-based guidelines. The use of these results by PHNs in the design of quality improvement activities have the potential to make a significant impact on both GP test result management activities and patient outcomes.

3.1 PROJECT AIM

The objectives of the study are to:

1. Define characteristics and changes over time in patient/general practice/pathology laboratory interactions and services;
2. Identify key areas to monitor compliance with evidence-based guidelines relating to the appropriate and quality use of pathology in general practice, and identify and measure variability using statistical process control methods; and
3. Co-design and evaluate the effectiveness of Primary Health Network (PHN)-led quality improvements.

The aim of the activity is to identify variation in pathology requests in general practice in the context of best practice guidelines, to improve the quality of pathology in general practice and patient outcomes.

3.2 PROJECT SETTING

This project covers the quality use of pathology in Australian general practices. The study was undertaken in three PHNs (Gippsland (GPHN), Eastern Melbourne (EMPHN) and South Eastern Melbourne (SEMPHN)) across the state of Victoria, covering metropolitan and rural areas. The networks cover an area totalling 48,903 km^2, delivering healthcare to 3,132,382 Australians (ERP 2014). Outcome Health, as a data custodian, uses its Population Level Analysis & Reporting (POLAR) data extraction tool to routinely gather de-identified and secured electronic patient data generated from various clinical information systems (CIS). These data are held within POLAR.

3.3 REVIEW OF GUIDELINES AND EVIDENCE

This project provides an overview of pathology testing in general practice in Australia, as well as reporting variation in testing across key indicators. These indicators were selected based on a variety of factors, including:

1. **Consultation with experts and stakeholders:** Recommendations were sought from experts in the field (GPs, pharmacists, and pathologists) as well as stakeholders (representatives from primary health networks (PHNs)) to determine (1) which diseases, conditions, or medications are monitored and diagnosed with pathology testing, and (2) which tests are routinely used, in general practice.
2. **Literature screening:** an evidence scan was conducted across peer-reviewed journals, general practice publications, the Medicare Benefits Schedule (MBS) Review, and clinical guidelines from both Australia and worldwide to determine best practice for each of these indicators, including which patients should receive specific pathology tests and frequency of testing for specific patient groups. These guidelines and recommendations formed a starting point from which to assess variation within general practice pathology testing data.

Indicators with the greatest potential for clinical impact and improvement to patient outcomes were selected to be included in the study, especially those which were of concern for specific regional areas as identified by PHNs. In many cases the selection was also made based on the availability and best quality of data within our datasets.

3.4 KEY FINDINGS

- **Data overview:** Active patients accounted for approximately 60–65% of total recorded patients from 2008-09 to 2017-18 in the original data. The demographic distributions of active patients in our sample and the samples collected by the national survey Bettering the Evaluation and Care of Health (BEACH) from 2015-2016 were relatively similar. The most common reasons for GP practice visits that appeared in the general practice data from Victoria and the national data (BEACH study and PBS data) were also similar. Overall, the 10 most commonly reported issues or reasons for patients' visits in 2017-2018 were for care management (i.e., care plan and review, prescription, results discussion, and referral), preventative care (i.e., immunisation, health assessment), and the most common diagnoses were respiratory tract infection (RTI), and hypertension. BEACH similarly indicated that hypertension, check-up, upper RTI and

immunisation were in the 10 most frequently encountered individual issues in all years from 2006-07 to 2015-16.

- **HbA1c and kidney function for monitoring type 2 diabetes:** The estimated prevalence and demographic distributions of type 2 diabetes from GP data from the three Victorian PHNs (6.2%) was consistent with the report from the national health survey from the Australian Institute of Health and Welfare (AIHW) published in 2018, which estimated 1.2 million or 6% of Australian adults had diabetes in 2017-18. While the majority of patients (71%-81%) in the Victorian data had kidney function tests annually as recommended by guidelines, only 50% or less of patients received HbA1c testing as per the guidelines' recommendation. Improvement in follow-up HbA1c testing appeared to be particularly required in those who had results outside of the recommended HbA1c level (>53mmol/mol), where the overall median time interval was 4.7 months (IQR: 3.5–6.6 months) and slightly above the recommended three months.
- **INR testing for patients taking warfarin:** There were substantial differences across PHNs in the proportion of patients on warfarin tested for INR. While the two metropolitan PHNs had 73–74% of patients tested for INR within the recommended timeframe (4-6 weekly), there were only 19% of patients in PHN2, which is situated in a regional area. Further investigations are required to identify the underlying causes of the disparity in INR testing between PHNs, and where appropriate, to plan improvement activities.
- **Kidney function testing for patients taking Non-vitamin K antagonist oral anticoagulants (NOACs):** The majority of patients (70%-83%) had their kidney function tested at least once a year as advised by clinical guidelines. The socio-demographic patterns of the patients who had annual testing however varied considerably by PHN, indicating that target populations within each PHN should be identified if further improvement in the annual monitoring is required.
- **Ferritin for iron deficiency:** While there were no noticeable differences by PHN, a greater proportion of ferritin test results returned lower results for younger females compared to other age and gender groups. We observed higher variation among practices in the rate of low ferritin tests in females compared to males. This suggests that ferritin tests may be ordered in a higher variety of situations for females. Targeted testing focusing on adolescent and younger females may ensure capturing the groups most at risk for iron deficiency.
- **Vitamin D testing:** Our results demonstrate an increase in the proportion of patients having vitamin D testing from 8% in 2014 to 11% in late 2018. We observed lower proportions of vitamin D tests with low test results in summer months (15-20%) compared to winter months (30-35%), potentially demonstrating lower value testing during the warmer months. We also observed high variation in Vitamin D testing among practices within PHNs, suggesting that there is a lack of consensus in regard to vitamin D testing.

- **Thyroid function testing (TFT):** Test ordering for patterns of thyroid function testing among Australian general practitioners align closely with recommended guidelines. Approximately 80% of initial thyroid function test ordering was in the form of a thyroid stimulating hormone test, which is in line with clinical guideline recommendations. There was also low variation observed among practices in the rate of tests returning with abnormal results, suggesting consistency in ordering patterns for these tests. Between 6.0% and 11.7% of TFT tests returned abnormal results depending on PHN and gender, indicating that more targeted testing may be necessary to improve the use of this panel of tests.
- **Vitamin B12 testing:** Overall, the proportion of patients tested for vitamin B12 was 24%, and females were tested more frequently than males (29% vs 19%, respectively). However, among older people (≥ 65 years), males were more likely to be tested for vitamin B12 (39% vs 29% form females in this age group). For patients tested on repeated occasions, the median time interval between tests was 8 months for serum vitamin B12 and 8.2 months for vitamin B12 marker, both of which were shorter than the 12-month re-testing interval recommended by the most recent Medicare Benefits Schedule (MBS) Review Taskforce. Findings were similar across PHNs.
- **Prostate specific antigen (PSA) for prostate cancer screening:** For men without symptoms of prostate cancer (PCa), the recommended testing age is between 50–69 years. Our analysis showed that the prevalence of PSA testing among patients aged 50–69 years was 45%, while for those aged 70 years and over, it was 39%. The proportion of patients tested multiple times increased with age, with 44% of those aged 70 years and over receiving repeat PSA testing. Furthermore, among patients aged 50–69 years, the testing interval following a normal PSA result was 12.4 months (vs recommended 2 years), whereas that of abnormal PSA results was 5.9 months (vs recommended 1-3 months). While PSA testing rates varied across PHNs, the frequency of testing and re-testing interval was similar.
- **Bowel cancer screening and colonoscopy referral:** The proportion of patients aged 50 – 74 years who had an immunochemical faecal occult blood test (iFOBT) result recorded was 0.9%. Of that proportion, 67% lived in inner regional areas. Overall, males (46%) had lower screening rates than females (54%). However, the proportion of tested males increased with age. The positivity rate overall was 5.3% (107 of 2,024 patients tested). These findings are comparable to those from the most recent National Bowel Screening Program (NBCSP) monitoring report. The low bowel cancer screening rate can be attributable to GP clinical systems not being able to extract iFOBT tests issued as part of the NBCSP.

- **Clozapine:** With the introduction of new supply arrangements for clozapine maintenance therapy, GPs no longer need to be affiliated with a hospital to prescribe clozapine as clozapine is available at community pharmacies. However, GPs are required to review patients' white blood cell and neutrophil counts monthly before each prescription, and follow standard clozapine monitoring protocols. Our analysis showed that 66% of patients had monthly clozapine prescriptions and 79% of prescriptions followed recommended treatment guidelines. Since the monitoring of these patients still remains the responsibility of the supervising psychiatrist and secondary care activity is not captured by the GP clinical system, these findings suggest that GP data may have limited usability in the monitoring of care delivered to patients on clozapine.
- **Folate:** Overall the proportion of patients tested for serum folate was 17%, and females had higher test rates than males (20% vs 13%, respectively). However, among older people (≥65 years), males had high rates of testing (37%) compared to females (28%). In patients tested repeatedly, the median time interval between tests was 8.1 months, which was shorter than the 12-month re-testing interval recommended by the most recent Medicare Benefits Schedule (MBS) Review Taskforce. Findings were similar across PHNs.

4. GLOSSARY

GLOSSARY OF GENERAL TERMS	
ACR	Albumin-creatinine ratio
AF	Atrial fibrillation
AIHI	Australian Institute of Health Innovation
AIHW	Australian Institute of Health and Welfare
ATC	Anatomical therapeutic chemical
BEACH	Bettering the Evaluation and Care of Health
CHSSR	Centre for Health Systems and Safety Research
CI	Confidence interval
CIS	Clinical information systems
eGFR	Estimation of the glomerular filtration rate
EHR	Electronic health record
fT3	Free triiodothyronine
fT4	Free thyroxine
GP	General practitioner
HbA1c	Glycated haemoglobin A1c
HIT	Health information technology
iFOBT	Immunochemical faecal occult blood test
INR	International normalised ratio
IQR	Interquartile range
IRSAD	Index of relative socio-economic advantage and disadvantage
LOINC	Logical observation identifiers names and codes
MBS	Medicare Benefits Schedule
NBCSP	National Bowel Cancer Screening Program
NC	Neutrophil count
NOACs	Non-vitamin K antagonist oral anticoagulants
PCa	Prostate cancer
PHN	Primary Health Network
POLAR	Population level analysis & reporting
PSA	Prostate-specific antigen
QUPP	Quality Use of Pathology Program
RACGP	Royal Australian college of general practitioners
RTI	Respiratory tract infection
SD	Standard deviation
SES	Socioeconomic status
SNOMED CT-AU	Australian edition of the systematised nomenclature of medicine, clinical terms
TFT	Thyroid function test
TSH	Thyroid stimulating hormone
VTE	Venous thromboembolism
WBC	White blood cell count

5. INTRODUCTION

5.1 OVERVIEW

General practitioners (GPs) play an increasingly important role in screening for chronic diseases and predisposition to disease development, and for ongoing patient management (1). The past decade has seen an increase in both visits to and problems managed by GPs in Australia, resulting in an estimated 24.2 million additional laboratory tests being ordered, and thus considerable growth in expenditure on testing (2). In Australia, general practice testing accounts for 70% of public funded pathology services (3) and is a major primary care contributor, with 87% of Australians visiting their GP at least once a year (4). Appropriate and efficient utilisation of pathology testing by GPs forms a key part of clinical decision-making, including diagnosing, screening, treating, and monitoring diseases. Despite benefits of screening and monitoring for patients, especially those with chronic conditions (5, 6), little is known about how general practice testing compares to recommended disease screening guidelines (7, 8).

Despite the significant implications of pathology testing on patient diagnosis and outcomes in general practice, the limited availability of high quality and reliable data about testing patterns from general practice historically has made it difficult to assess the utilisation of pathology tests in depth (9). General practice activity data has previously only been reported as aggregated data in self-reported cross-sectional surveys (10). Until recently, the survey-based *Bettering the Evaluation and Care of Health (BEACH)* study has provided the most comprehensive data on Australian general practice activity (11). However, one of its limitations was that its cross-sectional design did not reflect the longitudinal nature of patient-level changes and outcomes. The BEACH program was discontinued in 2016, its absence leaving a gap in our understanding of general practice activity, particularly in relation to pathology test ordering.

The now-widespread digitisation and use of health information technologies (HIT) by Australian GPs has prompted interest in the use of electronic health record (EHR) data as a research source for identifying variation in general practice activities, including pathology testing (10). While gathering electronic data from primary care is increasing worldwide, its secondary use in epidemiological research and health policy making is still relatively new and therefore limited (12). In Australia, pathology test data and its impact on patient outcomes in general practice has been an overlooked area of research, with few studies published. This is, at least partly due to the difficulty in accessing high-quality datasets. The paucity of research in this area is also due to concerns about access of data as well as the lack of standardisation between clinical software used by practices, resulting in difficulty combining datasets for research purposes. One recent source of general practice data has been the Australian Government Department of Health-funded NPS Medicinewise MedicinesInsight dataset, which contains a national collection of electronic health records (EHRs) from 650 practices as a representation of national data (11). This dataset has been used in several population health research projects, and has demonstrated the value of EHR data in research (12).

Outcome Health, as a data custodian, routinely gathers electronic health records (EHR) from GPs into the Population Level Analysis & Reporting (POLAR) Aurora research platform. The strengths of these data include its longitudinal nature, its comprehensiveness, large sample size (with over 1000 practices now using POLAR across Australia), and availability of demographic features of populations that span large geographic regions including both urban and remote regions. Another important advantage of these data

is the close working relationship with Primary Health Networks (PHNs), whose feedback allow for a deeper understanding of the data, as well as a pathway for translation of results into practice.

In addition to clinical guidelines for individual diseases or conditions, several guidelines have been established to encourage better utilisation of laboratory tests among GPs, such as *Choosing Wisely* (13), *National Institute for Health and Clinical Excellence (NICE)* (14) from the United Kingdom, and The Royal College of General Practitioners' *Guidelines for preventive activities in general practice 9th edition (Redbook)* (15). In addition, the Medicare Benefits Schedule (MBS) Review Taskforce recently released a report from the diagnostic medicine clinical committee recommending changes to ordering for certain common pathology tests (16). However, the Taskforce's recommendations were based only on MBS claims data using billing codes, which do not encompass all testing. There are currently no studies on how these guidelines have impacted on testing patterns and patient outcomes, and in many cases even baseline data are missing, thus it is important to capture the current actual testing patterns and variation in Australian general practice so that areas requiring quality improvement can be identified and targeted based on empirical evidence.

This study, undertaken in collaboration with Outcome Health's POLAR Aurora Research Consortia and its associated PHNs (Gippsland, Eastern Melbourne and South Eastern Melbourne), facilitates comprehensive analyses of general practice activity and its relationship to pathology testing through EHR data, and is one of the first such studies in Australia to do so. The key aim of this quantitative observational study is to provide much-needed benchmark data on how specific pathology tests are used in general practice and investigate how test ordering practices align with evidence-based pathology guidelines. The results contribute to the QUPP objectives by providing GPs and PHNs with data that can be used to support Quality Referrals (Requesting/Ordering) as well as Quality Pathology Practice, providing support to both patients and GPs with evidence-based, best practice test ordering. The use of these results by PHNs in their design of evidence-based quality improvement activities have the potential to make a significant impact on patient outcomes.

5.2 PROJECT AIMS

The objectives of the study are to:

1. Define characteristics and changes over time in patient/general practice/pathology laboratory interactions and services;
2. Identify key areas to monitor compliance with evidence-based guidelines relating to the appropriate and quality use of pathology in general practice, and identify and measure variability using statistical process control methods; and
3. Co-design and evaluate the effectiveness of Primary Health Network (PHN)-led quality improvements.

The aim of the activity is to identify variation in pathology requests in general practice in the context of best practice guidelines, to improve the quality of pathology in general practice and patient outcomes.

6. METHODS

6.1 STUDY SETTING

The research covers three PHNs (Gippsland, Eastern Melbourne and South Eastern Melbourne) across Victoria, covering metropolitan and rural areas. The networks cover an area totalling 48,903 km^2, delivering healthcare to 3,132,382 Australians (ERP 2014) of which 14,392 are Indigenous (Census 2011). Adults aged over 65 accounted for 16.7% of the population (ERP 2014), and 2.9% were from a non-English speaking background (Census 2011).

6.2 ETHICS APPROVAL

Outcome Health have ethical approval to use de-identified data extracted from general practices within this network for research purposes (RACGP National Research and Evaluation Ethics Committee (NREEC) 17-008).

Researchers within the Centre for Health Systems and Safety Research at Macquarie University were granted approval (Reference number 5201700872) from the Macquarie University Faculty of Medicine and Health Sciences Low-risk Ethics Subcommittee for ethical approval to use the data proposed within this project until 2022.

6.3 DATA SOURCES

The data presented in this report were originally acquired from (de-identified) general practice activity across three PHNs in the state of Victoria. Outcome Health, as a data custodian, uses its Population Level Analysis & Reporting (POLAR) data extraction tool to routinely gather de-identified and secured electronic patient data generated from various clinical information systems (CIS). These data are held within POLAR.

For this report, the de-identified EHRs were partially extracted from POLAR and made available to the secured system environment of Macquarie University by Outcome Health. The data primarily consists of three datasets: provider, practice, and patient information (Table 6.1). Provider data included provider's occupation type (e.g., GP, nurse, occupational therapy, administrator). Practice data contained each practice's affiliated PHN. Patient information consisted of six independent datasets, which were patient demographics, visit, service, diagnosis, pathology test, and prescription datasets.

Table 6.1. Provider, practice, and patient key data elements.

INFORMATION	DATASET	KEY VARIABLES
Practice	Practice	• Affiliated PHN
Provider	Provider	• Provider's occupation type
Patient	Demographics	• Year of birth • Gender • Postcode
	Visit	• Date and type of visit
	Service	• Medicare item number
	Diagnosis	• Australian edition of the systematised nomenclature of medicine, clinical terms (SNOMED CT-AU) • Date of record
	Pathology (All pathology orders issued by GP regardless tested or not)	• Ordered test name • Order date • Sample collection date • Result report date • Result value • Result unit • Logical Observation Identifiers Names and Codes (LOINC) codes
	Prescription (All prescriptions issued by GP regardless dispensed or not)	• Generic name • Anatomical Therapeutic Chemical (ATC) classification • Frequency • Dose • Quantity • Repeats • Date of record

Regional socioeconomic status (SES) and geographical rurality of patients' residence location were identifiable by linking patient postcodes in the demographic dataset with the public census data. In this report, we used the Index of Relative Socioeconomic Advantage and Disadvantage (IRSAD) from Census of Population and Housing: Socio-Economic Indexes for Areas as a proxy of patient's SES (17). Remoteness of patients' residence location was also mapped by linking with the Australian Statistical Geography Standard from Australian Bureau of Statistics (18).

6.4 DATA SELECTION FOR ANALYSIS

Several steps were undertaken to ensure the quality of data analysis. First, general practices were selected if their data yielded a full set of visit, prescription, pathology, diagnosis variables for at least two consecutive years. The process ensured data consistency as data from some practices could be intermittently extracted or missing for a period of time.

Secondly, since some visit data were recorded for administrative purposes (e.g., appointments or inquiries by email and phone) which did not represent a clinical encounter, we only included records by GPs or medical doctors, involving a direct interaction with a clinician. This meant that non-direct interactions between a patient and a GP, such as email, phone-call, and SMS, were excluded.

6.5 ACTIVE PATIENTS

In the dataset supplied, each patient was given a unique de-identified number for each general practice visited. There is a possibility that patients were double counted if they attended different practices within the dataset. To minimise this, we only included patients who attended general practices as active patients. Following the guideline from the RACGP, an active patient was defined as a patient who has attended the practice three or more times in the past two years at the time of visit (19).

6.6 STUDY PERIOD

A study period for each analysis was defined separately according to the aims of each study. However, to maintain a level of consistency, we defined that a year started on the 1st of October to the 30th of September in the following year; for instance, 2016-2017 indicates one year commencing from the 1st of October 1 in 2016 to the 30th of September in 2017. Thus, the data presented in this report includes the period up to 2017-18 or the 30th of September in 2018.

6.7 DATA ANALYSIS AND STATISTICAL METHODS

In order to allow comparisons between PHNs and with national data, the reporting includes crude population estimates from the data along with age and gender standardised estimations. The standard population used for the standardisation process was the Australian population in 2018 reported by the Australian Bureau of Statistics (20).

For descriptive analyses, numbers and rates (e.g., per 100 visits, per patient) were calculated. The basic statistical summary of data was presented by median and interquartile range (IQR; 0.25^{th} and 0.75^{th} percentiles), mean or 95% confidence interval (CI) as per the data distribution of interest. Missing data and duplicated data were removed from analyses.

7. OVERVIEW AND DESCRIPTIVE STATISTICS

7.1 OVERVIEW OF GP ACTIVITIES

This section aimed to illustrate the general characteristics of clinical activities across general practices. For the descriptive analyses in this section, only RACGP-defined active patients were used as the study population. All overview analyses were performed in R (version 3.4.1).

7.2 PATIENTS

Active patients accounted for approximately 60 – 65% of total recorded patients from 2008-09 to 2017-18 in the original data (Table 7.1). While the proportions of active patients were relatively consistent for the last several years, the number of active patients in the sample increased from a total of 256,133 in 2008-2009 to 726,263 in 2017-2018, which is likely due to the increased digitalisation of general practices over time (i.e., all new patients go into the CIS). The proportion of general practices where active patients were identified were at least 90% or above throughout the past ten years.

Table 7.1. Active patients and selected general practices from 2008-09 to 2017-18

	ACTIVE PATIENTS		SELECTED PRACTICE	
Year	n	% of total	n	% of total
2008-09	256,133	(61.9)	88	(98.9)
2009-10	325,517	(61.0)	108	(100.0)
2010-11	387,484	(64.2)	120	(99.2)
2011-12	437,281	(65.7)	137	(98.6)
2012-13	493,232	(66.1)	148	(99.3)
2013-14	534,225	(66.8)	163	(98.8)
2014-15	580,376	(65.9)	175	(98.9)
2015-16	636,284	(65.2)	193	(98.5)
2016-17	701,324	(64.9)	205	(94.9)
2017-18	726,263	(66.5)	203	(90.2)

The further longitudinal details of active patients by PHN are presented in Figure 7.1 and in Appendix Table 1. PHN1 had the largest number of active patients (e.g., 354,394 active patients in 2017-18) throughout the study period, followed by PHN3 (299,947 in 2017-18). PHN2 (71,922 active patients in 2017-18) is situated in a regional area with a smaller population, and a smaller active patient population in the PHN than the two PHNs situated in major cities. There were trends upwards in the number of active patients across all three PHNs.

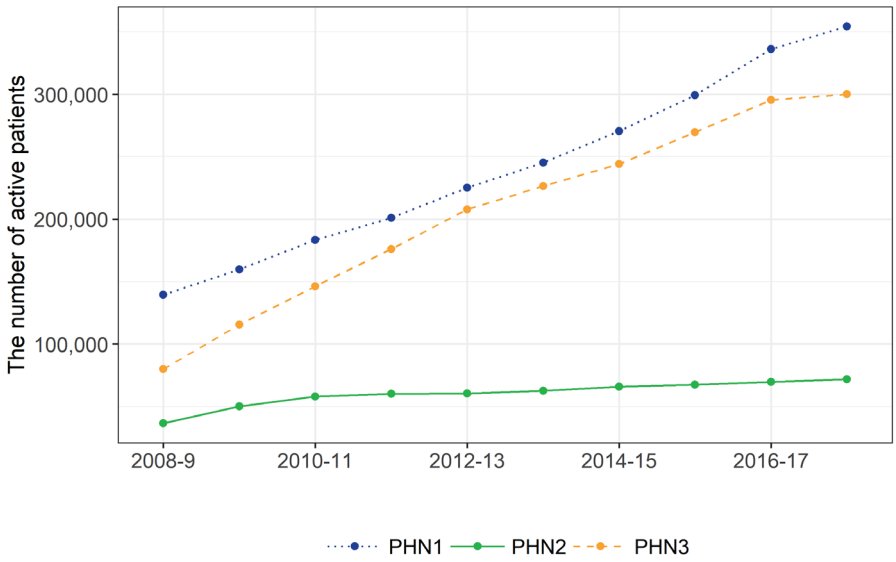


Figure 7.1. Active patients from 2008-09 to 2017-18 by PHN

The number and proportions of active patients by socio-demographic characteristics are presented in Table 7.2. Overall, the largest number of patients were aged between 25 to 44 years old (n=192,826). There were also more female patients (n=413,437) than male (312,040), socioeconomically advantaged than disadvantaged, and residing in a major city (n=617,894) than outer regional areas (n=12,530).

The distributions by socioeconomic status (IRSAD) and remoteness were substantially different by PHN. The socioeconomic status of active patients in PHN1 and 3 were predominantly middle or more advantaged status (i.e., IRSAD score 3 or above), whereas active patients in PHN2 primarily consisted of middle or less advantaged classes (i.e., IRSAD score 3 or below). In terms of remoteness, PHN1 and PHN3 had a majority of active patients in major city areas while PHN2 had most patients residing in inner and outer regional areas.

Table 7.2. Number and proportion of active patients by socio-demographic characteristics in 2017-18.

ACTIVE PATIENTS (% OF TOTAL RECORDED PATIENTS) *								
	Overall		PHN1		PHN2		PHN3	
Total	726,229	(65.7)	354,377	(65.1)	71,918	(64.6)	299,934	(66.9)
Age (missing n=34)†								
<1	14,563	(33.6)	7,203	(35.0)	1,283	(29.7)	6,077	(32.9)
1-4	41,844	(64.6)	21,102	(64.3)	3,537	(63.5)	17,205	(65.2)
5-14	62,230	(55.9)	30,248	(54.7)	5,735	(56.1)	26,247	(57.5)
15-24	75,016	(59.5)	36,730	(58.8)	6,660	(60.0)	31,626	(60.2)
25-44	192,826	(71.9)	95,171	(71.1)	14,736	(70.2)	82,919	(73.3)
45-64	187,100	(58.8)	89,912	(58.3)	19,374	(55.0)	77,814	(60.3)
65-74	81,839	(81.7)	40,061	(81.5)	11,523	(79.3)	30,255	(82.8)
75+	70,811	(87.3)	33,950	(86.8)	9,070	(85.7)	27,791	(88.4)
Gender (missing/other n=786)								
Female	413,437	(68.3)	203,549	(67.6)	40,373	(68.0)	169,515	(69.3)
Male	312,040	(63.1)	150,522	(62.5)	31,415	(61.1)	130,103	(64.4)
IRSAD (missing n=1,984)								
1 / Most disadvantaged	68,920	(66.9)	9,274	(62.3)	21,972	(68.1)	37,674	(67.3)
2	53,238	(63.3)	10,020	(60.9)	23,704	(62.1)	19,514	(66.1)
3	144,104	(67.7)	47,658	(65.6)	18,674	(67.0)	77,772	(69.2)
4	184,386	(66.9)	111,906	(66.7)	7,163	(64.0)	65,317	(67.5)
5 / Most advantaged	273,631	(64.3)	174,674	(64.3)	203	(15.1)	98,754	(64.7)
Remoteness (missing n=1,921)								
Major City	617,894	(66.0)	330,945	(65.3)	689	(18.8)	286,260	(67.2)
Inner Regional	93,490	(65.6)	22,067	(63.7)	59,249	(66.5)	12,174	(64.7)
Outer Regional	12,530	(60.8)	518	(39.0)	11,490	(64.2)	522	(40.8)
Remote	428	(42.8)	46	(19.6)	288	(55.0)	94	(36.4)

** The percentages are standardised to the Australian population in 2018; gender-standardised for age; age-standardised for gender; age- and gender-standardised for IRSAD and remoteness.*
† Overall missing or unknown

Figure 7.2 shows a comparison of patients' age and gender distributions between the extracted data and the national GP survey in 2015-16 (BEACH study) (10). As the extracted GP data primarily consisted of patients who were residing in major cities and socioeconomically advantaged, the extracted data had slightly less patients residing in remote areas and less socioeconomically advantaged than the national GP survey data. Despite the BEACH data not being standardised, the similarity in the overall pattern of patient distributions suggests comparability between the two data sources.

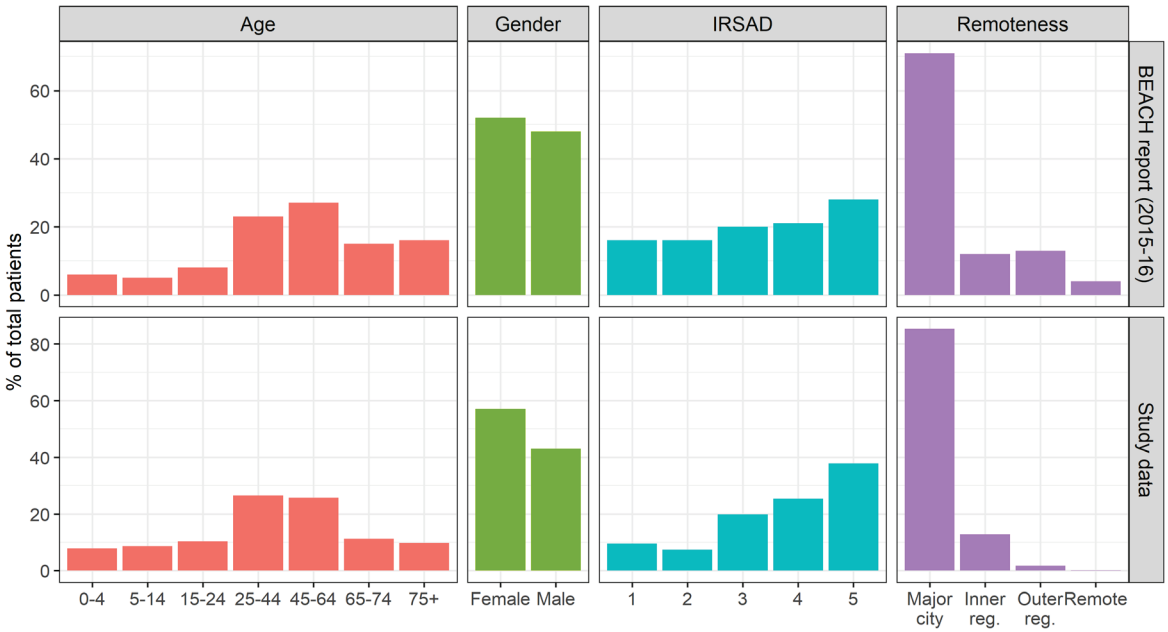


Figure 7.2. Patients distribution between the report data and the national report.

7.3 GP VISIT FREQUENCY

Overall, the annual total GP visit frequency by patient did not change over the past ten years, with the median frequency of 5 visits (IQR: 3–9 visits) per patient (Figure 7.3). Similarly, the frequency of GP visits was longitudinally constant in all three PHNs during study the period, with median frequencies of around 5 visits per person (Appendix Figure 1).

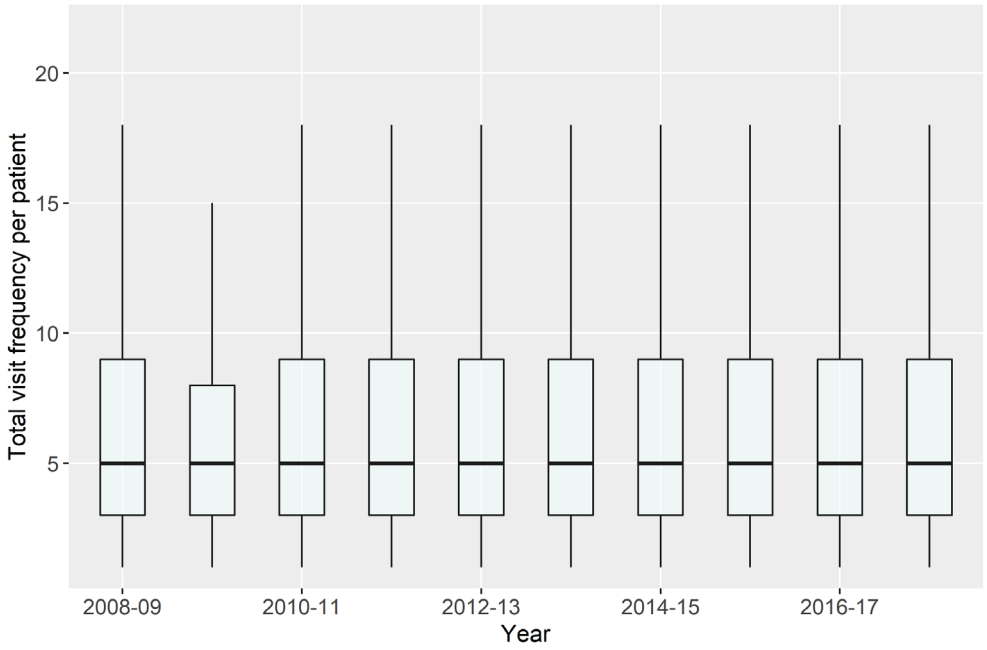


Figure 7.3. GP visit frequency from 2008-09 to 2017-18.

