

Assessing the Effect of the VHA PCMH Model on Utilization Patterns Among Veterans With PTSD

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The Veterans Health Administration (VHA) provides care to nearly 6 million veterans each year at more than 1000 clinics across the country.¹ On April 1, 2010, the VHA implemented a patient-centered medical home (PCMH)-based Patient Aligned Care Teams (PACT) model across the VHA system. Key goals of the PACT initiative include enhancing patient access, improving care coordination, and redesigning clinical teams.² To achieve these goals, VHA clinics have developed multidisciplinary care teams, increased their staffing ratios, expanded virtual access for patients, and implemented new health information technology tools, among other steps, to drive care coordination and expand access.³ Although the VHA PACT initiative has been described in greater detail elsewhere,³⁻⁶ more detail about PACT elements are outlined in [Table 1](#).

Literature reviews have found that elements of the PCMH, such as enhanced chronic disease management, longitudinal relationships with patients assigned to clinician panels, and multidisciplinary care teams, have been successful in improving access to primary physical and behavioral healthcare⁷⁻⁹ and reducing the number of specialty visits¹⁰ and emergency department (ED) utilization.¹¹ However, there is a lack of conclusive evidence that the PCMH model improves care for vulnerable patient populations with chronic conditions.^{7,8,12} One such vulnerable subgroup is veterans with posttraumatic stress disorder (PTSD), a condition that is often related to combat trauma¹³ and prevalent among veterans.¹⁴ Our research focuses on how PACT has affected the utilization patterns of veterans with PTSD at the VHA. The study population was selected because veterans suffer from PTSD at higher rates than the general public.^{14,15} Patients with PTSD suffer disproportionately from psychiatric and physical comorbidities,¹⁶ utilize health services at elevated rates,¹⁷ and face distinctive barriers to receiving mental health care.^{18,19} Furthermore, patients who suffer from mental illness, and PTSD specifically, face unique barriers to adhering to treatment plans and complying with their medication regimens.^{20,21}

The PCMH model has shown the potential to reduce high-intensity healthcare utilization for high-needs patients.^{8,22} Because

ABSTRACT

OBJECTIVES: The Veterans Health Administration (VHA) implemented a patient-centered medical home (PCMH)-based Patient Aligned Care Teams (PACT) model in 2010. We examined its effects on the utilization of health services among US veterans with posttraumatic stress disorder (PTSD).

STUDY DESIGN: We analyzed VHA clinical and administrative data to conduct an interrupted time series study. Encounter-level data were obtained for the period of April 1, 2005, through March 31, 2014. We identified 642,660 veterans with PTSD who were assigned to either a high- or low-PCMH implementation group using a validated VHA PCMH measurement instrument.

METHODS: We measured the effect of high-PCMH implementation on the count of hospitalizations and primary care, specialty care, specialty mental health, emergency department (ED), and urgent care encounters compared with low-PCMH implementation. We fit a multilevel, mixed-effects, negative binomial regression model and estimated average marginal effects and incidence rate ratios.

RESULTS: Compared with patients in low-PCMH implementation clinics, patients who received care in high-PCMH implementation clinics experienced a decrease in hospitalizations (incremental effect [IE], -0.036; 95% confidence interval [CI], -0.0371 to -0.0342), a decrease in specialty mental health encounters (IE, -0.009; 95% CI, -0.009 to -0.008), a decrease in urgent care encounters (IE, -0.210; 95% CI, -0.212 to -0.207), and a decrease in ED encounters (IE, -0.056; 95% CI, -0.057 to -0.054).

CONCLUSIONS: High PCMH implementation positively affected utilization patterns by reducing downstream use of high-cost inpatient and specialty services. Future research should investigate whether a reduction in utilization of health services indeed results in higher levels of virtual and non-face-to-face access, or if the PACT model has reduced necessary access to care.

Am J Manag Care. 2017;23(5):291-296

TAKEAWAY POINTS

This study provides several key contributions to the body of literature measuring the effectiveness of the patient-centered medical home (PCMH) model:

- ▶ Veterans with posttraumatic stress disorder (PTSD) comprise a particularly vulnerable patient subgroup. Results can help inform delivery system redesigns that target patients with mental health issues.
- ▶ Understanding changing utilization patterns among veterans with PTSD provides information about resource needs and constraints for policy makers and delivery system leaders considering PCMH adoption.
- ▶ This research sheds light on the effectiveness of the PCMH model in reducing inpatient and specialty care for veterans with PTSD.

this model intensifies primary care, a heightened need exists for physicians to effectively diagnose and treat patients with mental illness²³ and link these patients with mental health care specialists.²⁴ Additionally, better integration of primary and mental health care has been shown to lower costs. We hypothesized that PACT would increase the rate of primary care encounters and, subsequently, reduce rates of hospitalizations and specialty out-patient, urgent care, and ED encounters.

