

Patients With Chronic Illness in the Patient-Centered Medical Home:  
Costs, Use, Quality and Morbidity-Based Variation

David T. Liss

A dissertation

submitted in partial fulfillment of the  
requirements for the degree of

Doctor of Philosophy

University of Washington

2012

Reading Committee:

Paul A. Fishman, Co-Chair

Robert J. Reid, Co-Chair

David Grembowski

Carolyn M. Rutter

Program Authorized to Offer Degree:

Public Health - Health Services

©Copyright 2012  
David T. Liss

University of Washington

**Abstract**

Patients With Chronic Illness in the Patient-Centered Medical Home:  
Costs, Use, Quality and Morbidity-Based Variation

David T. Liss

Co-Chairs of the Supervisory Committee:

Paul A. Fishman, Affiliate Associate Professor

Robert J. Reid, Affiliate Associate Professor

Department of Health Services

Originally described in 1967 as a central source of a medical record for children with special health care needs, the “medical home” is now being tested on a national scale as a model of primary care delivery for children and adults. The recent rise in prominence of the patient-centered medical home (PCMH) coincides with increasing acknowledgement that primary care needs to be redesigned to address the needs of chronically ill individuals, whose care accounts for 85 percent of American health care costs. The PCMH unites the core attributes of primary care with the chronic care model, and has been implemented in the context of individual chronic illnesses, but many questions regarding the PCMH’s impacts on chronically ill individuals remain unanswered.

In this dissertation, I address gaps in the evidence base through three studies of patients with chronic illnesses in two sequential PCMH redesigns in an integrated health care delivery system. The first study investigated outcomes for patients with three common chronic illnesses in a 2007-08 PCMH prototype redesign at one clinic, compared to a control group with the same chronic illnesses at 19 non-intervention control sites. In the second study, I examined whether secure electronic messaging and telephone encounters substituted for, or complemented, primary care office visits among patients with diabetes in a 2009-10 system-wide PCMH redesign. The third study described changes in outpatient specialty care utilization, and variation according to overall morbidity burden, among patients with treated hypertension in the system-wide PCMH redesign.

I observed modestly improved quality of care at the PCMH prototype clinic during 2007-08. Compared to controls, PCMH patients had seven percent lower total health care costs over two years, largely driven by lower utilization, and associated costs, of inpatient and emergency/urgent care. Results from the second study suggested that telephone encounters and, to a lesser extent, secure electronic message threads served as complements to office visits for individuals with diabetes. In the final study, I observed, on average, small decreases in total specialty visits for patients with hypertension in the two years during and immediately following system-wide PCMH implementation. In low morbidity patients this decrease was rapid and sustained over three years.

Dissertation findings improve our understanding of the PCMH's impacts on costs, quality and health care use in chronically ill individuals, and can be applied to the planning, implementation and evaluation stages of future PCMH redesigns.

## ACKNOWLEDGMENTS

It has been a privilege to conduct this dissertation under the guidance of Rob, Paul, Carolyn and Dave. Their mentorship allowed me to shape initially amorphous ideas into concrete research topics and to conduct rigorous, policy-relevant health services research. Each committee member was generous with his or her time, patience and goodwill. Marie-Annette Brown was the perfect choice for a GSR.

I am also indebted to other members of GHRI's Medical Home Evaluation Team. Kelly Ehrlich helped me navigate administrative minefields and generously allotted time from biweekly team meetings to my work. Tyler Ross answered innumerable data-related questions and devoted considerable time to creating data files for my dissertation analyses. Eric Johnson offered guidance on biostatistics issues whenever I asked. The top-notch qualitative research of Clarissa Hsu and DeAnn Crompton provided valuable contextual information incorporated in each manuscript. Katie Coleman provided advice on many issues, particularly during planning. Thanks to the staff at the Department of Health Services, and the staff and mentors at the Institute of Translational Health Sciences. My friends and colleagues in the Health Services PhD program have provided tangible and intangible help since the day I began my studies at UW.

**DEDICATION**

For Dahl

## TABLE OF CONTENTS

<b>List of Figures</b> .....	vii
<b>List of Tables</b> .....	viii
<b>List of Appendices</b> .....	ix
<b>1. Introduction</b> .....	1
1.1 Background.....	1
1.2 Objectives.....	4
1.3 Conceptual Framework.....	6
1.4 References.....	9
<b>2. Quality, Utilization and Costs Among Chronically Ill Adults In A Medical Home Prototype</b> .....	13
2.1 Abstract.....	13
2.2 Introduction.....	14
2.3 Methods.....	16
2.4 Results.....	20
2.5 Discussion.....	23
2.6 References.....	26
<b>3. Do Electronic Message and Telephone Encounters Substitute or Complement Office Visits In The Medical Home?</b> .....	34
3.1 Abstract.....	34
3.2 Introduction.....	35
3.3 Methods.....	38
3.4 Results.....	44
3.5 Discussion.....	47
3.6 References.....	50
<b>4. Specialty Care Visits In The “Medical Neighborhood” Among Patients With Hypertension</b> .....	57
4.1 Abstract.....	57
4.2 Introduction.....	58
4.3 Methods.....	60
4.4 Results.....	67
4.5 Discussion.....	70
4.6 References.....	73
<b>5. Conclusions</b> .....	84
5.1 Introduction.....	84
5.2 Redesigning And Improving Care.....	84

5.3	Changing Health Care Utilization Patterns.....	86
5.4	Simultaneously Improving Quality And Reducing Costs.....	87
5.5	Variation in Medical Home Impacts: Morbidity Burden and Selection Issues.....	88
5.6	Business Case For The Medical Home.....	89
5.7	Opportunities For Future Research & Conclusions.....	90
5.8	References.....	93
	<b>Bibliography.....</b>	<b>95</b>
	<b>Vita.....</b>	<b>104</b>

**LIST OF FIGURES**

Figure 1.1	Conceptual Framework.....	8
Figure 3.1	Quarterly Patient Contacts With Primary Care Teams, Baseline - Post-Implementation.....	54
Figure 4.1	Proportion of the Study Population in Each ACG RUB Morbidity Burden Group During the Four Years Under Study.....	77
Figure 4.2	Mean Unadjusted Annual Specialty Care Utilization For Full Study Population and Each ACG RUB Morbidity Burden Group.....	78

## LIST OF TABLES

Table 2.1	Patient Characteristics at the PCMH Prototype Clinic and 19 Comparison Clinics at Baseline (Jan. 1, 2007).....	29
Table 2.2	Comparison of Disease-Specific Quality of Care at the PCMH Prototype Clinic and 19 Comparison Clinics During the 2006 Baseline Year and 2008 Follow-Up Year.....	30
Table 2.3	Comparison of In-Person Utilization and Virtual Medicine Use Over 12 Months and the Full Follow-Up Period at the PCMH Prototype Clinic and 19 Comparison Clinics.....	31
Table 2.4	Comparison of Monthly Health Care Costs Over 12 and 21 Months at the PCMH Prototype Clinic and 19 Comparison Clinics.....	32
Table 3.1	Population Characteristics at PCMH Baseline and Baseline Year Primary Care Contacts.....	53
Table 3.2	Elasticity of Office Visits With Respect to Secure Message and Telephone Encounters In Three Nested Regression Models.....	55
Table 3.3	Linear Combinations of Coefficients In Regression Model Incorporating Interactions for Patient Characteristics and Study Periods (Model C).....	56
Table 4.1	Population Characteristics at the Beginning of Group Health’s PCMH Redesign.....	76
Table 4.2	Results of Negative Binomial Regression Models Describing Adjusted Annual Differences in the Rate of Total Specialty Care Visits.....	79
Table 4.3	Results of Poisson Regression Models Describing Annual Relative Risks of Making Any Visits to Selected Medical and Surgical Specialties.....	80
Table 4.4	Results of Sensitivity Analysis Describing Stratum-Specific Differences in Annualized Year 3 Rates of Total Specialty Care Visits, According to Number of Months Enrolled During Year 3.....	81

**LIST OF APPENDICES**

Appendix 2A Case Definitions for Individual Chronic Illnesses.....33

Appendix 4A Prevalence of Health Care Conditions in Study Population, Based on ACG  
EDC Variables Collected at the End of the Pre-PCMH Baseline Year..... 82

## CHAPTER 1. INTRODUCTION

### 1.1 Background

Originally described in 1967 as a central source of a medical record for children with special health care needs,<sup>1,2</sup> the “medical home” is now being tested on a national scale as a model of primary care delivery for both children and adults.<sup>3,4</sup> Over time, new developments—such as introduction of the concept of patient-centered care,<sup>5</sup> accumulating evidence on the core elements<sup>6</sup> and benefits<sup>7</sup> of primary care, and advances in chronic care<sup>8</sup> and health information technology (IT)<sup>9</sup>—have contributed to new definitions of the medical home, perhaps most notably in the 2007 publication of “Joint Principles of the Patient-Centered Medical Home.”<sup>10</sup> This joint statement from primary care professional societies describes the patient-centered medical home (PCMH) as a model of primary care for children and adults characterized by: 1) A personal physician who provides first contact, continuous and comprehensive care; 2) Physician directed practice team; 3) Whole person orientation of care; 4) Care coordination and integration; 5) Quality and safety; 6) Enhanced access to care, and; 7) Payment that recognizes the value of a PCMH.<sup>10</sup>

In recent years the PCMH has attracted attention from a broad swath of groups across the American health care system<sup>11,12</sup> and been tested in a variety of settings.<sup>3,4</sup> Although PCMH definitions and elements vary across care settings and patient populations, PCMH redesigns are generally characterized by multicomponent interventions designed to enhance team-directed primary care delivery processes.<sup>3,4</sup> These efforts are justified by underlying theory and evidence demonstrating the benefits of the individual and co-occurring elements of the PCMH. Enhanced access, for example, is associated with reductions in disparities and hospitalizations,<sup>7,13</sup> while PCMH elements such as coordination, quality and safety are expected to improve technical

quality of care<sup>14</sup> through adherence to evidence-based care and associated reductions in overuse, underuse and misuse of services.<sup>15</sup> The patient-centered focus of the PCMH reflects the care model's focus on patient satisfaction and interpersonal quality of care,<sup>14</sup> while quality improvement can be facilitated by care processes supported by underlying practice structures. Clinical IT use can enhance the effectiveness and efficiency of care<sup>9</sup> and can enable providers to deliver key attributes of primary and chronic care, including continuity, access and evidence-based care.<sup>16-18</sup>

The PCMH's recent rise in prominence coincides with increasing acknowledgement that primary care structures and staffing models need to be redesigned to effectively address the needs of chronically ill individuals.<sup>19,20</sup> Estimates have attributed 85 percent of American health care costs to the care of chronically ill individuals,<sup>21,22</sup> particularly concentrated in patients with multiple chronic illnesses.<sup>23</sup> Virtually all of the rise in Medicare spending from 1987-2002 was among patients treated for 5 or more health conditions,<sup>24</sup> and a recent analysis found that per capita health care costs in non-elderly individuals with five or more chronic illnesses exceeded \$21,000.<sup>25</sup>

Patients with chronic illness have long been hypothesized to benefit from PCMH elements such as team-based care, productive patient-provider relationships, clinical IT use and delivery system design.<sup>26,27</sup> Chronic conditions are increasingly treated in the outpatient setting,<sup>28</sup> with primary care physicians treating patients' full spectrum of chronic and non-chronic health problems.<sup>29,30</sup> Physicians, however, cannot efficiently deliver guideline-based chronic care without contributions from other clinical team members.<sup>31,32</sup>

Given these realities, the PCMH's comprehensive, team-based approach to primary care may be a viable approach to treating the chronically ill. The PCMH unites the core attributes of

primary care<sup>6</sup> with the chronic care model (CCM),<sup>8</sup> and has been implemented in the context of individual chronic illnesses.<sup>33,34</sup> PCMH demonstration projects have frequently targeted chronically ill patients or patient populations with high chronic illness burdens,<sup>3,4,35</sup> and elements of the CCM have been incorporated in both PCMH intervention design<sup>36</sup> and PCMH assessment tools.<sup>37</sup>

Despite a nationwide surge in PCMH redesigns,<sup>11,38</sup> many questions pertaining to this care model have yet to be answered. While some evaluations have demonstrated the PCMH's potential to decrease unnecessary and high-cost emergency care or inpatient care,<sup>18,35,36</sup> little is known about the associations between the use of new primary care modalities in the PCMH—such as secure e-mail messaging and phone encounters—and that of traditional in-person primary care visits.<sup>39</sup> This issue is of particular relevance to primary care providers investing time and effort to implement the PCMH, and to payers attempting to achieve a return on investments supporting practice transitions to the PCMH.

Also unknown is how comprehensive PCMH-based primary care affects utilization and costs of care in the outpatient specialty care “medical neighborhood.”<sup>40</sup> Despite prior findings that comprehensive primary care reduces unnecessary and potentially harmful specialty care utilization,<sup>7</sup> early evaluations of a PCMH prototype clinic at Group Health—the delivery system under study in the following chapters—revealed, contrary to researchers' hypotheses, that patients in the PCMH had higher specialty care utilization than controls.<sup>17,41</sup> This finding motivates further investigation of Group Health's PCMH redesign in this dissertation.

## 1.2 Objectives

The purpose of this dissertation is to investigate patient outcomes and changes in utilization patterns for chronically ill individuals during and after a PCMH redesign at Group Health, an integrated health plan and care delivery system in the Pacific Northwest. The PCMH emphasizes ongoing relationships between patients and physician-led primary care teams, with care teams assuming responsibility for directing and coordinating efforts to ensure patients receive appropriate care across settings and over time. This approach to care provision may be especially effective for chronically ill individuals, whose acute and ongoing needs increasingly drive increases in health care costs in the United States.

Using observational data from automated clinical databases, this dissertation utilizes quasi-experimental study designs and multivariate regression analyses to investigate PCMH effects among patients with diabetes, hypertension or coronary heart disease, occurring alone or in combination. Aim 1 evaluates patient outcomes in a 2007-08 PCMH prototype redesign at one Group Health clinic in metropolitan Seattle. Aims 2 and 3 investigate chronically ill patients' utilization of primary care and specialty care during and after Group Health's 2009-10 system-wide PCMH implementation.

This dissertation makes important contributions to the evidence base by addressing in-depth, policy-relevant issues regarding patients with common chronic illnesses in the PCMH. It differs from prior PCMH research<sup>3,4</sup> in important ways, including: 1) Investigating outcomes in chronically ill subpopulations within PCMH redesigns in primary care populations, and; 2) Examining changes in outpatient utilization patterns in the PCMH in greater breadth and depth than prior research.

The specific aims of this dissertation are:

*Aim 1: Relationship between a PCMH prototype redesign and quality, use and costs*

Aim 1 investigates outcomes for patients with common chronic illnesses who were exposed to a 24-month PCMH prototype redesign in one Group Health clinic, compared to a control group with the same chronic illnesses at 19 non-intervention control sites at Group Health.

**Question 1.1:** What is the effect of the PCMH prototype redesign on disease-specific quality of care for chronically ill individuals?

**Question 1.2:** What is the effect of the PCMH prototype redesign on use of care in the outpatient, emergency and inpatient settings for chronically ill individuals?

**Question 1.3:** What is the effect of the PCMH prototype redesign on outpatient, emergency, inpatient and total health care costs for chronically ill individuals?

*Aim 2: Whether secure message and telephone encounters substitute for office visits*

Aim 2 investigates the use of secure e-mail messaging and telephone encounters, and potential substitution of these care modalities for in-person primary care office visits, among patients with diabetes before, during and after the implementation of Group Health's system-wide PCMH redesign.

**Question 2.1:** Do secure message threads and telephone encounters substitute for or complement office visits among patients with diabetes in the PCMH?

**Question 2.2:** Do patient characteristics or PCMH stage modify the extent to which secure messages and telephone visits substitute or complement office visits among patients with diabetes?

*Aim 3: Impact of PCMH care on chronically ill individuals' specialty care utilization*

Aim 3 describes changes in outpatient specialty care utilization among patients with treated hypertension during and after PCMH implementation.

**Question 3.1:** How do PCMH implementation and post-implementation impact total specialty care utilization in individuals with treated hypertension?

**Question 3.2:** Does overall morbidity burden modify the extent to which individuals with treated hypertension experience changes in total specialty care utilization in the PCMH?

**Question 3.3:** How is the relative risk of visiting selected specialty care departments—where patients receive care for uncontrolled hypertension, complications of hypertension and other health care conditions—impacted by PCMH-based primary care?

### **1.3 Conceptual Framework**

Figure 1.1 presents a conceptual framework illustrating the relationships between elements of Group Health's PCMH, patients' uptake of PCMH care and patient outcomes. This framework informs the design and analyses of dissertation aims and builds on Starfield's model of the health services system.<sup>6</sup> The framework incorporates structure, process, and outcome elements of Donabedian's work<sup>42</sup> but frames the PCMH as a robust source of primary care that serves as a point of entry into the health services system. It contains multiple causal pathways that function in tandem to generate outputs of the PCMH.

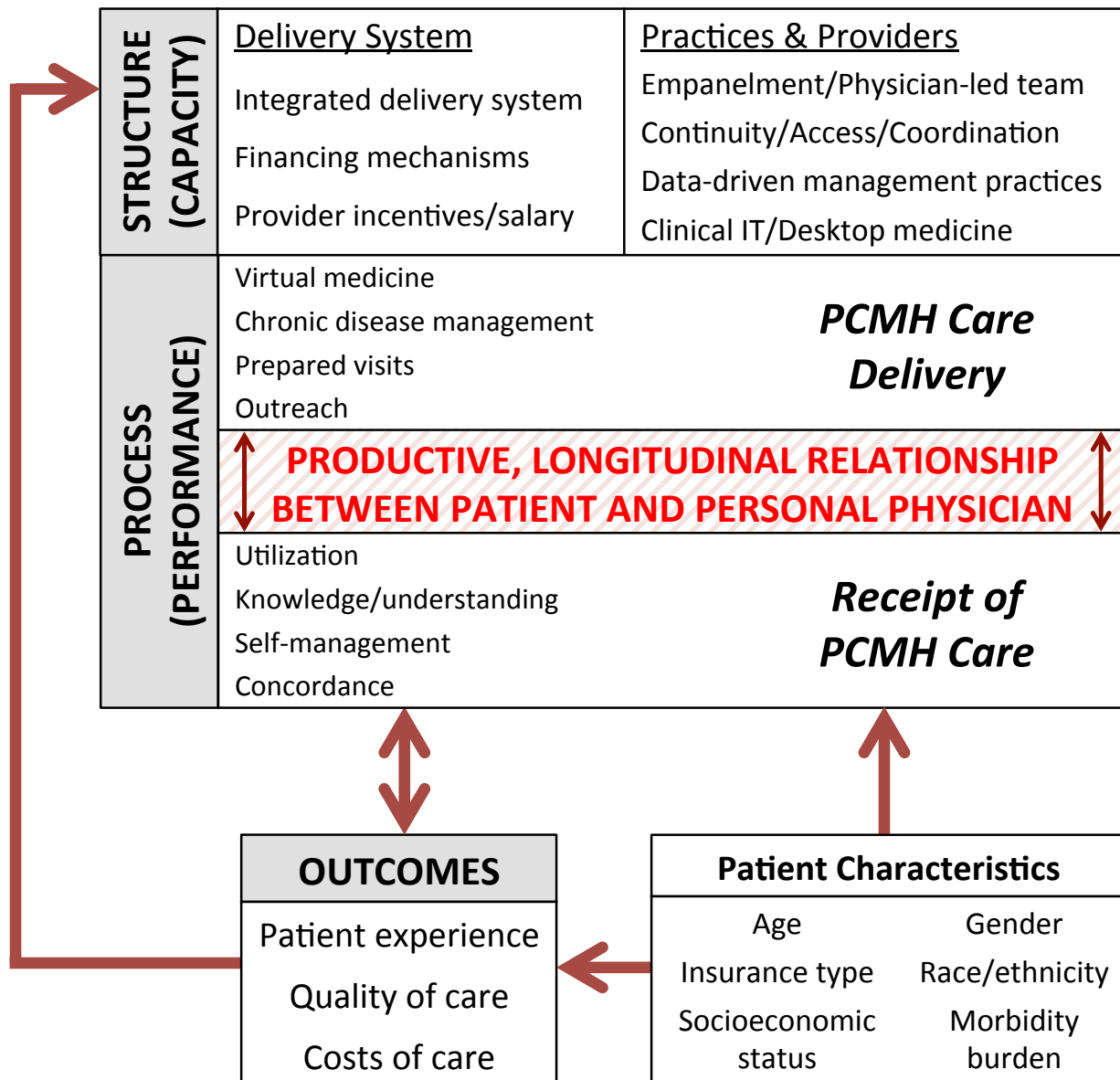
Central to the PCMH and the aims of this dissertation is the bidirectional interface within the cell entitled, "Productive, Longitudinal Relationship Between Patient And Personal Physician." This cell is contained within the framework's *Process* domain, between subdomains for *PCMH Care Delivery*—which contains individually implemented modules of the Group Health

PCMH<sup>43</sup>—and *Receipt of PCMH Care*. Elements within the framework’s *Structure* domain combine to establish the means and setting in which care is delivered at Group Health and within the PCMH. These elements are presented within two subdomains; *Delivery System* components govern the financial and organizational characteristics of the care delivery setting, while the *Practices & Providers* subdomain contains features of the Group Health PCMH and core characteristics of primary care.<sup>6</sup>

Variables within the framework’s *Outcomes* domain include patient experience and quality of care—which Donabedian describes, respectively, as technical and interpersonal quality of care<sup>14</sup>—as well as costs of care. These outcomes lie along numerous uni- and bidirectional causal pathways, reflecting relationships between: outcomes and patient characteristics (measured and unmeasured); care quality and patients’ self-management of medical conditions; and iterative feedback cycles, based on data-driven management practices that inform ongoing structural changes within the delivery system.

The following three dissertation chapters focus on selected elements and relationships depicted in Figure 1.1. Chapter 2 investigates how changes in structures and care delivery processes during Group Health’s PCMH prototype redesign impact chronically ill individuals’ receipt (utilization) and outcomes (quality, costs) of care. Chapter 3 identifies changes in receipt of primary care for among patients with diabetes—via secure electronic messaging, telephone encounters and in-person office visits—in Group Health’s system-wide PCMH redesign, and examines how use of the two former care modalities may be associated with the latter. Chapter 4 evaluates whether outpatient specialty care utilization among patients with treated hypertension is impacted by PCMH care structures—particularly the allocation of additional resources to physician-led primary care teams—and accompanying changes in care delivery processes.

Figure 1.1: Conceptual Framework



## 1.4 References

1. American Academy of Pediatrics, Council on Pediatric Practice. Pediatric Records and a “medical home”. *Standards of Child Care*. Evanston, IL: American Academy of Pediatrics; 1967.
2. Sia C, Tonniges TF, Osterhus E, Taba S. History of the medical home concept. *Pediatrics*. May 2004;113(5 Suppl):1473-1478.
3. Williams JW, Jackson GL, Powers BJ, et al. *The Patient-Centered Medical Home. Closing the Quality Gap: Revisiting the State of the Science. Evidence Report No. 208*. AHRQ Publication No. 12-E008-EF. Rockville, MD: Agency for Healthcare Research and Quality; 2012.
4. Peikes D, Zutshi A, Genevro J, Smith K, Parchman M, Meyers D. *Early Evidence on the Patient-Centered Medical Home*. AHRQ Publication No. 12-0020-EF. Rockville, MD: Agency for Healthcare Research and Quality; 2012.
5. *Crossing the Quality Chasm: A New Health System for the Twenty-First Century*. Washington, DC: Institute of Medicine;2001.
6. Starfield B. *Primary Care: Balancing Health Needs, Services, and Technology*. New York: Oxford University Press; 1998.
7. Starfield B, Shi L, Macinko J. Contribution of primary care to health systems and health. *Milbank Q*. 2005;83(3):457-502.
8. Wagner EH. Chronic disease management: what will it take to improve care for chronic illness? *Eff Clin Pract*. Aug-Sep 1998;1(1):2-4.
9. Buntin MB, Burke MF, Hoaglin MC, Blumenthal D. The benefits of health information technology: a review of the recent literature shows predominantly positive results. *Health affairs*. Mar 2011;30(3):464-471.
10. American Academy of Family Physicians, American Academy of Pediatrics, American College of Physicians, American Osteopathic Association. Joint principles of the patient-centered medical home. 2007; <http://www.pcpcc.net/content/joint-principles-patient-centered-medical-home>. Accessed October 15, 2012.
11. Center for Medicare and Medicaid Innovation. Catalog of Federal PCMH Activities as of June 2011. [http://pcmh.ahrq.gov/portal/server.pt/community/pcmh\\_home/1483/pcmh\\_federal\\_pcmh\\_activities\\_v2](http://pcmh.ahrq.gov/portal/server.pt/community/pcmh_home/1483/pcmh_federal_pcmh_activities_v2). Accessed March 16, 2012.
12. Dentzer S. One Payer's Attempt To Spur Primary Care Doctors To Form New Medical Homes. *Health Aff (Millwood)*. 2012;31(2):341-349.