The socio-demographic characteristics of GP visit frequency are presented in Figure 7.4. There seemed to be a U-shaped correlation with age; infants (<1 year old) and older adults (65+ years old) had more frequent visits than other age group populations. More frequent visits were also observed in female patients than male patients, and those who were less socioeconomically advantaged than those who were advantaged. Patients living in inner regional areas had more frequent GP visits than those in other areas. The socio-demographic patterns of visit frequency by PHN is also available in the Appendix Figure 2.

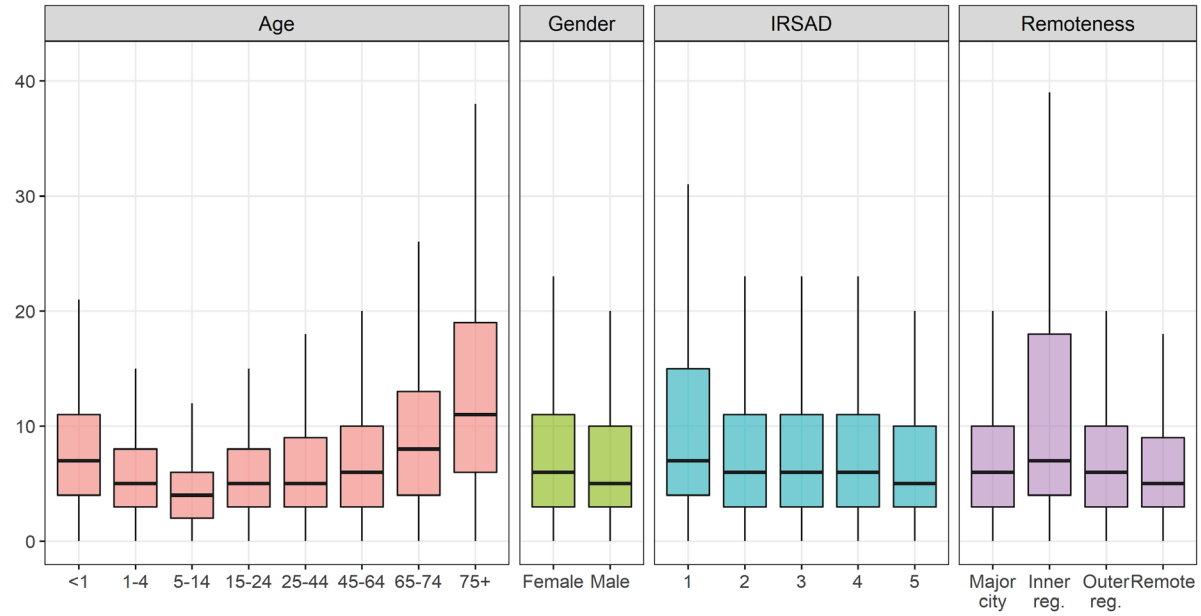


Figure 7.4. GP visit frequency by socio-demographic characteristics in 2017-18.

7.4 HEALTH CONDITIONS/ DIAGNOSES FOR GENERAL PRATICE VISITS

The recorded health conditions or diagnoses for general practice visits were identified from SNOMED-CT-AU code in the diagnosis dataset. Based on this dataset, overall, the 10 most commonly reported diagnoses for patients' visits in 2017-2018 were primarily for care management (i.e., care plan and review, prescription, results discussion, and referral), preventative care (i.e., immunisation, health assessment), with the most common diagnosis being respiratory tract infection (RTI), and hypertension (Table 7.3). The BEACH study published in 2016 (21) similarly indicated that hypertension, check-up, upper RTI and immunisation had been listed in the 10 most frequently managed individual issues in all years from 2006-07 to 2015-16.

Table 7.3. Most common health conditions and recorded diagnosis for visit in 2017-18.

	CONDITIONS AND DIAGNOSES FOR GP VISIT	N (%)
1	Care review	36,912 (4.3)
2	Result discussed	35,857 (4.1)
3	Prescription	25,741 (3.0)
4	Immunisation	23,899 (2.8)
5	Referral	16,348 (1.9)
6	Health assessment	13,067 (1.5)
7	Viral upper RTI	12,303 (1.4)
8	Upper RTI	10,852 (1.3)
9	Hypertensive disorder, systemic arterial	10,354 (1.2)
10	Care plan	8,299 (0.9)

The common SNOMED-coded diagnoses for GP visits were further broken down by age group. Table 7.4 presents three different age groups for infants (0-2 years old), young adults (25-44 years old) and older people (65 + years old) to present the different patterns of common issues by age (all age groups are available in Appendix Table 2).

The most frequent SNOMED-coded diagnoses or conditions for visits in patients aged 0 to 2 years (infants) primarily consisted of immunisation and acute respiratory or infection illness (i.e., RTI, otitis media, croup, cough, viral infection) whereas the adults aged 25 to 44 commonly presented for mental health issues (i.e., mental health care, anxiety) in addition to care management and RTI. Older patients (65+ years old), most commonly visited GPs for chronic illness (i.e., osteoarthritis, hypertension) and care management.

Table 7.4. 10 most common health conditions and recorded diagnosis for visits by age in 2017-18 (N (%)).

	0-2 YEARS (INFANTS)		25-44 YEARS (YOUNG ADULT)		65+ YEARS (OLDER PEOPLE)	
1	Immunisation	2,937 (11.5%)	Result discussed	11,019 (5.4%)	Care review	15,129 (5.6%)
2	Viral upper RTI	1,956 (7.7%)	Care review	6,886 (3.3%)	Prescription	10,776 (4.0%)
3	Otitis media	1,379 (5.4%)	Prescription	4,899 (2.4%)	Result discussed	8,955 (3.3%)
4	Upper RTI	1,371 (5.4%)	Immunisation	4,353 (2.1%)	Immunisation	7,160 (2.6%)
5	Care review	1,369 (3.8%)	Referral	3,841 (1.9%)	Health assessment	5,728 (2.1%)
6	Eczema	959 (3.0%)	Viral upper RTI	3,398 (1.7%)	Referral	5,025 (1.9%)
7	Croup	771 (2.4%)	Upper RTI	3,093 (1.5%)	Hypertensive disorder	4,671 (1.7%)
8	Viral infection	607 (2.4%)	Mental health care	2,366 (1.2%)	Care plan	3,502 (1.3%)
9	Cough	598 (1.9%)	Health assessment	2,250 (1.1%)	Osteoarthritis	2,684 (1.0%)
10	Conjunctivitis	483 (1.8%)	Anxiety	2,225 (1.1%)	Urinary tract infection	2,244 (0.8%)

7.5 PATHOLOGY TESTS

A pathology test can be ordered as a single test (e.g., HbA1c) or as a battery of tests (e.g., lipids, full blood count). GPs can record a pathology order either by individual test name or a battery name. In this report, pathology tests were counted as one request per patient per day if pathology tests were ordered regardless of whether it was an individual test or a battery of tests.

Overall, the annual total number of pathology requests per 100 visits did not significantly change over time. The median number of total pathology requests were consistently around 20 requests per 100 visits (IQR 0.0, 40) for a patient. The total frequency of pathology requests was similar across all three PHNs (Appendix Table 3).

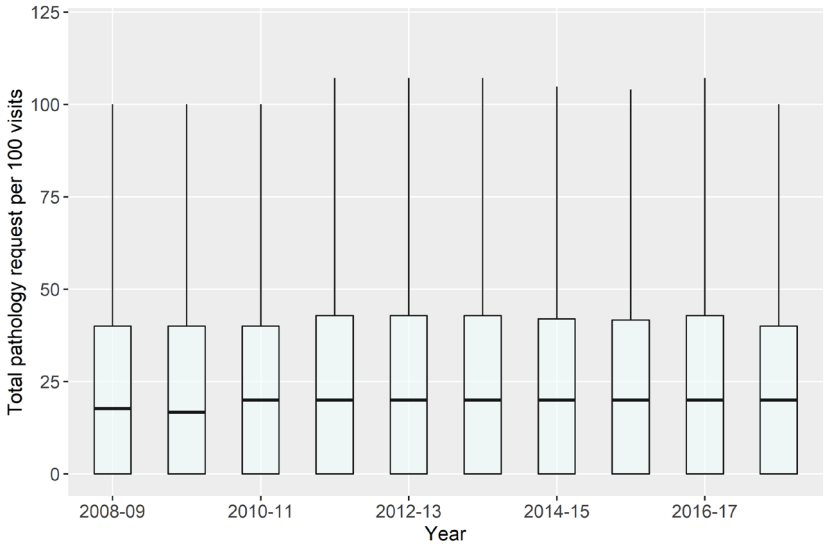


Figure 7.5. Annual pathology requests per 100 visits from 2008-09 to 2017-18.

The frequency of pathology requests by socio-demographic characteristics are presented in Figure 7.6. There were more pathology requests made for older patients, peaking for patients aged 65-74. There were slightly more pathology test requests for female patients than for male patients, and for patients who were socioeconomically advantaged than those who were less socioeconomically advantaged. More pathology requests were ordered for patients who resided in regional areas than in major cities and remote areas. Socio-demographic characteristics of PHNs are provided in the Appendix Figure 3.

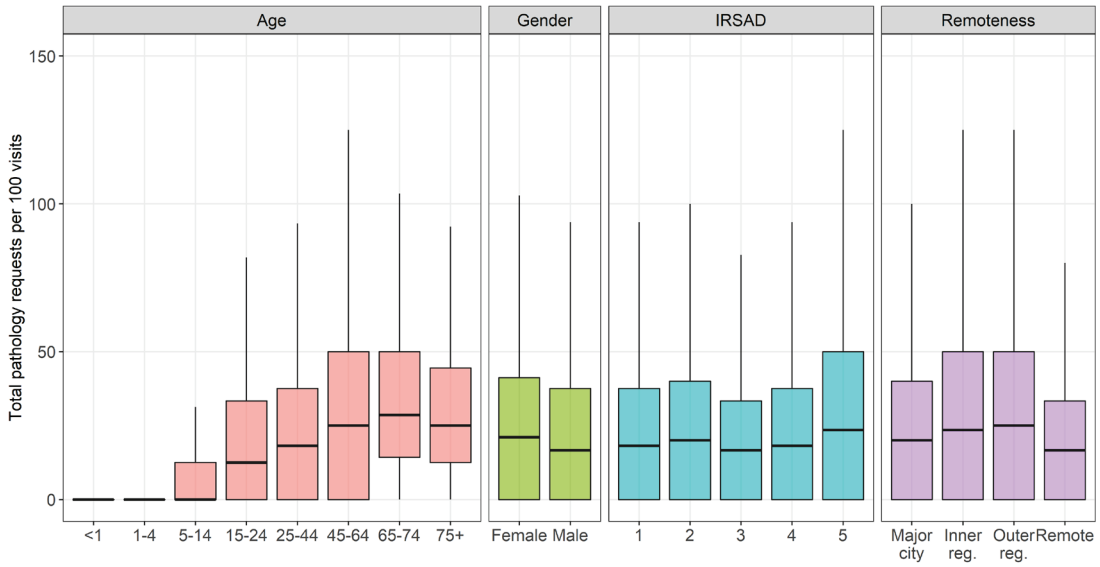


Figure 7.6. Total pathology requests per 100 visits by socio-demographic in 2017-18.

Based on the existence of reported results, it was possible to identify which pathology test requests were actually carried out by patients. In 2017-18, at the pathology test level, 65.3% of pathology requests (for which there may be more than one per patient) were carried out. However, at the patient level, only 34.7% of patients carried out all pathology requests ordered for them (Figure 7.7).

Overall, there were higher proportions of completed pathology requests for patients who were older, male, and residing in remote areas (Figure 7.8). Although it was more evident for PHN1 and 3, patients who were less socioeconomically advantaged appeared to carry out their pathology requests more than those who were socioeconomically advantaged (Appendix Figures 4 and 5).

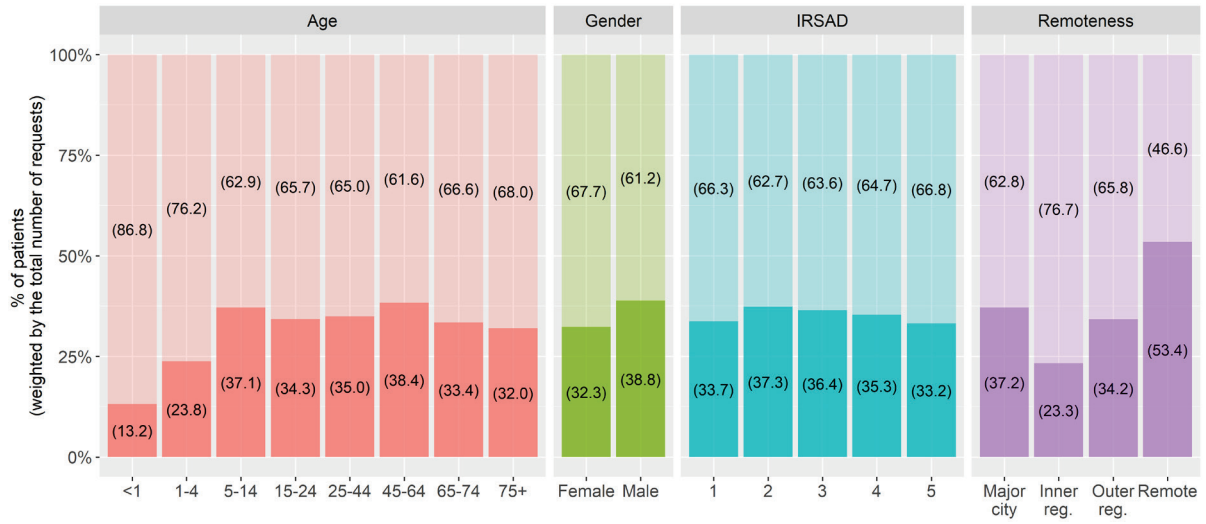


Figure 7.7. Proportion of patients completing all pathology requests by socio-demographic status in 2017-18.

Light shading represents the proportions of patients not completing all pathology requests
Lower bar (dark shading) represents the proportions of patients completing all pathology requests

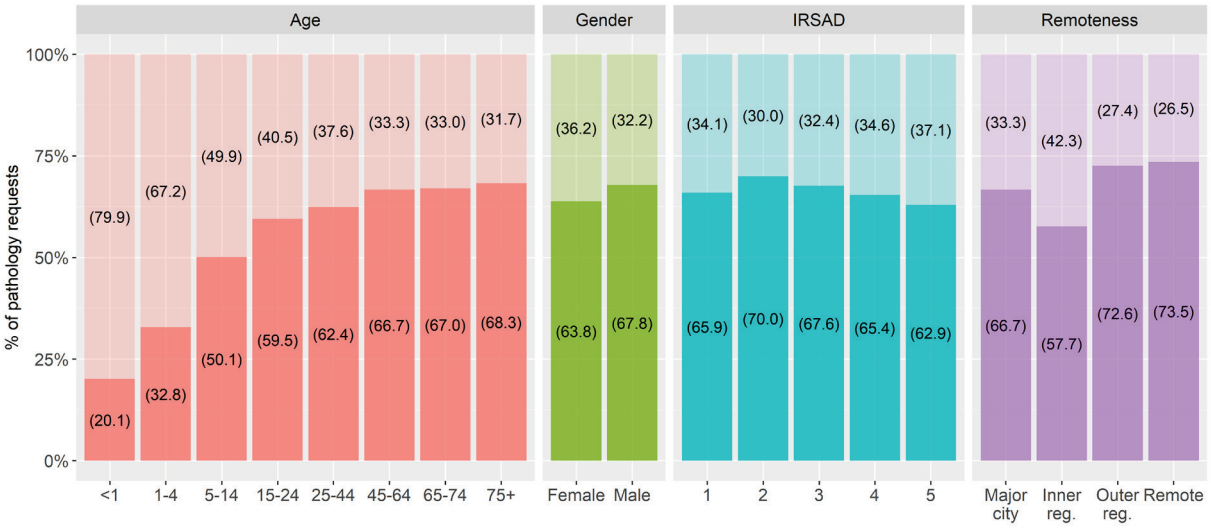


Figure 7.8. Proportion of completed pathology requests by socio-demographic status in 2017-18.

Light shading represents the proportions of pathology requests not completed
Dark shading represents the proportions of pathology requests completed

Where pathology requests were carried out, the time from a test request in general practice to sample collection at the laboratory was measured. As an example, we investigated a test that would commonly be ordered on many patients' test requests and that is not specific to any specific condition: haemoglobin. The time interval for haemoglobin testing was examined by socio-demographic characteristics to identify any potential patterns (Table 7.5).

For a haemoglobin test, the overall median time interval between the test request by the GP and sample collection was 2.5 days (IQR 0.0 – 19.0 days). The median time interval increased with age, and was slightly longer for male patients than female patients. Patients residing in outer regional and remote areas had a longer time interval than those who lived in major cities and inner regional areas. There was no noticeable difference in the time interval from test request to sample collection by socioeconomic status.

The test time interval for pathology requests was similarly evaluated with all types of pathology tests (Appendix Table 4) to examine whether these sociodemographic characteristics were consistent. The socio-demographic characteristics for patients undergoing all types of pathology tests were similar to those for haemoglobin tests. The estimated median time interval for all types of tests were also similar with the results from haemoglobin tests

Table 7.5. Time (day) required between haemoglobin test request to sample collection in 2017-2018

THE MEDIAN TIME (DAYS) FOR HAEMOGLOBIN TEST (IQR)								
	Overall		PHN1		PHN2		PHN3	
Total	2.5	(0.0, 19.0)	2.0	(0.0, 19.5)	3.0	(0.0, 19.0)	3.0	(0.0, 18.0)
Age								
<1 year	1.0	(0.0, 4.0)	5.0	(1.0, 35.0)	1.0	(0.8, 2.0)	0.0	(0.0, 2.0)
1-4 years	1.0	(0.0, 7.0)	1.0	(0.0, 6.5)	0.0	(0.0, 3.5)	2.0	(0.0, 9.0)
5-14 years	1.0	(0.0, 6.0)	1.0	(0.0, 6.1)	1.0	(0.0, 4.0)	1.0	(0.0, 7.0)
15-24 years	0.5	(0.0, 5.0)	0.0	(0.0, 4.5)	0.5	(0.0, 4.0)	1.0	(0.0, 5.0)
25-44 years	1.0	(0.0, 10.0)	1.0	(0.0, 10.0)	1.0	(0.0, 9.0)	1.0	(0.0, 10.0)
45-64 years	3.5	(0.0, 25.0)	3.0	(0.0, 26.0)	4.0	(0.5, 23.0)	4.0	(0.0, 24.3)
65-74 years	5.0	(0.0, 30.0)	4.5	(0.0, 31.0)	5.5	(1.0, 29.0)	4.5	(0.5, 29.0)
75+ years	3.0	(0.0, 19.0)	3.0	(0.0, 21.0)	3.0	(0.3, 17.5)	3.0	(0.0, 17.0)
Gender								
Female	2.0	(0.0, 17.0)	2.0	(0.0, 17.5)	3.0	(0.0, 17.0)	2.5	(0.0, 16.0)
Male	3.0	(0.0, 21.0)	3.0	(0.0, 23.0)	3.0	(0.0, 21.0)	3.0	(0.0, 20.0)
IRSAD								
1	3.0	(0.0, 16.0)	3.0	(0.0, 17.9)	3.0	(0.5, 17.8)	3.0	(0.0, 15.0)
2	3.0	(0.0, 17.0)	3.0	(0.0, 16.0)	2.0	(0.0, 17.0)	3.0	(0.0, 17.5)
3	2.0	(0.0, 16.0)	2.0	(0.0, 16.0)	4.0	(0.3, 23.0)	2.0	(0.0, 15.0)
4	2.0	(0.0, 18.0)	2.0	(0.0, 18.0)	5.0	(1.0, 26.0)	2.7	(0.0, 17.0)
5	3.0	(0.0, 22.0)	2.5	(0.0, 22.0)	1.0	(0.0, 11.5)	3.0	(0.0, 22.0)
Remoteness								
Major City	2.7	(0.0, 19.0)	2.2	(0.0, 20.0)	3.0	(0.0, 15.6)	3.0	(0.0, 18.0)
Inner Regional	2.0	(0.0, 17.5)	1.0	(0.0, 11.0)	3.0	(0.0, 19.5)	3.0	(0.0, 17.0)
Outer Regional	3.0	(0.5, 17.4)	0.0	(0.0, 7.1)	3.0	(0.5, 17.8)	2.0	(0.0, 13.0)
Remote	4.5	(1.0, 14.0)	0.0	(0.0, 4.5)	6.0	(1.0, 15.0)	2.0	(0.2, 5.0)

8. ENGAGEMENT WITH PRIMARY HEALTH NETWORKS (PHNS)

We met with the CEOs from three PHNs in November 2018. We also presented our results at a "Lunch and Learn" session with SEMPHN on 7th December 2018.

Continuing from this successful engagement, we initiated, with assistance from Outcome Health, an interactive videoconference meeting with a data research manager and engagement team from each of the three PHNs (SEMPHN 20 March 2019, EMPHN 21 March 2019, GPHN 1 April 2019). At each meeting, we presented a preliminary report of research results, and received feedback from PHNs on their key areas of interest.

We submitted a second result summary report to all 3 PHNs in May 2019, and met again with a data research manager from each PHN via teleconference (EMPHN 29 May 2019, GPHN 3 June 2019, SEMPHN 28 June 2019). Feedback was again documented and areas for quality improvement were identified by each PHN.

We presented our research entitled "Enhancing patient outcomes through evaluation of the appropriateness and quality use of pathology in general practice" at the Aurora Research Showcase on 18th July 2019 at South Eastern Melbourne Primary Health Network. This Showcase was attended by the data custodians (Outcome Health), CEOs and representatives from each of the PHNs, other PHNs not using POLAR, and other researchers also using POLAR data. Ongoing meetings with PHNs continued every 8 weeks or as needed.

We met with the research representative and a local GP from Gippsland PHN on 01 October 2019 to discuss more GPs being interested in being involved in the research, and to obtain advice on the direction of the research.

We have received positive responses and the PHNs are currently working to schedule a research roadshow for us to showcase our findings to GPs as part of the regular GP education activities hosted by the PHNs, but also to provide GPs a forum in which to provide feedback. This roadshow will take place in early 2020.

9. GLYCATED HAEMOGLOBIN A1C (HBA1C) AND KIDNEY FUNCTION TEST FOR MONITORING TYPE 2 DIABETES

9.1 INTRODUCTION

Glycated haemoglobin A1c (HbA1c) in blood provides a measure of a person's average blood glucose level in the past 8 to 12 weeks (22). HbA1c is currently used as a standard of care for testing and monitoring diabetes, particularly for type 2 diabetes (23). In Australia, clinical guidelines recommend HbA1c testing for patients with type 2 diabetes every 6 months if one's blood glucose level is within the target range (i.e., ≤ 53mmol/mol with the range 48 – 58mmol/mol) (24). If the HbA1c level is outside of the reference interval, monitoring within 3 months is recommended.

In addition to HbA1c testing, Australian guidelines recommend an annual kidney function test for patients with type 2 diabetes (23, 24). Diabetic kidney disease is one of the most frequent complications of type 2 diabetes, often leading to hospitalisations for renal transplant and dialysis, and a higher mortality rate especially from cardiovascular complications (25). As diabetic kidney disease has high social and economic costs, regular monitoring of renal function is key to disease prevention and management.

This section aimed to evaluate the frequency of HbA1c testing and kidney function tests in type 2 diabetes patients in comparison with guideline recommendations.

9.2 METHODS

Two years of data (from 2016-17 to 2017-18) were used for analyses. Analyses were performed using R (version 3.4.1). Patients for this analysis were eligible if they were 18 years old or older as of 2016, active patients during the study period, and had a recorded diagnosis of type 2 diabetes before the study period. Kidney function tests included albumin-creatinine ratio (ACR) and the estimation of the glomerular filtration rate (eGFR). If either test was performed, patients were considered to have taken a kidney function test.

9.3 RESULTS

A total of 21,370 patients were identified with type 2 diabetes during the study period. This accounted for 6.2% of the existing adult patients in the period, and 4.9% of the population if the prevalence was standardised to the Australian population in 2018. The age and gender distribution of type 2 diabetes patients (Figure 9.1) showed that the prevalence increased with age and was higher in males than females. The prevalence and the patterns of the age and gender distribution appeared consistent with the recent national survey report from the Australian Institute of Health and Welfare (AIHW) published in 2018, which reported an overall prevalence of 6.0% or 1.2 million Australian adults and 5.2% by standardized estimate, based on self-reported data, with age and gender profiles shown in Figure 9.1 (below) (26).

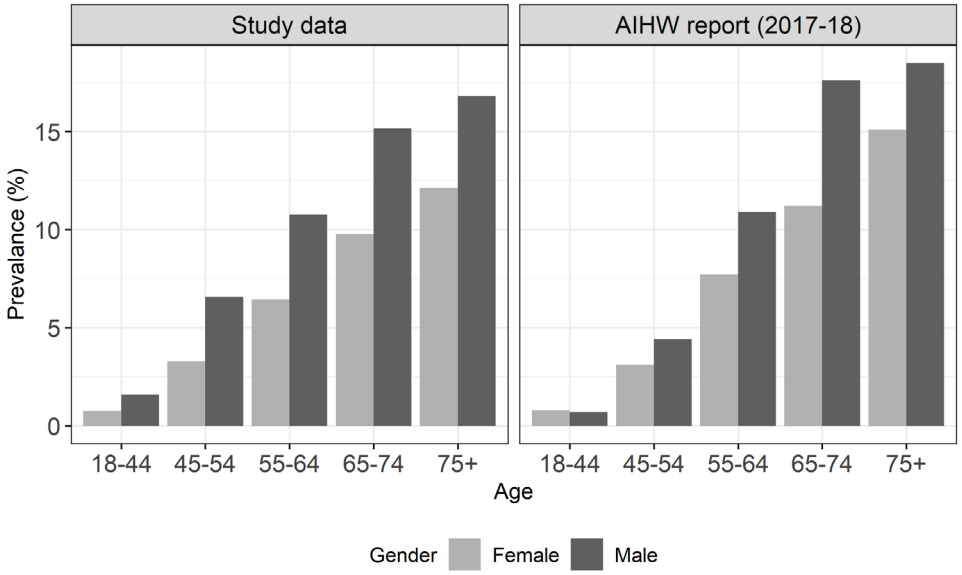


Figure 9.1. A comparison of age and gender distribution of patients with type 2 diabetes between study data and AIHW report.

Overall, 65% of all type 2 diabetes patients had HbA1c testing multiple times (2+ times) during the two years of this study. While HbA1c testing for diabetes patients is recommended at the maximum interval of 6 months, less than a half of all patients (43%) met the guidelines' recommendation (Figure 9.2). There were 34% of patients who had either no HbA1c testing or only one HbA1c test during the study period.

In PHN1, the majority of diabetes patients (83%) had HbA1c testing multiple times. However, only 55% of patients had HbA1c testing at the average ≤6 months interval. In PHN2, 37% of patients had an average HbA1c testing interval of ≤6 months.

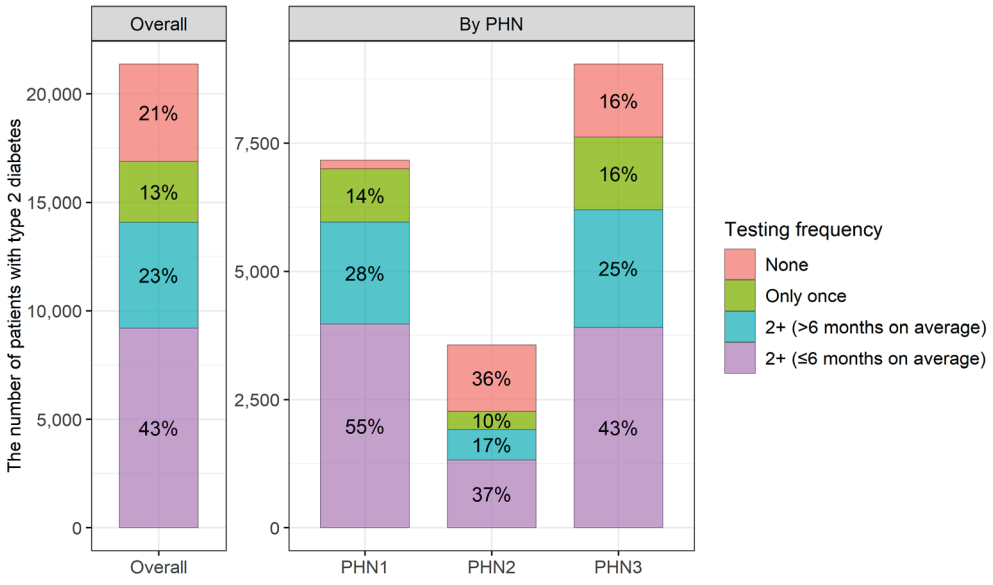


Figure 9.2. Proportions of patients by HbA1c testing frequency.

While crude estimates of the proportions of patients who had HbA1c testing ≤ 6 monthly ranged from 37% to 55% by PHN (Figure 9.2), the proportions in PHNs became more similar after age- and gender-standardisation (42.1% in PHN1, 36.9% in PHN2, and 37.5% in PHN3) as presented in Table 9.1. Table 9.1 also shows proportions of patients who carried out testing ≤ 6 monthly by socio-demographic variables. There were no noticeable differences in the proportions by socio-demographic status.

Table 9.1. Number of type 2 diabetes and proportion of patients who had HbA1c testing ≤ 6 monthly.

≤ 6 MONTHLY TESTED PATIENTS (STANDARDISED %)*								
	Overall		PHN1		PHN2		PHN3	
Total	9,203	(39.2)	3,967	(42.1)	1,322	(36.9)	3,914	(37.5)
Age								
18-44	321	(35.3)	149	(39.2)	34	(34.7)	138	(32.2)
45-54	893	(41.1)	383	(44.3)	113	(40.5)	397	(38.7)
55-64	1,998	(44.0)	811	(44.3)	308	(41.6)	879	(44.6)
65-74	3,053	(45.7)	1,372	(48.2)	468	(37.9)	1,213	(46.5)
75+	2,938	(40.7)	1,252	(42.9)	399	(31.9)	1,287	(42.1)
Gender								
Female	4,126	(39.3)	1,776	(42.1)	551	(34.3)	1,799	(38.5)
Male	5,077	(39.0)	2,191	(42.2)	771	(39.7)	2,115	(36.4)
IRSAD								
1	1,160	(32.7)	76	(36.8)	455	(30.9)	629	(34.3)
2	962	(40.6)	110	(30.8)	505	(46.3)	347	(39.6)
3	2,097	(40.6)	592	(39.3)	314	(36.6)	1,191	(42.1)
4	2,245	(43.5)	1,348	(46.2)	41	(45.6)	856	(39.7)
5	2,714	(36.3)	1,833	(39.4)	4	(69.9)	877	(30.9)
Remoteness								
Major Cities	7,411	(39.9)	3,757	(42.9)	8	(46.8)	3,646	(37.3)
Inner Regional	1,342	(35.5)	197	(28.1)	897	(36.7)	248	(42.8)
Outer Regional	413	(37.5)	4	(40.2)	403	(39.5)	6	(57.0)
Remote/Very remote	12	(53.2)	1	(50.0)	11	(62.2)	-	(0.0)

** Standardised to Australian population in 2018.Gender-standardised for age. Age-standardised for gender. Age- and gender-standardised for IRSAD and remoteness.*

For patients tested for HbA1c multiple times, the overall median time interval from their previous tests was within the target range of 6.1 months (IQR:4.6 – 8.4 months) (Table 9.2). The median time intervals across PHNs were approximately 6 months, consistent with guideline recommendations (6.0 months in PHN1, 5.9 months in PHN2, and 6.3 months in PHN3). The median intervals by socio-demographic group also showed little difference (± 0.5 months).

Table 9.2. Median time intervals between HbA1c tests when the previous blood glucose level was within the target range.

