THE EFFECT OF MENTAL HEALTH SPECIALIST USE ON HEALTHCARE UTILIZATION OF ADULTS WITH CO-OCCURRING DIABETES AND DEPRESSION

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ABSTRACT

Ching-Ching (Claire) Lin: The Effect of Mental Health Specialist Use on Healthcare Utilization of Adults with Co-occurring Diabetes and Depression
(Under the direction of Marisa E. Domino)

The population of individuals with multiple chronic conditions is growing and is estimated to have the highest healthcare utilization among other subgroups. Diabetes and major depressive disorder are two of the most common co-occurring chronic conditions. Those with co-occurring diabetes and major depressive disorder tend to incur higher healthcare utilization but lower rates of guideline-concordant care, compared to individuals with either condition only. While prior research has associated mental health specialist care with higher level of guideline-concordant depression care in individuals with depression, the increasingly shifting of treatment modality towards pharmacotherapy has led to more depression care at primary care settings. It is critical, therefore, to determine the effect of mental health specialist care on healthcare utilization, particularly among adults with co-occurring diabetes who are very primary care-based.

Using an economics theoretical framework, the objective of this study is to examine whether mental health specialist use affects healthcare utilization of adult Medicaid beneficiaries with co-occurring diabetes and major depressive disorder. First, with mental health specialist supply as instrumental variables and person-level fixed effect specification, this study examined primary care visit as well as guideline-concordant care for both major depressive disorder and diabetes as outcomes of interest. Second, this study investigated emergency department and hospitalization utilization outcomes with instrumental variables and General Estimating

Equations method. Results from this study show that mental health specialist care increases likelihood of receiving guideline-concordant depression care, reduces number of all-cause emergency department visits, and reduces likelihood of all-cause hospitalizations. It also increases probabilities of visiting a primary care provider and receiving annual eye exam, but decreases adherence level of receiving annual lipid test and A1c tests. Findings suggest that individuals with co-occurring diabetes and major depressive disorder will benefits from mental health specialist care as quality of depression care improves and emergency department and hospitalization utilization reduce. However, any policy aiming to improve mental health care delivery also needs to address the spillover effect of mental health care on other co-occurring conditions. Several areas for future research are suggested to advance our understanding of mental health care for people with multiple chronic conditions.

To Yicheng Egann Lin

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LIST OF ABBREVIATIONS

2SLS	Two-Stage-Least-Squares
2SRI	Two-Stage-Residual-Inclusion
ED	Emergency Department
FE	Fixed Effect
IV	Instrumental Variable
LPM	Linear Probability Model
MCC	Multiple Chronic Conditions
MDD	Major Depressive Disorder
N	Sample Size
OLS	Ordinary-Least-Squares

CHAPTER 1. OVERVIEW

1.1 Specific Aims

The population of individuals with multiple chronic conditions (MCC) is growing with the highest healthcare utilization in the US (G. Anderson, 2010; Goodman, Parekh, & Koh, 2012). Diabetes and major depressive disorders (MDD) are two of most common chronic conditions that tend to co-occur (Centers for Disease Control and Prevention, 2012; Egede & Ellis, 2010). Healthcare outcomes for these individuals tends to be worse, including lower adherence to guideline-concordant care and higher emergency room and inpatient utilization, compared to patients with either diabetes or MDD only (Desai, 2002; Egede, 2004). While depression is also a barrier to receiving guideline-concordant diabetes care, only a minority of patients with diabetes and MDD receive guideline-concordant care for depression (Egede & Ellis, 2010; W. J. Katon et al., 2004). The two major types of providers for depression care are primary care physicians and mental health specialists, including psychiatrists and other non-prescribers (Olfson et al., 2002; Wang et al., 2005b). Some research has demonstrated that mental health specialist care leads to 10%-20% higher levels of guideline-concordant depression care than primary care in individuals with MDD (W Katon, von Korff, Lin, Bush, & Ormel, 1992; Sturm, Meredith, & Wells, 1996). Yet mental health specialists and primary care were not directly compared in individuals with diabetes and co-morbid MDD. Thus evidence of mental health specialist care on guideline-concordant care in this population is less clear.

The utilization of mental health specialist care for depression remains low (Pratt & Brody, 2014b; Wang et al., 2005b; A. S. Young, Klap, Sherbourne, & Wells, 2001). In fact,

primary care physicians have become more engaged in providing depression care with pharmacotherapy (Lambert, Agger, & Hartley, 1999; Ng, Bardwell, & Camacho, 2002; Wang et al., 2005a). This is in part due to the introduction of newer antidepressants and the supply shortage of mental health specialist (Lambert et al., 1999). In reality, mental health specialists are not equally accessible to all patients. Thomas and colleagues reported that three-quarters of U.S. counties have a severe shortage of psychiatrists as well as other mental health specialists (Thomas, Ellis, Konrad, Holzer, & Morrissey, 2009). Lower supply of mental health specialist was associated with lower utilization of mental health specialist care among patients with MDD (Ettner & Hermann, 1997; Lindrooth, Lo Sasso, & Lurie, 2006). In light of the shortage of mental health specialist and the shifting of treatment modality towards pharmacotherapy, many studies have suggested that MDD is a chronic illness that can be effectively treated in primary care settings (Ford et al., 2002). As individuals with diabetes and MDD are mainly managed at primary care, examining the role of mental health specialist among this population is critical.