13. Bindman AB, Grumbach K, Osmond D, et al. Preventable hospitalizations and access to health care. *JAMA*. Jul 26 1995;274(4):305-311.
14. Donabedian A. The definition of quality: A conceptual exploration. *Explorations in quality assessment and monitoring: The definition of quality and approaches to its assessment. Vol 1*. Ann Arbor, MI: Health Administration Press; 1980.
15. Chassin MR, Galvin RW. The urgent need to improve health care quality. Institute of Medicine National Roundtable on Health Care Quality. *JAMA*. Sep 16 1998;280(11):1000-1005.
16. Ralston JD, Martin DP, Anderson ML, et al. Group health cooperative's transformation toward patient-centered access. *Med Care Res Rev*. Dec 2009;66(6):703-724.
17. Reid RJ, Coleman K, Johnson EA, et al. The group health medical home at year two: cost savings, higher patient satisfaction, and less burnout for providers. *Health Aff (Millwood)*. May 2010;29(5):835-843.
18. Wagner EH, Coleman K, Reid RJ, Phillips K, Abrams MK, Sugarman JR. The changes involved in patient-centered medical home transformation. *Prim Care*. Jun 2012;39(2):241-259.
19. Larson EB, Reid R. The patient-centered medical home movement: why now? *JAMA*. Apr 28 2010;303(16):1644-1645.
20. Margolius D, Bodenheimer T. Transforming primary care: from past practice to the practice of the future. *Health affairs*. May 2010;29(5):779-784.
21. Clancy C. *Chronic Conditions 101. Rising Rates of Chronic Conditions: What Can Be Done?* Washington, DC: Agency for Healthcare Research and Quality; July 31, 2008.
22. *Medical Expenditure Panel Survey*: Washington, DC: Agency for Healthcare Research and Quality; 2004.
23. Partnership for Solutions. *Chronic Conditions: Making the Case for Ongoing Care - September 2004 Update*: Robert Wood Johnson Foundation;2004.
24. Thorpe KE, Howard DH. The rise in spending among Medicare beneficiaries: the role of chronic disease prevalence and changes in treatment intensity. *Health Aff (Millwood)*. Sep-Oct 2006;25(5):w378-388.
25. Naessens JM, Stroebel RJ, Finnie DM, et al. Effect of multiple chronic conditions among working-age adults. *Am J Manag Care*. Feb 2011;17(2):118-122.
26. Bodenheimer T, Wagner EH, Grumbach K. Improving primary care for patients with chronic illness: the chronic care model, Part 2. *JAMA*. Oct 16 2002;288(15):1909-1914.

27. Bodenheimer T, Wagner EH, Grumbach K. Improving primary care for patients with chronic illness. *JAMA*. Oct 9 2002;288(14):1775-1779.
28. Decker SL, Schappert SM, Sisk JE. Use of medical care for chronic conditions. *Health Aff (Millwood)*. Jan-Feb 2009;28(1):26-35.
29. Starfield B, Lemke KW, Bernhardt T, Foldes SS, Forrest CB, Weiner JP. Comorbidity: implications for the importance of primary care in 'case' management. *Ann Fam Med*. May-Jun 2003;1(1):8-14.
30. Struijs JN, Baan CA, Schellevis FG, Westert GP, van den Bos GA. Comorbidity in patients with diabetes mellitus: impact on medical health care utilization. *BMC Health Serv Res*. 2006;6:84.
31. Wagner EH, Reid RJ. Are continuity of care and teamwork incompatible? *Med Care*. Jan 2007;45(1):6-7.
32. Ostbye T, Yarnall KS, Krause KM, Pollak KI, Gradison M, Michener JL. Is there time for management of patients with chronic diseases in primary care? *Ann Fam Med*. May-Jun 2005;3(3):209-214.
33. Wagner EH. Counterpoint: chronic illness and primary care. *Medical Care*. Nov 2011;49(11):973-975.
34. Coleman K, Austin BT, Brach C, Wagner EH. Evidence on the Chronic Care Model in the new millennium. *Health Aff (Millwood)*. Jan-Feb 2009;28(1):75-85.
35. Gilfillan RJ, Tomcavage J, Rosenthal MB, et al. Value and the medical home: effects of transformed primary care. *Am J Manag Care*. Aug 2010;16(8):607-614.
36. Reid RJ, Fishman PA, Yu O, et al. Patient-centered medical home demonstration: a prospective, quasi-experimental, before and after evaluation. *Am J Manag Care*. Sep 2009;15(9):e71-87.
37. Scholle SH, Pawlson LG, Solberg LI, et al. Measuring practice systems for chronic illness care: accuracy of self-reports from clinical personnel. *Jt Comm J Qual Patient Saf*. Jul 2008;34(7):407-416.
38. Patient-Centered Primary Care Collaborative. Pilots & Demonstrations in the United States. <http://www.pcpc.net/pcpc-pilot-projects>. Accessed September 14, 2012.
39. McGeady D, Kujala J, Ilvonen K. The impact of patient-physician web messaging on healthcare service provision. *Int J Med Inform*. Jan 2008;77(1):17-23.
40. Fisher ES. Building a medical neighborhood for the medical home. *N Engl J Med*. Sep 18 2008;359(12):1202-1205.

41. Fishman PA, Johnson EA, Coleman K, et al. Impact on seniors of the Patient Centered Medical Home: Evidence from a pilot project. *The Gerontologist*. 2012.
42. Donabedian A. Basic Approaches to Assessment: Structure, Process, and Outcome. *Explorations in quality assessment and monitoring: The definition of quality and approaches to its assessment. Vol 1*. Ann Arbor, MI: Health Administration Press; 1980.
43. Hsu C, Coleman K, Ross TR, et al. Spreading a patient-centered medical home redesign: a case study. *The Journal of ambulatory care management*. Apr 2012;35(2):99-108.

## CHAPTER 2. QUALITY, UTILIZATION AND COSTS AMONG CHRONICALLY ILL ADULTS IN A MEDICAL HOME PROTOTYPE

### 2.1 Abstract

**Objective:** To compare quality, utilization and costs of care among patients with selected chronic illnesses at a patient-centered medical home (PCMH) prototype site, relative to a comparison group at 19 non-intervention control sites.

**Study Design:** Nonequivalent pretest-posttest control group design investigated PCMH redesign results among patients with preexisting diabetes, hypertension and/or coronary heart disease.

**Methods:** Data from automated databases were collected to identify eligible enrollees in an integrated health care delivery system and for inclusion in analysis. Multivariable regression models assessed differences between PCMH patients and controls for several dependent measures of clinical processes, outcomes, monthly health care utilization and costs.

**Results:** Compared to controls over two years, patients at the PCMH prototype clinic had slightly better clinical outcome control in diabetes (0.15% lower mean hemoglobin A1c;  $p < 0.001$ ) and coronary heart disease (2.20 mg/dL lower mean LDL cholesterol;  $p < 0.001$ ). PCMH patients changed their patterns of primary care utilization, as reflected by 86% more e-mail contacts ( $p < 0.001$ ), 10% more telephone contacts ( $p = 0.003$ ) and 6% fewer in-person primary care visits ( $p < 0.001$ ). PCMH patients had 31% lower emergency and urgent care utilization ( $p < 0.001$ ) and 7% fewer inpatient stays ( $p = 0.002$ ) than controls. During the two-year redesign, we observed 17% lower inpatient costs ( $p < 0.001$ ) and 7% lower total health care costs ( $p < 0.001$ ) among patients at the PCMH prototype clinic.

**Conclusions:** Results provide evidence of the capacity of a population-based PCMH redesign to decrease downstream utilization and reduce total health care costs in a subpopulation of patients with common chronic illnesses.

## 2.2 Introduction

Many stakeholders in American health care have embraced the patient-centered medical home (PCMH) in recent years. A variety of small and large practices<sup>1</sup> and delivery systems<sup>2,3</sup> are implementing pilots and demonstration projects, with financial and operational support from payers<sup>4-6</sup> and multi-stakeholder collaboratives.<sup>7</sup> Although each medical home initiative reflects a unique blend of clinicians, patients, practice infrastructures and payment mechanisms, all PCMH interventions are rooted in the goal of providing patients with a continuous source of whole-person primary care.<sup>8-10</sup>

Most PCMH interventions emphasize mechanisms to improve care delivery for persons with chronic illness. Chronically ill patients have long been hypothesized to benefit from PCMH elements such as team-based care, productive patient-provider relationships, clinical IT use and delivery system design.<sup>11</sup> The chronic care model has been incorporated in PCMH interventions<sup>12</sup> and assessment tools,<sup>13</sup> and PCMH interventions have disproportionately targeted chronically ill patients<sup>14</sup> or elderly patients with high chronic illness burdens.<sup>3</sup>

Despite these links between the medical home and chronic illness care, the evidence base contains few, if any, rigorous evaluations of PCMH effects on the quality, utilization and costs of care in patients with chronic illnesses. We address this gap by reporting findings of a 2007-08 prototype PCMH redesign<sup>2</sup> among patients with at least one of three common chronic illnesses in which the majority of care is typically delivered in the primary care setting: diabetes,

hypertension and coronary heart disease (CHD). Our objective in conducting this study is to investigate differences in quality, utilization and costs of care between chronically ill patients at the PCMH site and comparable patients at 19 non-intervention control sites in the same health care system.

### Medical Home Prototype

We assess the impact of a PCMH redesign implemented at one clinic within Group Health, an integrated health plan and care delivery system in Washington State. The PCMH prototype clinic is located in metropolitan Seattle and is one of 20 clinics Group Health owns and operates in Washington's Puget Sound region. The clinic was chosen as the PCMH prototype because of the stability of its leadership and its history of successfully implementing change. Group Health pursued the PCMH redesign after a series of reforms in financing and primary care operations yielded mixed results.<sup>15</sup> Although the earlier reforms achieved their primary objectives of increasing patient access and satisfaction with care and reducing total costs, discouraging trends, such as increased emergency department costs and decreased job satisfaction among primary care physicians, were also observed.<sup>16</sup>

A comprehensive list of design principles and change components in the PCMH redesign is presented elsewhere,<sup>12</sup> but we describe selected key elements here. In the prototype clinic, increased primary care staffing supported reductions in physicians' patient panels from an average of 2327 patients to 1800 patients, physicians were paired in dyads with medical assistants and standard in-person primary care office visits were lengthened from 20 to 30 minutes. "Virtual medicine" encounters—secure e-mail messages and telephone visits—were emphasized by encouraging patients to register for a secure online patient portal and rerouting

patients' calls to an organizational consulting nurse service to primary care teams during normal clinic operating hours. Some PCMH components explicitly targeted chronically ill patients,<sup>2</sup> such as creation of collaborative care plans and providers' outreach, via phone or secure message, to manage chronic illness medications or schedule overdue monitoring tests.

Prior analyses reported two-year findings of the PCMH prototype redesign among the full practice population<sup>2</sup> and in elderly patients.<sup>17</sup> Both analyses observed fewer ambulatory care-sensitive hospital admissions and fewer combined emergency department and urgent care visits among PCMH patients.<sup>2,17</sup> Fewer all-cause hospitalizations, and accompanying lower inpatient costs, were additionally observed in the full practice.<sup>2</sup>

## **2.3 Methods**

### Study Design and Population

This study employed a nonequivalent pretest-posttest control group design,<sup>18</sup> including baseline data from 2006 and follow-up data from 2007-08. We used automated Group Health databases to identify adults with diabetes mellitus (types 1 and 2), hypertension or CHD. These data sources contain diagnoses, procedures and pharmacy data for care obtained at Group Health and at sites where providers deliver care to Group Health patients on a contracted basis; laboratory results and clinical encounter data are only available for care provided at Group Health. The accuracy and completeness of these data sources have been extensively validated.<sup>19-</sup>

<sup>22</sup> Group Health's institutional review board approved all study protocols.

Patients in the final study population were aged 18-85, received care at one of 20 Group Health clinics in western Washington State, had at least 6 months of enrollment during 2006, three or more months of enrollment in each of 2007 and 2008 and had at least one of the three

chronic illnesses. We also required enrollment during December 2006, which facilitated collection of baseline case mix variables.<sup>23</sup> To account for clinic-level factors and ensure comparability across study groups, we excluded patients who switched enrollment between clinics on a year-to-year basis. We excluded patients with dementia at baseline and women who gave birth during the study, as much of their health care use was presumably attributable to factors external to the PCMH redesign.

We identified patients with preexisting diabetes, hypertension and CHD using case definitions designed to achieve high specificity and high positive predictive value.<sup>24,25</sup> This approach utilized patterns of diagnoses, procedures, laboratory values and pharmacy fills to minimize erroneous inclusion of “false positive” patients with unconfirmed chronic illness. Case definitions are listed in the Appendix accompanying this article.

#### Data Collection and Measures

We collected data on disease-specific quality of care in the years 2006 and 2008. Laboratory results provided hemoglobin A1c (HbA1c) levels for patients with diabetes and low-density lipoprotein (LDL) cholesterol levels for patients with CHD. Systolic and diastolic blood pressure readings for patients with hypertension were acquired from electronic encounter data. If patients had clinical outcome data collected more than once in an individual year, we only used the last recorded value from that year.

Laboratory and blood pressure data were converted into disease-specific dependent variables for three types of quality measures: clinical processes, clinical outcome benchmarks and mean clinical outcomes. We created binary measures of clinical process performance based on whether laboratory data on HbA1c and LDL were collected annually. Outcome benchmarks were

assessed by binary measures of: HbA1c below 9.0% among patients with diabetes; blood pressure below 140/90 mm Hg among patients with hypertension; and LDL below 100 mg/dL among patients with CHD. Continuous HbA1c, systolic blood pressure and LDL cholesterol results provided mean clinical outcome measures for each chronic illness.

Utilization and cost data were collected for the 2006 baseline year and the 2007-08 PCMH redesign. Group Health's automated systems assigned patient costs on a monthly basis, reporting actual costs from the general ledger. Overhead costs, such as additional staffing costs during the PCMH redesign, were fully allocated to patient care departments. Cost and in-person utilization data were collected for primary care, specialty care, total inpatient admissions and combined emergency department and urgent care. We also collected data on ambulatory care-sensitive inpatient utilization<sup>26</sup> and total health care costs. Clinical databases provided data on patients' virtual medicine use, including secure message threads, telephone encounters and calls to the consulting nurse service. We accounted for changes in internal cost accounting at Group Health during Fall 2008 by truncating collection of cost and in-person utilization data at 21 months, which ensured consistency in these variables over time. Period-specific utilization and costs were converted to monthly rates based on patients' number of days of enrollment at Group Health during the baseline and PCMH redesign.

We collected data on patients' age, sex and Johns Hopkins Adjusted Clinical Groups (ACG) System case mix.<sup>23</sup> Aggregated Diagnosis Groups (ADG) variables from December 2006 provided a measure of patients' morbidity burden during the 2006 baseline year. The 32 ADG variables group ICD-9 diagnoses into clinically cogent morbidity clusters based on duration, severity, diagnostic certainty, etiology and expected need for specialty care, and have been extensively used for case mix ascertainment and adjustment in primary care populations.<sup>27-29</sup>

## Analysis

Multivariable regression models assessed differences between PCMH patients and controls during the 2007-08 follow-up period. Each model tested for the effect of the PCMH on outcomes by including a patient-level indicator of empanelment at the PCMH prototype clinic as the independent variable.

Quality of care analyses used data from the 2006 baseline and 2008 to investigate differences between PCMH patients and controls in condition-specific processes and outcomes. All patients with diabetes and CHD were included in the clinical process analysis; the clinical outcomes analysis for each chronic illness was restricted to patients who had disease-specific outcome data collected in both 2006 and 2008. We used modified Poisson regression models (Poisson distribution, log link) to investigate clinical processes and outcome benchmarks in 2008, incorporating robust variance estimates to obtain relative risks.<sup>30</sup> We used linear regression models to investigate differences in mean 2008 clinical outcomes. Each condition-specific regression controlled for age, sex and 2006 baseline outcome, and was restricted to patients with the targeted chronic illness.

Utilization analyses investigated patients' monthly in-person utilization and virtual medicine use during the redesign's first year and the full observation period (in-person utilization analysis was truncated at 21 months). We used Poisson regression models to estimate utilization rates, setting the scale parameter to the deviance divided by the residual degrees of freedom to preclude violations of model assumptions of over- or under-dispersion.<sup>31</sup> These models controlled for age, sex, ADG count and binary indicators for each of the three chronic illnesses.

We computed predicted utilization rates among patients at PCMH and control clinics by computing least squares means for the effect of the independent variable.

We used an algorithm recommended by Manning and Mullahy<sup>32</sup> to select models for cost outcomes that would provide unbiased estimates of covariate effects in right-skewed monthly cost data. This approach led us to select a generalized linear regression model with log link and gamma distribution and to report results in proportional—rather than dollar-based—cost differences. Final cost models controlled for age, sex and log-transformed baseline costs for each dependent cost variable (e.g., inpatient cost models controlled for log-transformed baseline inpatient costs).

All regression models in quality, utilization and cost analyses were estimated using generalized estimating equations (GEE) with independent working correlations and robust sandwich variance estimates.<sup>33</sup> This approach controlled for clustering at the level of patients' paneled primary care clinics and is robust to misspecification of within-cluster correlation. Analyses were conducted using SAS software, version 9.2 (Cary, NC).

Sensitivity analyses assessed stability of cost and utilization results. One sensitivity analysis included patients with asthma and chronic obstructive pulmonary disease (COPD). These patients were initially targeted for inclusion but were excluded from the final study population due to low prevalence at the PCMH clinic and unavailability of disease-specific quality outcome data. A utilization-only sensitivity analysis used DxCG risk adjustment variables<sup>34</sup> in place of ACG variables, which mimicked the risk adjustment approach of prior PCMH prototype analyses.<sup>2,12,17</sup>

## **2.4 Results**

The final study population included 37,938 adults with diabetes, hypertension and/or CHD, with 1,181 patients paneled to the PCMH prototype clinic and 36,757 patients paneled to other clinics (Table 1). On average, PCMH patients were 3.1 years older than patients at other clinics (mean age 65.0 vs. 61.9,  $p<0.001$ ) and more likely to be female (54% vs. 51%,  $p=0.04$ ). Patients at the PCMH clinic were less likely to have comorbid combinations of diabetes, hypertension and CHD (13% vs. 21%,  $p<0.001$ ), but had higher counts of ADG case mix variables (mean 7.2 vs. 6.9,  $p=0.01$ ), reflecting higher prevalence of health conditions other than the three targeted in this study. Ninety three percent of patients at both the PCMH prototype clinic and control clinics were enrolled at Group Health for the entire two-year follow-up period.

Quality of care analysis revealed differences between the PCMH clinic and control clinics (Table 2). Patients with diabetes at the PCMH clinic were 1% more likely to receive HbA1c testing ( $p=0.03$ ), 3% more likely to have HbA1c under 9.0% ( $p<0.001$ ) and had mean HbA1c 0.15% lower than controls ( $p<0.001$ ). Patients at the PCMH clinic with CHD were 11% more likely to have LDL below 100 mg/dL ( $p<0.001$ ) and had mean LDL cholesterol 2.20 mg/dL lower than controls ( $p<0.001$ ). Among patients with hypertension, we observed no significant differences in blood pressure outcomes.

Table 3 presents utilization results. Over the first 12 months of the PCMH redesign, patients at the PCMH prototype clinic had 29% fewer emergency and urgent care contacts than controls ( $p<0.001$ ), 23% fewer ambulatory care-sensitive inpatient admissions ( $p<0.001$ ) and 4% fewer total inpatient admissions ( $p=0.05$ ). Over 21 months, patients at the PCMH prototype clinic had 6% fewer in-person primary care contacts than controls ( $p<0.001$ ), 31% lower emergency and urgent care contacts ( $p<0.001$ ), 21% fewer ambulatory care-sensitive inpatient admissions

( $p < 0.001$ ) and 7% fewer total inpatient admissions ( $p = 0.002$ ). We observed no significant differences between groups in specialty care utilization.

Patients at the PCMH prototype clinic had more virtual medicine contacts with primary care teams. At 12 months, PCMH patients had 94% more secure e-mail threads ( $p < 0.001$ ) and 17% more telephone encounters than controls ( $p < 0.001$ ). These differences attenuated slightly in 24-month results but remained statistically significant at  $p \leq 0.003$ . PCMH patients had 18% and 22% fewer telephone calls to the consulting nurse service over 12 and 24 months, respectively ( $p < 0.001$  for both). This finding is consistent with the redesign's goal to decrease non-emergent consulting nurse calls by redirecting calls to the primary care team during clinic operating hours.<sup>12</sup>

We observed no significant differences in primary care costs between PCMH patients and controls (Table 4). Despite nonsignificant differences in specialty utilization, specialty care costs were 9% higher among PCMH patients over both 12 months ( $p = 0.004$ ) and 21 months ( $p = 0.02$ ). PCMH patients had 6% lower emergency department and urgent care costs over both 12 months and 21 months, though this finding was only statistically significant at 21 months ( $p = 0.01$ ). PCMH patients had 16% lower inpatient costs than controls at 12 months ( $p < 0.001$ ) and 17% lower inpatient costs over 21 months ( $p < 0.001$ ). Total per member per month costs were 8% lower among PCMH patients over 12 months ( $p < 0.001$ ) and 7% lower over 21 months ( $p < 0.001$ ).

Findings for virtual medicine use and 21-month in-person utilization and costs were robust to sensitivity analysis, while selected 12-month findings varied by analytic approach (results available upon request). When adjusting for DxCG variables or including patients with asthma and COPD—61 additional PCMH patients and 2,340 additional controls—in 12-month analyses,

we observed 5% greater specialty utilization among PCMH patients ( $p=0.05$  with DxCG adjustment;  $p=0.02$  including asthma and COPD) and no significant differences in all-cause inpatient admissions. Including patients with asthma and COPD also led to observation of 7% greater primary care costs among PCMH patients at 12 months ( $p=0.003$ ).

## 2.5 Discussion

We observed numerous associations between a PCMH redesign and the quality, utilization and costs of care among patients with diabetes, hypertension and CHD. PCMH patients changed their primary care utilization patterns over the two-year redesign, as reflected by simultaneously greater phone and e-mail use and lower in-person primary care utilization than controls. Despite these changes, we observed no group-level differences in primary care costs, presumably due to the longer length of in-person visits at the PCMH site and costing systems' allocation of PCMH implementation costs to the prototype clinic. Contrary to the redesign's original objectives,<sup>12</sup> PCMH patients had higher specialty care costs over 21 months. This finding requires further investigation but may be due to surveillance bias<sup>35</sup>—"the more you look, the more you find"—induced by a reduction of barriers to care. Over 21 months, we observed reduced utilization of downstream care at the PCMH site, including lower emergency and urgent care, ambulatory care-sensitive hospitalizations and total inpatient admissions. PCMH patients had 7% lower total health care costs over 21 months, largely driven by lower costs for inpatient care and emergency/urgent care. When applied to the \$697 unadjusted total monthly health care costs in this study population during the 2006 baseline year, the observed 7% cost reduction translates to approximately \$49 savings per month.

Improved clinical outcome control among patients with diabetes and CHD at the prototype site provides evidence of the PCMH's ability to globally reduce costs in this population while improving quality. Although these differences in clinical outcomes were statistically significant, they were quite small in magnitude, which is consistent with modest quality improvements observed in other settings in which practices transitioned to the PCMH.<sup>36</sup>

This study differed from prior medical home evaluations in important ways. Although findings on setting-specific cost and utilization are similar to prior analyses<sup>2,17</sup> of Group Health's PCMH prototype site, we additionally observed statistically significant reductions in total health care costs among chronically ill patients. Unlike several PCMH interventions in the research literature,<sup>37</sup> Group Health's PCMH prototype redesign did not embed care managers in a primary care practice, nor was the intervention confined to a subgroup of high-risk or chronically ill patients. It was instead implemented in the prototype practice's full patient population, incorporating fundamental tenets of primary care<sup>10</sup> and chronic care<sup>38</sup> to support productive, longitudinal relationships between physician-led primary care teams and patients.

Our encouraging findings were presumably attributable to an alignment of structures and processes at the PCMH clinic that allowed for effective provision of whole-person care. PCMH components that may have facilitated the productive patient-provider interactions envisioned by the chronic care model<sup>11</sup> include enhanced care team staffing, pairing longer office visits with promotion of increased virtual medicine use, and effective outreach for patients' chronic and acute needs.

This study has several limitations, including a lack of patient-reported outcomes. As in all observational studies, observed associations do not necessarily represent causal effects. Incomplete control of confounding for socioeconomic, racial/ethnic and other unmeasured

characteristics may have obscured the true relationship between the PCMH redesign and study outcomes, and highly specific case definitions presumably excluded patients with undiagnosed or untreated chronic illness. We are unable to definitively identify individual elements of the multicomponent redesign that were responsible for observed results.

A noteworthy limitation is the lack of generalizability due to non-random selection and implementation of a single-site PCMH redesign. The prototype clinic had a successful history of quality improvement compared to other clinics at Group Health, and may represent a best-case scenario with regard to motivation of clinical staff and availability of organizational resources. Because the PCMH redesign was implemented in an integrated system with salaried providers, external validity to other primary care settings may be limited.

These limitations are accompanied by strengths in sampling and analytic strategy. Consistent with recommendations of a recent AHRQ-commissioned white paper,<sup>39</sup> our study investigated PCMH effects among chronically ill patients and adjusted for clinic-level clustering.

Study findings provide evidence of the capacity of a population-based medical home redesign to serve the needs of chronically ill patients. Changes in practice structures and care delivery processes were associated with modest improvements in quality, lower downstream utilization and reduced health care costs. Cost reductions were apparent within one year and persisted over the full study period. Future studies should investigate particularly effective elements of the PCMH care model, the ability of treat-to-target protocols to achieve clinically meaningful changes in chronic care quality<sup>22,40</sup> and whether particular subgroups of chronically ill patients experience differentially large changes in quality, utilization or costs.

## 2.6 References

1. Crabtree BF, Nutting PA, Miller WL, Stange KC, Stewart EE, Jaen CR. Summary of the National Demonstration Project and recommendations for the patient-centered medical home. *Ann Fam Med.* 2010;8 Suppl 1:S80-90; S92.
2. Reid RJ, Coleman K, Johnson EA, et al. The group health medical home at year two: cost savings, higher patient satisfaction, and less burnout for providers. *Health Aff (Millwood).* May 2010;29(5):835-843.
3. Gilfillan RJ, Tomcavage J, Rosenthal MB, et al. Value and the medical home: effects of transformed primary care. *Am J Manag Care.* Aug 2010;16(8):607-614.
4. Dentzer S. One Payer's Attempt To Spur Primary Care Doctors To Form New Medical Homes. *Health Aff (Millwood).* 2012;31(2):341-349.
5. Blue Cross Blue Shield of Michigan. Physician Group Incentive Program Basics; 2011. [http://www.bcbsm.com/provider/value\\_partnerships/pgip/](http://www.bcbsm.com/provider/value_partnerships/pgip/). Accessed March 16, 2012.
6. Center for Medicare and Medicaid Innovation. Catalog of Federal PCMH Activities as of June 2011. [http://pcmh.ahrq.gov/portal/server.pt/community/pcmh\\_home/1483/pcmh\\_federal\\_pcmh\\_activities\\_v2](http://pcmh.ahrq.gov/portal/server.pt/community/pcmh_home/1483/pcmh_federal_pcmh_activities_v2). Accessed March 16, 2012.
7. Patient-Centered Primary Care Collaborative. Pilots & Demonstrations in the United States. <http://www.pcpcc.net/pcpcc-pilot-projects>. Accessed September 14, 2012.
8. Starfield B, Shi L, Macinko J. Contribution of primary care to health systems and health. *Milbank Q.* 2005;83(3):457-502.
9. Saultz JW, Lochner J. Interpersonal continuity of care and care outcomes: a critical review. *Ann Fam Med.* Mar-Apr 2005;3(2):159-166.
10. Starfield B. *Primary Care: Balancing Health Needs, Services, and Technology.* New York: Oxford University Press; 1998.
11. Wagner EH. Chronic disease management: what will it take to improve care for chronic illness? *Eff Clin Pract.* Aug-Sep 1998;1(1):2-4.
12. Reid RJ, Fishman PA, Yu O, et al. Patient-centered medical home demonstration: a prospective, quasi-experimental, before and after evaluation. *Am J Manag Care.* Sep 2009;15(9):e71-87.
13. Scholle SH, Pawlson LG, Solberg LI, et al. Measuring practice systems for chronic illness care: accuracy of self-reports from clinical personnel. *Jt Comm J Qual Patient Saf.* Jul 2008;34(7):407-416.