MEDIAN TIME INTERVALS IN MONTHS (IQR)				
	Overall	**PHN1**	**PHN2**	**PHN3**
Overall	6.1 (4.6, 8.4)	6.0 (4.6, 8.3)	5.9 (4.3, 8.1)	6.3 (4.8, 8.6)
Age				
18-44	6.3 (5.0, 9.2)	6.1 (4.8, 8.9)	6.1 (5.3, 7.5)	6.8 (5.2, 9.9)
45-54	6.3 (4.9, 8.7)	6.1 (4.8, 8.1)	6.0 (4.5, 8.1)	6.7 (5.2, 9.3)
55-64	6.2 (4.8, 8.6)	6.1 (4.6, 8.5)	6.1 (4.6, 8.0)	6.4 (4.9, 8.7)
65-74	6.0 (4.5, 8.3)	5.9 (4.5, 8.1)	5.9 (4.3, 8.2)	6.2 (4.7, 8.6)
75+	6.1 (4.6, 8.3)	6.1 (4.6, 8.4)	5.8 (4.2, 8.0)	6.1 (4.7, 8.3)
Gender				
Female	6.2 (4.6, 8.5)	6.1 (4.6, 8.5)	6.1 (4.4, 8.3)	6.2 (4.8, 8.7)
Male	6.1 (4.6, 8.3)	6.0 (4.6, 8.1)	5.7 (4.2, 8.0)	6.3 (4.8, 8.6)
IRSAD				
1	6.3 (4.8, 8.5)	6.0 (4.6, 7.6)	6.2 (4.5, 8.5)	6.5 (5.0, 8.7)
2	6.1 (4.5, 8.4)	6.3 (4.8, 8.7)	5.8 (4.2, 8.4)	6.3 (4.7, 8.5)
3	6.1 (4.6, 8.4)	6.0 (4.7, 8.3)	5.3 (4.1, 7.2)	6.2 (4.8, 8.8)
4	6.0 (4.6, 8.2)	6.0 (4.6, 8.0)	5.8 (4.5, 8.1)	6.2 (4.7, 8.4)
5	6.2 (4.7, 8.5)	6.1 (4.6, 8.4)	7.3 (6.7, 8.6)	6.3 (4.8, 8.7)
Remoteness				
Major Cities	6.1 (4.7, 8.4)	6.0 (4.6, 8.3)	6.9 (6.2, 8.0)	6.3 (4.8, 8.6)
Inner Regional	5.8 (4.4, 7.9)	6.4 (5.1, 8.8)	5.6 (4.2, 7.5)	6.2 (4.5, 8.6)
Outer Regional	6.4 (4.7, 9.5)	8.1 (7.7, 10.8)	6.4 (4.6, 9.5)	7.1 (5.7, 9.1)
Remote/Very remote	6.0 (5.0, 7.0)	-	6.0 (5.1, 6.6)	-

Conversely, where the previous HbA1c result was outside the target range, the overall median testing time interval was 4.7 months (IQR: 3.5–6.6 months), slightly above the recommended three months (Table 9.3). The median time intervals by PHNs were broadly similar (4.7 months in PHN1, 4.4 months in PHN2, 4.9 months in PHN3).

Although there were no major differences for gender, socioeconomic status (IRSAD), and remoteness, longer time intervals were observed for younger patients.

Table 9.3. Median time intervals of HbA1c testing when the previous blood glucose level was outside the target range.

	MEDIAN TIME INTERVALS IN MONTHS (IQR)			
	Overall	**PHN1**	**PHN2**	**PHN3**
Overall	4.7 (3.5, 6.6)	4.7 (3.5, 6.5)	4.4 (3.4, 6.4)	4.9 (3.7, 6.7)
Age				
18-44	5.3 (3.8, 7.7)	5.1 (3.6, 7.6)	5.5 (3.9, 7.7)	5.4 (3.9, 8.0)
45-54	5.2 (3.9, 7.3)	5.1 (3.8, 7.4)	4.6 (3.7, 6.4)	5.6 (4.1, 7.8)
55-64	5.0 (3.6, 7.0)	5.0 (3.5, 7.0)	4.3 (3.4, 6.6)	5.2 (3.9, 7.2)
65-74	4.5 (3.4, 6.1)	4.5 (3.4, 6.1)	4.4 (3.4, 6.2)	4.6 (3.5, 6.1)
75+	4.5 (3.4, 6.1)	4.5 (3.4, 6.0)	4.2 (3.4, 6.0)	4.5 (3.5, 6.2)
Gender				
Female	4.7 (3.6, 6.5)	4.7 (3.5, 6.4)	4.3 (3.4, 6.4)	4.9 (3.7, 6.8)
Male	4.7 (3.5, 6.6)	4.6 (3.4, 6.6)	4.4 (3.4, 6.3)	4.9 (3.7, 6.7)
IRSAD				
1	4.8 (3.6, 6.8)	5.0 (3.4, 7.0)	4.7 (3.6, 6.6)	4.9 (3.7, 6.9)
2	4.6 (3.6, 6.7)	6.2 (4.2, 7.9)	4.3 (3.4, 6.4)	4.7 (3.7, 6.7)
3	4.8 (3.5, 6.6)	4.7 (3.5, 6.7)	4.2 (3.4, 5.9)	5.0 (3.6, 6.8)
4	4.6 (3.4, 6.5)	4.5 (3.3, 6.4)	4.4 (3.9, 6.1)	4.9 (3.6, 6.9)
5	4.7 (3.6, 6.3)	4.7 (3.6, 6.3)	5.9 (5.1, 6.1)	4.8 (3.6, 6.4)
Remoteness				
Major Cities	4.8 (3.6, 6.6)	4.7 (3.5, 6.4)	6.0 (4.7, 6.3)	4.9 (3.7, 6.8)
Inner Regional	4.4 (3.4, 6.4)	5.3 (3.8, 7.4)	4.3 (3.4, 6.0)	4.5 (3.6, 6.3)
Outer Regional	4.8 (3.6, 6.7)	5.4 (4.6, 6.2)	4.8 (3.6, 6.8)	3.0 (1.9, 4.3)
Remote/Very remote	5.9 (4.2, 6.9)	-	-	5.6 (3.8, 6.2)

For kidney function tests, overall, the majority of type 2 diabetes patients were tested multiple times in two years, and 78% of the total had testing annually (Figure 9.3). Patient characteristics were relatively consistent across PHNs. While about 15-20% of patients did not have a kidney function test at all or only once during the study period, there were 70- 80% of patients who had the test annually. PHN2 had the highest percentage of annually tested patients among three PHNs.

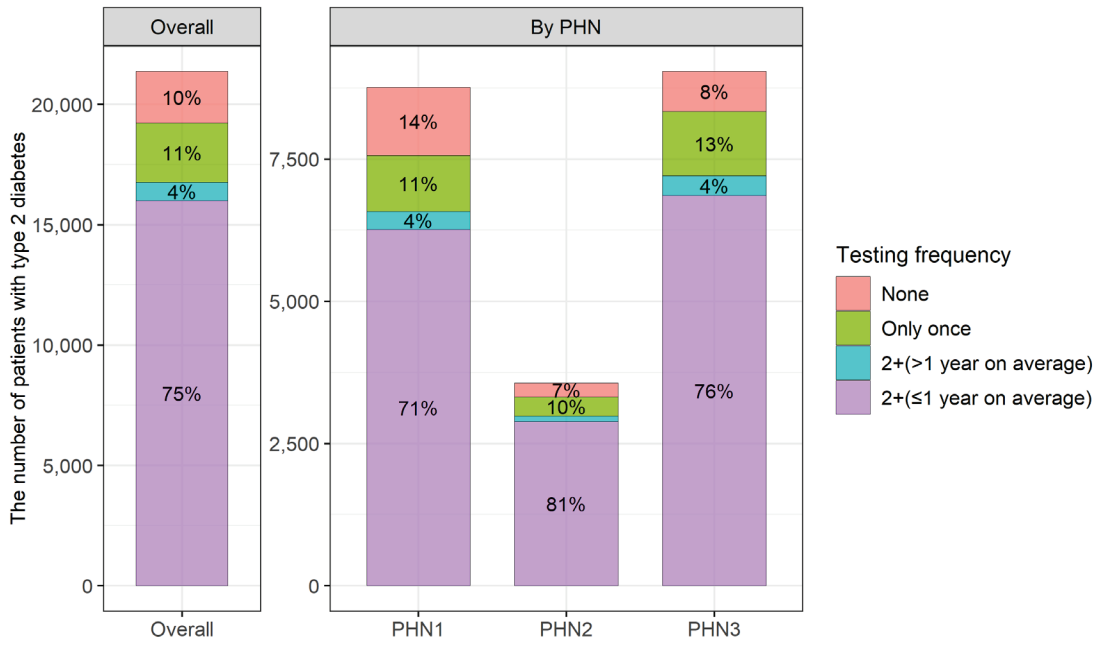


Figure 9.3. Proportions of patients by frequency of kidney function test.

Characteristics of patients who performed a kidney function test annually were further evaluated with age- and gender-standardised proportions (Table 9.4). Overall, the proportions of annually tested patients across PHNs were broadly similar following standardisation.

There was an increasing trend in the proportion of annually tested patients with age (Table 9.4). Females had a slightly higher proportion of annually tested patients than males, especially in PHN2. There were no distinct patterns observed for socioeconomic status (IRSAD) or geographic remoteness.

Table 9.4. Socio-demographic characteristics of patients with annual kidney function test.

ANNUALLY TESTED PATIENTS (STANDARDISED %) *								
	Overall		PHN1		PHN2		PHN3	
Overall	16,000	(66.7)	6,261	(65.9)	2,882	(69.8)	6,857	(66.3)
Age								
18-44	552	(60.7)	238	(62.6)	63	(61.8)	251	(58.4)
45-54	1,459	(67.2)	568	(65.2)	194	(70.3)	697	(68.0)
55-64	3,280	(72.5)	1,226	(67.3)	580	(78.9)	1,474	(74.9)
65-74	5,185	(77.7)	2,108	(74.0)	1,019	(84.0)	2,058	(78.9)
75+	5,524	(77.5)	2,121	(74.3)	1,026	(82.7)	2,377	(78.5)
Gender								
Female	7,337	(67.6)	2,853	(65.0)	1,296	(75.3)	3,188	(67.6)
Male	8,661	(65.7)	3,408	(66.8)	1,585	(63.9)	3,668	(64.8)
IRSAD								
1	2,356	(67.0)	119	(62.4)	1,165	(69.4)	1,072	(65.4)
2	1,545	(64.1)	176	(57.9)	828	(70.4)	541	(60.0)
3	3,600	(69.4)	964	(67.5)	663	(70.5)	1,973	(70.1)
4	3,772	(68.4)	2,122	(69.0)	216	(83.1)	1,434	(66.3)
5	4,690	(62.5)	2,868	(62.3)	5	(76.7)	1,817	(62.8)
Remoteness								
Major Cities	12,399	(66.1)	5,925	(66.4)	18	(66.8)	6,456	(66.1)
Inner Regional	2,826	(69.4)	314	(59.7)	2,141	(71.6)	371	(69.3)
Outer Regional	719	(65.1)	9	(61.3)	701	(68.6)	9	(71.2)
Remote/Very remote	20	(73.1)	2	(100.0)	17	(79.0)	1	(100.0)

** Standardised to Australian population in 2018.Gender-standardised for age. Age-standardised for gender. Age- and gender-standardised for IRSAD and remoteness.*

9.4 LIMITATIONS

The inability to track patients' activities across different practices is an important limitation in the current data. This means it is not possible to identify a patient's attendance at a practice outside the POLAR catchment. As a way to increase the reliability of the data we limited our sample to RACGP active patients only. Nevertheless, this data limitation means that some patients may have had HbA1c tests that did not appear in this dataset.

9.5 IMPLICATIONS

Despite the data limitations, the prevalence and population distribution of type 2 diabetes were relatively consistent with the national survey report from the Australian Institute of Health and Welfare (AIHW) (26). The similarity provides a level of confidence in the validity of the data, and the applicability of the findings to the general adult population with type 2 diabetes in Australia. Improvement in follow-up HbA1c testing appeared to be particularly required in those who had results outside of the recommended HbA1c level (>53mmol/mol), where the overall median time interval was 4.7 months (IQR: 3.5–6.6 months) and slightly above the recommended three months.

10. INR TESTING FOR PATIENTS TAKING WARFARIN

10.1 INTRODUCTION

Warfarin is an anti-coagulant medication commonly used to treat and prevent systemic embolism, stroke associated with atrial fibrillation (AF), and venous thromboembolism (VTE). Despite its widespread use, warfarin has a strict therapeutic regimen involving routine laboratory monitoring, patient-specific dose adjustment, and close monitoring due to interactions with diet and other drugs. Bleeding due to over-anticoagulation is a major concern in the use of warfarin (27).

The safety and efficacy of warfarin is critically dependent on maintaining the international normalised ratio (INR) within the target range. Patients are required to perform this blood test regularly while on the medication. Guidelines recommend frequent monitoring (e.g., daily) when commencing INR treatment. Once the INR and warfarin dose are stable, patients can be controlled with 4 to 6 weekly INR testing unless more frequently required (28-30). This section aimed to evaluate how often patients on regular use of warfarin have conducted INR testing as per guideline recommendations.

10.2 METHODS

Analyses were performed using R (version 3.4.1). To examine the frequency of INR testing, we evaluated the average testing time interval of each patient during the two years from 2016-17 to 2017-18. The recommended maximum interval was considered 6 weeks as per the clinical guideline. Eligible patients in this analysis were those who were aged 18 or above as of 2016, active patients throughout the period who had regular prescriptions of warfarin (brand names: Coumadin and Marevan).

A regular warfarin user was defined as a patient who had warfarin prescriptions in both 2016-17 and 2017-18 with ≥ 3 prescriptions per year (i.e., at least 6 prescriptions during the two years) with a prescription interval of up to 5 months. The prescription interval for defining a regular non-vitamin K antagonist oral anticoagulant (NOAC) user was determined as the maximum quantity of the warfarin that can be prescribed under PBS at once (i.e., max 150 tablets which is equivalent to 150 days if one tablet was taken daily) (31).

10.3 RESULTS

There was a total of 2,488 patients who were regularly on warfarin from 2016-17 to 2017-18, of which 1,137, 431, and 920 patients were from PHN1, 2, and 3 respectively. The overall prevalence of regular medication use among adult patients was 0.8%. PHN2 had the highest prevalence of regular medication use (1.2%) compared to 0.8 and 0.7% in PHN1 and 3, respectively. While prevalence varied by PHN, the age and gender distributions of regular warfarin users were consistent across PHNs. The proportion of patients who were regularly on warfarin increased with age, particularly after 65 years. A larger percentage of male patients were regular warfarin users in comparison to female patients (Figure 10.1).

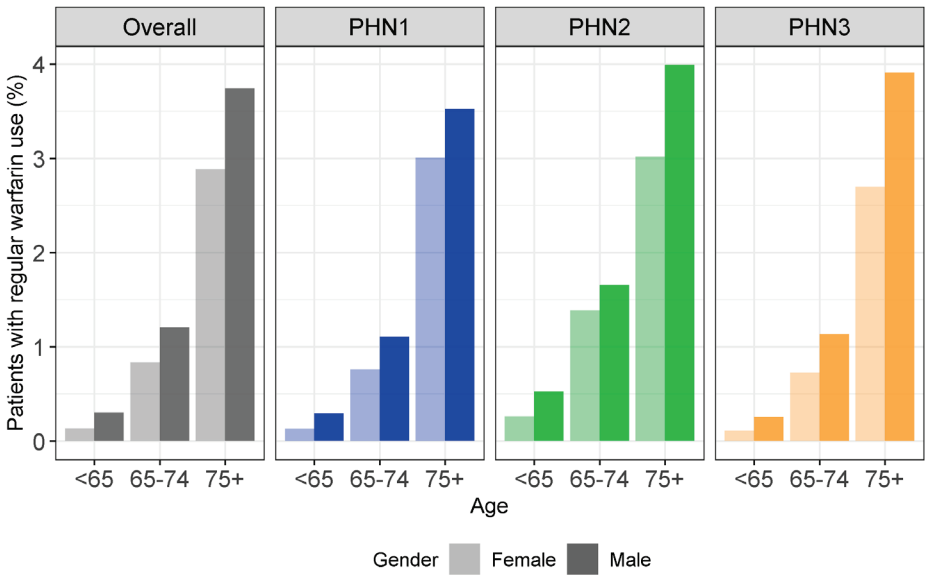


Figure 10.1 The prevalence (%) of regular warfarin use by age and gender.

Overall, more than a half of patients with regular use of warfarin (64%) had had an INR test within 6 weeks on average. There was 8% of patients who had an INR test multiple times (2+) but with time intervals of over 6 weeks. The remaining patients (28%) had either no INR testing or only one recorded INR test in two years.

Across PHNs, there were substantial differences in the proportion of patients having an INR test within a 6-week period (Figure 10.2), particularly with PHN2: the proportion of patients in PHN2 was much lower (19%) than the other two PHNs (73–74%). In PHN2, patients who had no INR testing or only one test accounted for 65% of patients whereas such patients comprised less than 25% in PHN1 and 3.

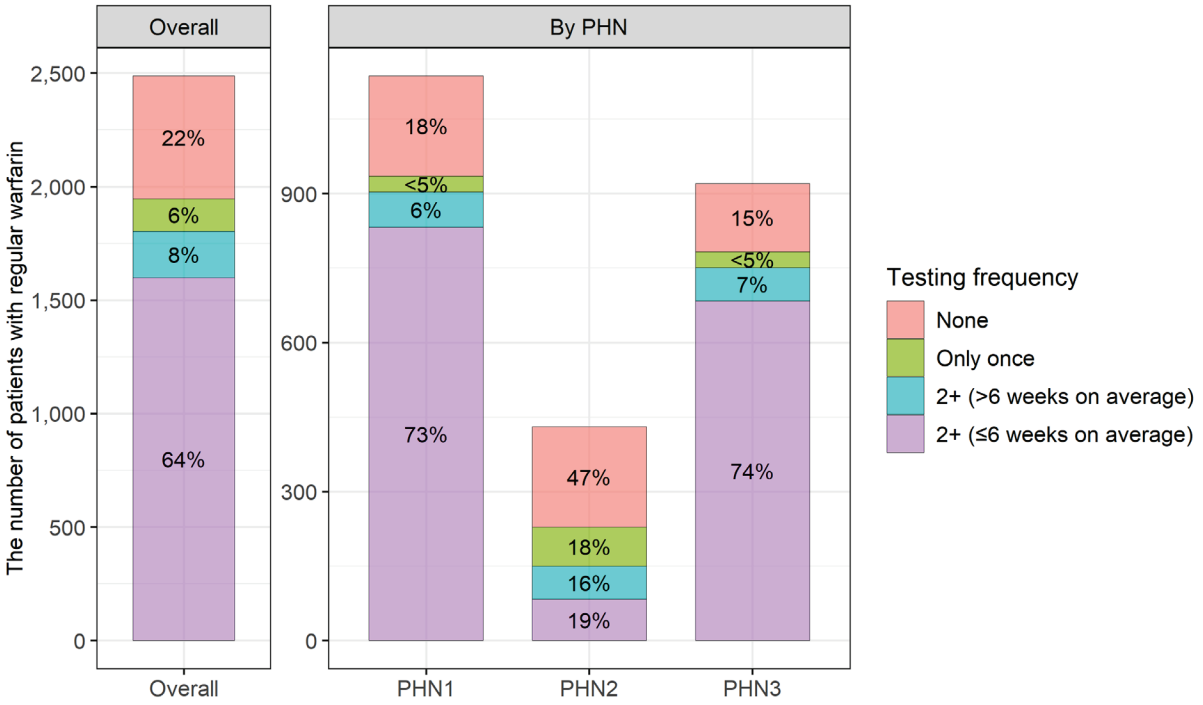


Figure 10.2. Proportions of patients on regular warfarin by frequency of INR testing.

Characteristics of patients who had an INR test at least once in a 6-week period are presented with age- and gender-standardised proportions in Table 10.1. In general, the proportions of patients taking INR testing within a 6-week were higher in patients who were older (75+) and in major cities. A higher percentage was also seen among female patients compared to male patients (Table 10.1).

Table 10.1. Socio-demographic characteristics of patients with INR testing ≤6 weekly.

	PATIENTS WHO HAD INR TESTING EVERY 6 WEEKS ON AVERAGE (%) *							
	Overall		PHN1		PHN2		PHN3	
Total	1,599	(59.2)	832	(69.7)	83	(16.0)	684	(69.0)
Age								
<65	239	(58.5)	128	(69.4)	12	(15.3)	99	(67.9)
65-74	321	(58.8)	160	(67.2)	23	(18.9)	138	(74.5)
75+	1,039	(68.2)	544	(76.5)	48	(21.4)	447	(76.3)
Gender								
Female	812	(63.2)	437	(76.0)	45	(15.7)	330	(73.7)
Male	787	(55.1)	395	(63.3)	38	(16.3)	354	(64.3)
IRSAD								
1	129	(34.4)	38	(81.9)	26	(18.8)	65	(58.1)
2	132	(42.0)	43	(82.0)	45	(20.3)	44	(94.7)
3	312	(69.2)	115	(73.8)	11	(18.9)	186	(76.5)
4	399	(67.0)	223	(67.4)	1	(25.0)	175	(72.2)
5	627	(64.5)	413	(66.8)	0	(0.0)	214	(60.6)
Remoteness								
Major Cities	1,450	(68.9)	786	(69.1)	0	(0.0)	664	(68.7)
Inner Regional	117	(32.5)	45	(83.5)	52	(15.1)	20	(90.0)
Outer Regional	32	(18.0)	1	(100.0)	31	(17.9)	-	-
Remote	-	-	-	-	-	-	-	-

** Standardised to Australian population in 2018.Gender-standardised for age. Age-standardised for gender. Age- and gender-standardised for IRSAD and remoteness.*

10.4 LIMITATIONS

The inability to track patients' activities across different practices is an important limitation in the current data. As a result, there is potential that some patients might have been double counted or had an INR test with a GP outside the POLAR catchment, or had the test ordered by a specialist or in hospital. Therefore, these tests would not be recorded in our data. However, it is considered unlikely that patients received regular warfarin prescriptions from more than one practice as the medication demands rigorous monitoring and its use is highly restricted.

10.5 IMPLICATIONS

The prevalence of AF increased with age, particularly in male populations aged 65 or over (32). Previous evidence shows that 1-2% of the adult population in developed countries have been prescribed warfarin (33). Although the figure from our study (0.8%) was slightly lower, our estimate is reasonable given that our focus was on long-term use of warfarin. Further investigations are required to identify what factors impact on the differences in INR testing between remote and metropolitan PHNs to ensure the safe and effective use of warfarin, improvements in which may have the potential to improve outcomes for patients taking warfarin for a variety of reasons, including stroke, dose control (e.g., excessive bleeding), thromboembolism, AF, valve replacements, and more.

11. KIDNEY FUNCTION TEST FOR NON-VITAMIN K ANTAGONIST ORAL ANTICOAGULANTS (NOACS)

11.1 INTRODUCTION

Non-vitamin K antagonist oral anticoagulants (NOACs) are relatively new medications used for non-valvular atrial fibrillation (AF) and venous thromboembolism (VTE). Historically, vitamin K antagonists (e.g., warfarin) have been the standard of care and the only oral option. However, warfarin is associated with many limitations in its use, requiring routine laboratory monitoring, patient-specific dose adjustment, and considerations related to interactions with diet, genetics, and existing illnesses (34). NOACs overcome many of the practical issues associated with the use of warfarin and are now widely used as alternatives to warfarin (35).

While the main difference between NOACs and warfarin is routine laboratory monitoring, there is a risk of bleeding if kidney function deteriorates even when using NOACs. NOACs are contraindicated in patients with end-stage renal failure and require careful use in patients with renal impairment. To ensure the safety of patients with an on-going prescription of NOACs, clinical guidelines (36, 37) recommend that kidney function be annually checked whenever a patient's clinical circumstances or medications change. This section aimed to evaluate the frequency of kidney function monitoring in patients with regular use of NOACs in light of guideline recommendations.

11.2 METHODS

Analyses were performed using R (version 3.4.1). To examine the frequency of kidney function tests, we evaluated the average test time interval of each patient during the two years from 2016-17 to 2017-18. The recommended test time interval was considered 1 year (±30 days) as per the clinical guidelines. Eligible patients in this analysis were those who were 18 years old or older, active throughout the study period, and had regular prescriptions of NOACs.

Three NOAC medications currently approved for use in Australia were included in this evaluation: Dabigatran (brand name: Pradaxa), Apixaban (Eliquis), and Rivaroxaban (Xarelto). Kidney function tests included estimated glomerular filtration rate (eGFR) or albumin and creatinine ratio (ACR). If either test was carried out during the study period, the patient was considered to have had a kidney function test. Patients were considered regular users of NOACs if they had ≥2 NOAC prescriptions per year during the two-year study period (i.e., at least a total of 4 prescriptions for two years) with prescription intervals between 5 weeks and 6 months. The prescription interval for regular NOAC use were determined from 5 weeks to exclude a temporal or short term NOAC use such as for hip replacement surgery. The maximum interval was up to 6 months based on the maximum quantity of the drug prescribed at once under PBS (i.e., 180 tables which is equivalent to 180 days if one table daily) (31, 38).

11.3 RESULTS

During the two years of the study period, there was a total of 2,058 patients who regularly used NOACs (PHN1: 1,004 patients, PHN2: 223 patients, PHN3: 831 patients). The overall prevalence of regular use by adult patients was 0.7% and the prevalence rates by PHN were similar (PHN1: 0.7% PHN2: 0.6%, PHN3: 0.6%). The age and gender distributions of the prevalence were consistent across PHNs: the anticoagulant medication was more commonly used in patients aged 65 or over and in males (Figure 11.1).

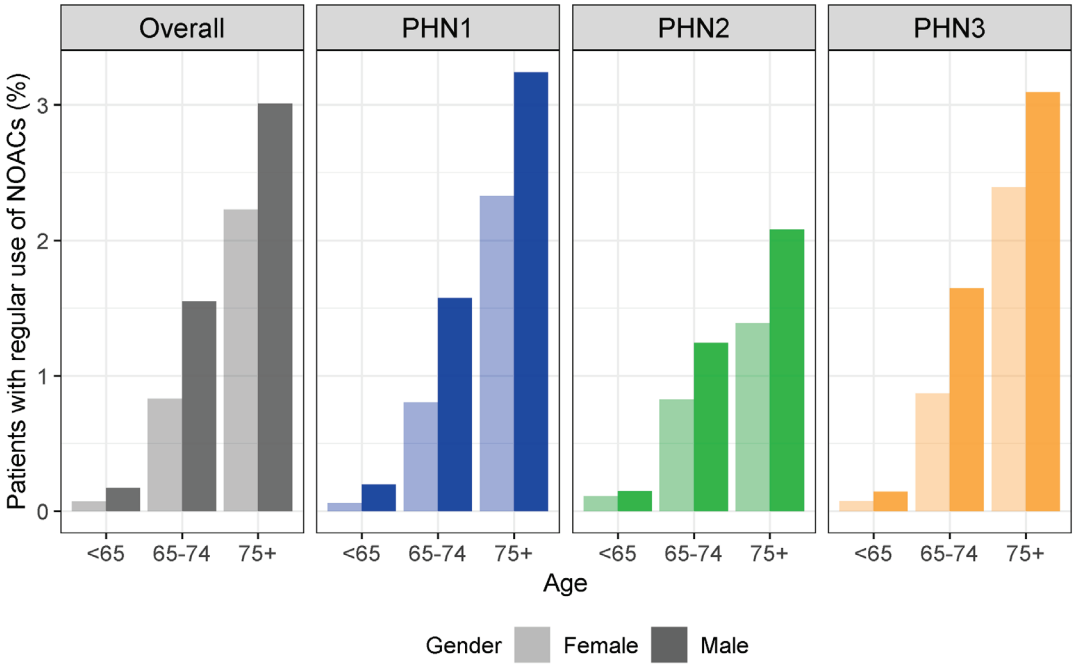


Figure 11.1. The prevalence (%) of regular use of NOACs by age and gender.

Among the patients with regular use of NOACs, the majority (75%) of the patients had a kidney function test at least once a year on average (Figure 11.2). Six percent of patients had a kidney function test multiple times (2+) during the study period, with average intervals between tests exceeding a year. The remaining 18% of patients did not have a kidney function test at all or had only one.

Although annually tested patients accounted for the majority of patients in all PHNs (71%-83%), the highest percentage of patients with an annual kidney function test was PHN2. While the percentage of annually tested patients was lowest in PHN1, patients with no test, or only one test in two years was much higher (23%) than the other two PHNs (13% in PHN2 and 15% in PHN3).

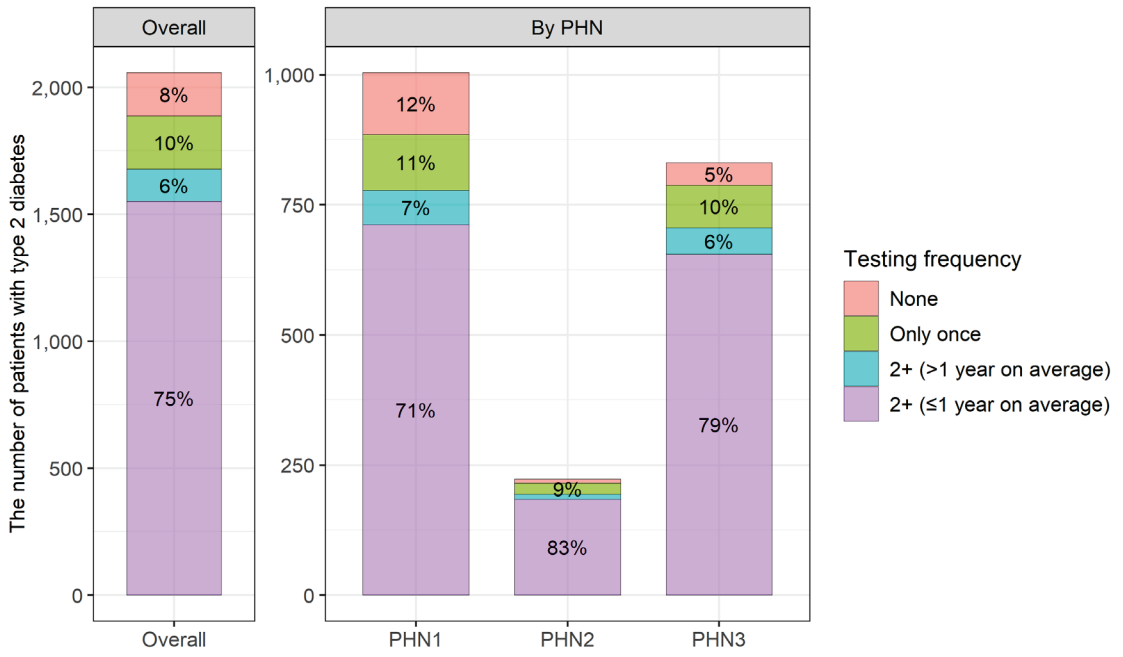


Figure 11.2. Proportions of patients with regular use of NOACs by frequency of kidney function test.

Table 11.1 shows the sociodemographic characteristics of patients who were annually tested for kidney function as recommended by clinical guidelines. The proportion of annually tested patients were age- and gender-standardised. The highest percentage of patients with a kidney function test remained in PHN2. Overall, those who were annually tested patients were more likely to be female, older, and of lower socioeconomic status (IRSAD).

Table 11.1. Sociodemographic characteristics of patients with annual kidney function test.

	THE NUMBER OF PATIENTS WITH ANNUAL KIDNEY FUNCTION TEST (%)*							
	Overall		PHN1		PHN2		PHN3	
Overall	1,551	(70.2)	712	(68.6)	184	(79.1)	655	(69.7)
Age								
<65	155	(69.4)	73	(68.5)	21	(78.3)	61	(68.0)
65-74	448	(71.5)	188	(64.1)	70	(84.5)	190	(76.0)
75+	948	(78.8)	451	(75.6)	93	(81.5)	404	(82.2)
Gender								
Female	728	(71.3)	335	(70.0)	81	(74.8)	312	(71.3)
Male	823	(69.1)	377	(67.2)	103	(83.5)	343	(68.0)
IRSAD								
1	171	(85.1)	28	(90.9)	57	(80.9)	86	(88.1)
2	146	(75.5)	16	(73.5)	76	(80.3)	54	(94.9)
3	315	(69.5)	101	(55.8)	42	(80.8)	172	(74.4)
4	384	(68.5)	232	(72.7)	9	(97.8)	143	(55.9)
5	535	(65.3)	335	(68.5)	-	-	200	(57.1)
Remoteness								
Major Cities	1,285	(68.8)	664	(68.6)	1	(100.0)	620	(69.2)
Inner Regional	204	(75.3)	47	(62.4)	123	(81.0)	34	(70.5)
Outer Regional	60	(75.5)	1	(100.0)	59	(75.5)	-	-
Remote/Very remote	2	(100.0)	-	-	1	(100.0)	1	(100.0)

** Standardised to Australian population in 2018; gender-standardised for age; age-standardised for gender; age- and gender-standardised for IRSAD and remoteness.*

11.4 LIMITATIONS

Patients' activities across practices cannot be tracked in the current data. Consequently, some patients may have been double counted, or omitted if kidney function testing occurred at a GP practice outside the POLAR catchment. However, it is unlikely that patients would attend more than one practice for continuing care with NOACs.