My long-term goal is to expand the understanding of the effect of different types of outpatient providers in the healthcare utilization of patients with co-occurring diabetes and depression. The objective of this dissertation is to examine how outpatient mental health specialist visits are affected by mental health specialist supply and whether mental health specialist use affects other types of healthcare utilization in this population. The central hypothesis is that mental health specialist use improves guideline-concordant care and reduces emergency room and inpatient services utilization. To test this hypothesis, this study proposes to conduct econometric analyses with Medicaid Claims data in North Carolina to test the following specific aims:

Among Adult Medicaid beneficiaries with co-occurring diabetes and depression,

***Aim* 1**: **To estimate the effect of mental health specialist supply on mental health specialist use and primary care visits**. The main hypothesis for this aim is that lower mental health specialist supply will decrease mental health specialist use, but mental health specialist visit could either increase or decrease primary care provider use depending whether primary care physicians and mental health specialists are substitution or complementary goods. By analyzing changes in local supply of mental health specialists, this Aim examined changes in probability of mental health specialist and primary care provider use using maximum likelihood estimation.

***Aim 2:* To estimate the causal effect of mental health specialist use on guideline-concordant care.** The main hypothesis for this aim is that mental health specialist care will improve guideline-concordant care for *both depression and diabetes*. It compared guideline-concordant care utilization between patients who had mental health specialist care and those who did not. The utilization outcomes are measured for depression care and diabetes care separately. An instrumental variable approach was implemented to correct the potential endogeneity of mental health specialist use.

***Aim 3:* To estimate the causal effect of mental health specialist use on emergency department and inpatient service use.** The main hypothesis for this aim is that increase in mental health specialist use reduces tertiary care. It compared tertiary care utilization between patients who had mental health specialist care and those who did not. An instrument variable approach was implemented to correct potential endogeneity of mental health specialist use.

1.2 Background

1.2.1. Individuals with multiple chronic conditions

Individuals with multiple chronic conditions (MCC) are a growing population in the United States. Roughly 1 in 4 Americans lives with the burden of more than one ongoing chronic condition, accounting for an estimated two-thirds of total US health care spending (G. Anderson, 2010; Machlin & Soni, 2013; Ward & Schiller, 2013). Individuals with MCC face complicated clinical needs and increased healthcare demands associated with adherence to complicated treatment regimens (E. a. Bayliss, Ellis, & Steiner, 2007). Healthcare utilization of individuals with MCC is usually much higher than their counterparts. For instance, the average expense among people with 4 or more chronic conditions was approximately 7 times greater than for people treated for no chronic conditions or only 1 chronic condition (Machlin & Soni, 2013), and nearly all of Medicare spending (96%) is on behalf of people with MCC (Weiss, 2007; Wolff et al., 2002). Today the number of persons living with MCC is still increasing dramatically in the United States (Bayliss et al., 2014). As this population grows, they and their healthcare needs have become challenging to both the clinical communities and policy authorities.

1.2.2. Diabetes and major depressive disorder

Diabetes and major depressive disorder (MDD) are two of the most common chronic diseases in the United States, and continue to increase in numbers and significance. Prevalence of diabetes has steadily increased since 1990 (Centers for Disease Control and Prevention, 2012). As of 2012, diabetes occurs in approximately 11.7 % of persons aged 45-64 and 18.9% of age 65+ in the US (Centers for Disease Control and Prevention, 2012). If the current growth trend continues, at least one of three adults in the US will be diagnosed with diabetes by 2050 (Boyle, Thompson, Gregg, Barker, & Williamson, 2010). As a major cause of heart disease and stroke,

diabetes can lead to severe health complication and even death when not managed appropriately (Centers for Disease Control and Prevention, 2012). MDD is also a common chronic condition in the US. It is a serious medical illness with mood, cognitive, and physical symptoms (American Psychiatric Association, 2013), associated with impaired functioning, diminished or lost productivity, increased health care utilization, decreased quality of life, and higher rates of other chronic disease (Egede & Ellis, 2010). Currently, MDD affects approximately 18.8 million adults, or about 9.5% of the U.S. population aged 18 years and older in a given year (Egede, 2007). Major depressive disorder is more prevalent among women than men, and approximately 25% of women and 16% of men will have a major depressive episode during their lifetime (Ronald C Kessler, Petukhova, Sampson, Zaslavsky, & Wittchen, 2012; Pratt & Brody, 2014b).