In the United States, mental illness cases are the fastest-growing component of ED utilization. Patients presenting to the ED with mental illness often have complex psychiatric, medical, and social histories.²⁵ Subsequent downstream encounters, such as inpatient admissions and ED visits, are often indicative of suboptimal care and may reflect encounters that could have been prevented with better primary care.²⁶ Untreated mental illness, such as PTSD, can lead to the exacerbation of other mental and physical ailments. Likewise, the development of physical illness can subsequently worsen the severity of PTSD symptoms,²⁷ creating adverse feedback loops for patients' health status. Overall, patients with mental health disorders have higher rates of unexplained medical complaints, utilize more specialty care, and incur nearly 2-fold higher medical costs.¹⁴ However, if mental health can be treated more effectively, there are opportunities to improve health outcomes among veterans with mental illness²⁸ and achieve savings from decreased utilization of downstream encounters.^{29,30}

Previous PCMH studies have often been constrained by methodological limitations, including inconsistent definitions of what constitutes a PCMH, an inability to define the level of PCMH implementation, and small sample sizes that limited generalizability.³¹ Moreover, PCMH research has often been hampered by an inability to decouple the PCMH model from other practice transformation initiatives and the confounding influence of electronic health records.^{10,12} Many PCMH studies have also been conducted using pre-post study designs, used short time periods of data, or measured several interventions simultaneously.^{8,12} Short time periods, in particular, are problematic because research indicates that the longer a PCMH model has been implemented, the more discernible are any true effects.⁷ As a result, it is difficult to infer

causality from many previous studies about the PCMH model. Finally, there is a limited number of studies that have focused on the relationship between PACT and utilization patterns among vulnerable patient populations with mental health conditions, such as veterans with PTSD.^{7,32}

The ability to assess causation in this study is aided by a number of factors, including an enhanced ability to measure the extent of PACT implementation at VHA clinics, longer time periods to better assess causal relationships,

and larger anticipated effect sizes due to higher rates of utilization among veterans with PTSD. Heterogeneous levels of PACT implementation at VHA clinics and the subsequent development of a validated instrument to measure PACT implementation at individual VHA clinics present a unique opportunity to detect potential causal effects of PACT. Lastly, this study was able to control for the potential confounding effects of Primary Care Mental Health Integration (PC-MHI), a model to embed behavioral health care in the primary care setting, implemented at a subset of VHA clinics in 2007.^{33,34}

METHODS

Data and Subjects

Data were collected from VHA administrative databases for the period between April 1, 2005, and March 31, 2014. We collected clinical and administrative data on veterans assigned to 1006 VHA hospital and community-based clinics, with each provider site being considered a unique clinic. We screened records from 11,546,562 veterans to assess whether they were diagnosed with PTSD. *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)* codes were used to identify patients with PTSD as well as for risk adjustment using the Elixhauser method.³⁵ Veterans with at least 1 inpatient or 2 outpatient encounters that included the PTSD *ICD-9-CM* code 309.81 within 1 year of a respective quarter were identified as having PTSD in that quarter.

Of all veterans screened, 1,455,295 were identified as having PTSD in at least 1 quarter of the research period. From this group, we identified veterans who received care at a clinic that was designated as either a low- or high-PACT implementation clinic. A low-PACT implementation clinic is one with a composite score on the PACT Implementation Progress Index (PI²) in the bottom quartile of the PI² score distribution, while a high-PACT implementation clinic is one with a composite score in the top quartile of the PI² score distribution. The PI² was developed by VHA researchers to measure the extent of PACT implementation at individual VHA clinics.³⁶ The PI² measures the level of implementation across key

domains that reflect meaningful adoption of the PCMH model.

Veterans were only included in the sample population if they were part of the Primary Care Management Module (PCMM), an indicator of receiving empaneled primary care from an assigned provider team. Only veterans in the PCMM were included because they would have had at least 1 primary care visit and would be able to receive the potential benefits of the PACT initiative in the primary care setting. At the clinic level, we utilized administrative data to assign a binary marker for whether a clinic had implemented the PC-MHI initiative.