11.5 IMPLICATIONS

Similar to warfarin, the prevalence of NOAC use sharply increased from the age of 65 in male patients as AF has a higher prevalence in that sub-population (39). Overall, the majority of the patients using NOACs had kidney function testing at least once a year as per clinical guidelines.

12. FERRITIN TESTING FOR IRON DEFICIENCY

12.1 INTRODUCTION

Iron is an essential nutrient for proper body function, enabling many important cellular functions, including oxygen transport, DNA and enzyme synthesis, energy production, erythropoiesis, and immune function (1). Increased loss of iron can result in iron deficiency, which is a state of malnutrition caused by reduced iron availability sufficient for the requirements of the body's needs. Iron deficiency is diagnosed through laboratory investigation of iron biomarkers in the body. In the absence of inflammation and chronic diseases, low serum ferritin (a protein that stores iron) is the most reliable indicator of iron deficiency (2).

Iron deficiency is the most common nutritional deficiency worldwide, and the leading underlying cause of iron deficiency anaemia, with the risk being highest for women due to blood loss through menstruation and increased iron requirements during pregnancy (3). In Australia, the 2012 Australian Health Survey suggested that approximately 3% of the population are anaemic, with 71% a result of iron deficiency (4). Other studies suggest a prevalence of iron deficiency anaemia ranging from 1% to 14% in young children, and 10% to 55% in women (5). The high prevalence and adverse consequences of iron deficiency and anaemia have prompted the World Health Organization (WHO) to identify the reduction of anaemia for women of reproductive age as one of the six global nutritional targets for 2025. WHO also aims to increase the understanding of anaemia among women, and increase its prevention and management, ultimately leading to a 50% reduction (6).

In this study, we aimed to identify population groups at high risk for iron deficiency in Australia. We also aimed to assess variation in its diagnosis by geographic location.

12.2 METHODS

We investigated the use of ferritin tests between 1 October 2017 and 30 September 2018. Analyses were performed using Stata/MP 16. We describe the proportion of ferritin tests returned with low results (as indicated by the pathology provider), by socio-demographics characteristics. All patient records with a ferritin pathology test were used in this analysis. We then investigated variation in the number of ferritin tests ordered and the number returning with abnormal test results by PHN and gender, according to the methods described by Spiegelhalter (7). Through this method, the proportion of tests with low (or abnormal) results are calculated for each practice. This proportion is subsequently plotted against the number of tests conducted within the practice. By adding several general practices on a plot, we are then able to calculate the average proportion of tests with low results among the included practices, as well as 2 and 3 standard deviations from the average. Results beyond 2 and 3 standard deviations indicates that the proportion of low results within a practice differs from 95% and 99.7% of the average of all practices, respectively. Of interest are practices below 2 and 3 standard deviations from the mean, as these practices would have a considerably lower proportion of tests returning with low results compared to the other practices, suggesting the possibility of overtesting (particularly for practices with a high number of tests).

12.3 RESULTS

287,735 ferritin tests were ordered in 211 practices: 103 from PHN1, 21 from PHN2, and 87 from PHN3 (Figure 12.1). The proportion of test results flagged as low was 13.7%, overall (Table 12.1).

Table 12.1. Descriptive profile of ferritin tests.

		TOTAL	LOW	
			n	%
Number of tests		287735	39431	13.7
PHN	1	159494	21070	13.2
	2	17185	1919	11.2
	3	111056	16442	14.8
Gender	Female	194889	34539	17.7
	Male	92526	4841	5.2
Age Group	0-10	4538	753	16.6
	11-20	16977	4153	24.5
	21-30	37953	7958	21.0
	31-40	47390	8901	18.8
	41-50	42445	7398	17.4
	51-60	39178	2707	6.9
	61-70	38388	2341	6.1
	71-80	34166	2733	8.0
	81-90	21884	2053	9.4
	91+	4816	434	9.0

There was a distinct difference in low ferritin results by gender, with a greater proportion of females having low ferritin test results compared to the proportion of males (Figure 12.1).

Figure 12.2 depicts the variation among the PHNs in ferritin test results with low results. In PHN1 for females, 9 practices (8.7%) were 2 standard deviations below the mean while a further 29 practices (28.1%) were 3 standard deviations below the mean. For males, 15 practices (14.6%) were 2 standard deviations below the mean while a further 4 (3.9%) were 3 standard deviations below the mean. In PHN2 for females, 1 practice (4.8%) was 2 standard deviations below the mean, while a further 3 (14.3%) were 3 standard deviations below the mean. For males, 1 practice (4.8%) was below 2 standard deviations, and a further 1 (4.8%) more was below 3 standard deviations from the mean. In PHN3 for females, 7 practices (8.0%) were 2 standard deviations below the mean, while a further 30 (34.5%) were 3 standard deviations below the mean. For males 13 practices (14.9%) were 2 standard deviations below the mean, while a further 7 (8.0%) were 3 standard deviations below the mean.

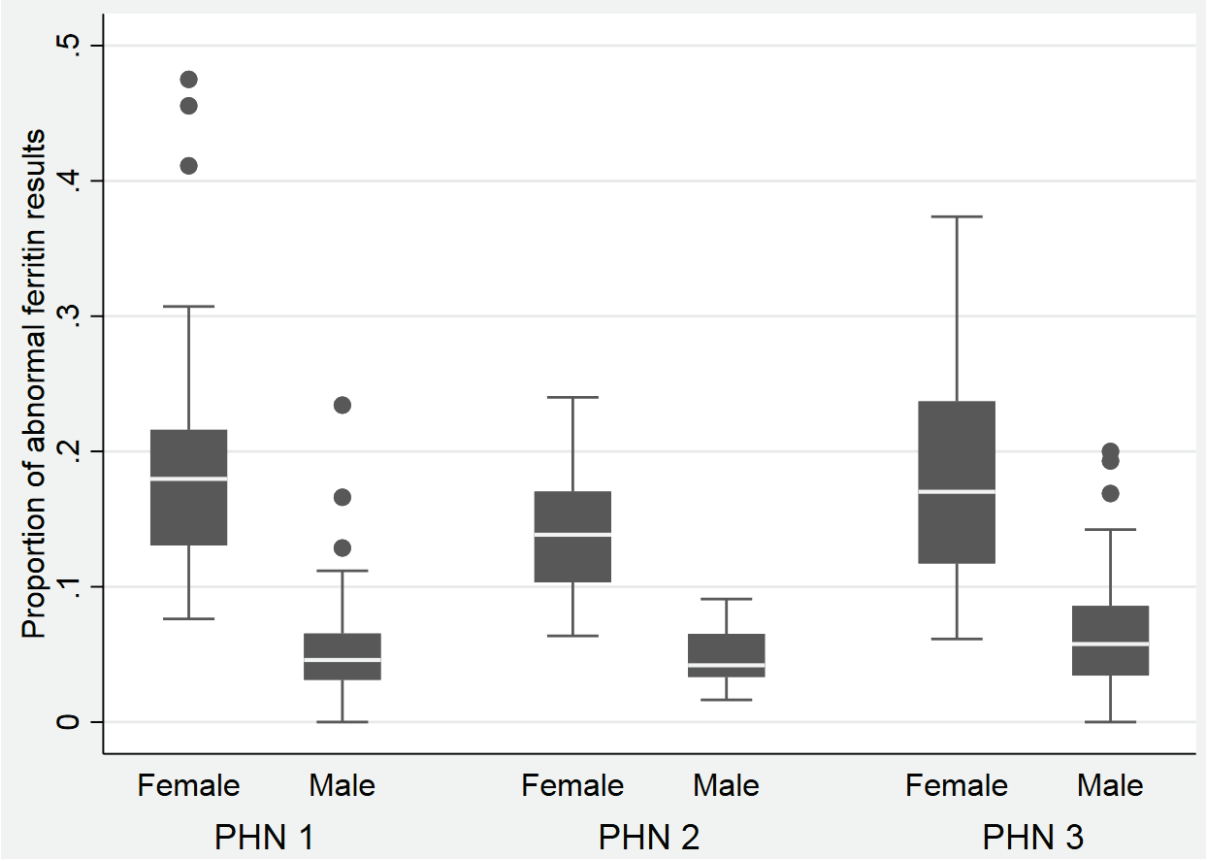


Figure 12.1. Variation in the ratio of low ferritin test results by PHN and gender.

12.4 LIMITATIONS

As the results are based on electronic health record data, some limitations should be taken into consideration while interpreting the results. Low test results are determined based on the pathology provider's reported indicator of the test results "abnormality", such as high, low, +, or -. Some test results might have comments rather than these indicators, which may result in some results being missed in our analysis. Nonetheless, we do not expect this limitation to substantially influence the conclusions drawn from this section.

12.5 IMPLICATIONS

There were higher proportions of low ferritin test results for younger females compared to other age groups and males. More variation in ferritin tests were observed for females compared to males, suggesting that ferritin tests may be ordered in a higher variety of situations in females. Targeted testing focusing on adolescent and younger females may ensure capturing the groups most at risk for iron deficiency.

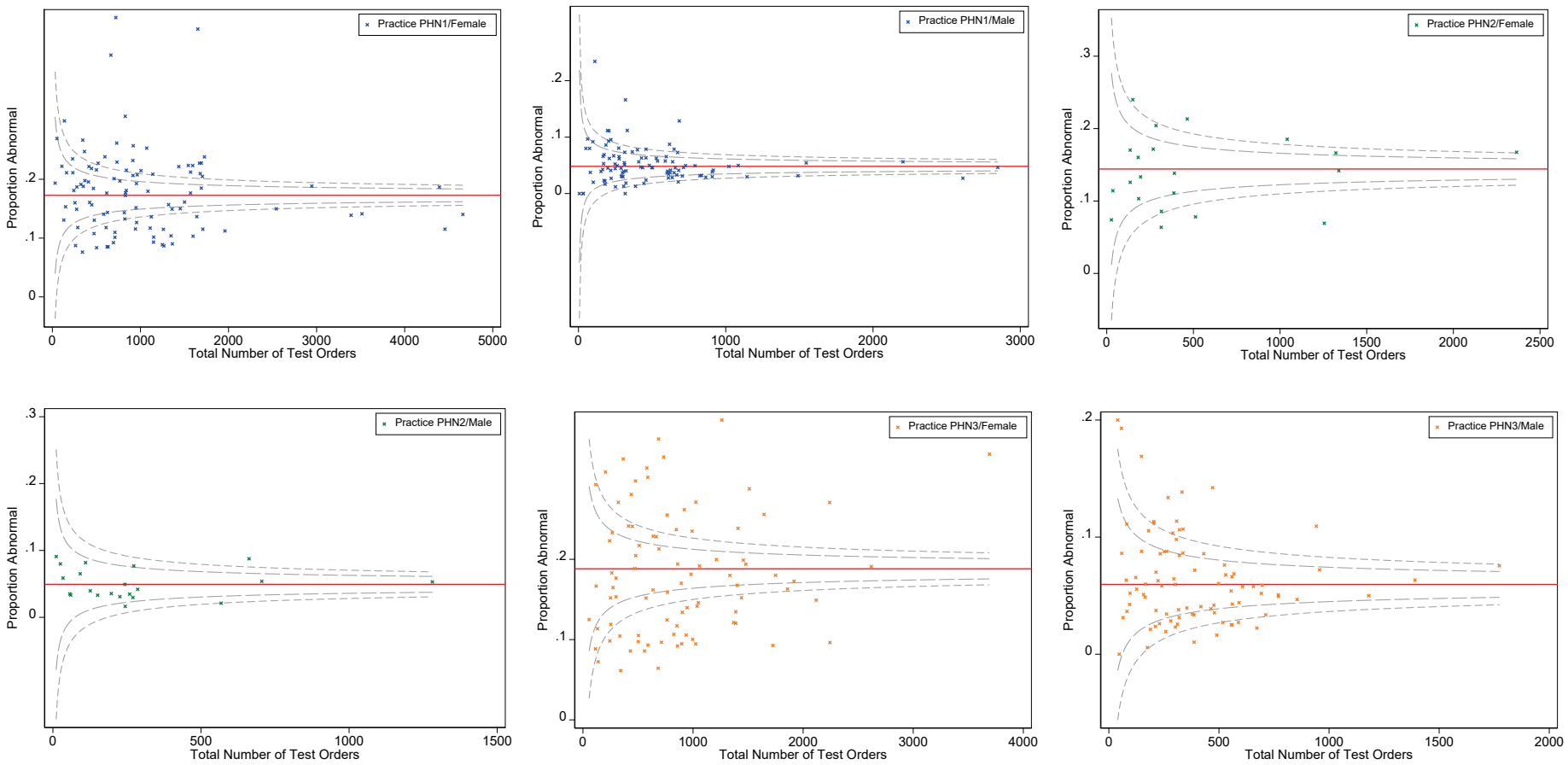


Figure 12.2. Variation in ferritin test results returning abnormal result, by PHN and gender.

Each point represents a practice. Mean is represented by the horizontal line crossing the vertical axis. Standard deviations, 2 and 3 respectively, are represented by the inner and outer dashed lines. Practices falling below 2 and 3 standard deviations indicate high variation from the average among their respective PHN for the gender category.

13. VARIATION AND TRENDS IN VITAMIN D TESTING

13.1 INTRODUCTION

A study by Bilinski and Boyages (1) on Medicare data reported a large increase in vitamin D testing across Australia between early 2000s and 2010. Most of the vitamin D test requests were made by GPs. Although this study could not determine the reason for ordering the test, the increasing availability and accessibility of vitamin D tests are thought to be contributing factors to the increase. The authors proposed the possibility that many of these tests could potentially be unnecessary, and recommended a review of the testing guidelines. The following year, in 2014, a review on vitamin D testing by the Australian Government Department of Health was released (2). The review found that a majority of the requests originated from GPs for the purposes of screening, and the conclusions drawn from the report led to changes to Medicare items. Following from the review and after changes implemented in Medicare, Boyages (3) observed a reduction in vitamin D testing, which was decreasing at the time of publication, in 2016. Whether the reduction observed following changes to Medicare was a sustained response or a short-term reaction to the review is not clear, as the Boyages study was published shortly after the changes. Furthermore, the previously mentioned studies demonstrate an increase in vitamin D testing in Australia, yet there remains a gap in our understanding of the outcomes of these tests, and variation on its use among general practices.

In this study we aimed to determine whether the trends observed through Medicare data are comparable to data obtained from electronic health records, and whether the changes following the review were sustained. Furthermore, we aimed to determine whether the appropriateness of testing had improved by describing the changes in tests results following low vitamin D test levels. We also investigated variation in vitamin D testing in the past year among the general practices in our study.

13.2 METHODS

Analyses were performed using Stata/MP 16. We investigated the trends in vitamin D testing for each month between 1 October 2007 and 30 September 2018 as a proportion of all tests requested during their respective month. We also described the proportion of those vitamin D tests which returned with a low test result as defined by the pathology provider in their report. For this analysis, all available vitamin D test requests and results, along with the socio-demographic characteristics of the population were used.

We investigated the variation in the use of vitamin D tests among the practices within the three PHNs of our study, separately by gender. This was achieved through the use of a funnel plot measuring the proportion of low test results in the number of tests ordered within the practice in the study period, through the method defined by Spiegelhalter (4). The method is described in detail in section 12.2. Methods.

13.3 TRENDS IN VITAMIN D TESTING

Consistent with previous reports we observed an increasing trend in vitamin D test requesting from 2007 until 2013, after which a decline was observed in 2014 (Figure 13.1). From 2016 onwards, a slight upwards trajectory of vitamin D testing has reappeared. We observed seasonality in test result normality, where more vitamin D results with low results occur in winter and early autumn compared to summer and early spring. The seasonal trend in tests with low results does not seem to have changed considerably following the review.

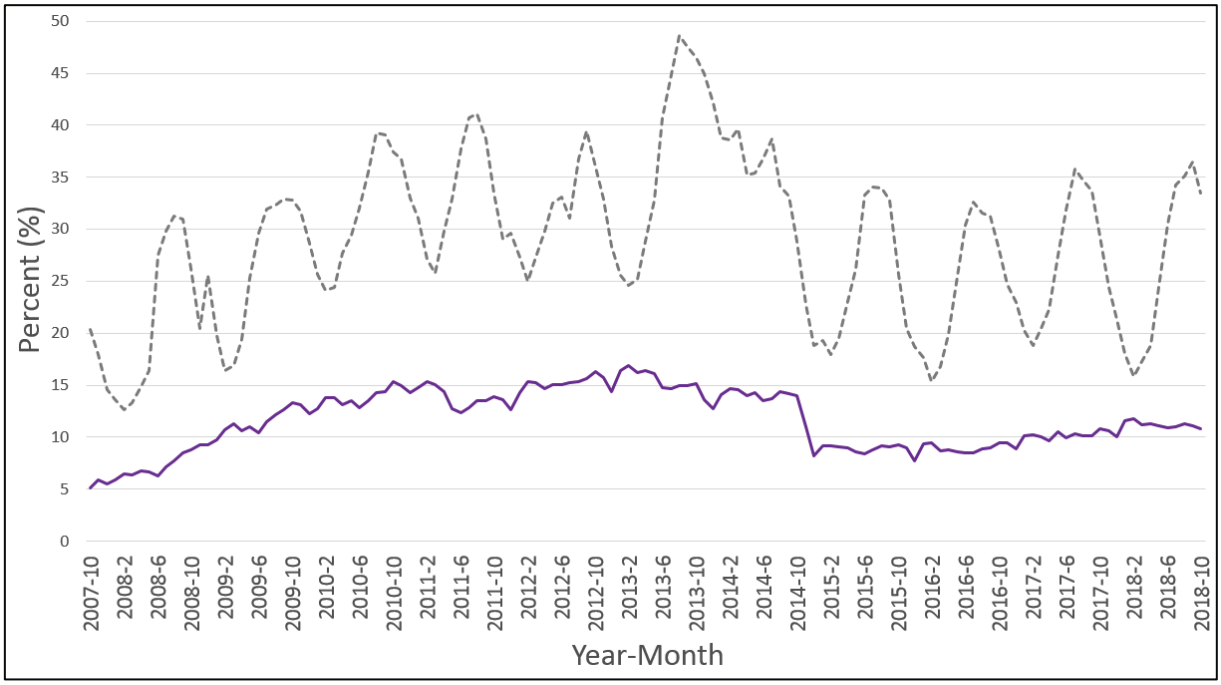


Figure 13.1. Trends in vitamin D testing from 2007 to 2018.

Purple (solid) line represents the proportion of test requests containing a vitamin D test during the respective month-year, while grey (dashed) line represents the proportion of vitamin D tests returning with a low result.

13.4 VARIATION IN VITAMIN D TESTING

We investigated variation in the number of tests ordered and the rate of low test results among general practices for 3 PHNs. A total of 211 practices were included in the analysis, 103 from PHN1, 21 from PHN2, and 87 from PHN3. For these PHNs, 140,028 vitamin D tests were requested between 1 October 2017 and 30 September 2018, of which 43,667 had low results. Our investigation into variation of vitamin D testing between PHNs reveals differences among PHNs, though not by gender (Figure 13.2). The proportion of low test results ranged from 0.2 to 0.55 (20% to 55%, respectively) in PHN2. PHN1 and PHN3 had similar ratios, with abnormal results mostly varying from 0.1 to 0.6 (10% to 60%, respectively).

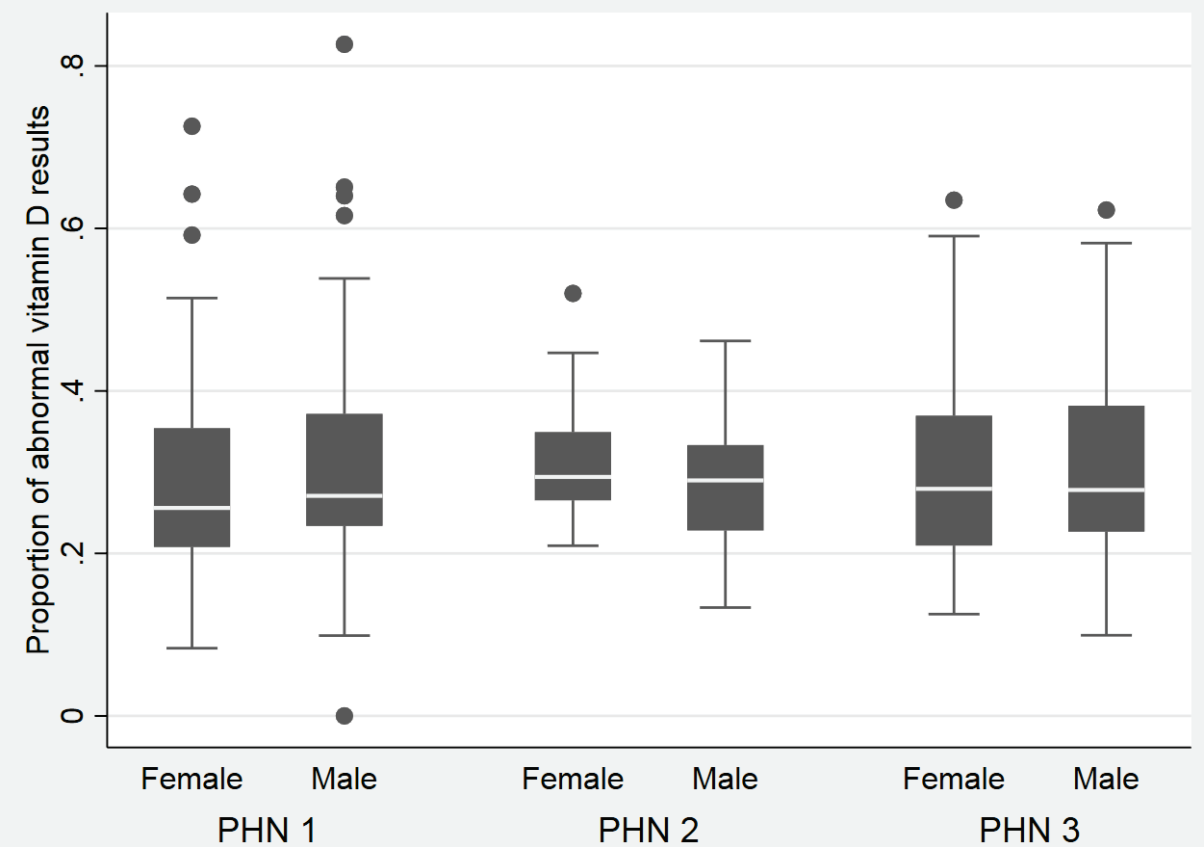


Figure 13.2. Proportion of vitamin D tests returning with low results, with differences among PHNs and by gender shown.

Our further investigation into variation of vitamin D testing between practices in each of the 3 PHNs reveals a high number of practices with a considerably lower proportion of tests with low results compared to the other practices within the PHN (Figure 13.3). Among female patients in PHN1, we observed 13 practices (12.6%) which fell below 2 standard deviation from the mean, while a further 25 (24.3%) fell 3 standard deviations from the mean. For male patients, 14 practices (13.6%) fell 2 standard deviation below the mean, while a further 12 (11.6%) fell 3 standard deviations below the mean. In PHN 2, only 1 practice (4.8%) fell below 3 standard deviations for females, and none for males. In PHN 3 for females, 11 practices (12.6%) fell below 2 standard deviations, with a further 28 (32.2%) falling 3 standard deviations below the mean. For males, 15 (17.2%) practices fell below 2 standard deviations, while a further 17 (19.5%) fell below 3 standard deviations from the mean.

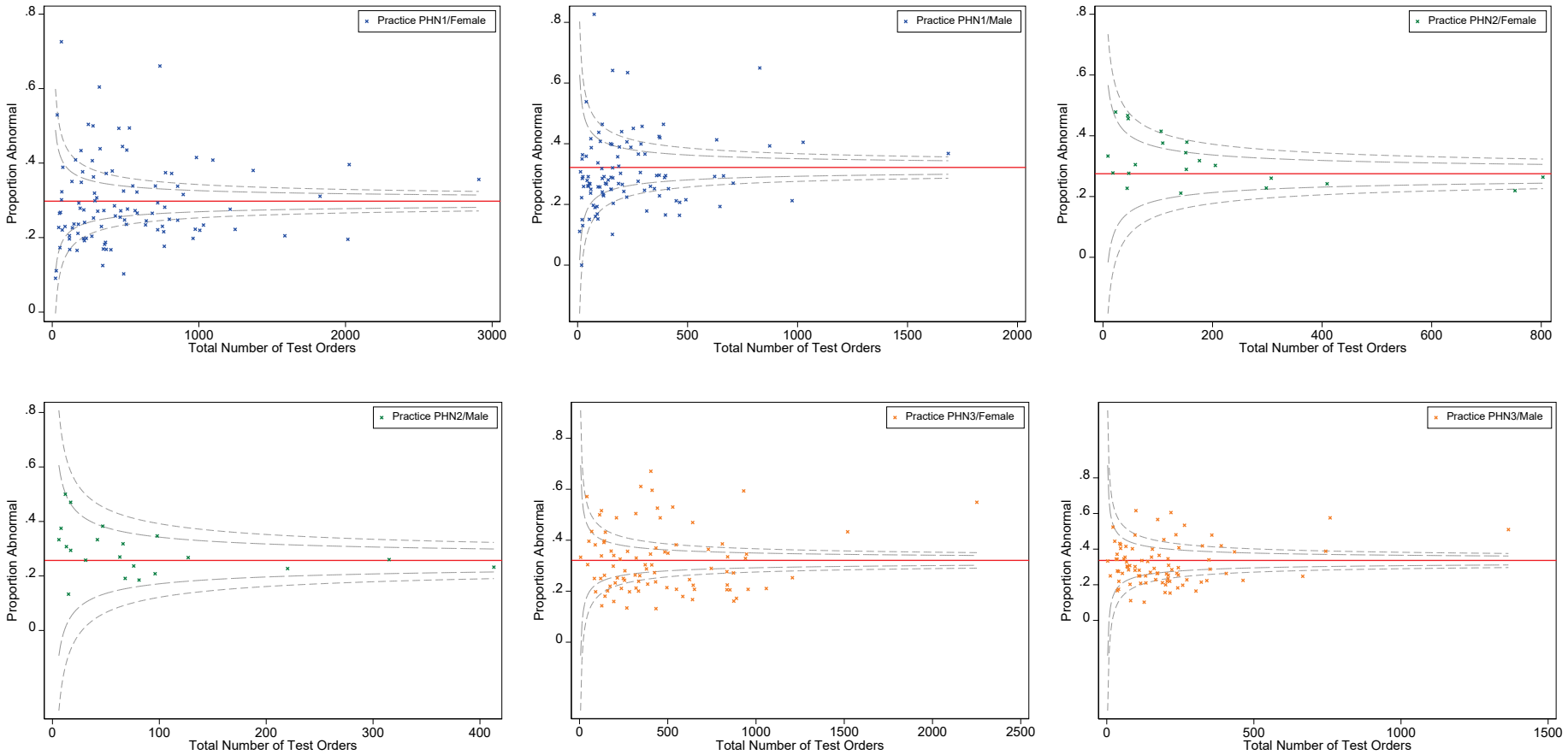


Figure 13.1. Variation in vitamin D tests returning with abnormal results in by PHN and gender.

Each point represents a practice. Vertical line crossing the horizontal axis represents the mean, while outer dashed lines are 3 standard deviations from the mean, and the inner dashed lines are 2 standard deviations from the mean. Of interest are the points which fall below 2 and 3 standard deviations from the mean, as these represent practices have considerably fewer test results having low results compared to other practices with similar test orders in the PHN.

13.5 LIMITATIONS

In this section, we defined a test request as a request for one or many pathology tests, which may occur at most once a day for a patient, which was based on the assumption that this would be true. Also, test results were based on a pathology provider's "abnormality indicator" which has limitations associated with it, as outlined in the previous section.

13.6 IMPLICATIONS

Our results demonstrate an increasing trend in vitamin D testing from 8% in 2014 to 11% in late 2018. We observed seasonal variation, with lower proportions of vitamin D tests with low test results in warmer months (15-20%) compared to colder months (30-35%), suggesting that vitamin D tests performed during summer periods might be less necessary in most cases. However, further investigation into the conditions for which tests were ordered may provide more insight into the reasons for test ordering. We also observed high variation among practices within PHNs, which will require further investigations to determine possible reasons.

14. USE OF THYROID FUNCTION TESTS (TFTS) IN THE INITIAL ASSESSMENT FOR THYROID DYSFUNCTION

14.1 INTRODUCTION

Thyroid functions tests (TFTs) are a commonly ordered tests among Australian general practitioners to screen and monitor patients for thyroid dysfunction. General practices account for around 75% of all TFT orders in Australia (1,2). This panel of tests consist of thyroid stimulating hormone (TSH), free triiodothyronine (fT3), and free thyroxine (fT4) tests. Guidelines on the use of this panel of tests recommend initial ordering of TSH tests, followed up by fT4 if the TSH test returns with abnormal (low or high) test results (3). In combination, these tests are indicative of hypothyroidism when TSH is high and fT4 is low, and hyperthyroidism when TSH is low and fT4 is high. In Australia, the use of TFTs has increased at a higher rate than population growth: 5.7% per year, in comparison to 1.6%, respectively (2). Whether this growth in testing has returned value to the healthcare system is unknown. In this study, we aimed to describe how the TFT panel of tests are initially ordered among Australian general practitioners, how often TSH test results return with abnormal values, and how much variation there is among the practices in their TSH ordering behaviour.

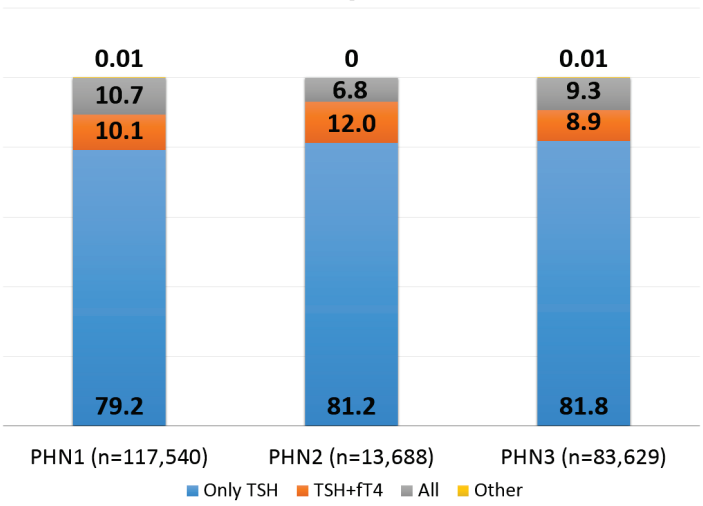
14.2 METHODS

For this analysis, we investigated TFT test results. Analyses were performed using Stata/MP 16. In order to study only the initial investigation of thyroid disorders and not ongoing monitoring for diagnosed patients, we only included tests which were not a repeat of a prior test. We did this by including tests that did not have a prior TFT test within the last year. We included tests ordered between 1 October 2017 and 30 September 2018. We also determined the proportion of TSH test results ordered returning with low results as defined by the pathology provider in their report. Furthermore, we investigated variation in the use and abnormality of TSH tests and results by PHN and gender, using a funnel plot as described by Spiegelhalter (4). A detailed description of the method of this study can be found in section 12.2 Methods.

14.3 RESULTS

There were 119 practices in PHN1, 23 practices in PHN2, and 94 practices in PHN3. A total of 214,857 TSH tests were ordered among the 3 PHNs between 2017/18. The highest proportion of TSH tests/number of practices was in PHN1 (987.7), followed by PHN3 (889.7). PHN2 had a far lower proportion (595.1).

Test ordering patterns were similar across the 3 PHNs (Figure 14.1). Ordering of TSH only was the most common manner in which TFT tests were ordered, contributing to around 80% of TFT test ordering patterns. Ordering of all TFT tests was the second most common ordering pattern in PHN1 and PHN3, while ordering of TSH+fT4 was the second most common for PHN2.



c

The proportion of TSH test results with low or high results was few. In PHN1, the mean proportion of abnormal results was 8.6% (SD 2.2%) for females and 6.0% (SD 2.2%) for males. In PHN2, the mean proportion was 11.7% (2.3%) for females and 7.9% (4.0%) for males. In PHN3, the mean proportion for females was 9.4% (SD 2.5%), and for males, 6.5% (SD 2.0%).

