

EVALUATING THE IMPACT ON ACCESS OF THE INTRODUCTION OF NURSE-
SUPPORTED CARE FOR PEOPLE WITH COMPLEX RHEUMATIC DISEASES IN
BRITISH COLUMBIA

by

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B.A. (Honours), McGill University, 2012

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR
THE DEGREE OF

MASTER OF SCIENCE

in

The Faculty of Graduate Studies and Postdoctoral Studies

(Pharmaceutical Sciences)

THE UNIVERSITY OF BRITISH COLUMBIA

(Vancouver)

August 2019

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EVALUATING THE IMPACT ON ACCESS OF THE INTRODUCTION OF NURSE-SUPPORTED CARE FOR PEOPLE WITH COMPLEX RHEUMATIC DISEASES IN BRITISH COLUMBIA

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the degree of Master of Science
in Pharmaceutical Sciences

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Abstract

Background

A 2010 workforce survey revealed British Columbia was facing a shortage of rheumatologists and a consequent crisis of access to rheumatology care. Rheumatic diseases are chronic, and early intervention is crucial to prevent progression and mitigate systemic damage. Recognizing nurses may be able to perform aspects of rheumatology care and thereby “free up” rheumatologist time, the Ministry of Health introduced billing code G31060 to facilitate nurse-supported consultations for the “complex” rheumatology cases most in need of attention. The objective of this thesis is to evaluate the impact of introducing this new billing code and model of care on access to rheumatology care for the population of BC living with rheumatic disease.

Methods

I conducted an interrupted time series analysis with a comparator using administrative health data on outpatient visits from Population Data BC. Patients with rheumatic diseases were identified using International Classification of Diseases codes and classified as those who received the intervention (i.e. nurse-supported rheumatologist care) or ‘status quo’ (i.e. rheumatologist care alone). Access was defined as 1) number of unique patients treated per month 2) number of service units billed per month. In sensitivity analyses I explored the impact of more restrictive definitions of intervention which required more “consistent” (at least once in every year) and “high-intensity” (at least 30 per year) billing of G31060.

Results

The primary cohort included 128,726 patients with rheumatic disease, seen by 29 intervention and 17 comparator rheumatologists. No statistically significant effect change in level or trend of unique patients ($p_{\beta_6}=0.682$ & $p_{\beta_7}=0.231$) or service units ($p_{\beta_6}=0.744$ & $p_{\beta_7}=0.419$) attributable to the

introduction of G31060 was detected in the primary analysis. Sensitivity analyses revealed statistically significant, increases in patients seen for rheumatologists billing “consistently” (62%) and with “high intensity” (168%) in April 2015 as compared to ‘status quo’.

Conclusion

The introduction of G31060 does not appear to impact the number of service units billed per month, nor does it necessarily increase the number of patients seen. However, consistent and high-intensity users of G31060 appear to increase the number of unique patients seen per month.

Lay Summary

In 2010, BC rheumatologists became concerned they were too few to support the needs of the province in future. Rheumatology concerns rheumatic diseases – chronic conditions ranging from localized arthritis to auto-immune conditions affecting multiple body systems. The sooner such conditions are treated the better. To help ensure access for patients, the BC Ministry of Health introduced nurse-supported care to rheumatology, hoping nurses could free up rheumatologist time by performing part of care. This time could allow rheumatologists to perform more tasks than under the status quo. By comparing the number of services provided and patients seen across rheumatologists who use nurses and those who do not, I am able to estimate the effect of introducing nurse-supported consultations on access to rheumatology care in BC. No effect on number of service units was found, but rheumatologists who frequently used nurses were able to increase the number of unique patients they saw.

Preface

The work contained in this thesis was conducted by Ross Duncan, under the supervision of Dr. Mark Harrison, and with assistance from members of the thesis committee (Drs. Mary De Vera, Annalijn Conklin, Kam Shojania, and Michael Law). The data used in this study come from Population Data BC, situated in the School of Population and Public Health at the University of British Columbia. Assistance was also provided by Daphne Guh, a staff statistician at the Centre for Health Evaluation and Outcome Sciences, at which Dr. Harrison is an affiliate research scientist.

This study was part of a larger project that was granted ethics approval by the University of British Columbia: H16-02934 “A population-based analysis of multi-disciplinary rheumatology nursing care for people with complex rheumatic diseases”

Table of Contents

Abstract	iii
Lay Summary	v
Preface	vi
Table of Contents	vii
List of Tables	xvii
List of Figures.....	xix
List of Abbreviations.....	xxi
Chapter 1: Introduction	1
1.1 Background – a “looming crisis”	1
1.1.1 What is Rheumatic Disease?.....	1
1.1.2 The epidemiology of rheumatic disease in British Columbia.....	2
1.1.3 Diagnosis, Management, and Monitoring	4
1.1.4 How would a patient receive rheumatology care?.....	7
Figure 1.1 Ideal care pathway for rheumatic disease diagnosis and management, Arthritis Alliance Canada (21).....	9
1.1.5 Proposed solutions to the challenge of access in British Columbia	11
1.1.6 Global evidence in support of multidisciplinary care models for rheumatology.....	12

1.1.7 The Multidisciplinary Conference for Community-based patients with complex rheumatic diseases (G31060) in BC.....	15
1.1.8 Assessments of multidisciplinary rheumatology consultations in BC under G31060	16
1.2 Research Objectives.....	16
1.2.1 What are the aims of the proposed analysis?	16
1.3 Thesis Outline.....	17
1.4 Disclaimer Statement.....	18
Chapter 2: Methodology	19
2.1 Data Sources	19
2.2 Methods: Preparing for analysis	20
2.2.1 Preparation of data sources for analysis	20
2.2.2 Defining the population under study	21
Table 2.1: Identifiable rheumatic diseases and their ICD codes.....	23
2.2.3 Identifying rheumatologists and rheumatology billings	23
Table 2.2 Rheumatology services under the British Columbia Medical Services Plan.....	24
2.2.4 Defining the intervention (“nurse”) and comparator (“status quo”) groups.....	25
Figure 2.1 Overview of time-periods, intervention, and comparator group	25
2.2.5 Defining “access” in the context of British Columbian rheumatology care	26
2.2.6 Hypothesized impact on access to rheumatology care.....	27
2.3 Methods: Descriptive statistics.....	28

2.4 Methods: Interrupted Time Series with Comparator.....	29
2.4.1 Simple Interrupted Time Series	29
Figure 2.2 Relationship of regression coefficients to plot, simple interrupted time series.....	29
2.4.2 Interrupted time series with comparator	31
Figure 2.3 Relationship of regression coefficients to plot of comparator ('status quo group') ...	33
Figure 2.4 Relationship of regression coefficients to plot, comparator vs intervention groups..	33
2.4.3 Time series and adjusting for autocorrelative processes	36
2.4.4 Predicting absolute and relative change.....	40
2.5 Cohort specifications	41
2.5.1 Sensitivity Analysis of interrupted time series specification	42
Table 2.3 Summary of criteria for inclusion to 'nurse group' by cohort specification.....	42
Chapter 3: Characterizing the population of individuals with rheumatic disease and patterns of rheumatology care in British Columbia	43
3.1 Results	43
3.1.1 Characteristics of the population of individuals with rheumatic disease in British Columbia	43
Table 3.1 Characteristics of the population of individuals with rheumatic disease in British Columbia.....	45
Table 3.2 Estimated prevalence per 100,000 of rheumatic disease by category.....	46
3.1.2 Patterns of rheumatology service provided in British Columbia, 2009-2015	46
Figure 3.1 Core rheumatology services versus others over time, number of billings.....	47

Figure 3.2 Core rheumatology services versus others over time, proportion of total number of billings	48
Figure 3.3 “Other” rheumatology services by rheumatology service category over time, number of billings.....	49
Figure 3.4 “Other” rheumatology services by rheumatology service category over time, proportion of total number of billings not including 31007 or 31010	50
Figure 3.5 Special rheumatology services over time, number of billings	51
Figure 3.6 Special rheumatology services over time, proportion of total number of special services billings.....	52
3.1.3 Patterns of rheumatologist entry and exit from billing activity, by group	52
Table 3.3 Rheumatologist entry and exit from MSP billing: all active, using G31060, not using G31060.....	54
3.1.4 Number of rheumatologists seen per patient, per calendar year	55
Table 3.4 Frequency of observed number of rheumatologists per patient by year and group in primary cohort, total	56
Table 3.5 Frequency of observed number of rheumatologists per patient by year and group in primary cohort, proportional	56
3.1.5 Number of unique service days per patient, per calendar year.....	57
Table 3.6 Average proportion of patients with one unique service visit per year, by group and inflammatory status of condition	58
Table 3.7 Frequency of unique service days per patient by year and group, totals – inflammatory conditions of primary cohort.....	59

Table 3.8 Frequency of unique service days per patient by year and group, proportions – inflammatory conditions of primary cohort	60
Table 3.9 Frequency of unique service days per patient by year and group, totals – non-inflammatory conditions of primary cohort	61
Table 3.10 Frequency of unique service days per patient by year and group, proportions – non-inflammatory conditions of primary cohort	62
3.1.6 Characteristics of patients within the primary cohort, by group.....	63
Table 3.11 Characteristics of patients within the primary cohort, by group.....	64
3.2 Discussion	65
3.2.1 Overview	65
3.2.2 Strengths.....	67
3.2.3 Limitations	68
3.3 Conclusion.....	69
Chapter 4: Impact on access to rheumatology care, an interrupted time-series analysis.....	70
4.1 Overview of Results.....	70
4.1.1 Cohort Descriptions	71
Table 4.1 Number of rheumatologists and patients in each group, by cohort.....	72
4.1.2 Testing and correcting for auto-correlative processes.....	72
4.2 Primary analysis – comparison of rheumatologists who ever billed G31060 with those who never billed.....	74
4.2.1 Impact on number of unique patients seen per month.....	74

Figure 4.1 Number of unique patients billed per month before and after the introduction of “Multidisciplinary conference for community-based patients” (G31060) in April 2011 by rheumatologists in the ‘nurse’ and ‘status quo’ groups. Primary analysis using ARMA(12,0) model.....	75
4.2.2 Impact on service units billed per month.....	75
Figure 4.2 Number of service units billed per month before and after the introduction of “Multidisciplinary conference for community-based patients” (G31060) in April 2011 by rheumatologists in the ‘nurse’ and ‘status quo’ groups. Primary analysis using ARMA(12,0) model.....	77
4.3 Sensitivity analysis 1: restricting the definition of intervention in the “nurse group” to consistent users (at least one billing of G31060 in every calendar year).....	77
4.3.1 Impact on number of unique patients seen per month.....	78
Figure 4.3 Number of unique patients billed per month before and after the introduction of “Multidisciplinary conference for community-based patients” (G31060) in April 2011 by rheumatologists in the ‘nurse’ and ‘status quo’ groups. Consistency analysis using ARMA(12,0) model.....	79
4.3.2 Impact on service units billed per month.....	80
Figure 4.4 Number of service units billed per month before and after the introduction of “Multidisciplinary conference for community-based patients” (G31060) in April 2011 by rheumatologists in the ‘nurse’ and ‘status quo’ groups. Consistency analysis using ARMA(12,0) model.....	81
4.4 Sensitivity analysis 2: restricting the definition of intervention in the “nurse group” to high intensity users (at least 30 billings of G31060 per month, on average)	81

4.4.1 Impact on number of unique patients seen per month.....	82
Figure 4.5 Number of unique patients billed per month before and after the introduction of “Multidisciplinary conference for community-based patients” (G31060) in April 2011 by rheumatologists in the ‘nurse’ and ‘status quo’ groups. High-Intensity analysis using ARMA(12,0) model.....	83
4.4.2 Impact on service units billed per month.....	84
Figure 4.6 Number of service units billed per month before and after the introduction of “Multidisciplinary conference for community-based patients” (G31060) in April 2011 by rheumatologists in the ‘nurse’ and ‘status quo’ groups. High-intensity analysis using ARMA(12,0) model.....	85
4.5 Summary of results.....	85
4.5.1 Interrupted time series.....	85
Table 4.2 Summary output of level and trend change attributable to the introduction of the multidisciplinary conference code for community-based patients (β_6 and β_7).....	86
4.5.2 Absolute change in measures of access	87
Table 4.3 Predicted absolute and relative change in number of unique patients per month, evaluated annually from the introduction of G31060 in April 2011. Model is specified as ARMA(12,0).....	88
4.6 Discussion	88
4.6.1 Overview	88
4.6.2 Interpretation and implications.....	89
4.6.3 Limitations	90

4.4.3 Strengths.....	91
4.7 Conclusion.....	93
Chapter 5: Discussion and Conclusions.....	94
5.1 Discussion	95
5.1.1 Uptake of the billing code and substitution effect.....	95
5.1.2 Access outcomes measured by unique patients.....	98
5.1.3 Access outcomes measured by service units billed	99
5.1.4 Interpretation of results	100
5.2. Strengths and Limitations	105
5.2.1 Strengths.....	105
5.2.2 Limitations	108
5.3 Implications.....	110
5.3.1 Implications: Patients	110
5.3.2 Implications: Rheumatologists	112
5.3.3 Implications: British Columbia Ministry of Health.....	114
5.4 Next Steps	115
5.5 Conclusion.....	117
Bibliography.....	118
Appendix 1: Detail regarding autocorrelative process and model specification.....	129

Table A1.1 Relationship of statistically significant autocorrelation lags to unique patients per month by order of lag and cohort specification, as identified by Durbin-Watson ($\alpha=0.05$), ...	129
Table A1.2 Relationship of statistically significant autocorrelation lags to service units per month by order of lag and cohort specification, as identified by Durbin-Watson ($\alpha=0.05$)	129
Table A1.3 Order of moving average process identified by plot of autocorrelation function..	130
Table A1.4 Order of autoregressive process identified by plot of partial autocorrelation function	130
Appendix 2: Regression outputs from primary and secondary analyses	132
Table A2.1: Primary cohort analyses of impact on the number of unique patients per month achieved by the introduction of the multidisciplinary conference code for community-based patients	132
Table A2.2: Primary cohort analyses of impact on the number of unique patients per month achieved by the introduction of the multidisciplinary conference code for community-based patients	132
Table A2.3: Consistent cohort analyses of impact on the number of unique patients per month achieved by the introduction of the multidisciplinary conference code for community-based patients	133
Table A2.4: Consistent cohort analyses of impact on the number of service units per month achieved by the introduction of the multidisciplinary conference code for community-based patients	133

Table A2.5: High-Intensity cohort analyses of impact on the number of unique patients per month achieved by the introduction of the multidisciplinary conference code for community-based patients	134
Table A2.6: High-Intensity cohort analyses of impact on the number of service units per month achieved by the introduction of the multidisciplinary conference code for community-based patients	134
Appendix 3: Age and sex of patient population stratified by rheumatic disease diagnosis.....	135
Table A3.1 Proportion of female patients (%) in study population, by primary rheumatic disease diagnosis.....	135
Table A3.2 Median age and interquartile range of patients in study population, by primary rheumatic disease diagnosis.....	135

List of Tables

Table 2.1: Identifiable rheumatic diseases and their ICD codes.....	23
Table 2.2 Rheumatology services under the British Columbia Medical Services Plan.....	24
Table 2.3 Summary of criteria for inclusion to ‘nurse group’ by cohort specification.....	42
Table 3.1 Characteristics of the population of individuals with rheumatic disease in British Columbia.....	45
Table 3.2 Estimated prevalence per 100,000 of rheumatic disease by category.....	46
Table 3.3 Rheumatologist entry and exit from MSP billing: all active, using G31060, not using G31060.....	54
Table 3.4 Frequency of observed number of rheumatologists per patient by year and group in primary cohort, total	56
Table 3.5 Frequency of observed number of rheumatologists per patient by year and group in primary cohort, proportional	56
Table 3.6 Average proportion of patients with one unique service visit per year, by group and inflammatory status of condition	58
Table 3.7 Frequency of unique service days per patient by year and group, totals – inflammatory conditions of primary cohort.....	59
Table 3.8 Frequency of unique service days per patient by year and group, proportions – inflammatory conditions of primary cohort.....	60
Table 3.9 Frequency of unique service days per patient by year and group, totals – non-inflammatory conditions of primary cohort	61
Table 3.10 Frequency of unique service days per patient by year and group, proportions – non-inflammatory conditions of primary cohort	62
Table 3.11 Characteristics of patients within the primary cohort, by group.....	64
Table 4.1 Number of rheumatologists and patients in each group, by cohort.....	72
Table 4.2 Summary output of level and trend change attributable to the introduction of the multidisciplinary conference code for community-based patients (β_6 and β_7).....	86
Table 4.3 Predicted absolute and relative change in number of unique patients per month, evaluated annually from the introduction of G31060 in April 2011. Model is specified as ARMA(12,0).	88
Table A1.1 Relationship of statistically significant autocorrelation lags to unique patients per month by order of lag and cohort specification, as identified by Durbin-Watson ($\alpha=0.05$), ...	129

Table A1.2 Relationship of statistically significant autocorrelation lags to service units per month by order of lag and cohort specification, as identified by Durbin-Watson ($\alpha=0.05$)	129
Table A1.3 Order of moving average process identified by plot of autocorrelation function..	130
Table A1.4 Order of autoregressive process identified by plot of partial autocorrelation function	130
Table A2.1: Primary cohort analyses of impact on the number of unique patients per month achieved by the introduction of the multidisciplinary conference code for community-based patients	132
Table A2.2: Primary cohort analyses of impact on the number of unique patients per month achieved by the introduction of the multidisciplinary conference code for community-based patients	132
Table A2.3: Consistent cohort analyses of impact on the number of unique patients per month achieved by the introduction of the multidisciplinary conference code for community-based patients	133
Table A2.4: Consistent cohort analyses of impact on the number of service units per month achieved by the introduction of the multidisciplinary conference code for community-based patients	133
Table A2.5: High-Intensity cohort analyses of impact on the number of unique patients per month achieved by the introduction of the multidisciplinary conference code for community-based patients	134
Table A2.6: High-Intensity cohort analyses of impact on the number of service units per month achieved by the introduction of the multidisciplinary conference code for community-based patients	134
Table A3.1 Proportion of female patients (%) in study population, by primary rheumatic disease diagnosis.....	135
Table A3.2 Median age and interquartile range of patients in study population, by primary rheumatic disease diagnosis.....	135

List of Figures

Figure 1.1 Ideal care pathway for rheumatic disease diagnosis and management, Arthritis Alliance Canada (21).....	9
Figure 2.1 Overview of time-periods, intervention, and comparator group	25
Figure 2.2 Relationship of regression coefficients to plot, simple interrupted time series.....	29
Figure 2.3 Relationship of regression coefficients to plot of comparator (“status quo group”) ...	33
Figure 2.4 Relationship of regression coefficients to plot, comparator vs intervention groups..	33
Figure 3.1 Core rheumatology services versus others over time, number of billings.....	47
Figure 3.2 Core rheumatology services versus others over time, proportion of total number of billings	48
Figure 3.3 “Other” rheumatology services by rheumatology service category over time, number of billings.....	49
Figure 3.4 “Other” rheumatology services by rheumatology service category over time, proportion of total number of billings not including 31007 or 31010	50
Figure 3.5 Special rheumatology services over time, number of billings	51
Figure 3.6 Special rheumatology services over time, proportion of total number of special services billings.....	52
Figure 4.1 Number of unique patients billed per month before and after the introduction of “Multidisciplinary conference for community-based patients” (G31060) in April 2011 by	

rheumatologists in the ‘nurse’ and ‘status quo’ groups. Primary analysis using ARMA(12,0) model.....	75
Figure 4.2 Number of service units billed per month before and after the introduction of “Multidisciplinary conference for community-based patients” (G31060) in April 2011 by rheumatologists in the ‘nurse’ and ‘status quo’ groups. Primary analysis using ARMA(12,0) model.....	77
Figure 4.3 Number of unique patients billed per month before and after the introduction of “Multidisciplinary conference for community-based patients” (G31060) in April 2011 by rheumatologists in the ‘nurse’ and ‘status quo’ groups. Consistency analysis using ARMA(12,0) model.....	79
Figure 4.4 Number of service units billed per month before and after the introduction of “Multidisciplinary conference for community-based patients” (G31060) in April 2011 by rheumatologists in the ‘nurse’ and ‘status quo’ groups. Consistency analysis using ARMA(12,0) model.....	81
Figure 4.5 Number of unique patients billed per month before and after the introduction of “Multidisciplinary conference for community-based patients” (G31060) in April 2011 by rheumatologists in the ‘nurse’ and ‘status quo’ groups. High-Intensity analysis using ARMA(12,0) model.....	83
Figure 4.6 Number of service units billed per month before and after the introduction of “Multidisciplinary conference for community-based patients” (G31060) in April 2011 by rheumatologists in the ‘nurse’ and ‘status quo’ groups. High-intensity analysis using ARMA(12,0) model.....	85

List of Abbreviations

ACREU - Arthritis Community Research and Evaluation Unit

AR - AutoRegressive

ARMA - AutoRegressive Moving Average model

BC - British Columbia

BCSR - BC Society of Rheumatologists

BSR - British Society of Rheumatologists

EULAR - European League Against Rheumatism

G31060 - Multidisciplinary conference for community-based patients (G31060)

ITS - Interrupted Time Series

MA - Moving Average

MSP - Medical Services Plan

Multidisciplinary conference code - Multidisciplinary conference for community-based patients
(G31060)

National Institute for Health and Care Excellence - NICE

SARDs - Systemic Autoimmune Rheumatic Diseases

Acknowledgements

I would like to thank Arthritis Alliance Canada's Inflammatory Arthritis Models of Care Executive Committee for granting me permission to use their Inflammatory Arthritis Care Path Toolkit in illustrating the diagnostic, treatment, and management pathway for rheumatology care within Canada.

Chapter 1: Introduction

1.1 Background – a “looming crisis”

A 2010 survey of rheumatology specialists (rheumatologists) in British Columbia (BC), Canada sounded the alarm regarding a “looming crisis” within rheumatology care. The survey revealed that there were simply too few rheumatologists available in BC; around 40 full-time-equivalents to cover all referred cases(1). Estimates from the BC Society of Rheumatologists (BCSR) placed the ratio of full-time rheumatologists per head of population at 1:140,000 in 2010 and 1:112,000 in 2014(1,2). Compared with the 2010 Canadian Rheumatology Association recommended ratio of 1:75,000, the ratio in BC represented a shortfall of approximately 30 full-time specialists(1). In a follow-up survey conducted in 2014, 60% of BC rheumatologists had been practicing for at least 20 years and 48% reported planning to retire within the next 10 years(2). If this trend continued unmitigated, BC would face a serious challenge in how to care for its citizens with rheumatic disease.

1.1.1 What is Rheumatic Disease?

“Rheumatic disease” is an umbrella term for many different conditions including: rheumatoid arthritis, osteoarthritis, gout, systematic lupus erythematosus, psoriatic arthritis, axial spondyloarthritis, fibromyalgia, osteoporosis, and systemic scleroderma. There are more than 200 rheumatic diseases, typically involving chronic pain, inflammation and damage of the joints and/or connective tissue as

well as the potential to harm organs. The BC Ministry of Health operationally defines complex rheumatic diseases as those for which care requires “continuing management by a rheumatologist” and/or “patients with rheumatoid arthritis or similar inflammatory disease.”(3) Rheumatic diseases have a broad range of impact upon the lives of those they affect, including: ability to work, financial situation, and use of the health care system, in addition to physical and mental health(4).

1.1.2 The epidemiology of rheumatic disease in British Columbia

A 2010 review of worldwide prevalence of arthritis and rheumatic disease by the Arthritis Community Research and Evaluation Unit (ACREU) identifies the overall prevalence of all forms of “arthritis” in BC as 14.7% or approximately 639,000 individuals, which is congruent with estimates from Ontario (16.9%) and Alberta (14.2%) (5) These Canadian provinces appear to be in line with national estimates from the United Kingdom (13%) and Australia (15%). The ACREU report also described the prevalence of several specific rheumatic disease categories in Canada; the most prevalent disease being osteoarthritis (10%). The review also identified the prevalence of rheumatoid arthritis (1%), ankylosing spondylitis (1%), systemic lupus erythematosus (0.02-0.05%) and gout (up to 3%) (5). Broten et al (2014) conducted a Canada-wide evaluation of prevalence among a subset of “SARDs”, or systemic autoimmune rheumatic diseases, that also stratified by sex, age, and rurality. The authors presented prevalence data for systemic lupus erythematosus, systemic sclerosis, primary sjögren’s syndrome, and polymyositis-dermatomyositis from 1988 to 2007. The study found that BC the overall prevalence of SARDs was 4.2 per 1,000 individuals. SARDs were more prevalent among women than men (6.1 per 1,000 [95% CI: 5.9-6.2] vs 2.2 per 1,000 [95% CI: 2.1-2.4]) and more prevalent in those over 45. The study also found that prevalence of SARDs tended to be higher in urban areas, a pattern that was more pronounced in British Columbia, where the prevalence was estimated to be 4.5 per 1,000 (95%

CI: 4.2-4.8) for women under 45 in an urban locale compared with 1.0 per 1,000 (95% CI: 0.8-1.2)) for women under 45 in a rural area. The authors speculate that British Columbia's position in the "Asia-Pacific gateway" and proportionally large, urbanized population of Canadians from East-Asian backgrounds may contribute to this difference in prevalence, as East-Asian ethnicity is associated with an increased risk of systemic lupus erythematosus and other SARDs. Unfortunately Broten et al did not have data containing immigration status or ethnicity, and this explanation could not be explored empirically(6). Rai et al conducted a study focusing on the prevalence and incidence of gout in BC from 2000-2012, noting that both prevalence and incidence increased over the time period. The study found that in 2012, incidence was 2.9 per 1,000 person-years and prevalence for the overall population was 3.8% (over 8% for those 60-69 years old)(7). High proportions of gout patients had other comorbid conditions, with 72% of 2012 gout patients having hypertension and 52% having hyperlipidemia (7).

It is more difficult to describe the incidence of various rheumatic diseases, perhaps in part to the rarity of some variants and the long diagnostic pathway. Consequently, I did not find many incidence rates specific to British Columbia. However, the United States and United Kingdom are comparable countries that do have incidence estimates available for some rheumatic diseases. In the United Kingdom, incidence of rheumatoid arthritis was found to be 54 per 100,000 person-years for women and 24 per 100,000 person-years for men at baseline in 2010(8). The United Kingdom also has a range of estimates for the incidence of gout, with the Rochester Epidemiology Project placing it around 46 per 100,000 person-years in 1995/96, and the Health Improvement Network primary care database at 268 per 100,000 person-years from 2000 through 2007 (9). Systemic Lupus Erythematosus has an estimated incidence rate of between 1.8 and 7.6 cases per 100,000 person-years within the United States, though this number stems from an older study(10).

A British Columbian patient-resource website, “Arthritis BC and Me”, reports that 1/5 British Columbians have “some form of arthritis” – with many being unaware of it. They further state that around 615,000 British Columbians are living with osteoarthritis, and approximately 40,000 were living with rheumatoid arthritis in 2010. Most striking are their projected estimates – by 2040 they expect ¼ (1.49 million) British Columbians will be living with osteoarthritis and 1/71 (~80,000) with rheumatoid arthritis. The authors translate this to concrete terms in a striking manner: “one person in British Columbia will be diagnosed [with osteoarthritis] every 8.8 minutes” and for rheumatoid arthritis “one person in British Columbia will be diagnosed with RA every 2.6 hours.”(11) What is clear that is that British Columbia has a present and growing challenge in how to diagnose, manage, and treat the growing number of its citizens living with rheumatic disease.

1.1.3 Diagnosis, Management, and Monitoring

Inflammatory rheumatic disease is diagnosed clinically, and cannot be definitively identified through any single form of investigation (x-ray, blood test, joint-pain count). Perhaps the most well-established guidelines for any rheumatic disease are those for rheumatoid arthritis, and so I will use those as the prototypical example when describing the care pathway for rheumatic disease in BC. The first step is to ensure that symptoms patients experience are the result of an inflammatory condition rather joint and/or ligament damage resulting from injury some other form of “wear-and-tear”(12). Diagnosis then proceeds to distinguishing rheumatoid arthritis from other forms of inflammatory arthritis, such as systemic lupus erythematosus or ankylosing spondylitis. When the most probable diagnosis is determined then disease management begins as soon as possible. Early treatment is critical because untreated synovitis, the swelling and inflammation of the joint lining, leads to joint destruction and

subsequent reduction in capabilities. Evidence suggests that a delay of more than 12 weeks from symptom onset to therapy initiation significantly lowers the chance of remission and increases chances of joint damage(13,14). Consequently, timely access to rheumatology care is crucial. In British Columbia, general practitioners who identify what they believe to be either early (less than three months of symptoms) or established (symptomatic inflammation and/or joint damage) rheumatoid arthritis are expected to refer the patient both to a rheumatologist and to a physical or occupational therapist for specialized care. The general practitioner then proceeds to patient education and pain management. For early rheumatoid arthritis, patients may be started on hydroxychloroquine until the diagnosis is confirmed by a rheumatologist or, if the general practitioner is confident about their diagnosis, may proceed directly to treatment with sulfasalazine and methotrexate. Ongoing disease management involves physiotherapy or occupational therapy, 3-6 month follow up with a general practitioner, and 6-12 month follow up with rheumatologist monitoring to ensure best disease control(12).

The care of complex rheumatic diseases varies considerably between the different diseases that fall under this description, as diagnosis, prognosis, and treatment mechanisms tend to be disease-specific. Even within a given disease cluster, individual patients may receive different pathways of care depending on when the disease is diagnosed, the speed of progression, the patient's own treatment goals, their response to and ability to tolerate various pharmacological interventions, and of course patient and provider preference. However, common to all diseases is a need for timely access to care to initiate treatment and prevent progression of disease and associated damage.