14. Gabbay RA, Bailit MH, Mauger DT, Wagner EH, Siminerio L. Multipayer patient-centered medical home implementation guided by the chronic care model. *Joint Commission journal on quality and patient safety / Joint Commission Resources*. Jun 2011;37(6):265-273.
15. Ralston JD, Martin DP, Anderson ML, et al. Group health cooperative's transformation toward patient-centered access. *Med Care Res Rev*. Dec 2009;66(6):703-724.
16. *Improving Access to Improve Quality: Evaluation of an Organizational Innovation*. Washington, DC: AcademyHealth; 2008.
17. Fishman PA, Johnson EA, Coleman K, et al. Impact on seniors of the Patient Centered Medical Home: Evidence from a pilot project. *The Gerontologist*. 2012.
18. Shadish WR, Cook TD, Campbell DT. *Experimental and Quasi-Experimental Designs for Generalized Causal Inference*. Boston: Houghton Mifflin; 2002.
19. Boudreau DM, Doescher MP, Saver BG, Jackson JE, Fishman PA. Reliability of Group Health Cooperative automated pharmacy data by drug benefit status. *Pharmacoepidemiol Drug Saf*. Dec 2005;14(12):877-884.
20. Newton KM, Wagner EH, Ramsey SD, et al. The use of automated data to identify complications and comorbidities of diabetes: a validation study. *J Clin Epidemiol*. Mar 1999;52(3):199-207.
21. Fishman PA, Wagner EH. Managed care data and public health: the experience of Group Health Cooperative of Puget Sound. *Annu Rev Public Health*. 1998;19:477-491.
22. Katon WJ, Lin EH, Von Korff M, et al. Collaborative care for patients with depression and chronic illnesses. *N Engl J Med*. Dec 30 2010;363(27):2611-2620.
23. *The Johns Hopkins ACG System: Technical Reference Guide, Version 10.0*. Baltimore, MD: Johns Hopkins University; 2011.
24. Solberg LI, Engebretson KI, Sperl-Hillen JM, Hroschikoski MC, O'Connor PJ. Are claims data accurate enough to identify patients for performance measures or quality improvement? The case of diabetes, heart disease, and depression. *Am J Med Qual*. Jul-Aug 2006;21(4):238-245.
25. Bullano MF, Kamat S, Willey VJ, Barlas S, Watson DJ, Brenneman SK. Agreement between administrative claims and the medical record in identifying patients with a diagnosis of hypertension. *Medical Care*. May 2006;44(5):486-490.
26. Bindman AB, Grumbach K, Osmond D, et al. Preventable hospitalizations and access to health care. *JAMA*. Jul 26 1995;274(4):305-311.
27. Reid RJ, MacWilliam L, Verhulst L, Roos N, Atkinson M. Performance of the ACG case-mix system in two Canadian provinces. *Med Care*. Jan 2001;39(1):86-99.

28. Pietz K, Ashton CM, McDonell M, Wray NP. Predicting healthcare costs in a population of veterans affairs beneficiaries using diagnosis-based risk adjustment and self-reported health status. *Med Care*. Oct 2004;42(10):1027-1035.
29. Rosen AK, Loveland S, Anderson JJ, et al. Evaluating diagnosis-based case-mix measures: how well do they apply to the VA population? *Med Care*. Jul 2001;39(7):692-704.
30. Zou G. A modified poisson regression approach to prospective studies with binary data. *Am J Epidemiol*. Apr 1 2004;159(7):702-706.
31. Hardin JW, Hilbe JM. *Generalized Linear Models and Extensions*. 2nd ed. College Station, TX: Stata Press; 2007.
32. Manning WG, Mullahy J. Estimating log models: to transform or not to transform? *J Health Econ*. Jul 2001;20(4):461-494.
33. Diggle P, Heagerty P, Liang K, Zeger S. *Analysis of Longitudinal Data*. 2nd ed. Norfolk, UK: Oxford University Press; 2002.
34. *DxCG RiskSmart Clinical Classifications Guide*. Boston, MA: DxCG Inc.; 2007.
35. Pierce CA, Haut ER, Kardooni S, et al. Surveillance bias and deep vein thrombosis in the national trauma data bank: the more we look, the more we find. *J Trauma*. Apr 2008;64(4):932-936; discussion 936-937.
36. Solberg LI, Asche SE, Fontaine P, Flottemesch TJ, Anderson LH. Trends in quality during medical home transformation. *Annals of Family Medicine*. Nov-Dec 2011;9(6):515-521.
37. Peikes D, Zutshi A, Genevro J, Smith K, Parchman M, Meyers D. *Early Evidence on the Patient-Centered Medical Home*. AHRQ Publication No. 12-0020-EF. Rockville, MD: Agency for Healthcare Research and Quality; 2012.
38. Wagner EH, Austin BT, Von Korff M. Organizing care for patients with chronic illness. *Milbank Q*. 1996;74(4):511-544.
39. Peikes D, Dale S, Lundquist E, Genevro J, Meyers D. *Building the evidence base for the medical home: what sample and sample size do studies need?* AHRQ Publication No. 11-0100-EF. Rockville, MD: Agency for Healthcare Research and Quality; 2011.
40. Riddle MC, Rosenstock J, Gerich J. The treat-to-target trial: randomized addition of glargine or human NPH insulin to oral therapy of type 2 diabetic patients. *Diabetes Care*. Nov 2003;26(11):3080-3086.

**Table 2.1:** Patient Characteristics at the PCMH Prototype Clinic and 19 Comparison Clinics at Baseline (Jan. 1, 2007)

<b>CHARACTERISTIC</b>	<b>PCMH Prototype (n = 1,181)</b>	<b>Other Clinics (n = 36,757)</b>	<b><i>p</i> Value</b>
Age, mean (SD)	65.0 (11.8)	61.9 (11.9)	<0.001
Age group, n (%)			
18 - 34	17 (1)	533 (1)	<0.001
35 - 44	31 (3)	2,093 (6)	
45 - 54	155 (13)	7,196 (19)	
55 - 64	361 (31)	12,070 (33)	
65 - 74	339 (29)	8,746 (24)	
75 - 85	278 (23)	6,119 (17)	
Female, n (%)	642 (54)	18,850 (51)	0.04
Chronic illnesses, n (%)			
Diabetes	421 (36)	14,913 (41)	<0.001
Hypertension	798 (68)	25,858 (70)	0.04
Coronary heart disease	139 (12)	5,051 (14)	0.05
Number of chronic illnesses (range: 1-3), n (%)			
1	1,024 (87)	28,842 (79)	<0.001
2	137 (11)	6,765 (18)	
3	20 (2)	1,150 (3)	
Count of health care conditions (ACG ADG), mean (SD)	7.2 (4.1)	6.9 (4.1)	0.01

Abbreviations: PCMH, patient-centered medical home; SD, standard deviation; ACG, Adjusted Clinical Groups; ADG, Aggregated Diagnosis Groups

**Table 2.2:** Comparison of Disease-Specific Quality of Care at the PCMH Prototype Clinic and 19 Comparison Clinics During the 2006 Baseline Year and 2008 Follow-Up Year

<i>Clinical Processes</i>	<i>n</i>	<b>2006 (%)</b>	<b>2008 (%)</b>	<b>2008: Adjusted Relative Risk*</b>
DM: HbA1c testing				
PCMH clinic	421	90	86	1.01 (1.00, 1.02) <sup>†</sup>
Other clinics	14913	90	85	--
CHD: LDL screening				
PCMH clinic	139	86	82	1.00 (0.98, 1.02)
Other clinics	5051	84	81	--
<i>Clinical Outcome Benchmarks<sup>¶</sup></i>	<i>n</i>	<b>2006 (%)</b>	<b>2008 (%)</b>	<b>2008: Adjusted Relative Risk*</b>
DM: HbA1c < 9.0%				
PCMH clinic	343	89	90	1.03 (1.02, 1.03) <sup>§</sup>
Other clinics	11902	86	86	--
HTN: BP < 140/90 mm Hg				
PCMH clinic	713	58	65	1.01 (0.98, 1.05)
Other clinics	22823	55	64	--
CHD: LDL < 100 mg/dL				
PCMH clinic	106	70	84	1.11 (1.08, 1.14) <sup>§</sup>
Other clinics	3638	69	75	--
<i>Clinical Outcomes (Mean)<sup>¶</sup></i>	<i>n</i>	<b>2006</b>	<b>2008</b>	<b>2008: Adjusted Difference**</b>
DM: HbA1c (%)				
PCMH clinic	343	7.22	7.20	-0.15 (-0.18, -0.13) <sup>§</sup>
Other clinics	11902	7.44	7.51	--
HTN: Systolic BP (mm Hg)				
PCMH clinic	713	136.3	133.3	-0.43 (-1.13, 0.28)
Other clinics	22823	136.1	133.5	--
CHD: LDL (mg/dL)				
PCMH clinic	106	90.5	84.9	-2.20 (-2.92, -1.49) <sup>§</sup>
Other clinics	3638	90.7	87.3	--

Abbreviations: PCMH, patient-centered medical home; DM, Diabetes mellitus; HbA1c, hemoglobin A1c; CHD, Coronary heart disease; LDL, low density lipoprotein; HTN, Hypertension; BP, blood pressure; GEE, generalized estimating equations

\*Adjusted relative risks from modified Poisson regressions (Poisson distribution, log link) estimated using GEE (independent working correlations, robust variance) and adjusting for age, sex and 2006 baseline outcome

\*\*Adjusted differences from linear regressions estimated using GEE (independent working correlations, robust variance) and adjusting for age, sex and 2006 baseline outcome

<sup>¶</sup> Restricted to patients with each chronic illness and outcome data collected in 2006 and 2008

<sup>†</sup>  $p < 0.05$ ; <sup>§</sup>  $p < 0.001$

**Table 2.3:** Comparison of In-Person Utilization and Virtual Medicine Use Over 12 Months and the Full Follow-Up Period at the PCMH Prototype Clinic and 19 Comparison Clinics

In-Person Contacts: PCMH Prototype Clinic vs. Other Clinics	Interval	Predicted Contacts (per 1000 patients per month)		Adjusted Rate Ratio (95% CI)	<i>p</i> Value
		PCMH Prototype	Other Clinics		
		Primary care	12 months		
	21 months	376 (370, 382)	399 (385, 413)	0.94 (0.91, 0.97)	<0.001
Specialty care	12 months	316 (303, 330)	305 (283, 328)	1.04 (0.99, 1.08)	0.11
	21 months	320 (309, 330)	313 (294, 333)	1.02 (0.98, 1.07)	0.32
Emergency/Urgent care	12 months	44 (42, 46)	61 (54, 70)	0.71 (0.63, 0.81)	<0.001
	21 months	45 (43, 47)	65 (58, 74)	0.69 (0.61, 0.79)	<0.001
Ambulatory care- sensitive inpatient	12 months	0.8 (0.7, 1.0)	1.0 (0.8, 1.2)	0.77 (0.68, 0.89)	<0.001
	21 months	0.9 (0.8, 1.1)	1.2 (1.0, 1.4)	0.79 (0.72, 0.87)	<0.001
All inpatient admissions	12 months	9.1 (8.5, 9.8)	9.5 (8.7, 10.4)	0.96 (0.92, 1.00)	0.05
	21 months	9.1 (8.5, 9.8)	9.5 (8.7, 10.4)	0.93 (0.89, 0.98)	0.002
Virtual Medicine Use: PCMH Prototype Clinic vs. Other Clinics	Interval	Predicted Contacts (per 1000 patients per month)		Adjusted Rate Ratio (95% CI)	<i>p</i> Value
		PCMH Prototype	Other Clinics		
		Secure message threads	12 months		
	24 months	385 (366, 404)	207 (187, 229)	1.86 (1.71, 2.02)	<0.001
Telephone encounters	12 months	507 (497, 516)	433 (407, 461)	1.17 (1.10, 1.24)	<0.001
	24 months	482 (473, 492)	437 (407, 469)	1.10 (1.03, 1.18)	0.003
Consulting nurse calls	12 months	110 (107, 114)	135 (126, 146)	0.82 (0.76, 0.88)	<0.001
	24 months	107 (104, 110)	138 (130, 146)	0.78 (0.73, 0.83)	<0.001

Abbreviations: PCMH, patient-centered medical home; CI, confidence interval; ADG, Aggregated Diagnosis Groups

Adjusted rate ratios obtained from Poisson regression models (Poisson distribution, log link) correcting for over- or under-dispersion and adjusting for age, sex, ADG count and indicators for diabetes, coronary heart disease and hypertension. Models estimated using generalized estimating equations with independent working correlations and robust variance. Predicted contacts obtained by computing least squares means for the effect of the PCMH independent variable.

**Table 2.4:** Comparison of Monthly Health Care Costs Over 12 and 21 Months at the PCMH Prototype Clinic and 19 Comparison Clinics

<b>Costs: PCMH Prototype Clinic vs. Other Clinics</b>	<b>Jan. 07 – Dec. 07 (12 months)</b>		<b>Jan. 07 – Sept. 08 (21 months)</b>	
	<b>Adjusted Cost Ratio (95% CI)</b>	<b><i>p</i> Value</b>	<b>Adjusted Cost Ratio (95% CI)</b>	<b><i>p</i> Value</b>
Primary care	1.04 (0.99, 1.09)	0.11	1.01 (0.95, 1.07)	0.75
Specialty care	1.09 (1.03, 1.15)	0.004	1.09 (1.02, 1.17)	0.02
Emergency/Urgent care	0.94 (0.87, 1.01)	0.08	0.94 (0.89, 0.99)	0.01
All inpatient admissions	0.84 (0.78, 0.91)	<0.001	0.83 (0.78, 0.89)	<0.001
Total PMPM costs	0.92 (0.90, 0.95)	<0.001	0.93 (0.90, 0.96)	<0.001

Abbreviations: PCMH, patient-centered medical home; CI, confidence interval

Adjusted cost ratios obtained from generalized linear models (gamma distribution, log link) adjusting for age, sex and log-transformed 2006 baseline costs. Models estimated using generalized estimating equations with independent working correlations and robust variance.

**Appendix 2A: Case Definitions for Individual Chronic Illnesses**

<b>Chronic Illness</b>	<b>Case Definition</b>
Diabetes (Type 1 or 2)	<p>Adults age 18-75 who met ANY of the following during 2005-06:</p> <p>A) 2 outpatient diagnoses (ICD-9 250.xx)</p> <p>B) 1 inpatient diagnosis (ICD-9 250.xx)</p> <p>C) HbA1c test result <math>\geq 6.5\%</math></p> <p>D) During a 1-year period:  2 fasting glucoses <math>\geq 126</math> mg/dl OR  2 non-fasting glucoses <math>\geq 200</math> mg/dl OR  1 of each type of high glucose reading</p> <p>E) Any filled prescription for insulin or oral diabetic agents</p> <p><i>Exclusions: Gestational diabetes (ICD-9 648.8x), Polycystic ovarian disease (ICD-9 256.4)</i></p>
Hypertension	<p>Adults age 18-85 who met BOTH of the following during 2005-06:</p> <p>A) 2 diagnoses (ICD-9 401.xx)</p> <p>B) 2 filled prescriptions for antihypertensive medications</p>
Coronary Heart Disease	<p>Adults age 18-75 who met ANY of the following during 2005-06:</p> <p>A) 2 diagnoses (any combination) of:  Acute myocardial infarction (ICD-9 410.xx)  Other acute and subacute forms of ischemic heart disease (ICD-9 411.xx)  Old myocardial infarction (ICD-9 412.xx)  Angina pectoris (ICD-9 413.xx)  Other forms of chronic ischemic heart disease (ICD-9 414.xx)</p> <p>B) 1 ICD-9 procedure code for:  Percutaneous transluminal coronary angioplasty/Atherectomy (00.66)  OR  Operations on vessels of heart (36.xx)</p> <p>C) 1 CPT code for a coronary vessel procedure:  Coronary artery bypass graft (33510-33514, 33516-33523, 33533-33536); Open coronary endarterectomy (33572); Percutaneous transluminal coronary thrombectomy (92973); Thrombolysis, coronary (92975, 92977); Transcatheter placement of an intra coronary stent(s) (92980, 92981); Coronary artery dilation (92982, 92984); Coronary atherectomy (92995); Coronary atherectomy add-on (92996)</p>

## **CHAPTER 3. DO ELECTRONIC MESSAGE AND TELEPHONE ENCOUNTERS SUBSTITUTE OR COMPLEMENT OFFICE VISITS IN THE MEDICAL HOME?**

### **3.1 Abstract**

**Objective:** To assess whether secure electronic messaging and telephone encounters substitute or complement primary care office visits among individuals with diabetes.

**Data Sources/Study Setting:** Secondary data from 2008-11, encompassing the period before, during and after a patient-centered medical home redesign in an integrated delivery system.

**Study Design:** We employed a one-group interrupted time series design. Counts of secure electronic message threads and telephone encounters were the principal independent variables. The dependent variable was office visit count.

**Data Collection/Extraction Methods:** Automated data were converted to quarterly measures included in log-linear regression models with a patient-quarter unit of analysis.

**Principal Findings:** After covariate adjustment, partial elasticities of office visits with respect to message threads and telephone encounters were 0.125 and 0.274, indicating that 10% increases in these care modalities were associated with 1.25% and 2.74% increases in office visits, respectively. Select patient characteristics modified observed complementary relationships in an interaction model, but combined elasticities for all patient strata remained positive at  $p < 0.001$ .

**Conclusions:** Telephone encounters and, to a lesser extent, secure message threads served as complements to office visits for individuals with diabetes in this medical home redesign. Future research should investigate generalizability to lower morbidity populations and whether these care modalities reduce emergency or inpatient use.

### 3.2 Introduction

Telephone- and internet-based communication between patients and providers has been associated with increased access to care<sup>1,2</sup> and, when incorporated into care management interventions, improved glycemic control among people with type 2 diabetes<sup>3</sup> and blood pressure control among people with hypertension.<sup>4</sup> When paired with frequent in-person visits, telephone-based care coordination interventions have been linked to reduced hospitalizations in the chronically ill.<sup>5</sup> In addition to offering opportunities for more frequent patient contact, these care modalities do not require individuals to incur the time, effort or cost of traveling to providers' offices.<sup>1,2</sup> Furthermore, the asynchronous nature of electronic messaging offers the convenience to initiate communication at any time.<sup>6</sup>

For several years, prominent voices in American medicine,<sup>7-9</sup> have recommended that the locus of care delivery expand beyond traditional office physician visits to include alternative modes of communication. New care delivery models such as the patient-centered medical home (PCMH)<sup>10</sup> are seen as a way to achieve these changes,<sup>11</sup> and several PCMH redesigns rely on new care modalities to facilitate team-based care delivery.<sup>12</sup>

Despite these efforts to simultaneously encourage the use of new forms of care while decreasing reliance on office visits, early research varies on whether electronic messaging and telephone encounters impact patients' demand for in-person visits.<sup>6</sup> An early study found that telephone encounters were a feasible substitute for follow-up at a Veterans Health Administration clinic.<sup>13</sup> A Scottish trial, however, found that patients with telephone encounters for acute complaints had more follow-up visits than individuals with an initial office visit.<sup>14</sup> Studies of electronic messaging have also produced varying findings, and were restricted to small groups of early adopters,<sup>15</sup> indicating potential selection bias. Although studies in

Norway<sup>16</sup> and at Kaiser Permanente<sup>17</sup> observed fewer office visits after the introduction of electronic messaging, an analysis of individuals with diabetes observed contrasting findings of higher office visit utilization among those engaging in secure electronic messaging.<sup>18</sup>

We address gaps in the evidence base by investigating whether a patient population with diabetes uses electronic messages and telephone encounters as alternatives—or, in contrast, as an additive or complementary form of care—to primary care office visits. We include data on individuals' primary care use during the years 2008-11, encompassing three study periods before, during and after a PCMH redesign in an integrated health care delivery system. As detailed elsewhere,<sup>19</sup> this redesign was reliant on promoting electronic messaging and telephone visits as a means to improve access, continuity and follow-up. This study's primary objective is to assess the degree to which secure messaging threads and telephone encounters in this natural experiment substitute for or complement office visits in a chronically ill population. Our secondary objective is to investigate whether patient characteristics or study period modify the main effects under study.

#### Study Setting and Patient-Provider Communication Patterns

We investigate the impact of secure message and telephone encounters on patients' use of primary care office visits at Group Health, an integrated health plan and care delivery system that undertook a PCMH care redesign throughout its group practice. Since launching a secure online patient portal in 2000, Group Health added website functionalities and pursued strategies that encouraged copay-free communication between patients and providers through electronic messaging and telephone encounters.<sup>20</sup> Patients who complete ID-verified registration have been able to send and receive electronic messages to their providers through a secure patient portal

since 2002.<sup>21</sup> After promoting secure messaging and telephone encounters as a means to improve access,<sup>22</sup> Group Health subsequently emphasized these care modalities during a 2007-08 PCMH prototype redesign at one metropolitan Seattle clinic.<sup>23</sup>

These developments led to steadily increased secure message and telephone encounter use, particularly in the chronically ill. From 2004-05, 14% of Group Health patients exchanged at least one secure message with a provider;<sup>24</sup> among patients with diabetes this rate was 19%.<sup>18</sup> During the PCMH prototype redesign, changes in primary care use patterns led to observation of 86% more secure message threads and 10% more telephone encounters among chronically ill individuals at the PCMH clinic, compared to control patients at other Group Health clinics.<sup>25</sup>

After observing reduced staff burnout, lower downstream utilization and a net return on investment at the PCMH prototype clinic,<sup>23</sup> Group Health pursued a system-wide PCMH redesign in which each of the 26 clinics it owns and operates engaged in a one-year PCMH implementation.<sup>19</sup> Implementation start dates were staggered across clinics during the first four months of 2009, and implementation was completed in all clinics by March 2010.

Secure messaging and telephone encounters were incorporated within overlapping PCMH implementation efforts to improve access, continuity and follow-up.<sup>19</sup> Care team members contacted patients to discuss diagnostic results and therapeutics, and to follow up on recent visits to urgent care clinics, emergency departments and hospitals. Secure message and telephone contacts facilitated reminders and scheduling of screening and monitoring tests, and were selectively employed as alternatives to office visits. Medical assistants conducted “fishing” of physician schedules to identify patients with upcoming office visits who might be better served by telephone or secure message encounters,<sup>26</sup> and appointing center staff offered telephone visits to patients requesting office visits for common uncomplicated complaints, such as earache or

follow-up care. When conducting outreach following emergency department visits or to schedule overdue tests, providers only initiated telephone encounters if patients had not registered for the online portal or had stated they did not want to receive secure messages. Chronic condition case management and outreach following hospital discharges were primarily conducted via telephone.

During and after PCMH implementation, Group Health reporting systems tracked physician encounters through two process measure targets: one or more telephone encounters per half-day clinic session, and at least 30% of physician encounters conducted via electronic message. Results on process measure targets were displayed within clinics and updated on a weekly basis. A comprehensive description of Group Health's system-wide PCMH redesign is available elsewhere.<sup>19</sup>

### **3.3 Methods**

#### Study Design and Population

This study employed a one-group interrupted time series design<sup>27</sup> using quarterly patient observations ('patient-quarters') as the unit of analysis. We included data from the four-year period between January 2008 and December 2011 and divided quarterly data into three periods: pre-PCMH baseline (four quarters), PCMH implementation (four quarters) and a post-implementation period (up to eight quarters). We collected variables from automated Group Health databases to identify the eligible study population and collect variables for analysis. Group Health's institutional review board approved all study protocols.

The study population included all adults with diabetes mellitus (type 1 or 2) who were age 18-75 on the first day of PCMH implementation at their primary care clinic. Our case definition for diabetes was designed to achieve high specificity and high positive predictive value,<sup>28</sup> and

included individuals meeting any of the following criteria during the 24 months preceding implementation: two outpatient International Classification of Diseases, Ninth Revision (ICD-9) diagnoses of diabetes (250.xx); one inpatient ICD-9 diabetes diagnosis (250.xx); one hemoglobin A1c test result  $\geq 6.5\%$ ; one or more filled prescriptions for insulin or oral diabetic agents; during a one-year time frame, two fasting glucose test results  $\geq 126$  mg/dL, two non-fasting glucose test results  $\geq 200$  mg/dL or one of each type of glucose test result. We excluded women with polycystic ovarian disease (ICD-9 256.4) or gestational diabetes (ICD-9 648.8x), as well as all diabetic women with pregnancy or delivery-related codes.

We required continuous enrollment at Group Health during the pre-PCMH baseline period and at least the first two quarters of PCMH implementation. Patients with preexisting dementia were excluded because providers may communicate differently with these patients and their caregivers. Individuals were censored from the analysis after death, disenrollment from Group Health or aging out of the included 18-75 age range.

### Measures

Variables collected by Group Health databases on a monthly basis were converted to quarterly measures. Using previously documented methods,<sup>29</sup> we extracted data on health service use from Group Health's automated data systems. Monthly primary care utilization data were rolled up to quarterly counts of office visits, secure message threads, and telephone encounters. Secure message threads were defined as an original message and all messages in subsequent replies.<sup>30</sup> A thread could include one message or multiple messages between a patient and care team, as long as all replies originated from the same initial message. In addition to categorization

by study period, each patient-quarter was classified by calendar quarter to account for seasonal effects.