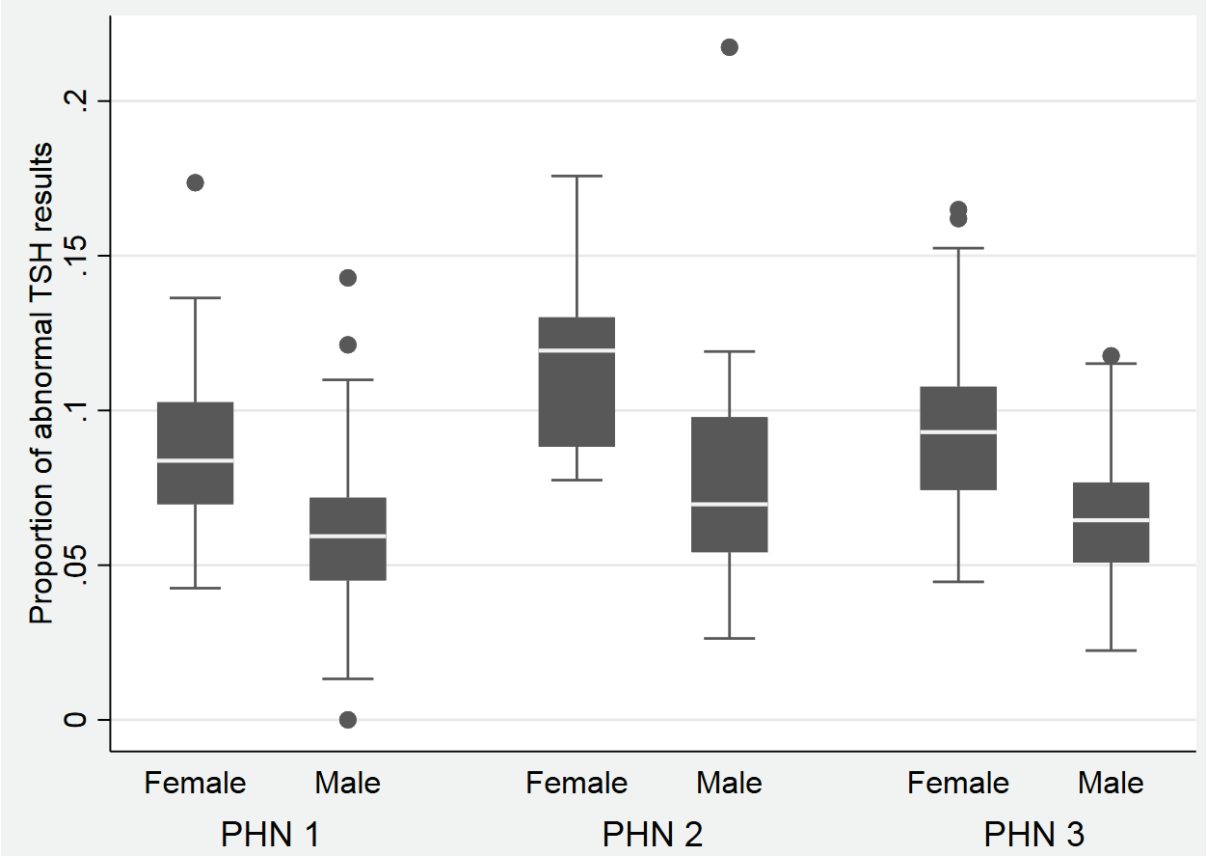


Figure 14.2. Variation in ratio of abnormal TSH test results by PHN and gender.

Among all PHNs, variation in the proportion of abnormal test results by gender was apparent, with a higher proportion of abnormal results for TSH among females (Figure 14.2). Between PHNs, variation among practices in the proportion of abnormal test results was low, suggesting consistency in practices in test ordering for TSH (Figure 14.3). In PHN1, for females, 10 practices (8.4%) fell 2 SDs below the mean and a further 3 fell (2.5%) 3 SD below. For males, 6 (5.0%) fell 2 SD below the mean, and 2 (1.7%) fell 3 SDs below. In PHN2, 2 practices (8.7%) fell 2 SD below while none fell 3 SDs below the mean for both females and males. In PHN3 for females, 9 practices (9.6%) fell 2 SDs below the mean, while a further 4 (4.2%) fell 3 SDs below the mean. For males, 6 (6.4%) and 2 (2.1%) fell 2 and 3 SDs below the mean, respectively.

14.4 LIMITATIONS

Although differences were observed among PHNs, these could be associated with different demographic profiles such as ethnicity which were not accounted for in this study. This may prompt more tests among one group compared to another, resulting in the variation observed.

14.5 IMPLICATIONS

Test ordering for patterns of TFTs among Australian general practitioners align closely with recommended guidelines. Nonetheless, there is still some room for improvement in reducing initial test orders other than TSH. Variation among practices within PHNs were low, suggesting consistency in how TFTs are used in initial ordering of the test. Current rates of abnormal TSH test results sit mostly below 20%, with a large proportion being around 7% to 10%. Further studies investigating reasons for current TFT ordering are required to determine current practice.

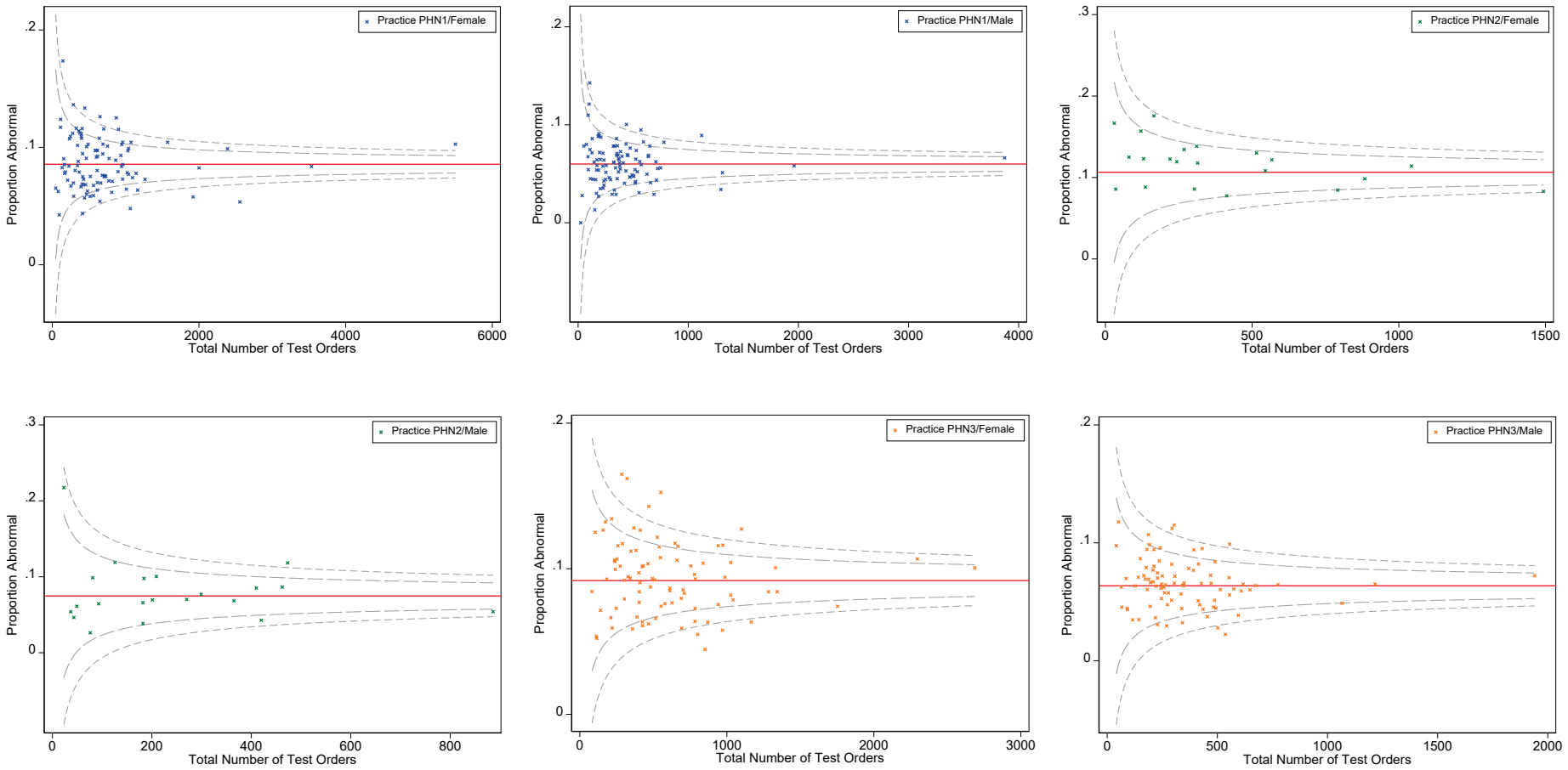


Figure 14.3. Variation in TSH test results returning abnormal result, by PHN and gender.

Each point represents a practice. Mean is represented by the horizontal line crossing the vertical axis. Standard deviations, 2 and 3 respectively, are represented by the inner and outer dashed lines. Practices falling below 2 and 3 standard deviations indicate high variation from the average among their respective PHN for the gender category.

15. VITAMIN B12 TESTING

15.1 INTRODUCTION

Following a recent Medicare Benefits Schedule (MBS) Review Taskforce (16), recommendations about changes to vitamin B12 testing in general practice have been proposed to align current practice with current clinical evidence, and ultimately improve health outcomes for patients. These recommendations include a 12-month re-testing interval restriction on vitamin B12 marker, to match with the current 12-month re-testing interval restriction on serum vitamin B12, and the establishment of national harmonised decision limits for serum vitamin B12. Guidelines related to the use of vitamin B12 tests vary widely (40), and there is no commonly accepted consensus of what defines vitamin B12 deficiency and when a patient should be tested (41). However, it is proposed that tiredness alone, without psychiatric or haematologic symptoms, is not an indication for vitamin B12 testing, and no guidelines support repeat vitamin B12 testing more frequently than annually.

This section aims to provide a descriptive overview of vitamin B12 testing in general practice by measuring the level of variation across PHNs and a benchmark for those recommendations.

15.2 METHODS

For this analysis, we included active patients between 1st October 2016 and 30th September 2018. Analyses were performed using SAS (version 9.4). Vitamin B12 (serum and marker) test results recorded during this period were used to determine the prevalence of vitamin B12 testing and to identify the demographics of the tested population and any variation across PHNs. The prevalence of B12 testing was calculated as the number of patients tested for B12 divided by the total number of active patients during the analysis period 1st October 2016 and 30th September 2018, and the number of tests per patient was used to evaluate the frequency of testing in each age group. Furthermore, to describe current vitamin B12 testing practices we investigated the proportion of patients tested multiple times, and the time interval between these tests.

15.3 RESULTS

There was a total of 709,050 patients across 182 practices. The prevalence of vitamin B12 testing is shown in Figure 15.1. The horizontal bars represent the distribution of patients across PHNs as well as the proportion of tested patients. The overall prevalence of vitamin B12 testing was 24% (i.e., 24% of active patients received B12 testing from 1st October 2016 and 30th September 2018), and this varied from 20% at PHN2 to 26% at PHN1. The percentage of tested females (from 24 to 30%) was higher than that of males (from 16 to 20%) across all PHNs, therefore the tests were undertaken more frequently in female patients.

The pattern of usage for vitamin B12 tests is shown in Figure 15.2. For males, the number of tests being performed increased with age, and the proportion of tests undertaken at each age group varied across PHNs. While the usage of vitamin B12 tests in each age group was similar between PHN1 and PHN3, with the proportion of tests among males aged 21–44 years varied between 25% and 28%, and that of those aged 45 and over varying from 66% and 68%, respectively. For PHN2 the distribution was 15% and 80% for males aged 21–44 and 45 years and over, respectively.

For females, the proportion of tests undertaken among those aged 21-44 years was the highest at PHN1 and PHN3 (with 38% and 37%, respectively), while at PHN2 the pattern of usage increased with age.

When comparing males and females across all PHNs, females aged 21–44 years on average, had 1.6 times more tests for vitamin B12, whereas for those aged 65 years and over males had 1.3 times more tests.

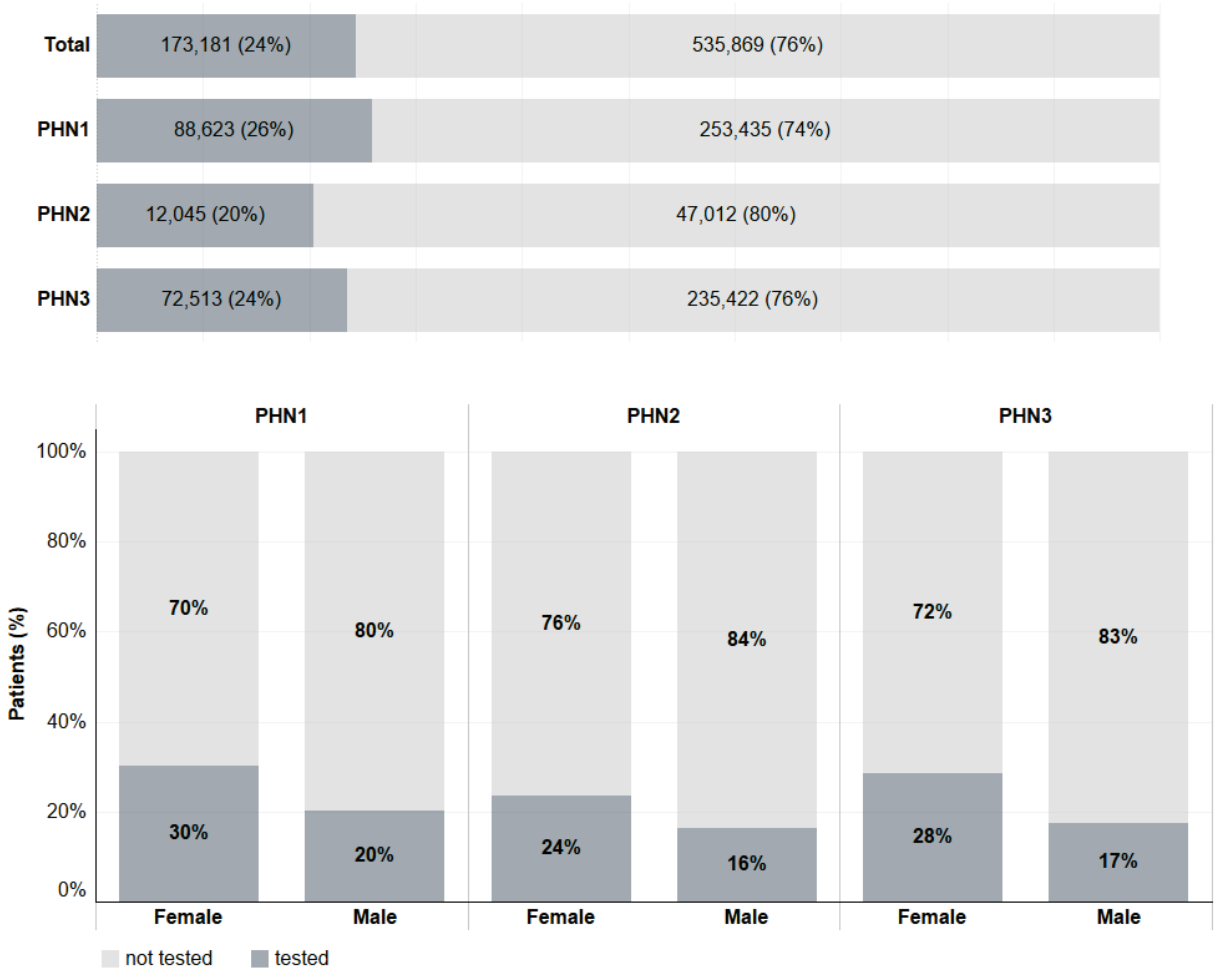


Figure 15.1. Prevalence of B12 testing.

The horizontal bars on the top show the overall prevalence, including the number of patients, while the vertical bars on the bottom describe the prevalence of vitamin B12 testing by gender.

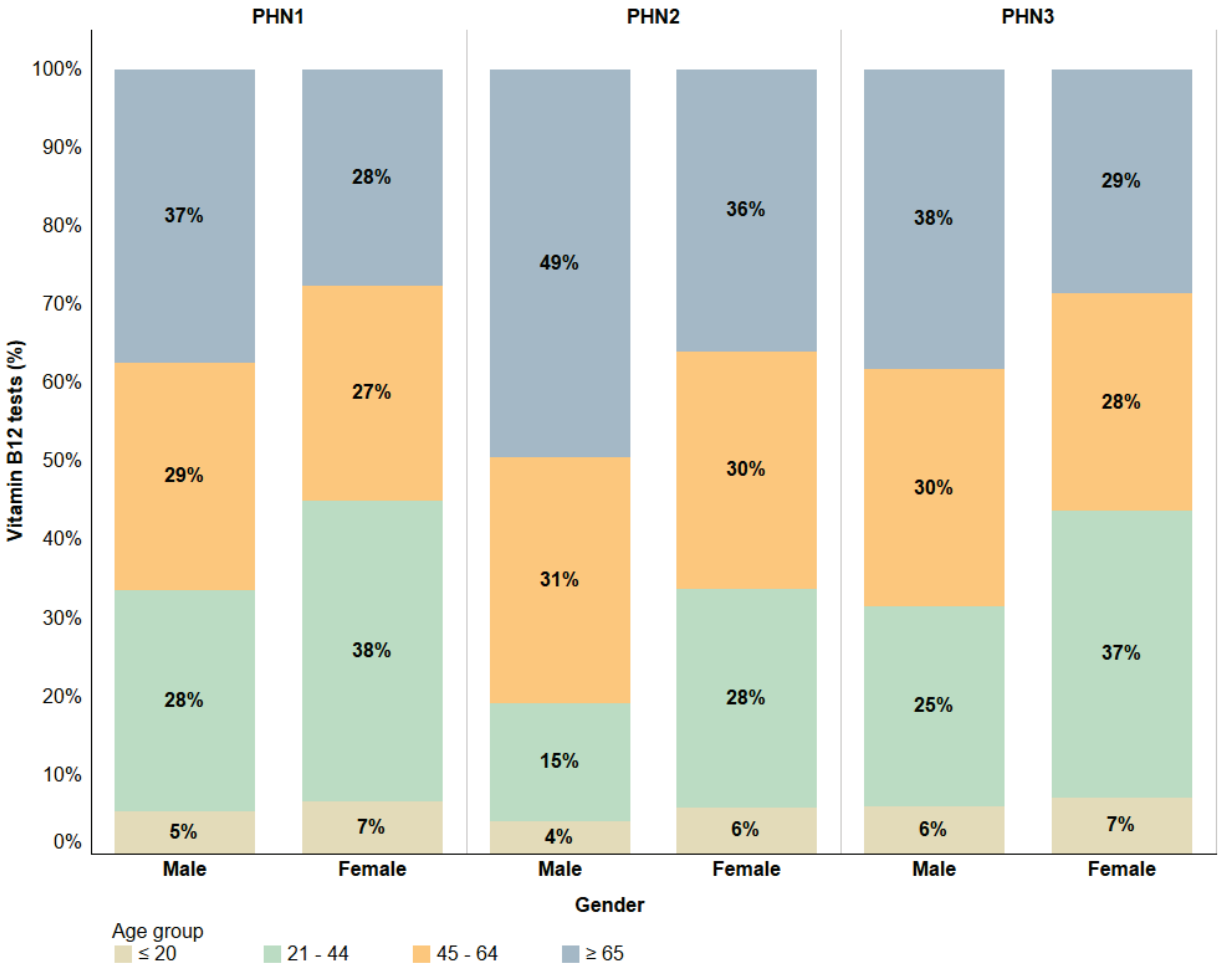


Figure 15.2. Usage of vitamin B12 tests by age and gender.

Each line represents the proportion of tests undertaken for each age group across gender.

As shown in Table 15.1, a total of 166,742 patients were tested for serum vitamin B12, while vitamin B12 marker test was undertaken in 88,312 patients during the analysis window. Overall, the proportion of patients receiving one serum or marker vitamin B12 test was 76% and 80%, respectively, and there was little variation across PHNs. Among those tested multiple times, the median interval between tests was 8 months, and this frequency of testing was similar for both serum and marker across PHNs.

Table 15.1. Frequency of vitamin B12 testing.

VITAMIN B12 TESTS	TOTAL	PHN1	PHN2	PHN3
Serum				
Patients, N	166,742	84,635	11,435	70,672
Single, N (%)	126,860 (76%)	64,122 (76%)	9,204 (80%)	53,534 (76%)
Repeat, N (%)	39,882 (24%)	20,513 (24%)	2,231 (20%)	17,138 (24%)
interval (months), median (IQR)	8 (4.7 - 12.2)	8.4 (5 - 12.3)	7.5 (4 - 11.9)	7.7 (4.6 - 12.1)
Marker				
Patients, N	88,312	43,922	6,497	37,893
Single, N (%)	70,979 (80%)	35,061 (80%)	5,340 (82%)	30,578 (81%)
Repeat, N (%)	17,333 (20%)	8,861 (20%)	1,157 (18%)	7,315 (19%)
interval (months), median (IQR)	8.2 (4.9 - 12.3)	8.6 (5.2 - 12.4)	8.5 (4.4 - 12.4)	7.8 (4.6 - 12.1)

15.4 LIMITATIONS

Test dates are based on when test results were recorded, therefore, test requests which have not been fulfilled were not included in this analysis.

Some patient activity that occurred across practices was not accounted for in this analysis as unique patient identification number is assigned in each practice. To address this potential issue, only active patients (those who visited the same practice regularly) were included.

15.5 IMPLICATIONS

Overall the proportion of patients tested for vitamin B12 was 24%, and females were tested more frequently than males (29% vs 19%, respectively). However, among older people (≥65 years), the proportion of tested males was 39% and that of females was 29%. In patients tested repeatedly, the median time interval between tests was 8 months for serum vitamin B12 and 8.2 months for vitamin B12 marker, both of which were shorter than the 12-month re-testing interval recommended by the most recent Medicare Benefits Schedule (MBS) Review Taskforce (16). Findings were similar across PHNs.

The high proportion of patients tested once during the study period suggest that the majority of vitamin B12 tests may have been undertaken for the purpose of screening, while the short interval between tests, among patients tested repeatedly, may indicate overtesting of vitamin B12, and aligns with findings from the analysis of MBS claims data presented in the MBS Review Taskforce. Further study should be undertaken to understand the reasons and context for B12 test ordering.

16. PROSTATE-SPECIFIC ANTIGEN (PSA) TESTING

16.1 INTRODUCTION

Prostate cancer (PCa) is the second most commonly diagnosed cancer and the second most common cause of cancer death in Australian men (48). It is estimated that each year, at least 20% of Australian men aged 45–74 have a prostate-specific antigen (PSA) test for PCa (42). The Medicare Benefits Schedule (MBS) Review Taskforce recommends alignment of PSA testing with guidelines from the Cancer Council of Australia and the Prostate Cancer Foundation of Australia (16). However, evidence indicates that inappropriate utilisation of PSA testing exists with regard to the frequency of testing and the target population tested (43-46).

Summary of PSA testing guidelines (42):

For men without symptoms of PCa, the general recommendation is to offer:

- PSA test every 2 years from the age of 50 to 69.
- Repeat PSA as well as the measure free-to-total PSA percentage within 1 – 3 months for those with initial PSA higher than 3 ug/L.
- Prostate biopsy for those with a repeat PSA greater than 5.5 ug/L, regardless of free-to-total PSA percentage, or those with repeat PSA greater than 3 ug/L and less than 5.5 ug/L and free-to-total PSA below 25%.

This section aims to measure the level of variation in PSA testing in patients without symptoms of PCa across PHNs, and to compare current PSA testing practices among those aged between 50 and 69 years, against the guidelines specified above.

16.2 METHODS

For this analysis, we included active male patients aged 20 years and over who had at least one PSA test result available between 1st October 2016 and 30th September 2018. Analyses were performed using SAS (version 9.4). The prevalence of PSA testing was calculated as the number of male patients tested for PSA divided by the total number of male patients in each age group, and the number of tests per patient was used to evaluate the frequency of testing in each age group. To compare current PSA testing practices against guidelines, we investigated the proportion of patients aged 50–69 years who were tested multiple times and the time interval between these tests. Patients with a recorded diagnosis, family history or symptoms of PCa, or those with prostatic diseases were excluded. Age was calculated as at 2018, so as to include patients who were over 18 years old in 2016.

16.3 RESULTS

A total of 233,486 active male patients had at least one PSA result available during the study period. The overall prevalence of PSA testing was 24% (56,859 patients). Figure 16.1 shows the prevalence of PSA testing by age groups. Among all patients aged 50–69 years, 45% had at least one PSA test, ranging from 24% to 52% across PHNs. For those aged 70 years and over, the overall PSA testing rate was 39% and this varied from 19% to 46% across PHNs. PHN2 had lower age-related PSA testing rates when compared with PHN1 and PHN3.

Among patients tested for PSA, 19,059 (34%) were tested multiple times during the 2-year analysis period. The frequency of PSA testing by age group is shown in Figure 16.2. The proportion of patients tested multiple times increased with age, and this pattern was similar across PHNs. The overall proportion of patients aged 70 years and over tested repeatedly was 44%, ranging from 31% to 47% across PHNs.

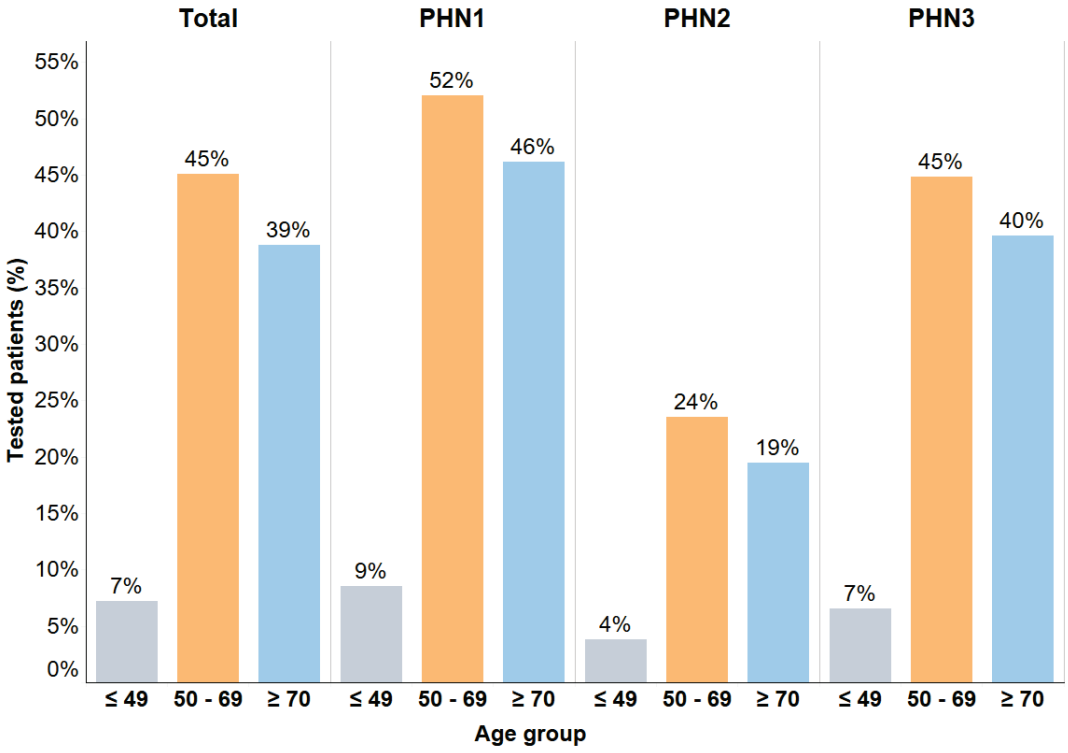


Figure 16.1. Prevalence of PSA testing by age group.

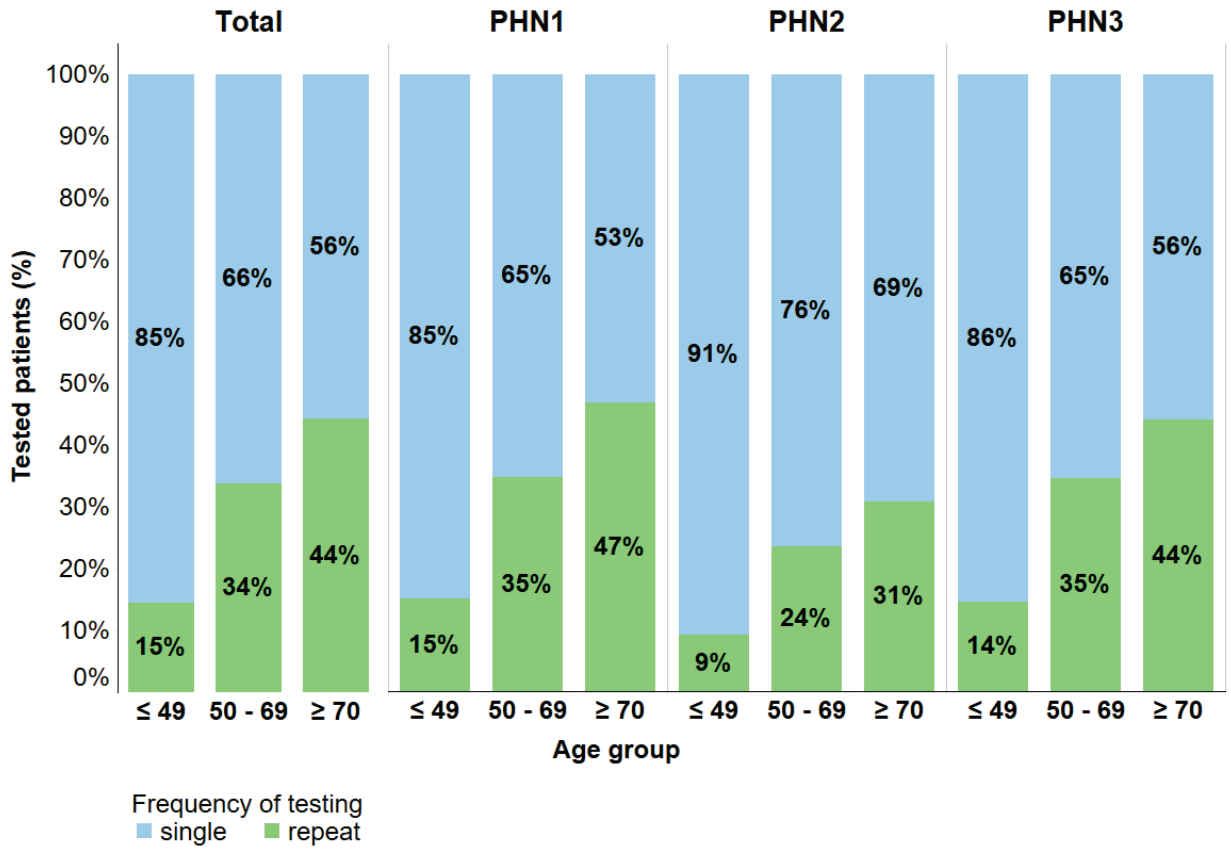


Figure 16.2. Frequency of PSA testing by age group.

A total of 14,001 PSA tests undertaken among patients aged 50–69 years were followed by subsequent testing. Overall, 11,774 (84%) tests returned normal (<=3 ug/L), and the median time interval until the subsequent PSA test was 12.4 months. Similarly, 2,227 (16%) tests had abnormal results (>3 ug/L), and the median testing interval to a repeat PSA test was 5.9 months. Across PHNs, there was little variation in the distribution of test results and the interval between follow up tests. PHN2 showed a slightly higher percentage of abnormal results (21%) and a longer interval (6.4 months) following an abnormal test.

Table 16.1. Proportion of PSA test results and median testing interval (months) among patients aged 50 – 69 years with repeated tests.

	NORMAL		ABNORMAL	
	n (%)	median (IQR)	n (%)	median (IQR)
PHN1	5,959 (84%)	12.6 (10.2-15)	1,131 (16%)	5.9 (2.8-10.3)
PHN2	534 (79%)	12.5 (7.9-15.4)	144 (21%)	6.4 (2.5-10)
PHN3	5,281 (85%)	12.4 (8.8-14.7)	952 (15%)	5.7 (2.9-11.1)
Total PSA tests	11,774 (84%)	12.4 (9.6-14.9)	2,227 (16%)	5.9 (2.8-10.6)

16.4 LIMITATIONS

- Test dates were based on when test results were recorded, therefore, test requests which were not fulfilled were not included in this analysis.
- As unique patient identification numbers were assigned in each practice, same-patient activity across practices could not be identified in this analysis. To address this potential issue, only active patients (those who visited the same practice regularly) were included.
- Since age was calculated as at 2018, a small proportion of tested patients may have transitioned between age groups (e.g., patients who were 69 years old in 2016 and turned 71 years in 2018).
- Uncollected free-text data and variation in recoding rate across GPs and practices may have led to underestimation of the number of patients excluded due to a diagnosis related to prostate disease.