Unfortunately, real world implementation of diagnosis and management guidelines for any disease rarely matches the text perfectly, and this is true for rheumatology care in British Columbia. Reviewing

administrative data from 1996-2000, Lacaille et al found that only 43% of rheumatoid arthritis patients had received a disease modifying anti-rheumatic drug at least once over 5 years, and only 48% had seen a rheumatologist during that period, well below recommendations(15). For patients continuously followed by a rheumatologist, the use of disease modifying anti rheumatic drugs was 84%, declining to 73% of patients who “intermittently” saw a rheumatologist. For patients who did not see a rheumatologist, these figures were even lower; 40% of those who saw an internist, and 10% of those following a family physician, were using disease modifying anti rheumatic drugs(15). In this instance, it would appear that patients being unable (or unwilling) to access rheumatology care contributed to the therapeutic failure to maintain guidelines. Fortunately, it does seem as if providers and the BC health system have responded to this problem. A 2017 evaluation of hospitalization rates in gout and rheumatoid arthritis in BC, found that the annual hospitalization rate for rheumatoid arthritis what declined from 15.4 to 7.9 per 100,000 from 2000-2011, a 49% decline that the authors credit in part to improved management strategies for the disease (16). However, the same study identifies that the annual rate of hospitalization for gout double from 3.8 to 7.6 per 100,000 during the same time period, despite effective, available pharmacological options for disease management (16). It is the opinion of Rai et al that, while incidence for gout has increased, much of the inpatient trend is likely due to suboptimal care. Rai et al cited an abstract from the 2014 Boston American College of Rheumatology meeting that claims 89% of hospitalizations with gout as the primary diagnosis were preventable – implying said hospitalizations occurred due to inefficient or inadequate care (16). So it would appear that while strides have been made for some conditions, management of other rheumatic diseases may still lag behind recommended standards of care.

Rheumatology care is often complicated by the impacts of chronic inflammation on other comorbidities, as explored by De Vera et al in a 2011 study of the relationship between statin discontinuation and acute myocardial infarction among rheumatoid arthritis patients in British Columbia(17). Rheumatoid arthritis is a known risk factor for cardiovascular disease, and patients in the study that discontinued statin use experienced a 67% increase in risk of acute myocardial infarction, with the risk of increasing 2% for every one-month off statins (17). This suggests that appropriate management of rheumatic disease likely encompasses more than specifically rheumatologic concerns, with a holistic assessment of patient health, risk factors, and medications required in order to provide the highest quality care.

1.1.4 How would a patient receive rheumatology care?

Maintaining rheumatoid arthritis as my prototypical case, the diagnostic and care pathway would most likely begin with a primary care provider, such as a general practitioner, performing initial, clinical assessment of a patient to determine whether they have clinical features recommending referral to a rheumatologist. It should not be based on the results of lab tests if there are no clinical features recommending referral, as there is no test that can reliably diagnose rheumatoid arthritis(18).

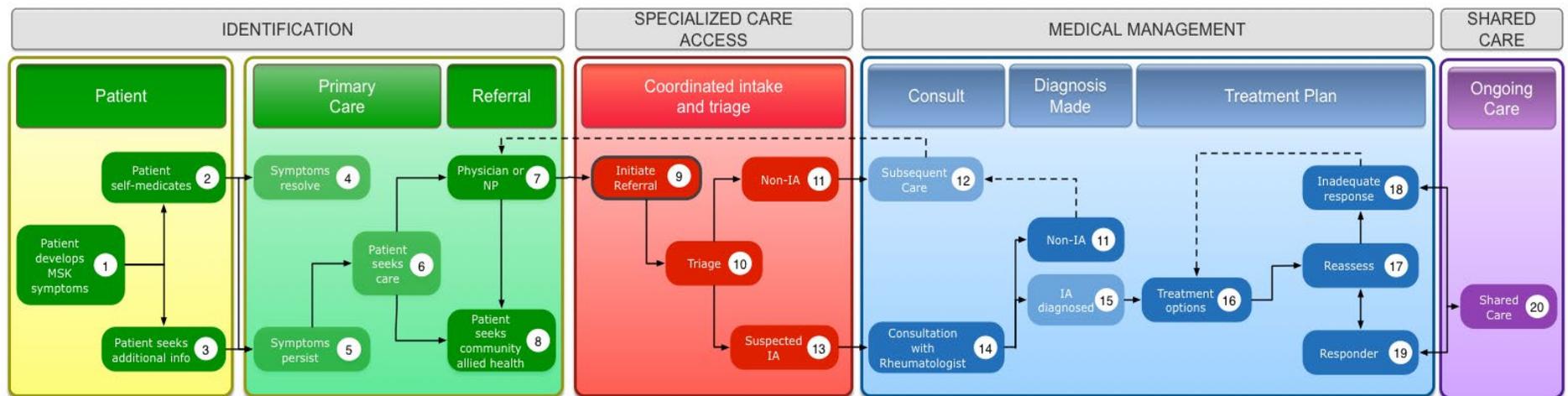
Within British Columbia, rheumatologists primarily work as independent owner-operators of outpatient clinics. Patients visit the rheumatologist at their clinic for a consultation, and are then billed for the services received. In most cases, the billing will be applied to the patient's Medical Services Plan (MSP), British Columbia's public health insurance. All BC residents are required to be enrolled in the Medical Services Plan the under the Medicare Protection Act. The Medical Services Plan covers

all medical procedures and services that are deemed by the Province of British Columbia to be “required care”, which is operationally defined as:

“...medically necessary services provided by physicians and midwives, dental and oral surgery performed in a hospital, eye examinations if medically required and some orthodontic services. In addition, MSP pays for diagnostic services including x-rays.” (19)

For purposes of billing, all procedures recognized as being “required”, or medically necessary, are assigned a code that defines the context of their usage and the amount to be paid for the service. Items given in hospital are considered to be medically necessary, though those same drugs may not be covered outside of that setting – including if prescribed at an outpatient clinic. These list and its details are compiled by the Medical Services Commission and can be viewed on the provincial government’s website(20). A corollary of this is that if any given procedure does not have a code, it could only be undertaken if paid out-of-pocket or by a private insurer. A theoretical framework for the diagnostic and treatment pathway of inflammatory rheumatic disease can be seen in Figure 1.1, used with permission of the Arthritis Alliance of Canada.

Figure 1.1 Ideal care pathway for rheumatic disease diagnosis and management, Arthritis Alliance Canada (21)



There is little practice-level data available to describe the provision and operation of outpatient rheumatology clinics in British Columbia, and Canada more broadly. A 2010 provincial survey in BC identified 49 rheumatologists contributing 32 clinical full-time equivalents (FTE) for a population of over four million. A FTE of 1 for rheumatologist was defined as 5 clinical working days per week. Accounting for FTE, British Columbia had a ratio of 1 rheumatologist for every 140,000 residents, almost half as many rheumatologists the Canadian Rheumatology Association's recommended 1 per 75,000(22). This shortfall is by no means restricted to British Columbia. "Stand Up and Be Counted" was a 2015 workforce survey run by the Canadian Rheumatology association, in response to concerns that policymakers and researchers had insufficient data for workforce planning and assessment in rheumatology(23). This survey found that no Canadian province met the recommended 1 rheumatologist per 75,000 resident ratio. The deficit per province ranged from 1 to 77 full time rheumatologists, with a shortfall of 203 full time rheumatologists nationwide(23). Of the 355 national respondents, 51 rheumatologists from British Columbia participated in this survey, 40 of which indicated they "bill as a rheumatologist" (24). In an average week, British Columbian rheumatologists surveyed conducted 7 (IQR 4-9) half-day clinics, saw 10 (IQR 6-16) new patients, and conducted 40 (IQR 18-61) follow-ups. The number of half-day clinics, used to define clinical FTE, is in line with the national overall average of 7 (IQR 4-8) but lower than the national community-based median of 8 half-day clinics a week (IQR 6-9) (23). Of possible importance to this study is the national median of 2.5 days per week spent on clinical paperwork – a significant portion of time (23). With the introduction of G31060, it is possible that rheumatologists could complete some of this paperwork during the nurse portion of the assessment, or delegate some of this work to nurses, thereby freeing up other time later for additional consultations.

Additional practice level data was reported from the Canadian Council of Academic Rheumatologists in 2014, finding an average FTE of 0.81, of which 0.55 (range 0.15-0.75) was spent on clinical care (22). The approximate 1/3 of time spent on non-clinical duties is significant if true in British Columbia, as it could mean slower uptake of G31060. However, rheumatologists consistently report a lack of access to appropriate allied health professionals as a barrier to rheumatology care, with 57% reporting inadequate access to nurses in a 2013 survey(22). This is encouraging for the uptake of G31060, which is meant to integrate nurses into community practice. The Arthritis Alliance of Canada has proposed that the number of rheumatologists per capita be used as a performance measure for care, but this is stymied by a lack of reporting regarding the regional location of rheumatologists in relation to the population they serve (22). This is unfortunate as data that is available would suggest that there is significant regional and national disparity in access to rheumatology care (22).

1.1.5 Proposed solutions to the challenge of access in British Columbia

In 2011, Kur and Koehler, both rheumatologists with practice experience in BC, suggested three possible approaches to expand the supply of, and thereby access to, rheumatology care in British Columbia (25). First, they suggested improving the remuneration of rheumatologists, claiming that a gap in pay exists between rheumatologists and other specialties. They argued this gap is exacerbated by high overhead costs associated with outpatient practice, and that these financial pressures may drive prospective rheumatologists into other disciplines during training(25). A second suggestion was to expand the number of funded positions for trainees in rheumatology – at the time (2011), only two were available. This study focuses on the impact of their last suggestion - to fund a multidisciplinary model of care for rheumatology in BC. The authors argued that stable funding for multidisciplinary

care would “...increase the ability of the rheumatologist to provide care to a wider spectrum of patients and have an impact on the lengthy waits that exist for access to rheumatology consultation.”(25)

Shifting to a multi-disciplinary model of care has been integrated into rheumatology practice guidelines in Europe and the United Kingdom (26,27). The BC Society of Rheumatologists successfully lobbied the BC Ministry of Health for funds towards the facilitating the new care model identified by Kur and Koehler, resulting in a Medical Services Commission specialty billing code (G31060) that would shift to a multidisciplinary model of care by integrating nurses into rheumatology consultations and follow ups(25). This intervention is the subject of this thesis.

1.1.6 Global evidence in support of multidisciplinary care models for rheumatology

As far back as 2004, The Arthritis and Musculoskeletal Alliance (ARMA) Standards of Care for Inflammatory Arthritis suggested that, during the an initial consultation, “[s]ome of this time may be spent with a specialist nurse ...” and that “[p]eople should be offered the opportunity to talk to a clinical nurse ... in order to enable a more in-depth discussion than may have been possible when the diagnosis was first given.”(28) ARMA’s 2004 Standards of Care are listed as a key resource by the current Royal College of Nursing, demonstrating that these standards have been at least nominally provide guidance for clinical practice(29). These recommendations persist into contemporary National Institute for Health and Care Excellence (NICE) guidelines for the management of rheumatoid arthritis in adults, whose latest guidance makes specific reference to ongoing access to a multidisciplinary team in order to ensure the opportunity for periodic assessment and disease management, using “specialist nurse” as an example(30).

International harmonization regarding the role of nurses in rheumatology appears to have begun around 2010. In 2011, the European League Against Rheumatism (EULAR) task force identified recommendations regarding the role of nursing in managing chronic inflammatory arthritis. Strong evidence was found supporting patient access to a nurse for: education on disease management, improving communication, and continuity and satisfaction with care. High evidentiary support was also found for nurses participating in comprehensive disease management to control disease activity and improve patient preferred outcomes – as well as assessing and addressing psychosocial issues(31). The British Society of Rheumatologists (BSR) guideline for the management of rheumatoid arthritis explicitly outlines multidisciplinary teamwork between doctors, nurses, physical/occupational therapists, pharmacists, and others in the first two years of treatment(32). BSR guidelines for beyond this initial two year period following RA diagnosis do not expand upon this, but clearly exist within a multidisciplinary team framework(33).

In North America, it is unclear to what extent nursing has become a standard part of rheumatology care. A 2014 EULAR multinational evaluation of the management of chronic inflammatory arthritis estimates 37% of US patients had access to nursing care, based on the responses of 19 American individuals(31). The American College of Rheumatology (ACR) 2015 guidelines for the treatment of rheumatoid arthritis do not mention nurses, allied health professionals, or even multidisciplinary care. Discussion of models of care and multidisciplinary teams is similarly absent from the Canadian Rheumatology Association (CRA) recommendations for the treatment of rheumatoid arthritis (34–36). In both countries, pharmacological treatment appears the focus of national-level rheumatology organizations.

Prior to the introduction of the multidisciplinary conference code (G31060), British Columbia seems to recognize that multidisciplinary teams should be a part of care, but had not introduced any mechanisms to promote their use. Patient education materials suggest working with a physiotherapist and/or occupational therapist to help them manage pain(37). Provider guidelines recognize that psychosocial support is necessary and that “[o]ptimal outcome is achieved through a multi-disciplinary approach coordinated by the primary care physician”(12). However, there do not appear to be formal structures defining multidisciplinary team care or the framework in which such a team would operate. Before the introduction of G31060, there was also no funding available for outpatient rheumatology clinics to begin building their own multidisciplinary teams.

In both Europe and the United States, nurses have begun to take on more of leadership role in the multidisciplinary teams that care for rheumatology patients(38). Typically, the role is taken on by Licensed Practical Nurses (LPN) and Registered Nurses (RN), with experience and/or training in rheumatology. Trials in these European nations have suggested that the patient care and level of satisfaction provided by rheumatology nurses could be similar to that provided by a specialist (39–41). I worked with Hall et al in 2018 to summarize the economic evaluation of nurse-supported care across various European countries. The studies we summarized suggested that the cost-effectiveness of nurse-led care varies by the health-system in question – with nurse-led care more effective and less costly than rheumatologist-led care in Denmark but the reverse being true in the United Kingdom. This suggests that the patterns and models of care within a nation may have a significant impact on cost-effectiveness (38). Earlier work by Hall within Canada suggests that Canadians have higher patient satisfaction in collaborative care models which incorporate allied health professionals beyond the physician than physicians working alone (or in teams from their own profession) (42).

1.1.7 The Multidisciplinary Conference for Community-based patients with complex rheumatic diseases (G31060) in BC

In April 2011, the billing code of interest in this thesis, G31060: “Multidisciplinary Conference for Community-based patients”, was approved for coverage by the medical services plan after successful lobbying from the BC Society of Rheumatologists. Also approved as special rheumatology services alongside G31060 were G31050, “extended consultation”, and G31055 “rheumatology immunosuppressant review”. Level and trends of these three codes are evaluated in section 3.1.2, but the introduction of G31060 is the intervention of interest for the purpose of this study.

G31060 is intended “for the ongoing management of complex disorders of the musculoskeletal system where the complexity of the condition requires the continuing management by a rheumatologist”, restricted to rheumatology, once every 6 months per patient, and requires either an LPN or an RN to be present for part of the process(20). It cannot be paid in addition to 31010, 31012, or G31050 (other consultation codes), or 31007 (subsequent office visit). The code also calls for “assessment, written treatment plan, and any other counselling the patient needs for management”, which suggests the code is intended to be used differently than the other special services consultation code, G31050, which calls for “examination, review of history, laboratory, X-ray findings, necessary to initiate care.” That G31060 refers only to “management” while G31050 refers specifically to initiation of care suggests that the former could be used for follow-up as well as initial consultation after referral(3).

For the remainder of this thesis, “multidisciplinary conference code for community-based patients”, “multidisciplinary conference code”, and “G31060” should all be taken to referring to the same billing code.

1.1.8 Assessments of multidisciplinary rheumatology consultations in BC under G31060

A 2014 electronic chart review of three Vancouver, BC rheumatology clinics using the multidisciplinary conference code showed that nurse-supported consults typically involved disease and rheumatic drug counselling, as well as general education – tasks that would traditionally be performed by the rheumatologist alone(43). The majority of patients receiving multidisciplinary care had rheumatoid arthritis (53%), lupus (17%) or connective tissue disorders (17%)(43). Preliminary data from a 2018 BCSR internal survey shows that 66% of BC rheumatologists (51 of 77 respondents) were already using nurse-supported care in their clinics (44).

To date there has been no formal evaluation of how introducing G31060 has impacted rheumatology care on a population level in either grey or academic literature. As the code has significant room for heterogeneity in implementation, how the code may impact care and the magnitude of that impact remain uncertain for BC at this time.

1.2 Research Objectives

1.2.1 What are the aims of the proposed analysis?

This study aims to evaluate the impact on access to rheumatology care of the introduction of the “multidisciplinary conference code for community-based patients” (G31060). My thesis assessed the impact of this change as a natural experiment, analyzed according to two objectives:

- 1) To describe the population of persons living with rheumatic in disease in British Columbia and the patterns of rheumatology care that they receive, both before and after the introduction of G31060
- 2) To evaluate the introduction of G31060 with regard to impact on access to rheumatology care as defined by the number of unique patients treated per month and number of rheumatology service units billed per month

Objective 1 is descriptive analysis and does not involve the testing of a formal hypothesis. It is explored in Chapter 3 of this thesis.

Objective 2 is the primary analysis of this study, explored in Chapter 4. The development of the hypothesis for objective 2 is outlined in section 2.2.6.

1.3 Thesis Outline

The thesis consists of five chapters. This first chapter has introduced the context of rheumatic disease and rheumatology care in BC, and the overall structure for this thesis. The second chapter outlines the methodology used in addressing the aims of this thesis. Chapter 3 addresses aim 1, describing the population of persons living with rheumatic in disease in British Columbia, and the patterns of rheumatology care that they receive. The fourth chapter describes the results of aim 2, examining the impact of the billing code on access to rheumatology care. The fifth and final chapter synthesizes and

summaries my finding in order to discuss their implication for patients, rheumatologists, and the Ministry of Health.

1.4 Disclaimer Statement

All inferences, opinions, and conclusions drawn in the production of this thesis reflect the author, and do not reflect the opinions or policies of the Ministry of Health and their data stewards.

Chapter 2: Methodology

2.1 Data Sources

This study considers entire population of individuals living with rheumatic disease in British Columbia and receiving active rheumatology treatment from April 1st 2009 through to March 31st 2016, and their rheumatologists. It is therefore retrospective, and will use the linkage of routinely collected administrative databases to generate analysis of rheumatology care in British Columbia over the study period. Patient health identification numbers and practitioner numbers will be anonymized.

Data were obtained through Population Data BC, “a multi-university data and education resource that works to facilitate interdisciplinary research on the determinants of human health, well-being, and development.”(45) Population Data BC has existing relationships with both federal and provincial administrative databases that allow the linkage of individual-level, anonymized, longitudinal data on British Columbia’s residents. The linked datasets are then made available on a secure server that approved study members can access through a two-step encrypted Virtual Private Network. For my thesis, I will be using the following data sources:

1) Medical Services Plan Payment Information File (April 1st, 2006- March 31st, 2016)

- Identification of population under study via anonymized unique patient identifier codes associated with rheumatology billing codes and the International Classification of Disease

(ICD) -9/10 diagnostic codes affiliated with those billings (2006-2008 two-year lookback for prevalent cases, 2009-2016 for identification and analysis)

- Assignment of rheumatologists to nurse and status quo arms, as identified by practitioner number and billing patterns
- Assignment to nurse and ‘status quo group’s for patients, as identified by the practitioner number(s) affiliated with rheumatology billings for patient’s unique study identification number in the population
- Computation of number of rheumatology service units billed by practitioners and number of unique patients seen by practitioners

2) Consolidation File (April 01, 2006 – March 31 2016)

- Used to provide descriptive data on the population under study. Available for patients
- Demographic dataset: local health area, health service delivery area, health authority
- Registry dataset: sex, month and year of birth, days registered in Medical Services Plan

2.2 Methods: Preparing for analysis

2.2.1 Preparation of data sources for analysis

Population Data BC provides raw data files in a highly compressed data-format that requires extraction to the desired working data-format and then subsequent “cleaning” of the data for each variable to ensure that it matches the variable-format as described in the data dictionary for that particular dataset

(e.g. character versus numeric, length of variable, easily interpretable dates, interpretable labels for categorical levels). As my thesis work is a portion of a larger, Canadian Institutes for Health Research grant, data files had been extracted and formatted by a statistician (Daphne Guh, Centre for Health Evaluation and Outcome Sciences) prior to my beginning analysis.

During the early stages of analysis, I identified an implausible increase in billing numbers for several years during the study period. We (myself in consultation with my supervisor, Mark Harrison, and the statistician, Daphne Guh) identified these patterns as stemming from how the medical services plan corrects erroneous, cancelled, or unapproved billings. Medical Services Plan data does not remove erroneous or inappropriate billings retroactively, but corrects those billings in one of two ways. Either the initial billing has its number of service units set to 0, or a new billing item is generated with negative service units equal to the number of units billed for in error. In order to ensure accurate counts, the duplications generated by instances of 0 and negative service units have been stripped from the MSP dataset.(46)

2.2.2 Defining the population under study

My study examines all British Columbians living with rheumatic disease identified prior to (prevalent) or during the study (incident), as identified by ICD-9 or ICD-10 diagnostic codes contained in Medical Services Plan billing data, and receiving treatment from a rheumatologist during the study. Rheumatologists were identified using a list containing the practitioner/payee number for all practicing rheumatologists which was submitted to PopData and included in the MSP file as an anonymous provider number. This ensures that I am assessing the impact of introducing nurse-supported consultations on the largest possible number of persons receiving active rheumatology care.

As I hypothesize that G31060 will free up additional rheumatologist time, any patient encounter with a rheumatologist will be included in this study (irrespective of diagnosis). I include any diagnosis because even though the nurse-supported consultation requires an inflammatory diagnosis, the rheumatologist could use the hypothesized time-saved to conduct follow-up with non-inflammatory patients.

To be considered for part of the cohort, patients must have been identified as living with rheumatic or disease either during the lookback period of April 1st 2006-December 31st 2008 or during the study period of April 1st 2009 through March 31st 2016. I use an algorithm designed to identify people living with rheumatic disease that has been validated in prior BC administrative data studies (47–51). This prior research used a three-stage algorithm to confirm diagnosis using ICD-9/10 code:

- 1) The first stage assigns a patient to our population if they have an ICD-9/10 code that identifies a rheumatic disease attached to a billing by a rheumatologist in their Medical Services Plan data.
- 2) Second, any patient in hospital separations data (the nationally collected discharge abstract database) whose discharge data contains an ICD-9/10 code that identifies a rheumatic disease.
- 3) Finally, a patient with two consistent ICD-9/10 codes over a period of greater than two months but less than two years attached to Medical Services Plan billings from a service provider other than a rheumatologist.

For the purposes of my research, I have restricted the full algorithm to only the first stage. This is because my population of interest is individuals living with rheumatic disease and receiving care from

a rheumatologist. While the latter two stages of the algorithm may successfully identify persons with rheumatic disease, those persons may never actually see a rheumatologist during the study period. Consequently, such persons would not be considered part of my population of interest. In the event that an individual who would have been identified by stage two or three does see a rheumatologist, those persons would be identified by the first stage of the algorithm. The complete list of ICD-9/10 codes used is provided in table 2.1 below.

Table 2.1: Identifiable rheumatic diseases and their ICD codes

Rheumatic Disease	ICD Codes	Inflammatory
Rheumatoid arthritis	714.X; M05.X; M06.X	Yes
Systemic lupus erythematosus and other connective tissue diseases	710.X, M30.X - M36.X	Yes
Psoriatic arthritis	696.X, L40.X	Yes
Ankylosing spondylitis	720.X, M45.X	Yes
Juvenile idiopathic arthritis	714.X, M08.X, M09.X	Yes
Gout	274.X, M10.X	Yes
Systemic vasculitis	446.X, M31.X	Yes
Soft tissue pain	729.X, M79.X	No
Osteoporosis	733.X, M81.X	No
Osteoarthritis	715.X, M19.X	No
Back pain	724.X, M54.X	No
Tendonitis	729.X, M79.X	No
Joint issues	719.X, M79.X, M25.X	No
Crystal arthritis	712.X	No

2.2.3 Identifying rheumatologists and rheumatology billings

The Medical Services Commission fee schedule divides possible “necessary” medical interventions and their respective fee codes into specialty disciplines. Fee codes specific to a given specialty are only billable by practitioners with that specialty. In this study, “rheumatology billings” refers to billings in

MSP data whose fee code corresponds to services listed under “rheumatology” in the Medical Services Commission fee schedule. A complete list of rheumatology fee codes is provided in table 2.2 below. In MSP datasets, each rheumatologist is assigned a unique identifier for billing purposes. For this study, those have been anonymized into unique “practitioner numbers”. These are used to track individual rheumatologist billings in the data, and the ‘nurse group’ or ‘status quo group’ designation is tagged to those practitioner numbers.

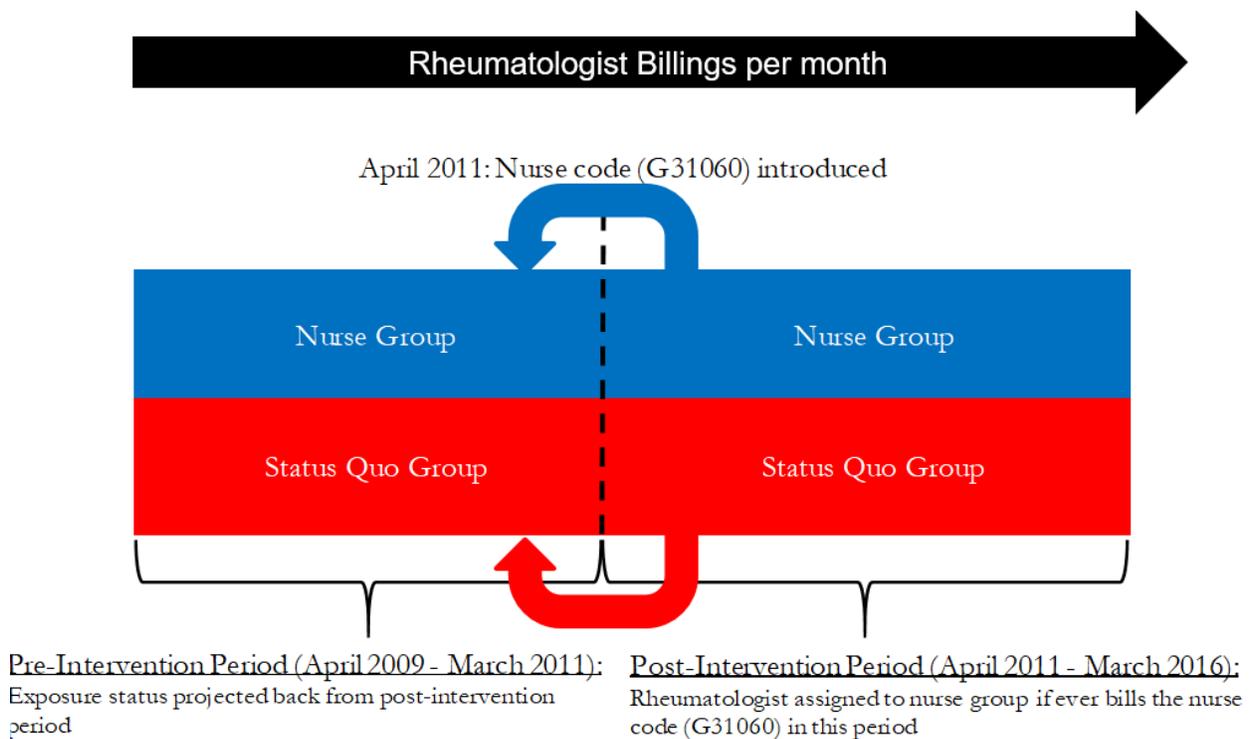
Table 2.2 Rheumatology services under the British Columbia Medical Services Plan

Category	Code	Service
Continuing Care	31005	Emergency visit when specifically called
	31006	Directive Care
	31007	Subsequent office visit
	31008	Subsequent hospital visit
	P31015	Rheumatology management of complex joint(s) requiring aspiration and/or injection
Referred Cases	31010	Consultation
	31012	Repeat or limited consultation
	31014	Prolonged visit for counselling
Telehealth	31106	Telehealth directive care
	31107	Telehealth subsequent office visit
	31108	Telehealth subsequent hospital visit
	31110	Telehealth consultation
	31112	Telehealth repeat or limited consultation
Special Services	G31050	Extended consultation
	G31055	Rheumatology immunosuppressant review
	G31060	Multidisciplinary conference for community-based patients

2.2.4 Defining the intervention (“nurse”) and comparator (“status quo”) groups

For this study, I treat rheumatologists who bill for the nurse-supported consultation fee code, G31060, as my intervention group, and rheumatologists who never use G31060 as my comparator group. My intervention group is hereafter known as the ‘nurse group’, and my comparator group hereafter as the ‘status quo group’. After the introduction of G31060 in April 2011, any rheumatologist who uses that code once at any point during the remaining study period is considered to be a nurse-group rheumatologist. Assignment to the ‘status quo group’ is then a negative definition, with status-quo rheumatologists being those that never bill G31060. See figure 2.1 for an overview of the study groups and their assignment over the study period.

Figure 2.1 Overview of time-periods, intervention, and comparator group



2.2.5 Defining “access” in the context of British Columbian rheumatology care

Rheumatology care: All services listed under the rheumatology section(s) of either the standard or specialist Medical Services Commission payment schedule (see table 2.2) are considered “rheumatology care” for the purposes of this study.

Access: From a population perspective, impacts on access are likely best understood as change in the rate of utilization. A given level of billing or number of patients seen does not, in itself, say much about access. However, when that level shifts in response to policy, it is reasonable to state that access “increased” if the rate of billing increases, and “decreased” if the rate of billing decreased. What has shifted is the level of “reasonable access” possible under the health system(52). Reasonable access in terms of physical availability of medically necessary services has been interpreted under the Canada Health Act using the “where and as available” rule. Thus, residents of a province or territory are entitled to have access on uniform terms and conditions to insured health services at the setting “where” the services are provided and “as” the services are available in that setting.” (52) Given the hypothesized impacts of introducing G31060, this study will measure access two ways: (1) the number of rheumatology service units, and (2) the number of unique rheumatology patients seen, both per month. This ensures I capture both access of the same individuals to a wider range of, or more frequent care, and also the increased pool of individuals able to access rheumatology care.