Data for patient-level covariates captured information on patients' needs and the prices they faced for office visits. We abstracted data on patients' age and sex and used methods developed by Krieger et al.<sup>31</sup> to create ecologic measures of education and income at PCMH baseline. Census tract-level education was classified as low, medium or high based on the most frequently occurring category: high school or less (low); some college or an associate's degree (medium); and college graduate or more (high). Census tract median household income was divided into four categories ( $\leq$ \$45,000; \$45,001-55,000; \$55,001-65,000;  $>$ \$65,000). Time-varying data on insurance coverage and benefits were collected for each patient-quarter. Variables for individuals' insurance type (commercial, Medicare or Medicaid/state-subsidized), provider network (restricted HMO vs. point-of-service plan) and indicators of pharmaceutical coverage and a waiver of copayments for well-care visits provided proxy measures of office visit prices.

Resource Utilization Band (RUB) variables from Johns Hopkins Adjusted Clinical Groups (ACG) System case mix software<sup>32</sup> characterized overall morbidity burden during each quarter. RUB measures classify morbidity on a six-point ordinal scale, from very low to very high, based on groupings of the complement of ICD-9 diagnoses during the previous 12 months. The three lowest RUB values were recoded to moderate based on two assumptions: 1) patients with diabetes have at least moderate morbidity burden based on the ACG classification schema, and; 2) our case definition for diabetes achieved comprehensive capture of diabetes-related morbidity by incorporating two years of ICD-9 diagnoses, laboratory results and prescription fills.

Laboratory and blood pressure data were incorporated in three quarterly measures of clinical processes and outcomes in diabetes care. We created three-point categorical variables based on

the last value of hemoglobin A1c (HbA1c), blood pressure and low-density lipoprotein (LDL) cholesterol data collected during the preceding patient-quarter. Individuals with outcome data collected in the year preceding each patient-quarter were classified according to common thresholds of diabetes quality:<sup>33</sup> HbA1c below 8.0%; blood pressure below 140/80 mm Hg; and LDL below 100 mg/dL. Since diabetes care guidelines recommend annual collection of each of these three proximal outcome measures,<sup>33</sup> individuals with no clinical measure data collection during the prior year received a separate code indicating clinical process noncompliance.

After linking individuals to their paneled primary care physicians, we created measures categorizing the proportions of total encounters—the sum of secure message threads, telephone encounters and office visits—conducted by primary care physicians via secure message and telephone. Low physician secure message use was defined as lower than the 30% target identified by Group Health. We classified medium secure messaging use as 30-50% of quarterly encounters, and high secure messaging use as greater than 50%. Since Group Health did not establish targets for the proportion of physicians' encounters conducted via telephone, we empirically defined quarterly physician telephone encounter use as low (below 5%), medium (5-10%) or high (greater than 10%).

### Analysis

We computed descriptive statistics for primary care use—including mean quarterly counts of secure message threads, telephone encounters and office visits—and study covariates at PCMH baseline. We used a log-linear regression model with log-transformed independent and dependent variables to assess the degree to which secure message and telephone encounters substituted or complemented office visits.<sup>34,35</sup> This study's log-linear model took the form:

$$\ln OV = \beta_0 + \beta_{SM} \ln X_{SM} + \beta_{Ph} \ln X_{Ph} + \sum_{c=1}^d \beta_c X_c \quad (\text{Equation 1})$$

Where  $OV$  represents the quarterly count of office visits,  $X_{SM}$  is the quarterly count of secure message threads,  $X_{Ph}$  is the quarterly count of telephone encounters and is  $X_c$  is one of an included set of covariates. While  $\beta$  coefficients in traditional linear regression represent the absolute change in the dependent variable  $Y$  associated with a one-unit increase in an independent variable  $X_i$ , a  $\beta$  coefficient in a log-linear model represents the proportional change in  $Y$  associated with a proportional increase in  $X_i$ , also known as the elasticity of  $Y$  with respect to  $X_i$ .

In Equation 1 above,  $\beta_{SM}$  represents the partial elasticity of office visits with respect to secure message threads, while  $\beta_{Ph}$  is the partial elasticity of office visits with respect to telephone encounters (the term partial elasticity is used because all other covariates are held constant). The sign of each elasticity provides inference on whether two variables substitute or complement one another; negative elasticities demonstrate substitution of secure message or telephone encounters for office visits, while positive elasticities demonstrate complementarity.<sup>35</sup>

We estimated three nested log-linear regression models. Prior to log transformation we added a constant of one to quarterly counts of each primary care modality, which ensured transformation of uniformly positive data but did not interfere with desirable statistical properties of the log-normal distribution.<sup>36</sup> Individuals' log-transformed quarterly office visit count was the dependent variable in all three models.

The first model (Model A) contained two independent variables: log-transformed quarterly counts of secure message threads and telephone encounters. The second model (Model B) contained Model A variables plus a variety of covariates, including: sex, baseline education and

income, an indicator of secure messaging use during the baseline year, and time-varying measures of age, morbidity, insurance segment and plan generosity. Categorical covariates for HbA1c, blood pressure and LDL controlled for quarterly diabetes processes and outcomes. The model also controlled for study period, calendar quarter and categorical measures of secure messaging and telephone use by each patient's primary care physician.

A third model (Model C) contained covariate-by-log-count interactions to investigate whether study period or selected patient characteristics modified the elasticities under study. We included interactions for individuals' age, sex, morbidity, insurance type and plan generosity. Interactions for each study period reflected temporal differences in use and promotion of secure messaging and telephone encounters, and interactions for physicians' secure messaging and telephone use partially captured differential effects of provider behaviors on patients' patterns of primary care use. Other than the interactions for physicians' secure messaging and telephone use—which interacted with counts of patient secure messaging threads and telephone encounters, respectively—all potential effect modifiers were included in two patient-level interactions: one for quarterly secure messaging and one for quarterly telephone encounters.

After carrying out Model C regression analysis, we obtained linear combinations of coefficients and reported individual interaction effects. If an interaction effect had the same sign—positive or negative—as a main effect, we described its effect as increasing overall substitution or complementarity. If an interaction had the opposite sign as a main effect, we stated that it reversed or attenuated the main effect.

The inclusion of several effect modifiers in Model C required that  $\beta$  coefficients be interpreted in the context of multiple interactions. For example, an individual with Medicare insurance and very high morbidity may not have had the same partial elasticities as an individual

with Medicare insurance and moderate morbidity. Although partial elasticities for individuals varied according to observed values for each effect modifier, this issue did not affect our ability to interpret whether interaction effects increased, reversed or attenuated main effects. Variation in elasticities across individuals precluded our ability to use  $\beta$  coefficients to represent overall elasticities, however, leading us to report population average marginal effects, which were calculated at the observational level and then averaged.

We estimated each log-linear model using generalized estimating equations (GEE) and autoregressive-1 (AR1) working correlations to model longitudinal patient-level time series data. Robust sandwich variance estimates ensured that the model was robust to misspecification of within-cluster correlation.<sup>37</sup> Log-linear model assumptions dictated the use of Gaussian error and identity link. Analysis was conducted using Stata, version 12.0 (College Station, TX).

### **3.4 Results**

The study population included 18,486 adults with diabetes who were age 18-75 on the first day of PCMH implementation (Table 1). As would be expected in a population with diabetes, 70% of individuals were age 55 or greater and 34% had high or very high morbidity based on the ACG software's RUB categories. Majorities of this population had commercial insurance (65%), a restricted HMO network (88%), a well-care waiver (77%) and pharmaceutical coverage (92%). Sixty two percent lived in neighborhoods with medium or high education, 53% lived in neighborhoods with median household incomes of at least \$55,000, and only 2% had Medicaid or state-subsidized insurance, reflecting relatively high socioeconomic status in this insured population. The study population contributed a total of 256,397 patient-quarters (mean 13.9, range 6-16) to the analysis.

Observed primary care use patterns were in alignment with expected changes induced by PCMH implementation. Patients' quarterly rates of secure message threads and telephone encounters steadily increased over the 16-quarter observation period, while mean quarterly office visits declined slightly (Figure 1). Patients averaged 0.88 (SD 1.77) secure message threads per quarter during baseline, 1.23 (SD 2.63) threads per quarter during PCMH implementation (40% increase) and 1.64 (SD 2.83) threads per quarter in the post-implementation period (86% total increase), while mean quarterly telephone encounters rose from 1.64 (SD 2.05) during baseline to 1.82 (SD 2.34) during implementation and 1.94 (SD 2.49) during post-implementation (18% total increase). On average, patients had 0.93 (SD 0.93), 0.90 (SD 0.97) and 0.86 (SD 0.89) office visits during the sequential study periods (8% total decrease). Mean total quarterly primary care contacts, largely driven by growth in secure messaging, increased from 3.46 (SD 3.48) during baseline to 3.95 (SD 4.33) during implementation and 4.44 (SD 4.68) during post-implementation (28% total increase). During PCMH implementation, primary care physicians of individuals in the study population averaged 46% of patient encounters via secure message and 8% via telephone. These proportions increased slightly to 49% and 10% in the post-implementation period.

Positive partial elasticities in all three modeled log-linear regressions demonstrated that both secure messages and telephone encounters served as complements to office visits (Table 2). In Model A, the partial elasticity of office visits with respect to secure messaging was 0.104 (95% CI, 0.100-0.108), which means that a 10% increase in secure message threads was associated with a 1.04% increase in office visits. A partial elasticity of office visits with respect to telephone encounters of 0.291 (95% CI, 0.287-0.295) indicated that a 10% increase in telephone encounters was associated with a 2.91% increase in office visits.

After covariate adjustment in Model B, partial elasticities of office visits with respect to secure messages and telephone encounters increased slightly to 0.125 (95% CI, 0.121-0.129) and decreased slightly to 0.274 (95% CI, 0.270-0.277), respectively. After the addition of interactions in Model C, the average marginal elasticity of office visits with respect to secure messages across the study population was 0.130 (95% CI, 0.126-0.134); the average marginal elasticity of office visits with respect to telephone encounters remained at 0.274 (95% CI, 0.270-0.277).

We observed some group-level variation measured by interaction effects (Table 3). Complementarity between secure messages and office visits was higher for individuals with pharmaceutical coverage ( $p=0.004$ ; referent, none). Male sex attenuated the elasticity of office visits with respect to telephone encounters ( $p=0.003$ ; referent, female), while Medicaid insurance increased the complementary relationship between these care modalities ( $p=0.002$ ; referent, commercial insurance). Complementarity between office visits and telephone encounters was greater among individuals aged 18-44 ( $p=0.03$ ; referent, 55-64) and 45-54 ( $p<0.001$ ). High morbidity (referent, moderate) and point-of-service networks (referent, HMO) attenuated the complementary relationships between office visits and both secure messages ( $p\leq 0.03$ ) and telephone encounters ( $p\leq 0.008$ ), while very high morbidity attenuated complementarity between secure messages and office visits ( $p<0.001$ ). Though we observed no significant differences in the elasticity of office visits with respect to secure messages across study periods, the elasticity of office visits with respect to telephone encounters attenuated over time; it was highest during the baseline period ( $p=0.01$ ; referent, implementation) and further attenuated during the post-implementation period ( $p<0.001$ ).

Although we observed some statistically significant interaction effects, linear combinations of coefficients for all strata of patient characteristics and study periods in Model C were positive

at  $p < 0.001$ , highlighting overall complementarity of office visits with respect to telephone encounters and, to a lesser extent, secure message threads.

### **3.5 Discussion**

Though we observed consistent increases in secure messaging and telephone encounters in a patient population with diabetes, we found that these two primary care modalities served as complements—rather than substitutes—to primary care office visits before, during and after a system-wide PCMH implementation. Interaction analysis revealed limited variation across patient subgroups, and some attenuation of the complementary effect between telephone encounters and office visits during sequential study periods. The latter finding is likely attributable to organizational protocols at Group Health that selectively encouraged telephone visit use in place of office visits within the PCMH redesign.

While our results run contrary to prior findings that new modes of communication are linked to decreased in-person office visit utilization,<sup>16,17</sup> the overall increase in primary care contacts presumably reflects patients' enhanced access to primary care teams, one of the pillars of PCMH-based care.<sup>10</sup> Care teams' continuous outreach to patients via telephone and secure messaging also aligns with recommended care delivery processes for chronically ill patients.<sup>5</sup>

It is not surprising that electronic messages and telephone visits did not generally substitute for office visits in this setting and population. Group Health enlarged its primary care workforce during PCMH implementation, enabling more providers to conduct more patient contacts, and did not place any constraints—financial or otherwise—on patients' use of secure messaging or telephone contacts. Though providers may have sometimes used secure messages and telephone encounters to curtail demand for office visits, these modes of communication presumably created

additional demand for care by reducing access barriers and encouraging patients to address previously unmet needs. When used for purposes other than follow-up, secure messages and telephone encounters may have delayed, but not substituted for, subsequent office visits.<sup>2,14</sup>

Substitutability was further limited by differences between primary care modalities with regard to resource intensity and the content of patient-provider interactions. Office visits are the most intensive, time-consuming primary care modality.<sup>38,39</sup> Although telephone encounters and secure messaging may facilitate important elements of chronic care delivery<sup>40</sup> such as follow up and patient self-management,<sup>1,2</sup> office visits offer opportunities for providers to conduct physical exams while observing patients' verbal and non-verbal cues,<sup>1</sup> leading to greater opportunities for assessment and diagnosis.

This study has several limitations. We did not conduct content analyses of individual primary care contacts, limiting our ability to comment on clinical issues addressed in each care modality. We cannot definitively identify whether each primary care encounter was initiated by a patient or a member of the primary care team. The analysis only partially controlled for primary care teams' behaviors because we were only able to collect physician-level data.

Generalizability to other settings may also be limited. The study population was universally insured and of relatively high socioeconomic status. Secure electronic messaging and telephone encounters have been conducted at Group Health for several years, facilitating high adoption rates that may be difficult to readily replicate in other settings. Group Health's salary-based provider reimbursement undoubtedly facilitated observed care delivery and utilization patterns, highlighting the need for payment reform in care models that de-emphasize visit-based care.

Our findings point to several opportunities for future research. Randomized trials can assess whether electronic messaging or telephone use cause reduced emergency and inpatient demand.

Replication of this analysis in low-morbidity patients may reveal patterns of substitution or complementarity that differ from this chronically ill population. Development of new definitions of primary care utilization—and accompanying new payment models—that encapsulate and reward primary care teams' efforts to improve the health of patients can lead to important gains for patients, providers and payers.

Through a novel application of an established econometric approach, we found that secure message threads and telephone encounters complemented, rather than substituted for, primary care office visits in individuals with diabetes. Selected patient characteristics attenuated or increased the complementary relationship between office visits and other care modalities. Study findings provide early evidence of the ways that new modes of patient-provider communication affect demand for office visits.

### 3.6 References

1. Car J, Sheikh A. Email consultations in health care: 1--Scope and effectiveness. *BMJ*. Aug 21 2004;329(7463):435-438.
2. Car J, Sheikh A. Telephone consultations. *BMJ*. May 3 2003;326(7396):966-969.
3. Ralston JD, Hirsch IB, Hoath J, Mullen M, Cheadle A, Goldberg HI. Web-based collaborative care for type 2 diabetes: a pilot randomized trial. *Diabetes Care*. Feb 2009;32(2):234-239.
4. Green BB, Cook AJ, Ralston JD, et al. Effectiveness of home blood pressure monitoring, Web communication, and pharmacist care on hypertension control: a randomized controlled trial. *JAMA*. Jun 25 2008;299(24):2857-2867.
5. Brown RS, Peikes D, Peterson G, Schore J, Razafindrakoto CM. Six features of medicare coordinated care demonstration programs that cut hospital admissions of high-risk patients. *Health affairs*. Jun 2012;31(6):1156-1166.
6. McGeady D, Kujala J, Ilvonen K. The impact of patient-physician web messaging on healthcare service provision. *Int J Med Inform*. Jan 2008;77(1):17-23.
7. Berwick DM, Nolan TW, Whittington J. The triple aim: care, health, and cost. *Health affairs*. May-Jun 2008;27(3):759-769.
8. Margolius D, Bodenheimer T. Transforming primary care: from past practice to the practice of the future. *Health affairs*. May 2010;29(5):779-784.
9. *Crossing the Quality Chasm: A New Health System for the Twenty-First Century*. Washington, DC: Institute of Medicine;2001.
10. American Academy of Family Physicians, American Academy of Pediatrics, American College of Physicians, American Osteopathic Association. Joint principles of the patient-centered medical home. 2007; <http://www.pcpcc.net/content/joint-principles-patient-centered-medical-home>. Accessed October 15, 2012.
11. Berenson RA, Hammons T, Gans DN, et al. A house is not a home: keeping patients at the center of practice redesign. *Health Aff (Millwood)*. Sep-Oct 2008;27(5):1219-1230.
12. Peikes D, Zutshi A, Genevro J, Smith K, Parchman M, Meyers D. *Early Evidence on the Patient-Centered Medical Home*. AHRQ Publication No. 12-0020-EF. Rockville, MD: Agency for Healthcare Research and Quality; 2012.
13. Wasson J, Gaudette C, Whaley F, Sauvigne A, Baribeau P, Welch HG. Telephone care as a substitute for routine clinic follow-up. *JAMA*. Apr 1 1992;267(13):1788-1793.
14. McKinstry B, Walker J, Campbell C, Heaney D, Wyke S. Telephone consultations to manage requests for same-day appointments: a randomised controlled trial in two practices.

*The British journal of general practice : the journal of the Royal College of General Practitioners.* Apr 2002;52(477):306-310.

15. Rogers EM. *Diffusion of Innovations - 5th ed.* New York: Free Press; 2003.
16. Bergmo TS, Kummervold PE, Gammon D, Dahl LB. Electronic patient-provider communication: will it offset office visits and telephone consultations in primary care? *Int J Med Inform.* Sep 2005;74(9):705-710.
17. Zhou YY, Garrido T, Chin HL, Wiesenthal AM, Liang LL. Patient access to an electronic health record with secure messaging: impact on primary care utilization. *Am J Manag Care.* Jul 2007;13(7):418-424.
18. Harris LT, Haneuse SJ, Martin DP, Ralston JD. Diabetes quality of care and outpatient utilization associated with electronic patient-provider messaging: a cross-sectional analysis. *Diabetes Care.* Jul 2009;32(7):1182-1187.
19. Hsu C, Coleman K, Ross TR, et al. Spreading a patient-centered medical home redesign: a case study. *The Journal of ambulatory care management.* Apr 2012;35(2):99-108.
20. Ralston JD, Coleman K, Reid RJ, Handley MR, Larson EB. Patient experience should be part of meaningful-use criteria. *Health Aff (Millwood).* Apr 2010;29(4):607-613.
21. Ralston JD, Carrell D, Reid R, Anderson M, Moran M, Hereford J. Patient web services integrated with a shared medical record: patient use and satisfaction. *J Am Med Inform Assoc.* Nov-Dec 2007;14(6):798-806.
22. Ralston JD, Martin DP, Anderson ML, et al. Group health cooperative's transformation toward patient-centered access. *Med Care Res Rev.* Dec 2009;66(6):703-724.
23. Reid RJ, Coleman K, Johnson EA, et al. The group health medical home at year two: cost savings, higher patient satisfaction, and less burnout for providers. *Health Aff (Millwood).* May 2010;29(5):835-843.
24. Ralston JD, Rutter CM, Carrell D, Hecht J, Rubanowice D, Simon GE. Patient use of secure electronic messaging within a shared medical record: a cross-sectional study. *J Gen Intern Med.* Mar 2009;24(3):349-355.
25. Liss DT, Fishman PA, Rutter CM, et al. Outcomes among chronically ill adults in a medical home prototype. *Under Review: American Journal of Managed Care.*
26. Reid RJ, Larson EB. Improvement Happens: Doctors Talk About the Medical Home : An Interview with Charles Mayer, MD, MPH and Eric Seaver, MD. *Journal of General Internal Medicine.* Apr 7 2012.
27. Shadish WR, Cook TD, Campbell DT. *Experimental and Quasi-Experimental Designs for Generalized Causal Inference.* Boston: Houghton Mifflin; 2002.

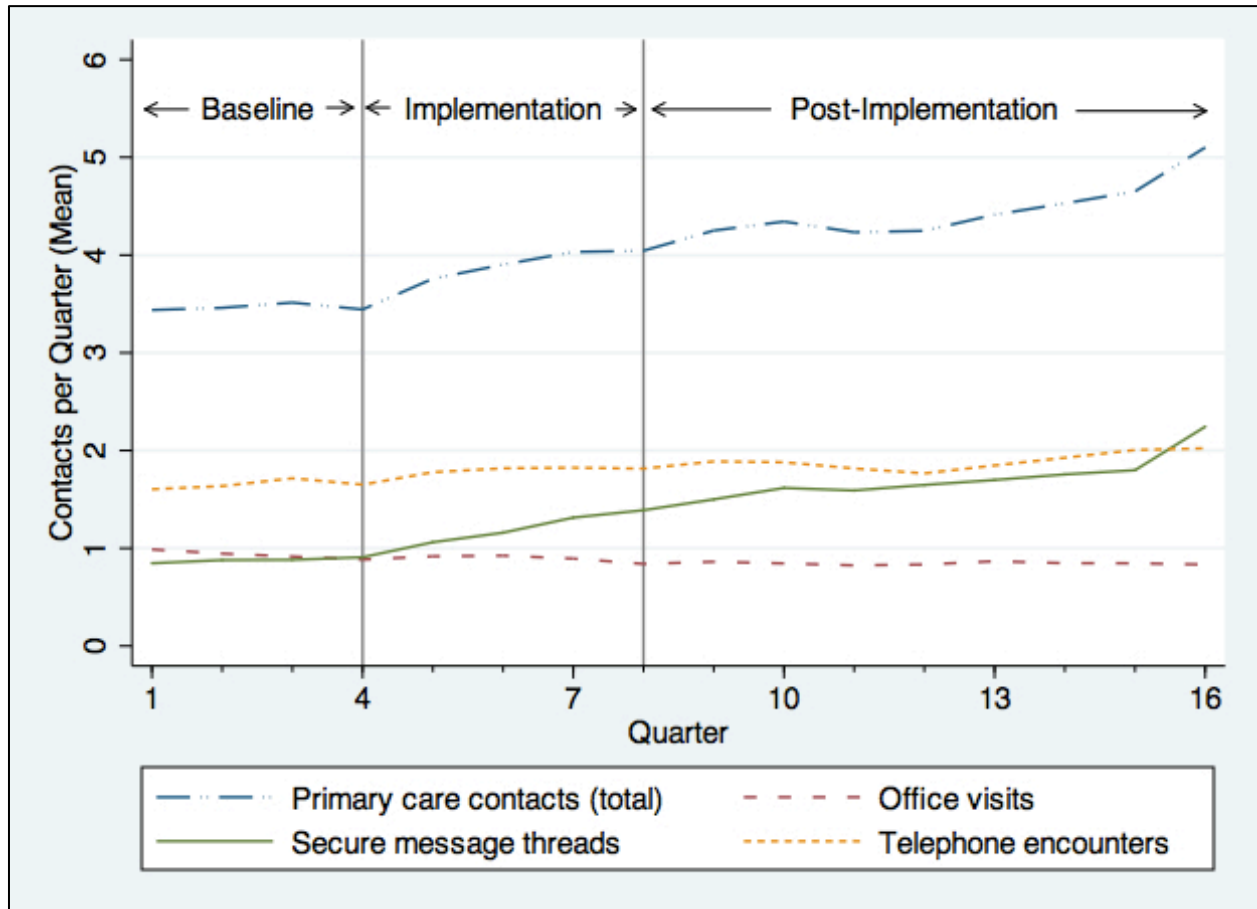
28. Solberg LI, Engebretson KI, Sperl-Hillen JM, Hroschikoski MC, O'Connor PJ. Are claims data accurate enough to identify patients for performance measures or quality improvement? The case of diabetes, heart disease, and depression. *Am J Med Qual.* Jul-Aug 2006;21(4):238-245.
29. Reid RJ, Fishman PA, Yu O, et al. Patient-centered medical home demonstration: a prospective, quasi-experimental, before and after evaluation. *Am J Manag Care.* Sep 2009;15(9):e71-87.
30. Carrell D, Ralston J. Messages, strands and threads: measuring use of electronic patient-provider messaging. *AMIA Annu Symp Proc.* 2005:913.
31. Krieger N. Overcoming the absence of socioeconomic data in medical records: validation and application of a census-based methodology. *Am J Public Health.* May 1992;82(5):703-710.
32. *The Johns Hopkins ACG System: Technical Reference Guide, Version 10.0.* Baltimore, MD: Johns Hopkins University; 2011.
33. *HEDIS 2012: Technical Specifications for Health Plans, Volume 2.* Washington, D.C.: National Committee for Quality Assurance;2011.
34. McFadden D. Constant Elasticity of Substitution Production Functions. *The Review of Economic Studies.* 1963;30(2):73-83.
35. Gujarati DN. *Essentials of Econometrics (3rd ed.)*. New York: McGraw-Hill/Irwin; 2006.
36. Duan N. Smearing Estimate: A Nonparametric Retransformation Method. *Journal of the American Statistical Association.* 1983;78(383):605-610.
37. Diggle P, Heagerty P, Liang K, Zeger S. *Analysis of Longitudinal Data.* 2nd ed. Norfolk, UK: Oxford University Press; 2002.
38. Sittig DF. Results of a content analysis of electronic messages (email) sent between patients and their physicians. *BMC Med Inform Decis Mak.* Oct 1 2003;3:11.
39. Kravitz RL, Bell RA, Franz CE. A taxonomy of requests by patients (TORP): a new system for understanding clinical negotiation in office practice. *The Journal of family practice.* Nov 1999;48(11):872-878.
40. Wagner EH. Chronic disease management: what will it take to improve care for chronic illness? *Eff Clin Pract.* Aug-Sep 1998;1(1):2-4.