It is well established that psychiatric disorders tend to co-occur with chronic general medical illness. While both diabetes and MDD have significant public health implications, diabetes and MDD is actually one of the most prevalent combinations (Sambamoorthi, Olfson, Wei, & Crystal, 2006). They are considered one of the "natural clusters" of chronic illnesses—illnesses that tend to co-occur, mal-adaptively affect each other's course, and for which there are often overlapping guideline recommendations (Wayne Katon, Unützer, Wells, & Jones, 2010). Adults with diabetes have an increased risk of experiencing one or more depressive episodes in their lifetime than the general population, and the prevalence of MDD in patients with diabetes is estimated to be between 11% and 20% (Ali, Stone, Peters, Davies, & Khunti, 2006; Wayne Katon, Maj, & Sartorius, 2011). In one study, the prevalence of MDD among individuals with type II diabetes was even up to 39% (Sambamoorthi et al., 2006; Téllez-Zenteno & Cardiel, 2002). A meta-analysis concludes that comorbid MDD is more prevalent in individuals with diabetes than in other primary care patients (R. J. Anderson, Freedland, Clouse, & Lustman,

2001). Major depressive disorders are also shown to be associated with increased risk of obesity and developing diabetes (Eaton, Armenian, Gallo, Pratt, & Ford, 1996; Knol et al., 2006; Pratt & Brody, 2014a).

1.2.3. Worse health outcome associated with diabetes and major depressive disorder

Substantial evidence has suggested that MDD is associated with adverse health outcomes in diabetes such as higher HbAlc levels and an increased likelihood of complications among patients with diabetes. For example, an earlier meta-analysis concluded that MDD was significantly associated with poor glycemic control in individuals with diabetes with a standardized effect size of 0.17 increase on glycohemoglobin (Lustman et al., 2000). Higher HbA1c and more diabetes complications were found in African Americans with higher depressive symptoms (measured by Epidemiological Studies Depression scale (CESD)) after controlling for confounders (mean difference: 0.20 on HbA1c, 0.47 on number of complications) (Wagner, Abbott, Heapy, & Yong, 2009). Another meta-analysis found significantly greater diabetes complications including diabetic retinopathy, nephropathy, neuropathy, microvascular complications, and sexual dysfunction among patients with co-morbid MDD (De Groot, Anderson, Freedland, Clouse, & Lustman, 2001). A potential pathway from co-morbid MDD to worse diabetic outcome is worse adherence to diabetes care. Depressive symptom severity is associated with less adherence to dietary recommendations (adherence z-score -0.18 vs 0.28) and approximately twice as many interruptions in refills of oral hypoglycemics (Ciechanowski, Katon, & Russo, 2000). A systematic review of treatment adherence among individuals with diabetes and MDD also indicated that there was a significant relationship between MDD and treatment non-adherence (mean difference in HbA1c: 0.13) (Richardson, Egede, Mueller, Echols, & Gebregziabher, 2008).

Therefore, just like most MCC combinations, the impact of those two chronic conditions on health outcomes is greater than what it would be for patients with single conditions. Individuals with diabetes and comorbid MDD have higher odds of functional disability compared with individuals with either diabetes or MDD alone (Egede, 2004). Another large study also found that the coexistence of diabetes and MDD is associated with significantly higher mortality, and this risk is beyond that due to having either diabetes or MDD alone (Egede, Nietert, & Zheng, 2005). Further, while diabetes and MDD were independently associated with a greater risk for dementia, the combined association of both exposures with the risk for all-cause dementia was stronger than the additive association (Wayne Katon et al., 2015).

1.2.4. Mental health specialists and primary care providers for depression care

The major providers for depression care in the US are primary care physicians and mental health specialists, including prescribers and non-prescribers (Olfson et al., 2002; Wang et al., 2005a; A. S. Young et al., 2001). The core mental health specialist group as six major professions: psychiatrists, psychologists, advanced practice psychiatric nurses, social workers, licensed professional counselors, and marriage and family therapists. These six groups constitute a majority of mental health professionals, and information about them is critically important for mental health policy and planning, such as designation of shortage in the mental health profession (Health Resources and Services Administration, n.d.). Their roles in providing mental health services could be distinct as well as overlapping. For instance, psychiatrists prescribe medicine and conduct psychotherapy, while other non-prescriber specialists only provide psychotherapy. Psychologists provide testing and group therapy in institutional settings, while social workers and other therapists also provide family counseling, psychosocial assessments, and discharge planning (Stefos, Burgess, Cohen, Lehner, & Moran, 2012).

The introduction of selective serotonin reuptake inhibitors (SSRI) shifted treatment modality towards more pharmacotherapy during the 1990s (Olfson et al., 2002). Many SSRIs need only once-a-day dosing, require less frequent dose iterations, and are associated with fewer adverse events (Simon et al., 1996). Beginning in 1999, the SSRIs and other new antidepressants like bupropion began coming off patent and the availability of generics further continued the trend of greater medication use. For example, between 1996 to 2005, the percentage of adults with depression who received antidepressants increased from 65.1% to 75.2%, and the percentage who received psychotherapy for depression decreased from 56.6% % to 37.5 % among Florida Medicaid beneficiaries (Fullerton, Busch, Normand, McGuire, & Epstein, 2011). Rural individuals are even more reliant on pharmacotherapy than psychotherapy compared to those in urban areas (J. C. Fortney, Harman, Xu, & Dong, 2010).