The final study sample, which included 1,405,185 veterans who were identified as having PTSD, was an imbalanced longitudinal (eg, a repeated cross-sectional) sample. The average veteran included in this sample was in the data set for an average of 30 quarters, or 7.5 years, indicating that the majority was tracked over a significant period and had been in the data set in both the pre- and post-PACT periods. Based on the PTSD inclusion criteria, this equates to 12.2% of veterans having PTSD. This figure is slightly lower than other estimates of PTSD prevalence among veterans,¹⁴ but can be explained by this study's more stringent inclusion criteria.

Main Measures

The independent variable of interest was a binary indicator of whether a veteran was assigned to a VHA clinic in the high- or low-PACT implementation cohort, based on whether the clinic's PI² score was in the highest or lowest quartile of the PI² score distribution, respectively. The primary outcomes in this study were the quarterly counts of specific health services. These outcomes included: 1) hospitalizations, 2) primary care encounters, 3) specialty care encounters (excluding mental health), 4) specialty mental health encounters, 5) ED encounters, and 6) urgent care encounters. We focused on these outcomes based on a conceptual model and a priori assumptions about PACT's impact. Multivariate regression models adjusted for age, sex, race, VHA co-pay status (an indicator of financial resources and access to care), marriage status, percent service connected disability, and Elixhauser comorbidity score.³⁷ Because we hypothesized that the PC-MHI model would likely confound the relationship between PACT and utilization patterns, we included this marker as a binary covariate in the multivariate model.

Estimating the Effect of PACT on Utilization

We conducted an interrupted time-series study to explore the effect of PACT on utilization patterns. An interrupted time-series

TABLE 1. Key Components of the PACT model

PACT Component	Description
Enhancing Access	<ul style="list-style-type: none"> • Offer same-day appointments and same-day access to specialists • Increase shared medical appointments • Increase nonappointment care through wider access to, and use of, electronic messaging and telephone appointments/consultations • Actively identify and mitigate barriers to care for vulnerable patient populations
Improving Care Management and Coordination	<ul style="list-style-type: none"> • Identify and proactively manage care for high-risk and chronically ill patients • Rationalize care to allow physicians and nurse practitioners to focus on higher-need patients and delegate noncritical tasks to other team members • Measure performance on key process and outcome indicators, as well as patient experiences for defined patient populations
Redesigning Clinical Practices	<ul style="list-style-type: none"> • Develop multidisciplinary care teams that consist of physicians, nurse practitioners or registered nurses, clinical assistants (eg, LPNs), and a medical clerk • Increase staffing levels of core PACT team and ancillary providers to meet PACT staffing ratio guidelines • Care teams are responsible for providing longitudinal care for an assigned patient population • Redesign scheduling practices to promote easier patient access

LPN indicates licensed practical nurse; PACT, Patient Aligned Care Teams model.

design that utilizes a control group has been described as the strongest quasi-experimental study design available, in part because of the ability to control for secular trends (eg, macroeconomic factors) that would otherwise confound estimated effects.³⁸ The study identified clinics with high and low levels of PACT implementation using a validated instrument known as PI², a survey developed by the VHA researchers to measure the extent of PACT implementation at individual clinics across 8 domains.³⁶ Clinics with high levels of PACT implementation, defined as having a PI² score in the top quartile of the distribution of PACT scores, were identified as the case group of high-implementation clinics. Conversely, clinics in the bottom quartile of the PI² distribution were considered low-implementation clinics and comprised the control group. Out of those facilities, we then identified those that had implemented the PC-MHI starting in 2007 and controlled for the implementation of this initiative.

We modeled trends in the utilization of specified health outcomes at the patient level using a multilevel mixed-effects negative binomial regression. Such models have been applied to various health services research studies involving multilevel clustered data and, specifically, count data.³⁹ These have also been used to model other health services outcomes when the data structure includes several clusters of correlated observations⁴⁰ and have been shown to reduce bias from intracluster correlation relative to models that ignore clustering at 1 or more levels.⁴¹ The imbalanced longitudinal sample data used for this analysis contains correlated

TABLE 2. Sample Patient Population Characteristics in High- and Low-PACT Implementation Clinics

Characteristic	High-PACT Implementation Clinics: Mean	Low-PACT Implementation Clinics: Mean
Age, years	54.68	54.90
Male, %	92.4	91.7
Black race, %	16.4	16.7
Other race, %	18.0	18.5
Elixhauser Comorbidity Index	0.833	0.813
No co-pay, %	93.4	94.1
Service connected disability, %	53.2	57.8

PACT indicates Patient Aligned Care Teams model.