**Table 3.1:** Population Characteristics at PCMH Baseline and Baseline Year Primary Care Contacts

Characteristic	Total, N (%)	Baseline Year Primary Care Contacts, Mean (SD)		
		Secure Message Threads	Telephone Encounters	Office Visits
<i>Total, N</i>	18486	3.5 (7.1)	6.6 (8.2)	3.7 (3.7)
Age				
18-44	1637 (9)	3.5 (6.9)	4.9 (6.0)	3.5 (3.4)
45-54	3944 (21)	3.5 (6.5)	5.6 (7.1)	3.6 (3.5)
55-64	7400 (40)	3.7 (7.5)	6.3 (7.8)	3.6 (3.9)
65-75	5505 (30)	3.4 (6.9)	8.2 (9.7)	4.0 (3.7)
Sex				
Female	8879 (48)	3.7 (7.7)	7.3 (8.8)	4.0 (3.7)
Male	9607 (52)	3.4 (6.5)	6.0 (7.6)	3.4 (3.7)
Morbidity (ACG RUB)				
Moderate	12073 (65)	2.5 (4.4)	4.1 (4.4)	2.6 (2.1)
High	3963 (21)	4.8 (9.0)	8.4 (7.7)	4.9 (3.3)
Very high	2450 (13)	6.7 (11.7)	15.7 (14.1)	7.4 (6.6)
Insurance Type				
Commercial	11924 (65)	3.5 (6.4)	5.4 (6.5)	3.4 (3.4)
Medicaid/State-subsidized	408 (2)	2.2 (5.4)	5.5 (5.9)	3.7 (3.2)
Medicare	6154 (33)	3.7 (8.3)	8.9 (10.5)	4.3 (4.2)
Provider Network				
HMO	16193 (88)	3.6 (7.2)	6.8 (8.4)	3.8 (3.8)
Point-of-service	2293 (12)	3.0 (5.9)	5.0 (6.4)	3.5 (3.4)
Well-Care Waiver				
Yes	14251 (77)	3.6 (7.3)	6.6 (8.2)	3.7 (3.7)
No	4235 (23)	3.4 (6.3)	6.6 (8.1)	3.7 (3.6)
Pharmaceutical Coverage				
Yes	17051 (92)	3.5 (7.0)	6.5 (8.0)	3.7 (3.6)
No	1435 (8)	3.6 (8.3)	8.2 (10.2)	3.9 (4.7)
Census Tract Education				
Low	7101 (38)	3.0 (6.5)	6.8 (8.4)	3.8 (3.6)
Medium	6269 (34)	3.5 (6.5)	6.4 (8.2)	3.9 (3.9)
High	5116 (28)	4.4 (8.3)	6.6 (8.0)	3.4 (3.6)
Census Tract Income				
≤ \$45,000	4111 (22)	3.0 (6.8)	6.8 (8.7)	4.0 (3.9)
\$45,001 - \$55,000	4435 (24)	3.2 (6.2)	6.4 (7.8)	3.8 (3.7)
\$55,001 - \$65,000	4341 (23)	3.7 (7.9)	6.7 (8.5)	3.7 (3.6)
> \$65,000	5599 (30)	4.1 (7.3)	6.5 (7.9)	3.5 (3.6)
Baseline Secure Messaging				
Yes	9803 (53)	6.7 (8.6)	6.8 (8.3)	3.9 (3.7)
No	8683 (47)	0 (0)	6.3 (8.1)	3.5 (3.7)

Abbreviations: PCMH, patient-centered medical home; SD, standard deviation; ACG, Adjusted Clinical Groups; RUB, Resource Utilization Band; HMO, health maintenance organization

**Figure 3.1:** Quarterly Patient Contacts With Primary Care Teams, Baseline - Post-Implementation



**Table 3.2:** Elasticity of Office Visits With Respect to Secure Message and Telephone Encounters In Three Nested Regression Models

Log-Linear Regression Model (Independent Variables)	Elasticity of Office Visits With Respect to Secure Messages**		Elasticity of Office Visits With Respect to Telephone Encounters**	
	Elasticity	95% CI	Elasticity	95% CI
Model A (Unadjusted)*	0.104	(0.100, 0.108)	0.291	(0.287, 0.295)
Model B (Model A + Covariates)‡	0.125	(0.121, 0.129)	0.274	(0.270, 0.277)
Model C (Model B + Interactions)§	0.130	(0.126, 0.134)	0.274	(0.270, 0.277)

Abbreviations: CI, confidence interval; HbA1c, hemoglobin A1c; LDL, low-density lipoprotein

\* Independent variables: log-transformed quarterly secure message threads and log-transformed quarterly telephone encounters

‡ Adjusts for age, sex, morbidity, insurance type, provider network, well-care waiver, pharmaceutical coverage, education, income, baseline secure messaging use, HbA1c, blood pressure, LDL, study period, calendar quarter, physician secure messages, physician telephone encounters

§ Contains interactions for age, sex, morbidity, insurance type, provider network, well-care waiver, pharmaceutical coverage, study period, primary care physician secure messaging, primary care physician telephone encounters

\*\* Average marginal effects presented, which are identical to  $\beta$  coefficients in Models A and B. Model C's elasticities and  $\beta$  coefficients vary across individuals due to covariate-level interactions

**Table 3.3:** Linear Combinations of Coefficients In Regression Model Incorporating Interactions for Patient Characteristics and Study Periods (Model C)

Patient Subpopulation	Elasticity of Office Visits With Respect to Secure Messages**		Elasticity of Office Visits With Respect to Telephone Encounters**	
	Elasticity	95% CI	Elasticity	95% CI
Age				
18-44	0.128	(0.103, 0.153)	0.293 <sup>‡</sup>	(0.270, 0.317)
45-54	0.121	(0.099, 0.143)	0.294 <sup>‡</sup>	(0.274, 0.314)
55-64 (ref*)	0.114	(0.093, 0.135)	0.274	(0.255, 0.293)
65-75	0.122	(0.093, 0.150)	0.281	(0.256, 0.306)
Sex				
Female (ref*)	0.114	(0.093, 0.135)	0.274	(0.255, 0.293)
Male	0.118	(0.097, 0.139)	0.262 <sup>§</sup>	(0.243, 0.281)
Morbidity (ACG RUB)				
Moderate (ref*)	0.114	(0.093, 0.135)	0.274	(0.255, 0.293)
High	0.084 <sup>§</sup>	(0.062, 0.106)	0.266 <sup>§</sup>	(0.246, 0.286)
Very high	0.069 <sup>§</sup>	(0.045, 0.093)	0.272	(0.251, 0.293)
Insurance Type				
Commercial (ref*)	0.114	(0.093, 0.135)	0.274	(0.255, 0.293)
Medicaid/State-subsidized	0.100	(0.063, 0.138)	0.316 <sup>‡</sup>	(0.283, 0.348)
Medicare	0.096	(0.068, 0.123)	0.278	(0.253, 0.303)
Provider Network				
HMO (ref*)	0.114	(0.093, 0.135)	0.274	(0.255, 0.293)
Point-of-service	0.100 <sup>§</sup>	(0.076, 0.123)	0.257 <sup>§</sup>	(0.236, 0.279)
Well-Care Waiver				
Yes	0.123	(0.104, 0.142)	0.268	(0.251, 0.285)
No (ref*)	0.114	(0.093, 0.135)	0.274	(0.255, 0.293)
Pharmaceutical Coverage				
Yes	0.138 <sup>‡</sup>	(0.125, 0.151)	0.274	(0.262, 0.286)
No (ref*)	0.114	(0.093, 0.135)	0.274	(0.255, 0.293)
Period				
Baseline	0.113	(0.089, 0.138)	0.293 <sup>‡</sup>	(0.270, 0.315)
PCMH implementation (ref*)	0.114	(0.093, 0.135)	0.274	(0.255, 0.293)
Post-implementation	0.120	(0.098, 0.141)	0.257 <sup>§</sup>	(0.238, 0.277)

Abbreviations: CI, confidence interval; ACG, Adjusted Clinical Groups; RUB, Resource Utilization Band; HMO, health maintenance organization; PCMH, patient-centered medical home; HbA1c, hemoglobin A1c; LDL, low-density lipoprotein

\* ref: Referent group; <sup>‡</sup> Positive interaction at  $p \leq 0.05$  increased complementarity, compared to referent group; <sup>§</sup> Negative interaction at  $p \leq 0.05$  attenuated complementarity, compared to referent group

\*\* Model covariates: income, education, baseline secure messaging use, HbA1c, blood pressure, LDL, calendar quarter, physician secure messages, patient-by-physician secure message interaction (referent, 30-50% of physician encounters), physician telephone encounters, patient-by-physician telephone encounter interaction (referent, 5-10% of physician encounters)

## CHAPTER 4. SPECIALTY CARE VISITS IN THE “MEDICAL NEIGHBORHOOD” AMONG PATIENTS WITH HYPERTENSION

### 4.1 Abstract

**Background:** Little is known about how delivery of primary care in the patient-centered medical home (PCMH) influences individuals’ use of outpatient specialty care. To address this gap, we describe changes in specialty care utilization among a chronically ill patient population in a PCMH redesign.

**Methods:** We used a one-group interrupted time series design with patient-year unit of analysis. Negative binomial regression models were used to describe annual differences in total specialty visit rates. Poisson regression models were used to describe annual differences in the relative risk of any visits to selected medical and surgical specialties. Categorical study year was the key predictor in all regression models.

**Results:** The study population included 36,805 individuals with treated hypertension. Compared to pre-PCMH baseline, there were, on average, fewer total specialty care visits during PCMH implementation (7%,  $p<0.001$ ) and the first post-implementation year (4%,  $p=0.020$ ), after adjusting for potential confounders. In a model with morbidity group-by-year interactions, patients with low morbidity had at least 27% fewer specialty visits during each of the three years following baseline ( $p<0.001$ ), while high morbidity patients had higher specialty utilization during the first (3%,  $p=0.052$ ) and second post-implementation years (5%,  $p=0.009$ ). Patients were 12% less likely to have any cardiology visits during PCMH implementation and 13% less likely during the first post-implementation year ( $p<0.001$ ).

**Conclusions:** In the two years following the PCMH redesign, we observed, on average, small decreases in total specialty care visits for patients with hypertension. In low morbidity patients

this decrease was rapid and sustained over three years. Study findings suggest that more comprehensive primary care in the PCMH can impact outpatient specialty utilization patterns.

## 4.2 Introduction

In recent years the patient-centered medical home (PCMH)<sup>1</sup> has attracted attention as a potential solution to systemic deficiencies in American health care.<sup>2</sup> As PCMH demonstrations are launched across the country and early findings are published,<sup>3,4</sup> the PCMH research agenda<sup>5,6</sup> has largely addressed the ability of this care model to improve quality of care or to reduce utilization, and associated costs, in emergency and inpatient settings.

Early evaluations have not yet addressed the impact of PCMH-based primary care on outpatient specialty care utilization patterns. Although researchers have posited that some tasks currently provided by specialists may be reallocated to generalists in the medical home,<sup>7,8</sup> to our knowledge the evidence base contains no studies investigating this potential shift in care delivery processes. Comprehensive PCMH care from primary care teams,<sup>1</sup> rather than necessarily inducing reductions in specialty care utilization, is characterized by coordination of care across a “medical neighborhood”<sup>9</sup> in which specialists selectively offer advice, conduct procedures and co-manage patient care with primary care providers.<sup>10</sup>

Comprehensive PCMH care should enable care teams to deliver more care for conditions commonly treated in the primary care setting, leading to potential decreases in outpatient specialty care. Patients with high morbidity burdens or complex health care needs, however, may not make fewer specialty visits as a result of receiving PCMH-based primary care. Prior analyses of primary care populations not exposed to the PCMH observed a positive relationship between overall morbidity burden and specialty visits in managed care<sup>11</sup> and Medicare populations,<sup>12</sup> and

a Canadian analysis<sup>13</sup> found an additive relationship between primary care contacts and subsequent specialty visits for patients with hypertension, particularly those with high morbidity. These results suggest that when the total number of contacts between chronically ill individuals and primary care teams increase in the PCMH,<sup>14,15</sup> providers could be especially motivated to refer high morbidity patients to specialists. These referrals may be clinically indicated for several reasons, such as a lack of clear treatment guidelines in the presence of comorbid conditions<sup>16</sup> or for rare conditions that specialists are well-equipped to treat.<sup>17</sup>

We conducted this study to address gaps in the evidence base on patterns of specialty care use within the PCMH. We focus on specialty care for patients with treated hypertension—a chronic condition for which the majority of care is typically delivered in the primary care setting—who received care before, during and following a 2009-10 PCMH redesign. Our primary objective is to describe changes in patients' rates of specialty care visits during and after PCMH implementation, and potential differences in observed changes according to level of overall morbidity burden. Our secondary objective is to describe changes in patients' relative risk of making any visits to selected medical and surgical specialties.

### Study Setting

This study took place at Group Health (GH), an integrated health plan and care delivery system in the Pacific Northwest that undertook an organization-wide PCMH redesign during 2009-10.<sup>18</sup> Prior to transforming primary care across the system of 26 clinics that it owns and operates, GH tested a PCMH prototype redesign at one clinic during 2007-08. Previous evaluations found that the prototype redesign achieved several objectives,<sup>8,19</sup> including improved

performance on composite quality measures and reductions in inpatient and emergency/urgent care.

Contrary to expectations, however, patients at GH's PCMH prototype site had 6% more specialty care visits, compared to other GH clinics, during the first year of the redesign, and 3% more specialty visits over two years.<sup>19</sup> In subgroup analyses, elderly PCMH patients had similar increases in specialty utilization over both the first year (8%) and the full two-year redesign (5%),<sup>20</sup> and adults with hypertension, diabetes or coronary heart disease experienced slightly smaller increases that were not statistically significant at either one year (4%) or two years (2%).<sup>14</sup>

PCMH prototype results may have been attributable to changes in care structures and processes that enabled primary care teams to devote more time and attention to patients' needs. PCMH redesign components such as lengthened in-person visits, higher primary care staffing and increases in secure messaging and telephone contacts<sup>19</sup> may have created opportunities to address previously unmet needs, some of which required specialty referrals.

We expected that GH's system-wide PCMH redesign would enable primary care teams to deliver more accessible, comprehensive care to their patients, resulting in a shift in the boundaries between the primary care and specialty care settings.<sup>21</sup> We also expected that these changes would lead to reductions in specialty care utilization among less complex patients, but that increased detection of new or existing health care conditions could induce additional specialty referrals for more complex patients.

### **4.3 Methods**

#### Study Design and Population

This study employed an interrupted time series design<sup>22</sup> using annual patient observations (‘patient-years’) as the unit of analysis. Study data were obtained from files containing data originally collected for an evaluation of the system-wide PCMH redesign in GH’s full patient population.<sup>23</sup> GH’s institutional review board approved all study protocols.

We collected data from the four-year period between January 2008 and December 2011. Because GH staggered the system-wide rollout of PCMH implementation between January-April 2009 (four groups across 26 total clinics),<sup>18</sup> we linked clinic-specific dates of PCMH initiation with patient enrollment data to identify the month each patient was first exposed to the PCMH redesign. Patient-years were then categorized according to four annual periods: pre-PCMH baseline (year 0), PCMH implementation (year 1) and the first (year 2) and second (year 3) post-implementation years.

The study population included continuously enrolled adults aged 18-85 who were diagnosed with and treated for hypertension prior to the study period. Individuals met our case definition for treated hypertension if they had both of the following during the 24 months preceding the pre-PCMH baseline year: two or more International Classification of Diseases, Ninth Revision (ICD-9) diagnoses for hypertension (401.xx) and; two or more filled prescriptions for antihypertensive medications. We included these inclusion criteria based on prior findings of high specificity and moderate sensitivity.<sup>24</sup>

We required that individuals be continuously enrolled at GH during both the pre-PCMH baseline year and the PCMH implementation year, which ensured collection of case mix-related covariates and receipt of at least one year of care within the PCMH redesign. We did not, however, establish any enrollment requirements for the 24-month period during which individuals met our case definition for treated hypertension. So long as GH automated databases

contained two or more ICD-9 diagnoses for hypertension and two or more filled prescriptions for antihypertensive medications, patients could have been enrolled at GH for any period of time during the 24 months preceding PCMH baseline. We excluded 469 individuals with any ICD-9 diagnosis of end-stage renal disease (585.6, V45.1, V56.x) because these dialysis patients are managed by GH nephrology providers, who not did transform their practices to the PCMH. Using a set of codes compiled for a prior study of medication safety during pregnancy,<sup>25</sup> we also excluded 159 women who gave birth during the study period, due to the potential for pregnancy-related complications in chronic hypertension care and risks for preeclampsia.<sup>26</sup> Individuals were censored during the final two study years due to death, aging out of the included 18-85 cohort or any period of disenrollment from GH during 2010 or 2011.

### Measures

We collected secondary data from automated databases containing information on GH enrollees and care they receive at GH sites and sites where providers deliver care to GH patients on a contracted basis. Data on specialty care utilization were drawn from databases linked to GH's automated costing systems, which categorize outpatient specialty visits according to the type of provider delivering care.

After extracting monthly counts of office visits across all specialties and in selected medical and surgical specialties, we summed monthly measures to patient-year totals. We collected data on three types of primary care contacts—in-person visits, secure electronic messaging threads<sup>27</sup> and telephone encounters—and calculated total primary care contact rates by summing rates of all three encounter types. Because of the staggered nature of PCMH implementation, individuals in the study population contributed between 9-12 months of data during the final patient-year

concluding in December 2011. We annualized outpatient use totals for this period by multiplying observed counts by  $(12/X)$ , where  $X$  represents the number of months of enrollment.

Several potential confounders were collected for multivariable regression analyses. Other than data on individuals' sex, all covariate data were collected on an annual, time-varying basis. We grouped individuals' age on the first day of each patient-year as 18-44, 45-54, 55-64, 65-74 or 75-85, and categorized each patient-year by twelve-month calendar interval to account for seasonal effects.

After linking monthly data on individuals' empaneled primary care clinics to internet-based driving directions to the nearest of six specialty care sites within GH's multispecialty group practice,<sup>28</sup> we created a concurrent measure of proximity to specialty care. Patients' primary care clinics were coded according to whether they had co-located specialty care (6 clinics), were within fifteen miles (14 clinics) or greater than fifteen miles (6 clinics) from the nearest GH specialty care site (patients are permitted to visit any site they desire). Since individuals could switch between multiple primary care clinics on a month-to-month basis over the course of a patient-year, we summarized annual proximity to specialty care based on the observed monthly mode during each patient-year. If an individual had more than one mode during a given year (e.g., 6 months of enrollment at a site with co-located specialty care and 6 months of enrollment at a site that was greater than fifteen miles from the nearest specialty care site), we selected the mode indicating the nearer proximity to specialty care.

We utilized methods developed by Krieger et al.<sup>29</sup> to create ecologic measures of income and education, with 2001 census tract-level median household income grouped into approximate empirical quartiles ( $\leq$  \$50,000; \$50,001-60,000; \$60,001-70,000;  $>$  \$70,000) and census tract education categorized as low, medium or high based on the most frequently occurring category:

high school or less (low); some college or an associate's degree (medium); or college graduate or more (high). We classified insurance type as commercial, Medicare or Medicaid/state-subsidized, and collected data on the relative generosity of individuals' health plans with regard to provider network (restricted HMO vs. point-of-service plan), pharmaceutical coverage and waiver of copayment for well-care visits.

We used several variables from the Johns Hopkins Adjusted Clinical Groups (ACG) System case mix software<sup>30</sup> for population profiling and case mix adjustment. ACG Resource Utilization Band (RUB) variables were collected from the first month of each patient-year to characterize overall morbidity burden. RUB measures classify individuals' overall morbidity burden on a six-point ordinal scale, from very low to very high, based on groupings of all ICD-9 diagnoses from the previous 12 months.

We then defined three morbidity groups based on RUB overall morbidity. We first recoded RUB values of none or very low to a value of low. If an individual had comorbid diabetes, we recoded RUB values of low to the moderate category. This recoding was based on two assumptions: 1) ACG classification schema, which are based on the prior year of ICD-9 diagnoses, assign at least low morbidity to patients with hypertension, and at least moderate morbidity to patients with diabetes; 2) Our case definitions for hypertension and diabetes, which incorporate up to two years of ICD-9 diagnoses, laboratory results and prescription fills (depending on the length of time an individual was enrolled during the 24 months preceding the pre-PCMH baseline year), may capture additional data on condition-related morbidity beyond what is described by ACG software. After recoding, we used RUB data to divide the study population into three morbidity burden groups: low (RUB=low), medium (RUB=moderate) and high (RUB=high or RUB=very high). Our case definition for diabetes is presented elsewhere.<sup>15</sup>

We separately profiled individual health care conditions diagnosed in the study population during the baseline year by collecting all 269 Expanded Diagnosis Cluster (EDC) variables and all 27 Major EDC (MEDC) variables from the ACG software. Unlike RUBs—which present a summary measure of overall morbidity burden based on the expected need for health care resources—EDC variables present a complementary morbidity perspective based on organ system and pathophysiologic process.<sup>31</sup> The ACG software creates each EDC variable by grouping individual diagnoses into a defined set of conditions and combinations of conditions (e.g., ischemic heart disease, depression, gout). MEDC variables map each EDC into one of 27 broad clinical categories identifying the physician specialty most likely to provide care for each EDC (e.g., Parkinson’s disease is one of 20 EDCs that map to the Neurologic MEDC). The supplementary Appendix contains a list of EDCs common to the study population, as defined by 5% prevalence or more.

After matching EDCs that were prevalent in the study population during the baseline year to several relevant specialties, we collected binary measures (0/1) of whether patients made any visits to the following providers during each year: eye care (optometrists and ophthalmologists), cardiology, orthopedic surgery, gastroenterology, consultative internal medicine, general surgery, behavioral health (psychiatrists, psychologists, chemical dependency providers), urology, neurology and obstetrics/gynecology (females only). Data limitations in the classification of specialties by Group Health databases precluded collection of visit data for some specialties, including dermatology, endocrinology and pulmonology. Other than consultative internal medicine, which requires a physician referral, GH patients have been able to self-refer to all specialties under study here since 2003.<sup>32</sup>

## Analysis

We estimated two multivariable negative binomial regression models to describe annual differences in total specialty care visits. This approach was pursued after model diagnostics for Poisson regressions suggested violation of model assumptions due to overdispersion.<sup>33</sup> The first negative binomial model described average findings across the study population, while the second provided more detailed findings, according to RUB morbidity burden group, by testing for effect modification. For both models, the outcome variable was the total specialty care visit count during each patient-year. The key predictor was categorical study year, with the pre-PCMH baseline year serving as the referent category. We adjusted for confounding by including several additional covariates in our model: sex and annual measures of age, morbidity group, binary indicator of diabetes, insurance type, provider network, pharmaceutical coverage, well-care waiver, census tract-level income, census tract-level education and indicators for each nine-to-twelve-month calendar period. In the second model, morbidity group-by-year interactions tested for differences in specialty utilization by morbidity burden. When presenting interaction model results, we reported linear combinations of coefficients comparing year-to-year results within each morbidity group.

We estimated Poisson regression models to describe binary utilization outcomes and estimate annual relative risks.<sup>34,35</sup> Because individuals contributed between 9-12 months of data to the final patient-year ending December 2011, we adjusted for exposure time by including an offset term representing individuals' number of months of enrollment during each patient-year. The first Poisson regression model described total specialty visits; its outcome variable was a binary indicator of whether an individual had one or more visits to any specialty provider during each patient-year. Additional Poisson regression models described the annual relative risk of

making one or more visits to each of the ten medical and surgical specialties identified during our review of EDC variables. The outcome variable in these regression models was a binary indicator of one or more annual visits to each respective specialty setting. The key independent variable in all Poisson regression models was categorical study year (referent, pre-PCMH baseline year). These regression models included the same potential confounders as negative binomial models, but did not include any interaction terms.

We conducted a separate sensitivity analysis to examine the potential impact of differential year 3 enrollment lengths on adjusted total specialty visit rates. After creating four strata defined by the number of months enrolled during year 3, we estimated stratum-specific multivariable negative binomial regression models. These regression models included the same key predictor and potential confounders as negative binomial models for the full study population, but did not include any interaction terms.

All regression models were estimated using generalized estimating equations (GEE). This approach accounted for longitudinal data clustered at the level of the patient using an independent working correlation matrix. Robust sandwich variance estimates were used to ensure models were robust to misspecification of within-cluster correlation.<sup>36</sup> Analyses were conducted using Stata, version 12 (College Station, TX).

#### **4.4 Results**

The study population included 36,805 adults with treated hypertension who were age 18-85 (mean 64.2, SD 11.9) on the first day of PCMH implementation (Table 1). Similar proportions of individuals had commercial or Medicare insurance, while only 1% had Medicaid or state-subsidized insurance. Fifty-five percent of the study population was female, 28% had diabetes,

and large majorities had a restricted HMO network, a well-care waiver and pharmaceutical coverage. Sixty four percent lived in neighborhoods with medium or high education, and 71% lived in neighborhoods with median household incomes of at least \$50,000. The study population contributed a total of 138,136 patient-years (mean 3.8, range 2-4) to the analysis.

At the beginning of the pre-PCMH baseline year, 7.2% of individuals had low morbidity burden, as defined by the low category of the ACG RUB measure, and the high morbidity group (high/very high RUB categories) contained 34.5% of the study population (Figure 1). The proportion of individuals in the medium morbidity group (moderate RUB category) declined by 4.2% over the course of the study—from 58.3% of the study population in the baseline year to 54.1% of the study population in year 3—while the proportions of individuals defined as having low and high morbidity burden concurrently increased slightly.

As observed previously,<sup>15,19</sup> rates of total primary care contacts increased during and after PCMH implementation, largely driven by increases in secure electronic messaging threads and telephone encounters. Mean annual primary care contacts increased from 12.83 contacts (SD 12.91) during baseline to 15.73 contacts (SD 16.87) in year 3, while mean in-person primary care visits decreased on a year-to-year basis, from 3.78 (SD 3.55) visits per year during baseline to 3.26 (SD 3.70) visits per year in year 3.

Unadjusted specialty care utilization in the full study population increased in each successive year, but not in all morbidity burden groups (Figure 2). Among individuals with low morbidity, mean specialty utilization decreased from 2.70 annual baseline visits (SD 4.22) to 1.96 visits (SD 3.62) during PCMH implementation, remaining largely stable during year 2 (mean 2.05 visits per year, SD 3.71) and year 3 (mean 2.01, SD 3.92). Mean specialty utilization fell from 4.04 (SD 5.57) to 3.83 (SD 5.31) visits per year during PCMH implementation in

medium morbidity patients, but ultimately rose to a level slightly exceeding the baseline rate (mean 4.13, SD 6.20). Annual specialty utilization steadily increased in high morbidity patients, from 8.68 baseline visits (SD 9.11) to 9.67 year 3 visits (SD 10.65).