Back to 1990s, a much higher proportion of individuals with major depression used depression care at mental health specialty sectors than at general medical sectors (21.2% vs 12.1%), according to the National Comorbidity Survey conducted in 1992 (R C Kessler et al., 1999). As the modality shifted to more pharmacotherapy, primary care physicians have become more engaged in providing depression care with pharmacotherapy, especially in rural areas where there is a limited supply of mental health specialist (Lambert et al., 1999; Ng et al., 2002). In fact, the National Comorbidity Survey replication in 2003 showed that 32.5% of individuals with major depression utilized services in the general medical sector, while only 20.6% used psychiatrist services and 23.1% used services provided by other mental health specialists (Wang et al., 2005a). The growth of depression care utilization in primary care is higher than that in mental health specialty sectors (Wang et al., 2005a), as both the growth rate and use rate of mental health specialist remained low (Wang et al., 2005a; A. S. Young et al., 2001). Low rates

of mental health specialist among individuals with depression are also documented in other studies. For example, a prior telephone survey found that during 1997 and 1998, while 77.7% of individuals with a depressive disorder have seen a primary care physician, only 17.7% had seen a mental health specialist (A. S. Young et al., 2001). A more current National Health and Nutrition Examination Survey found that during 2009-2012, only 35% of all Americans with severe depressive symptoms reported having seen a mental health professional within the year (Pratt & Brody, 2014b).

1.2.5. Mental health specialist supply

The lack of access to mental health specialists has been a critical factor contributing to the low growth and low rate of mental health specialist use. An earlier study indicated that in 2001, over 50% of U.S. counties have whole county shortages of mental health specialist (Merwin, Hinton, Dembling, & Stern, 2003). In 2007, Thomas and colleagues reported that about three-quarters of U.S. counties were estimated to have a severe shortage of psychiatrists as well as other mental health specialists (Thomas et al., 2009). Literature indicated that provider supply is an important determinant of outpatient service utilization in general populations, and its effect is particularly evident in the mental health sector. For example, Ettner and colleagues (1997) found a greater number of psychiatrist per 1,000 county residents is associated with a higher probability of mental health specialist use in Medicare beneficiaries with depression as well as other mental health conditions (Relative Risk 1.34 for aged and 1.12 for disabled) (Ettner & Hermann, 1997). Although Ettner and colleagues (1997) found that a greater number of psychologists is associated with lower probability of mental health specialist use among disabled Medicare beneficiaries, they argued that this is because many beneficiaries pay out-of-pocket for psychologist services (Ettner & Hermann, 1997). Lambert and colleagues (1999) also found that

higher number of core mental health providers in a Primary Care Analysis Area (PCAA) is associated with both higher odds (OR: 1.12) and higher number (0.133) of mental health specialist visits among Medicaid beneficiaries with depression in Maine (Lambert et al., 1999). A lower mental health specialist supply might reduce utilization through longer distance to care or more travel time, as mental health care utilization is very sensitive to distance to providers (Lindrooth et al., 2006; Schmitt, Phibbs, & Piette, 2003). Increased travel time to providers was found to be associated with fewer visits and a lower probability of receiving care consistent with guidelines for the treatment of depression (J. Fortney, Rost, Zhang, & Warren, 1999). Although the extent to which primary care providers can act as substitutes for mental health specialists has been unclear (Eisenberg, 1992; Mechanic, 1990), a low supply of mental health specialist might also contribute to the rising rate of primary care physicians treating mental health problems, along with the treatment modality shifting. Lower number of psychiatrists per county was found associated with increased use in the primary care sector among Medicare beneficiaries with mental health conditions (Relative Risk 1.34 for aged and 1.12 for disabled) (Ettner & Hermann, 1997).

1.2.6. Mental health specialist care for individuals with co-occurring diabetes and major depressive disorder

For individuals with MCC, mental health services are often provided by primary care physicians in conjunction with care of non-psychiatric conditions (Robiner, 2006). Primary care physicians are often the initial health care contact for patients with depression (Norquist & Regier, 1996; Williams et al., 1999; A. S. Young et al., 2001). Given patients' frequent contact with primary care providers, the impact of mental health specialist care in this population is unclear. As mental health specialists are not accessible to all, it is important to investigate the

implications of mental health specialist care among those with co-occurring mental health and physical health conditions. This study is focused on individuals with co-occurring diabetes and depression, as those two are the most prevalent chronic conditions. The previous literature presented the effect of mental health specialist on guideline-concordant depression care among those with depression, but provided limited evidence on the population with co-morbid diabetes. Further, prior studies that investigated the effect of mental health specialist care on guideline-concordant diabetes care had notable study limitations, and the evidence is still inconclusive. Finally, very little evidence is available on the effect of mental health specialist care on ER/hospitalization use in individuals with depression and diabetes. In the era of promoting integrating mental health into primary care settings, it is critical to re-examine the role of mental health specialists in caring for depression as well as the effect of mental health specialist care on other types of healthcare utilization for individuals with MCC.