TABLE 3. Unadjusted Utilization Rates per Quarter, Pre-PACT and Post-PACT Periods

Outcome	Pre-PACT Period	Post-PACT Period
Hospitalizations	0.026	0.029
Primary care encounters	1.178	1.238
Specialty care encounters	2.508	3.579
Mental health encounters	2.021	2.289
ED encounters	0.015	0.022
Urgent care visits	0.103	0.139

ED indicates emergency department; PACT, Patient Aligned Care Teams model.

observations at the individual patient level and the clinic level. To account for intracluster correlation, the mixed-effects model treats these clusters as random effects and estimates a random intercept and slope for each cluster. In the mixed-effects model, the fixed effects are analogous to standard regression coefficients and are estimated directly.

To determine the functional form, we first fit a multilevel, mixed-effects Poisson model. We then tested for overdispersion to assess if the mean-variance equality assumption held, as violation of the mean-variance equality assumption may produce unstable estimates.⁴² Overdispersion tests were significant, indicating that the mean-variance assumption was violated and the Poisson models were inappropriate.⁴³ Consequently, we tested the multilevel, mixed-effects negative binomial model and assessed goodness of fit using the Pearson Correlation, Pregibon's Link, and Hosmer-Lemshow tests.

The negative binomial model applies 2 parameterizations of overdispersion. The first is the mean parameterization, where the overdispersion is a function of the mean:

$$1 + \alpha E(Y|x), \alpha > 0$$

The second is the constant parameterization, where the overdispersion is a constant function:

$$1 + \delta, \delta \geq 0.$$

We specified clustering at the clinic and patient levels and estimated robust standard errors, creating estimates that are cluster- and heteroskedastic-robust.⁴⁴ Postestimate Wald tests were utilized to test the significance of coefficients. Results were considered significant at $\alpha = 0.05$. For interpretation of fixed effects, we calculated incidence-rate ratios to estimate the percent change in utilization. We then utilized the recycled predictions method to estimate the incremental effect on utilization on a linear scale.⁴⁵ To obtain this estimated incremental effect, we interpreted the model parameter that interacts: 1) a binary indicator of whether the patient received care at a high-PACT implementation clinic, 2) a binary indicator of whether the care was received before or after PACT implementation, and 3) a quarter term centered at PACT implementation. See the **eAppendix** (eAppendices available at ajmc.com) for more details on the parameterization of the Interrupted Time Series model. We also estimated the incidence rate ratio, which transforms the log-count of services into a percentage change in the count of services for all utilization outcomes.

RESULTS

We screened administrative records from 11,546,562 unique veterans and identified 1,405,185 veterans with at least 1 PTSD diagnosis in the study time frame. Based on the aforementioned criteria for identifying a veteran with PTSD, the prevalence of PTSD among screened veterans was 12.2%. Of those veterans with PTSD, 642,660 were assigned to either the case or control groups based on their VHA clinic affiliation, and were thus included in the final sample population. Characteristics of individuals with PTSD in the High-PACT and Low-PACT cohorts are shown in **Table 2**.

Before conducting multivariate modeling, we first examined unadjusted utilization rates in both the pre-PACT and post-PACT periods. The unadjusted rates (**Table 3**) reflect the mean utilization count for each outcome per quarter across all quarters before PACT implementation and across all quarters after PACT implementation. Unadjusted post-PACT utilization rates were uniformly higher in the post-PACT period than the pre-PACT period. As anticipated, the most frequent encounters were specialty care, specialty mental health, and primary care encounters in both the pre- and post-PACT encounters.

We estimated the average marginal effect of receiving care in a high-PACT implementation clinic and the corresponding incidence rate ratio for each outcome. The marginal effects can be interpreted as the adjusted average marginal effect of a veteran receiving care at a clinic identified as a high-PACT implementation clinic compared with receiving care at a low-PACT implementation clinic, on

the count of encounters for a particular utilization outcome (see [Table 4](#) for adjusted results). The adjusted marginal effects were as follows: on hospitalizations, an estimated -0.036 (95% confidence interval [CI], -0.037 to -0.034), for an estimated 3.3% reduction in hospitalizations per quarter for each veteran; on mental health encounters, an estimated -0.009 (95% CI, -0.009 to -0.008), which equates to an estimated 0.9% reduction in specialty mental health encounters per quarter for each veteran; on ED encounters, an estimated -0.056 (95% CI, -0.057 to -0.055), equating to an estimated 5.5% reduction in ED encounters per quarter for each veteran; and on urgent care encounters, an estimated -0.210 (95% CI, -0.022 to -0.020), for an estimated 19% reduction in urgent care encounters per quarter for each veteran. We did not find significant PACT effects on primary or specialty care encounters.