The Poisson regression model describing adjusted specialty care utilization estimated that individuals were on average 3% less likely to have any specialty visits during both PCMH implementation and year 2, compared to baseline ( $p<0.001$ ). In year 3, individuals were 21% more likely to have any specialty visits ( $p<0.001$ ).

Negative binomial regression models estimated decreases in average adjusted total specialty utilization rates during PCMH implementation and the first post-implementation year, and substantial variation across morbidity burden groups (Table 2). Compared to the pre-PCMH baseline year, the full study population had, on average, 7% fewer specialty visits in year 1 ( $p<0.001$ ) and 4% fewer specialty visits in year 2 ( $p=0.020$ ). We observed no significant difference in total specialty utilization between baseline and year 3. In the model providing more detailed findings according to RUB morbidity burden group, low morbidity patients had 28% fewer specialty visits during year 1, 27% fewer visits in year 2 and 28% fewer visits in year 3 ( $p<0.001$  for all). Medium morbidity patients had 9% lower specialty utilization during year 1 ( $p<0.001$ ) and 5% lower specialty utilization in year 2 ( $p=0.007$ ). High morbidity patients, on the other hand, had 3% higher specialty utilization during year 2 ( $p=0.052$ ) and 5% higher utilization during year 3 ( $p=0.009$ ).

During years 1 and 2, individuals in the study population were less likely to have any annual visits to specific medical and surgical specialties, as demonstrated by relative risks less than 1.00 (Table 3). Compared to baseline, the adjusted relative risk of any cardiology visits was 12% lower during year 1 and 13% lower in year 2 ( $p<0.001$  for both). During each of the three years

following baseline, the relative risk of any gastroenterology visits was reduced by at least 12% ( $p<0.001$ ), and the relative risk of any consultative internal medicine visits was reduced by at least 30% ( $p<0.001$ ). The relative risk of any general surgery visits was 10% lower during year 2 ( $p=0.010$ ).

Individuals were more likely to visit some specialties in year 3, as demonstrated by relative risks greater than 1.00. During this year, the study population was 11% more likely to have any orthopedic surgery visits, 23% more likely to have any behavioral health visits and 24% more likely to have any neurology visits. The relative risk of any eye care visits was 4% lower than baseline during year 2, but 8% higher in year 3 ( $p<0.001$  for all).

The sensitivity analysis examining the potential impact of differential enrollment lengths during year 3 did not reveal any clear trends corresponding to higher or lower enrollment length (Table 4). Patients enrolled for 11 months during year 3 had an average of 5% fewer adjusted specialty visits, compared to year 0 ( $p=0.036$ ), but we observed no significant differences in average adjusted specialty visits between year 3 and year 0 in the other three enrollment strata.

#### **4.5 Discussion**

Results demonstrate how an increase in the volume of services delivered by primary care providers can influence specialty care utilization patterns. Implementation of the PCMH redesign at GH led to two years of small decreases in average adjusted specialty utilization in the full study population. In low morbidity patients this decrease was rapid and sustained, while high morbidity patients had increased adjusted specialty utilization during the two post-implementation years.

Decreased relative risks of cardiology and consultative internal medicine visits in the years during and after PCMH implementation support the notion that more hypertension care was delivered through PCMH-based primary care. Though we are unable to definitively identify new clinical tasks that primary care teams conducted as a result of the PCMH redesign, these two specialties are where GH patients most often receive care for hypertensive-related complications and medical comorbidities. Observed increases in the relative risks of year 3 visits—compared to year 0—to selected specialties, including eye care and orthopedic surgery, may represent an attenuation of the PCMH redesign’s impact over time.

Observed variation across morbidity groups reflects primary care providers’ need to refer highly complex patients to specialty care. Reduced specialty utilization in the low morbidity group probably occurred because some of these patients’ needs were within the scope of primary care practice, and because the PCMH redesign gave primary care teams additional time and resources to deliver care.<sup>18</sup> High morbidity patients, on the other hand, have hypertension and other comorbid conditions; these patients need to receive care and co-management from both primary care providers and specialists.<sup>10</sup> Our findings suggest that future iterations of the PCMH will require tighter links between primary care teams and specialists to optimize care for high morbidity patients.

This study has several limitations. The integrated delivery system under study differs from the majority of American care settings, both with regard to financing mechanisms and the ways in which primary care providers can coordinate and co-manage patient care with specialists employed by the same large organization. We were unable to collect data on whether individual specialty visits were due to patient self-referral or provider referral (though provider referrals are required for consultative internal medicine visits), and limitations in data collection precluded

our ability to study some specialties. Results in this patient population with hypertension may not be generalizable to populations with different types of health care conditions or different distributions of morbidity burden groups.

Further limitations include the large number of statistical tests conducted in Poisson regression models, which increase the potential for type I error due to statistically significant but spurious findings. Although we annualized year 3 utilization rates (negative binomial regression models) and adjusted for exposure time using an offset term (Poisson regression models) to account for truncation of data collection after December 2011, these statistical approaches may not have fully compensated for this limitation in data collection. Sensitivity analysis findings, however, did not suggest any clear links between year 3 enrollment length and adjusted specialty care utilization rates. “The Great Recession” of 2007-09<sup>37</sup> also could have contributed to observed decreases in specialty utilization, though a review of monthly mean specialty utilization during the two years preceding GH’s system-wide PCMH redesign revealed no noteworthy changes following the starts of the economic contraction (December 2007) or the financial crisis (September 2008).

This study expands the scope of the PCMH research agenda and increases our understanding of the ways that comprehensive primary care impacts patterns of specialty care use. Redesigning care to the PCMH can enable primary care teams to more thoroughly address conditions within the scope of their practice, leading to fewer specialty visits for less complex patients. Continued high rates of referrals for more complex patients require primary care teams to effectively coordinate care across settings and over time. Future research is needed to develop and test refinements to the PCMH in which tight links between primary care teams and specialists allow these providers to jointly deliver care to high morbidity, clinically complex patients.

## 4.6 References

1. American Academy of Family Physicians, American Academy of Pediatrics, American College of Physicians, American Osteopathic Association. Joint principles of the patient-centered medical home. 2007; <http://www.pcpcc.net/content/joint-principles-patient-centered-medical-home>. Accessed October 15, 2012.
2. Berenson RA, Hammons T, Gans DN, et al. A house is not a home: keeping patients at the center of practice redesign. *Health Aff (Millwood)*. Sep-Oct 2008;27(5):1219-1230.
3. Peikes D, Zutshi A, Genevro J, Smith K, Parchman M, Meyers D. *Early Evidence on the Patient-Centered Medical Home*. AHRQ Publication No. 12-0020-EF. Rockville, MD: Agency for Healthcare Research and Quality; 2012.
4. Williams JW, Jackson GL, Powers BJ, et al. *The Patient-Centered Medical Home. Closing the Quality Gap: Revisiting the State of the Science. Evidence Report No. 208*. AHRQ Publication No. 12-E008-EF. Rockville, MD: Agency for Healthcare Research and Quality; 2012.
5. Rittenhouse DR, Thom DH, Schmittiel JA. Developing a policy-relevant research agenda for the patient-centered medical home: a focus on outcomes. *J Gen Intern Med*. Jun 2010;25(6):593-600.
6. Rosenthal MB, Beckman HB, Forrest DD, Huang ES, Landon BE, Lewis S. Will the patient-centered medical home improve efficiency and reduce costs of care? A measurement and research agenda. *Med Care Res Rev*. Aug 2010;67(4):476-484.
7. Hollingsworth JM, Saint S, Hayward RA, Rogers MA, Zhang L, Miller DC. Specialty care and the patient-centered medical home. *Med Care*. Jan 2011;49(1):4-9.
8. Reid RJ, Fishman PA, Yu O, et al. Patient-centered medical home demonstration: a prospective, quasi-experimental, before and after evaluation. *Am J Manag Care*. Sep 2009;15(9):e71-87.
9. Fisher ES. Building a medical neighborhood for the medical home. *N Engl J Med*. Sep 18 2008;359(12):1202-1205.
10. Forrest CB. A typology of specialists' clinical roles. *Arch Intern Med*. Jun 8 2009;169(11):1062-1068.
11. Starfield B, Lemke KW, Bernhardt T, Foldes SS, Forrest CB, Weiner JP. Comorbidity: implications for the importance of primary care in 'case' management. *Ann Fam Med*. May-Jun 2003;1(1):8-14.
12. Starfield B, Lemke KW, Herbert R, Pavlovich WD, Anderson G. Comorbidity and the use of primary care and specialist care in the elderly. *Ann Fam Med*. May-Jun 2005;3(3):215-222.

13. Roos NP, Carriere KC, Friesen D. Factors influencing the frequency of visits by hypertensive patients to primary care physicians in Winnipeg. *CMAJ*. Oct 6 1998;159(7):777-783.
14. Liss DT, Fishman PA, Rutter CM, et al. Outcomes among chronically ill adults in a medical home prototype. *Under Review: American Journal of Managed Care*.
15. Liss DT, Reid RJ, Grembowski D, Rutter CM, Ross TR, Fishman PA. Do secure message and phone encounters substitute or complement office visits in the medical home? *Under Review: Health Services Research*.
16. Starfield B. Point: the changing nature of disease: implications for health services. *Medical Care*. Nov 2011;49(11):971-972.
17. Forrest CB, Reid RJ. Prevalence of health problems and primary care physicians' specialty referral decisions. *J Fam Pract*. May 2001;50(5):427-432.
18. Hsu C, Coleman K, Ross TR, et al. Spreading a patient-centered medical home redesign: a case study. *The Journal of ambulatory care management*. Apr 2012;35(2):99-108.
19. Reid RJ, Coleman K, Johnson EA, et al. The group health medical home at year two: cost savings, higher patient satisfaction, and less burnout for providers. *Health Aff (Millwood)*. May 2010;29(5):835-843.
20. Fishman PA, Johnson EA, Coleman K, et al. Impact on seniors of the Patient Centered Medical Home: Evidence from a pilot project. *The Gerontologist*. 2012.
21. Grembowski DE, Cook K, Patrick DL, Roussel AE. Managed care and physician referral. *Medical care research and review*. Mar 1998;55(1):3-31.
22. Shadish WR, Cook TD, Campbell DT. *Experimental and Quasi-Experimental Designs for Generalized Causal Inference*. Boston: Houghton Mifflin; 2002.
23. Reid RJ, Johnson EA, Hsu C, et al. Spreading a PCMH redesign: Effects on emergency room use and hospital admissions. *Under Review: Annals of Family Medicine*.
24. Bullano MF, Kamat S, Willey VJ, Barlas S, Watson DJ, Brenneman SK. Agreement between administrative claims and the medical record in identifying patients with a diagnosis of hypertension. *Medical Care*. May 2006;44(5):486-490.
25. Andrade SE, Davis RL, Cheetham TC, et al. Medication exposure in pregnancy risk evaluation program. *Matern Child Health J*. Oct 2012;16(7):1349-1354.
26. Sibai BM. Diagnosis and management of chronic hypertension in pregnancy. *Obstetrics and gynecology*. Sep 1991;78(3 Pt 1):451-461.
27. Carrell D, Ralston J. Messages, strands and threads: measuring use of electronic patient-provider messaging. *AMIA Annu Symp Proc*. 2005:913.

28. Google Maps. <https://maps.google.com/>. Accessed September 1, 2012.
29. Krieger N. Overcoming the absence of socioeconomic data in medical records: validation and application of a census-based methodology. *Am J Public Health*. May 1992;82(5):703-710.
30. *The Johns Hopkins ACG System: Technical Reference Guide, Version 10.0*. Baltimore, MD: Johns Hopkins University; 2011.
31. Forrest CB, Nutting PA, Starfield B, von Schrader S. Family physicians' referral decisions: results from the ASPN referral study. *J Fam Pract*. Mar 2002;51(3):215-222.
32. Ralston JD, Martin DP, Anderson ML, et al. Group health cooperative's transformation toward patient-centered access. *Med Care Res Rev*. Dec 2009;66(6):703-724.
33. Gardner W, Mulvey EP, Shaw EC. Regression analyses of counts and rates: Poisson, overdispersed Poisson, and negative binomial models. *Psychol Bull*. Nov 1995;118(3):392-404.
34. Zou G. A modified poisson regression approach to prospective studies with binary data. *Am J Epidemiol*. Apr 1 2004;159(7):702-706.
35. Zou GY, Donner A. Extension of the modified Poisson regression model to prospective studies with correlated binary data. *Stat Methods Med Res*. Nov 8 2011.
36. Diggle P, Heagerty P, Liang K, Zeger S. *Analysis of Longitudinal Data*. 2nd ed. Norfolk, UK: Oxford University Press; 2002.
37. Rockford Register Star. Key dates of the Great Recession. 2012; <http://www.rrstar.com/x417563916/Key-dates-of-the-Great-Recession>. Accessed October 27, 2012.

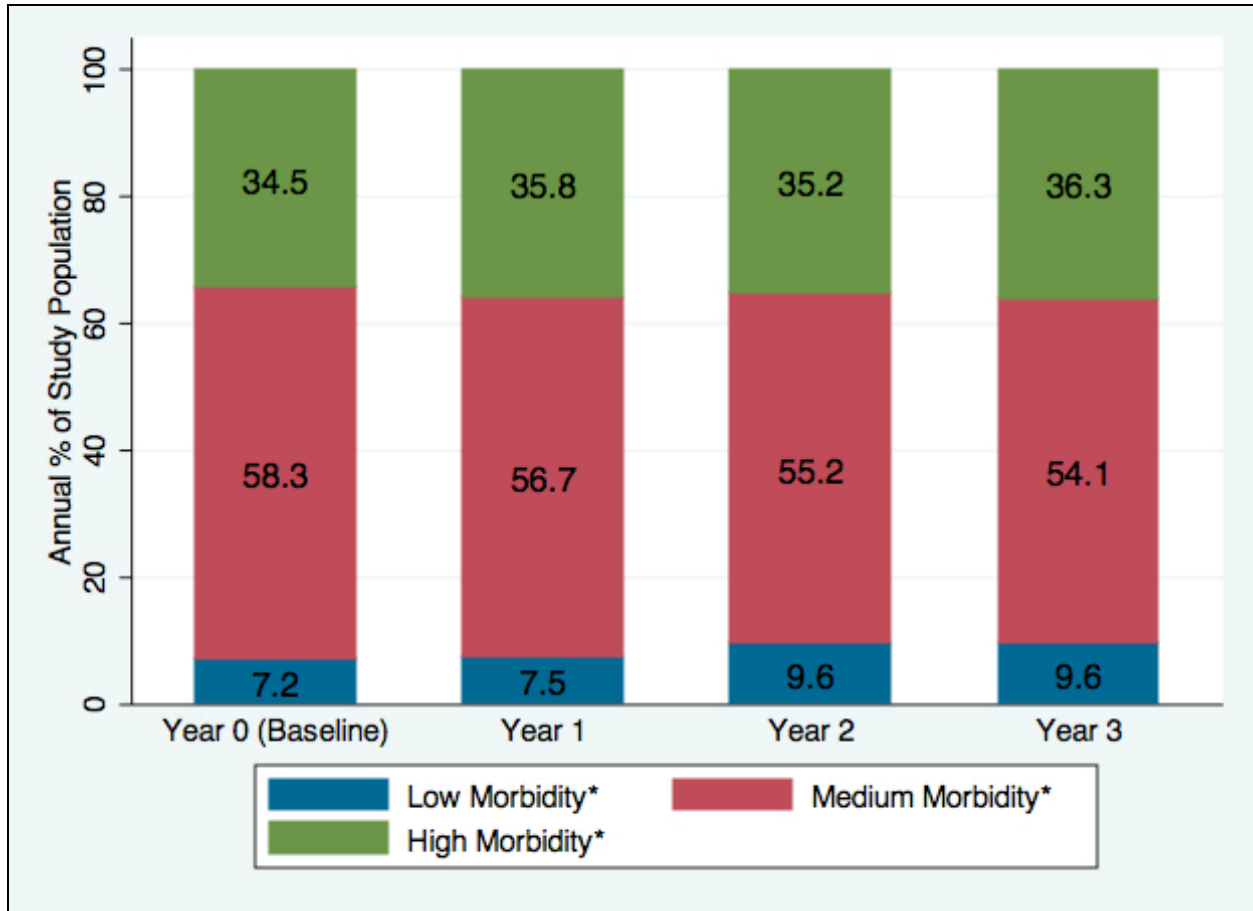
**Table 4.1:** Population Characteristics at the Beginning of Group Health’s PCMH Redesign

POPULATION CHARACTERISTICS, n (%)	Total, N (%)	Morbidity Burden Group		
		Low*	Medium*	High*
<i>N (%)</i>	36805	2770 (7)	20871 (57)	13164 (36)
Age, mean (SD)	64.2 (11.9)	58.0 (11.1)	62.8 (11.6)	67.8 (11.5)
Age group				
18 - 44	1831 (5)	284 (10)	1175 (6)	372 (3)
45 - 54	5966 (16)	722 (26)	3824 (18)	1420 (11)
55 - 64	11173 (30)	1066 (39)	6926 (33)	3181 (24)
65 - 74	9176 (25)	469 (17)	4998 (24)	3709 (28)
75 - 85	8659 (24)	229 (8)	3948 (19)	4482 (34)
Female Sex	20294 (55)	1321 (48)	11600 (56)	7373 (56)
Insurance Segment				
Commercial	17975 (49)	2040 (74)	11478 (55)	4457 (34)
Medicaid/State-subsidized	474 (1)	51 (2)	308 (1)	115 (1)
Medicare	18356 (50)	679 (24)	9085 (44)	8592 (65)
HMO Provider Network	33565 (91)	2393 (86)	18816 (90)	12356 (94)
Well-Care Waiver	29730 (81)	2160 (78)	16746 (80)	10824 (82)
Pharmaceutical Coverage	32806 (89)	2493 (90)	18706 (90)	11607 (88)
Diabetes (Type 1 or 2)	10462 (28)	0 (0)	5720 (27)	4742 (36)
Census Tract Education				
Low	13089 (36)	974 (35)	7517 (36)	4598 (35)
Medium	11786 (32)	877 (32)	6576 (32)	4333 (33)
High	11930 (32)	919 (33)	6778 (32)	4233 (32)
Census Tract Income				
≤ \$50,000	10696 (29)	789 (28)	6096 (29)	3811 (29)
\$50,001 - \$60,000	9228 (25)	694 (25)	5190 (25)	3344 (25)
\$60,001 - \$70,000	7386 (20)	540 (20)	4236 (20)	2610 (20)
> \$70,000	9495 (26)	747 (27)	5349 (26)	3399 (26)
Proximity to Specialty Care				
Co-located with primary care	13400 (36)	1012 (37)	7631 (37)	4757 (36)
Near (<15 miles by car)	16506 (45)	1276 (46)	9479 (45)	5751 (44)
Distant (>15 miles by car)	6899 (19)	482 (17)	3761 (18)	2656 (20)

Abbreviations: PCMH, patient-centered medical home; SD, standard deviation; ACG, Adjusted Clinical Groups; RUB, Resource Utilization Band; HMO, health maintenance organization

\* Time-varying morbidity burden defined by annual ACG RUB value: Low morbidity, RUB=Low; Medium morbidity, RUB=Moderate; High morbidity, RUB=High/Very high

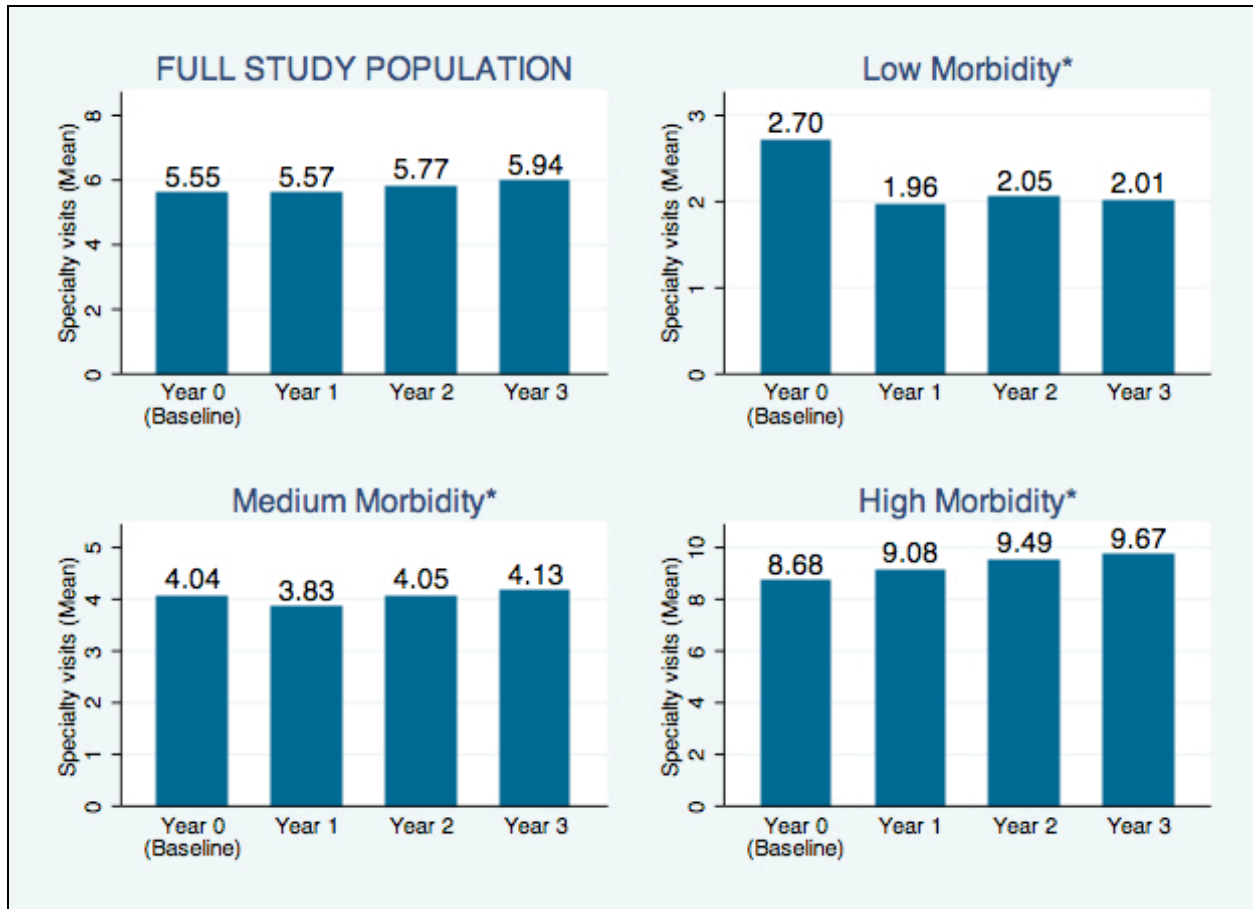
**Figure 4.1:** Proportion of the Study Population in Each ACG RUB Morbidity Burden Group During the Four Years Under Study



Abbreviations: ACG, Adjusted Clinical Groups; RUB, Resource Utilization Band

\* Time-varying morbidity burden defined by annual ACG RUB value: Low morbidity, RUB=Low; Medium morbidity, RUB=Moderate; High morbidity, RUB=High/Very high

**Figure 4.2:** Mean Unadjusted Annual Specialty Care Utilization For Full Study Population and Each ACG RUB Morbidity Burden Group



Abbreviations: ACG, Adjusted Clinical Groups; RUB, Resource Utilization Band

\* Time-varying morbidity burden defined by annual ACG RUB value: Low morbidity, RUB=Low; Medium morbidity, RUB=Moderate; High morbidity, RUB=High/Very high

**Table 4.2:** Results of Negative Binomial Regression Models Describing Adjusted Annual Differences in the Rate of Total Specialty Care Visits

Specialty Visits, Rate*	Year	Period	Adjusted Rate Ratio	95% CI	p Value
Full Study Population	0	Pre-PCMH Baseline <sup>‡</sup>	1.00	N/A	N/A
	1	PCMH Implementation	0.93	(0.91, 0.96)	<0.001
	2	Post-Implementation, Year 1	0.96	(0.94, 0.99)	0.020
	3	Post-Implementation, Year 2	0.98	(0.95, 1.01)	0.23
Specialty Visits, Rate**	Year	Period	Adjusted Rate Ratio	95% CI	p Value
Low Morbidity <sup>§</sup>	0	Pre-PCMH Baseline <sup>‡</sup>	1.00	N/A	N/A
	1	PCMH Implementation	0.72	(0.65, 0.78)	<0.001
	2	Post-Implementation, Year 1	0.73	(0.67, 0.80)	<0.001
	3	Post-Implementation, Year 2	0.72	(0.66, 0.80)	<0.001
Medium Morbidity <sup>§</sup>	0	Pre-PCMH Baseline <sup>‡</sup>	1.00	N/A	N/A
	1	PCMH Implementation	0.91	(0.88, 0.95)	<0.001
	2	Post-Implementation, Year 1	0.95	(0.92, 0.99)	0.007
	3	Post-Implementation, Year 2	0.97	(0.93, 1.01)	0.14
High Morbidity <sup>§</sup>	0	Pre-PCMH Baseline <sup>‡</sup>	1.00	N/A	N/A
	1	PCMH Implementation	1.00	(0.97, 1.04)	0.77
	2	Post-Implementation, Year 1	1.03	(1.00, 1.07)	0.052
	3	Post-Implementation, Year 2	1.05	(1.01, 1.09)	0.009

Abbreviations: PCMH, patient-centered medical home; ACG, Adjusted Clinical Groups; RUB, Resource Utilization Band; CI, confidence interval

\* Negative binomial regression model describing average annual differences in total specialty visit rates and adjusting for the following covariates: sex, age, morbidity burden, diabetes, insurance characteristics, census tract-level income, census tract-level education, calendar period

\*\* Linear combinations of coefficients from negative binomial regression model including morbidity group-by-year interactions and adjusting for covariates

§ Time-varying morbidity burden defined by annual ACG RUB value: Low morbidity, RUB=Low; Medium morbidity, RUB=Moderate; High morbidity, RUB=High/Very high