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CHAPTER 2. STUDY 1: WHO SHOULD TREAT DEPRESSION AMONG ADULTS WITH CO-OCCURRING DIABETES? – THE EFFECT OF MENTAL HEALTH SPECIALIST USE ON GUIDELINE-CONCORDANT DIABETES CARE OF ADULTS WITH CO-OCCURRING DIABETES AND MAJOR DEPRESSIVE DISORDER

2.1 Background

Individuals with multiple chronic conditions are a growing population in the United States. From 2001 through 2010, the prevalence of multiple chronic conditions has significantly increased from 21.8% to 26.9% (Ward & Schiller, 2013). While both diabetes and major depressive disorder (MDD) have significant public health implications, diabetes and MDD are one of the most prevalent combinations of common chronic conditions that tend to co-occur and affect each other's course (Ali, Stone, Peters, Davies, & Khunti, 2006; Eaton, Armenian, Gallo, Pratt, & Ford, 1996; Katon, Maj, & Sartorius, 2011; Pratt & Brody, 2014a; Sambamoorthi, Olfson, Wei, & Crystal, 2006). Adults with diabetes have an increased risk of experiencing one or more depressive episodes in their lifetime than the general population, and the prevalence of MDD in patients with diabetes is estimated to be between 11% and 20% (Ali et al., 2006; Wayne Katon et al., 2011). Further, MDD is shown to be associated with increased risk of obesity, glycemic level, diabetic complications including diabetic retinopathy, nephropathy, neuropathy, microvascular complications, and higher mortality among individuals with diabetes (De Groot et al., 2001; Eaton et al., 1996; Egede et al., 2005; Knol et al., 2006; Lustman et al., 2000; Pratt & Brody, 2014a).

A potential pathway from co-morbid MDD to worse diabetic outcome is worse adherence to diabetes care. A systematic review of treatment adherence among individuals with diabetes and MDD indicated that there was a significant relationship between MDD and treatment non-

adherence (mean difference in HbA1c: 0.13) (Richardson et al., 2008). It is well documented that adherence to recommended preventive screenings for diabetes was associated with significantly reduced rates of hospitalization and better health outcomes (Harman et al., 2010; Sloan, Bethel, Lee, Brown, & Feinglos, 2004; UK Prospective Diabetes Study (UKPDS) Group, 1998; Vijan, Hofer, & Hayward, 2000), yet rates of screening are still suboptimal. Roughly, 50% of patients with diabetes in the US did not receive appropriate diabetes preventive care (Banta, Morrato, Lee, & Haviland, 2009; Beckles et al., 1998; Peters, Legorreta, Ossorio, & Davidson, 1996; Sloan et al., 2004). It is concerning that individuals with co-occurring diabetes and MDD are less likely to receive guideline-concordant diabetes care compared with those with diabetes only (Desai, 2002; Domino et al., 2014; Druss et al., 2012; Egede, Ellis, & Grubaugh, 2009; Lin et al., 2004). For example, individuals with MDD had lower odds of receiving an annual eye exam than those without (OR=0.70) (Egede et al., 2009). A survey conducted in a large health maintenance organization also found that those with MDD are less likely to receive HbA1c test within the last year than those without depression (6.3% vs 4.0%) (Lin et al., 2004).

Guidelines recommended that individuals diagnosed with MDD be treated with antidepressant medication, psychotherapy, or a combination of the two modalities (American Psychiatric Association, 2010). An important group of providers for depression care are mental health specialists, including prescribers, such as psychiatrists and psychiatric nurses, and other non-prescribers, such as psychologists, social workers, family and marriage therapists, and counselors. However, over half of U.S. counties have shortages of mental health specialists (Merwin, Hinton, Dembling, & Stern, 2003), and about three-quarters of U.S. counties were estimated to have a severe shortage of psychiatrists (Thomas, Ellis, Konrad, Holzer, & Morrissey, 2009). On the other hand, the treatment modality of depression care has been shifted towards

more pharmacotherapy since the 1990s (Olfson et al., 2002). This treatment modality change coupled with the lack of access to mental health specialists has contributed to the shifting of depression care utilization from mental health specialty to primary care settings (Ettner, Hermann, & Tang, 1999; Wang et al., 2005). Research using the National Health and Nutrition Examination Survey found that during 2005-2006, only 39% of all Americans with severe depressive symptoms reported having seen a mental health professional within a year, and this statistic dropped to 35% during 2009-2012 (Pratt & Brody, 2008, 2014b). Primary care physicians have become more engaged in providing depression care with pharmacotherapy, especially in rural areas where there is a limited supply of mental health specialists (Lambert, Agger, & Hartley, 1999; Ng, Bardwell, & Camacho, 2002).

Some literature has indicated mental health specialist care improves depression symptoms more significantly than other providers among those with MDD only (Katz, Kessler, Lin, & Wells, 1998; Sturm, Meredith, & Wells, 1996; A. S. Young, Klap, Sherbourne, & Wells, 2001); in theory, as MDD is associated with lower adherence to diabetes care, improvement in depression symptoms could lead to better adherence to diabetes care (Gonzalez et al., 2008). On the other hand, mental health specialist care may also impose additional costs through the addition of another specialist and further crowd out guideline-concordant diabetes care. The effect of mental health specialist care on guideline-concordant diabetes care among individuals with co-occurring diabetes and MDD, however, is less investigated.