16.5 IMPLICATIONS

This analysis showed that PSA test ordering practices varied across age groups and PHNs. A high proportion of patients aged 70 and over were tested, and a large number of those were tested multiple times during the study. Provided that this age group falls outside the recommended testing age, these findings may suggest overtesting. Furthermore, among those aged 50–69 years, median testing intervals following a normal PSA result was shorter than recommended across all PHNs, whereas those following abnormal PSA results exceeded the recommended timeframe.

17. BOWEL CANCER SCREENING AND COLONOSCOPY REFERRAL

17.1 INTRODUCTION

Bowel cancer is the third most commonly diagnosed cancer in Australia, with an estimated 12,250 people diagnosed every year (47, 48). The incidence of bowel cancer is higher among those aged 50 years and older, although all age groups can be affected. Immunochemical faecal occult blood test (iFOBT) is the most common bowel cancer screening tool, recommended to be performed every two years in those aged between 50 and 74 years by the latest Clinical Practice Guidelines for Prevention, Early Detection and Management of Colorectal Cancer (49). In Australia, the National Bowel Cancer Screening Program (NBCSP) aims to reduce the morbidity and mortality from bowel cancer by actively screening this target population (47).

This section aims to provide an overview of bowel cancer screening using general practice data and a comparison of findings with the most recent results from the NBCSP monitoring report (47).

17.2 METHODS

This was a retrospective observational study of active patients aged between 50 and 74 years who had an iFOBT test result recorded. Analyses were performed using SAS (version 9.4). Data were extracted from GPs across three PHNs in Victoria. It was not possible to distinguish between symptomatic and asymptomatic patients, nor if the tests were ordered by GPs or as part of the NBCSP or purchased at pharmacies by patients. A relevant diagnosis/outcome recorded following a positive iFOBT test was defined as: carcinoma of colon, colonoscopy, colonoscopy normal, colostomy, endoscopy of stomach, partial resection of colon, polyp of colon, referral for colonoscopy, screening for colon cancer, or villous adenoma of colon.

17.3 RESULTS

A total of 218,439 active patients aged 50–74 years were included in the study period. Of these patients, 2,024 (0.9%) had an iFOBT test result recorded. Figure 17.1 shows the gender distribution by age groups of tested patients. Overall, males (46%) had lower screening rates than females (54%). The proportion of tested males increased with age.

The remoteness and socioeconomic characteristics of tested patients are presented in Figure 17.2. The screening rate was highest for those living in inner regional areas (67%) followed by patients living in major cities (32%). The proportion of patients living in the lowest and highest socioeconomic areas was 26% and 29%, respectively. Screening rate was similar to that of the NBCSP monitoring report (47), with the highest rates being 45% for those living in inner regional areas, and 43% for those living in the highest socioeconomic areas.

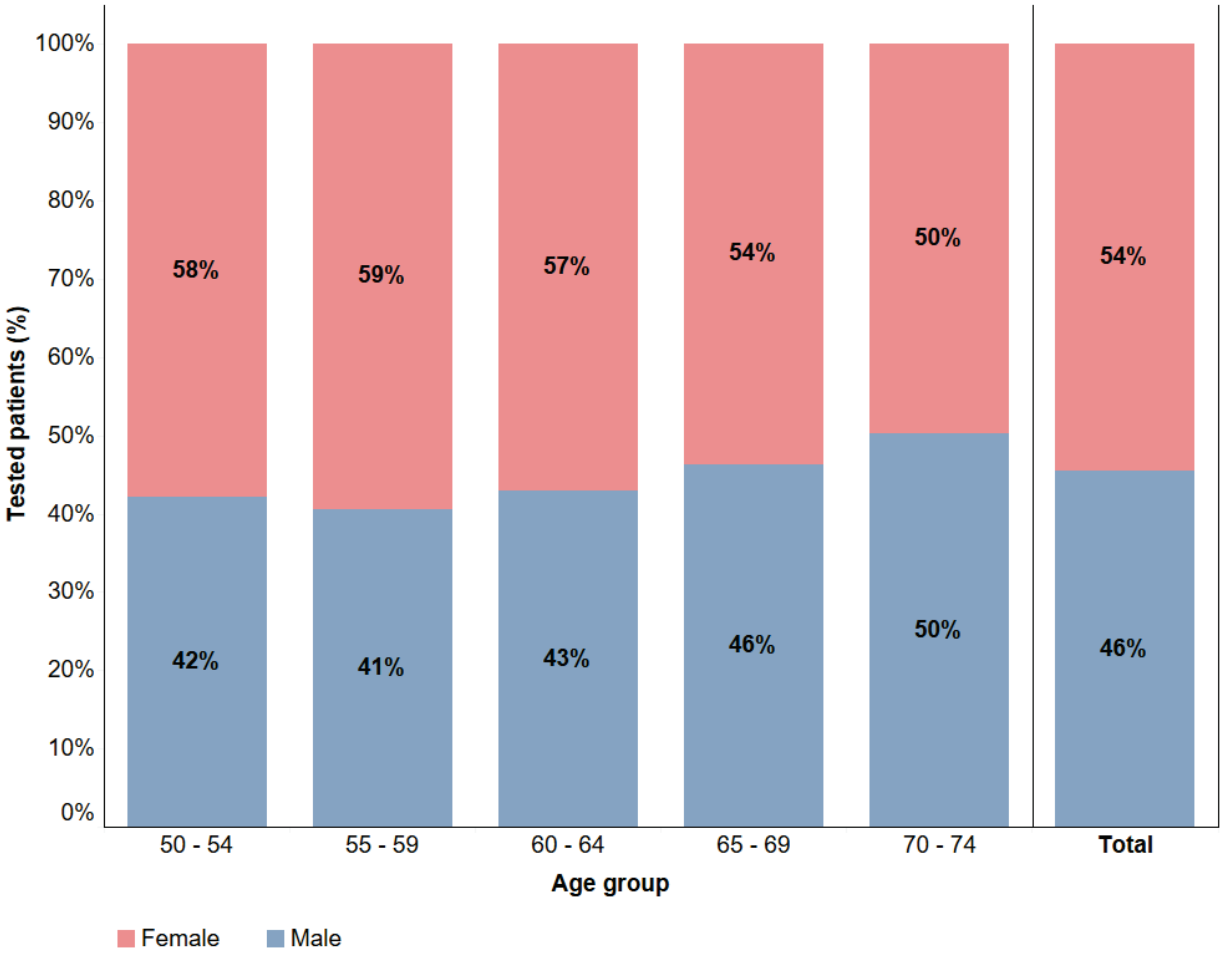


Figure 17.1. Gender distribution of patients tested for iFOBT by age groups (n = 2,024).

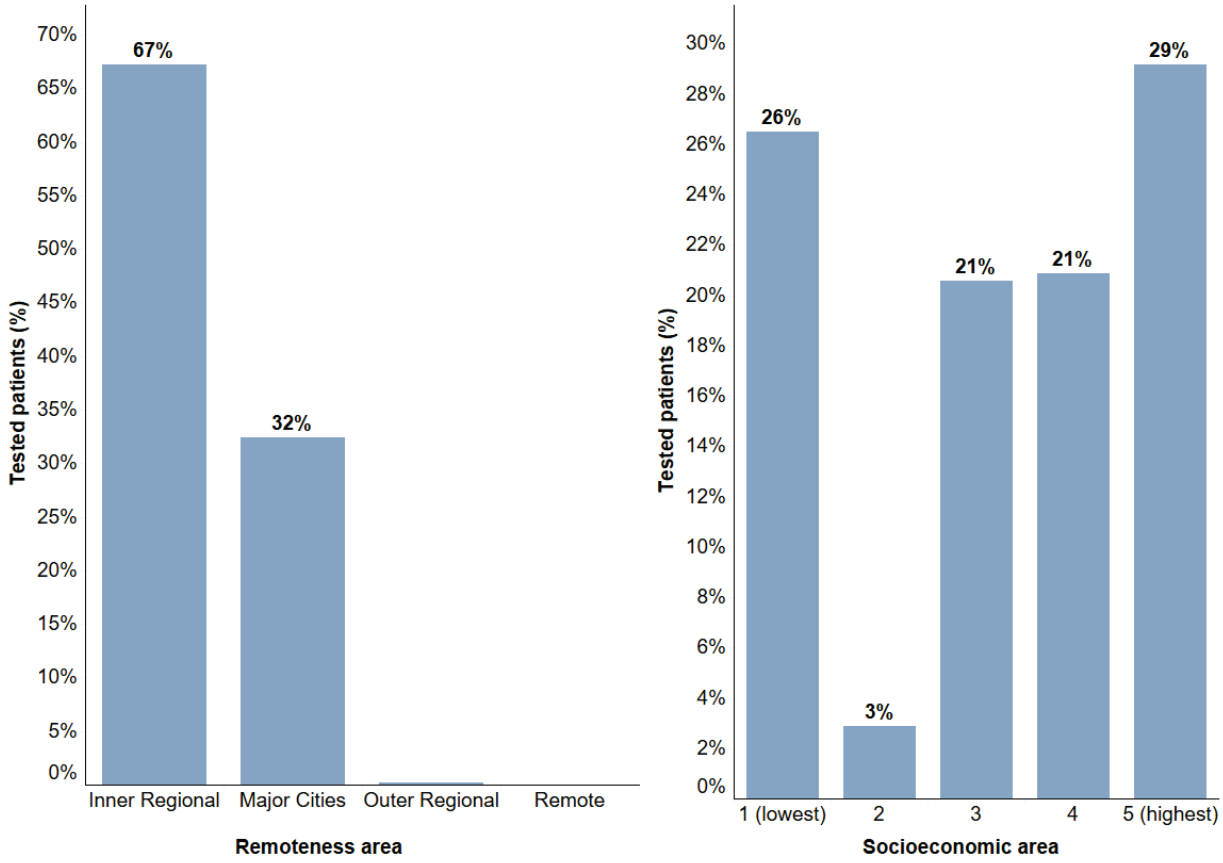


Figure 17.2. Distribution of tested patients by remoteness and socioeconomic areas.

Positivity rate

Among 2,024 tested patients, 107 (5.3%) returned positive iFOBT results, and that of the NBCSP monitoring report was 7.9% (47).

As shown in Figure 17.3, there was no difference between males and females overall. However, examination of positivity rates across age groups reveals that the proportion of females (80%) in positive results was four times that of males (20%) for those aged 55–59 years. Similarly, in patients aged 60–64 years the proportion of males testing positive (65%) was higher than that of females (35%).

The remoteness and socioeconomic characteristics of patients testing positive for iFOBT are presented in Figure 17.4. The positivity rate was the highest for those living in inner regional areas (66%) followed by patients living in major cities (32%). The proportion of patients living in the lowest and highest socioeconomic areas were 31% and 26%, respectively.

A total of 104 (97%) patients who received a positive test result had a median follow-up GP visit of 10 days after the test result was recorded, and a total of 32 (30%) of those screened positive had a relevant diagnosis recorded.

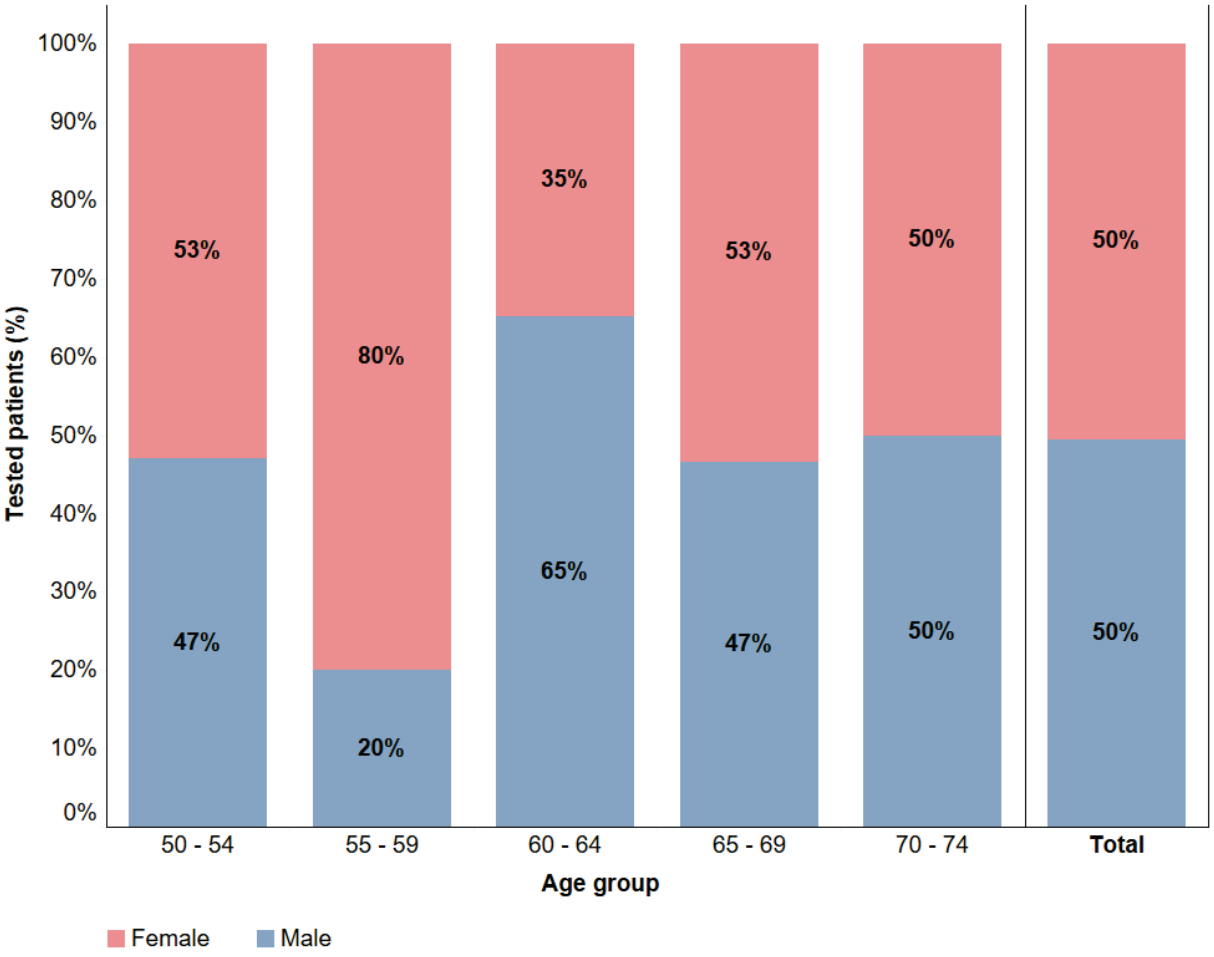


Figure 17.3. Gender distribution of patients tested positive for iFOBT by age groups (n = 107).

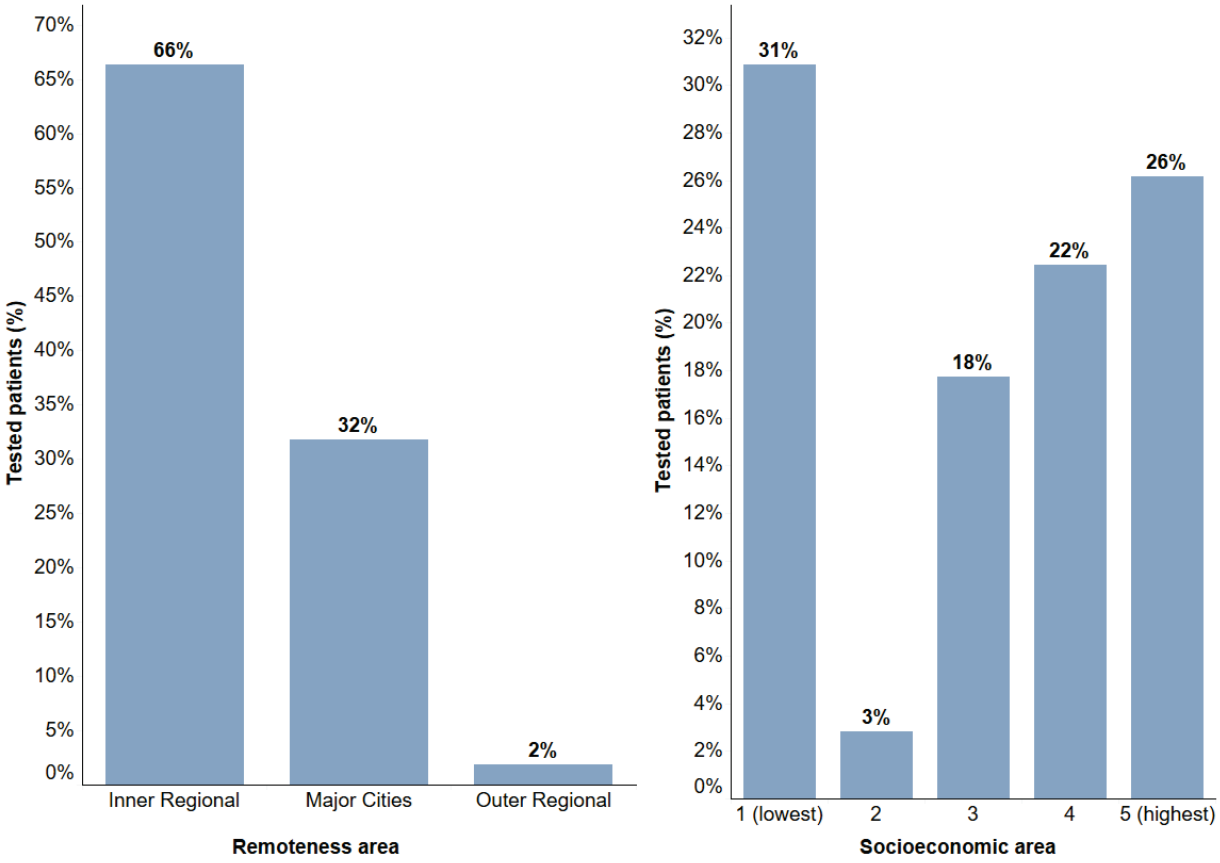


Figure 17.4. Distribution of patients tested positive for iFOBT by remoteness and socioeconomic areas.

17.4 LIMITATIONS

- Test dates are based on when test results were recorded, therefore, test requests which have not been fulfilled were not included in this analysis.
- As unique patient identification numbers are assigned in each practice, same-patient activity across practices could not be accounted for in this analysis. To address this potential issue, only active patients (those who visited the same practice regularly) were included.
- It was not possible to distinguish if the tests were ordered by GPs or as part of the NBCSP, or if tests performed under the NBSCP were recorded and captured in our data.
- Due to the low screening and positivity rates, variations across PHNs could not be reported.
- Uncollected free-text data and variation in recoding rate across GPs and practices may have led to underestimation of the number of patients with a relevant diagnosis recorded following a positive iFOBT.

17.5 IMPLICATIONS

Males had a lower bowel cancer screening rate than females overall, but testing for iFOBT among males increased with age. Also, patients living in inner regional areas and those in the highest socioeconomic suburbs were more likely to be tested. These results are similar to those of the NBCSP monitoring report (47). Overall, males and females had similar iFOBT positivity rates. However, this rate was higher among females aged 55–59, while males aged 60–64 were more likely to return positive results.

Regular screening with iFOBT has been shown to reduce bowel cancer mortality (50) and a recent study highlighted the importance of the engagement of general practitioners as a complement to the current population-based screening method in Australia (51).

18. MONITORING PATIENTS ON CLOZAPINE MEDICATION

18.1 INTRODUCTION

Clozapine is an antipsychotic drug used in patients with treatment-resistant schizophrenia. Due to safety concerns, patients prescribed clozapine must be closely monitored for the development of neutropenia or agranulocytosis, which occurs in 3.8% of patients (52, 53).

Due to its potential toxicity and life-threatening side effects, clozapine is classified as a highly specialised and restricted drug on the Pharmaceutical Benefits Scheme (PBS). A number of administrative requirements must be met in relation to the prescribing and dispensing of clozapine to patients. The two clozapine brands, Clozaril and Clopine, currently available in Australia run their own monitoring system where treatment centres, patients, prescribers and pharmacists must be registered (54). Furthermore, pharmacists cannot dispense the medication if the prescription is not accompanied with appropriate white cell count and neutrophil count results (55, 56).

Prior to 1 July 2015, prescribers of clozapine for maintenance therapy were required to be affiliated with specialist units and clozapine was available from hospital pharmacies only. From 1 July 2015, new supply arrangements were introduced for clozapine maintenance therapy, in which prescribers no longer needed to be affiliated with a hospital and clozapine became available at community pharmacies (54). Initial treatment was provided in a hospital setting under a psychiatrist for a period of at least 18 weeks, and transfer to community-based management occurred only following approval from the treating psychiatrist once a patient's clozapine dosage had stabilised.

Summary of clozapine monitoring guidelines (57, 58)

- After the initial 18 weeks of treatment, patients taking clozapine must have their white blood cell count (WBC) and neutrophil count (NC) assessed at least monthly.
- Prescribers must order and review blood test results before each prescription.
- Treatment centres, patients, prescribers and pharmacists must be registered with the appropriate patient monitoring system before clozapine can be prescribed or dispensed.
- Blood results must be within 48 hours of the script being written to be valid.

This section aims to provide an overview of the state of monitoring for patients on clozapine.

18.2 METHODS

This was a retrospective observational study of active patients who had at least one clozapine prescription (Clozaril or Clopine). Analyses were performed using SAS (version 9.4). To describe the availability of WBC and NC prior to each prescription, we performed data linkage between clozapine prescriptions and pathology requests using a ±3-day window between pathology result date and prescription date. Age was calculated as at 2018.

18.3 RESULTS

During the analysis period, there were a total of 247 patients on clozapine. Figure 18.1 shows the gender distribution by age group. Men were the most common recipients of clozapine, predominantly among patients aged 20 – 59 (over 70%) whereas in patients aged 60 and over, the proportion of female patients on clozapine was slightly higher (53% vs 48%).

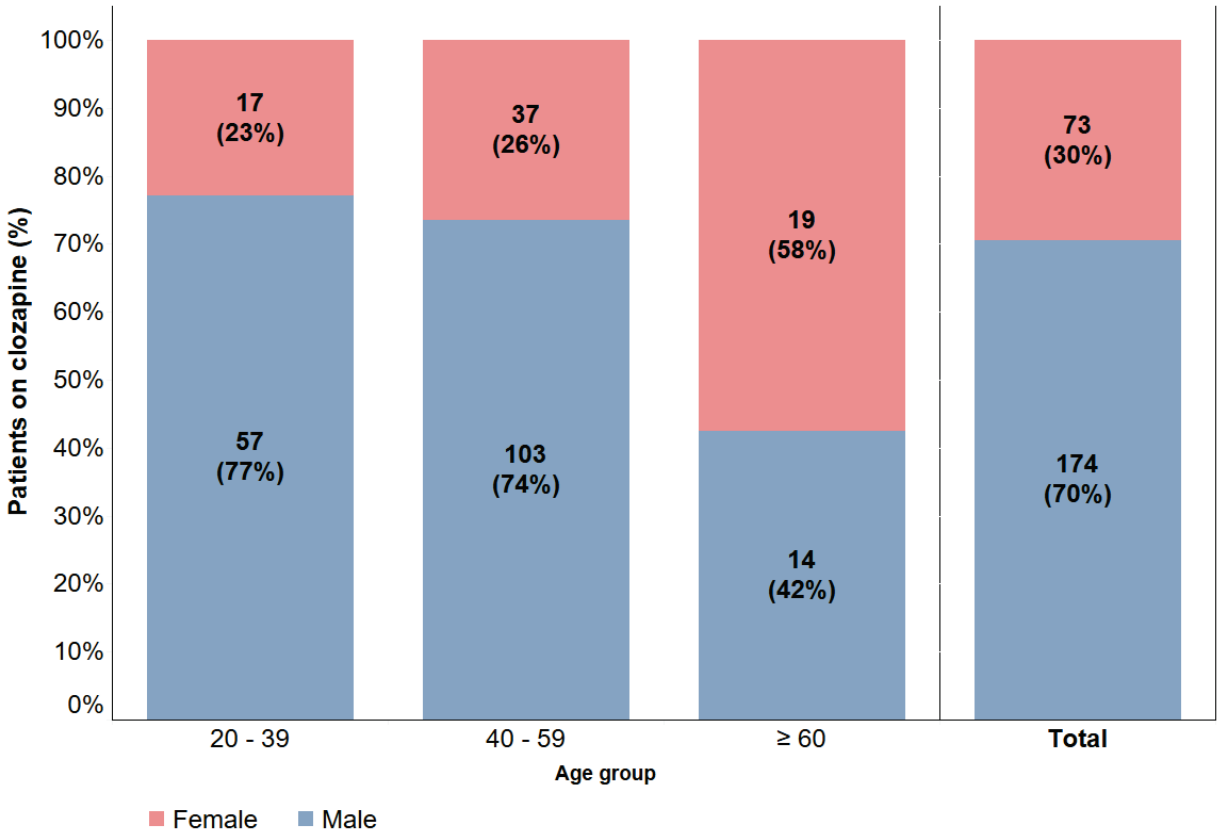


Figure 18.1. Gender distribution by age groups of active patients on clozapine.

A total of 3,404 clozapine prescriptions were issued to 247 active patients during the study period. Median interval (days) between prescriptions is presented below (Table 18.1).

Table 18.1. Interval between prescriptions.

NUMBER OF PATIENTS	NUMBER OF PRESCRIPTIONS	MEDIAN INTERVAL (DAYS) BETWEEN PRESCRIPTIONS
58 (23%)	58 (2%)	-
164 (66%)	3,280 (96%)	28
25 (10%)	66 (2%)	> 28
247	3,404	

As can be seen from Table 18.1, 164 (66%) patients had monthly clozapine prescriptions, as per guidelines, whereas 83 patients had either only one clozapine prescription (23%) or gaps during treatment (10%). This could be explained by the fact that although clozapine can now be prescribed by approved general practitioners, the monitoring remains under the supervision of a psychiatrist. Also, secondary care activity (prescriptions and pathology requests) is not captured by GP clinical information systems.

Guidelines on clozapine monitoring therapy, based on the assessment of WBC and NC test results before each prescription, are shown in Figure 18.2.

Blood count results		Recommended actions
Green range	WBC greater than 3.5 x 10^9/L and NC greater than 2.0 x 10^9/L	Continue with clozapine therapy
Amber range	WBC 3.0 to 3.5 x 10^9/L and/or NC 1.5 to 2.0 x 10^9/L	Increase monitoring to twice weekly until a green result is obtained
Red range	WBC less than 3.0 x 10^9/L and/or NC less than 1.5 x 10^9/L	STOP IMMEDIATELY. Repeat test in 24 hours. Seek haematologist advice if wish to continue clozapine therapy.

Figure 18.2. Clozapine blood count monitoring protocol.

(WBC and NC are stratified into ranges which indicate the level of risk to the patient). Source: Safe and quality use of clozapine therapy in mental health services **(57, 58)** *– Developed by the Queensland Psychotropic Medication Advisory Committee*

Table 18.2 shows the distribution of WBC and NC. It can be seen that 689 (21%) prescriptions had no linked pathology results, whereas 2,692 (79%) prescriptions fell within recommended guidelines.

Table 18.2. Assessment of clozapine monitoring protocol.

WBC	NC	PRESCRIPTIONS	%
Green (> 3.5)	Green (> 2.0)	2,692	79%
NA	NA	698	21%
Green (> 3.5)	Amber (1.5 - 2.0)	10	0.3%
Amber (3.0 - 3.5)	Green (> 2.0)	2	0.1%
Amber (3.0 - 3.5)	Amber (1.5 - 2.0)	1	0.03%
Green (> 3.5)	Red (< 1.5)	1	0.03%
		3,404	

**NA = not available*

18.4 LIMITATIONS

- Most patients starting or continuing clozapine receive their first or subsequent prescriptions from a psychiatrist, therefore many GPs may not have this recorded as a medication but may still do the test and receive the results.
- Test dates were based on when test results were recorded, therefore, test requests which have not been fulfilled were not included in this analysis.
- As unique patient identification numbers were assigned in each practice, same-patient activity across practices was not accounted for in this analysis. To address this potential issue, only active patients (those who visited the same practice regularly) were included.
- Data on medications were based on when the prescription was issued and not when they were dispensed.

18.5 IMPLICATIONS

The analysis presented in this report suggest that general practice data alone is insufficient in providing a complete overview of care delivered to patients on clozapine. This is because data on secondary care activities are not captured, hence the prescription and pathology request gaps shown above.

19. FOLATE TESTING

19.1 INTRODUCTION

Based on analysis of MBS claims data, the Medicare Benefits Schedule (MBS) Review Taskforce (16) has made recommendations on the appropriate folate testing in alignment with current clinical evidence to improve health outcomes for patients. These include a 12-month frequency restriction on serum folate test and the establishment of national harmonised decision limits for serum folate. Current guidelines related to the use of folate tests vary widely (40) and there is no internationally clear consensus on the appropriate cut-off for folate deficiency (59, 60). However, it is accepted that folate testing is only warranted for patients with macrocytosis or malabsorption issues, and no guidelines support repeat folate testing more frequently than annually.

This section aims to provide a descriptive overview of folate testing in general practice by measuring the level of variation across PHNs and for establishing a benchmark for further studies.

19.2 METHODS

For this analysis, we included active patients between 1st October 2016 and 30th September 2018. Analyses were performed using SAS (version 9.4). Serum folate test results recorded during the same period were used to determine the prevalence of folate testing, to identify the demographics of the tested population and any variation across PHNs. The prevalence of folate testing was calculated as the number of patients tested for folate divided by the total number of active patients during the analysis period 1st October 2016 and 30th September 2018, and the number of tests per patient was used to evaluate the frequency of testing in each age group. Furthermore, to describe current folate testing practices we investigated the proportion of patients tested multiple times and the interval between these tests.

19.3 RESULTS

There was a total of 709,050 patients across 182 practices. The prevalence of folate testing is presented in Figure 19.1. The horizontal bar chart shows the distribution of patients across PHNs as well as the proportion of patients tested. The overall prevalence of folate testing was 17%, which varied from 15% at PHN2 to 18% at PHN1. The vertical bar chart shows that the percentage of tested females was higher than that of males across PHNs, which indicates that tests were undertaken more frequently in female patients.

The pattern of usage for folate tests is shown in Figure 19.2. For males, the number of tests being performed increased with age, and the proportion of tests undertaken at each age group varied across PHNs. The usage of folate tests in each age group was similar for PHN1 and PHN3, with the proportion of tests among males aged 21–44 years varying between 28% and 25%, and that of those aged 45 and over varying from 65% and 69%, respectively. Within PHN2, the distribution was 16% and 79% for males aged 21–44 and 45 years and over, respectively.

For females, the proportion of tests undertaken among those aged 21–44 years was highest at PHN1 (38%) and PHN3 (36%), while at PHN2 the pattern of usage followed that of males and increased with age.

A comparison of males and females showed that, consistently across all PHNs, females are on average 1.5 times more likely to be tested for folate among patients aged 21–44 years, whereas males were 1.3 times more likely to be tested for those aged 65 years and over.