‡ Modeled referent category

**Table 4.3:** Results of Poisson Regression Models Describing Annual Relative Risks of Making Any Visits to Selected Medical and Surgical Specialties

Medical/Surgical Specialty**	Year 0: Pre-PCMH Baseline*	Year 1: PCMH Implementation		Year 2: Post-Implementation, Year 1		Year 3: Post-Implementation, Year 2	
	Any Visits, N (%)	Adjusted RR <sup>¶</sup>	95% CI <sup>¶</sup>	Adjusted RR <sup>¶</sup>	95% CI <sup>¶</sup>	Adjusted RR <sup>¶</sup>	95% CI <sup>¶</sup>
Eye Care	17991 (49)	1.02	(1.00, 1.05)	<b>0.96</b>	<b>(0.94, 0.98)</b>	<b>1.08</b>	<b>(1.06, 1.11)</b>
Cardiology	12461 (34)	<b>0.88</b>	<b>(0.85, 0.91)</b>	<b>0.87</b>	<b>(0.84, 0.89)</b>	0.99	(0.95, 1.02)
Orthopedic Surgery	6062 (16)	0.96	(0.92, 1.00)	0.96	(0.91, 1.01)	<b>1.11</b>	<b>(1.05, 1.17)</b>
Gastroenterology	5354 (15)	<b>0.88</b>	<b>(0.83, 0.93)</b>	<b>0.82</b>	<b>(0.77, 0.87)</b>	<b>0.86</b>	<b>(0.81, 0.93)</b>
Consultative Internal Medicine <sup>§</sup>	3578 (10)	<b>0.70</b>	<b>(0.64, 0.77)</b>	<b>0.56</b>	<b>(0.51, 0.62)</b>	<b>0.61</b>	<b>(0.54, 0.68)</b>
General Surgery	2932 (8)	0.95	(0.88, 1.02)	<b>0.90</b>	<b>(0.84, 0.98)</b>	1.01	(0.93, 1.10)
Behavioral Health	2666 (7)	1.02	(0.96, 1.08)	1.05	(0.98, 1.12)	<b>1.23</b>	<b>(1.14, 1.33)</b>
Urology	2626 (7)	0.98	(0.91, 1.05)	0.98	(0.91, 1.06)	1.04	(0.95, 1.13)
Neurology	2140 (6)	1.00	(0.91, 1.09)	1.06	(0.96, 1.16)	<b>1.24</b>	<b>(1.13, 1.37)</b>
Obstetrics/ Gynecology <sup>‡</sup>	1618 (8)	0.93	(0.85, 1.01)	0.98	(0.90, 1.08)	1.09	(0.98, 1.21)

Abbreviations: PCMH, patient-centered medical home; RR, relative risk; CI, confidence interval

<sup>¶</sup> Bolded cells in these columns indicate statistically significant results at p<0.05

\* Modeled referent category: relative risks presented for years 1, 2 and 3 are relative to year 0

\*\* Poisson regression models adjusted for exposure time, using an offset term representing the number of months enrolled during each patient-year, and adjusted for the following covariates: sex, age, morbidity burden, diabetes, insurance characteristics, census tract-level income, census tract-level education, calendar period

<sup>§</sup> Physician referral required to see providers in this specialty; <sup>‡</sup> Females only (n = 20294)

**Table 4.4:** Results of Sensitivity Analysis Describing Stratum-Specific Differences in Annualized Year 3 Rates of Total Specialty Care Visits, According to Number of Months Enrolled During Year 3

<b>Months Enrolled, Year 3</b>	<b>N, Year 3 (%)<sup>∞</sup></b>	<b>Annualized Year 3 Specialty Visits, Unadjusted Mean (SD)<sup>¶</sup></b>	<b>Adjusted Rate Ratio<sup>*‡</sup></b>	<b>95% CI<sup>**‡</sup></b>
<i>Full Study Population</i>	31016 (100)	5.94 (8.47)	0.98	(0.95, 1.01)
9	11300 (36)	5.91 (8.66)	0.98	(0.95, 1.02)
10	9060 (29)	6.26 (8.81)	1.01	(0.98, 1.05)
11	6414 (21)	5.37 (7.64)	0.95	(0.91, 1.00)**
12	4242 (14)	6.20 (8.36)	1.01	(0.95, 1.07)

Abbreviations: CI, confidence interval

<sup>∞</sup> Year 1 and year 2 data were included in sensitivity analysis, but results for these years are not presented in Table 4 because there was not differential enrollment across the study population during these years. Stratum-specific year 1 and year 2 results available from authors upon request.

<sup>¶</sup> Annualized year 3 specialty visit totals calculated by multiplying observed visit counts by (12/X), where X represents the number of months of enrollment

\* Adjusted rate ratios and confidence intervals from negative binomial regression models describing average annual differences in total specialty visit rates and adjusting for the following covariates: sex, age, morbidity burden, diabetes, insurance characteristics, census tract-level income, census tract-level education, calendar period

<sup>‡</sup> Adjusted year 3 rate ratios and confidence intervals are relative to year 0, the modeled referent category

\*\* p=0.036

**Appendix 4A: Prevalence of Health Care Conditions in Study Population, Based on ACG EDC Variables Collected at the End of the Pre-PCMH Baseline Year**

<b>MEDC</b>	<b>Common EDC Variables* In the Study Population (N=36805)</b>	<b>N (%)</b>
<i>Cardiovascular</i>	Hypertension, without major complications	29388 (80)
	Disorders of lipid metabolism	11552 (31)
	Ischemic heart disease (excluding acute myocardial infarction)	4835 (13)
	Cardiovascular signs & symptoms	4696 (13)
	Cardiac arrhythmia	4437 (12)
	Congestive heart failure	1901 (5)
<i>Administrative</i>	Preventive care	25887 (70)
	Administrative concerns & non-specific laboratory abnormalities	14864 (40)
	Surgical aftercare	9821 (27)
<i>Musculoskeletal</i>	Musculoskeletal signs & symptoms	12389 (34)
	Low back pain	8572 (23)
	Degenerative joint disease	5146 (14)
	Bursitis, synovitis, tenosynovitis	5083 (14)
	Acute sprains & strains	4497 (12)
	Cervical pain syndromes	3726 (10)
	Musculoskeletal disorders, other	3075 (8)
	Joint disorders, trauma related	2068 (6)
	Acquired foot deformities	1849 (5)
<i>Eye</i>	Refractive errors	12658 (34)
	Cataract, aphakia	8166 (22)
	Glaucoma	3523 (10)
	Disorders of the eyelid & lacrimal duct	2742 (7)
	Eye, other disorders	2383 (6)
	Ophthalmic signs & symptoms	2001 (5)
	Retinal disorders (excluding diabetic retinopathy)	1945 (5)
<i>Skin<sup>‡</sup></i>	Skin keratoses	4718 (13)
	Other skin disorders	3477 (9)
	Dermatitis & eczema	3280 (9)
	Benign neoplasm of skin & subcutaneous tissues	2617 (7)
	Contusions & abrasions	2531 (7)
	Dermatophytoses	2273 (6)
	Exanthems	1847 (5)
<i>Neurologic</i>	Peripheral neuropathy, neuritis	4969 (14)
	Sleep problems	2622 (7)
	Vertiginous syndromes	2586 (7)

	Neurologic signs & symptoms	2465 (7)
	Headaches	2014 (5)
<b><i>Endocrine<sup>‡</sup></i></b>	Type 2 diabetes, with complications	4624 (13)
	Type 2 diabetes, without complications	4491 (12)
	Hypothyroidism	2740 (7)
<b><i>Respiratory<sup>‡</sup></i></b>	Respiratory signs and symptoms	4732 (13)
	Acute lower respiratory tract infection	3840 (10)
	Cough	3825 (10)
	Sinusitis	2822 (8)
	Sleep apnea	2464 (7)
	Emphysema, chronic bronchitis, COPD	2298 (6)
<b><i>General signs &amp; symptoms</i></b>	Chest pain	4919 (13)
	Nonspecific signs & symptoms	3970 (11)
	Debility & undue fatigue	3175 (9)
	Edema	2110 (6)
<b><i>General Surgery</i></b>	Benign & unspecified neoplasm	4360 (12)
	Abdominal pain	3944 (11)
	Nonfungal infections of skin & subcutaneous tissue	2775 (8)
<b><i>Gastrointestinal/ Hepatic</i></b>	Gastroesophageal reflux	4535 (12)
	Gastrointestinal signs & symptoms	2987 (8)
	Gastroenteritis	2222 (6)
<b><i>Psychosocial</i></b>	Depression	4089 (11)
	Anxiety, neuroses	3366 (9)
	Tobacco use	2495 (7)
<b><i>Genitourinary</i></b>	Urinary symptoms	3812 (10)
	Urinary tract infections	2684 (7)
	Prostatic hypertrophy**	1396 (8)
	Other male genital disease**	1231 (7)
<b><i>Nutrition</i></b>	Obesity	4986 (14)
<b><i>Ear, Nose, Throat</i></b>	Acute upper respiratory tract infection	3641 (10)
<b><i>Renal</i></b>	Fluid & electrolyte disturbances	3092 (8)
	Chronic renal failure	1900 (5)
<b><i>Allergy</i></b>	Allergic rhinitis	2590 (7)
	Asthma, without status asthmaticus	2444 (7)
<b><i>Hematologic</i></b>	Iron deficiency, other deficiency anemias	2502 (7)

Abbreviations: ACG, Adjusted Clinical Groups; EDC, Expanded Diagnosis Cluster; MEDC, Major Expanded Diagnosis Cluster; COPD, chronic obstructive pulmonary disease

\* Table only contains EDC variables that were prevalent in 5% or more of the study population

\*\* Males only (n=16511)

‡ Limitations in classification of specialties by study databases prevented collection of data for dermatology, endocrinology and pulmonology visits

## CHAPTER 5. CONCLUSIONS

### 5.1 Introduction

In this dissertation, I investigated several outcomes in chronically ill individuals who received care at an integrated health care delivery system that undertook two sequential health care reforms. Chapter 2 examined multiple patient outcomes for patients with one or more of three common chronic illnesses—diabetes, hypertension and coronary heart disease—in Group Health’s 2007-08 prototype PCMH redesign, which took place at one non-randomly selected clinic. In subsequent chapters, I described outcomes observed among patients with diabetes (Chapter 3) and hypertension (Chapter 4) during and after the 2009-10 system-wide PCMH redesign in all 26 Group Health clinics. I conducted this research to address some of the many unanswered questions regarding the PCMH’s ability to improve quality, change utilization patterns and control health care costs in chronically ill individuals, particularly those with high morbidity burdens.<sup>1,2</sup>

This chapter is organized in the following fashion: sections 5.2 to 5.6 synthesize results of Chapters 2, 3 and 4, describe this dissertation’s contributions to the expanding PCMH evidence base, and how observed findings selectively demonstrate the ability—or inability—of the PCMH to meet the lofty goals espoused by some of this care model’s proponents.<sup>3,4</sup> Section 5.7 presents suggestions for future research and concluding remarks.

### 5.2 Redesigning And Improving Care

This dissertation provides multiple examples of Group Health’s successes in redesigning care structures and processes to align with the seven Joint Principles of the PCMH.<sup>5</sup> Chapter 3

presents data on changes in primary care use, highlighting the ways in which Group Health increased access to care teams by offering many forms of care, not just face-to-face visits.

Chapter 2 presented compelling evidence of the PCMH's ability to effectively deliver high-quality, whole-person care in a high-performing clinic. Over two years, we detected small increases in the quality of care, including mean lower mean HbA1c in PCMH patients with diabetes and lower LDL cholesterol in PCMH patients with coronary heart disease, compared to controls. Chronically ill individuals at the PCMH clinic also had 31% fewer emergency and urgent care contacts, 21% fewer ambulatory care-sensitive inpatient admissions and 7% fewer total inpatient admissions. These outcomes reveal particular benefits that patients with chronic illness can derive from coordinated and integrated PCMH-based care.

Chapter 4 examined Group Health's PCMH through a different lens. By assessing changes in specialty care utilization, and differences across morbidity burden groups, I presented quantitative evidence of primary care teams' ability to coordinate care across the "medical neighborhood"<sup>6</sup> with specialty care providers. Though decreases in specialty utilization were largely concentrated in low morbidity patients—who had at least 27% fewer adjusted specialty care visits during each year following pre-PCMH baseline—study results revealed 7% and 4% fewer adjusted specialty visits in the full study population during PCMH implementation and the following year, respectively.

I also observed decreased relative risks of cardiology and consultative internal medicine visits in the years during and after PCMH implementation. Although total annual specialty care utilization was unchanged or increased for high morbidity patients, these findings support the notion that more hypertension care was delivered through PCMH-based primary care.

### 5.3 Changing Health Care Utilization Patterns

Each study in this dissertation demonstrates how a PCMH redesign can lead to changes in health care use and utilization, both in primary care and other care settings. In Chapter 2, patients at Group Health’s PCMH prototype clinic had 94% more secure messaging threads, 17% more telephone encounters and 6% fewer in-person primary care contacts than controls. Concurrent reductions in downstream utilization at the PCMH site suggest that the pilot redesign succeeded in helping chronically ill individuals avoid what Ed Wagner has described as an “expensive and potentially dangerous spiral”<sup>7</sup> caused by deficiencies such as discontinuity of care attributable to a lack of care coordination.

Chapter 3 presents an in-depth account of changes in primary care use, and the interplay between primary care modalities, among patients with diabetes in Group Health’s system-wide PCMH redesign. Although observed changes in primary care use reflect patients’ enhanced access to care and providers’ delivery of recommended care,<sup>8</sup> we found that secure messaging and phone encounters served as complements—rather than substitutes—to primary care office visits in this setting. These results demonstrate that an increase in the degree to which care was patient-centered resulted in additional work for primary care providers; namely, patients’ increased use of new care modalities was associated with increased demand for in-person visits.

Chapter 4 demonstrates the ways that specialty care utilization changed for chronically ill individuals in the PCMH. Provision of more comprehensive primary care led to small decreases in adjusted annual specialty visit rates during years 1 and 2, largely driven by reductions in specialty care utilization among less complex patients. Lower relative risks of any Cardiology visits during PCMH implementation and the first post-implementation year may signify primary care teams’ delivery of additional hypertension care, or that proactive care delivery in the PCMH

reduced patients' need to obtain specialty care for uncontrolled hypertension or complications of hypertension.

Chapter 4 also demonstrates that comprehensive evaluations of primary care redesigns for chronically ill individuals should include a thorough investigation of care utilization in specialty care settings. Though prior PCMH evaluations have largely focused on emergency and inpatient utilization,<sup>4,9</sup> Chapter 4's findings of reductions in cardiology and consultative internal medicine utilization among patients with treated hypertension suggest that changes in primary care structures and processes can enable primary care providers to deliver more chronic illness care, particularly to patients with few comorbidities or low-to-medium overall morbidity burden. Future studies should build on these findings by examining changes in both primary care and specialty care utilization patterns for populations of patients with common index conditions.

#### **5.4 Simultaneously Improving Quality And Reducing Costs**

Chapter 2 proves that dramatic improvements in outpatient clinical quality are not a necessary precursor to achieving health care cost reductions in chronically ill individuals. Improvements in clinical processes and outcomes for diabetes and coronary heart disease were quite small in magnitude, a finding consistent with modestly increased quality observed in other PCMH settings.<sup>10</sup> Although observed increases in quality may not have been clinically significant, they were accompanied by 7% lower total health care costs among patients at the PCMH clinic over 21 months, largely driven by lower costs for inpatient care and emergency/urgent care.

As represented by the conceptual framework in Figure 1.1, cost savings due to reduced downstream care were presumably due to an alignment of structures and processes at the PCMH

clinic that allowed for effective provision of longitudinal PCMH-based care. Although we are unable to definitively identify individual elements of the multicomponent redesign that were responsible for observed results, the chronic care model<sup>11</sup> leads us to believe that observed impacts may have been attributable to redesign components such as enhanced care team staffing, pairing longer office visits with promotion of increased secure messaging and phone encounter use, and effective outreach for patients' chronic and acute needs.

### **5.5 Variation in Medical Home Impacts: Morbidity Burden and Selection Issues**

Chapter 4's study of changes in specialty care utilization in the system-wide PCMH redesign identified substantial differences across morbidity burden groups. Stratification of the study population into three morbidity burden groups—based on annual values of the ACG software's RUB measure<sup>12</sup>—allowed us to detect at least 27% fewer specialty care visits in low morbidity patients during and after PCMH implementation. Medium morbidity patients had lower specialty care utilization during years 1 and 2, while high morbidity patients had 5% higher specialty utilization during year 3.

These findings tell us much about the variability of changes in specialty care utilization induced by Group Health's PCMH redesign. Patients with hypertension and low morbidity experienced a rapid and lasting decrease in specialty visits, probably due to enhancements in primary care teams' ability to take on new care tasks for patients whose clinical needs were not particularly complex. Results suggest that more comprehensive primary care in the PCMH can impact outpatient specialty utilization patterns, and that care for high morbidity, clinically complex patients in the PCMH requires tight links between primary care teams and specialists.

Chapter 2 provides evidence of the capacity of a population-based PCMH redesign to decrease downstream utilization and reduce total health care costs in patients with common chronic illnesses. Results, however, may represent a best-case scenario with regard to motivation of clinical staff and availability of organizational resources. Group Health's PCMH prototype clinic had a successful history of quality improvement compared to other clinics at Group Health, demonstrating a potential lack of generalizability due to non-random selection. A subsequent analysis of the full patient population in the system-wide PCMH redesign<sup>13</sup> did not reveal a reduction in inpatient admissions, highlighting the challenges of replicating findings from the single prototype site in the entire 26-clinic system.

The patient population at the PCMH prototype clinic also differed from those of other Group Health clinics. Compared to patients at control clinics, chronically ill individuals under study in Chapter 2 were older and had fewer of the three included chronic illnesses. These and other unmeasured characteristics may have allowed these individuals to accrue particular benefits in the prototype redesign. Multivariable regression analyses did not include socioeconomic and racial/ethnic covariates, limiting the extent to which we were able to control for potential confounding.

## **5.6 Business Case For The Medical Home**

This dissertation identifies selected patient populations and care settings in which the PCMH is associated with reductions in costly forms of health care. Cost savings observed in Chapter 2 translate to approximately \$49 per patient per month savings in this study population, which is noteworthy given the general lack of evidence of cost savings in other PCMH redesigns.<sup>4,9</sup>

Chapter 4 advances the PCMH evidence base through its identification of a patient subgroup whose clinical needs, though not complex, are especially amenable to potential reductions in health care utilization, and associated costs, in the outpatient specialty care setting. Although low morbidity patients comprised no more than 10% of the study population in any year, they experienced dramatic reductions in specialty visits. Chapter 4 is also noteworthy because, to the best of my knowledge, it represents the first study where a relatively low-risk patient group—albeit a chronically ill one—experienced reduced health care utilization in a PCMH redesign.

Observed or potential cost savings in chronically ill patients, however, must be weighed against potential increases in costs incurred for care redesigns in full patient populations, both at the prototype clinic and throughout Group Health. Despite Chapter 2 findings, Reid et al. demonstrated overall cost neutrality of Group Health’s PCMH prototype redesign in the full prototype clinic population.<sup>14</sup> In Chapter 4, reductions in specialty visits among low morbidity patients were offset by increased specialty utilization in high morbidity patients during year 3.

These results highlight the tensions inherent to efforts to decrease costs while increasing the quality and patient-centeredness of health care delivery. While it is well known that the U.S. health care system is characterized by waste<sup>15</sup> and low value attributable to under-reliance on primary care,<sup>16</sup> the financial resources required to redesign primary care to the PCMH may not be recouped through savings in other settings, particularly over a short time horizon.

## **5.7 Opportunities For Future Research & Conclusions**

By incrementally improving our understanding of the PCMH’s impacts on costs, quality and health care use in chronically ill patients, this dissertation has produced findings that can be applied in the planning, implementation and evaluation of future PCMH redesigns.

Modest improvements in care quality observed in Chapter 2 suggest that additional efforts, such as interventions incorporating treat-to-target protocols,<sup>17,18</sup> may be required to achieve clinically meaningful changes in chronic care quality. Chapter 3 points to several future directions for research on new care modalities in the PCMH. Since our results indicate that secure electronic messaging and telephone encounters did not substitute for primary care office visits, future studies can investigate whether secure messaging or phone use led to observed reductions in downstream care at Group Health.<sup>13,14</sup> Researchers should also examine whether relatively healthy patients use secure messaging and phone encounters in similar, or different, ways than patients with diabetes. Secure messages and phone encounters may ultimately be found to substitute for office visits for particular diagnoses or clinical scenarios, given that these new care modalities have successfully been incorporated in follow-up care<sup>19</sup> and chronic illness self-management.<sup>20,21</sup>

Chapter 4 findings present several opportunities for future research, and highlight the need for future evaluations to examine changes in specialty care utilization patterns—in addition to changes in emergency and inpatient utilization—for chronically ill individuals. Qualitative, as well as quantitative, evaluations can shed light on the ways that primary care teams may have assumed new patient care responsibilities, offering insights to other organizations and individuals interested in spreading observed reductions to higher morbidity groups. Efforts to investigate the root causes of Chapter 4 findings in high morbidity patients can increase our understanding of potentially overlapping forces, such as the PCMH redesign's creation of opportunities to address previously unmet needs or primary care teams' inability to address complex clinical issues in the absence of advice from specialists.

Chapter 2 findings add to prior evaluations<sup>14,22</sup> of Group Health’s PCMH prototype redesign, and demonstrate that the potential benefits of this care delivery model—such as simultaneously higher quality and lower costs—may differentially accrue to chronically ill individuals. Chapter 3 makes a valuable contribution to the evidence base on new modes of patient-provider communication, and how the use of patient-centered care modalities in the PCMH can impact demand for primary care office visits in the chronically ill. Chapter 4 demonstrates how PCMH redesigns can impact care delivery in the “medical neighborhood,”<sup>6</sup> and that overall morbidity burden can serve as an important predictor of outcomes among patients with chronic illness in the PCMH.

Findings from this dissertation are selectively concordant with those of other recent PCMH evaluations,<sup>4,9</sup> which have observed incremental benefits to patients, providers and payers associated with this new model of primary care delivery. This dissertation also, however, makes new and important contributions to the evidence base regarding the PCMH’s impacts on chronically ill patients. It is my hope that the individual parts and collective whole of this dissertation will aid the work of those who seek to improve the quality, value and performance of the American health care system through patient-centered primary care redesign.

## 5.8 References

1. Thorpe KE, Howard DH. The rise in spending among Medicare beneficiaries: the role of chronic disease prevalence and changes in treatment intensity. *Health Aff (Millwood)*. Sep-Oct 2006;25(5):w378-388.
2. Naessens JM, Stroebel RJ, Finnie DM, et al. Effect of multiple chronic conditions among working-age adults. *Am J Manag Care*. Feb 2011;17(2):118-122.
3. Berenson RA, Hammons T, Gans DN, et al. A house is not a home: keeping patients at the center of practice redesign. *Health Aff (Millwood)*. Sep-Oct 2008;27(5):1219-1230.
4. Peikes D, Zutshi A, Genevro J, Smith K, Parchman M, Meyers D. *Early Evidence on the Patient-Centered Medical Home*. AHRQ Publication No. 12-0020-EF. Rockville, MD: Agency for Healthcare Research and Quality; 2012.
5. American Academy of Family Physicians, American Academy of Pediatrics, American College of Physicians, American Osteopathic Association. Joint principles of the patient-centered medical home. 2007; <http://www.pcpcc.net/content/joint-principles-patient-centered-medical-home>. Accessed October 15, 2012.
6. Fisher ES. Building a medical neighborhood for the medical home. *N Engl J Med*. Sep 18 2008;359(12):1202-1205.
7. Wagner EH, Coleman K, Reid RJ, Phillips K, Abrams MK, Sugarman JR. The changes involved in patient-centered medical home transformation. *Prim Care*. Jun 2012;39(2):241-259.
8. Brown RS, Peikes D, Peterson G, Schore J, Razafindrakoto CM. Six features of medicare coordinated care demonstration programs that cut hospital admissions of high-risk patients. *Health affairs*. Jun 2012;31(6):1156-1166.
9. Williams JW, Jackson GL, Powers BJ, et al. *The Patient-Centered Medical Home. Closing the Quality Gap: Revisiting the State of the Science. Evidence Report No. 208*. AHRQ Publication No. 12-E008-EF. Rockville, MD: Agency for Healthcare Research and Quality; 2012.
10. Solberg LI, Asche SE, Fontaine P, Flottemesch TJ, Anderson LH. Trends in quality during medical home transformation. *Annals of Family Medicine*. Nov-Dec 2011;9(6):515-521.
11. Wagner EH. Chronic disease management: what will it take to improve care for chronic illness? *Eff Clin Pract*. Aug-Sep 1998;1(1):2-4.
12. *The Johns Hopkins ACG System: Technical Reference Guide, Version 10.0*. Baltimore, MD: Johns Hopkins University; 2011.
13. Reid RJ, Johnson EA, Hsu C, et al. Spreading a PCMH redesign: Effects on emergency room use and hospital admissions. *Under Review: Annals of Family Medicine*.

14. Reid RJ, Coleman K, Johnson EA, et al. The group health medical home at year two: cost savings, higher patient satisfaction, and less burnout for providers. *Health Aff (Millwood)*. May 2010;29(5):835-843.
15. Berwick DM, Hackbarth AD. Eliminating waste in US health care. *JAMA*. Apr 11 2012;307(14):1513-1516.
16. Macinko J, Starfield B, Shi L. The contribution of primary care systems to health outcomes within Organization for Economic Cooperation and Development (OECD) countries, 1970-1998. *Health Services Research*. Jun 2003;38(3):831-865.
17. Katon WJ, Lin EH, Von Korff M, et al. Collaborative care for patients with depression and chronic illnesses. *N Engl J Med*. Dec 30 2010;363(27):2611-2620.
18. Riddle MC, Rosenstock J, Gerich J. The treat-to-target trial: randomized addition of glargine or human NPH insulin to oral therapy of type 2 diabetic patients. *Diabetes Care*. Nov 2003;26(11):3080-3086.
19. Wasson J, Gaudette C, Whaley F, Sauvigne A, Baribeau P, Welch HG. Telephone care as a substitute for routine clinic follow-up. *JAMA*. Apr 1 1992;267(13):1788-1793.
20. Green BB, Cook AJ, Ralston JD, et al. Effectiveness of home blood pressure monitoring, Web communication, and pharmacist care on hypertension control: a randomized controlled trial. *JAMA*. Jun 25 2008;299(24):2857-2867.
21. Ralston JD, Hirsch IB, Hoath J, Mullen M, Cheadle A, Goldberg HI. Web-based collaborative care for type 2 diabetes: a pilot randomized trial. *Diabetes Care*. Feb 2009;32(2):234-239.
22. Fishman PA, Johnson EA, Coleman K, et al. Impact on seniors of the Patient Centered Medical Home: Evidence from a pilot project. *The Gerontologist*. 2012.