The objective of this study is to examine whether the use of mental health specialists for depression care affects guideline-concordant care for diabetes. Because the use of mental health specialists is potentially endogenous, I controlled for person-level fixed effects to address the endogeneity of mental health specialist use caused by unobserved time invariant person-level

characteristics that could jointly determine mental health specialist use and the probability of receiving guideline-concordant diabetes care. I also use instrumental variables that identify three different constructs of mental health specialist supply. Those instruments together are credibly excluded from the main equation predicting guideline-concordant diabetes care. To the best of my knowledge, this study is the first to model mental health specialist use as endogenous with instrument/fixed effect specifications to determine the "spillover" effect of mental health specialist care on receiving guideline-concordant care.

2.2 The Effect of Mental Health Specialist Care

Overall, the roles of different types of mental health specialists in providing mental health services could be distinct as well as overlapping. For instance, only psychiatrists and psychiatric nurses can prescribe medicine, but most specialists can provide some types of psychotherapy, including testing and group therapy in institutional settings, family counseling, and psychosocial assessments (Stefos, Burgess, Cohen, Lehner, & Moran, 2012). On the other hand, primary care providers can prescribe medicine, but most of them are not trained to provide any psychotherapy.

2.2.1 Effect of mental health specialist care on depression care outcomes

Many studies have demonstrated the positive effect of mental health specialist care on improving guideline-concordant depression care. In the quasi-experimental Medical Outcomes Study, patients with MDD seen by psychiatrists had better guideline-concordant depression care, measured by antidepressant use and counseling, than those treated by primary care physicians only (Sturm & Wells, 1995). In an analysis of the National Comorbidity Survey, 29% of individuals with MDD seen by mental health specialists received appropriate management

(medication and four or more mental health visits), while only 13.8% of those seen by general physicians received same appropriate care, and this difference is higher for persons with greater severity of illness (Katz et al., 1998). However, this study examined the cross-sectional correlations without differentiating effect of mental health specialist care from effect of different baseline factors between those seeing specialists and general physicians. A quasi-experimental study also reported similar findings. This study with a telephone survey among individuals with MDD and anxiety disorders examined appropriate care, defined as use of either appropriate psychotropic medication or appropriate counseling during the prior year. Their results showed a much higher proportion of receiving appropriate care in those with some mental health specialist visits than in those with primary care visits only (88.6%-89.9% vs 19.5%) (A. S. Young et al., 2001). Those results did not directly apply to estimate the effect on care for MDD as separate from anxiety disorders (A. S. Young et al., 2001).

2.2.2 Effect of mental health specialist care on diabetes care

Very few studies focused on the effect of mental health specialist care on guideline-concordant diabetes care outcome among individuals with MDD or other psychiatric co-morbidities. A study utilizing Medicaid claims data investigated the effect of a seeing a fee-for-service psychiatrist on receiving guideline-concordant diabetes care among California Medicaid enrollees with diabetes and psychiatric co-morbidities. Results showed that those seen by a fee-for-service psychiatrist had higher odds of having lipid testing (OR 2.35) or eye examinations (OR 2.03), but had no significant difference on the odds of receiving annual A1c test (Banta et al., 2009). However, it is unclear whether the same effect applies to the subsample with MDD and diabetes, as this study was not depression focused.

Many collaborative care models incorporate mental health specialty care into primary care for individuals with co-occurring diabetes and depression. In a large randomized clinical trial (RCT), an intervention delivered by a depression clinical specialist nurse in collaboration with the primary care physician showed significant greater improvement in the adequacy of the dosage of antidepressant medication treatment, but showed no improvement in HbA1c (W. J. Katon et al., 2004). In another RCT for low-income Hispanic subjects, the intervention provided psychotherapy by a social worker and antidepressant prescribed by primary care physicians with a psychiatrist providing supervision and consultation, while the control arm provided antidepressants from primary care physicians only; their results showed improvements in functioning and decreased diabetes and pain symptom burden (Ell et al., 2010). To the best of my knowledge, there have been no studies examining the effect of mental health specialists on guideline-concordant diabetes care for individuals with co-occurring MDD and diabetes.

2.3 Method

2.3.1 Conceptual framework

I consider two types of providers for depression care: mental health specialists and primary care providers. I posit that depression care provided by mental health specialists would affect receipt of guideline-concordant diabetes care differently than depression care provided by primary care providers. There are two potential causal pathways for this differential treatment effect.

First, mental health specialist care increases the probability of receiving of diabetes care by increasing the marginal returns on health to depression care. Major depressive disorder has been found to be associated with lower adherence to preventive care for diabetes (Desai, 2002;

Domino et al., 2014; Druss et al., 2012; Egede et al., 2009; Lin et al., 2004). Specifically, individuals with more severe depression symptoms are more likely to avoid activities that will bring rewards in the future, such as healthier diets or exercise (Wenze, Gunthert, & German, 2012). As a decision maker, while accounting for future consequences of present health investment in diabetes care, an individual with depression may misperceive probabilities of benefits and harms on future health production from their current health investments. As mental health specialists may provide better depression care than primary care providers and more effectively alleviate depression symptoms (Katz et al., 1998; Sturm & Wells, 1995; A. S. Young et al., 2001), individuals receiving mental health specialist care may perceive higher marginal benefits of current investments in diabetes care on health. Therefore, the marginal return of mental health specialist care on health production could be higher than that of primary care, and thus leads to better adherent to guideline-concordant diabetes care.