DISCUSSION

Along with improving patient outcomes and patient experience, PACT seeks to reduce per capita cost, in line with Triple Aim goals.⁴⁶ For the PACT model to be successful and capture savings that offset significant implementation costs,⁶ veterans must receive improved preventive care to ultimately reduce the use of costly and resource-intensive downstream inpatient, ED, and specialist services. Veterans with mental illness, such as PTSD, are of particular concern because of the high prevalence of the condition among service members: combat veterans demonstrate a 2- to 4-fold increase in PTSD compared with civilians,¹⁴ and longitudinal studies have found that deployment increased PTSD incidence among service members.¹⁵ The results from this study indicate that the VHA has achieved modest levels of success in reducing the utilization rate of inpatient, specialty mental health, ED, and urgent care services. Assuming that access to necessary care has not been jeopardized, this is a promising finding, albeit with slight effects on utilization that are detectable in part because of the very large sample population available.

We hypothesized that primary care encounters would increase after PACT implementation. For patients to realize the benefits of enhanced primary care, we anticipate that they would have more frequent and regular contact with their primary care clinician teams. This effect was not observed. If PACT is simply driving reduced access to care across the range of health services, it is difficult to conclude that the model has succeeded in its broader aims. However, it is also possible that primary care encounters have been replaced by virtual or telephonic communication between patients and physicians. Future research should investigate the impact of the PCMH model on the rates of virtual, telephonic, and other alternative care modules that may be replacing traditional primary care encounters.

The results of this study are largely positive and indicate that the PCMH has led to decreased utilization of costly inpatient, ED, and

TABLE 4. Multivariate Results: Average Marginal Effects and Incidence Rate Ratios

Utilization Outcome	ME (95% CI)	Incidence Rate Ratio	Delta Method Standard Error
Hospitalizations	-0.036^a (-0.037 to -0.034)	0.967 ^a	0.001
Primary care encounters	-0.006 (-0.011 to 0.01)	0.999	0.009
Specialty care encounters	-0.001 (-0.003 to 0.001)	0.998	0.010
Mental health encounters	-0.009^a (-0.009 to -0.008)	0.992 ^a	0.001
ED encounters	-0.056^a (-0.057 to -0.055)	0.945 ^a	0.001
Urgent care visits	-0.210^a (-0.022 to -0.020)	0.811 ^a	0.001

CI indicates confidence interval; ED, emergency department; ME, marginal effect. ^aDenotes statistically significant difference in means. Results were considered significant at $\alpha = 0.05$.

specialty services for veterans with PTSD, the types of services that effective primary care and integrated physical and mental health may help avoid. These results are consistent with previous findings about the broader PACT initiative and the impact of the medical home on utilization patterns, which have typically also identified reductions in inpatient and ED utilization for both the general patient population⁷ and for veterans with PTSD.² However, PACT may be reducing access to some types of services, with potentially adverse consequences for patient care. Future research should seek to explore how PACT is affecting key population health measures.

Limitations

Our findings are not necessarily generalizable to broader patient populations because the veteran population is, on average, older than the general population, heavily male, and has high rates of mental illness and comorbidities.⁴⁷ This research also took place at a large delivery system and may not apply to PCMH models in smaller provider settings. An additional limitation is that veterans were identified as having PTSD by *ICD-9-CM* codes,⁴⁸ creating the possibility that some veterans with PTSD were excluded from the final sample because of coding issues.⁴⁹ Finally, the estimates of PACT's effects are likely conservative because we are estimating the effect of a veteran receiving care in a high-PACT clinic compared with a low-PACT implementation clinic and not the presence and absence of the PCMH model, potentially attenuating the effect size and increasing the possibility of statistical type II error. ■

Acknowledgments

This material is based on work supported by the Department of Veterans Affairs, Veterans Health Administration, Office of Research and Development, Health Services Research and Development. The authors would like to thank the members of the PACT Demonstration Laboratory initiative for

their contributions, and specifically thank John Messina for assistance with communication, scheduling and data tables, and Idamay Curtis for coordinating so many different tasks.