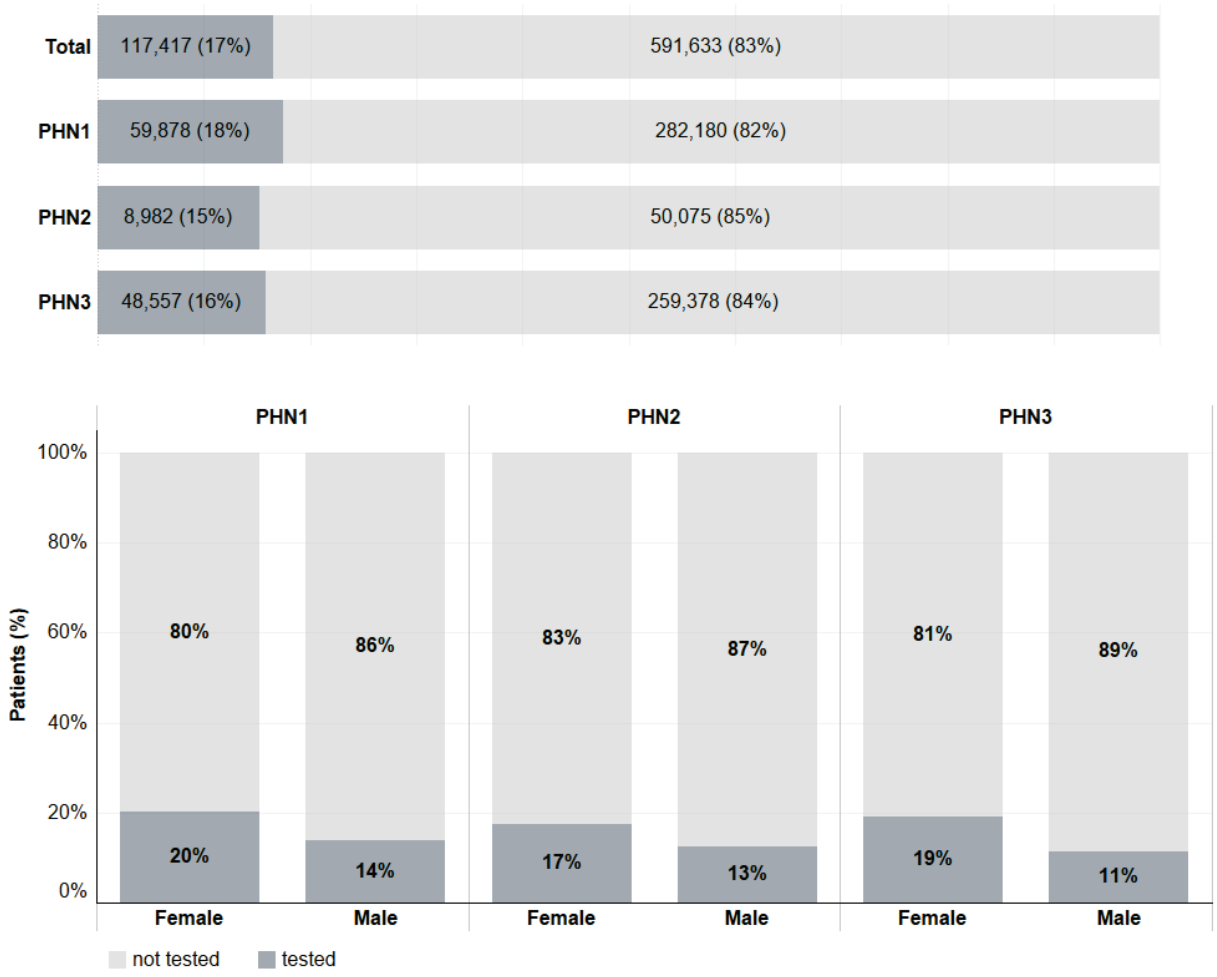


Figure 19.1. Prevalence of folate.

The horizontal bars on the top show the overall prevalence, including the number of patients, while the vertical bars on the bottom describe the prevalence of folate testing by gender.

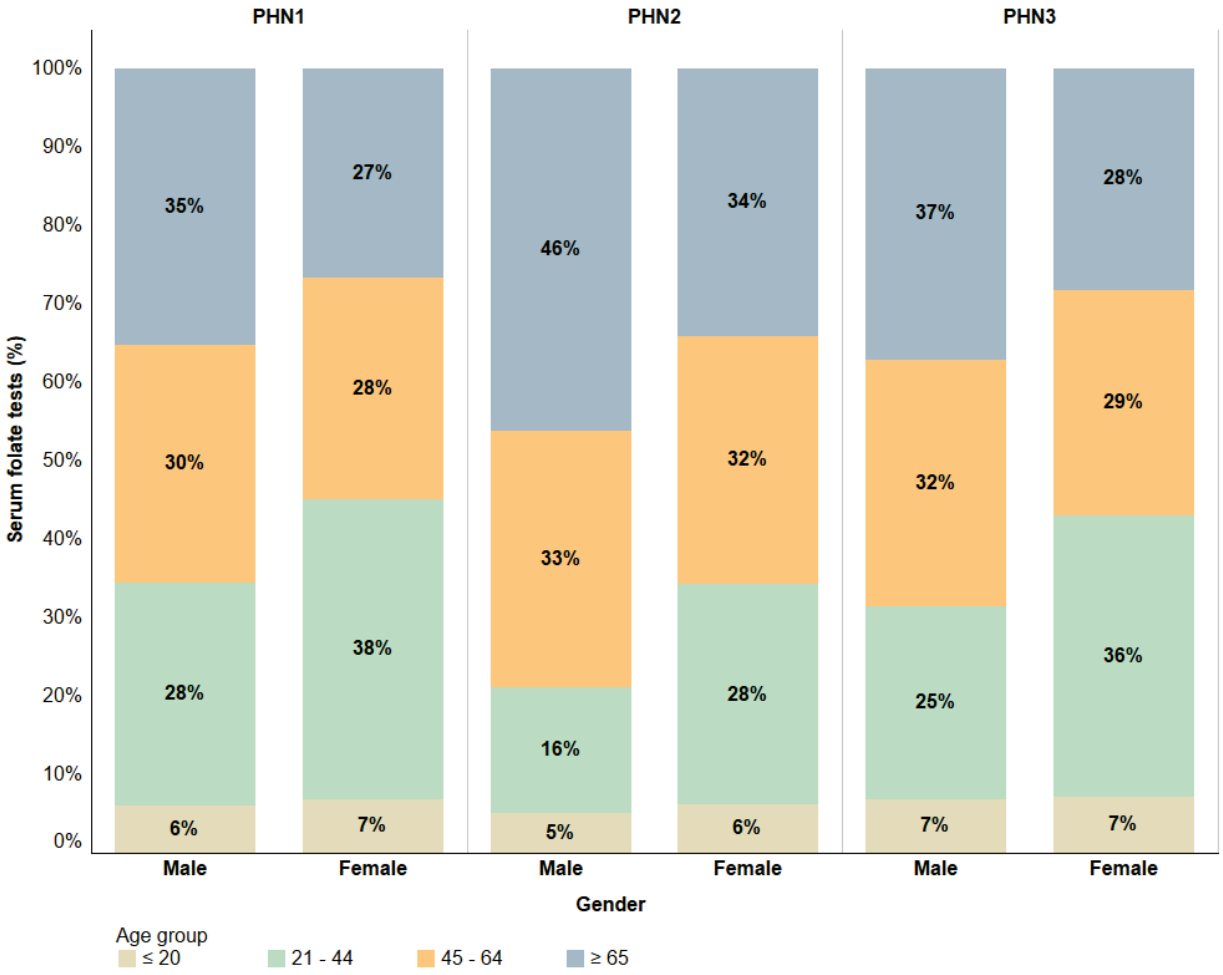


Figure 19.2. Usage of folate tests by age and gender.

Each bar represents the proportion of tests undertaken for each age group by gender.

A total of 117,417 serum folate tests were performed during the analysis period (Table 19.1). Overall, the proportion of patients receiving one folate test was 79%, ranging from 79% at PHN1 to 84% at PHN2. Among those tested multiple times, the median interval between tests was 8 months, which was similar across PHNs.

Table 19.1. Frequency of folate testing.

FOLATE	TOTAL	PHN1	PHN2	PHN3
Patients, N	117,417	59,878	8,982	48,557
Single, N (%)	93,240 (79%)	47,059 (79%)	7,519 (84%)	38,662 (80%)
Repeat, N (%)	24,177 (21%)	12,819 (21%)	1,463 (16%)	9,895 (20%)
interval (months), median (IQR)	8.1 (4.9 – 12.2)	8.4 (5.1 – 12.3)	8.3 (4.3 – 12.4)	7.7 (4.6 – 11.9)

19.4 LIMITATIONS

- Test dates were based on when test results were recorded. Therefore, test requests which have not been fulfilled were not included in this analysis.
- As unique patient identification numbers were assigned in each practice, same-patient activity across practices could not be accounted for in this analysis. To address this potential issue, only active patients (those who visited the same practice regularly) were included.

19.5 IMPLICATIONS

Folate testing varied across gender, age groups and PHNs. The high proportion of patients tested once during the study period suggests that the majority of folate testing was undertaken for screening purposes. In addition, the short interval between tests among patients tested repeatedly may indicate potential overtesting of folate, which corresponds with findings from the MBS Review Taskforce.

20. MONITORING FOR AMINOGLYCOSIDE ANTIBIOTICS (GENTAMICIN, AMIKACIN AND TOBRAMYCIN)

While aminoglycosides are highly effective parenteral antibiotics to treat serious bacterial infections, the use of this medication can lead to nephrotoxicity and subsequent kidney injuries as one of its side effects. As a minimum standard, current clinical guidelines (61, 62) recommend monitoring kidney function tests (i.e., serum creatine) in all patients before and during administration of the antibiotics.

To evaluate whether kidney function had been tested at the time of prescription, active patients prescribed aminoglycoside antibiotics (gentamicin, amikacin and tobramycin) in 2008-09 to 2017-18 were identified. The number of patients with prescriptions for these antibiotics were, however, insufficient for further analyses of patients who had kidney function tests (Table 20.1).

The prescription use of aminoglycosides was considerably limited in general practice, probably due to the fact that the medication is generally used for serious infections, which is likely to require specific care from specialists or in hospitals.

Table 20.1. Patients with aminoglycoside antibiotics prescription and kidney function test.

YEAR	N	KIDNEY FUNCTION	(%)
2008-09	88	4	(4.5)
2009-10	98	4	(4.1)
2010-11	93	17	(18.3)
2011-12	99	13	(13.1)
2012-13	72	16	(22.2)
2013-14	82	14	(17.1)
2014-15	66	4	(6.1)
2015-16	74	6	(8.1)
2016-17	54	6	(11.1)
2017-18	52	6	(11.5)

21. DISCUSSION AND IMPLICATIONS

Pathology laboratory tests play an essential role in managing chronic conditions in primary care. However, until recently, data limitations prevented in-depth and longitudinal studies on pathology testing in the general practice setting. An understanding of the current landscape of pathology testing in general practice in Australia is essential to inform quality improvements so that they are evidence-based. The ability to track data over time is important in evaluation of the effects of any future (or even past) improvements implemented on ordering behaviour and patient outcomes.

Throughout the project, we have closely liaised with our stakeholders, PHNs to identify and design the specific key areas (diseases, medications, and conditions along with their associated tests and screening programs) to evaluate in the data with the aim of guiding quality improvement activities led by PHNs. Active involvement of the PHNs was key in all stages of the project and helped ensure that the areas studied were relevant and of value to stakeholders. A model for engagement was developed in partnership with the stakeholders and each was able to nominate a desired level of engagement, with the future goal of reaching the top level of co-developing quality improvement activities (Figure 8.1).

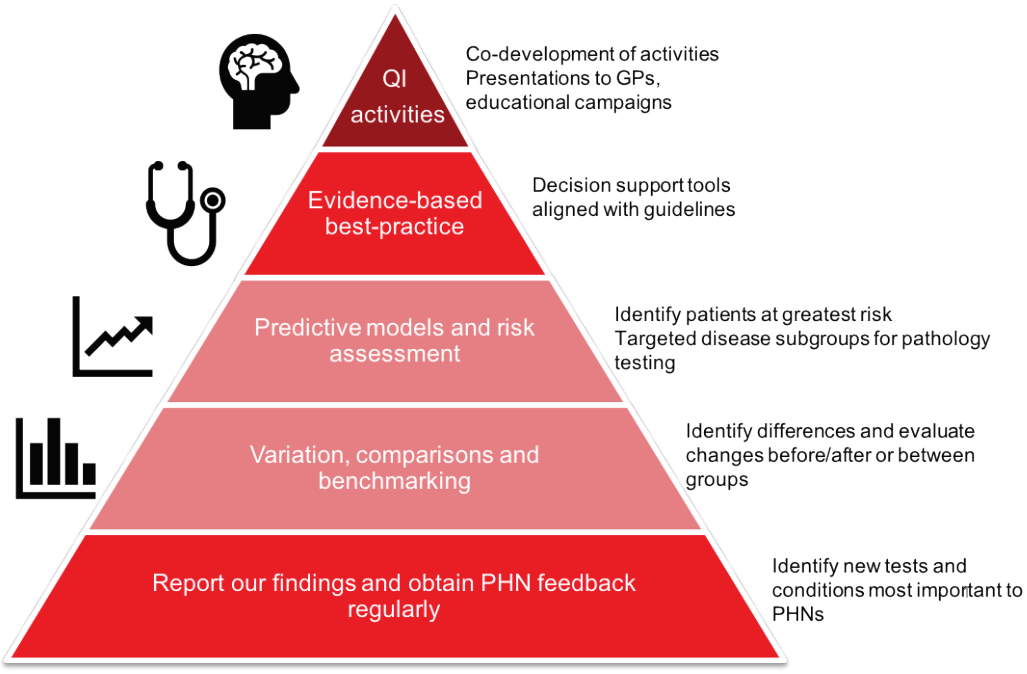


Figure 21.1. A model for engagement of PHNs.

In this project, we have demonstrated both the usefulness of the data, as well as present benchmark data on how specific pathology tests are used in general practice and investigate how test ordering practices align with current evidence-based pathology guidelines.

The results from this project will improve our appreciation and understanding of the variation in pathology testing in general practice. The use of these results by PHNs in the design of evidence-based quality improvement activities has the potential to make a significant impact on both GP ordering activities and patient outcomes.

21.1 FUTURE STUDY

The reported variation results from this project hold important implications for future studies, one of the most important being to understand the drivers of test ordering behaviours, which are known to be complex. One must also consider the patient/provider relationship (63-65) in order to develop effective and evidence-informed quality enhancements in pathology use. For example, the Medicare Benefits Schedule (MBS) Review Taskforce recently released a report from the diagnostic medicine clinical committee recommending quality improvements including clinical decision support (CDS) for many common pathology tests (16). This highlights a need for quality improvement that may be facilitated by tools such as decision support for GP diagnostic ordering. The logical next step in bridging the gap in developing such tools is to understand the context under which GPs order tests and their needs to ensure integration with their workflows. This will involve sharing the study results with GPs and other general practice staff and seeking their advice and guidance on designing decision support tools in general practices.

21.2 LIMITATIONS

While the data used in this project were a rich and valuable source of robust information about pathology testing activity in Australia, several limitations existed. In many cases these limitations were able to be minimised due to the careful quality control measures taken in the early stages of the project. The following issues were encountered:

- A limitation of using currently available electronic health records is that recording of clinical data are not well-standardised, and thus variations and inconsistencies are often encountered (66, 67). One of the downsides of the data, pooled from different general practice systems on a large scale, is the complexity caused by unstandardised data coding and the different information systems and software used within and across practices (68). The lack of comparability between software packages and coding regimes has led to difficulty in linkage and analyses on the aggregated data. The diagnosis and prescription data extracted from EHRs by POLAR have been enhanced by systematic coding using SNOMED CT-AU and ATC. However, pathology data, for which the standards for measurement and classification of tests are not well defined remain highly intricate, and lack structured coding (69). Pathology data based on general practice data requires efforts in coding standardisation for further improvement in data integrity (70).
- Free-text data, lack of recorded comorbidities and diagnoses, and missing data raise the possibility of under-reporting of exposures and outcomes, and therefore unintended exclusion from the analyses. However, due to the large sample size obtained for each of the analyses, owing to the source population, a large amount of high-quality data was still available for analyses, even after data cleaning to either standardise or remove many inconsistencies (e.g., LOINC codes and test names).
- There were limitations to data for certain conditions or medications that, in addition to GP management, may also be monitored by specialists (e.g., diabetes) or within national registries (e.g., cancer screening programs) or even pharmaceutical registries (e.g., clozapine) therefore these data would not be captured within the patient's record held in general practice.

- As unique patient identification numbers were assigned in each clinic, there is a potential to double count patients in this report if they attended multiple practices that were captured in POLAR. This is less likely to impact on cases where the interest of study is a total frequency of medical services (e.g., vitamin D testing) at a given period of time, but might affect results if the interest of study is related to a longitudinal evaluation or outcomes are measured by rate per patient. For analyses where double counting needed to be minimised, we mitigated this by using active patients as the study population. By including only active patients, patients who attended a certain practice regularly could be targeted, particularly for health conditions that require on-going medical assistance or monitoring such as diabetes and hypertension. However, this process still does not capture data on their visits to other practices, an issue which may be resolved in future studies with a universal patient ID across all practices.
- Reasons for GP visits identified from the diagnosis dataset may be underestimated due to incomplete data. The information relevant to patients' health conditions and issues could be also recorded by free text in visit and prescription in the patient's electronic record as "reason for visit" or "reason for prescription"; however, free text data were not extracted for this report.

Despite these limitations of general practice pathology data, there are advantages of these data over other research data sources, which often rely on patients and health professionals to provide information (71). As general practice information systems collect activity and patient data directly from general practices at the time of service, the electronic data provides historical data with no recall biases. In addition, the enormous number of patients that can be combined in a pooled database facilitates a sufficient sample size for cohort studies, even for rare diseases or conditions. The data extracted from EHRs is a critically important resource to evaluate activities in general practice effectively and efficiently.

21.3 CONCLUSION

The outcome of this project is a comprehensive description of the use of pathology testing and variation in Australian general practice for the care and monitoring of patients. Additionally, our strong relationship with stakeholders has allowed us to provide PHNs with an evidence base for their quality improvement activities. This bidirectional flow of information has facilitated the direct translation of research to general practice.

This project contributes to the QUPP objectives by providing robust benchmark data to inform PHNs and clinicians about their pathology referral practices. Our regular dissemination and feedback of these results to stakeholders including GPs constitute the first steps in the quality improvement pathway. Future work in conjunction with PHNs will expand on this benchmark data by collaboratively designing quality improvements based on the findings of this study: addressing both the need to improve the quality of pathology test management and its impact on patient care outcomes.

The results of this study can potentially benefit a range of different stakeholders in the healthcare system:

Patients/consumers:

Patients/consumers will benefit from Primary Health Network (PHN)-led quality improvements based on this data, leading to improvements in the care process. This will result in improved quality use of pathology in general practice. Evidence to inform these improvements can be formed from our benchmark data on pathology referral practices. This will lead to a reduction in unnecessary tests, encourage more targeted testing for those for whom it is most necessary (e.g., those at risk for certain conditions or complications), and thus allow for better use of pathology services to improve patients' treatment pathway. These improvements should in turn improve the effectiveness, safety and quality of care for patients/consumers.

General Practice:

Pathology services contribute to all branches of medicine. They assist the clinical decision-making process and make a major contribution to the well-being of patients. This project will inform PHNs, which will in turn provide general practitioners (GPs) with variation data and benchmark data regarding the quality of pathology referrals in Australia. Such information will enable GPs to reflect on their own pathology referral practices and, where significant deviations from best practice care are identified, adjust their practices to improve the quality of care that they deliver to their patients.

Pathology laboratories:

Pathology laboratories provide a critical component of patient care. This project will contribute important findings that can enhance the test management process in general practice, so as to enhance the use of best practice and evidence-based guidelines.

Primary Health Networks:

The analysis of the quality of pathology referrals at different sites allows PHNs to perform a comparison of the effectiveness of pathology services across their respective networks. The benchmark data of pathology service utilisation at different sites can also be used by the PHNs to inform decisions for quality improvement by highlighting areas that may need additional support.

Government Departments of Health:

Departments of Health can use the benchmark results from the project to influence macro-level decision making and monitor the quality of pathology in general practice across different jurisdictions. This will contribute to major improvements in the quality of pathology and impact positively on patient outcomes.

22. REFERENCES

1. Australian Bureau of Statistics. National Health Survey: First Results Australia 2017-18. Australia; 2018.
2. Britt H MG, Bayram C, Henderson J, Valenti L, Harrison C, Pan Y, Charles J, Pollack AJ, Chambers T, Gordon J, Wong C. A decade of Australian general practice activity 2006–07 to 2015–16. Sydney: Sydney University Press; 2016.
3. Bayram C BH, Miller G, Valenti L Evidence-practice gap in GP pathology test ordering: a comparison of BEACH pathology data and recommended testing. Syndey, NSW; 2009.
4. Commonwealth of Australia the Department of Health. Annual Medicare Statistics: Financial year 1984-85 to 2017-18. Canberra, ACT: Commonwealth of Australia the Department of Health,; 2018 [Available from: http://www.health.gov.au/internet/main/publishing.nsf/Content/Annual-Medicare-Statistics.
5. Australian Government Department of Health. Pathology- The Facts. Why do I need a pathology test? 2013 [Available from: http://www.health.gov.au/internet/publications/publishing.nsf/Content/qupp-benefits-and-risks-for-consumers-of-pathology-testing~qupp-why-do-i-need-a-pathology-test.
6. Ontario Ministry of Health and Long-Term Care. Preventing and Managing Chronic Disease: Ontario's Framework. 2007.
7. Yarnall KS, Pollak KI, Ostbye T, Krause KM, Michener JL. Primary care: is there enough time for prevention? Am J Public Health. 2003;93(4):635-41.
8. Grunfeld E, Manca D, Moineddin R, Thorpe KE, Hoch JS, Campbell-Scherer D, et al. Improving chronic disease prevention and screening in primary care: results of the BETTER pragmatic cluster randomized controlled trial. BMC Fam Pract. 2013;14:175.
9. Australian Institute of Health and Welfare (AIHW). Primary health care data development: AIHW; 2018 [Available from: https://www.aihw.gov.au/reports-data/health-welfare-services/primary-health-care/primary-health-care-data-development.
10. Britt H MG, Henderson J, Bayram C, Harrison C, Valenti L, Pan Y, Charles J, Pollack AJ, Wong, C, Gordon J. . General practice activity in Australia 2015–16. Sydney, NSW; 2015.
11. Pope CJ, Braithwaite J, Hyde P. Introduction: Why focus on culture and climate? In: Braithwaite J, Hyde P, Pope C, editors. Culture and Climate in Health Care Organizations. Basingstoke, London, England: Palgrave Macmillan; 2010. p. 1-3.
12. Gentil ML, Cuggia M, Fiquet L, Hagenbourger C, Le Berre T, Banatre A, et al. Factors influencing the development of primary care data collection projects from electronic health records: a systematic review of the literature. Bmc Medical Informatics and Decision Making. 2017;17.
13. Bhatia RS, Levinson W, Shortt S, Pendrith C, Fric-Shamji E, Kallewaard M, et al. Measuring the effect of Choosing Wisely: an integrated framework to assess campaign impact on low-value care. BMJ Quality & Safety. 2015;24(8):523.
14. Braithwaite J. Preface. In: Iedema RA, editor. The Discourses of Hospital Communication: Tracing Complexities in Contemporary Health Care Organizations. Basingstoke, England: Palgrave McMillan; 2007. p. x-xi
15. Braithwaite J. The next health reforms and the role of Area Health Service arrangements in Australia. In: Matsuyama Y, editor. Reform of medical systems and economic growth. Tokyo, Japan: Japan Medical Planning; 2010. p. 199-206.
16. Australian Government Department of Health. Medicare Benefits Schedule Review Taskforce - Report from the Diagnostic Medicine Clinical Committee. 2018.
17. Australian Bureau of Statistics. Census of Population and Housing: Socio-Economic Indexes for Areas (SEIFA), Australia, 2016 Canberra, ACT2018 [Available from: https://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/2033.0.55.001~2016~Main%20Features~IRSAD~20.
18. Australian Bureau of Statistics. Australian Statistical Geography Standard (ASGS): Canberra, ACT; 2018 [Available from: https://www.abs.gov.au/websitedbs/D3310114.nsf/home/Australian+Statistical+Geography+Standard+(ASGS).
19. The Royal Australian College of General Practitioners. Standards for general practices (4th edition). East Melbourne, VIC: The Royal Australian College of General Practitioners; 2015.
20. 3101.0 - Australian Demographic Statistics, Dec 2018 [Internet]. Australian Bureau of Statistics,. 2019. Available from: http://www.abs.gov.au/.
21. Britt H MG, Henderson J, Bayram C, Valenti L, Harrison C, Pan Y,Wong C,Charles J,Gordon J,Pollack AJ,Chambers T. A decade of Australian general practice activity 2005–06 to 2014–15. Sydney, NSW; 2015.
22. Nathan DM, Turgeon H, Regan S. Relationship between glycated haemoglobin levels and mean glucose levels over time. Diabetologia. 2007;50(11):2239-44.

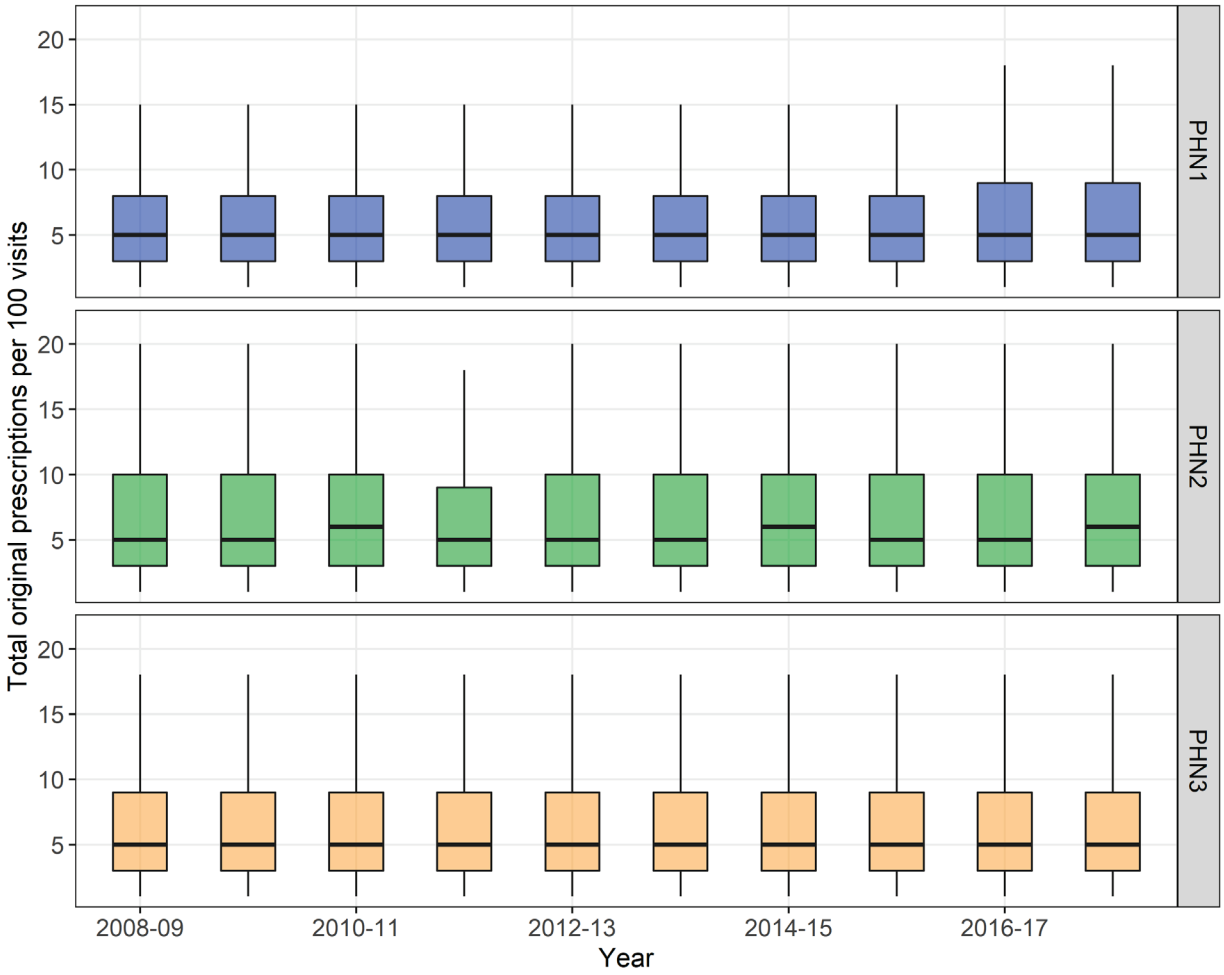
23. Chadban S HM, Twigg S, Thomas M, Jerums G, Alan C, Campbell D, Nicholls K, Tong A,, Mangos G SA, McIsaac R, Girgis S, Colagiuri R, Colagiuri S, Craig J. National Evidence Based Guideline for Diagnosis, Prevention and Management of Chronic Kidney Disease in Type 2 Diabetes. Canberra: Diabetes Australia and the NHMRC; 2009.
24. The Royal Australian College of General Practitioners (RACGP). Guidelines for preventive activities in general practice. 9th edn. East Melbourne, Vic: RACGP; 2016.
25. Pecoits-Filho R, Abensur H, Betônico CCR, Machado AD, Parente EB, Queiroz M, et al. Interactions between kidney disease and diabetes: dangerous liaisons. Diabetology & Metabolic Syndrome. 2016;8(1):50.
26. Australian Institute of Health Welfare. Diabetes snapshot. Canberra: AIHW; 2018.
27. Tideman PA, Tirimacco R, St John A, Roberts GW. How to manage warfarin therapy. Aust Prescr. 2015;38(2):44-8.
28. Gallus AS, Baker RI, Chong BH, Ockelford PA, Street AM. Consensus guidelines for warfarin therapy. Recommendations from the Australasian Society of Thrombosis and Haemostasis. The Medical journal of Australia. 2000;172(12):600-5.
29. Wigle P, Hein B, Bloomfield HE, Tubb M, Doherty M. Updated guidelines on outpatient anticoagulation. American family physician. 2013;87(8):556-66.
30. Queensland Health. Guidelines for warfarin management in the community. Brisbane, QLD: Queensland Health; 2016.
31. Australian Government Department of Health. PBS Schedule. Canberra: Australian Government Department of Health.; 2017 [Available from: http://www.pbs.gov.au/pbs/home.
32. Bjorck S, Palaszewski B, Friberg L, Bergfeldt L. Atrial fibrillation, stroke risk, and warfarin therapy revisited: a population-based study. Stroke. 2013;44(11):3103-8.
33. Morgan A, Joshy G, Schaffer A, Laba T-L, Litchfield M, Pearson S, et al. Rapid and substantial increases in anticoagulant use and expenditure in Australia following the introduction of new types of oral anticoagulants. PLOS ONE. 2018;13(12):e0208824.
34. Brieger D, Curnow J. Anticoagulation: a GP primer on the new oral anticoagulants. Australian Family Physician. 2014;43:254-9.
35. Fanaroff AC, Ohman EM. Non–Vitamin K Antagonist Oral Anticoagulants in the Treatment of Atrial Fibrillation. Annual Review of Medicine. 2019;70(1):61-75.
36. Clinical Excellence Comission. Non-vitamin K Antagonist Oral Anticoagulant (NOAC) Guidelines, Updated July 2017. Sydney: Clinical Excellence Comission; 2017.
37. SA Health. Safe prescribing of new oral anticoagulants: apixaban, rivaroxaban and dabigatran. Adelaide, SA: SA Health; 2015.
38. NPS MedicineWise. NOAC indications and PBS listings Surry Hills, NSW: NPS MedicineWise; 2017 [Available from: https://www.nps.org.au/professionals/anticoagulants/noac-indications-and-pbs-listings#supporting-information.
39. Andrade J, Khairy P, Dobrev D, Nattel S. The clinical profile and pathophysiology of atrial fibrillation: relationships among clinical features, epidemiology, and mechanisms. Circulation research. 2014;114(9):1453-68.
40. Willis CD, Metz MP, Hiller JE, Elshaug AG. Vitamin B12 and folate tests: the ongoing need to determine appropriate use and public funding. Medical Journal of Australia. 2013;198(11):586-8.
41. Australian Government Department of Health. MBS Reviews Vitamin B12 Testing Report. 2014.
42. Prostate Cancer Foundation of Australia and Cancer Council Australia PSA Testing Guidelines Expert Advisory Panel. Draft clinical practice guidelines for PSA testing and early management of test-detected prostate cancer. Sydney (2016).
43. Carmichael LK, Goldsbury DE, O'Connell DL. Prostate cancer screening for men aged 75 to 84 years in New South Wales. Australian and New Zealand Journal of Public Health. 2013;37(5):492-4.
44. Ranasinghe WKB, Kim SP, Lawrentschuk N, Sengupta S, Hounsome L, Barber J, et al. Population-based analysis of prostate-specific antigen (PSA) screening in younger men (<55 years) in Australia. BJU Int. 2014;113(1):77-83.
45. Litchfield MJ, Smith DP, Le Couteur DG, Blyth FM, Handelsman DJ, Waite LM, et al. Prostate-specific antigen levels in men aged 70 years and over: findings from the CHAMP study.(Report). The Medical Journal of Australia. 2012;196(6):395-8.
46. Smith DP, Banks E, Clements MS, Gardiner RA, Armstrong BK. Evidence-based uncertainty: recent trial results on prostate-specific antigen testing and prostate cancer mortality. Medical Journal of Australia. 2009;191(4):199-200.
47. Australian Institute of Health Welfare. National Bowel Cancer Screening Program: monitoring report 2019. Canberra: AIHW; 2019.