Second, mental health specialist care could also crowd out diabetes care investment and lead to lower adherence to diabetes care guidelines. Individuals who see a mental health specialist may be more likely to shift resources from diabetes care to depression care. For instance, due to the limited supply of mental health specialists in many areas, travel cost for visiting a mental health specialist is usually higher than visiting a primary care provider. In theory, within the same budget constraint, the cost and time available for diabetes care will become lower among individuals receiving mental health specialist care than among those without. Therefore, those individuals are less likely to receive guideline-concordant diabetes care.

Another deciding factor for receiving guideline-concordant diabetes care could be the dynamic and focus of a primary care visit, as it could be different once an individual receives mental health specialist care and the direction of the effect is ambiguous. The “competing

demands" model suggests that during a primary care visit for individuals with multiple chronic conditions, patients and physicians bring an implicit agenda of issues; however they can only address some of the problems due to time constraints, leaving some other problems for subsequent visits (Nutting, Rost, Smith, Werner, & Elliot, 2000; Rost et al., 2000). If receiving mental health specialist care brings more focus on MDD care during primary care visits, diabetes care might be left out or postponed to subsequent visits. As the marginal benefits of subsequent primary care visits are reduced, patients are less likely to make those visits; as a result, diabetes care is substituted with depression care.

Alternatively, the focus of primary care might actually increase the focus on diabetes care. As mental health specialists have shared some part of depression care, the primary care visits may be increasingly diabetes-focused. Therefore, a subsequent primary care visit on health could increase as the quality of diabetes care increases, and this increase in marginal return could further increase investment in diabetes care.

In sum, although mental health specialist care might increase receiving of guideline-concordant diabetes care through better depression care, the higher marginal cost of mental health specialist care might impose an opposite effect on diabetes care. Further, the focus of primary care visits could either increase or decrease the probability of adherence to diabetes guideline through affecting the marginal return of diabetes care, depending whether those visits are more depression or diabetes-focused. Therefore, the effect of mental health specialist visits on diabetes care outcomes is ambiguous a priori and an important empirical question

2.3.2 Data

2.3.2.1 Estimation Sample

Data come from the North Carolina Medicaid Analytic Extracts (MAX) from 2006-2011, which contains enrollment information and final action claims for all Medicaid fee-for-service beneficiaries in North Carolina. The available types of claims include outpatient care, prescriptions, emergency room visits, and hospitalization. I restricted the estimation sample to adult beneficiaries aged 18 or older who had at least one inpatient or at least two outpatient diagnoses of diabetes (International Classification of Disease version 9 [ICD-9] code: 250.XX 357.2X, 362.0X, 366.41) and MDD ([ICD-9] code: 296.2X, 296.3X, 300.4X, 311.XX) during the study period. Data were collapsed to annual summaries and a person-year is included if the beneficiary had at least one month of Medicaid enrollment in that year. I excluded person-years with: (1) Medicaid and Medicare dual coverage (potential for incomplete information on healthcare utilization); (2) long-term care facility service use (beneficiaries are less likely to receive outpatient visit claims) or (3) one of the five (of 100) counties where mental health services were carved-out during this time period (mental health care utilization for such patients were incomplete in MAX files). The final estimation sample includes 22,392 unique persons with co-occurring diabetes and MDD during 2006-2011, contributing 76,369 person-years to the analysis. Average age was 45, 22% of the sample were male, 41% were African American, 79% lives in an urban area, and the average enrollment in a calendar year was 11 months (Table 2.1).

2.3.2.2 Key measures

The primary dependent variables include three binary indicators of guideline-concordant diabetes care, following Healthcare Effectiveness Data and Information Set recommendations (The Healthcare Effectiveness Data and Information Set, n.d.): whether individual had (1) a lipid

test at least once during the year, (2) an A1c test at least twice during the year, and (3) an eye exam at least once during the year. It is important to note the different settings for these tests: the lipid and A1c tests are usually performed at primary care, where as the eye exam is typically performed at an eye specialty setting. .

Our secondary outcome was having a primary care visit, as two of the three quality measures are mostly delivered through primary care (Egede et al., 2009; Sloan et al., 2004). Primary care use is measured as an indicator of whether a patient has any visits to a primary care provider in a year, identified by outpatient visits to providers with primary care-relevant specialty codes. On average, nearly three quarters (72.71%) of the annual observations had at least one primary care visit per year during 2006-2011. The average rates of preventive screenings are 58.04%, 39.59%, and 17.62% for an annual lipid test, two A1c tests a year, and annual eye exam (Table 2.1).

Mental health specialist use is the key independent variable in this study. It is defined as a binary indicator of whether an individual had any visits to a psychiatrist, psychologist, psychological associate, mental health nurse practitioner, licensed clinical social worker, mental health HMO, Assertive Community Treatment Team, or Critical Access Behavioral Health Agencies. On average, 31.6% of the annual observations in this study had at least one mental health specialist visit during a year.