2.2.6 Hypothesized impact on access to rheumatology care

The multidisciplinary conference code requires that both a nurse and a rheumatologist participate in the consultation, but it does not define specific roles or time allotment to those roles(3). This permits wide variation in models of care. One could imagine nurses independently conducting segments of the consultation, such as assessment or education, and then bringing in the rheumatologist for final discussion and decision making. However, more restrictive roles where nurses perform fewer tasks, perhaps even seeing the patient at the same time as the rheumatologist may also be utilized. In the former, the potential impact on access is that during this nurse-supported portion of the consultation, the rheumatologist could be using that time to see other patients or catch up on other administrative work. I would expect that this allows rheumatologists to perform more tasks within their clinic, and consequently I anticipate that the number of billings per month should increase. If a standard consult is approximately 60 minutes and the nurse performs patient assessment and education, the rheumatologist could be out of the room for half an hour or more. Assuming the rheumatologist also sees those with well-managed disease for follow up, those patients could be seen under billing code 31007 (subsequent office visit) essentially parallel to multidisciplinary conference. In the latter case, it seems probable that access is unchanged from the status quo, as no additional rheumatologist time is “freed up”. It may, however, facilitate or normalize the 6-month cycle of follow-up for complex patients. If such patients are normally only seen annually, the shift in care to a 6-month cycle as described in G31060 would still constitute an expansion of access.

I am basing this expectation on the theoretical framework of physician utility outlined by Chandra and Skinner in their discussion of Technological Growth and Expenditure Growth in health care (53). In brief, this framework treats physician utility as derived both from their own remuneration and the

utility of their patients, as measured by health gains experienced while under the care of the physician. This model allows for altruistic behavior by physicians, and an explanation for behaviors beyond profit-maximization in their billing activity.

2.3 Methods: Descriptive statistics

The population that met inclusion criteria for this study will be characterized by number, rheumatic condition, sex, health authority, age, rurality, income, and death. Continuous numeric variables will be described by mean and standard deviation or median and interquartile range. Categorical variables will be summarized by N and proportion of the population or subgroup under analysis.

Trends in billing will be analyzed over time in a stepwise manner from the largest billings into overall service categories, with a focus on special services billing – to which G31060 belongs. These trends will be shown both in absolute (total) and relative (proportional) terms. Rheumatologist entry and exit from billing in Medical Services plan will tracked over time, both overall and stratified by group. I will compute frequency tables for the number of rheumatologists that patients see in each calendar year of the study period. This will also be done for the primary cohort, stratified by group assignment. I will also use frequency tables to evaluate the number unique rheumatology service days per patient for each calendar year of the study. This will also be done for the primary cohort, stratified by group assignment.

The primary cohort will be summarized by the same characteristics as the population, with testing for statistically significant differences between ‘nurse’ and ‘status quo’ groups. Two-sample t-tests will be

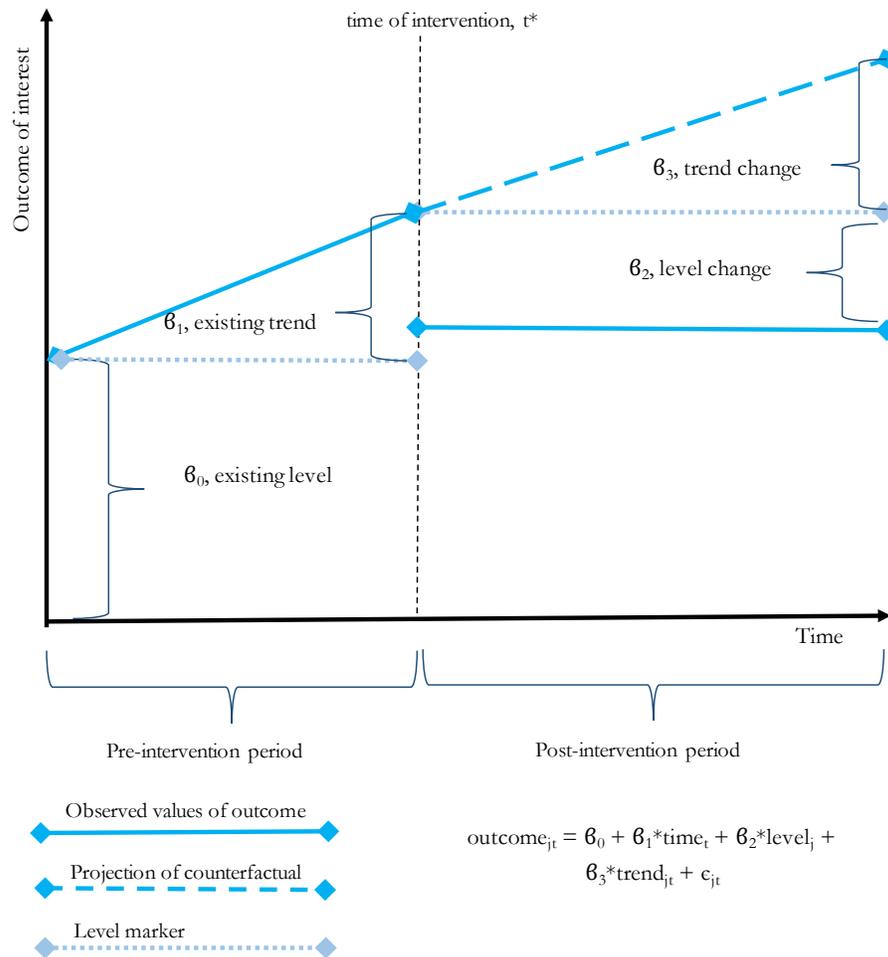
used for continuous numeric variables, and chi-squared tests for categorical variables where appropriate.

2.4 Methods: Interrupted Time Series with Comparator

2.4.1 Simple Interrupted Time Series

My analytical approach to explore the impact on access of introducing nurse-supported consultations via G31060 will use comparative interrupted time series. It will utilize a bespoke dataset from Population Data BC. This approach is an extension of multilinear regression analysis, specifically time series analysis. The basic principle of an interrupted time series is that if I know when a given intervention or policy change has taken place, I can estimate the impact of that change by fragmenting the time-series data into pre- and post-intervention periods around the date of intervention. This facilitates modelling of a counterfactual, or what would have been expected had the change not occurred. The counterfactual is then compared to the observed post-intervention data. The difference in how level (magnitude on the y-axis) and trend (the slope of the line) change between the counterfactual and observed data provide our estimates of the policy's effect. Standard interrupted time series projects the pre-intervention period level and trend into the post-intervention period to generate the counterfactual, which is then compared to the post-intervention observed values(54). Figure 2.2 illustrates a simple interrupted time series.

Figure 2.2 Relationship of regression coefficients to plot, simple interrupted time series



The components of the interrupted time series equation are:

- outcome, measure of access (monthly number of rheumatology service units or unique patients per month)
- time, is a discrete numeric variable that counts the number of time periods elapsed from the beginning of the study (e.g. $t=1$ indicates the first time period of the study, $t=2$ indicates the second, & etc.)
- level, indicator variable for level change post-intervention. Takes value of 1 in post intervention period, 0 otherwise

- trend, is a discrete numeric variable that counts the number of time periods elapsed from the introduction of the intervention (e.g. trend=1 indicates the first time period of the study post-intervention, t=2 indicates the second, & etc.)

Note that all coefficients should be interpreted as the average magnitude of an effect. The estimates (β) from the model are as follows:

- β_0 is the y-intercept of the regression line, and the value of y at time 0 in the pre-period
- β_1 is the effect on y of moving forward one period in time, on average. The “pre-trend”.
- β_2 is the effect on y of moving from the pre to post-intervention period, the “level change”.
- β_3 is the interaction of moving forward in time in the pre-period vs the post-period, the “trend change”

The key variables of interest for standard interrupted time series are β_2 and β_3 . These reflect how the existing level and trend change, respectively, when moving from pre- to post-intervention periods.

2.4.2 Interrupted time series with comparator

In a complex system such as healthcare there may be several effects either ongoing, beginning, or ending that would also impact access to rheumatology care in parallel with the multidisciplinary conference code. As a hypothetical example, if the Medical Services Commission revised the rheumatology code for subsequent office visits (31007) so that it was capped at two uses per patient per year, we may anticipate a reduction in access for patients seeking follow up appointments with rheumatologists. The introduction of this cap on the number of follow up appointments per patient

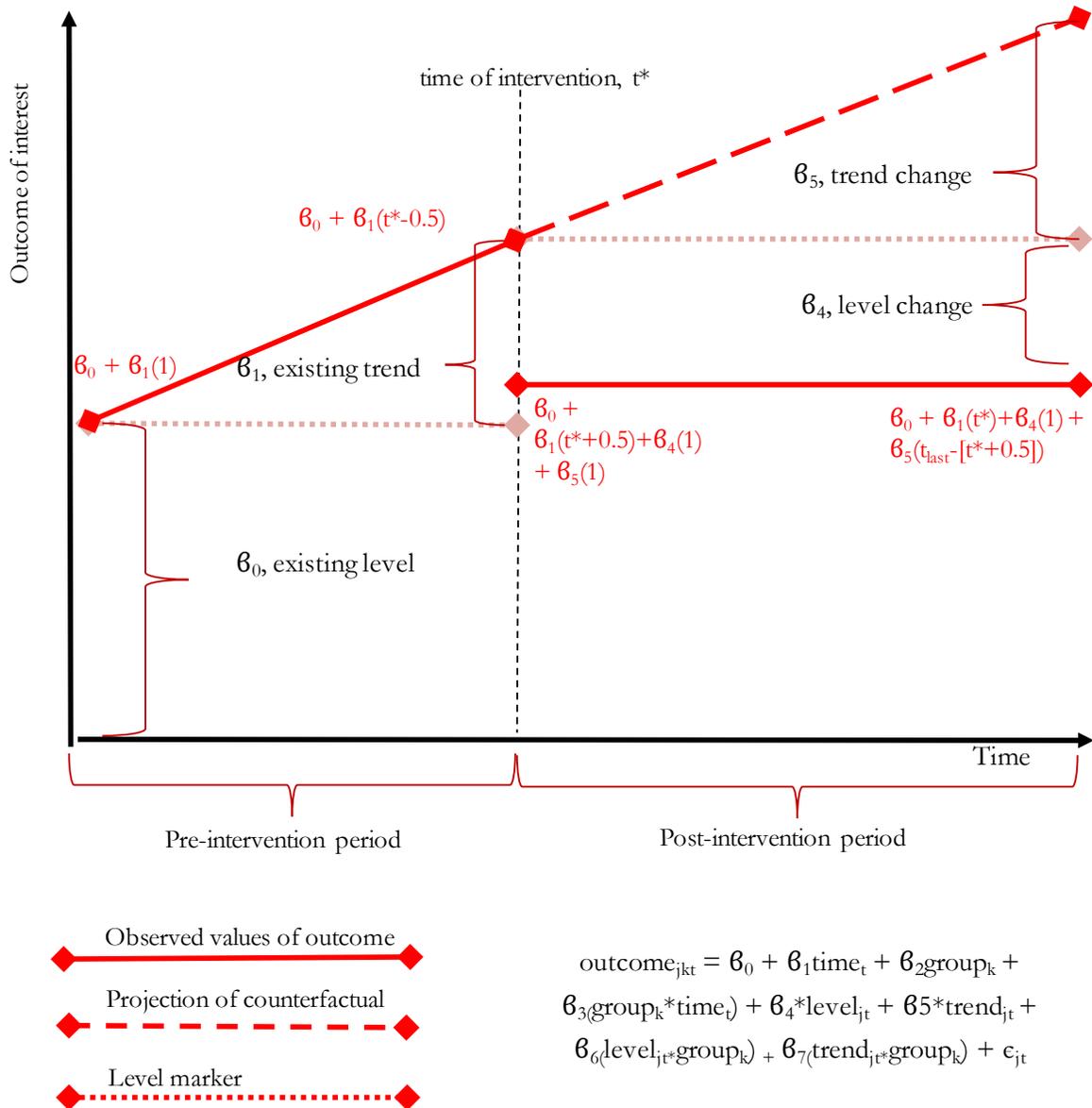
per year would affect both rheumatologists using nurses and those that do not. Assuming the restriction of 31007 occurred around the same time as the introduction of G31060, standard interrupted time series would only show me the net effect of the two policies without being able to isolate any impact on access attributable to the introduction of nurse-supported consultations.

However, by expanding the standard interrupted time series to include a comparator group, I can mitigate the effect of factors other than the intervention of interest. An appropriate comparator group is one that would *not* be affected by the policy of interest, but *would* plausibly be affected by the same cluster of shocks and trends as the intervention group (55). As the comparator group should not have been affected by the introduction of this policy, this gives us a more accurate estimate of the policy-effect, as it models what would have happened absent the intervention.

For this study, I treat rheumatologists who bill for the multidisciplinary conference code, G31060, as my intervention group, and rheumatologists who never use G31060 as my comparator group. While both groups would be affected by a secular trend or history shock, such a restriction on the number of follow ups per patient per year, only the intervention group is affected by the introduction of G31060. The comparator group persists in status quo rheumatology care during and after the policy change. As observed values of the comparator in the post-intervention period are theoretically unaffected by the intervention of interest, we use them to model the counterfactual. The observed values of my comparator group should reflect the impact of shocks and/or existing trends that, while unrelated to the intervention of interest, my intervention group would also be exposed to. This allows us to “net-out” the effect of those factors when comparing the intervention group post-intervention with the counterfactual, the resulting difference attenuated to the effect of the policy. Figure 2.3 illustrates the modelling of the comparator group, note the similarity to the simple case presented in

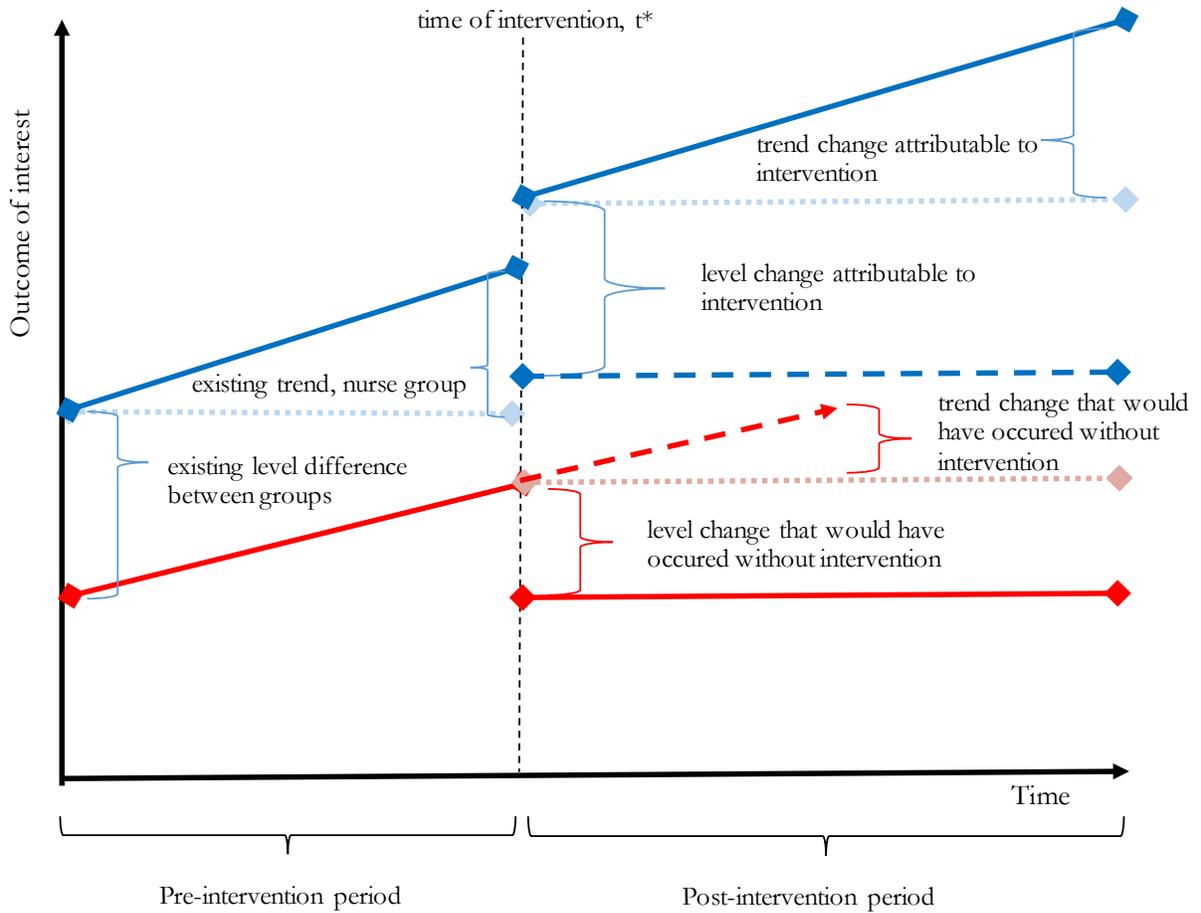
Figure 2.2. Figure 2.4 then demonstrates how the counterfactual from the comparator is used to generate estimates of the intervention effect for the study.

Figure 2.3 Relationship of regression coefficients to plot of comparator ('status quo group')



$$\text{outcome}_{jkt} = \beta_0 + \beta_1 \text{time}_t + \beta_2 \text{group}_k + \beta_3 (\text{group}_k * \text{time}_t) + \beta_4 * \text{level}_{jt} + \beta_5 * \text{trend}_{jt} + \beta_6 (\text{level}_{jt} * \text{group}_k) + \beta_7 (\text{trend}_{jt} * \text{group}_k) + \epsilon_{jt}$$

Figure 2.4 Relationship of regression coefficients to plot, comparator vs intervention groups



- Observed values of outcome
- Projection of counterfactual
- Level marker

$$\text{outcome}_{jkt} = \beta_0 + \beta_1 \text{time}_t + \beta_2 \text{group}_k + \beta_3 (\text{group}_k * \text{time}_t) + \beta_4 * \text{level}_{jt} + \beta_5 * \text{trend}_{jt} + \beta_6 (\text{level}_{jt} * \text{group}_k) + \beta_7 (\text{trend}_{jt} * \text{group}_k) + \epsilon_{jt}$$

Nurse Group
 Status Quo Group

The components of the interrupted time series with comparator equation are:

- outcome, our measure of access, as in standard interrupted time series
- time, is a discrete numeric variable that counts the number of time periods elapsed from the beginning of the study (e.g. $t=1$ indicates the first time period of the study, $t=2$ indicates the second, & etc.) time
- group, a categorical variable with unique levels for each of the different groups under analysis, for this study $k=0$ describes the ‘status quo group’, and $k=1$ describes the ‘nurse group’
- level, indicator variable for level change post-intervention. Takes value of 1 in post intervention period, 0 otherwise
- trend, is a discrete numeric variable that counts the number of time periods elapsed from the introduction of the intervention (e.g. $trend=1$ indicates the first time period of the study post-intervention, $trend=2$ indicates the second, & etc.)

As with standard interrupted time series, all coefficients should be interpreted as the average magnitude of an effect. The estimates (θ) from the model are as follows:

- β_0 , is the value of outcome at time 0 in the pre-intervention period
- β_1 , is the effect on the outcome of shifting from the comparator to intervention group
- β_2 , is the “pre-trend” from standard ITS, draws from both groups
- β_3 , is the interaction of time and being in the intervention group, the “pre-trend” specific to the intervention group

- β_4 , the level change that occurs moving from the pre- to post-intervention periods, estimate computed from observations in both groups
- β_5 , the trend change that occurs moving from the pre- to post-intervention periods, estimate computed from observations in both groups
- β_6 , the interaction of moving from pre to post and being in the intervention group. The level change associated with being in the intervention group
- β_7 , the interaction of time, moving from pre to post, and being in the intervention group. The trend change associated with being in the intervention group

The key estimates for interrupted time series with comparator are β_6 and β_7 , as they tell us the level change and trend change specific to the intervention group, respectively. These estimates are, in turn, interpreted as the average level change and average trend change attributable to the intervention (the billing code reflecting nurse involvement in rheumatology care).

2.4.3 Time series and adjusting for autocorrelative processes

Multiple linear regression typically uses the “Ordinary Least Squares” method to compute the estimates of regression coefficients. This method has four core assumptions. First, that the relationship between the outcome and explanatory variables is linear. Second, the error term for any given set of values for explanatory variables is independent of the error for any other given set. Third, that the distribution of those error terms is normally distributed. Fourth and finally, that those error terms have the same variance for any given values of the explanatory variables. The assumptions underpinning ordinary least squares regression should be tested and verified for any regression model, however, time-series regression in particular is likely to violate them.

The reason that time-series analysis is prone to break the assumptions of ordinary least squares regression is because a time-series uses the passage of time itself as a key explanatory variable. In time-series analysis, we are tracking the impact of the same set of observation-generating process on our outcome over time. In this study, I am analyzing the billing activity of a set of rheumatologists from month to month over the study period. The notion that the billing activity of a given rheumatologist in this month (time t) may be well predicted by their billing activity in prior month (time $t-1$) seems reasonable barring a massive shock in the interim. Unfortunately, the existence of this pattern within billing activity month-to-month implicitly violates the ordinary least squares assumption of independence of errors. The notion that month-to-month billings may be correlated is a fairly straightforward example of how ordinary least squares assumptions may break in the time-series context. However, there are a number of ways that prior outcomes may be correlated to the present, or that the error of our current measure may be correlated with prior errors. These sorts of relationships fall under the umbrella of “autocorrelation”, the correlation of future values of a regression variable with its past values. Failing to identify and adjust for these broken assumptions renders the estimates of regression coefficients generated by ordinary least squares method unreliable (56).

In this study, I have used the Durbin-Watson test to identify the presence of autocorrelation. The Durbin-Watson test assumes that the error of time t can be described as a linear product of prior error terms ($\epsilon_t = a \epsilon_{t-1} + v_t$) and constructs the following test statistic:

$$d = \frac{\sum_{t=2}^T (e_t - e_{t-1})^2}{\sum_{t=1}^T e_t^2}$$

The null hypothesis is that the Pearson correlation between the residual of the current period (e_t) and the residual of the prior period (e_{t-1}) is 0, indicating that there is no autocorrelation, and the alternative that it is non-zero, indicating that there is autocorrelation. The equation above is a test for autocorrelation at one “lag”, one time period into the past, but Durbin-Watson can be run for any number of lags (56). In my analysis, I test lags from 1 to 12, or one month in the past to 12 months into the past. The decision of how many lags to evaluate is a judgement call based on contextual understanding of the data under analysis. The rule of thumb is that one should only test for (or up to) the number of lags for which there is a reasonable explanation of what may lie behind the autocorrelation. Lags were consequently capped at 12 (representing 12 months into the past) as it is not clear what process would drive correlation between billings more than a year apart in a way not explained by fluctuations within a year-long period.

Once detected, one must determine the form of autocorrelation in order to determine how to adjust the model. This can be done by plotting the autocorrelation function against lagged terms. The autocorrelation function contains the complete set of correlations between terms across time. This includes the correlation moderated by intermediate terms. For example, if X_t is correlated with X_{t-1} , and X_{t-1} is correlated with X_{t-2} , then there will be a transitive component of correlation between X_t and X_{t-2} . The plot of this function is used to identify the “moving average” (MA) processes of the ARMA (AutoRegressive Moving Average) model used to adjust for autocorrelation. To identify the “autoregressive” processes (the AR), we plot the *partial* autocorrelation function for various lags. The partial autocorrelation function contains only the direct correlations between terms at different times, without the moderated correlation being based through subsequent intermediate terms. For both plots, one looks for the largest “spike” in correlation at a given lag followed by geometric decay in

correlation. The spike tells us the “order” of the MA and AR processes, identified as q and p respectively(57).

Moving Average Process:
$$X_t = \mu + \varepsilon_t + \theta_1 \varepsilon_{t-1} + \dots + \theta_q \varepsilon_{t-q} \quad \varepsilon_t \sim \text{iid}(0, \sigma^2)$$

For a moving average process of order “ q ”, the value of X at time t can be described as a sum of: 1) the mean of the series, 2) the value of the residual at time t , 3) the values of prior residuals multiplied by a time-specific constant for all $t-1$ to q . In other words, the value of X at time t under a moving average process order q is a linear combination of the value of residuals from time t back to time $t-q$. In simplest terms, the value of X at time t is dependent on the *residuals* of prior time periods.

Autoregressive Process:
$$X_t = c + \sum_{i=1}^p \varphi_i X_{t-i} + e_t \quad e_t \sim \text{iid}(0, \sigma^2)$$

For an autoregressive process of order “ p ”, the value of X at time t can be described as a sum of: 1) a constant associated with X at time t , 2) the values of X in prior time period $t-1$ to p , multiplied by a time-period specific constant, and 3) the residual at time t , treated as white noise. In other words, the value of X at time t under an autoregressive process order p is a linear combination of the prior values of X from time $t-1$ back to time $t-p$. In simplest terms, the value of X at time t is dependent on the prior values of X up to p periods in the past.

2.4.4 Predicting absolute and relative change

In the context of this study, absolute and relative change is based on the difference in the outcome's observed values as compared to the counterfactual. The "change" is the difference between the outcome value that I observe post-intervention, and what I expect the outcome's value would have been had the intervention not occurred.

Absolute change is calculated by subtracting the computed value of the counterfactual at a given time point from the fitted (or predicted) values of the intervention group from the model at the same time:

$$\Delta\text{absolute}[t] = \text{predicted}[t] - \text{counterfactual}[t]$$

Relative change is the conversion of the absolute measure into percentage change. To do so we divide absolute change by the counterfactual at the same time point. (58)

$$\Delta\text{relative}[t] = \text{absolute}[t]/\text{counterfactual}[t]$$

Relative change is most salient when it would be misleading to measure change purely on magnitude. If we were comparing the impact of several different interventions, the populations affected by those interventions may differ in size. The magnitude of those populations will necessarily be reflected in the estimated absolute change. Let us take two hypothetical policies to expand access to rheumatology care in BC. Policy X is designed in such a way that it would affect 100,000 individuals, and results in 500 more unique patients seen at time t than would have been seen had the intervention not taken place. Policy Y is designed to affect 10,000 individuals, and results in 80 more unique patients being

seen at time t than would have been seen had the intervention not taken place. Absolute change would show 500 more unique patients for Policy X and only 80 more unique patients for Policy Y at the same point in time, which implies that X is superior. However, when accounting for the size of population affected, policy Y is almost twice as effective. The relative importance of absolute versus relative change depends on the question one is aiming to answer, and the context in which one is operating. Reporting only one of the two may be misleading, and so both must be considered in combination within the greater context of the research question.

2.5 Cohort specifications

The primary cohort considers all rheumatologists who are actively billing throughout the study period. In other words, the cohort of rheumatologists is longitudinal (or closed) for the study period. This is to ensure that we have observations of billing patterns both prior to and after the introduction of G31060, and that those observations are taking place over the same amount of time. Rheumatologists are assigned to the nurse (intervention) group if they *ever* billed G31060 in the post-intervention period, as it indicates that they had a nurse working in their practice, and to the status quo (comparator) group if they never billed this code. This gives us the most comprehensive view of the impact of the introduction of G31060 on access at a population level, but has caveats. First, interrupted time series with comparator requires longitudinal data. Therefore, I can only analyze data produced by the subset of rheumatologists who are active during the entire study period. This will necessarily only be a portion of all rheumatologists practicing within British Columbia during the study period. Consequently, while the interrupted time series with comparator method provides strong internal validity, my analysis is not necessarily reflective of all rheumatology practice in British Columbia. Secondly, the criteria for

assigning a rheumatologist to the ‘nurse group’ is quite inclusive. That a rheumatologist uses a nurse at least once during the post-intervention period does not mean that they use nurses on a consistent basis. Even among rheumatologists who do use nurses consistently, the frequency at which nurse-supported consultations are utilized may vary substantially from practice to practice. This heterogeneity in how, and how frequently, G31060 is utilized within the ‘nurse group’ of rheumatologists may add significant noise to my estimate of how nurse-supported consultations impact access to rheumatology care.

2.5.1 Sensitivity Analysis of interrupted time series specification

In order to determine whether, and to what degree, my estimates are distorted by this heterogeneity within nurse group rheumatologists, I generated two alternative cohorts that vary the criteria by which a rheumatologist is assigned to the ‘nurse group’ (table 2.3). The first restricts the nurse group to those rheumatologists billing for G31060 at least once in each calendar year of the study period, as a check on “consistent” use of nurses. The second identifies “high-intensity” users of G31060, defined as rheumatologists who average 30 or more service units of G31060 per month over the study period, as a check on how frequency of nurse-supported consultations may impact access.

Table 2.3 Summary of criteria for inclusion to ‘nurse group’ by cohort specification

Cohort	Criteria for rheumatologist to be assigned to nurse group			
	Active full study period	Bill ≥ 1 units of G31060	Bill G31060 in every possible year	Bill ≥ 30 units of G31060 per month, on average
Primary	✓	✓	x	x
Consistency	✓	✓	✓	x
High-Intensity	✓	✓	✓	✓

Chapter 3: Characterizing the population of individuals with rheumatic disease and patterns of rheumatology care in British Columbia

3.1 Results

3.1.1 Characteristics of the population of individuals with rheumatic disease in British Columbia

Using the algorithm described in 2.2.3, 152,251 individuals with rheumatic disease and actively under care of a rheumatologist were identified during the period of 2009-2016. Table 3.1 outlines the characteristics of this population. Most of these patients are identified as having non-inflammatory conditions (55%). The second most likely diagnosis was rheumatoid arthritis (22%), followed by connective tissue disorders (7%), ankylosing spondylitis and psoriatic arthritis (both 5%), and all other rheumatic diseases with less than 5% per condition. The population is heavily urban (72%), and concentrated in Fraser and Vancouver Coastal health authorities (35% & 28% respectively). Those health authorities are also the largest two in the 2011/2012 BC Auditor General's report (59). Estimates of prevalence have been computed in table 3.2 using the 2009 population of British Columbia, sourced from the government of British Columbia statistics. As there may be individuals with rheumatic disease who are not, or were not, undergoing active rheumatology care during the study and lookback period, these estimates are likely conservative. For rheumatoid arthritis, the estimates appear to be approximately accurate (753 per 100,000 in study population versus the

common figure of ~1%, or 1,000 per 100,000). Estimates of the prevalence of other rheumatic disease, such as gout, seem lower than expected. It may be the case that individuals with long-term gout receive care through their primary care provider rather than a rheumatologist, in which case they would not have been captured by our inclusion algorithm. Comparison of the prevalence of each condition to other Canadian markers is difficult due to heterogeneity in methodology and varying definitions for combining or splitting rheumatic disease categories.