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Source of Funding: Veterans Health Administration, Division of Health Services Research and Development.

Author Disclosures: The authors are (or were at the time of authorship) employees of the US Department of Veterans Affairs. The views expressed in this article are those of the authors and do not necessarily reflect the position or policy of the Department of Veterans Affairs or the United States government.

Authorship Information: Concept and design (IR); acquisition of data (IR); analysis and interpretation of data (IR, GC, BD, CJ); drafting of the manuscript (IR, CJ); critical revision of the manuscript for important intellectual content (IR, CM, GC, BD, CJ); statistical analysis (IR, GC); provision of patients or study materials (IR); obtaining funding (IR); administrative, technical, or logistic support (IR, CM, CJ); and supervision (IR, CM, BD, CJ).

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REFERENCES

- Panangala SV. Health care for veterans: answers to frequently asked questions. Federation of American Scientists website. <https://fas.org/sqpl/crs/misc/R42747.pdf>. Published April 21, 2016. Accessed March 15, 2017.
- Randall I, Mohr DC, Maynard C. VHA patient-centered medical home associated with lower rate of hospitalizations and specialty care among veterans with posttraumatic stress disorder [published online November 12, 2015]. *J Healthc Qual*.
- Klein S. The Veterans Health Administration: implementing patient-centered medical homes in the nation's largest integrated delivery system. The Commonwealth Fund website. <http://www.commonwealthfund.org/publications/case-studies/2011/sep/vha-medical-homes>. Published September 13, 2011. Accessed April 2016.
- Rosland AM, Nelson K, Sun H, et al. The patient-centered medical home in the Veterans Health Administration. *Am J Manag Care*. 2013;19(7):e263-e272.
- Nelson KM, Helfrich C, Sun H, et al. Implementation of the patient-centered medical home in the Veterans Health Administration: associations with patient satisfaction, quality of care, staff burnout, and hospital and emergency department use. *JAMA Intern Med*. 2014;174(8):1350-1358. doi: 10.1001/jamainternmed.2014.2488.
- Hebert PL, Liu C, Wong S, et al. Patient-centered medical home initiative produced modest economic results for Veterans Health Administration, 2010 through 2012. *Health Aff (Millwood)*. 2013;33(6):980-987. doi: 10.1377/hlthaff.2013.0893.
- Nielsen M, Buelt L, Kavita P, Nichols LM. The patient-centered medical home's impact on cost & quality. annual review of evidence 2014-2015. Patient-Centered Primary Care Collaborative website. http://fmahealth.org/sites/default/files/2015_ANNUAL_EVIDENCE_REPORT.pdf. Published 2016. Accessed April 2016.
- Jackson G, Powers B, Chatterjee R, Bettger JP. Improving patient care: the patient-centered medical home: a systematic review. *Ann Intern Med*. 2013;158(3):169-178.
- Stange KC, Nutting PA, Miller WL, et al. Defining and measuring the patient-centered medical home. *J Gen Intern Med*. 2010;25(6):601-612. doi: 10.1007/s11606-010-1291-3.
- Kaushal R, Edwards A, Kern LM. Association between the patient-centered medical home and healthcare utilization. *Am J Manag Care*. 2005;21(5):378-386.
- Hoff T, Weller W, DePuccio M. The patient-centered medical home: a review of recent research. *Med Care Res Rev*. 2012;69(6):619-644. doi: 10.1177/1077558712447688.
- Peikes D, Zutshi A, Genevro J, Smith K, Parchman MI, Meyers D. Early evidence on the patient-centered medical home. Agency for Healthcare Research and Quality website. <https://pcmh.hqr.gov/sites/default/files/attachments/Early%20Evidence%20on%20the%20PCMH%202028%2012.pdf>. Accessed March 2016.
- Richardson LK, Frueh BC, Acierno R. Prevalence estimates of combat-related post-traumatic stress disorder: critical review. *Aust N Z J Psychiatry*. 2010;41(1):4-19. doi: 10.3109/0048670903393597.