48. Cancer Council Australia. Understanding Bowel Cancer. Last medical review of this booklet: February 2019.
49. Cancer Council Australia Colorectal Cancer Guidelines Working Party. Clinical practice guidelines for the prevention, early detection and management of colorectal cancer. Cancer Council Australia. 2019.
50. Hewitson P, Glasziou P, Watson E, Towler B, Irwig L. Cochrane systematic review of colorectal cancer screening using the fecal occult blood test (hemoccult): an update. The American Journal Of Gastroenterology. 2008;103(6):1541-9.
51. Dodd N, Carey M, Mansfield E, Oldmeadow C, Evans T-J. Testing the effectiveness of a general practice intervention to improve uptake of colorectal cancer screening: a randomised controlled trial. Australian and New Zealand Journal of Public Health. 2019;43(5):464-9.
52. Myles N, Myles H, Xia S, Large M, Kisely S, Galletly C, et al. Meta-analysis examining the epidemiology of clozapine-associated neutropenia. Acta Psychiatrica Scandinavica. 2018;138(2):101-9.
53. Winckel K, Siskind D. Clozapine in primary care. Australian prescriber. 2017;40(6):231.
54. Australian Government Department of Health. Frequently asked questions - New options for clozapine maintenance supply [cited 2018 19 Nov]. Available from: http://www.pbs.gov.au/general/changes-to-certain-s100-programs/faqs-hsd-ca-clozapine-25-june-2015.pdf.
55. Ally B, Ally M. Frontline care: Clozapine in the community. AJP: The Australian Journal of Pharmacy. 2015;96(1145):66-71.
56. Knowles S-A, McMillan S, Murphy K, Wheeler A. Providing clozapine in community pharmacy. Australian Pharmacist. 2016;35(1):56-60.
57. Government of South Australia. Clozapine Management Clinical Guideline. Government of South Australia. 2017.
58. State of Queensland. Safe and quality use of clozapine therapy in mental health services.2016 [cited 2018 13 Dec]. Available from: https://www.health.qld.gov.au/__data/assets/pdf_file/0025/625354/qh-gdl-437.pdf.
59. Health AGDo. MBS Reviews Folate Testing Report. 2014.
60. Aparicio-Ugarriza R, Palacios G, Alder M, González-Gross M. A review of the cut-off points for the diagnosis of vitamin B12 deficiency in the general population. Clinical Chemistry and Laboratory Medicine (CCLM)2015. p. 1149.
61. Barach P, Johnson J. Assessing risk and harm in the clinical microsystem: A systematic approach to patient safety. In: Sollecito W, Johnson J, editors. Continuous quality improvement in health care: Theory, implementations, and applications, 4th edition. New York, USA: Jones and Bartlett; 2013. p. 249-74.
62. Government of South Australia. Clinical guideline. In: Health S, editor. Aminoglycoside: recommendations for use, dosing and monitoring, March 2017. Adelaide, SA: Infection Control Service; 2017.
63. Morgan S, Coleman J. We live in testing times - teaching rational test ordering in general practice. Aust Fam Physician. 2014;43(5):273-6.
64. van Bokhoven MA, Pleunis-van Empel MC, Koch H, Grol RP, Dinant GJ, van der Weijden T. Why do patients want to have their blood tested? A qualitative study of patient expectations in general practice. BMC Fam Pract. 2006;7:75.
65. Verstappen WH, ter Riet G, Dubois WI, Winkens R, Grol RP, van der Weijden T. Variation in test ordering behaviour of GPs: professional or context-related factors? Fam Pract. 2004;21(4):387-95.
66. Liaw ST, Taggart J, Yu H, de Lusignan S. Data extraction from electronic health records - existing tools may be unreliable and potentially unsafe. Australian family physician. 2013;42(11):820-3.
67. Young J, Eley D, Fahey P, Patterson E, Hegney D. Enabling research in general practice--increasing functionality of electronic medical records. Australian family physician. 2010;39(7):506-9.
68. Liaw ST, Powell-Davies G, Pearce C, Britt H, McGlynn L, Harris MF. Optimising the use of observational electronic health record data: Current issues, evolving opportunities, strategies and scope for collaboration. Australian family physician. 2016;45(3):153-6.
69. Klepeis V, Garcia C, Gilbertson J. Importance of Data Quality Improvement and Assessment in Anatomic Pathology. American Journal of Clinical Pathology. 2015;144(suppl_2):A355-A.
70. Legg M. Standardisation of test requesting and reporting for the electronic health record. Clinica Chimica Acta. 2014;432:148-56.
71. New JP, Leather D, Bakerly ND, McCrae J, Gibson JM. Putting patients in control of data from electronic health records. BMJ. 2018;360:j5554.

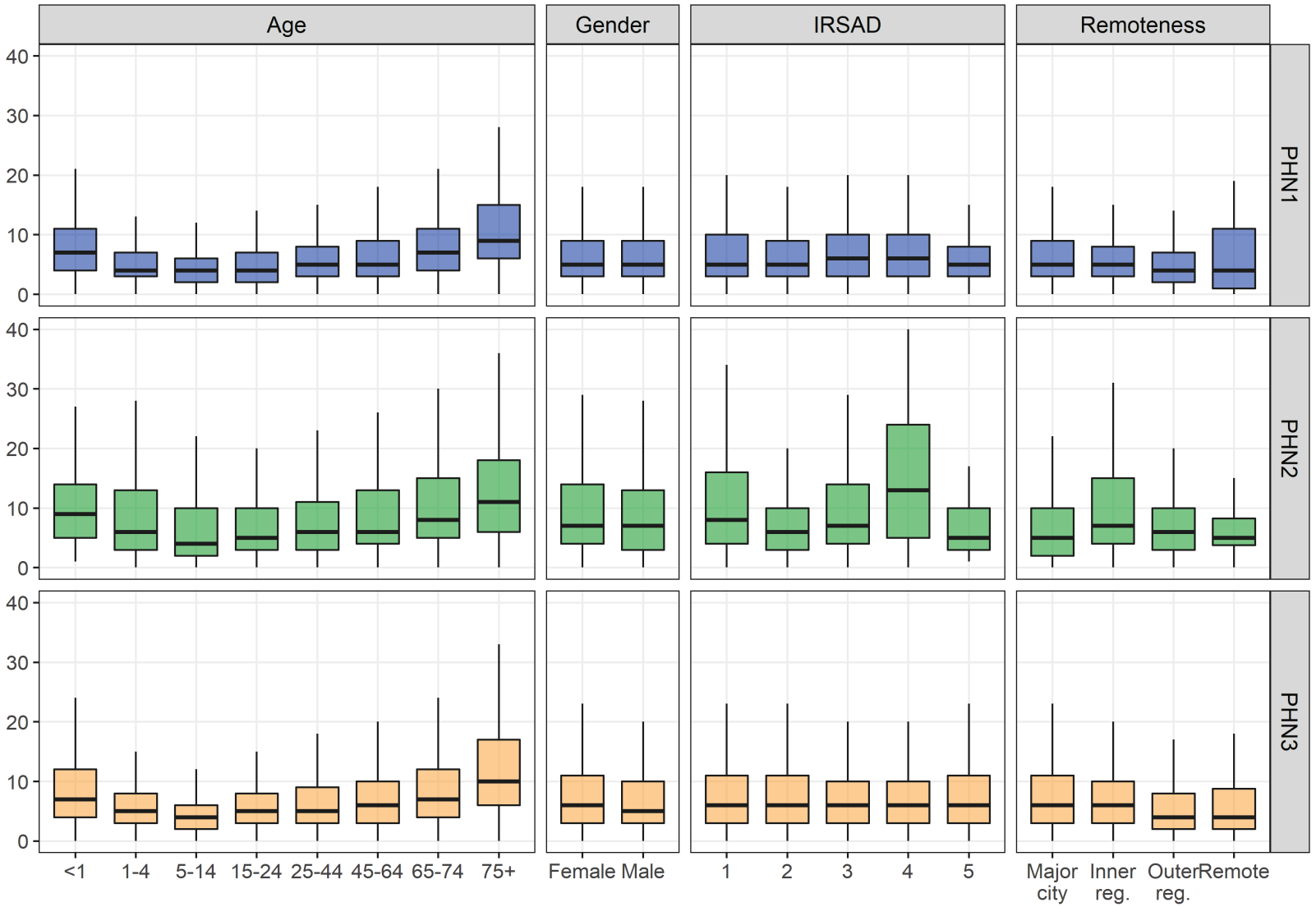
23. APPENDIX TABLES AND FIGURES

Appendix Table 1. Active patients and selected GP clinics by PHN from 2008-09 to 2017-18.

	PHN1				PHN2				PHN3			
	Active patients		Selected practice		Active patients		Selected practice		Active patients		Selected practice	
Year	n	% of total	n	% of total	n	% of total	n	% of total	n	% of total	n	% of total
2008-09	139,512	(61.5)	41.0	(97.6)	36,572	(64.4)	11	(100.0)	80,049	(61.6)	36	(100.0)
2009-10	159,811	(62.5)	50.0	(100.0)	50,106	(59.5)	13	(100.0)	115,600	(59.6)	45	(100.0)
2010-11	183,283	(63.9)	56.0	(98.2)	57,967	(65.4)	16	(100.0)	146,234	(64.2)	48	(100.0)
2011-12	200,962	(66.0)	62.0	(96.9)	60,149	(67.2)	17	(100.0)	176,170	(64.9)	58	(100.0)
2012-13	225,061	(65.4)	69.0	(98.6)	60,349	(68.0)	17	(100.0)	207,822	(66.4)	62	(100.0)
2013-14	245,098	(65.9)	76.0	(97.4)	62,635	(66.7)	20	(100.0)	226,492	(67.7)	67	(100.0)
2014-15	270,387	(64.8)	85.0	(100.0)	65,805	(67.5)	20	(100.0)	244,184	(66.9)	70	(97.2)
2015-16	299,223	(64.3)	93.0	(97.9)	67,520	(67.8)	20	(100.0)	269,541	(65.7)	80	(98.8)
2016-17	336,172	(63.7)	98.0	(93.3)	69,651	(67.1)	23	(100.0)	295,501	(65.9)	84	(95.5)
2017-18	354,394	(65.9)	96.0	(87.3)	71,922	(67.3)	23	(100.0)	299,947	(67.1)	84	(91.3)



Appendix Figure 1. Annual frequency of GP visit by PHN from 2008-09 to 2017-18.



Appendix Figure 2. Socio-demographic characteristics of visit frequency by PHN in 2017-18.

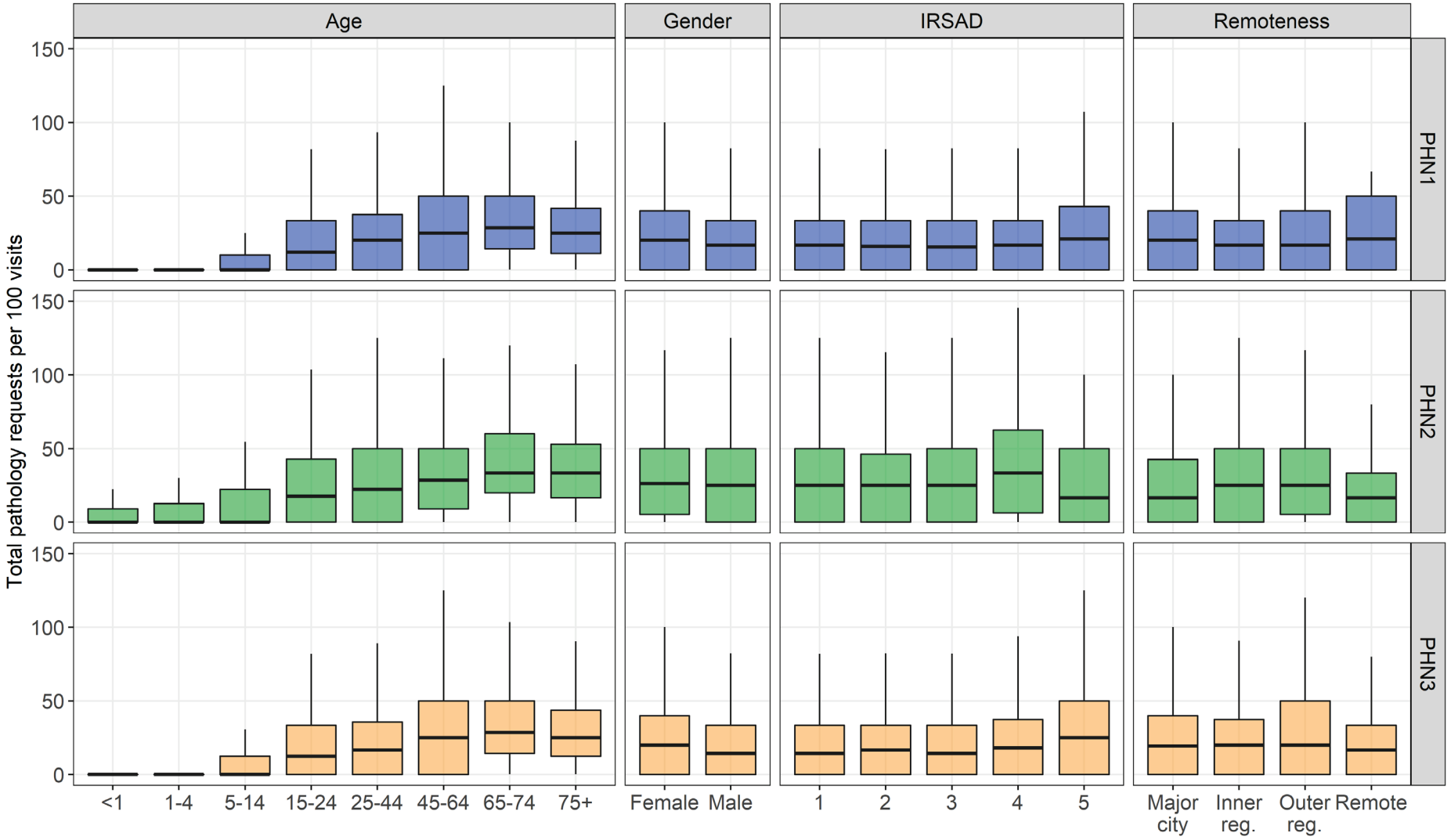
Appendix Table 2. Most common issues and reasons for GP visits in 2017-18.

	0-2 YEARS (INFANCY)	(%)	3-12 YEARS (CHILDHOOD)	(%)	13-24 YEARS (ADOLESCENCE)	(%)
1	Immunisation	(11.5)	Immunisation	(6.1)	Result discussed	(6.1)
2	Viral upper RTI	(7.7)	Viral upper RTI		Immunisation	(4.4)
3	Otitis media	(5.4)	Care review	(5.0)	Care review	(2.9)
4	Upper RTI	(5.4)	Upper RTI	(3.8)	Viral upper RTI	(2.7)
5	Care review	(3.8)	Otitis media	(3.5)	Prescription	(2.4)
6	Eczema	(3.0)	Result discussed	(3.0)	Upper RTI	(2.1)
7	Croup	(2.4)	Referral	(2.4)	Referral	(1.7)
8	Viral infection	(2.4)	Asthma	(2.2)	Oral contraception	(1.7)
9	Cough	(1.9)	Tonsillitis	(2.2)	Mental health care	(1.7)
10	Conjunctivitis	(1.8)	Viral infection	(1.9)	Tonsillitis	(1.5)

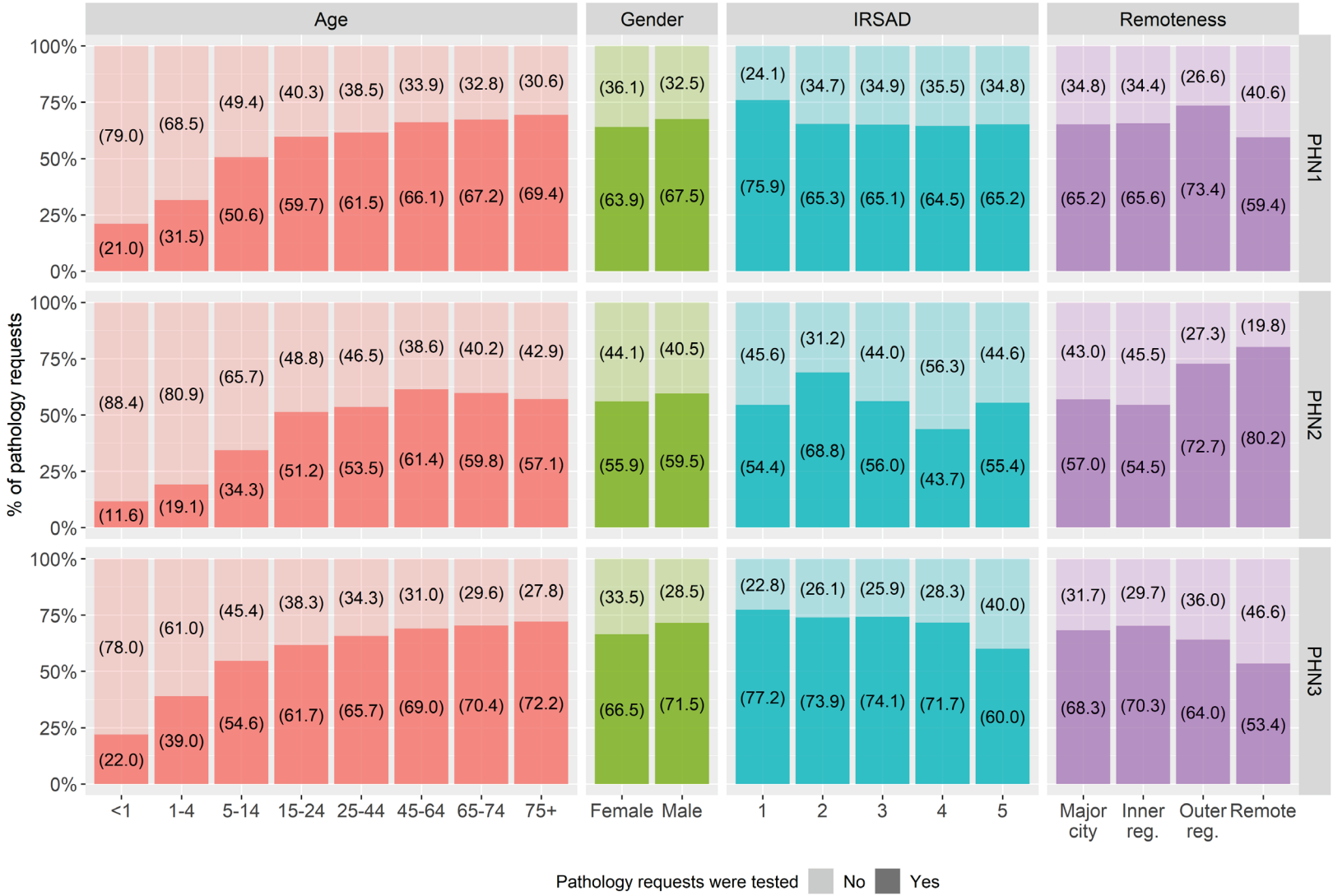
	25-44 YEARS (YOUNG ADULT)	(%)	45-64 YEARS (OLDER ADULT)	(%)	65+ YEARS (SENIORS)	(%)
1	Result discussed	(5.4)	Result discussed	(4.6)	Care review	(5.6)
2	Care review	(3.3)	Care review	(4.1)	Prescription	(4.0)
3	Prescription	(2.4)	Prescription	(3.4)	Result discussed	(3.3)
4	Immunisation	(2.1)	Referral	(2.0)	Immunisation	(2.6)
5	Referral	(1.9)	Hypertensive disorder	(1.8)	Health assessment	(2.1)
6	Viral upper RTI	(1.7)	Health assessment	(1.8)	Referral	(1.9)
7	Upper RTI	(1.5)	Immunisation	(1.8)	Hypertensive disorder	(1.7)
8	Mental health care	(1.2)	Care plan	(1.1)	Care plan	(1.3)
9	Health assessment	(1.1)	Hypercholesterolaemia	(1.0)	Osteoarthritis	(1.0)
10	Anxiety	(1.1)	Upper RTI	(0.9)	Urinary tract infection	(0.8)

Appendix Table 3. The number of pathology requests per 100 visits by PHN from 2008-09 to 2017-18.

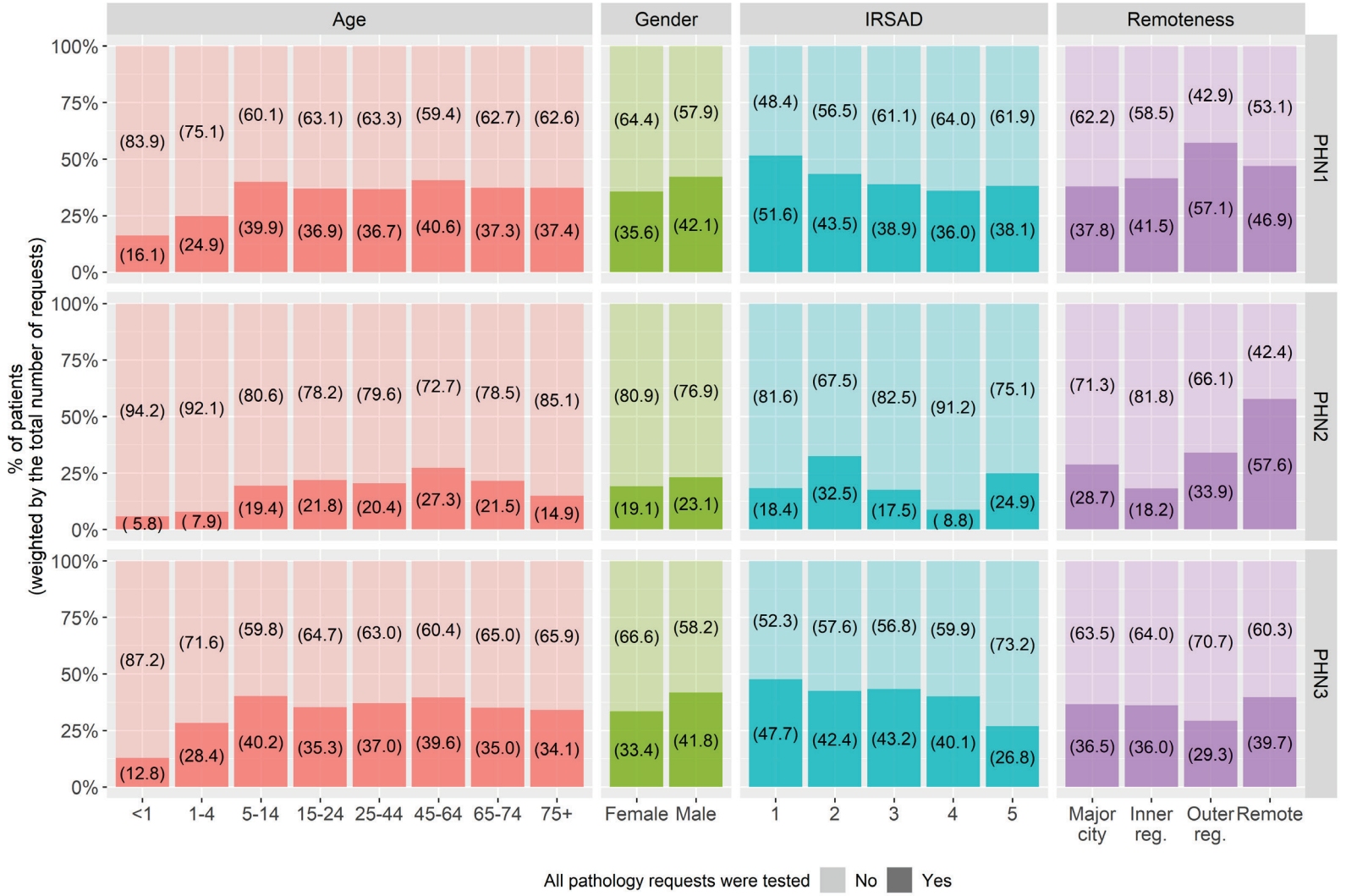
THE MEDIAN NUMBER OF TOTAL PATHOLOGY REQUESTS PER 100 VISITS (IQR)								
Year	Overall		PHN1		PHN2		PHN3	
2008-09	17.6	(0.0,40.0)	16.7	(0.0,33.3)	20.0	(0.0,42.9)	20.0	(0.0,40.0)
2009-10	16.7	(0.0,40.0)	16.7	(0.0,37.5)	20.0	(0.0,40.0)	16.7	(0.0,40.0)
2010-11	20.0	(0.0,40.0)	18.8	(0.0,40.0)	22.2	(0.0,50.0)	20.0	(0.0,40.0)
2011-12	20.0	(0.0,42.9)	20.0	(0.0,40.0)	25.0	(0.0,50.0)	20.0	(0.0,40.0)
2012-13	20.0	(0.0,42.9)	20.0	(0.0,40.0)	25.0	(0.0,50.0)	20.0	(0.0,42.9)
2013-14	20.0	(0.0,42.9)	20.0	(0.0,40.0)	25.0	(0.0,50.0)	20.0	(0.0,40.0)
2014-15	20.0	(0.0,41.9)	20.0	(0.0,40.0)	25.0	(0.0,50.0)	20.0	(0.0,40.0)
2015-16	20.0	(0.0,41.7)	20.0	(0.0,40.0)	25.0	(0.0,50.0)	19.0	(0.0,40.0)
2016-17	20.0	(0.0,42.9)	20.0	(0.0,40.0)	25.0	(0.0,50.0)	20.0	(0.0,40.0)
2017-18	20.0	(0.0,40.0)	20.0	(0.0,38.9)	25.0	(0.0,50.0)	19.6	(0.0,40.0)



Appendix Figure 3. Socio-demographic characteristics of the number of pathology requests per 100 visits by PHN in 2017-18.



Appendix Figure 4. Socio-demographic characteristics of the proportions of completed pathology requests in 2017-18.



Appendix Figure 5. The proportion of patients who carried out all requested tests in 2017-18.

Appendix Table 4. Time (day) required between pathology test order and sample collection in 2017-2018.

THE AVERAGE (MEDIAN) DAYS FOR ALL TYPES OF PATHOLOGY TESTS (IQR)								
	Overall		PHN1		PHN2		PHN3	
Total	2.7	(0.0, 17.0)	2.5	(0.0, 17.4)	3.2	(0.4, 17.5)	2.9	(0.0, 16.0)
Age								
<1 year	0.0	(0.0, 1.0)	0.0	(0.0, 1.0)	0.0	(0.0, 1.0)	0.0	(0.0, 1.0)
1-4 years	0.0	(0.0, 1.0)	0.0	(0.0, 1.0)	0.0	(0.0, 1.0)	0.0	(0.0, 1.2)
5-14 years	0.0	(0.0, 2.0)	0.0	(0.0, 2.0)	0.0	(0.0, 2.0)	0.0	(0.0, 3.0)
15-24 years	0.4	(0.0, 3.9)	0.2	(0.0, 3.4)	0.8	(0.0, 3.8)	0.6	(0.0, 4.0)
25-44 years	1.0	(0.0, 7.6)	1.0	(0.0, 7.1)	1.0	(0.0, 7.2)	1.0	(0.0, 8.0)
45-64 years	4.4	(0.3, 24.6)	4.2	(0.1, 25.8)	5.0	(0.8, 24.0)	4.5	(0.5, 23.6)
65-74 years	7.5	(1.0, 32.9)	7.7	(1.0, 35.0)	7.9	(1.5, 30.6)	7.3	(1.0, 30.6)
75+ years	4.4	(0.6, 21.4)	4.8	(0.4, 24.4)	4.0	(0.9, 18.0)	4.0	(0.6, 19.2)
Gender								
Female	2.3	(0.0, 14.6)	2.0	(0.0, 15.0)	3.0	(0.2, 15.0)	2.5	(0.0, 14.0)
Male	3.2	(0.0, 21.0)	3.0	(0.0, 22.0)	4.0	(0.6, 22.0)	3.2	(0.0, 20.0)
IRSAD								
1	3.0	(0.2, 14.9)	3.0	(0.0, 16.9)	3.6	(0.6, 18.0)	2.8	(0.1, 13.0)
2	3.0	(0.1, 15.5)	2.6	(0.0, 15.0)	3.0	(0.3, 16.4)	3.0	(0.0, 14.6)
3	2.3	(0.0, 14.0)	2.0	(0.0, 13.5)	3.4	(0.4, 18.3)	2.4	(0.0, 14.0)
4	2.6	(0.0, 16.4)	2.3	(0.0, 16.0)	3.6	(0.2, 20.7)	3.0	(0.0, 17.0)
5	3.0	(0.0, 19.9)	2.8	(0.0, 19.9)	1.5	(0.0, 14.8)	3.0	(0.0, 19.8)
Remoteness								
Major city	2.7	(0.0, 17.0)	2.6	(0.0, 17.9)	4.1	(0.0, 21.2)	2.9	(0.0, 16.0)
Inner regional	2.6	(0.0, 16.0)	1.4	(0.0, 12.7)	3.0	(0.2, 17.2)	2.8	(0.0, 16.3)
Outer regional	3.5	(0.7, 18.0)	1.6	(0.0, 16.0)	3.6	(0.8, 18.0)	2.5	(0.0, 16.1)
Remote	5.2	(1.0, 15.0)	5.7	(2.8, 11.2)	5.6	(1.0, 15.0)	2.6	(0.0, 22.3)

Appendix Table 5. The total number of prescriptions from 2008-09 to 2016-17 by PHN.

	ORIGINAL PRESCRIPTIONS						TOTAL PRESCRIPTIONS					
	PHN1		PHN2		PHN3		PHN1		PHN2		PHN3	
Year	Med	(IQR)	Med	(IQR)	Med	(IQR)	Med	(IQR)	Med	(IQR)	Med	(IQR)
2008-09	80.0	(38.1, 133.3)	66.7	(27.3, 123.5)	90.9	(50.0, 140.0)	180.0	(75.0, 407.1)	144.4	(57.1, 400.0)	200.0	(100.0, 458.3)
2009-10	78.9	(36.4, 133.3)	66.7	(27.3, 120.0)	87.5	(42.9, 138.9)	175.0	(71.4, 416.7)	146.4	(54.5, 383.3)	200.0	(100.0, 450.0)
2010-11	83.3	(40.0, 133.3)	66.7	(25.0, 116.7)	83.3	(40.0, 133.3)	200.0	(80.0, 433.3)	133.3	(50.0, 375.0)	195.2	(80.0, 433.3)
2011-12	80.0	(37.5, 133.3)	63.2	(25.0, 116.7)	77.8	(33.3, 133.3)	183.3	(75.0, 427.3)	133.3	(50.0, 381.8)	171.4	(66.7, 413.3)
2012-13	75.0	(33.3, 129.4)	60.0	(22.2, 114.3)	75.0	(33.3, 130.0)	179.6	(66.7, 421.9)	133.3	(50.0, 380.0)	166.7	(66.7, 400.0)
2013-14	75.0	(33.3, 133.3)	62.5	(22.2, 116.7)	75.0	(33.3, 128.6)	180.0	(66.7, 431.6)	133.3	(50.0, 390.9)	163.6	(66.7, 400.0)
2014-15	75.0	(33.3, 125.0)	60.0	(25.0, 112.5)	75.0	(33.3, 125.0)	166.7	(66.7, 410.5)	133.3	(50.0, 375.0)	155.6	(66.7, 400.0)
2015-16	69.2	(33.3, 120.0)	58.3	(22.2, 109.1)	66.7	(30.8, 122.2)	150.0	(57.9, 400.0)	131.6	(50.0, 369.2)	150.0	(58.3, 385.7)
2016-17	68.8	(33.3, 120.0)	60.0	(25.0, 110.0)	66.7	(33.3, 120.0)	150.0	(60.0, 400.0)	139.1	(50.0, 380.0)	150.0	(60.0, 386.2)
2017-18	66.7	(33.3, 120.0)	66.7	(33.3, 120.0)	70.0	(33.3, 120.0)	160.0	(57.1, 400.0)	200.0	(75.0, 420.0)	161.5	(61.5, 388.9)

This page has been left blank intentionally.

AUSTRALIAN INSTITUTE OF HEALTH INNOVATION
Macquarie University
NSW 2109, Australia

L6, 75 Talavera Road
North Ryde, NSW 2113
T: (02) 9850 2400

mq.edu.au

MACQUARIE University

CRICOS Provider 00002J