Table 3.1 Characteristics of the population of individuals with rheumatic disease in British Columbia

	Population Summary	N	%	
Unique Patients	N	152,251	100%	
Condition	Non-inflammatory	83,763	55%	
	Rheumatoid arthritis	33,197	22%	
	Connective tissue disorders	11,307	7%	
	Ankylosing spondylitis	7,909	5%	
	Psoriatic arthritis	7,075	5%	
	Gout	4,183	3%	
	Systemic lupus erythematosus	4,281	3%	
	Systemic vasculitides	806	1%	
	Sex	Female	103,924	68%
		Male	48,589	32%
Health Authority	Fraser	53,926	35%	
	Vancouver Coastal	42,575	28%	
	Interior	27,688	18%	
	Vancouver Island	24,894	16%	
	Northern	2,814	2%	
	Unknown or Missing	270	0%	
Age	Median	56		
	Interquartile Range	67 - 45		
Urban/Rural	Urban	109,260	72%	
	Rural	20,845	14%	
	Missing or Unknown	22,059	14%	
Income Quintile	1 - Highest	30,014	20%	
	2	30,156	20%	
	3	30,174	20%	
	4	29,828	20%	
	5 - Lowest	30,361	20%	
	Missing or Unknown	1,525	1%	
Death	No	142,265	93%	
	Yes	10,256	7%	

Table 3.2 Estimated prevalence per 100,000 of rheumatic disease by category

Rheumatic disease	Prevalence per 100,000*
Non-inflammatory	1,899
Rheumatoid arthritis	753
Connective tissue disorders	256
Ankylosing spondylitis	179
Psoriatic arthritis	160
Systemic lupus erythematosus	97
Gout	95
Systemic vasculitides	18

* Based on the 2009 population of British Columbia: 4,410,506(60)

3.1.2 Patterns of rheumatology service provided in British Columbia, 2009-2015

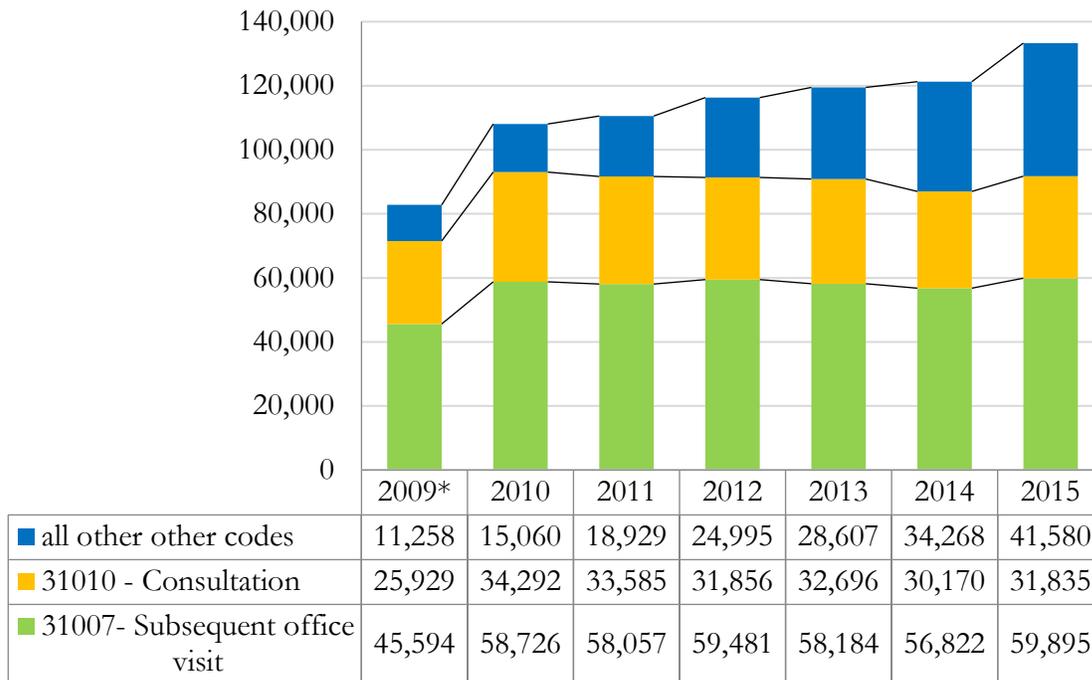
Evaluating the number of service units billed for each rheumatology service reveals two predominant, or “core”, services provided by rheumatologists. Figure 3.1 shows the absolute counts of rheumatology billings for those two codes and the aggregation of all other codes, while figure 3.2 shows the proportion of total billings that each core code and the aggregation of all other codes constitute in each time period. The first core code is the “subsequent office visit” (31007), used as follow-up for established patients in a rheumatology practice, and constituting 45-55% of all rheumatology billings in each calendar year. While the absolute number of 31007 billings increases from 45,594 in 2009Q2-Q4 to 59,895 in 2015 (figure 3.1), its share of total rheumatology billings proportionally declines from 55% in 2009Q2-Q4 to 45% in 2015 (figure 3.2).

The second is “consultation” (31010), used for the first meeting with a newly referred patient. While the absolute number of 31010 billings increases from 25,929 in 2009Q2-Q4 to 31,835 in 2015 (figure

3.1), its share of total rheumatology billings proportionally declines from 30% in 2009Q2-Q4 to 25% in 2015 (figure 3.2).

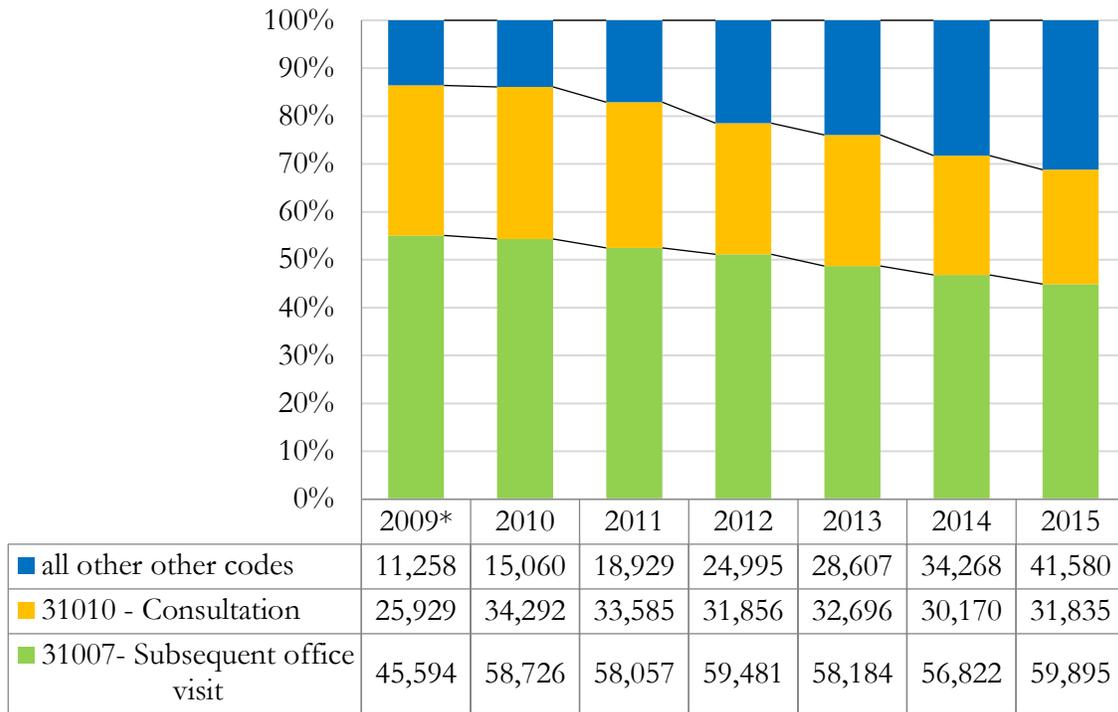
The aggregation of all other billings only constitutes around 15% in 2009 and 2010, but grow steadily from 2011 to become 30% of all rheumatology billings by the end of the study period (figure 3.2). This suggests that while 31007 and 31010 grow in absolute terms, other billings are increasingly being substituted for the core codes as the time progresses.

Figure 3.1 Core rheumatology services versus others over time, number of billings



*2009 only contains data from Q2-Q4

Figure 3.2 Core rheumatology services versus others over time, proportion of total number of billings

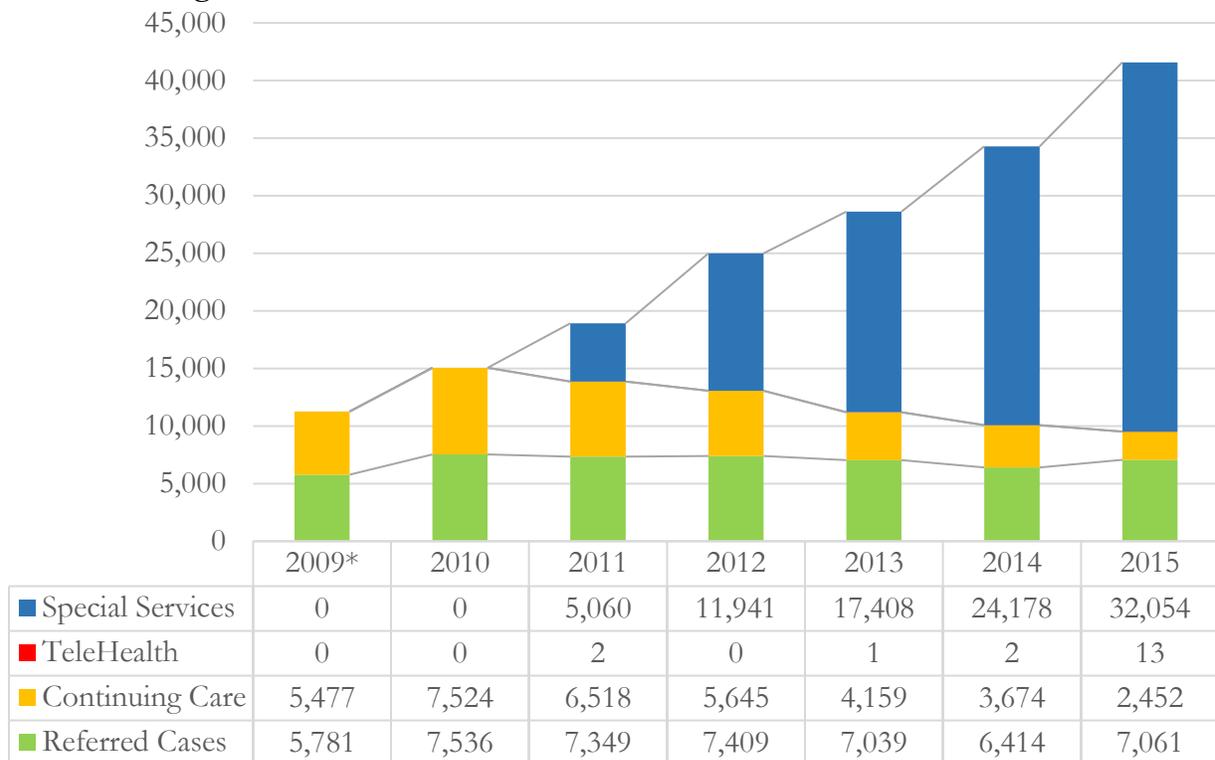


*2009 only contains data from Q2-Q4

A more granular investigation of “all other billings” was warranted to explore their expansion. These billings were broken down by the category of service, according to the medical services commission fee schedule for rheumatology: The fee schedule breaks rheumatology codes into four categories: “referred cases”, “continuing care”, “telehealth”, and “special services.” (3) The core consultation code, 31010 is technically categorized as “referred cases”, the category of codes to be billed for newly referred patients. However, it has been excluded from the analysis of “all other billings”, as its magnitude would overwhelm the other codes and render it impossible to determine trends of less frequently billed codes. The core follow-up code, 31007, is technically categorized under “continuing care”, the category of codes to be billed for established patients. It has also been excluded from the analysis of all other billings, for the same reason as 31010 – the volume of billing is so much larger than other codes of its kind that it would impede the ability to make any inferences.

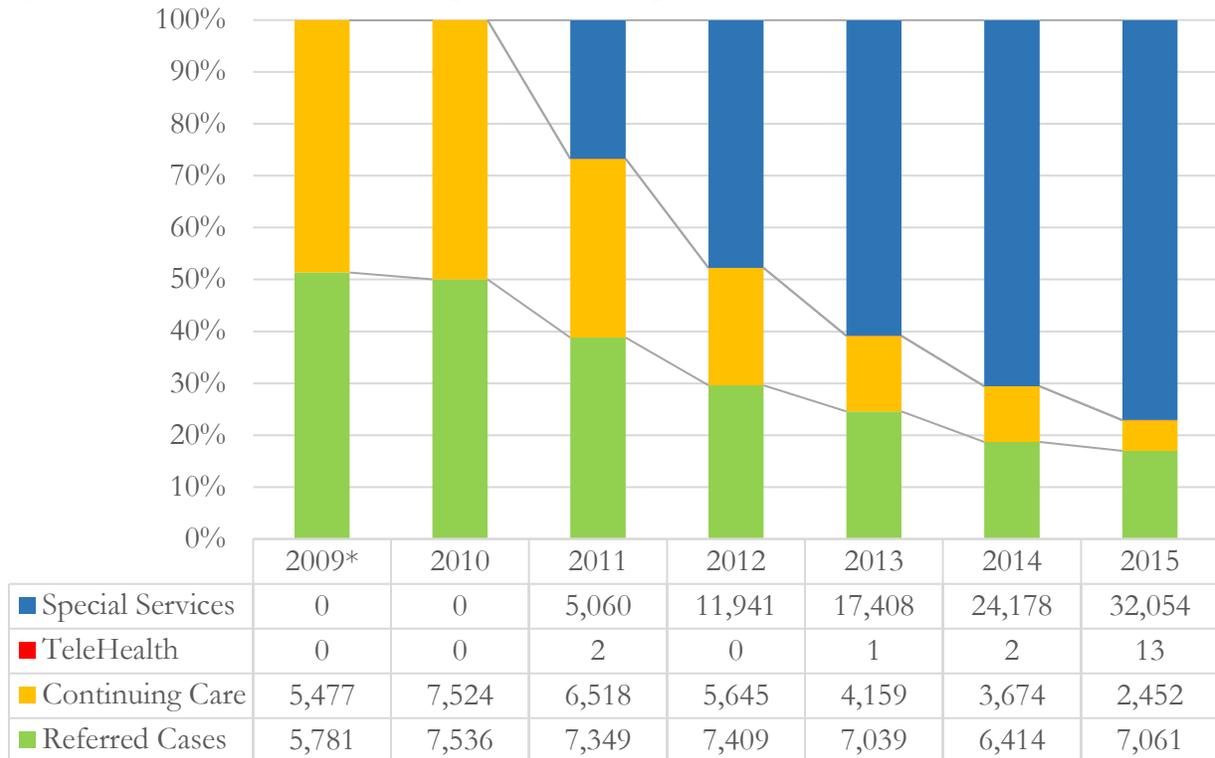
As with the core codes, the four categories of other billings were observed over time both in absolute number of billings (figure 3.3) and proportion of total billings (figure 4.4). Note that “total” here refers to the total of all other billings, not the total of all rheumatology billings. First impressions reveal that telehealth is almost never used, continuing care appears to be in decline from 2010 onwards, and referred cases is effectively flat (figure 3.3). Examination of the proportion of total, other billings held by each category shows that both continuing care and referred cases are in decline over the study period, with special services increasing their share dramatically from their introduction in 2011 (figure 3.4). Indeed, the growth in all other billings appears to be explained largely by the service category of “special services”, which rapidly expands from its introductory level of 25% in 2011 to around 75% of all other rheumatology services billed by the end of the study (figure 3.4).

Figure 3.3 “Other” rheumatology services by rheumatology service category over time, number of billings



*2009 only contains data from Q2-Q4

Figure 3.4 “Other” rheumatology services by rheumatology service category over time, proportion of total number of billings not including 31007 or 31010



The special service codes, those funded by the special services committee (see section 1.1.7), are made up of G31060 “Multidisciplinary conference for community-based patients”, G31055 “Rheumatology Immunosuppressant Review” and G31050 “Extended consultation”. They were all introduced simultaneously in 2011. The multidisciplinary conference for community based-patients (G31060), is the code whose impact I am interested in for the purposes of this thesis. The use of these codes has increased from approximately 5,000 billings in 2011 to over 32,000 by 2015 (figure 3.3).

As with the previous two iterations, special services billings have been broken out over time both in terms of absolute billings (figure 3.5) and proportion of the total billings (figure 3.6), where the total refers to the total number of special services billings. The use of G31060 “Multidisciplinary conference for community-based patients”, which facilitates the use of nurses in rheumatology consultations, has

increased from 1,445 in 2011, ~30% of special services billings, to 15,003 in 2015 (figure 3.5), and constitutes almost 50% of special services billings by 2015 (figure 3.6). Although use of all service billing codes has expanded significantly since their introduction, the use of G31060 has grown faster than the rest, ending around 10 times higher than its initial level, compared with the use of G31050 “Extended consultation”, which increased to around 7 times higher than its initial level and G31055 “Rheumatology Immunosuppressant Review”, which ended around 3.5 times higher than its initial level. This suggests G31060, my code of interest, was the primary driver of growth in special services from 2009Q2-Q4 to 2016Q1, and thereby also the primary driver of all other billings.

Figure 3.5 Special rheumatology services over time, number of billings

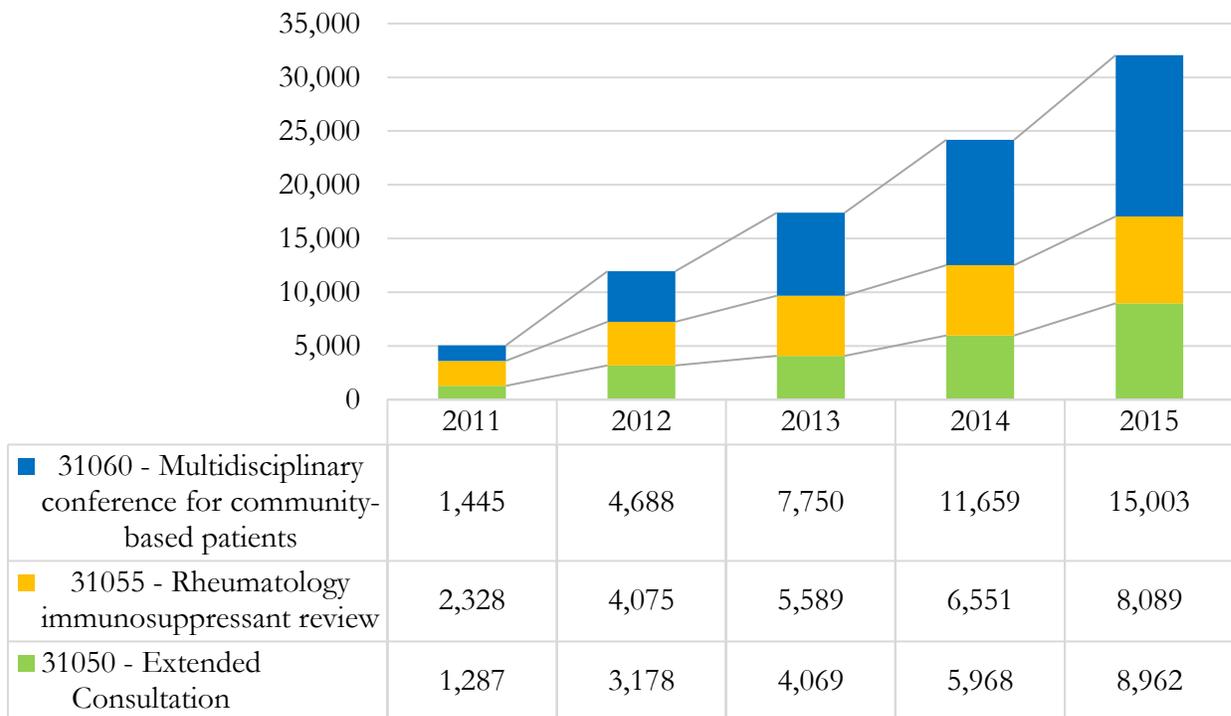
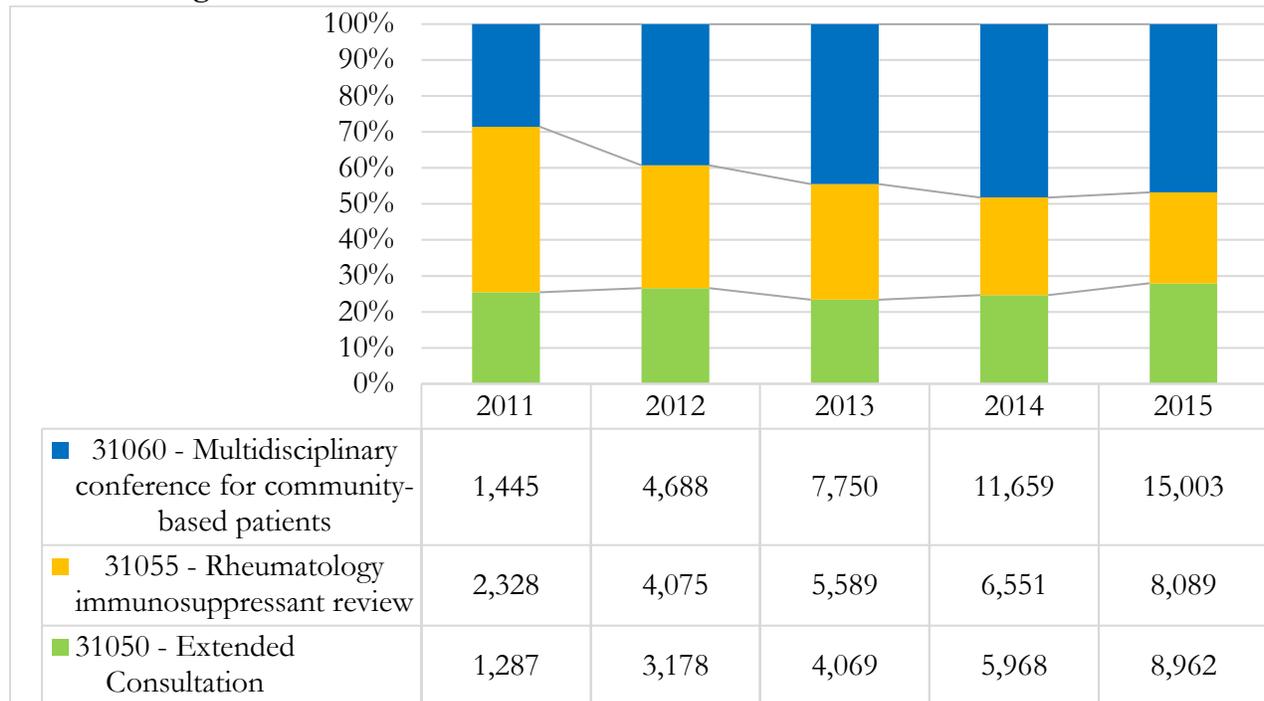


Figure 3.6 Special rheumatology services over time, proportion of total number of special services billings



3.1.3 Patterns of rheumatologist entry and exit from billing activity, by group

A total of 77 unique rheumatologist practitioners were identified from 2009Q2 through 2016 Q1, though there were never more than 72 active at one time. The population of active rheumatologists changed over time, with 25 rheumatologists beginning to bill and 6 who ceased billing during the study period. Eleven of the 25 new rheumatologists began billing in 2015. Only 46 of 77 rheumatologists were active in every period of the study. Table 3.3 illustrates the entry and exit of rheumatologists to active billing in MSP for all rheumatologists, and stratified by rheumatologists who used G31060 in that year and those that did not.

There were 51 unique rheumatologists who used the code G31060 following its introduction. 29 (57%) of these rheumatologists who billed G31060 were active for the entire study period, and will form the 'nurse group' for the primary cohort. Use of the G31060 was common amongst the 25 new rheumatologists entering the study; 15 (60%) used G31060 during the study period. Uptake of G31060 is low initially (by 15 of 52 active rheumatologists in 2011) but grew steadily over the course of the study, suggesting a lag in the adoption of a new model of care. By the end of the study period, the rheumatologists using G31060 constitute a majority (45/72) of active rheumatologists within the province (table 3.3). In contrast, there were 26 rheumatologists who never billed code G31060. 17 (65%) of these rheumatologists who never billed G31060 were active for the entire study period and will form the 'status quo group' for the primary cohort.

Table 3.3 Rheumatologist entry and exit from MSP billing: all active, using G31060, not using G31060

	2009Q2-Q4	2010	2011	2012	2013	2014	2015	2016Q1	Total Unique
Active Rheumatologists	52	52	52	56	58	61	71	72	77
Entering MSP	0	1	2	3	3	4	11	1	25
Exiting MSP	0	1	2	0	1	1	1	0	6
Active During Full Study	-	-	-	-	-	-	-	-	46
Active & Using G31060	-	-	15	23	30	38	45	45	51
Entering MSP	0	1	2	2	2	4	3	1	15
Exiting MSP	0	0	2	0	1	1	1	0	5
Active & Using G31060 During Full Study	-	-	-	-	-	-	-	-	29
Active & Not Using G31060	52	52	37	33	28	23	26	27	26
Entering MSP	0	0	0	1	1	0	8	0	10
Exiting MSP	0	1	0	0	0	0	0	0	1
Active & Not Using G31060 During Full Study	-	-	-	-	-	-	-	-	17

3.1.4 Number of rheumatologists seen per patient, per calendar year

It is possible that patients may receive rheumatology care from more than one rheumatologist. This may occur if they are a patient at a group practice, the management of their disease is sufficiently complex to require collaboration among sub-specialties, or the patient may prefer seeing one specialist for certain issues and another provider for others. As we are tracking individual practitioner numbers, it may be difficult to make inferences on how individual billing activity reflects access to care if a large proportion of patients actually receive multi-specialist care. Table 3.4 gives the frequency counts for number of rheumatologists in absolute terms for each calendar year of the study. Table 3.5 converts these frequency counts into proportions for easier interpretation. From 2009 Q2 to 2016 Q1, between 97.05% and 99.86% of ‘nurse group’ patients saw a single rheumatologist in any given calendar year, with an average of 97.80% across all years. Approximately 2% saw two rheumatologists, on average, and an extremely small minority saw multiple rheumatologists (tables 3.4 & 3.5). The highest observed number of rheumatologists for a ‘nurse group’ patient was 7. For ‘status quo group’ patients, the proportion seeing a single rheumatologist ranged between 99.08% and 99.72%, with an average of 99.34% across all years. Just under 1% of ‘status quo group’ patients saw more than one rheumatologist in a year, and no patient in the ‘status quo group’ ever saw more than three rheumatologists in a year (tables 3.4 & 3.5).

Table 3.4 Frequency of observed number of rheumatologists per patient by year and group in primary cohort, total

	Rheumatologists Per Patient	2009Q2-4	2010	2011	2012	2013	2014	2015	2016Q1
Nurse Group	1	23,587	27,575	27,314	27,431	27,776	28,157	27,414	10,607
	2	422	670	582	665	668	537	726	11
	3	94	101	77	61	37	44	87	3
	4	8	14	5	8	8	12	16	1
	5	4	2	1	0	3	1	3	0
	6	1	0	0	0	1	0	0	0
	7	0	0	1	0	0	0	0	0
Status Quo Group	1	11,819	14,177	14,315	14,009	13,922	13,925	13,990	5,736
	2	54	103	103	100	100	98	129	16
	3	0	2	2	2	1	0	1	0

Table 3.5 Frequency of observed number of rheumatologists per patient by year and group in primary cohort, proportional

	Rheumatologists Per Patient	2009Q2-4	2010	2011	2012	2013	2014	2015	2016Q1
'nurse group'	1	97.81%	97.23%	97.62%	97.39%	97.48%	97.93%	97.05%	99.86%
	2	1.75%	2.36%	2.08%	2.36%	2.34%	1.87%	2.57%	0.10%
	3	0.39%	0.36%	0.28%	0.22%	0.13%	0.15%	0.31%	0.03%
	4	0.03%	0.05%	0.02%	0.03%	0.03%	0.04%	0.06%	0.01%
	5	0.02%	0.01%	0.00%	0.00%	0.01%	0.00%	0.01%	0.00%
	6	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	7	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
'status quo group'	1	99.55%	99.26%	99.27%	99.28%	99.28%	99.30%	99.08%	99.72%
	2	0.45%	0.72%	0.71%	0.71%	0.71%	0.70%	0.91%	0.28%
	3	0.00%	0.01%	0.01%	0.01%	0.01%	0.00%	0.01%	0.00%

3.1.5 Number of unique service days per patient, per calendar year

This section examines the number of visits per year rheumatology patients have in British Columbia in each year of the study (2009Q2-Q4 to 2016Q1), as described by unique dates of rheumatology service recorded in MSP data. Table 3.6 summarizes the average proportion of patients who have only a single visit to the rheumatologist each year, stratified by whether or not they have an inflammatory condition and whether they are assigned to the ‘nurse group’ or ‘status quo group’. Tables 3.7 and 3.8 summarize the frequency of visits by inflammatory patients to the rheumatologist by counts and proportions in each calendar, respectively, stratified by ‘nurse group’ and ‘status quo group’. Tables 3.9 and 3.10 do the same for non-inflammatory patients.