- Thielke S, Vannoy S, Unützer J. Integrating mental health and primary care. *Prim Care*. 2007;34(3):571-592.
- Litz B, Schlenger WE. PTSD in service members and new veterans of the Iraq and Afghanistan Wars: a bibliography and critique. *PTSD Research Quarterly*. 2009;20(1):1-8.
- Magruder KM, Frueh BC, Knapp RG, et al. Prevalence of posttraumatic stress disorder in Veterans Affairs primary care clinics. *Gen Hosp Psychiatry*. 2005;27(3):169-179.
- Outcalt SD, Yu Z, Hoen HM, Pennington TM, Krebs EE. Health care utilization among veterans with pain and posttraumatic stress symptoms. *Pain Med*. 2014;15(11):1872-1879. doi: 10.1111/pme.12045.
- Brooks E, Novins DK, Thomas D, et al. Personal characteristics affecting veterans' use of services for post-traumatic stress disorder. *Psychiatr Serv*. 2012;63(9):862-867. doi: 10.1176/appi.ps.201100444.
- Bower P, Gilbody S. Managing common mental health disorders in primary care: conceptual models and evidence base. *BMJ*. 2005;330(7495):839-842.
- Kronish IM, Edmondson D, Goldfinger JZ, Fei K, Horowitz CR. Posttraumatic stress disorder and adherence to medications in survivors of strokes and transient ischemic attacks. *Stroke*. 2012;43(8):2192-2197. doi: 10.1161/STROKEAHA.112.655209.
- Dimatteo MR, Lepper HS, Croghan TW. Depression is a risk factor for noncompliance with medical treatment: meta-analysis of the effects of anxiety and depression on patient adherence. *Arch Intern Med*. 2000;160(14):2101-2107.
- 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*. 2009;15(9):e71-e87.
- Wang PS, Demler O, Olsson M, Pincus HA, Wells KB, Kessler RC. Changing profiles of service sectors used for mental health care in the United States. *Am J Psychiatry*. 2006;163(7):1187-1198.
- Integrating mental health treatment into the patient centered medical home. Agency for Healthcare Research and Quality website. <https://pcmh.hqr.gov/page/integrating-mental-health-treatment-patient-centered-medical-home>. Published June 2010. Accessed March 16, 2017.
- Boudreaux ED, Clark S, Camargo CA. Mood disorder screening among adult emergency department patients: a multicenter study of prevalence, associations and interest in treatment. *Gen Hosp Psychiatry*. 2008;30(1):4-13. doi: 10.1016/j.genhosppsych.2007.09.006.
- Caminal J, Starfield B, Sánchez E, Casanova C, Morales M. The role of primary care in preventing ambulatory care sensitive conditions. *Eur J Public Health*. 2004;14(3):246-251.
- Hammer M. Exacerbation of posttraumatic stress disorder symptoms with medical illness. *Gen Hosp Psychiatry*. 1994;16(2):135-137.
- Simon GE, VonKorff M, Barlow W. Health care costs of primary care patients with recognized depression. *Arch Gen Psychiatry*. 1995;52(10):850-856.
- Katon W, Unützer J, Fan M-Y, Williams J. Cost-effectiveness and net benefit of enhanced treatment of depression for older adults with diabetes and depression. *Diabetes Care*. 2006;29(2):265-270.
- Unützer J, Harbin H, Schoenbaum M, Druss BG. The Collaborative Care Model: an approach for integrating physical and mental health care in Medicaid health homes. CMS website. <https://www.medicare.gov/stateresource-center/medicaid-state-technical-assistance/health-homes-technical-assistance/downloads/hh-irccollaborative-5-13.pdf>. Published May 2013. Accessed March 2016.
- Rich E, Lipson D, Libersky J, Parchman M. Coordinating care for adults with complex care needs in the patient-centered medical home: challenges and solutions. Agency for Healthcare Research and Quality website. <https://pcmh.hqr.gov/sites/default/files/attachments/Coordinating%20Care%20for%20Adults%20with%20Complex%20Care%20Needs.pdf>. Published January 2012. Accessed March 16, 2017.
- Peikes D, Chen A, Schore J, Brown R. Effects of care coordination on hospitalization, quality of care, and health care expenditures among Medicare beneficiaries: 15 randomized trials. *JAMA*. 2009;301(6):603-618. doi: 10.1001/jama.2009.126.