## BIBLIOGRAPHY

American Academy of Family Physicians, American Academy of Pediatrics, American College of Physicians, American Osteopathic Association. 2007. "Joint principles of the patient-centered medical home" [accessed on October 15, 2012]. Available at:

<http://www.pcpcc.net/content/joint-principles-patient-centered-medical-home>.

American Academy of Pediatrics, Council on Pediatric Practice. 1967. "Pediatric Records and a "medical home"." In *Standards of Child Care*. Evanston, IL: American Academy of Pediatrics.

Andrade, S. E., R. L. Davis, T. C. Cheetham, W. O. Cooper, D. K. Li, T. Amini, S. J. Beaton, S. Dublin, T. A. Hammad, P. A. Pawloski, M. A. Raebel, D. H. Smith, J. A. Staffa, S. Toh, I. Dashevsky, K. Haffenreffer, K. Lane, R. Platt, and P. E. Scott. 2012. "Medication exposure in pregnancy risk evaluation program." *Maternal and child health journal* 16(7): 1349-54.

Berenson, R. A., T. Hammons, D. N. Gans, S. Zuckerman, K. Merrell, W. S. Underwood, and A. F. Williams. 2008. "A house is not a home: keeping patients at the center of practice redesign." *Health Aff (Millwood)* 27(5): 1219-30.

Bergmo, T. S., P. E. Kummervold, D. Gammon, and L. B. Dahl. 2005. "Electronic patient-provider communication: will it offset office visits and telephone consultations in primary care?" *International journal of medical informatics* 74(9): 705-10.

Berwick, D. M. and A. D. Hackbarth. 2012. "Eliminating waste in US health care." *JAMA* 307(14): 1513-6.

Berwick, D. M., T. W. Nolan, and J. Whittington. 2008. "The triple aim: care, health, and cost." *Health affairs* 27(3): 759-69.

Bindman, A. B., K. Grumbach, D. Osmond, M. Komaromy, K. Vranizan, N. Lurie, J. Billings, and A. Stewart. 1995. "Preventable hospitalizations and access to health care." *JAMA* 274(4): 305-11.

Blue Cross Blue Shield of Michigan. 2011. "Physician Group Incentive Program Basics" [accessed on March 16, 2011]. Available at:

[http://www.bcbsm.com/provider/value\\_partnerships/pgip/](http://www.bcbsm.com/provider/value_partnerships/pgip/).

Bodenheimer, T., E. H. Wagner, and K. Grumbach. 2002a. "Improving primary care for patients with chronic illness." *JAMA* 288(14): 1775-9.

Bodenheimer, T., E. H. Wagner, and K. Grumbach. 2002b. "Improving primary care for patients with chronic illness: the chronic care model, Part 2." *JAMA* 288(15): 1909-14.

Boudreau, D. M., M. P. Doescher, B. G. Saver, J. E. Jackson, and P. A. Fishman. 2005. "Reliability of Group Health Cooperative automated pharmacy data by drug benefit status." *Pharmacoepidemiol Drug Saf* 14(12): 877-84.

- Brown, R. S., D. Peikes, G. Peterson, J. Schore, and C. M. Razafindrakoto. 2012. "Six features of medicare coordinated care demonstration programs that cut hospital admissions of high-risk patients." *Health affairs* 31(6): 1156-66.
- Bullano, M. F., S. Kamat, V. J. Willey, S. Barlas, D. J. Watson, and S. K. Brennehan. 2006. "Agreement between administrative claims and the medical record in identifying patients with a diagnosis of hypertension." *Medical Care* 44(5): 486-90.
- Buntin, M. B., M. F. Burke, M. C. Hoaglin, and D. Blumenthal. 2011. "The benefits of health information technology: a review of the recent literature shows predominantly positive results." *Health affairs* 30(3): 464-71.
- Car, J. and A. Sheikh. 2003. "Telephone consultations." *BMJ* 326(7396): 966-9.
- Car, J. and A. Sheikh. 2004. "Email consultations in health care: 1--Scope and effectiveness." *BMJ* 329(7463): 435-8.
- Carrell, D. and J. Ralston. 2005. "Messages, strands and threads: measuring use of electronic patient-provider messaging." *AMIA Annu Symp Proc*: 913.
- Center for Medicare and Medicaid Innovation. 2011. "Catalog of Federal PCMH Activities as of June 2011" [accessed on March 16, 2011]. Available at: [http://pcmh.ahrq.gov/portal/server.pt/community/pcmh\\_home/1483/pcmh\\_federal\\_pcmh\\_activities\\_v2](http://pcmh.ahrq.gov/portal/server.pt/community/pcmh_home/1483/pcmh_federal_pcmh_activities_v2).
- Chassin, M. R. and R. W. Galvin. 1998. "The urgent need to improve health care quality. Institute of Medicine National Roundtable on Health Care Quality." *JAMA* 280(11): 1000-5.
- Clancy, C. 2008. "Chronic Conditions 101. Rising Rates of Chronic Conditions: What Can Be Done?" Washington, DC: Agency for Healthcare Research and Quality; July 31, 2008.
- Coleman, K., B. T. Austin, C. Brach, and E. H. Wagner. 2009. "Evidence on the Chronic Care Model in the new millennium." *Health Aff (Millwood)* 28(1): 75-85.
- Crabtree, B. F., P. A. Nutting, W. L. Miller, K. C. Stange, E. E. Stewart, and C. R. Jaen. 2010. "Summary of the National Demonstration Project and recommendations for the patient-centered medical home." *Ann Fam Med* 8 Suppl 1: S80-90; S92.
- Crossing the Quality Chasm: A New Health System for the Twenty-First Century*. 2001. Washington, DC: Institute of Medicine.
- Decker, S. L., S. M. Schappert, and J. E. Sisk. 2009. "Use of medical care for chronic conditions." *Health Aff (Millwood)* 28(1): 26-35.
- Dentzer, S. 2012. "One Payer's Attempt To Spur Primary Care Doctors To Form New Medical Homes." *Health Aff (Millwood)* 31(2): 341-49.

Diggle, P., P. Heagerty, K. Liang, and S. Zeger. 2002. *Analysis of Longitudinal Data*. Norfolk, UK: Oxford University Press.

Donabedian, A. 1980a. "Basic Approaches to Assessment: Structure, Process, and Outcome." In *Explorations in quality assessment and monitoring: The definition of quality and approaches to its assessment. Vol 1*. Ann Arbor, MI: Health Administration Press.

Donabedian, A. 1980b. "The definition of quality: A conceptual exploration." In *Explorations in quality assessment and monitoring: The definition of quality and approaches to its assessment. Vol 1*. Ann Arbor, MI: Health Administration Press.

Duan, N. 1983. "Smearing Estimate: A Nonparametric Retransformation Method." *Journal of the American Statistical Association* 78(383): 605-10.

*DxCG RiskSmart Clinical Classifications Guide*. 2007. Boston, MA: DxCG Inc.

Fisher, E. S. 2008. "Building a medical neighborhood for the medical home." *N Engl J Med* 359(12): 1202-5.

Fishman, P. A., E. A. Johnson, K. Coleman, E. B. Larson, C. Hsu, T. R. Ross, D. Liss, J. Tufano, and R. J. Reid. 2012. "Impact on seniors of the Patient Centered Medical Home: Evidence from a pilot project." *The Gerontologist*.

Fishman, P. A. and E. H. Wagner. 1998. "Managed care data and public health: the experience of Group Health Cooperative of Puget Sound." *Annu Rev Public Health* 19: 477-91.

Forrest, C. B. 2009. "A typology of specialists' clinical roles." *Arch Intern Med* 169(11): 1062-8.

Forrest, C. B., P. A. Nutting, B. Starfield, and S. von Schrader. 2002. "Family physicians' referral decisions: results from the ASPN referral study." *The Journal of family practice* 51(3): 215-22.

Forrest, C. B. and R. J. Reid. 2001. "Prevalence of health problems and primary care physicians' specialty referral decisions." *The Journal of family practice* 50(5): 427-32.

Gabbay, R. A., M. H. Bailit, D. T. Mauger, E. H. Wagner, and L. Siminerio. 2011. "Multipayer patient-centered medical home implementation guided by the chronic care model." *Joint Commission journal on quality and patient safety / Joint Commission Resources* 37(6): 265-73.

Gardner, W., E. P. Mulvey, and E. C. Shaw. 1995. "Regression analyses of counts and rates: Poisson, overdispersed Poisson, and negative binomial models." *Psychological bulletin* 118(3): 392-404.

Gilfillan, R. J., J. Tomcavage, M. B. Rosenthal, D. E. Davis, J. Graham, J. A. Roy, S. B. Pierdon, F. J. Bloom, Jr., T. R. Graf, R. Goldman, K. M. Weikel, B. H. Hamory, R. A. Paulus, and G. D. Steele, Jr. 2010. "Value and the medical home: effects of transformed primary care." *Am J Manag Care* 16(8): 607-14.

"Google Maps" [accessed on September 1, 2012]. Available at: <https://maps.google.com/>.

Green, B. B., A. J. Cook, J. D. Ralston, P. A. Fishman, S. L. Catz, J. Carlson, D. Carrell, L. Tyll, E. B. Larson, and R. S. Thompson. 2008. "Effectiveness of home blood pressure monitoring, Web communication, and pharmacist care on hypertension control: a randomized controlled trial." *JAMA* 299(24): 2857-67.

Grembowski, D. E., K. Cook, D. L. Patrick, and A. E. Roussel. 1998. "Managed care and physician referral." *Medical care research and review*: 55(1): 3-31.

Gujarati, D. N. 2006. *Essentials of Econometrics (3rd ed.)*. New York: McGraw-Hill/Irwin.

Hardin, J. W. and J. M. Hilbe. 2007. *Generalized Linear Models and Extensions*. College Station, TX: Stata Press.

Harris, L. T., S. J. Haneuse, D. P. Martin, and J. D. Ralston. 2009. "Diabetes quality of care and outpatient utilization associated with electronic patient-provider messaging: a cross-sectional analysis." *Diabetes Care* 32(7): 1182-7.

*HEDIS 2012: Technical Specifications for Health Plans, Volume 2*. 2011. Washington, D.C.: National Committee for Quality Assurance.

Hollingsworth, J. M., S. Saint, R. A. Hayward, M. A. Rogers, L. Zhang, and D. C. Miller. 2011. "Specialty care and the patient-centered medical home." *Medical care* 49(1): 4-9.

Hsu, C., K. Coleman, T. R. Ross, E. Johnson, P. A. Fishman, E. B. Larson, D. Liss, C. Trescott, and R. J. Reid. 2012. "Spreading a patient-centered medical home redesign: a case study." *The Journal of ambulatory care management* 35(2): 99-108.

Katon, W. J., E. H. Lin, M. Von Korff, P. Ciechanowski, E. J. Ludman, B. Young, D. Peterson, C. M. Rutter, M. McGregor, and D. McCulloch. 2010. "Collaborative care for patients with depression and chronic illnesses." *N Engl J Med* 363(27): 2611-20.

Kravitz, R. L., R. A. Bell, and C. E. Franz. 1999. "A taxonomy of requests by patients (TORP): a new system for understanding clinical negotiation in office practice." *The Journal of family practice* 48(11): 872-8.

Krieger, N. 1992. "Overcoming the absence of socioeconomic data in medical records: validation and application of a census-based methodology." *Am J Public Health* 82(5): 703-10.

Larson, E. B. and R. Reid. 2010. "The patient-centered medical home movement: why now?" *JAMA : the journal of the American Medical Association* 303(16): 1644-5.

Liss, D. T., P. A. Fishman, C. M. Rutter, D. Grembowski, T. R. Ross, E. A. Johnson, and R. J. Reid. "Outcomes among chronically ill adults in a medical home prototype." *Under Review: American Journal of Managed Care*.

Liss, D. T., R. J. Reid, D. Grembowski, C. M. Rutter, T. R. Ross, and P. A. Fishman. "Do secure message and phone encounters substitute or complement office visits in the medical home?" *Under Review: Health Services Research*.

Macinko, J., B. Starfield, and L. Shi. 2003. "The contribution of primary care systems to health outcomes within Organization for Economic Cooperation and Development (OECD) countries, 1970-1998." *Health Services Research* 38(3): 831-65.

Manning, W. G. and J. Mullahy. 2001. "Estimating log models: to transform or not to transform?" *J Health Econ* 20(4): 461-94.

Margolius, D. and T. Bodenheimer. 2010. "Transforming primary care: from past practice to the practice of the future." *Health affairs* 29(5): 779-84.

McFadden, D. 1963. "Constant Elasticity of Substitution Production Functions." *The Review of Economic Studies* 30(2): 73-83.

McGeady, D., J. Kujala, and K. Ilvonen. 2008. "The impact of patient-physician web messaging on healthcare service provision." *International journal of medical informatics* 77(1): 17-23.

McKinstry, B., J. Walker, C. Campbell, D. Heaney, and S. Wyke. 2002. "Telephone consultations to manage requests for same-day appointments: a randomised controlled trial in two practices." *The British journal of general practice : the journal of the Royal College of General Practitioners* 52(477): 306-10.

*Medical Expenditure Panel Survey*. 2004. Agency for Healthcare Research and Quality.

Naessens, J. M., R. J. Stroebel, D. M. Finnie, N. D. Shah, A. E. Wagie, W. J. Litchy, P. J. Killinger, T. J. O'Byrne, D. L. Wood, and R. E. Nesse. 2011. "Effect of multiple chronic conditions among working-age adults." *Am J Manag Care* 17(2): 118-22.

Newton, K. M., E. H. Wagner, S. D. Ramsey, D. McCulloch, R. Evans, N. Sandhu, and C. Davis. 1999. "The use of automated data to identify complications and comorbidities of diabetes: a validation study." *J Clin Epidemiol* 52(3): 199-207.

Ostbye, T., K. S. Yarnall, K. M. Krause, K. I. Pollak, M. Gradison, and J. L. Michener. 2005. "Is there time for management of patients with chronic diseases in primary care?" *Ann Fam Med* 3(3): 209-14.

Partnership for Solutions. 2004. "Chronic Conditions: Making the Case for Ongoing Care - September 2004 Update." Robert Wood Johnson Foundation.

Patient-Centered Primary Care Collaborative. "Pilots & Demonstrations in the United States" [accessed on September 14, 2012]. Available at: <http://www.pcpcc.net/pcpcc-pilot-projects>.

Peikes, D., S. Dale, E. Lundquist, J. Genevro, and D. Meyers. 2011. "Building the evidence base for the medical home: what sample and sample size do studies need?" AHRQ Publication No. 12-0020-EF. Rockville, MD: Agency for Healthcare Research and Quality.

- Peikes, D., A. Zutshi, J. Genevro, K. Smith, M. Parchman, and D. Meyers. 2012. "Early Evidence on the Patient-Centered Medical Home." AHRQ Publication No. 11-0100-EF. Rockville, MD: Agency for Healthcare Research and Quality.
- Pierce, C. A., E. R. Haut, S. Kardooni, D. C. Chang, D. T. Efron, A. Haider, P. J. Pronovost, and E. E. Cornwell, 3rd. 2008. "Surveillance bias and deep vein thrombosis in the national trauma data bank: the more we look, the more we find." *The Journal of trauma* 64(4): 932-6; discussion 36-7.
- Pietz, K., C. M. Ashton, M. McDonnell, and N. P. Wray. 2004. "Predicting healthcare costs in a population of veterans affairs beneficiaries using diagnosis-based risk adjustment and self-reported health status." *Med Care* 42(10): 1027-35.
- Ralston, J. D., D. Carrell, R. Reid, M. Anderson, M. Moran, and J. Hereford. 2007. "Patient web services integrated with a shared medical record: patient use and satisfaction." *J Am Med Inform Assoc* 14(6): 798-806.
- Ralston, J. D., K. Coleman, R. J. Reid, M. R. Handley, and E. B. Larson. 2010. "Patient experience should be part of meaningful-use criteria." *Health Aff (Millwood)* 29(4): 607-13.
- Ralston, J. D., I. B. Hirsch, J. Hoath, M. Mullen, A. Cheadle, and H. I. Goldberg. 2009a. "Web-based collaborative care for type 2 diabetes: a pilot randomized trial." *Diabetes Care* 32(2): 234-9.
- Ralston, J. D., D. P. Martin, M. L. Anderson, P. A. Fishman, D. A. Conrad, E. B. Larson, and D. Grembowski. 2009b. "Group health cooperative's transformation toward patient-centered access." *Med Care Res Rev* 66(6): 703-24.
- Ralston, J. D., C. M. Rutter, D. Carrell, J. Hecht, D. Rubanowice, and G. E. Simon. 2009c. "Patient use of secure electronic messaging within a shared medical record: a cross-sectional study." *J Gen Intern Med* 24(3): 349-55.
- Reid, R. J., K. Coleman, E. A. Johnson, P. A. Fishman, C. Hsu, M. P. Soman, C. E. Trescott, M. Erikson, and E. B. Larson. 2010. "The group health medical home at year two: cost savings, higher patient satisfaction, and less burnout for providers." *Health Aff (Millwood)* 29(5): 835-43.
- Reid, R. J., P. A. Fishman, O. Yu, T. R. Ross, J. T. Tufano, M. P. Soman, and E. B. Larson. 2009. "Patient-centered medical home demonstration: a prospective, quasi-experimental, before and after evaluation." *Am J Manag Care* 15(9): e71-87.
- Reid, R. J., E. A. Johnson, C. Hsu, K. Ehrlich, K. Coleman, C. Trescott, M. Erikson, T. R. Ross, D. T. Liss, D. Crompton, and P. A. Fishman. "Spreading a PCMH redesign: Effects on emergency room use and hospital admissions." *Under Review: Annals of Family Medicine*.
- Reid, R. J. and E. B. Larson. 2012. "Improvement Happens: Doctors Talk About the Medical Home : An Interview with Charles Mayer, MD, MPH and Eric Seaver, MD." *Journal of General Internal Medicine*.

- Reid, R. J., L. MacWilliam, L. Verhulst, N. Roos, and M. Atkinson. 2001. "Performance of the ACG case-mix system in two Canadian provinces." *Med Care* 39(1): 86-99.
- Riddle, M. C., J. Rosenstock, and J. Gerich. 2003. "The treat-to-target trial: randomized addition of glargine or human NPH insulin to oral therapy of type 2 diabetic patients." *Diabetes Care* 26(11): 3080-6.
- Rittenhouse, D. R., D. H. Thom, and J. A. Schmittdiel. 2010. "Developing a policy-relevant research agenda for the patient-centered medical home: a focus on outcomes." *J Gen Intern Med* 25(6): 593-600.
- Robert Wood Johnson Foundation. 2008. "Improving Access to Improve Quality: Evaluation of an Organizational Innovation." Washington, DC: AcademyHealth.
- Rockford Register Star. 2012. "Key dates of the Great Recession" [accessed on October 27, 2012]. Available at: <http://www.rstar.com/x417563916/Key-dates-of-the-Great-Recession>.
- Rogers, E. M. 2003. *Diffusion of Innovations - 5th ed.* New York: Free Press.
- Roos, N. P., K. C. Carriere, and D. Friesen. 1998. "Factors influencing the frequency of visits by hypertensive patients to primary care physicians in Winnipeg." *CMAJ: Canadian Medical Association journal* (7): 777-83.
- Rosen, A. K., S. Loveland, J. J. Anderson, J. A. Rothendler, C. S. Hankin, C. C. Rakovski, M. A. Moskowitz, and D. R. Berlowitz. 2001. "Evaluating diagnosis-based case-mix measures: how well do they apply to the VA population?" *Med Care* 39(7): 692-704.
- Rosenthal, M. B., H. B. Beckman, D. D. Forrest, E. S. Huang, B. E. Landon, and S. Lewis. 2010. "Will the patient-centered medical home improve efficiency and reduce costs of care? A measurement and research agenda." *Med Care Res Rev* 67(4): 476-84.
- Saultz, J. W. and J. Lochner. 2005. "Interpersonal continuity of care and care outcomes: a critical review." *Ann Fam Med* 3(2): 159-66.
- Scholle, S. H., L. G. Pawlson, L. I. Solberg, S. C. Shih, S. E. Asche, A. F. Chou, and M. J. Thoele. 2008. "Measuring practice systems for chronic illness care: accuracy of self-reports from clinical personnel." *Jt Comm J Qual Patient Saf* 34(7): 407-16.
- Shadish, W. R., T. D. Cook, and D. T. Campbell. 2002. *Experimental and Quasi-Experimental Designs for Generalized Causal Inference.* Boston: Houghton Mifflin.
- Sia, C., T. F. Tonniges, E. Osterhus, and S. Taba. 2004. "History of the medical home concept." *Pediatrics* 113(5 Suppl): 1473-8.
- Sibai, B. M. 1991. "Diagnosis and management of chronic hypertension in pregnancy." *Obstetrics and gynecology* 78(3 Pt 1): 451-61.

Sittig, D. F. 2003. "Results of a content analysis of electronic messages (email) sent between patients and their physicians." *BMC medical informatics and decision making* 3: 11.

Solberg, L. I., S. E. Asche, P. Fontaine, T. J. Flottemesch, and L. H. Anderson. 2011. "Trends in quality during medical home transformation." *Annals of Family Medicine* 9(6): 515-21.

Solberg, L. I., K. I. Engebretson, J. M. Sperl-Hillen, M. C. Hroschikoski, and P. J. O'Connor. 2006. "Are claims data accurate enough to identify patients for performance measures or quality improvement? The case of diabetes, heart disease, and depression." *American journal of medical quality : the official journal of the American College of Medical Quality* 21(4): 238-45.

Starfield, B. 1998. *Primary Care: Balancing Health Needs, Services, and Technology*. New York: Oxford University Press.

Starfield, B. 2011. "Point: the changing nature of disease: implications for health services." *Medical Care* 49(11): 971-2.

Starfield, B., K. W. Lemke, T. Bernhardt, S. S. Foldes, C. B. Forrest, and J. P. Weiner. 2003. "Comorbidity: implications for the importance of primary care in 'case' management." *Ann Fam Med* 1(1): 8-14.

Starfield, B., K. W. Lemke, R. Herbert, W. D. Pavlovich, and G. Anderson. 2005a. "Comorbidity and the use of primary care and specialist care in the elderly." *Annals of family medicine* 3(3): 215-22.

Starfield, B., L. Shi, and J. Macinko. 2005b. "Contribution of primary care to health systems and health." *Milbank Q* 83(3): 457-502.

Struijs, J. N., C. A. Baan, F. G. Schellevis, G. P. Westert, and G. A. van den Bos. 2006. "Comorbidity in patients with diabetes mellitus: impact on medical health care utilization." *BMC health services research* 6: 84.

*The Johns Hopkins ACG System: Technical Reference Guide, Version 10.0*. 2011. Baltimore, MD: Johns Hopkins University.

Thorpe, K. E. and D. H. Howard. 2006. "The rise in spending among Medicare beneficiaries: the role of chronic disease prevalence and changes in treatment intensity." *Health Aff (Millwood)* 25(5): w378-88.

Wagner, E. H. 1998. "Chronic disease management: what will it take to improve care for chronic illness?" *Effective clinical practice : ECP* 1(1): 2-4.

Wagner, E. H. 2011. "Counterpoint: chronic illness and primary care." *Medical Care* 49(11): 973-5.

Wagner, E. H., B. T. Austin, and M. Von Korff. 1996. "Organizing care for patients with chronic illness." *Milbank Q* 74(4): 511-44.

- Wagner, E. H., K. Coleman, R. J. Reid, K. Phillips, M. K. Abrams, and J. R. Sugarman. 2012. "The changes involved in patient-centered medical home transformation." *Primary care* 39(2): 241-59.
- Wagner, E. H. and R. J. Reid. 2007. "Are continuity of care and teamwork incompatible?" *Med Care* 45(1): 6-7.
- Wasson, J., C. Gaudette, F. Whaley, A. Sauvigne, P. Baribeau, and H. G. Welch. 1992. "Telephone care as a substitute for routine clinic follow-up." *JAMA* 267(13): 1788-93.
- Williams, J. W., G. L. Jackson, B. J. Powers, R. Chatterjee, J. Prvu Bettger, A. R. Kemper, V. Hasselblad, R. J. Dolor, R. J. Irvine, B. L. Heidenfelder, A. S. Kendrick, and R. Gray. 2012. "The Patient-Centered Medical Home. Closing the Quality Gap: Revisiting the State of the Science. Evidence Report No. 208." AHRQ Publication No. 12-E008-EF. Rockville, MD: Agency for Healthcare Research and Quality.
- Zhou, Y. Y., T. Garrido, H. L. Chin, A. M. Wiesenthal, and L. L. Liang. 2007. "Patient access to an electronic health record with secure messaging: impact on primary care utilization." *Am J Manag Care* 13(7): 418-24.
- Zou, G. 2004. "A modified poisson regression approach to prospective studies with binary data." *Am J Epidemiol* 159(7): 702-6.
- Zou, G. Y. and A. Donner. 2011. "Extension of the modified Poisson regression model to prospective studies with correlated binary data." *Statistical methods in medical research*.

**VITA**

David Liss grew up in Armonk, New York. In 2002 he received a Bachelor of Arts degree from Northwestern University, where he double-majored in Economics and History. In 2005, he began conducting health services research as a Project Coordinator at the Division of Internal Medicine at Northwestern's Feinberg School of Medicine, and he received a Master of Arts degree in Public Policy and Administration from Northwestern in June 2008. David began his doctoral studies in Health Services at the University of Washington in September 2008, and completed his doctoral dissertation in December 2012. His research has focused on improving the quality and value of primary care delivery for individuals with chronic illnesses.