Over the study period, between 94.88% and 96.48% of ‘nurse group’ patients with an inflammatory condition had a single visit (unique service date) with a rheumatologist during the year, with an average of 95.88% across all years (tables 3.6 & 3.8). On average, 3.74% of inflammatory, ‘nurse group’ patients had two visits, around half a percent had 3 visits, and an extremely small minority had in excess of three visits (tables 3.7 & 3.8). For ‘status quo group’ patients with an inflammatory condition, the proportion with a single rheumatologist visit per year ranged between 94.77% and 97.12%, with an average of 96.26% across all years (tables 3.6 & 3.8). On average, 3.52% of inflammatory, ‘status quo group’ patients had two visits, around half a percent had 3 visits, and an extremely small minority had in excess of three visits (tables 3.7 & 3.8)

Between 91.10% and 95.56% of ‘nurse group’ patients with non-inflammatory conditions had a single visit with a rheumatologist during the year, with an average of 92.72% across all years (tables 3.6 & 3.10). On average, 5.24% of the non-inflammatory ‘nurse group’ patients had two visits, around 1%

had 3 visits, and a small minority had in excess of three visits (tables 3.9 & 3.10). For ‘status quo group’ patients with a non-inflammatory condition, the proportion with a single rheumatologist visit per year ranged between 96.35% and 97.55%, with an average of 97.14% across all years (Tables 3.6 & 3.10). On average, 3.52% of inflammatory, ‘status quo group’ patients had two visits, around half a percent had 3 visits, and an extremely small minority had in excess of three visits (Tables 3.9 & 3.10)

Table 3.6 Average proportion of patients with one unique service visit per year, by group and inflammatory status of condition

	Inflammatory	Non-Inflammatory
Nurse	95.88%	92.72%
Status Quo	96.26%	97.14%

Table 3.7 Frequency of unique service days per patient by year and group, totals – inflammatory conditions of primary cohort

	Unique service days per year	2009Q2-4	2010	2011	2012	2013	2014	2015	2016Q1
'nurse group'	1	26,489	36,272	37,448	39,806	41,704	43,053	43,908	9,776
	2	982	1,254	1,411	1,745	1,760	2,016	1,780	304
	3	175	189	219	236	228	187	193	35
	4	66	64	75	74	62	63	70	13
	5	33	27	48	38	33	36	22	1
	6	14	13	10	15	15	14	8	2
	7	12	9	6	9	13	5	13	1
	8	4	8	1	7	5	2	4	1
	9	1	2	3	0	3	1	1	0
	10+	6	14	5	7	13	1	2	0
'status quo group'	1	12,165	16,999	17,225	17,768	18,313	18,158	18,017	3,845
	2	565	636	709	724	708	572	580	98
	3	75	94	64	98	70	73	55	12
	4	26	20	19	19	25	23	13	2
	5	6	4	1	14	5	8	3	1
	6	0	3	0	3	3	4	2	0
	7	0	0	0	2	1	0	0	1
	8	0	0	0	1	2	0	0	0

Table 3.8 Frequency of unique service days per patient by year and group, proportions – inflammatory conditions of primary cohort

	Unique service days per year	2009Q2-4	2010	2011	2012	2013	2014	2015	2016Q1
'nurse group'	1	95.35%	95.83%	95.47%	94.92%	95.14%	94.88%	95.45%	96.48%
	2	3.53%	3.31%	3.60%	4.16%	4.01%	4.44%	3.87%	3.00%
	3	0.63%	0.50%	0.56%	0.56%	0.52%	0.41%	0.42%	0.35%
	4	0.24%	0.17%	0.19%	0.18%	0.14%	0.14%	0.15%	0.13%
	5	0.12%	0.07%	0.12%	0.09%	0.08%	0.08%	0.05%	0.01%
	6	0.05%	0.03%	0.03%	0.04%	0.03%	0.03%	0.02%	0.02%
	7	0.04%	0.02%	0.02%	0.02%	0.03%	0.01%	0.03%	0.01%
	8	0.01%	0.02%	0.00%	0.02%	0.01%	0.00%	0.01%	0.01%
	9	0.00%	0.01%	0.01%	0.00%	0.01%	0.00%	0.00%	0.00%
	10+	0.02%	0.04%	0.01%	0.02%	0.03%	0.00%	0.00%	0.00%
'status quo group'	1	94.77%	95.74%	95.60%	95.38%	95.74%	96.39%	96.50%	97.12%
	2	4.40%	3.58%	3.93%	3.89%	3.70%	3.04%	3.11%	2.48%
	3	0.58%	0.53%	0.36%	0.53%	0.37%	0.39%	0.29%	0.30%
	4	0.20%	0.11%	0.11%	0.10%	0.13%	0.12%	0.07%	0.05%
	5	0.05%	0.02%	0.01%	0.08%	0.03%	0.04%	0.02%	0.03%
	6	0.00%	0.02%	0.00%	0.02%	0.02%	0.02%	0.01%	0.00%
	7	0.00%	0.00%	0.00%	0.01%	0.01%	0.00%	0.00%	0.03%
	8	0.00%	0.00%	0.00%	0.01%	0.01%	0.00%	0.00%	0.00%

Table 3.9 Frequency of unique service days per patient by year and group, totals – non-inflammatory conditions of primary cohort

	Unique service days per year	2009Q2-4	2010	2011	2012	2013	2014	2015	2016Q1
'nurse group'	1	12,994	15,472	13,977	13,202	12,224	11,530	10,752	1,938
	2	715	994	983	916	771	634	455	67
	3	167	140	165	127	154	141	115	20
	4	34	74	61	48	31	35	30	2
	5	38	27	35	20	28	21	8	0
	6	24	15	30	20	13	10	17	0
	7	19	22	29	18	10	30	1	0
	8	24	29	21	14	4	8	2	0
	9	16	15	16	15	9	16	4	1
	10+	27	44	25	37	9	46	0	0
'status quo group'	1	10,163	13,332	12,658	12,140	12,065	12,212	12,165	2,470
	2	350	322	381	400	367	383	375	51
	3	31	29	26	33	29	42	22	11
	4	2	8	6	4	4	7	6	0
	5	1	0	0	2	3	5	5	0
	6	1	1	0	2	1	0	0	0
	7	0	0	0	0	0	0	1	0
	8	0	0	0	0	0	0	0	0

Table 3.10 Frequency of unique service days per patient by year and group, proportions – non-inflammatory conditions of primary cohort

	Unique service days per year	2009Q2-4	2010	2011	2012	2013	2014	2015	2016Q1
'nurse group'	1	92.43%	91.92%	91.10%	91.57%	92.24%	92.45%	94.45%	95.56%
	2	5.09%	5.91%	6.41%	6.35%	5.82%	5.08%	4.00%	3.30%
	3	1.19%	0.83%	1.08%	0.88%	1.16%	1.13%	1.01%	0.99%
	4	0.24%	0.44%	0.40%	0.33%	0.23%	0.28%	0.26%	0.10%
	5	0.27%	0.16%	0.23%	0.14%	0.21%	0.17%	0.07%	0.00%
	6	0.17%	0.09%	0.20%	0.14%	0.10%	0.08%	0.15%	0.00%
	7	0.14%	0.13%	0.19%	0.12%	0.08%	0.24%	0.01%	0.00%
	8	0.17%	0.17%	0.14%	0.10%	0.03%	0.06%	0.02%	0.00%
	9	0.11%	0.09%	0.10%	0.10%	0.07%	0.13%	0.04%	0.05%
	10+	0.19%	0.26%	0.16%	0.26%	0.07%	0.37%	0.00%	0.00%
'status quo group'	1	96.35%	97.37%	96.84%	96.49%	96.76%	96.55%	96.75%	97.55%
	2	3.32%	2.35%	2.91%	3.18%	2.94%	3.03%	2.98%	2.01%
	3	0.29%	0.21%	0.20%	0.26%	0.23%	0.33%	0.17%	0.43%
	4	0.02%	0.06%	0.05%	0.03%	0.03%	0.06%	0.05%	0.00%
	5	0.01%	0.00%	0.00%	0.02%	0.02%	0.04%	0.04%	0.00%
	6	0.01%	0.01%	0.00%	0.02%	0.01%	0.00%	0.00%	0.00%
	7	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%
	8	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

3.1.6 Characteristics of patients within the primary cohort, by group

Table 3.11 shows that the patients under care of ‘nurse group’ rheumatologists are statistically significantly different from the ‘status quo group’ in nearly all characteristics. When compared against the ‘status quo group’, the ‘nurse group’ has: 1) fewer non-inflammatory patients, 2) fewer female patients, 3) a different distribution across health authorities, 4) older patients, 5) arguably more rural patients, 6) more patients dying, and 8) lower income patients (Table 3.11). For age, it is unclear if the difference is clinically significant, as median age is only a year higher in the ‘nurse group’ for the primary cohort. The same could be said of the distribution of sex, as the ‘status quo group’ is only 1 percentage point higher more female than the ‘nurse group’. Rurality is difficult to gauge in this case as the ‘status quo group’ appears to have significant missing data with respect to residence. As that group also has fewer patients with inflammatory conditions, it may be that non-inflammatory patients captured during the lookback period are missing study-period data on residence.

The impression generated by these differences is that the ‘nurse group’ patients may be more complex and likely face more barriers to access than their ‘status quo group’ counterparts.

Table 3.11 Characteristics of patients within the primary cohort, by group

Variable	Level or Measure	Nurse		Status Quo		P-value		
		N	%	N	%			
Unique Patients	N	91,999	-	42,113	-			
Unique Rheumatologists	N	29	-	17	-			
Condition	Ankylosing spondylitis	4,963	6%	1,680	4%	<0.01*		
	Connective tissue disorders	6,029	7%	2,862	7%			
	Gout	2,384	3%	1,072	3%			
	Psoriatic arthritis	4,701	5%	1,271	2%			
	Rheumatoid arthritis	20,313	23%	7,576	19%			
	Systemic lupus erythematosus	2,604	3%	1,292	3%			
	Systemic vasculitides	553	1%	79	0%			
	Noninflammatory	46,966	53%	24,381	61%			
	Sex	Female	59,837	68%	27,728		69%	<0.01*
		Male	28,669	32%	12,483		31%	
Health Authority	Interior	16,796	19%	8,492	21%			
	Fraser	30,424	34%	13,510	34%			
	Vancouver Coastal	25,879	29%	12,958	32%			
	Vancouver Island	12,947	15%	4,591	11%			
	Northern	2,117	2%	542	1%			
	Unknown or Missing	167	0%	61	0%			
Age	Median	57	-	56	-	0.08**		
	Interquartile Range	68 to 45	-	67 to 47	-			
Geographic Location	Rural	13,972	16%	3,272	8%	<0.01*		
	Urban	62,919	71%	27,851	69%			
	Missing or Unknown	11,439	13%	9,031	23%			
Income Quintile	1 - Highest	17,182	20%	8,226	21%	<0.01*		
	2	16,727	19%	8,497	21%			
	3	17,434	20%	7,984	20%			
	4	17,759	20%	7,432	19%			
	5 - Lowest	18,239	21%	7,558	19%			
Death	Missing or Unknown	933	1%	425	1%	<0.01**		
	No	81,488	92%	37,968	94%			
	Yes	7,025	8%	2,245	6%			

* chi-squared test, ** two-sample t-test

3.2 Discussion

3.2.1 Overview

The aim of this chapter was to address objective 1, “to describe the population of persons living with rheumatic in disease in British Columbia, the patterns of rheumatology care that they receive, both before and after the introduction of G31060.” The population of individuals living with rheumatic disease and receiving treatment from a rheumatologist in BC over 7 years appears to be representative of what would be expected from a population of rheumatic disease patients in British Columbia, though prevalence estimates may be lower than expected (gout, for example, with 95 per 100,000). This reduced prevalence may be due to the inclusion criteria requiring active treatment by a rheumatologist – this may miss long term patients with stable disease who are primarily being managed by a general practitioner or other primary care provider.

Examination of rheumatology billings shows that the “core” codes of 31007 (follow up) and 31010 (initial consultation) are proportionally being crowded out by rapid growth in special services billings, driven primarily by G31060, which increased from ~30% to almost 50% of all special services billings by end of the study. It is likely that G31060 is being substituted for 31007, as we can see the latter decline and neither G31050 (an extended consult) or G31055 (immunosuppressant review) are plausible substitutes for the core follow up code. It is probable that that G31060 is being substituted for 31010 as well, as we see a proportional decline in overall billings for 31010 and G31060 is billed more frequently than G31050, the only plausible alternative.

Of 77 unique rheumatologists identified, 46 are actively billing through the study. The population of rheumatologists fluctuates, with 25 rheumatologists beginning to bill and 6 ceasing billing over the course of the study. Calendar year 2015 sees an influx of 11 rheumatologists, nearly three times more than any other year (table 3.3). New rheumatologists disproportionately (60%) use nurses. To construct my primary cohort for interrupted time series with comparator, 29 of the 46 with longitudinal data were assigned to the ‘nurse group’ and 17 ‘status quo group’ (3.1.3). This disproportionate growth in rheumatologists in one group illustrates why interrupted time series with comparator must be performed with longitudinal data on a closed cohort. Allowing new rheumatologists to enter the cohort may lead to an increase in access related to the disproportionate increase in new rheumatologists who employ a nurse via G31060 being mistakenly attributed to the introduction of this code, when in fact it is simply the that the number of providers has increased.

The vast majority (over 97%) of patients see a single rheumatologist in any given year. ‘nurse group’ patients have a higher proportion seeing multiple rheumatologists, and the maximum number of rheumatologists seen is higher in that group (3.1.4). This may be the case if the case-mix of patients in the ‘nurse group’ are more complex, requiring consultations from colleagues and /or more frequent follow up.

Patients with inflammatory conditions are almost always seen once a year (around 95% or higher), with about 3-4% having two visits, and around half a percent have three visits. This is true for both groups, though the ‘nurse group’ distribution has a larger tail, with an extremely small number having many visits in a year (3.1.5). Non-inflammatory patients in the ‘status quo group’ have a single annual visit over 96% of the time, with ~3% having two visits and less than half a percent having three visits. In the ‘nurse group’, Over 91% of patients have a single visit, ~5% have two visits, and another 1%

have three visits. This is an unexpected result, but may be a result of including non-inflammatory patients who are actively seeing a rheumatologist. The selection bias here would be that these patients may still be engaged in the diagnostic pathway, and require multiple visits to conclusively rule out inflammatory disease.

The vast majority of patients receiving a single annual visit likely has auto-correlative implications, as “cohorts” of patients receive care on a 12-month cycle.

The results of analysis between ‘nurse group’ and ‘status quo group’ characteristics, would seem to show that the patients of the ‘nurse group’ are systematically older, poorer, have more complex disease, and may be more rural than the ‘status quo group’. If this is the case, it may explain why ‘nurse group’ patients see more rheumatologists and similarly why they have more visits per year - they may have a more complex diagnostic and treatment pathway requiring more intensive care.

3.2.2 Strengths

The administrative datasets provided by Population Data BC provide a reliable basis for analysis on many patient characteristics and rheumatologist billing activity. This allows us to observe all patients in the province seeing a rheumatologist and then classify rheumatologists by billing pattern to obtain both an intervention and control group. That patient population appears to be largely representative of what would be expected for a rheumatic disease population in BC, based on observed: sex (68% female), age (median 56, IQR: 45-67), income (evenly distributed quintiles), geographic location (14% rural) and concentration in the Fraser (35%) and Vancouver Coastal (28%) health authorities.

The method employed for identifying patients with rheumatic disease has been validated in prior studies, and with the restriction to those actively seeing a rheumatologist it seems likely that diagnoses are accurate. (2.2.3 & 3.1.1).

3.2.3 Limitations

It is a persistent limitation of British Columbian administrative data that one cannot view any physician related characteristics, only their outputs (like number of billings). I cannot see FTE, or how time balanced between research and clinical practice, type of clinical practice (solo or group), or hospital affiliation. While these aspects do not affect the results presented, it makes interpretation difficult. Adoption of G31060 could be higher among community practitioners as it assists them in their professional focus on clinical work. Conversely, it could be higher among researchers who find nurses useful in reducing their workload within the clinic. The former is likely to increase access, the latter may have no discernable effect. Solo practitioners may be systematically less likely to take on a nurse as they may have fewer resources and less physical space than a group practice. Conversely, they may prefer to use nurses as they are particularly vulnerable to shocks in workload. Not knowing who is driving the adoption of G31060 makes it more difficult to know why I am observing these results, and consequently more difficult to make a cogent policy recommendation. However, this limitation is in no way unique to this study and represents a pervasive limitation to the study of the rheumatology workforce in Canada (1.1.9).

Unfortunately, the medical services plan dataset only has partial 2016 and 2009 billings. The 2008/2009 fiscal year billings are substantially lower than 2009/2010, and so is not a complete record of MSP billings but rather only those pertaining to identifying patients with rheumatic disease in the lookback period.

It is a limitation of the study that I cannot directly observe demand for rheumatology services and so I operate under the assumption that if more billings occur or more patients are seen that is reflective of genuine need.

3.3 Conclusion

The Multidisciplinary Conference for Community-based patients with complex rheumatic diseases (G31060) appears to have had good uptake, though it has been more of a steady build than immediate adoption. While many rheumatologists use the nurse code, only a minority do so consistently. Most new rheumatologists use the nurse code (60%), suggesting that G31060 billings will continue to grow. Comparison across the ‘nurse’ and ‘status quo’ groups suggest that rheumatologists that use nurses may treat patients who face greater barriers to access and/or more complex rheumatic disease than the status quo arm.

Chapter 4: Impact on access to rheumatology care, an interrupted time-series analysis

4.1 Overview of Results

This chapter contains results from the interrupted time series with comparator analysis conducted on the primary cohort, as well as secondary analyses performed on two alternate cohort specifications. The aim of this analysis was to evaluate the impact on access to rheumatology care of introducing the multidisciplinary conference code for community-based patients. Access to rheumatology care has been measured two ways for the purposes of this analysis. First, I consider the impact on the number of unique patients seen for rheumatology care per month. This can be conceptualized as an extensive margin for rheumatology care, and answers the question “how many people are being seen within British Columbia and how has it changed since introducing the multidisciplinary conference code for community-based patients?” Second, I consider the impact on the number of rheumatology service units billed per month. This can be conceptualized as an intensive margin for rheumatology care, and answers the questions “what is the volume of rheumatology service provided within British Columbia and how has it changed since introducing the multidisciplinary conference code for community-based patients?” Complete regression outputs of mean effect corresponding to each regression coefficient, 95% confidence intervals, and p-value are available in Appendix 2.

4.1.1 Cohort Descriptions

The definition for my primary analysis relied (1) on a rheumatologist being present (i.e. billing at least once per year) during the entire study period (2009Q2-Q4-2016), and (2) that rheumatologist ever having billed G31060. I identified 46 rheumatologists who were active in MSP through the study period, 60% of the 77 unique practitioners identified. 29 (63%) of these rheumatologists present for the full study period had ever used G31060 and were classified as the ‘nurse group’. The remaining 17 (37%) rheumatologists who has never billed for G31060 were classified as ‘status quo group’. The numbers of patients and rheumatologist assigned to each group can be seen in table 4.1.

Applying the first of my secondary analysis definitions, consistently billing for the code G31060 at least once in each calendar year, reduced my cohort of rheumatologists active in MSP through the study to 40; reducing the “nurse group” to 13 of 29 (45%) consistently that used the code at least once in each calendar year (tables 3.3 & 4.1). The number of rheumatologists and patients in the ‘status quo group’ was unaffected.

The second of my secondary analysis definitions further restricted my cohort of rheumatologists active in MSP through the study to 23. Of those, only 6 met the criteria of billing an average of at least 30 service units per month of G31060 throughout the study period, and were so assigned to the ‘nurse group.’ The remaining 17 were the same ‘status quo group’ rheumatologists as the primary and consistency analysis.

A small proportion of patients (5%, 4%, and 3% in the primary and each of the secondary cohorts respectively) are seen by more than one rheumatologist, some of whom are in different groups.

Table 4.1 Number of rheumatologists and patients in each group, by cohort

Cohort	N	'nurse group'	'status quo group'	Both
Primary	Rheumatologists	29	17	-
	Patients	91,999	42,113	5,386
Consistency	Rheumatologists	13	17	-
	Patients	44,093	42,113	2,738
High Intensity	Rheumatologists	6	17	-
	Patients	23,580	42,113	1,425

4.1.2 Testing and correcting for auto-correlative processes

Identification and adjustment for auto-correlative processes was performed in accordance with the methods outlined in section 2.4.3. More detailed summary of the results of each step are available in Appendix 1. Durbin-Watson tests were performed up to 12 lags (12 months into the past), as there was reasonable basis to suspect an annual pattern to billing. This assumption is supported by the results in section 3.1.5, which demonstrated in excess of 90% of patients are seen for one visit per year. For patients with chronic conditions, it is then to be expected that patients will return around approximately the same time each subsequent year for follow-up. Significant, positive autocorrelation was identified at 6 and 12 lags for all models. This appears to be corroborated by the Partial Autocorrelation Function plots, which showed strong auto-correlative effects of order 12 (or 12 lags), as well as some at order 6. Likelihood ratio tests of ARMA(6,0) and ARMA(12,0) models consistently

showed ARMA(12,0) to have better fit. Consequently, ARMA(12,0) specification was used for all subsequent analysis.

Interpretation of AR(6) process: An autoregressive process of order 6 means that y_t is correlated with y_{t-6} for all t . In the context of my analysis this means that the billing activity in any given month is correlated with the billing activity of the period six months prior. In the context of rheumatology, it is recommended that patients with inflammatory rheumatic disease are assessed twice a year. The billing code G31060 has this built in, as it is restricted to one usage every six months for any given patient. We can therefore think of the order 6 autocorrelation as reflecting the set of patients under the care of a given rheumatologist returning for assessment on this bi-annual cycle, in any given month. Concretely, if you are a patient who first sees your rheumatologist in January 2011, you would be expected for a follow up in July 2011, and then January 2012, &etc.

Interpretation of AR(12) process: An autoregressive process of order 12 means that y_t is correlated with y_{t-12} for all t . In the context of my analysis this means that the billing activity in any given month is correlated with the billing activity of the period twelve months prior. Put another way, the billing activity in any given month is correlated with the activity in that same month of the prior year. In the context of rheumatology care, an order 12 process may be at work if rheumatologists tend to follow a certain pattern of billing activity over the course of each year. For example, if rheumatologists tend to take holidays in December, we would expect to observe a pattern of lower billing activity in the month of December across each year of the study. The Decembers of consecutive years would then be correlated on a 12-month lag. Additionally, if rheumatologists conduct patient follow up on an annual rather than bi-annual basis, then AR(12) has an interpretation much like AR(6), only shifted to

an annual rather than bi-annual pattern. Given the results of 3.1.5 show the vast majority of patients are seen annually, there is contextual evidence that a 12th-order lag may be at work in the billing data.

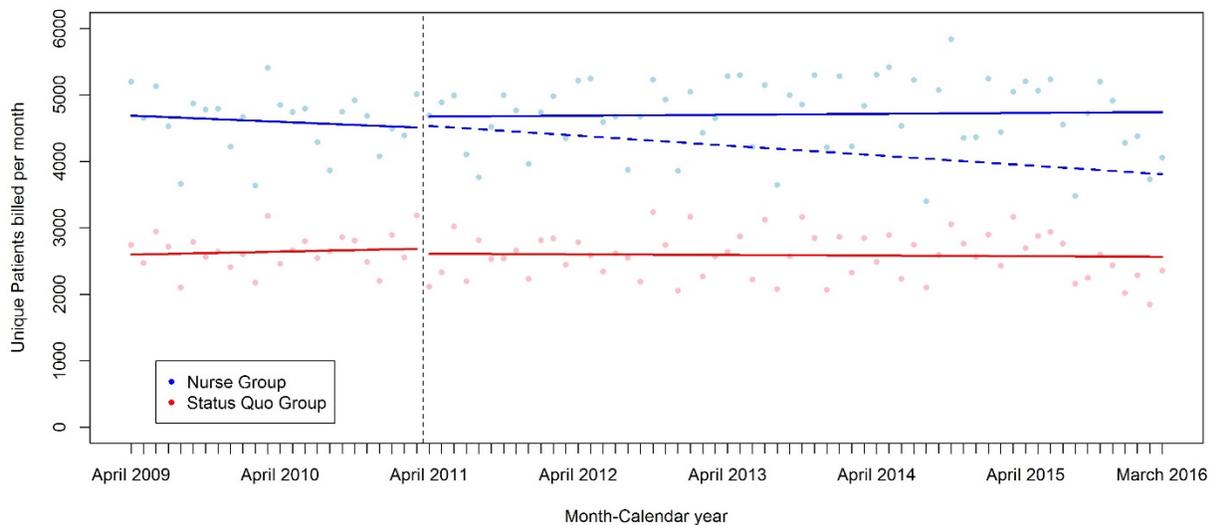
4.2 Primary analysis – comparison of rheumatologists who ever billed G31060 with those who never billed

4.2.1 Impact on number of unique patients seen per month

The number of unique patients treated by the 29 rheumatologists in the ‘nurse group’ was higher than the number treated by the 17 rheumatologists in the comparison group, in absolute terms (5,199 vs 2,742 unique patients at t=1, April 2009). This difference equates to approximately 179 unique patients per rheumatologist in the ‘nurse group’ compared with 161 unique patients per rheumatologist in the ‘status quo group’. The trend in the number of unique patients before the introduction of the G31060 billing code were increasing slightly in the ‘status quo’ group (Time, β_1 : 4 per month, 95% CI -11,19) but decreasing slightly in the ‘nurse group’ (β_3 , -12 per month, 95% CI -33, 10). There were significant differences between the pre-intervention levels of each group (β_2 , $p=0.000$) but time was not statistically significant for either group (β_1 , $p=0.624$ & β_3 , $p=0.293$). The difference in pre-intervention level is likely only reflective of the ‘nurse group’ being larger than the ‘status quo group’. Following the introduction of the G31060 code in 2011, there was no significant change in the level of unique patients in the ‘nurse group’ (β_6 , $p=0.682$) or the ‘status quo’ group (β_4 , $p=0.815$). The trend in the ‘status quo’ group appeared to plateau, and there was no statistically significant difference in the trend (β_5 , $p=0.564$). In the “nurse group” the trend in unique patients also appeared to plateau (β_7 , $p=0.231$).

In the 60 months following the introduction of G31060 to the end of the study period, there was no statistically significant change in the level or trend for the ‘nurse’ or ‘status quo’ groups ($\alpha=0.05$) of unique patients per month attributable to the introduction of G31060 in the Primary analysis. Figure 4.1 visually represents the results of the analysis, plotting according to the mean values represented by the regression coefficients.

Figure 4.1 Number of unique patients billed per month before and after the introduction of “Multidisciplinary conference for community-based patients” (G31060) in April 2011 by rheumatologists in the ‘nurse’ and ‘status quo’ groups. Primary analysis using ARMA(12,0) model.



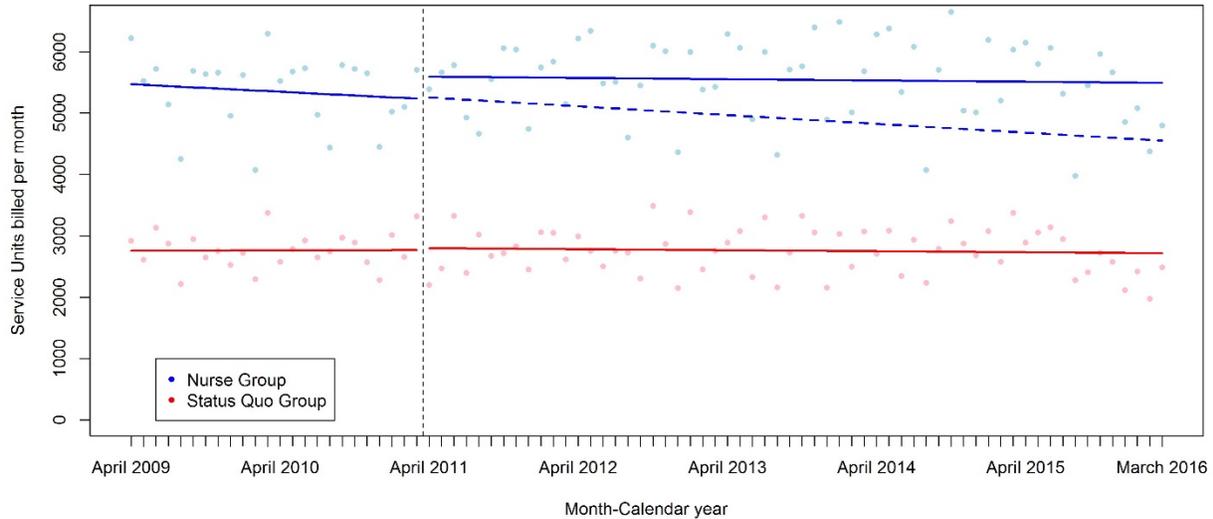
Hatched line indicates the counterfactual, what would be expected absent the intervention

4.2.2 Impact on service units billed per month

The number of rheumatology service units billed by the 29 rheumatologists in the ‘nurse group’ was higher than by the 17 rheumatologists in the ‘status quo group’, in absolute terms (6,225 vs 2,921 service units at $t=1$, April 2009). This difference equates to approximately 215 service units per

rheumatologist in the 'nurse group' compared with 172 service units per rheumatologist in the 'status quo group'. The trend in the number of service units before the introduction of the G31060 billing code is flat in the 'status quo' group (Time, β_1 : 0 per month, 95% CI -17,18) but decreasing slightly in the 'nurse group' arm (β_3 : -11 per month, 95% CI -35, 14). There were significant differences between the pre-intervention levels of each group (β_2 , $p=0.000$) but time was not statistically significant for either group (β_1 : $p=0.9612$ & β_3 : $p=0.3964$). The difference in pre-intervention level is likely only reflective of the 'nurse group' being larger than the 'status quo group'. Following the introduction of the G31060 code in 2011, there was no significant change in the level of service units in the 'nurse group' (β_6 : $p=0.744$) or the 'status quo' group (β_4 : $p=0.654$). The trend in the 'status quo' group appeared to plateau, and there was no statistically significant difference in the trend (β_5 : $p=0.842$). In the 'nurse group' the trend in service units also appeared to plateau (β_7 , $p=0.810$). In the 60 months following the introduction of G31060 to the end of the study period, there was no statistically significant change in the level or trend for the 'nurse' or 'status quo' groups ($\alpha=0.05$) of service units per month attributable to the introduction of G31060 in the Primary analysis. Figure 4.2 visually represents the results of the analysis, plotting according to the mean values represented by the regression coefficients.