- Post E. VA PCMH Integration Update. http://www.powershow.com/view/d4098a3-JE1M/Edward_P_Post_MD_PhD_National_Medical_Director_PC-MH_powerpoint_ppt_presentation. Accessed February 2016.
- Braver PA, Brugh AMT, Martelli RP, et al. Enhancing entrance into PTSD treatment for post-deployment veterans through collaborative/integrative care. *Transl Behav Med*. 2011;1(4):609-614. doi: 10.1007/s13142-011-0097-0.
- Sharabian MT, Aylin P, Bottle A. Systematic review of comorbidity indices for administrative data. *Med Care*. 2012;50(12):1109-1118. doi: 10.1097/MLR.0b013e31825f64d0.
- Nelson KM, Helfrich C, Sun H, et al. Implementation of the patient-centered medical home in the Veterans Health Administration: associations with patient satisfaction, quality of care, staff burnout, and hospital and emergency department use. *JAMA Intern Med*. 2014;174(8):1350-1358. doi: 10.1001/jamainternmed.2014.2488.
- Li B, Evans D, Farris P, Dean S, Quan H. Risk adjustment performance of Charlson and Elixhauser comorbidities in ICD-9 and ICD-10 administrative databases. *BMC Health Serv Res*. 2008;8:12. doi: 10.1186/1472-6963-8-12.
- Penfold RB, Zhang F. Use of interrupted time series analysis in evaluating health care quality improvements. *Acad Pediatr*. 2013;13(suppl 6):S38-S44. doi: 10.1016/j.acap.2013.08.002.
- Rabe-Hesketh S, Skrondal A. Multilevel and Longitudinal Modeling Using Stata. *Stat Methods Med Res*. 2016;25(6):3069.
- Hedeker D. A mixed-effects multinomial logistic regression model. *Stat Med*. 2003;22(9):1433-1446.
- Ten Have TR, Kunselman AR, Tran L. A comparison of mixed effects logistic regression models for binary response data. *Stat Med*. 1999;18(8):947-960.
- Cameron AC, Trivedi PK. Regression-based tests for overdispersion in the Poisson model. *J Econom*. 1990;46(3):347-364.
- Gardner W, Mulvey EP, Shaw EC. Regression analyses of counts and rates: Poisson, overdispersed Poisson, and negative binomial models. *Psychol Bull*. 1995;118(3):392-404.
- Cameron AC, Trivedi PK. *Microeconomics Using Stata: Revised Edition*. Stata Press; 2010.
- Kleinman LC, Norton EC. What's the risk? a simple approach for estimating adjusted risk measures from nonlinear models including logistic regression. *Health Serv Res*. 2009;44(1):288-302. doi: 10.1111/j.1475-6773.2008.00900.x.
- Berwick DM, Nolan TW, Whittington J. The triple aim: care, health, and cost. *Health Aff (Millwood)*. 2008;27(3):759-769. doi: 10.1377/hlthaff.27.3.759.
- Kessler RC, Bhandardkar S, Casey P, Tenner A. Predicting patient patterns in veterans administration emergency departments. *West J Emerg Med*. 2011;12(2):204-207.
- Using the PTSD Checklist (PCL). National Center for Posttraumatic Stress Disorder website. <https://sph.umd.edu/sites/default/files/files/PTSDChecklistScoring.pdf>. Published 2012. Accessed February 2016.
- O'Malley KJ, Cook KF, Price MD, Wildes KR, Hurdle JF, Ashton CM. Measuring diagnoses: ICD code accuracy. *Health Serv Res*. 2005;40(5, pt 2):1620-1639. doi: 10.1111/j.1475-6773.2005.00444.x.

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eAppendix

For the Interrupted Time Series study design that adjusts for PC-MHI, a general specification of the model is as follows:

$$g[E(Y|X)] = \beta_0 + \beta_1 * High_PACT_Implementation + \beta_2 * PACT(0,1) + \beta_3 * QTR + \beta_4 * PCMHI(0,1) + \beta_5 * PACT_QTR + \beta_6 * HPI_PACT + \beta_7 * HPI_QTR + \beta_8 * HPI_PACT_QTR + \beta_9 * PCMHI_QTR + \beta_{10} * PCMHI_PACT + \beta_{11} * PCMHI_HPI + \beta_{12} * PCMHI_HPI_PACT + \beta_{13} * PCMHI_QTR_HPI + \beta_{14} * PCMHI_PACT_QTR + \beta_{15} * X_i + \epsilon_{ij}$$

where: g is a link function estimated using a Flexible Mean Model; HPI = High Pact Implementation (veteran received care from a clinic in the top quartile of the PI^2 distribution); QTR represents quarter of data centered at PACT implementation on April 1, 2010; PC-MHI indicates that the patient had an encounter within the PC-MHI module; and, PACT = 1 in the post-PACT period.