Figure 4.2 Number of service units billed per month before and after the introduction of “Multidisciplinary conference for community-based patients” (G31060) in April 2011 by rheumatologists in the ‘nurse’ and ‘status quo’ groups. Primary analysis using ARMA(12,0) model.



Hatched line indicates the counterfactual, what would be expected absent the intervention

4.3 Sensitivity analysis 1: restricting the definition of intervention in the “nurse group” to consistent users (at least one billing of G31060 in every calendar year)

In order to determine whether, and to what degree, my estimates are distorted by this heterogeneity within ‘nurse group’ rheumatologists, I generated two alternative cohorts that vary the criteria by which a rheumatologist is assigned to the ‘nurse group’ (see table 2.8). This section (4.3) considers an alternative cohort specification that restricts the ‘nurse group’ to those rheumatologists billing for

G31060 at least once in each calendar year of the study period, as a check on “consistent” use of nurses.

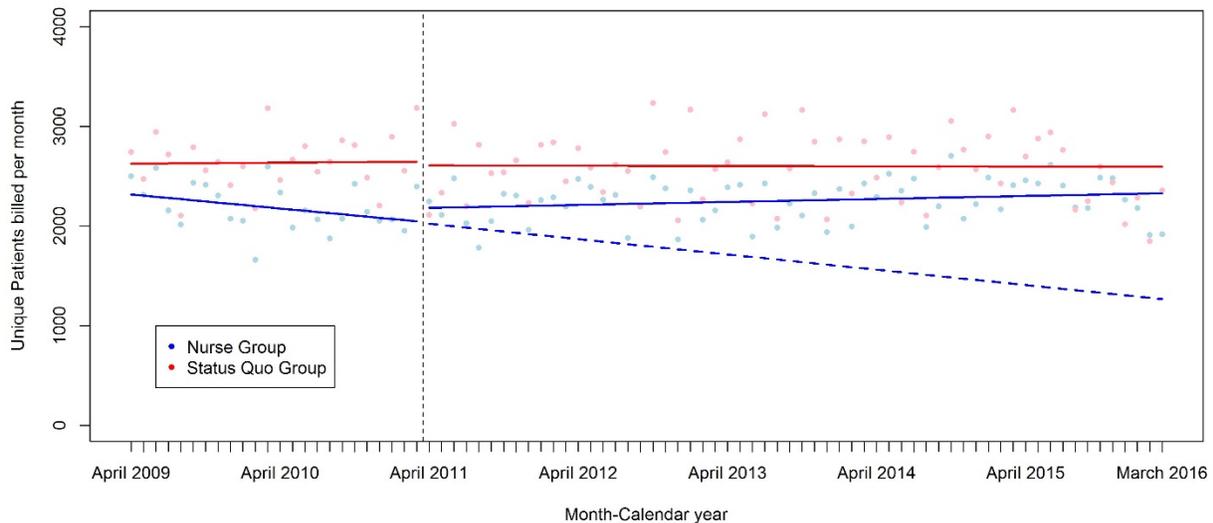
There was a statistically significant, positive change in the trend (slope) of the number of unique patients per month attributable to the introduction of G31060 in the consistency cohort ($\alpha=0.05$). The trend change associated with being in the ‘nurse group’ was +15 unique patients per month ($p=0.03$) in the Consistency cohort, with the baseline trend change being -1 unique patients per month but not statistically significant ($p=0.821$). Results are summarized in table 4.2.

4.3.1 Impact on number of unique patients seen per month

The number of unique patients treated by the 13 rheumatologists in the intervention ‘nurse group’ was lower than the number treated by the 17 rheumatologists in the ‘status quo group’, in absolute terms (2,501 vs 2,742 unique patients at $t=1$, April 2009). This difference equates to approximately 192 unique patients per rheumatologist in the ‘nurse group’ compared with 161 unique patients per rheumatologist in the ‘status quo group’. The trend in the number of unique patients before the introduction of the G31060 billing code were increasing slightly in the ‘status quo group’ (β_1 : 1 per month, 95% CI -9,11) but decreasing in the ‘nurse group’ (β_3 : -13 per month, 95% CI -26, 1). There were significant differences between the pre-intervention levels of each group (β_2 , $p=0.004$) but time was not statistically significant for either group (β_1 : $p=0.860$ & β_3 : $p=0.076$). The difference in pre-intervention level is likely only reflective of the ‘nurse group’ being smaller than the ‘status quo group’. Following the introduction of the G31060 code in 2011, there was no significant change in the level of unique patients in the ‘nurse group’ (β_6 : $p=0.097$) or the ‘status quo’ group (β_4 : $p=0.898$). There was no statistically significant difference in the baseline trend (β_5 : $p=0.821$). In the ‘nurse group’ the

trend change in unique patients was statistically significant and positive (β_7 : +15 unique patients per month, 95% CI 2, 29). In the 60 months following the introduction of G31060 to the end of the study period, there was no statistically significant change in the level for the ‘nurse’ or ‘status quo’ groups ($\alpha=0.05$) However, positive trend change was observed for the nurse-group, suggesting the number of unique patients seen per month can be expanded for a threshold level of consistency in use of the multidisciplinary conference code for community-based patients. Figure 4.3 visually represents the results of the analysis, plotting according to the mean values represented by the regression coefficients.

Figure 4.3 Number of unique patients billed per month before and after the introduction of “Multidisciplinary conference for community-based patients” (G31060) in April 2011 by rheumatologists in the ‘nurse’ and ‘status quo’ groups. Consistency analysis using ARMA(12,0) model

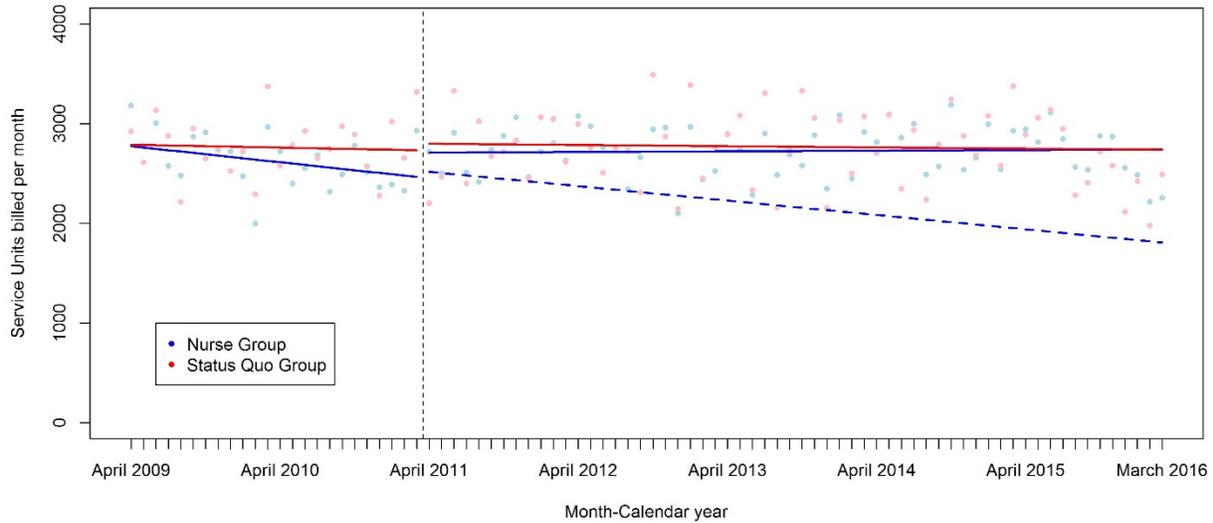


Hatched line indicates the counterfactual, what would be expected absent the intervention

4.3.2 Impact on service units billed per month

The number of rheumatology service units billed by the 13 rheumatologists in the ‘nurse group’ was lower than the number billed by the 17 rheumatologists in the ‘status quo group’, in absolute terms (3,181 vs 2,921 service units at t=1, April 2009). This difference equates to approximately 245 service units per rheumatologist in the ‘nurse group’ compared with 172 service units per rheumatologist in the ‘status quo group’. The trend in the number of service units before the introduction of the G31060 billing code is in slight decline for the ‘status quo’ group (β_1 : -2 per month, 95% CI -14,10) and decreasing in the ‘nurse group’ arm (β_3 : -22 per month, 95% CI -28, 6). There were no significant differences between the pre-intervention levels of each group (β_2 , p=0.978) and time was not statistically significant for either group (β_1 : p=0.698 & β_3 : p=0.209). Following the introduction of the G31060 code in 2011, there was no significant change in the level of service units in the “nurse group” (β_6 : p=0.407) or the ‘status quo’ group (β_4 : p=0.654). The trend in the ‘status quo’ group appeared to plateau, but there was no statistically significant difference in the trend (β_5 : p=0.824). In the ‘nurse group’ the trend change in service units also appeared to plateau (β_7 , p=0.151). In the 60 months following the introduction of G31060 to the end of the study period, there was no statistically significant change ($\alpha=0.05$) in the level or trend for the ‘nurse’ or ‘status quo’ groups of service units per month attributable to the introduction of G31060 in the Primary analysis. Figure 4.4 visually represents the results of the analysis, plotting according to the mean values represented by the regression coefficients.

Figure 4.4 Number of service units billed per month before and after the introduction of “Multidisciplinary conference for community-based patients” (G31060) in April 2011 by rheumatologists in the ‘nurse’ and ‘status quo’ groups. Consistency analysis using ARMA(12,0) model.



Hatched line indicates the counterfactual, what would be expected absent the intervention

4.4 Sensitivity analysis 2: restricting the definition of intervention in the “nurse group” to high intensity users (at least 30 billings of G31060 per month, on average)

In order to determine whether, and to what degree, my estimates are distorted by this heterogeneity within ‘nurse group’ rheumatologists, I generated two alternative cohorts that vary the criteria by which a rheumatologist is assigned to the ‘nurse group’ (Table 2.8). This section (4.4) considers an alternative cohort specification that restricts the ‘nurse group’ to those rheumatologists billing for

G31060 at least 30 times per month on average, as a check on the impact of “high-intensity” usage of the multidisciplinary conference code for community-based patients.

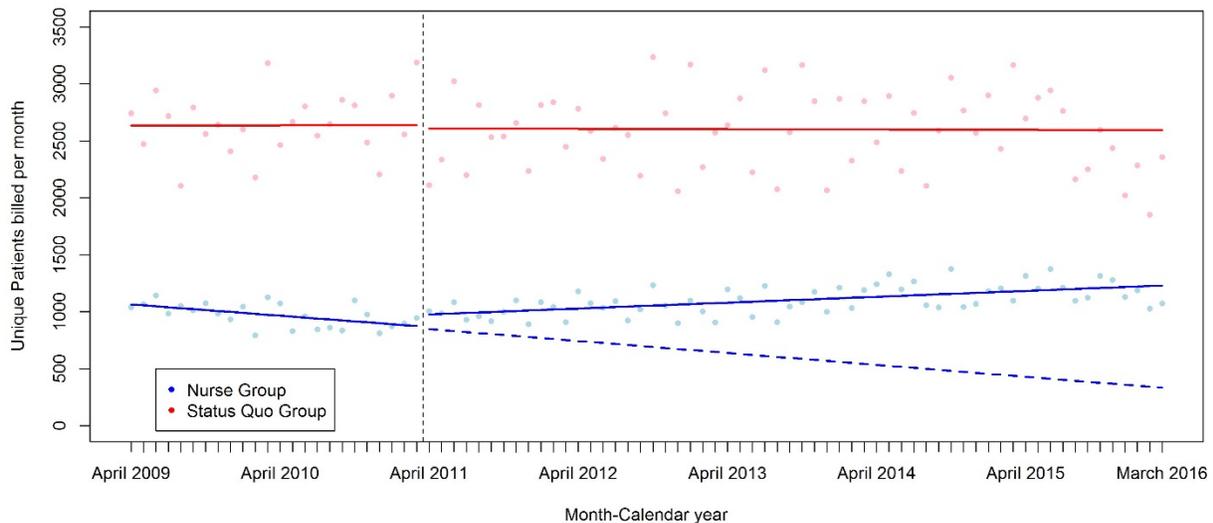
There was a statistically significant, positive change in the trend (slope) of the number of unique patients per month attributable to the introduction of G31060 in the high-intensity cohort ($\alpha=0.05$). The trend change associated with being in the ‘nurse group’ was +13 unique patients per month ($p=0.03$), with the baseline trend change being 0 unique patients per month and not statistically significant ($p=0.821$). Results are summarized in table 4.2.

4.4.1 Impact on number of unique patients seen per month

The number of unique patients treated by the 6 rheumatologists in ‘nurse group’ was lower than number treated by the 17 rheumatologists in the comparison group, in absolute terms (1,041 vs 2,742 unique patients at $t=1$, April 2009). This difference equates to approximately 174 unique patients per rheumatologist in the ‘nurse group’ compared with 161 unique patients per rheumatologist in the ‘status quo group’. The trend in the number of unique patients before the introduction of the G31060 billing code was flat in the ‘status quo’ group (β_1 : 0 per month, 95% CI -9, 11) but decreasing in the ‘nurse group’ (β_3 : -8 per month, 95% CI -20, 3). There were statistically significant differences between the pre-intervention levels of each group (β_2 , $p=0.000$) but time was not statistically significant for either group (β_1 : $p=0.960$ & β_3 : $p=0.163$). The difference in pre-intervention level is likely only reflective of the ‘nurse group’ being smaller than the ‘status quo group’. Following the introduction of the G31060 code in 2011, there was no significant change in the level of unique patients in the ‘nurse group’ (β_6 : $p=0.067$) or the ‘status quo’ group (β_4 : $p=0.715$). There was no statistically significant difference in the baseline trend (β_5 : $p=0.692$). In the ‘nurse group’ the trend change in unique patients

was statistically significant and positive (β_7 : +13 unique patients per month, 95% CI 1, 25). In the 60 months following the introduction of G31060 to the end of the study period, there was no statistically significant change in the level for the ‘nurse’ or ‘status quo’ groups ($\alpha=0.05$) of unique patients per month attributable to the introduction of G31060 when the ‘nurse group’ was restricted to rheumatologists billing G31060 at least 30 times a month on average. However, positive trend change was observed for the nurse-group, suggesting the number of unique patients seen per month can be expanded for a threshold level of intensity in use of the multidisciplinary conference code for community-based patients. Figure 4.5 visually represents the results of the analysis, plotting according to the mean values represented by the regression coefficients.

Figure 4.5 Number of unique patients billed per month before and after the introduction of “Multidisciplinary conference for community-based patients” (G31060) in April 2011 by rheumatologists in the ‘nurse’ and ‘status quo’ groups. High-Intensity analysis using ARMA(12,0) model

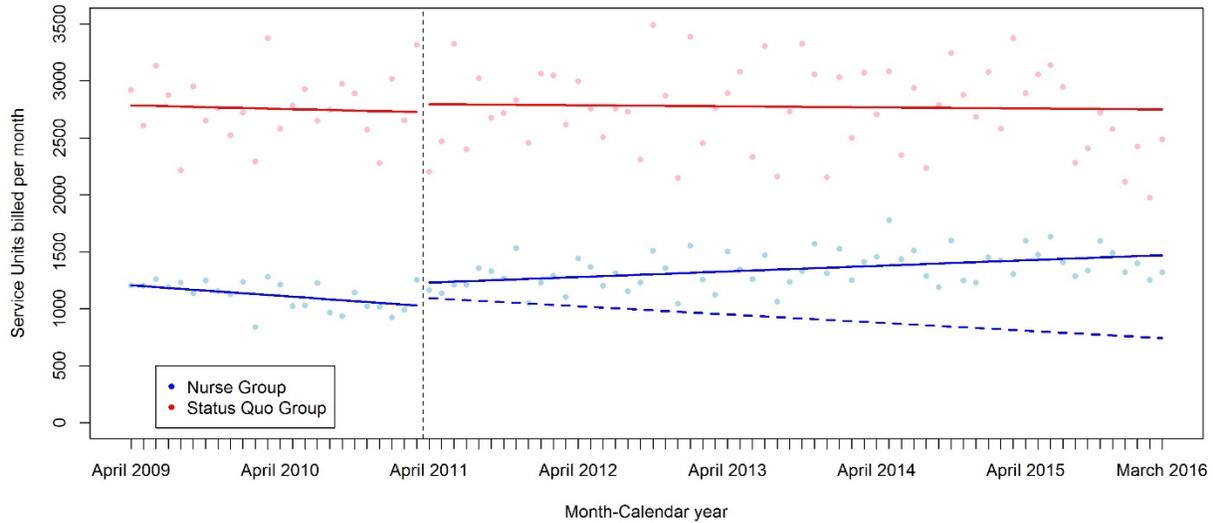


Hatched line indicates the counterfactual, what would be expected absent the intervention

4.4.2 Impact on service units billed per month

The number of rheumatology service units billed by the 6 rheumatologists in the ‘nurse group’ was lower than the number billed by the 17 rheumatologists in the ‘status quo group’, in absolute terms (1,206 vs 2,921 service units at t=1, April 2009). This difference equates to approximately 201 service units per rheumatologist in the “nurse group” compared with 172 service units per rheumatologist in the “status quo group.’ The trend in the number of service units before the introduction of the G31060 billing code is in slight decline for the ‘status quo’ group (β_1 : -3 per month, 95% CI -14, 10) and the ‘nurse group’ (β_3 : -5 per month, 95% CI -18, 7). There were significant differences between the pre-intervention levels of each group (β_2 , $p=0.000$) but time was not statistically significant for either group (β_1 : $p=0.572$ & β_3 : $p=0.422$). Following the introduction of the G31060 code in 2011, there was no significant change in the level of service units in the ‘nurse group’ (β_6 : $p=0.279$) or the ‘status quo group’ (β_4 : $p=0.715$). The trend in the ‘status quo’ group appeared to plateau, but there was no statistically significant difference in the trend (β_5 : $p=0.692$). In the ‘nurse group’ the trend change in service units also appeared to plateau (β_7 , $p=0.114$). In the 60 months following the introduction of G31060 to the end of the study period, there was no statistically significant change in the level or trend for the ‘nurse’ or ‘status quo’ groups ($\alpha=0.05$) of service units per month attributable to the introduction of G31060 in the Primary analysis. Figure 4.6 visually represents the results of the analysis, plotting according to the mean values represented by the regression coefficients.

Figure 4.6 Number of service units billed per month before and after the introduction of “Multidisciplinary conference for community-based patients” (G31060) in April 2011 by rheumatologists in the ‘nurse’ and ‘status quo’ groups. High-intensity analysis using ARMA(12,0) model



Hatched line indicates the counterfactual, what would be expected absent the intervention

4.5 Summary of results

4.5.1 Interrupted time series

A positive, statistically significant effect on trend change in number of unique patients per month attributable to introduction of the multidisciplinary conference code for community-based patients was detected in secondary analyses of nurses billing the code at least once per calendar year (“consistency”, β_7 : +15, $p=0.030$) and nurses billing the code at least 30 times per month, on average (“intensity”, β_7 : +13, $p=0.031$). This is seen in the increased slope of the ‘nurse group’ in the post-intervention period, as compared to the ‘status quo group’. No statistically significant effect on level

change (a vertical shift of the regression line) attributable to the introduction of the multidisciplinary conference code for community-based patients was identified at the 5% level for either secondary analyses of unique patients (β_6 , consistency: $p=0.097$ & β_6 , high-intensity: $p=0.067$).

Secondary analyses of the number of rheumatology service units per month did not detect a statistically significant level or trend change attributable to the introduction of the multidisciplinary conference code for community-based patients at the 5% level (consistency β_6 : $p=0.407$, β_7 : $p=0.151$ & high-intensity β_6 : $p=0.279$, β_7 : $p=0.114$).

Primary analysis did not reveal any statistically significant effect on level or trend change attributable to the introduction of the multidisciplinary conference code for community-based patients for either the number of unique patients treated (β_6 : $p=0.682$, β_7 : $p=0.231$) or for the number of rheumatology service units billed (β_6 : $p=0.744$, β_7 : $p=0.419$). Table 4.2 summarizes the results by the regression coefficients that measure the level and trend change attributable to the introduction of the multidisciplinary conference code (β_6 and β_7 , respectively).

Table 4.2 Summary output of level and trend change attributable to the introduction of the multidisciplinary conference code for community-based patients (β_6 and β_7)

Unique patients	β_6 Δ Level (Unique patients, n)			β_7 Δ Trend (Unique patients, n)		
	Mean	95%CI	p-value	mean	95%CI	p-value
Primary analysis	-88	-509 to 333	0.682	13	-9 to 36	0.231
Secondary analyses:						
1. Consistency	-199	-432 to 35	0.097	15	2 to 29	0.030
2. High Intensity	-185	-381 to 12	0.067	13	1 to 25	0.031
Service items	β_6 Δ Level (Service items, n)			β_7 Δ Trend (Service items, n)		
	Mean	95%CI	p-value	mean	95%CI	p-value
Primary analysis	78	-388 to 544	0.744	10	-15 to 35	0.419
Secondary analyses:						
1. Consistency	-125	-419 to 169	0.407	13	-5 to 30	0.151
2. High Intensity	-113	-427 to 91	0.279	10	-7 to 10	0.114

4.5.2 Absolute change in measures of access

I have calculated the absolute and relative change in both access measures for the analyses with statistically significant results, the secondary analyses of unique patients per month, to describe the clinical significance of the changes observed. Taking April 2011 as the baseline, I have computed the number of patients at 12-month intervals as far as able for the duration of the study, using the method described in section 2.4.4. The “absolute” number in April 2012 then refers to the additional number of patients seen in April 2012 as a consequence of the introduction of the multidisciplinary conference code for community-based patients. Thus, for rheumatologists using the code at least 30 times a month on average, they were collectively able to see an additional 272 unique patients than otherwise would have been possible in that month, a 36% increase over what would have been expected without the introduction of the code.

Note that while the absolute change for the Consistency cohort is greater than the High Intensity cohort at each annual evaluation, the reverse is true for relative change. This is because the Consistency cohort is larger, both in terms of rheumatologists and patients, than the High Intensity cohort. Relative change is more salient for interpreting the policy effect when comparing between cohorts.

Table 4.3 Predicted absolute and relative change in number of unique patients per month, evaluated annually from the introduction of G31060 in April 2011. Model is specified as ARMA(12,0).

Analysis	Measure of change	April 2011	April 2012	April 2013	April 2014	April 2015
Sensitivity 1:	Absolute	0	+327	+511	+695	+879
Consistency	Relative	0	17%	30%	44%	62%
Sensitivity 2:	Absolute	0	+272	+428	+584	+739
High Intensity	Relative	0	36%	66%	107%	168%

4.6 Discussion

4.6.1 Overview

This chapter sought to evaluate the impact of the introduction of the multidisciplinary conference code for community-based patients (G31060) on access to rheumatology care, as represented by the unique number of patients treated and number of rheumatology services billed per month. The findings of my primary analysis indicated that the introduction of the code had no statistically significant effect on level or trend change of unique patients seen by rheumatologists, or their overall billing activity as measured by service units.

When I restricted membership in the ‘nurse group’ to require more consistent (Sensitivity analysis 1) and then more intensive (Sensitivity analysis 2) billing of the code, a positive, statistically significant trend change attributable to the introduction of the code was observed for both secondary analyses

of the number of unique patients seen per month. However, there was no statistically significant trend change attributable to the introduction of G31060 for the number of rheumatology service units billed per month in the primary, consistency, or high-intensity cohorts.

No statistically significant effect on the level change attributable to the introduction of G31060 (β_6) is detectable for the number of rheumatology service units billed per month in the primary, consistency, and high-intensity cohorts ($\alpha=0.05$).

In the consistency cohort, an additional 879 unique patients were seen in April 2015, a 62% increase over the number that would have been seen had G31060 not been introduced. In the high-intensity cohort, an additional 739 unique patients were seen in April 2015, a 168% increase over the number that would have been seen had G31060 not been introduced.

4.6.2 Interpretation and implications

This study appears to demonstrate that a threshold level of billing is required before benefits can accrue from the multidisciplinary conference code as both secondary analyses saw an increase in the number of unique patients seen, while primary analysis criteria for inclusion – ever having billed G31060 – appears to be too relaxed, as it did not see any statistically significant effects on either outcome.

Within the secondary analyses of unique patients per month, a stronger effect on relative change can be seen for the high-intensity cohort. This can be thought of as similar to dose-response, wherein a certain blood-concentration of the therapeutic drug is necessary in order to obtain a clinical outcome.

It also corroborates concern that the base criteria for inclusion in the ‘nurse group’, billing G31060 at least once at any time in the post-intervention period, is overly generous. Additionally, it confirms the added value of the secondary, sensitivity analyses. It seems likely that there is some minimum frequency of utilizing nurses that is necessary to expand access. A higher frequency of billing G31060 appears to provide a greater benefit when examining the relative change in unique patients seen per month (table 4.3), with rheumatologists billing G31060 at least 30 times a month on average experiencing greater predicted relative change in the number of unique patients seen in a given month as compared to rheumatologists only billing at least once in every calendar year cohort (168% increase over the number that otherwise would have been seen in April 2015 versus a 62% increase).

The lack of significant effect on number of service units billed while simultaneously observing a positive effect on number of unique patients seen is intriguing but difficult to explain using administrative data. One explanation would be that rheumatologists are using the nurses to permit more time per appointment, and that the service units they are billing in order to see more patients must be preventing the necessity of additional visits, or we would see an effect on service units. This in turn implies that physicians may be attempting to maximize quality of care over financial benefit. A physician providing fewer, longer consults when they could be billing a greater number of short appointments suggests decision making outside of profit-maximizing behavior, possibly explained by altruism toward the patient (2.2.6)

4.6.3 Limitations

There are a number of limitations in the data and analysis that require consideration.

The number of rheumatologists active through the entire study period is only 46, which bifurcates into 29 ‘nurse group’ and 17 ‘status quo group’ when assigning groups for the interrupted time series with comparator (Table 3.3). Consequently, it cannot be said that this analysis is of the population of rheumatologists, only a sample. For the sensitivity cohorts, the numbers in the ‘nurse group’ are sufficiently small (13 and 6) that the external validity of conclusions drawn from those cohorts is questionable.

The ‘nurse group’ appears to experience a pre-period downward trend that the ‘status quo group’ lacks. Without practice-level data, there is no clear explanation for why this is the case. Comparing the characteristics of patients across the groups in the primary analysis cohort suggests that patients in the ‘nurse group’ may be lower income and more rural, both of which are known barriers to access (3.1.6). However, without knowing which rheumatologists practice together, it is difficult to know if this is an artifact of tracking billings using a practitioner number or can be said to be reflective of rheumatologist behavior at the clinic level. It is also unknown whether, in the case of group practices, ‘nurse group’ and ‘status quo group’ rheumatologists may work in tandem. Additionally, such practices may use nurse-supported conferences for all eligible patients, but only have one rheumatologist billing G31060 in the administrative data. This leaves considerable room for confounding, particularly when the number of rheumatologists in the secondary analyses ‘nurse group’s is not large (13 and 6, respectively). However, I suspect that it is a consequence of the type of patients that the ‘nurse group’ sees, who may be more complex cases and face more barriers to access (3.2.1).

4.4.3 Strengths

This study constitutes the first population-based evaluation of introducing a billing code that facilitates nurse-supported care in British Columbia. Pre- and post-intervention observations of the ‘status quo group’ appear to be effectively flat, indicating that the choice of comparator was appropriate and no significant shocks occurred during the study period.

Due to the interrupted time series with control study design, internal validity of my results is likely to be high. Tracking the longitudinal trends both before and after the introduction of the multidisciplinary conference code for community based-patients means both pre- and post-intervention periods are well described and estimates are unlikely to be distorted by unobserved shocks or underlying trends. The major assumption of interrupted time series with comparator is that the existing level and trend in the outcome among those exposed to the intervention would have changed identically to the control group absent the intervention. My comparator, the ‘status quo group’, are drawn from the same pool of individuals and show effectively no change after the introduction of the change, suggesting this assumption is likely to hold. Selection-History, bias that stemming from a historical shock around the time of the intervention that systematically affects one group greater than the other, could have posed a concern if one group has been subject to a shock, but this does not appear to be the case. The other possible threat to internal validity for interrupted time series with comparator is Selection-Instrumentation, which stems from a change in measurement that systematically affects one group around the same time as the intervention (55). Aside from the introduction of the special services codes in 2011, no changes to the variables under measurement are known to occur around this time, making such bias unlikely.

Sensitivity analysis that attenuated the primary cohort along consistency and intensity of billing acts as an analogue to dose-response in a pharmaceutical intervention. The demonstration of this effect in

4.3 and 4.4 deepens this study by examining the impact of consistency and intensity of use of the multidisciplinary conference code for community based-patients. This should ensure it is of greater use to policymakers and other interested stakeholders.

4.7 Conclusion

Rheumatologists that consistently use G31060 obtain a statistically significant increase in the number of unique patients they see per month ($\alpha=0.05$). For the Consistency cohort, this translates to an additional 879 unique patients, or a 62% increase, in the number of unique patients seen in April 2015 (four years out) over the number of unique patients that would have been seen had G31060 not been implemented. For the High-Intensity cohort, this translates to an additional 739 unique patients, or a 168% increase, in the number of unique patients seen in April 2015 (four years out) over the number of unique patients that would have been seen had G31060 not been implemented. The use of nurse-supported consultations does not appear to have a statistically significant impact on the number of rheumatology services billed per month, regardless of the consistency or intensity of use. Infrequent and/or intermittent use of G31060, as represented by the primary cohort, does not have any significant effect on either number of unique patients seen or rheumatology services billed per month.

Chapter 5: Discussion and Conclusions

The Multidisciplinary Conference for Community-based patients with complex rheumatic diseases (G31060) appears to be well established by the end of the study based on its apparent growth and status as the highest billed special service code, the class of codes that experienced the greatest growth over the period of 2009 Q2 to 2016 Q1. However, this has been a gradual, if steady, process rather than a sudden transition. Comparison of patient characteristics across the ‘nurse’ and ‘status quo group’ suggest that rheumatologists that use nurses may treat patients who face greater barriers to access and/or more complex rheumatic disease than the status quo arm.

While there was no statistically significant effect detectable in the primary cohort, rheumatologists that consistently use G31060 (at least once per calendar year) obtain a statistically significant increase in the number of unique patients they see per month ($\alpha=0.05$). There was a statistically significant, positive change in the trend (slope) of the number of unique patients per month attributable to the introduction of G31060 in the Consistency (Figure 4.2) and High Intensity (Figure 4.3) Cohorts ($\alpha=0.05$). The slope increased by 15 unique patients per month ($p=0.03$) in the Consistency cohort and by 13 unique patients per month ($p=0.03$) in the High-Intensity cohort.

The positive trend change attributable to G31060 resulted in an additional 879 unique patients were seen in April 2015, a 62% increase over the number that would have been seen had G31060 not been introduced in the consistency cohort. In the high-intensity cohort, an additional 739 unique patients were seen in April 2015, a 168% increase over the number that would have been seen had G31060 not been introduced.

No statistically significant effect on level or trend change attributable to the introduction of the multidisciplinary conference code was detectable for the number of rheumatology service units billed per month for any cohort specification.

5.1 Discussion

This study evaluated the impact of the introduction of the multidisciplinary conference code for community-based patients (G31060) on access to rheumatology care in British Columbia. Access was measured in two ways: first, as the number of unique patients seen per month, and second, as the number of rheumatology service units billed per month. In order to properly contextualize access to rheumatology care in British Columbia during the period of analysis (2009 Q2 – 2016 Q1), descriptive statistics of the study population, trend of rheumatology billings, and characteristics of patient-rheumatologist interaction were also explored. These tasks pertain to objective two and objective one of my thesis, as stated in section 1.2.1. To my knowledge, this is the first study to use administrative data to develop a population-based evaluation of the impact of the introduction of the multidisciplinary conference code for community-based patients.

5.1.1 Uptake of the billing code and substitution effect

A small core of 15 rheumatologists were earlier adopters of the code in 2011, constituting a minority of active rheumatologists at the time (15/52). However, the number of active rheumatologists using

G31060 steadily increased by 7-8 per year (23 in 2012, 30 in 2013, 38 in 2014, 45 in 2015) until they finally constituted a majority by the end of the study (45 of 72 in 2016 Q1). This is a notably steady, linear uptake by rheumatologists, with no sudden jumps or drops in number of users. A description of the entry and exit of rheumatologists to active billing, and whether or not they use G31060, is available in table 3.3.

Trends in the billing codes themselves show two core rheumatology codes. Those codes are 31007 (subsequent office visit), constituting between 45-55% of all rheumatology billings between April 2009 and 2015, and 31010 (consultation), constituting 15-30% of all rheumatology billings in that same period. The first, 31007 “subsequent office visit”, is the standard code for follow-up with an established patient. The second, 31010 “consultation”, is the standard code for an initial consultation for a newly referred case. While 31007 continues to increase in absolute terms and 31010 remains approximately stable (figure 3.1), they both decline proportionally over the study period compared to all other rheumatology codes, reaching their lowest relative levels in 2015 (figure 3.2). When exploring the “other” codes that 31007 and 31010 are losing out to in relative terms, it becomes clear that the codes driving the growth in billing are the special services codes introduced in 2011, with other categories of care (TeleHealth, Continuing Care, Referred Cases) either flat or declining over the study. This can be seen in absolute terms in figure 3.3, and relative terms in figure 3.4. Within special services, the multidisciplinary conference code for community-based patients (G31060) initially accounts for around 30% of all special services billings, but increases to almost 50% by the end of the study (figure 3.6), reflecting the higher rate of growth of G31060 compared to other special services billings. From this, I conclude that G31060 is being substituted for 31010, 31007, or both. My reasoning is that the largest proportion of growth in ‘special services’ billing is attributable to G31060, and the growth in

other billings versus 31007 and 31010 is attributable almost entirely to ‘special services’ billing. Furthermore, I found evidence of a proportional decline of billing for 31007 and 31010 compared with all other billings. The text of the G31060 code is sufficiently open-ended enough to allow a “multidisciplinary conference” to be used to replace either a standard consultation or standard follow up, so this substitution seems plausible (3).

Interrupted time series with comparator revealed what appears to be a downward sloping trend for the ‘nurse group’ in the pre-intervention while the ‘status quo group’ remained flat (figures 4.2-4.6). This suggests that there is may be some inherent difference between ‘nurse group’ and ‘status quo group’ rheumatologists, prior to G31060 being introduced. This could be due to the characteristics of their patients, the characteristics of their practices, both, or some other unknown influence. Examination of patient characteristics in section 3.1.6 does suggest that ‘nurse group’ patients differ from ‘status quo group’ patients, being more inflammatory, lower income, and possibly more rural. As these all complicate access to rheumatology care, the suggestion of a more challenging case mix for rheumatologists who go on to use nurses may explain why they were having difficulty maintaining access in the pre-intervention period. The observed pre-period differences in trend may also be the result of a selection effect, wherein rheumatologists who were having difficulty maintaining access were more likely to adopt the multidisciplinary conference code. The opportunity cost of introducing a new model of care may not be worthwhile in practices that had no such issues. This issue is discussed further in section 5.2.2, as many of the possible explanations cannot be answered either within the scope of this study or with available data and so constitute limitations.

5.1.2 Access outcomes measured by unique patients

The primary analysis involved comparison of a ‘nurse group’ consisting of 29 rheumatologists who billed G31060 at least once in the post-intervention period and a ‘status quo group’ consisting of 17 rheumatologists who never did. This analysis did not reveal a statistically significant effect on the level or trend change in number of unique patients per month attributable to the introduction of the multidisciplinary billing code for community-based patients. Details are available in section 4.2.

The first sensitivity, or secondary, analysis involved a ‘nurse group’ consisting of 13 rheumatologists who billed G31060 at least once in every calendar year of the post-intervention period and the same ‘status quo group’ as primary analysis. This was conceived as a test of consistent use of the billing code over time, and has been referred to as the “consistency” cohort throughout this thesis. This analysis identified a positive, statistically significant effect on the trend change in number of unique patients per month attributable to the introduction of the multidisciplinary billing code for community-based patients. The trend change was an increase of 15 unique patients per month (95% CI: 2-29). This resulted in a predicted absolute increase of 879 unique patients seen in the month of April 2015, a 62% increase over the number that would have been seen had G31060 not been introduced. No significant level change attributable to the introduction of the code was identified. Further detail is available in section 4.3.

The second sensitivity, or secondary, analysis involved a ‘nurse group’ consisting of 6 rheumatologists who billed G31060 at least 30 times per month on average in the post-intervention period and the same ‘status quo group’ as primary analysis. This was conceived of a test on high-intensity use of the

billing code, and has been referred to as the “high-intensity” cohort throughout this thesis. This analysis identified a positive, statistically significant effect on the trend change in number of unique patients per month attributable to the introduction of the multidisciplinary billing code for community-based patients. The trend change was an increase of 13 unique patients per month (95% CI: 1-25). This resulted in a predicted absolute increase of 739 unique patients seen in the month of April 2015, a 168% increase over the number that would have been seen had G31060 not been introduced. No significant level change attributable to the introduction of the code was identified. Further detail is available in section 4.4.

5.1.3 Access outcomes measured by service units billed

The primary analysis involved a ‘nurse group’ consisting of 29 rheumatologists who billed G31060 at least once in the post-intervention period and a ‘status quo group’ consisting of 17 rheumatologists who never did. This analysis did not reveal a statistically significant effect on the level or trend change in number of service units per month attributable to the introduction of the multidisciplinary billing code for community-based patients. Details are available in section 4.2.

Neither the secondary analysis involving 13 rheumatologists ‘nurse group’ who billed G31060 at least once in every calendar year of the post-intervention period (the “consistency” cohort), nor secondary analysis of the 6 rheumatologists who billed G31060 at least 30 times per month on average (the “high-intensity” cohort) revealed statistically significant effects on the level or trend change in number of service units per month attributable to the introduction of the multidisciplinary billing code for community-based patients. Details are available in sections 4.3 and 4.4.

5.1.4 Interpretation of results

Synthesizing the results from Chapters 3 and 4, I would suggest that rheumatologists in the “nurse group” were in practices facing barriers to access for their patients, and/or had particularly complex patients. This case-mix was likely present in both the pre- and post-intervention periods, and may explain why a downward trend was observed in the pre-intervention period for the ‘nurse group’ (before they employ a nurse) versus the ‘status quo’ group (4.4.2). While the assignment of rheumatologists to each group is based on post-intervention billing of G31060, the group status is retroactively applied in the pre-intervention period in order to control for the pre-period trends within each group. It is important to recall that at the pre-intervention stage the only elements differentiating the ‘status quo’ and ‘nurse group’ are their patients and their practice-level characteristics. Both groups are rheumatologists in BC with access to subgroups of patients within the same population and using the same billing codes (as G31060 has not yet been introduced). If rheumatologists in the ‘nurse group’ do, in fact, have a more difficult set of patients, this then suggests that ‘nurse group’ rheumatologists may actively choose to take on challenging cases. There may be a certain outlook or approach to practice brought by these rheumatologists that has spillover effects to their billing activity.

There is also an *a priori* argument for this apparent difference between ‘nurse’ and ‘status quo’ groups during the pre-intervention period. The BC Society of Rheumatologists proposed G31060 as a solution to the problem of access (1.1, 1.1.7), so at least some portion of BC rheumatologists were likely aware of the purpose of the code. Dr. Jason Kur was key in pushing for the introduction of a multidisciplinary billing code, publishing twice on the demographic challenges that BC rheumatologists were facing (25,61) in British Columbian health journals and becoming president of the BC Society of Rheumatologists shortly after the introduction of the special services codes(62). It

seems likely that, given Dr. Kur's interest in the matter and prominence within the BC rheumatology community, that a significant portion of BC rheumatologists were both aware of G31060 and its intended effects regarding access. From a data-naïve perspective, one would anticipate that rheumatologists experiencing problems with access to care would be more likely to adopt and continue to use the code than those who are not. Consequently, rheumatologists with access-related challenges in the pre-intervention period might be those who adopt and fully utilize the G31060, and thereby became the 'nurse group'. Rheumatologists who did not face similar challenges had no reason to change their current practice, and in absence of a benefit to be gained from doing so may have decided the cost and disruption of modifying their model of care to be unjustified. These rheumatologists would continue standard practice as the 'status quo' arm.

The multidisciplinary conference code for community-based patients does not set any specific time limit for the consultation, does not assign roles to the required elements (assessment, written treatment plan, counselling), and does not specify how much time the nurse and rheumatologist respectively need to spend in the consultation (3) . There is a great deal of room for heterogeneity in the use of nurses within this code, and consequently it is not possible to *a priori* determine the time saved per use. In order to build a reliable estimate, one would have to obtain data on how the code is used from each rheumatology practice that does so. While this is beyond the scope of this thesis, with some basic assumptions I believe it is possible to hypothesize on why, based on my secondary analyses, it would appear that a certain threshold level of billing G31060 must be reached before any impact is visible.

First, the length of time that a multidisciplinary conference takes will likely depend on whether it is being used in lieu of 31010, the standard consultation code for newly referred cases, or is replacing

31007, the most commonly used follow-up code for established patients. Evidence in the trends of billing for rheumatology services suggests that G31060 is likely being used as a replacement for both (section 3.1.2). It is unclear how long a follow-up appointment (31007) would be expected to take, and this likely varies substantially by patient. However, it seems reasonable to assume that a follow-up should be expected to take less time than an initial consultation. Dependent on which code G31060 is replacing, the impact may be different, because the time involved may vary. The total length of the appointment determines the amount of potential time “saved” by delegating to a nurse, and consequently shorter appointments would contribute proportionately less to overall time “saved.” The immediate implication of this is that for any given number of substitutions, 31010 will generate a stronger impact on access than the same number of substitutions for 31007. However, due to the variable nature of time-saved, it is likely that multiple billings per rheumatologist would have to be observed in order to extract any definitive signal regarding gains to access that result through substitution of either 31010 or 31007 by the multidisciplinary conference code.

Another potential reason that it appears a threshold of G31060 billings must be met in order to observe an impact on access is that the multidisciplinary conference code may be subject to a form of economy of scale. The initial process of training a nurse for the rheumatology outpatient setting, determining and implementing the division of labour, establishing productive communication, and then streamlining that division of labour, is likely to be an intensive one. The rheumatologist and nurse are not only learning to utilize what constitutes an entirely novel model of care within the BC rheumatology context, they are also learning to work with one another as colleagues. Infrequent or intermittent uses of the multidisciplinary code may not provide sufficient time to properly integrate the nurse(s) into the rheumatology practice. Once the nurse and rheumatologist are comfortable

communicating, coordinating, and have a defined plan regarding how to run such multidisciplinary conferences, then efficiencies may accrue. Before that point, introduction of the nurse(s) may actually impede access in the short term as the new model of care is integrated into clinical practice. Dr. Michelle Teo, an early-adopter of the multidisciplinary conference code, acknowledges that the initial integration period may actually be more inefficient than prior practice in her 2017 presentation at Arthritis Alliance of Canada annual meeting (63).

Given the heterogeneity possible in use of the multidisciplinary conference code for community-based patients, it is not altogether surprising that no significant signal was found in the primary cohort. Variation in the frequency of use alone was likely enough to bias the result to the null, as 16 of 29 members of the “nurse group” did not even bill G31060 in every calendar year (see section 4.1.1). However, it may also be the case that frequency of use and the way in which nurses are used to support practice of use are correlated. That is, rheumatologists who use nurses more frequently may operationalize the multidisciplinary conference in a distinct way from those that use nurse less frequently. This is further reason to obtain practice-level data on clinics that use nurses, especially with regard to how they use the nurse. The increase in number of unique patients this study attributes to consistency and/or intensity of billing may be dependent on a particular operational structure that administrative data cannot capture.

The flexibility of the multidisciplinary conference code for community-based patients also allows for the possibility that not all rheumatologists adopted the code with the primary intention of expanding access. Rheumatology care has begun to follow a broader trend in medicine towards multidisciplinary, patient centered care. Such care models are becoming preferred because of beliefs regarding their

ability to better incorporate and support patient decision making, and to fully utilize the skills of allied health practitioners in providing patient care. The Arthritis Alliance of Canada advocates for the use of multidisciplinary care teams for the care of inflammatory arthritis (64), as does the European League Against Rheumatism (26). Rheumatologists who are drawn to the multidisciplinary conference code on the basis of improving their quality of care may operationalize its implementation differently than those concerned primarily with access. A 2014 chart review of 3 BC rheumatology clinics who adopted G31060 soon after its introduction reveals that at least some BC rheumatologists were aware of the potential benefits to both access and quality of care (65). The consequence of rheumatologist variation in what aspects of care they chose to prioritize when implementing multidisciplinary conferences would likely be to bias the impact on access toward the null versus the ‘status quo’ group.

An interesting and somewhat surprising result of this study is that while consistency (billing G31060 at least once a year) and high-intensity (billing G31060 at least 30 times per month, on average) do have a positive impact on the number of unique patients seen, no statistically significant effect was observed for the number of service units per month. The simplest explanation for this would be that the multidisciplinary conference reduces the need to repeat appointments while allowing more unique patients to be seen. The explicit requirement for patient counselling and a written treatment plan (3) may promote a more comprehensive coverage of the patient’s needs during the visit, and allows the patient to have a document to reference regarding their ongoing care. Fewer, but higher quality care-episodes reduce the necessity of additional follow up before the next recommended visit. It is also worth considering the profit-motive, a single billing of G31060 is \$225.96, nearly three times more than the standard follow-up code, which bills for \$86.84. Condensing follow up into a single high-quality episode of care rather than repeated follow ups may not only be more efficient but actually

profit-maximizing from the rheumatologist's perspective, assuming one can substitute a sufficient number of standard follow-up codes (31007) for G31060. However, these interests are not necessarily mutually exclusive and under the Chandra and Skinner framework for physician utility, a utility function that contains both the health status of the patient and the physician's own utility, this pattern of rheumatology behavior would be both perfectly rational and beneficial to patients (53).

5.2. Strengths and Limitations

5.2.1 Strengths

The administrative datasets provided by Population Data BC provide a reliable basis for analysis on many patient characteristics and rheumatologist billing activity. For any fee-for-service rheumatologist in BC, this means a complete capture of any procedure or service they performed, assuming that he or she seeks reimbursement. This also means that all patients seen in this fee-for-service manner are captured. This provided the opportunity to observe 152,251 patients as they received care in either the 'nurse group' or 'status quo' group during the period in which the billing code was conducted. The patient population appears to be largely representative of what one would expect for a rheumatic disease population in BC, reflecting a highly urbanized population living predominantly in the Fraser and Vancouver Coastal health authorities, and possessed of an even distribution of income across quintiles. Stratification of rheumatic disease by sex corroborates the expected proportion of women across diseases with well-known disparities in the sex of those they affect. Of these, 87% of persons with systematic lupus erythematosus were women, which is consistent with the 9:1 female-male ratio often associated with the condition(66). 73% of those with rheumatoid arthritis were women, which

is slightly higher than the expected 3:1 female-male ratio(67). However, as these are patients receiving active rheumatology care, rather than all diagnosed patients, factors such as the propensity of genders to remain under consistent rheumatology care may be at play. Finally, only 19% of persons with gout were women, which is on the higher end of the 7:1-9:1 ratio of males to females often cited for those under 65 (68). The proportion of women for each rheumatic disease can be found in Appendix 3.

This study constitutes the first population-based evaluation of introducing a billing code that facilitates nurse-supported care in British Columbia – certainly for rheumatology care.

The use of interrupted time series with comparator provides protection from many potential biases that can occur from tracking data observationally over time. This is predominantly accomplished by tracking the longitudinal trends both before and after intervention of interest. Shocks (unpredictable events) that affect the outcome being measured will be visible and adjusted for provided they are sufficiently far from the intervention, and any underlying trends within the data are built into the analysis and “netted-out” when assessing the final impact of introducing the multidisciplinary billing code for community-based patients. Both pre- and post-intervention periods are well described by tens of thousands of observations and estimates and with no other shocks known near the time of intervention in April 2011. Interrupted time series with comparator makes one major assumption: that existing level and slope of the outcome in the “exposed”, intervention group (nurse) changes in the same way as the ‘unexposed’, comparator group (‘status quo’) absent the intervention. My comparator, the ‘status quo’ group, are drawn from the same pool of individuals and show effectively no change after the introduction of the change, suggesting this assumption is likely to hold. Consequently, the internal validity for this study is likely to be high.

I conducted a sensitivity analysis that explored the impact of tightening the definition of intervention to require consistency (as defined by billing G31060 at least once per year) and high-intensity (billing G31060 at least 30 times per month, on average) billing. This is conceptually similar to the idea of testing increasing doses of a therapeutic agent in order to determine the necessary threshold for the intended effect (“dose-response”). Observing this gradient of response strengthens the likelihood that increased use of G31060 is, in fact, causal in the observed increase in unique patients per month (69). Although the increasingly strict definitions of the secondary analyses reduced the number of rheumatologists under observation in the ‘nurse group’ from the primary analysis cohort, doing so revealed a positive, significant impact of introducing G31060 on the post-period change in trend for the ‘nurse group’ in both secondary analyses of unique patients treated per month.

While the behavior of 13 or 6 rheumatologists should be not taken to be reflective of the general pattern of rheumatologist behavior, the real-world nature of this study does mean that, were other rheumatologists to adopt those same behaviors of consistency and intensity of billing, it is likely that they would experience a similar increase in the number of unique patients per month seen. Unlike a randomized clinical trial, which can strictly control clinical conditions, practitioner behavior, and participant characteristics, an observational study must take the world as it is. While there is undoubtedly a great deal of noise introduced by the natural heterogeneity of a population-based study, it also means that the findings of such a study are reflective of real-world practice. The lessons learned from this analysis have strong external generalizability within British Columbia and other Canadian provinces with similarly structured health care systems, such as Ontario.

5.2.2 Limitations

As interrupted time series with comparator requires longitudinal data, this study has to rely on relatively few rheumatologists present throughout the full study period. This may compromise the generalizability of these results, as it is difficult to claim that the 13 rheumatologists who billed G31060 at least once per year or the 6 rheumatologists that billed G31060 at least 30 times a month are representative of the general patterns of rheumatologist behavior. However, if the consistency and high-intensity cohorts are thought of more as a proof of concept than descriptive of broader behavior, they still have value in demonstrating what could be achieved if the behavior of those ‘nurse group’ rheumatologists were adopted more broadly.

I am presently unable to explain the apparent difference in pre-period slope between the ‘nurse-group’ and ‘status quo’ group. Analysis of the patient characteristics in either arm of the primary cohort suggest there are some differences that may contribute to the ‘nurse group’ having a more challenging case-mix with regard to access. These include the ‘nurse group’ having more inflammatory conditions, lower income patients, and likely fewer urban patients. However, given the large sample sizes involved, a simple test of statistically significance difference in means or frequency between the groups is insufficient to support this hypothesis. An extension of this thesis would be further exploration of whether the patient characteristics discernable from my administrative dataset can answer this question at all, as the difference may come down to characteristics of the rheumatology practices (ex. group or solo, female or male practitioner(s), researcher or community clinician, time to retirement) that are unobservable in my datasets. It is worth considering that “time” and “nurse*time”, variables whose coefficients (β_1 and β_3 respectively) describe the pre-period slope for either group, were not statistically significant at the 5% level in any primary or secondary analyses for either measure of

access, so it is possible that the apparent discrepancy is only that – apparent. Appendix 2 has a complete list of regression variables, the mean value of their coefficient, 95% confidence interval, and p-value for all primary and secondary analyses.

As I am not able to observe any data at the rheumatology practice level, I am also not able to observe or adjust for any practice level shocks, existing trends, or inherent barriers that may confound this analysis. If, for example, a group practice lost a colleague, they may find it more desirable to use a nurse. Group practices may also have a nurse, or set of nurses, that see all the eligible patients in the practice while only one of multiple rheumatologists takes responsibility for running them. These and similar considerations may affect results and/or their interpretation in a way that BC administrative data, as it currently stands, is not capable of addressing.

The situation described above would lead to my analysis falsely indicating his or her colleagues as ‘status quo’ practitioners and so biasing the impact toward the null. Solo practitioners may not physically have enough space to bring in additional providers like nurses to assist them. If this is a sufficiently common problem, then solo practitioners should likely have been excluded from analysis as they could not have reasonably used the code. Rheumatologists approaching retirement may find it desirable to take on a nurse to help them maintain access and quality of care while the work to wind down their practice. While this is still a legitimate use of the code, it is not precisely the intended usage. Generally speaking, lack of practice-level data leaves a lot of room for unexplained heterogeneity in this study.

Patients in this study are heavily clustered in urban areas, with health authorities mostly represented by Vancouver Coastal and Fraser Health, reflecting 28 and 35% of the study population respectively.

While this is representative of the British Columbian population, it also means that we have comparatively little data from rural regions, and what I do have is likely diluted significantly by the urban presence in the cohorts. To understand the impact of introducing G31060 in rural or remote environments, a more targeted study would need to be done that focuses specifically on patients and practices in those regions.

Finally, on a personal level, time was an exogenous limitation in my analysis for this study, with the complete dataset not being received until December of 2018. This left 8 months of time to develop, test, and revise the code and analytic techniques used in this study. This thesis was originally intended to include assessment of a quality of care outcome – medication adherence – to complement analysis of the impact on access, but that avenue had to be dropped for feasibility reasons.

5.3 Implications

5.3.1 Implications: Patients

This study did not examine patient outcomes directly, but it would appear that the introduction of G31060 has had a positive impact on patients whose rheumatologist consistently uses nurses. I observed an increase in unique patients seen per month for the consistency and high-intensity cohorts. This likely means less time for new patients to wait before a consultation, and greater access to follow-up appointments for established patients, if necessary. As noted in section 1.1.3, early treatment is critical to avoid spread and intensification of inflammation, as well as reduce bone and organ damage. The window to achieve remission and avoid permanent damage is brief – only about 3 months (70,71).

Patients of a rheumatologist that uses the G31060 billing code consistently (at least once per year) and/or with high-intensity (at least 30 times a month, on average) are more likely to be seen within this window, and consequently have a greater likelihood of a better prognosis and quality of life.

Beyond the direct clinical outcomes, work done by Hall et al showed that nursing-led care of patients with rheumatic disease generally had higher reported patient satisfaction than care from a rheumatologist alone. Patients viewed nurse-led care as more person-centered, felt care was more consistent, and that a stronger patient-provider relationship was built(42). This is consistent with the proposed benefits of the “working alliance” concept within multidisciplinary care. A “working alliance” is characterized by the relationship between patient and provider(s), specifically communication of goals and tasks to take place over treatment, agreement on those goals, and mutual like and trust (72). The former two are also key-components of “treat-to-target”, frequently employed in rheumatology care. While overlapping personal preferences are the most likely source of harmony between patient and physician , working alliance models believe trust can be built, and is built, through the process of communication and agreement over shared goals (72). The multidisciplinary conference code for community-based (G31060) patients actually requires certain elements of this working alliance. The multidisciplinary conference code states that assessment, written treatment plan, and any other counselling the patient needs for management of their particular diagnosis must be addressed during each care episode. The latter is a condition that opens the door to open communication with the patient regarding their needs and desires for management of their disease. While administrative data cannot reveal the precise form by which these requirements are met, it is certainly suggestive of a working-alliance structure. Such a structure is typically associated with better adherence, patient satisfaction, and quality of life (72). Future research will be required to establish whether or not such

alliance is generated by the use of G31060, but it holds promise for improved, more person-centered patient care.

5.3.2 Implications: Rheumatologists

The findings of Chapter 3 and 4 in conjunction would suggest that rheumatologists facing a difficult case-mix and/or caring for patients with barriers to access ought to consider implementing G31060, if they have not done so already. However, the code must be applied consistently (as defined as at least once a year) and/or with high-intensity (as defined as at least 30 times a month, on average) or it is unlikely that any given rheumatology practice will see any improvement in access to care for their patients. However, even maintaining access to care is important for quality rheumatology care, and while no great improvement was observed for the primary cohort, the feared “crisis” of access did not occur. As new rheumatologists were excluded, this cannot be wholly attributed to an incoming cohort filling the gap. If it is the case that G31060 simply helps maintain the current level of access, it may still be beneficial from a practice perspective. Lacaille et al demonstrated precipitous decline in use of disease modifying anti-rheumatic drugs among rheumatoid arthritis patients unwilling or unable to access a rheumatologist. For patients continuously followed by a rheumatologist, the use of disease modifying anti rheumatic drugs was 84%, declining to 73% of patients who “intermittently” saw a rheumatologist, 40% of those who saw an internist, and 10% of those following a family physician(15). As such drugs are a core component of care for rheumatoid arthritis, as well as numerous other rheumatic diseases, it would seem critical to ensure at least “intermittent” access to rheumatologists. In this way, access is could be a considered a necessary condition to ensure quality of care.

It remains to be seen what the impact of introducing the multidisciplinary conference code for community-based patients may be on quality of care. Rheumatologists are often treating multi-morbid patients, and having nursing support may help specialists keep track of non-rheumatology considerations when managing their patients. For example, including a nurse in the consultation may improve the chances of a discussion of cardiovascular disease risk and adherence to statins for a new rheumatoid arthritis patient. As G31060 requires that the nurse and rheumatologist provide both a written treatment plan and any counselling the patient needs for disease management, patients seeing a nurse may be able to better manage their medications. The multidisciplinary conference code has criteria that lend themselves well to medication management, and the additional time facilitate by the presence of a nurse means that greater attention could be paid to adherence than was previously.

Analysis of the 'status quo' group in this study appears to show that rheumatologists who are not presently facing challenges regarding access do not need to use G31060 to maintain their current level of provision, as the level and trend of this group remains effectively flat for both number of unique patients and service units per month across pre and post intervention periods. However, it is possible that utilizing nurse-supported consultations may allow them to expand their practice beyond its current size and/or see patients more frequently than present. If future research reveals quality of care benefits, rheumatologists with no concerns regarding access may be able to boost the quality of their practice by adopting the multidisciplinary conference code for community-based patients.

5.3.3 Implications: British Columbia Ministry of Health

While the primary cohort does not show any significant effects, it is important to note that the secondary analyses of consistent use (as defined as at least once a year) and high-intensity use (as defined as at least 30 times a month, on average) of the multidisciplinary billing code for community-based patients both showed a statistically significant, positive trend change in the number of unique patients seen per month. This suggests the code has to be used in a certain way, or at least at a certain frequency, in order to be of benefit to expanding access. Rheumatologists themselves likely do not have the time or resources to evaluate the precise parameters of “how much” and “how often” are necessary. However, the BC Ministry of Health could assist rheumatologists in determining the appropriate level of billing for their clinic by providing additional resources to rheumatologists interested in adopting G31060, and/or the Ministry could conduct its own research to determine the optimal level of billing G31060. The BC Ministry of Health would be approaching the problem from the payer perspective, and so this determination would likely be based on some form of cost-benefit and/or cost-effectiveness analysis. Ideally, more research into the impact on quality of care of introducing G31060 would be done prior to implementing any binding regulations, as the code likely has impacts along more axes than access alone. Patients would also preferably be consulted for their preferences regarding nurse-supported versus rheumatologists only care before any final decisions on the appropriate level of billing is made. Computation of benefits and costs ought to incorporate the improved prognosis and quality of life gained from earlier diagnosis and improved management. However, it is certainly within the Ministry’s power to alter G31060 in such way that, on the lower end of intervention, creates incentives for rheumatologists to bill to the optimum, or, on the higher end of intervention, actually require rheumatologists to bill at a certain level according to the decision rules the BC Ministry of Health has developed.

Additionally, it would be helpful to both research community and the Ministry of Health itself if the Ministry found a way to obtain data at the level of the rheumatology clinic (practice-level data) as part of routine administrative data collection, in a manner than the rheumatologists themselves would find acceptable. The ability to make accurate predictions and interpretations of the behaviour of rheumatology practices is severely curtailed by the current dearth of data at this level. For example, both practice type and the sex of the rheumatologist have been identified as relevant when predicting rheumatology workforce needs, and neither variable is accessible to researchers or planners beyond infrequent workforce surveys (73). The upcoming 2020 “Stand Up and Be Counted” workforce survey may be a good time to begin building those bridges(74).

5.4 Next Steps

There are several areas for future research to further examine the impact of introducing G31060 on access. First, a qualitative research design that interviews key stakeholders - patients, rheumatologists, and nurses - at the clinic level would go a long way to explaining the “how” and “why” of implementation. It would also provide an opportunity for patients to speak on their experience in a way not possible using quantitative analysis.

Second, a targeted analysis focusing on health authorities with higher proportions of rural patients, such as the Interior or Northern health authorities, would be of benefit to understanding access to rheumatology care at the margins. Regional disparity is often discussed but few studies have explored

this issue in great detail, likely due to the lack of available data (22). The focus of this thesis was the impact on the entire BC population, but a consequence of that focus is the potential “washing-out” of the impact of introducing G31060 in less populated, more remote, and more rural areas by the supermajority (72%) of patients living in urban areas.

The work done within this thesis could be extended by using a regression discontinuity design that tracks rheumatologists longitudinally as before, but uses a set number of months before and after the rheumatologist uses G31060 as the “pre-intervention” and “post-intervention” periods. In this case the “intervention” is the individual rheumatologist’s choice to begin using the multidisciplinary conference code for community-based patients, as compared to the British Columbia-wide intervention of introducing the code. This would allow the inclusion of rheumatologists who used G31060 but were not present from 2009 Q2, if those rheumatologists have a sufficient amount of time before they adopted the code to provide an appropriate assessment of pre-period level and trend. As the low number of rheumatologists in the ‘nurse group’ of the secondary analyses is a limitation, this could provide a more robust estimate of the impact of introducing G31060 than was possible in this study. It may be necessary to extend the end of the study period in order to ensure appropriate amounts of time in pre-G31060 and post-G31060 periods for late-adopting rheumatologists.

5.5 Conclusion

The impact on access to rheumatology care of introducing the multidisciplinary conference for community-based patients (G31060) varied depending on the consistency and intensity by which the code is used. Primary cohort analysis, which assigned rheumatologists who ever billed G31060, did not see any statistically significant impact on either the number of unique patients seen or rheumatology service items billed per month ($\alpha=0.05$). Secondary analyses that checked for consistency in billing to be included in the ‘nurse group’, as defined by at least one use of G31060 per year, found a statistically significant, positive increase in post-intervention slope attributable to the introduction of the multidisciplinary code for unique patients per month, but no statistically significant effect on the number of rheumatology service items per month. In an alternate secondary analysis that tested for intensity, as defined by billing G31060 at least 30 times per month on average, a similar significant and positive increase in post-intervention slope attributable to the introduction of the multidisciplinary code was observed for unique patients seen per month, and similarly no effect on rheumatology service items. In conclusion, the multidisciplinary conference code has the potential to improve the number of patients seen by rheumatologists, but requires an as-yet-to-be-determined threshold of utilization in order to obtain this improvement. This analysis suggests that higher levels of utilization are associated with higher levels of improvement with regard to the number of unique patients per month seen.

Bibliography

1. Kur J, Koehler B. Rheumatologist demographics in British Columbia: A looming crisis. *BC Med J*. 2011 Apr;53(3):128–31.
2. Chan J, Kur J. Update on Rheumatologist Demographics in British Columbia. *CRAJ* [Internet]. 2014 [cited 2018 Aug 21];24(4). Available from: http://craj.ca/archives/2014/English/Winter/PDFs/CRAJ_Winter_2014_Chan.pdf
3. Ministry of Health. Medical Services Commission Payment Schedule [Internet]. 2017 [cited 2018 Sep 11]. Available from: <https://www2.gov.bc.ca/assets/gov/health/practitioner-pro/medical-services-plan/msc-payment-schedule-december-2017.pdf>
4. EULAR Secretariat. 10 things you should know about rheumatic diseases [Internet]. [cited 2018 Sep 11]. Available from: <https://www.eular.org/myUploadData/files/10%20things%20on%20RD.pdf>
5. Wong R, Davis AM, Badley E, Grewal R, Mohammed M. A Growing Burden and Implications for Health Care Needs. 2010;110.
6. Broten L, Aviña-Zubieta JA, Lacaille D, Joseph L, Hanly JG, Lix L, et al. Systemic Autoimmune Rheumatic Disease Prevalence in Canada: Updated Analyses Across 7 Provinces. *J Rheumatol*. 2014 Apr 1;41(4):673–9.

7. Rai SK, Aviña-Zubieta JA, McCormick N, De Vera MA, Shojania K, Sayre EC, et al. The rising prevalence and incidence of gout in British Columbia, Canada: Population-based trends from 2000 to 2012. *Semin Arthritis Rheum.* 2017;46(4):451–6.
8. Humphreys JH, Verstappen SMM, Hyrich KL, Chipping JR, Marshall T, Symmons DPM. The incidence of rheumatoid arthritis in the UK: comparisons using the 2010 ACR/EULAR classification criteria and the 1987 ACR classification criteria. Results from the Norfolk Arthritis Register. *Ann Rheum Dis.* 2013 Aug 1;72(8):1315–20.
9. Roddy E, Choi H. Epidemiology of Gout. *Rheum Dis Clin North Am.* 2014 May;40(2):155–75.
10. Gaubitz M. Epidemiology of connective tissue disorders. *Rheumatology.* 2006 Oct 1;45(suppl_3):iii3–4.
11. Disease Info – Arthritis BC [Internet]. 2018 [cited 2018 Jul 9]. Available from: <http://arthritisbcandme.info/disease-info/>
12. Ministry of Health. Rheumatoid Arthritis - Diagnosis, Management and Monitoring - Province of British Columbia [Internet]. [cited 2018 Sep 11]. Available from: <https://www2.gov.bc.ca/gov/content/health/practitioner-professional-resources/bc-guidelines/rheumatoid-arthritis>
13. Lard LR, Visser H, Speyer I, vander Horst-Bruinsma IE, Zwinderman AH, Breedveld FC, et al. Early versus delayed treatment in patients with recent-onset rheumatoid arthritis: comparison of two cohorts who received different treatment strategies. *Am J Med.* 2001 Oct 15;111(6):446–51.

14. van der Linden MPM, le Cessie S, Raza K, van der Woude D, Knevel R, Huizinga TWJ, et al. Long-term impact of delay in assessment of patients with early arthritis. *Arthritis Rheum.* 2010 Dec 1;62(12):3537–46.
15. Lacaille D, Anis AH, Guh DP, Esdaile JM. Gaps in care for rheumatoid arthritis: A population study. *Arthritis Care Res.* 2018 Jul 24;53(2):241–8.
16. Rai SK, Aviña-Zubieta JA, McCormick N, De Vera MA, Lacaille D, Sayre EC, et al. Trends in Gout and Rheumatoid Arthritis Hospitalizations in Canada From 2000 to 2011. *Arthritis Care Res.* 2017;69(5):758–62.
17. Vera MAD, Choi H, Abrahamowicz M, Kopec J, Goycochea-Robles MV, Lacaille D. Statin discontinuation and risk of acute myocardial infarction in patients with rheumatoid arthritis: a population-based cohort study. *Ann Rheum Dis.* 2011 Jun 1;70(6):1020–4.
18. Health M of. Rheumatoid Arthritis - Diagnosis, Management and Monitoring - Province of British Columbia [Internet]. 2018 [cited 2018 Jul 9]. Available from: <https://www2.gov.bc.ca/gov/content/health/practitioner-professional-resources/bc-guidelines/rheumatoid-arthritis>
19. Ministry of Health. Services Covered by MSP - Province of British Columbia [Internet]. [cited 2018 Sep 11]. Available from: <https://www2.gov.bc.ca/gov/content/health/health-drug-coverage/msp/bc-residents/benefits/services-covered-by-msp>
20. Ministry of Health. MSC Payment Schedule - Province of British Columbia [Internet]. [cited 2018 Sep 11]. Available from: <https://www2.gov.bc.ca/gov/content/health/practitioner-professional-resources/msp/physicians/payment-schedules/msc-payment-schedule>

21. Ahluwalia V, Mosher D, Frank C, Zummer M. A pan-Canadian Approach to Inflammatory Arthritis Models of Care [Internet]. Arthritis Alliance of Canada; 2014 Apr [cited 2018 Sep 11]. Available from: <http://www.arthritisalliance.ca/images/PDF/eng/20140430-2030-IA-MOCFINAL.pdf>
22. Brophy J, Marshall DA, Badley EM, Hanly JG, Aaverns H, Ellsworth J, et al. Measuring the Rheumatology Workforce in Canada: A Literature Review. *J Rheumatol*. 2016 Jun 1;43(6):1121–9.
23. Barber CEH, Jewett L, Badley EM, Lacaille D, Cividino A, Ahluwalia V, et al. Stand Up and Be Counted: Measuring and Mapping the Rheumatology Workforce in Canada. *J Rheumatol*. 2017 Feb 1;44(2):248–57.
24. Barber CEH, Jewett L, Badley EM, Lacaille D, Cividino A, Ahluwalia V, et al. Stand Up and Be Counted: Measuring and Mapping the Rheumatology Workforce in Canada. *J Rheumatol*. 2017 Feb 1;44(2):248–57.
25. Kur J, Koehler B. Rheumatologist demographics in British Columbia: A looming crisis. *BC Med J*. 2011 Apr;53(3):128–31.
26. Eijk-Hustings Y van, Tubergen A van, Boström C, Braychenko E, Buss B, Felix J, et al. EULAR recommendations for the role of the nurse in the management of chronic inflammatory arthritis. *Ann Rheum Dis*. 2011 Oct 1;annrheumdis-2011-200185.
27. Luqmani R, Hennell S, Estrach C, Birrell F, Bosworth A, Davenport G, et al. British Society for Rheumatology and British Health Professionals in Rheumatology Guideline for the

- Management of Rheumatoid Arthritis (the first two years). *Rheumatology*. 2006 Sep 1;45(9):1167–9.
28. ARMA Standards of Care for people with MSDs/ MSK/ Arthritis [Internet]. [cited 2018 Aug 27]. Available from: <http://arma.uk.net/resources/standards-of-care/>
 29. Rheumatology | Subject Guide | Royal College of Nursing [Internet]. The Royal College of Nursing. [cited 2018 Aug 7]. Available from: </library/subject-guides/rheumatology>
 30. Rheumatoid arthritis in over 16s | Guidance and guidelines | NICE [Internet]. [cited 2018 Aug 7]. Available from: <https://www.nice.org.uk/guidance/qs33/chapter/quality-statement-7-annual-review#quality-statement-7-annual-review>
 31. van Eijk-Hustings Y, Ndosì M, Buss B, Fayet F, Moretti A, Ryan S, et al. Dissemination and evaluation of the European League Against Rheumatism recommendations for the role of the nurse in the management of chronic inflammatory arthritis: results of a multinational survey among nurses, rheumatologists and patients. *Rheumatology*. 2014 Aug 1;53(8):1491–6.
 32. Luqmani R, Hennell S, Estrach C, Birrell F, Bosworth A, Davenport G, et al. British Society for Rheumatology and British Health Professionals in Rheumatology Guideline for the Management of Rheumatoid Arthritis (the first two years). *Rheumatology*. 2006 Sep 1;45(9):1167–9.
 33. Luqmani R, Hennell S, Estrach C, Basher D, Birrell F, Bosworth A, et al. British Society for Rheumatology and British Health Professionals in Rheumatology guideline for the management of rheumatoid arthritis (after the first 2 years). *Rheumatology*. 2009 Apr 1;48(4):436–9.

34. Karsh J. Management of Rheumatoid Arthritis 2012: A Canadian State of the Art. *J Rheumatol*. 2012 Aug 1;39(8):1497–9.
35. Bykerk VP, Akhavan P, Hazlewood GS, Schieir O, Dooley A, Haraoui B, et al. Canadian Rheumatology Association Recommendations for Pharmacological Management of Rheumatoid Arthritis with Traditional and Biologic Disease-modifying Antirheumatic Drugs. *J Rheumatol*. 2012 Aug 1;39(8):1559–82.
36. Bombardier C, Hazlewood G, Akhavan P, Schieir O, Dooley A, Haraoui B, et al. Canadian Rheumatology Association Recommendations for the Pharmacological Management of Rheumatoid Arthritis with Traditional and Biologic Disease-modifying Antirheumatic Drugs: Part II Safety. *J Rheumatol*. 2012 Jun 15;39:1583–602.
37. BC Guidelines.ca. Rheumatoid Arthritis: A Guide for Adult Patients [Internet]. 2012 [cited 2018 Sep 13]. Available from: https://www2.gov.bc.ca/assets/gov/health/practitioner-pro/bc-guidelines/rheumatoid_arthritis_pg.pdf
38. Hall J, Kaal KJ, Lee J, Duncan R, Tsao N, Harrison M. Patient Satisfaction and Costs of Multidisciplinary Models of Care in Rheumatology: a Review of the Recent Literature. *Curr Rheumatol Rep*. 2018 Apr 1;20(4):19.
39. Hill J, Bird HA, Harmer R, Wright V, Lawton C. AN EVALUATION OF THE EFFECTIVENESS, SAFETY AND ACCEPTABILITY OF A NURSE PRACTITIONER IN A RHEUMATOLOGY OUTPATIENT CLINIC. *Rheumatology*. 1994 Mar 1;33(3):283–8.

40. Ndosi M, Lewis M, Hale C, Quinn H, Ryan S, Emery P, et al. The outcome and cost-effectiveness of nurse-led care in people with rheumatoid arthritis: a multicentre randomised controlled trial. *Ann Rheum Dis*. 2013 Aug 24;annrheumdis-2013-203403.
41. Hill J, Thorpe R, Bird H. Outcomes for patients with RA: a rheumatology nurse practitioner clinic compared to standard outpatient care. *Musculoskeletal Care*. 2003 Mar 1;1(1):5–20.
42. Hall JJ, Katz SJ, Cor MK. Patient Satisfaction with Pharmacist-Led Collaborative Follow-Up Care in an Ambulatory Rheumatology Clinic. *Musculoskeletal Care*. 2017;15(3):186–95.
43. Sun M, Jamal S, Kur J. Analysis of Rheumatology Nursing Interventions in Out-patient Practice Settings. *J Can Rheumatol Assoc*. 2014;24(3):18–22.
44. Kur, Jason. Preliminary Results request: BCSR Survey. 2018.
45. Population Data BC | www.popdata.bc.ca [Internet]. [cited 2019 Jul 4]. Available from: <https://www.popdata.bc.ca/home>
46. Guh D, Duncan R, Harrison M. Access Analysis. 2019.
47. Bernatsky S, Joseph L, Pineau CA, Belisle P, Hudson M, Clarke AE. Scleroderma prevalence: Demographic variations in a population-based sample. *Arthritis Care Res*. 2009 Mar 15;61(3):400–4.
48. Bernatsky S, Joseph L, Pineau CA, Bélisle P, Boivin JF, Banerjee D, et al. Estimating the prevalence of polymyositis and dermatomyositis from administrative data: age, sex and regional differences. *Ann Rheum Dis*. 2009 Jul 1;68(7):1192–6.

49. Lacaille D, Anis AH, Guh DP, Esdaile JM. Gaps in care for rheumatoid arthritis: A population study. *Arthritis Care Res.* 53(2):241–8.
50. MacLean CH, Louie R, Leake B, McCaffrey DF, Paulus HE, Brook RH, et al. Quality of Care for Patients With Rheumatoid Arthritis. *JAMA.* 2000 Aug 23;284(8):984–92.
51. MacLean C, Park G, Traina S, Liu H, Hahn B, Paulus H, et al. Positive predictive value (PPV) of an administrative data-based algorithm for the identification of patients with rheumatoid arthritis. *G.* 2001 Nov;(11).
52. Canada H. Canada Health Act Annual Report 2017-2018 [Internet]. aem. 2019 [cited 2019 Apr 13]. Available from: <https://www.canada.ca/en/health-canada/services/publications/health-system-services/canada-health-act-annual-report-2017-2018.html#s6-10>
53. Chandra A, Skinner JS. Technology Growth and Expenditure Growth in Health Care [Internet]. National Bureau of Economic Research; 2011 Apr [cited 2018 May 6]. Available from: <http://www.nber.org/papers/w16953>
54. Penfold RB, Zhang F. Use of Interrupted Time Series Analysis in Evaluating Health Care Quality Improvements. *Acad Pediatr.* 2013 Nov 1;13(6):S38–44.
55. Law M. Week 1: Introduction, ITS with a Control Group [Internet]. EdX; [cited 2019 Jun 30]. (Policy Analysis Using Interrupted Time Series). Available from: <https://courses.edx.org/courses/course-v1:UBCx+ITSx+1T2017/course/>
56. Law M. Week 3: Adding a Control Group, Step 7: Autocorrelation [Internet]. EdX; [cited 2019 Jun 30]. (Policy Analysis Using Interrupted Time Series). Available from: <https://courses.edx.org/courses/course-v1:UBCx+ITSx+1T2017/course/>

57. Nau R. Identifying the orders of AR and MA terms in an ARIMA model [Internet]. ARIMA models for time series forecasting. [cited 2019 Jun 30]. Available from:
<https://people.duke.edu/~rnau/411arim3.htm>
58. Law M. Week 2: Modeling an Interrupted Time Series, Step 10: Predicted Changes [Internet]. EdX; [cited 2019 Jun 30]. (Policy Analysis Using Interrupted Time Series). Available from:
<https://courses.edx.org/courses/course-v1:UBCx+ITSx+1T2017/course/>
59. Health Authority: Overview | Auditor General of British Columbia [Internet]. [cited 2019 Aug 2]. Available from: <https://www.bcauditor.com/online/pubs/775/782>
60. Services M of C. Population Estimates - Province of British Columbia [Internet]. [cited 2019 Jul 3]. Available from: <https://www2.gov.bc.ca/gov/content/data/statistics/people-population-community/population/population-estimates>
61. Chan J, Kur J. Update on Rheumatologist Demographics in British Columbia. CRAJ [Internet]. 2014 [cited 2018 Aug 20];24(4). Available from:
http://craj.ca/archives/2014/English/Winter/PDFs/CRAJ_Winter_2014_Chan.pdf
62. Kur J. Background on billing code 31060 and possible co-interventions: Conversation with Dr. Jason Kur. 2018.
63. Teo DM. How to set up a practice: :15.
64. Arthritis Alliance - Pan-Canadian Approach to IA Models of Care [Internet]. 2018 [cited 2018 Aug 29]. Available from: <http://www.arthritisalliance.ca/en/pan-canadian-approach-to-ia-models-of-care>

65. Sun M, Jamal S, Kur J. Analysis of Rheumatology Nursing Interventions in Out-patient Practice Settings. *J Can Rheumatol Assoc.* 2014;24(3):18–22.
66. Weckerle CE, Niewold TB. The Unexplained Female Predominance of Systemic Lupus Erythematosus: Clues from Genetic and Cytokine Studies. *Clin Rev Allergy Immunol.* 2011 Feb;40(1):42–9.
67. van Vollenhoven RF. Sex differences in rheumatoid arthritis: more than meets the eye... *BMC Med.* 2009 Mar 30;7:12.
68. Kumar S, Gupta R, Suppiah R. Gout in women: differences in risk factors in young and older women - *New Zealand Medical Journal.* *N Z Med J* [Internet]. 2012 Oct 12 [cited 2019 Aug 1];125(1363). Available from: <https://www.nzma.org.nz/journal/read-the-journal/all-issues/2010-2019/2012/vol-125-no-1363/article-kumar>
69. Fedak KM, Bernal A, Capshaw ZA, Gross S. Applying the Bradford Hill criteria in the 21st century: how data integration has changed causal inference in molecular epidemiology. *Emerg Themes Epidemiol* [Internet]. 2015 Sep 30 [cited 2019 Aug 1];12. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4589117/>
70. van der Linden MPM, le Cessie S, Raza K, van der Woude D, Knevel R, Huizinga TWJ, et al. Long-term impact of delay in assessment of patients with early arthritis. *Arthritis Rheum.* 2010 Dec 1;62(12):3537–46.
71. Lard LR, Visser H, Speyer I, vander Horst-Bruinsma IE, Zwinderman AH, Breedveld FC, et al. Early versus delayed treatment in patients with recent-onset rheumatoid arthritis:

comparison of two cohorts who received different treatment strategies. *Am J Med.* 2001 Oct 15;111(6):446–51.

72. Bennett JK, Fuertes JN, Keitel M, Phillips R. The role of patient attachment and working alliance on patient adherence, satisfaction, and health-related quality of life in lupus treatment. *Patient Educ Couns.* 2011 Oct 1;85(1):53–9.
73. Barber CEH, Nasr M, Barnabe C, Badley EM, Lacaille D, Pope J, et al. Planning for the Rheumatologist Workforce: Factors Associated With Work Hours and Volumes. *JCR J Clin Rheumatol.* 2019 Apr;25(3):142.
74. Barber C, Landon K, Shupak R, Marshall D. So We Stood Up and Got Counted... Now What? 2018 Dec 18;

Appendix 1: Detail regarding autocorrelative process and model specification

Table A1.1 Relationship of statistically significant autocorrelation lags to unique patients per month by order of lag and cohort specification, as identified by Durbin-Watson ($\alpha=0.05$),

Lag	Primary	Consistency	High-Intensity
1	not sig	-	-
3	not sig	not sig	+
6	+	+	+
7	not sig	-	-
10	-	not sig	not sig
12	+	+	+

Table A1.2 Relationship of statistically significant autocorrelation lags to service units per month by order of lag and cohort specification, as identified by Durbin-Watson ($\alpha=0.05$)

Lag	Primary	Consistency	High-Intensity
1	not sig	-	-
3	not sig	not sig	+
6	+	+	+
7	-	-	-
10	-	not sig	not sig
12	+	+	+

All cohort specifications have significant, positive autocorrelation processes at 6 and 12 lags. Both the Consistency and High-Intensity specifications have significant order 1 lags. These cohorts are also consistent in the significance and sign of each lag across outcomes. The Primary cohort has consistency in sign across outcomes but lag of order 7 is significant for service units and not for unique patients.

Table A1.3 Order of moving average process identified by plot of autocorrelation function

	<u>Order Q</u>		
	Primary	Consistency	High-Intensity
Unique Patients	0	0	0
Service Units	0	0	0

Plotting the autocorrelation function for all cohorts and outcomes reveals a large spike at 0 followed by geometric decay of correlation as order increases. This suggests there is no moving average process.

Table A1.4 Order of autoregressive process identified by plot of partial autocorrelation function

	<u>Order P</u>		
	Primary	Consistency	High-Intensity
Unique Patients	12 or 6?	12 or 6?	12, 6 or, 1?
Service Units	12 or 6?	12 or 6?	12, 6 or, 1?

Plots of the partial autocorrelation function for each pairing of cohort and outcome are rather more complicated than their respective autocorrelation function plots. All exhibit spikes followed by decay followed by other spikes, a period of decay, and sometimes yet another spike in correlation and subsequent decay as order increases. This would suggest that there may be several autoregressive processes occurring simultaneously. ARMA only facilitates the selection of a single order for each process and so a judgement call must be made. As all cohort-outcome pairs have significant lags at order 12, and those correlation at those lags is universally the strongest, ARMA(12,0) specification is likely the most appropriate across the three cohorts.

Likelihood ratio testing of the nested models ARMA(1,0), ARMA(6,0), and ARMA(12,0) for each cohort-outcome pair corroborates this assessment. ARMA(6,0) is always a better fit than ARMA(1,0), and ARMA(12,0) is always a better fit than both, according to likelihood ratio tests ($\alpha=0.05$).

Interpretation of AR(1) process:

An autoregressive process of order 1 means that y_t is correlated with y_{t-1} for all t . In the context of this analysis this means that the billing activity in any given month is correlated with the billing activity of the prior month. This can be conceptualized as the prior month of activity providing the “baseline” for the subsequent month. Unless something is particularly special about a given month in the study period, we would expect it to be more or less the same as the last one for any given rheumatologist’s billing activity.

Appendix 2: Regression outputs from primary and secondary analyses

Table A2.1: Primary cohort analyses of impact on the number of unique patients per month achieved by the introduction of the multidisciplinary conference code for community-based patients

		Mean	95% CI	p-value
β_0	intercept	2,594	2375 to 2811	0.000
β_1	time	4	-11 to 19	0.624
β_2	'nurse group'	2,013	1795 to 2411	0.000
β_3	'nurse group' * time	-12	-33 to 10	0.293
β_4	level	36	-262 to 333	0.815
β_5	trend	-5	-20 to 11	0.564
β_6	'nurse group' * level	-88	-509 to 333	0.682
β_7	'nurse group' * trend	13	-9 to 35	0.231

Table A2.2: Primary cohort analyses of impact on the number of unique patients per month achieved by the introduction of the multidisciplinary conference code for community-based patients

		Mean	95% CI	p-value
β_0	intercept	2,757	2,511 to 3,004	0.000
β_1	time	0	-17 to 18	0.961
β_2	'nurse group'	2,725	2,376 to 3,073	0.000
β_3	'nurse group' * time	-11	-35 to 14	0.396
β_4	level	75	-254 to 405	0.654
β_5	trend	2	-19 to 16	0.842
β_6	'nurse group' * level	78	-388 to 544	0.744
β_7	'nurse group' * trend	10	-15 to 35	0.419

Table A2.3: Consistent cohort analyses of impact on the number of unique patients per month achieved by the introduction of the multidisciplinary conference code for community-based patients

		Mean	95% CI	p-value
β_0	intercept	2,623	2,485 to 2,761	0.000
β_1	time	1	-9 to 11	0.86
β_2	'nurse group'	-294	-489 to -99	0.004
β_3	'nurse group' * time	-13	-26 to 1	0.076
β_4	level	-11	-176 to 154	0.898
β_5	trend	-1	-11 to 9	0.821
β_6	'nurse group' * level	-199	-432 to 35	0.097
β_7	'nurse group' * trend	15	2 to 29	0.030

Table A2.4: Consistent cohort analyses of impact on the number of service units per month achieved by the introduction of the multidisciplinary conference code for community-based patients

		Mean	95% CI	p-value
β_0	intercept	2,790	2,620 to 2,960	0.000
β_1	time	-2	-14 to 10	0.698
β_2	'nurse group'	-3	-344 to 238	0.978
β_3	'nurse group' * time	-22	-28 to 6	0.209
β_4	level	33	-175 to 240	0.758
β_5	trend	1	-11 to 13	0.824
β_6	'nurse group' * level	-125	-419 to 169	0.407
β_7	'nurse group' * trend	13	-5 to 30	0.151

Table A2.5: High-Intensity cohort analyses of impact on the number of unique patients per month achieved by the introduction of the multidisciplinary conference code for community-based patients

		Mean	95% CI	p-value
β_0	intercept	2632	2,514 to 2,750	0.000
β_1	time	0	-8 to 9	0.96
β_2	'nurse group'	-1,559	-1,725 to -1,392	0.000
β_3	'nurse group' * time	-8	-20 to 3	0.163
β_4	level	-18	-157 to 121	0.796
β_5	trend	0	-9 to 8	0.913
β_6	'nurse group' * level	-185	-381 to 12	0.067
β_7	'nurse group' * trend	13	1 to 25	0.031

Table A2.6: High-Intensity cohort analyses of impact on the number of service units per month achieved by the introduction of the multidisciplinary conference code for community-based patients

		Mean	95% CI	p-value
β_0	intercept	2788	2,663 to 2,912	0.000
β_1	time	-3	-11 to 6	0.572
β_2	'nurse group'	-1,573	-1,749 to -1398	0.000
β_3	'nurse group' * time	-5	-18 to 7	0.422
β_4	level	27	-117 to 171	0.715
β_5	trend	2	-7 to 10	0.692
β_6	'nurse group' * level	-113	-427 to 91	0.279
β_7	'nurse group' * trend	10	-2 to 22	0.114

Appendix 3: Age and sex of patient population stratified by rheumatic disease diagnosis

Table A3.1 Proportion of female patients (%) in study population, by primary rheumatic disease diagnosis

Rheumatic disease	Proportion Female (%)	N
Systemic lupus erythematosus	87	4,281
Connective tissue disorders	80	11,307
Rheumatoid arthritis	73	33,197
Systemic vasculitides	73	806
Noninflammatory	69	83,763
Psoriatic arthritis	54	3,828
Ankylosing spondylitis	46	7,909
Gout	19	4,183

Table A3.2 Median age and interquartile range of patients in study population, by primary rheumatic disease diagnosis

Rheumatic disease	Median Age at Diagnosis	IQR	N
Systemic vasculitides	72	64 to 79	806
Gout	63	52 to 73	4,183
Noninflammatory	60	49 to 71	83,763
Rheumatoid arthritis	59	49 to 69	33,197
Connective tissue disorders	53	43 to 64	11,307
Psoriatic arthritis	53	43 to 61	3,828
Systemic lupus erythematosus	49	38 to 60	4,281
Ankylosing spondylitis	47	36 to 57	7,909