2.3.2.3 Instrumental variables

Mental health specialist use is subject to potential endogeneity. First, visits and testing may reflect severity of illness not recorded in claims data and not accounted for by the other independent variables. Second, since treatment choice could be heavily driven by personal preferences, decisions to visit a mental health specialist or another provider could be jointly

determined by unobservable person-level factors. Therefore, the effect of mental health specialist care would not be identified without correcting for endogeneity.

Three variables were identified as potential instruments to correct the endogeneity: a local preference-based variable determined by the utilization pattern of mental health specialist use among Medicaid beneficiaries at the county-level (Basu, Heckman, Navarro-Lozano, & Urzua, 2007), the total number of licensed mental health specialists in each county from North Carolina Health Professions Data System (HPDS) (Richman, Fraher, & Gaul, 2015), and the total number of mental health specialists accepting Medicaid patients. As valid instruments, all variables should be independent of diabetes care and only affect diabetes care outcomes through mental health specialist use. In theory, the regional supply of mental health specialists affects individual mental health specialist use through affecting travel cost to a Medicaid mental health specialist or simply through changing local preferences for mental health specialty care.

The first instrument, mental health specialist use rate, is defined as the proportion of all Medicaid beneficiaries who had any mental health specialist use during the year at the county-level. This variable represents local preference and geographic variation in mental health specialist care selection. The variation in local treatment selection is possibly through a historical practice style, which is plausibly independent of underlying health, preferences and outcomes of the patients (Basu et al., 2007). The full Medicaid sample regardless of diagnosis was used to generate variables reflecting total number of Medicaid beneficiaries enrolled by county as well as the proportion of beneficiaries with at least one mental health specialist visit at county-level.

The second measure, defined as the total number of psychiatrists and psychologists in a county, comes from North Carolina Health Professions Data System (HPDS) (Richman et al., 2015). Due to data availability in HPDS, this measure includes only psychiatrists and

psychologists, the two major types of mental health specialist (Richman et al., 2015). Nevertheless, this measure is likely to reflect the availability of mental health specialist services more generally, as indicated by the high correlation between number of psychiatrists, psychologists, and other non-prescriber specialists at the county level (Ellis, Konrad, Thomas, & Morrissey, 2009).

The third measure, Medicaid mental health specialist supply, is defined as the number of mental health specialists that had seen at least one Medicaid beneficiaries in a year at county-level. A Medicaid provider is identified with a unique provider identifier that had at least one claim for a Medicaid beneficiary in a year. The unique identifiers used are state-assigned Medicaid billing identifiers prior to 2009 and National Provider Identifier (NPI) beginning 2009. The Medicaid mental health specialist supply is measured as the total number of Medicaid mental health specialist in a year at county-level. Note that a provider could be counted more than once as she might be identified from different counties in a year. The full sample regardless of diagnosis was used to identify Medicaid mental health specialist. The correlation coefficient between those two supply measures is 0.6398.

2.3.2.4 Other control variables

Other important control variables included patient demographics, diabetes complications, other psychiatric co-morbidities, and other co-morbidities. Patient demographics include age, gender, race, and living in a rural area. Although the claims data do not contain direct measurement of complications and co-morbidity, I used specific associated diagnoses as proxy. For diabetes, I included the following major complications (Bethel, Sloan, Belsky, & Feinglos, 2007): diabetic eye disease (low vision or blindness), chronic renal failure, ESRD, gangrene, debridement, amputation, myocardial infarction, congestive heart failure, and stroke. I

included an index of diabetic complication in the model, defined as the sum of the number of diabetes complications each year. In the eye exam model, the diabetic eye disease was excluded from this index but was controlled as an independent binary variable, as having a diabetic eye disease is likely to increase the probability of visiting a specialty optometry setting. I also identified any insulin use for diabetes in the model, as insulin use typically indicates more severe diabetes (Gamble, Simpson, Eurich, Majumdar, & Johnson, 2010; B. A. Young et al., 2008). I used binary indicators for bipolar disorder and schizophrenia, as individuals with those conditions might be more likely to use both mental health specialist care and primary care.

In addition to diabetes complications and other psychiatric co-morbidities, I also included general co-morbidities in all analyses. Risk adjustment models with both diabetes-specific and generic comorbidity measures have been found to be associated with greater predictive power on healthcare expenditures than either diabetes-specific or generic comorbidity measure alone (Maciejewski, Liu, & Fihn, 2009). Therefore, the combination of generic and disease-specific measures should lead to greater predictive power on probability of receiving different types of outpatient care utilization. I used the Chronic Illness and Disability Payment System (CDPS) to identify general co-morbidities during the year. There are twenty major categories of diagnoses in CDPS (version 6.0), and most of the major categories are further divided into several subcategories according to the degree of the increased expenditures associated with the diagnoses (Kronick, Gilmer, Dreyfus, & Lee, 2000). I included binary indicators for all 58 subcategories for current year in the model.

2.3.3 Empirical specifications

To estimate the effect of mental health specialist use on the four outcome measures, the empirical estimation takes two different forms of specification: Two-Stage-Least-Squares

(2SLS) and Probit-Probit Two-Stage-Residual-Inclusion (2SRI) with raw residuals. The 2SLS estimation takes the following two major equations with *i* denotes individual, *t* denotes year (2006-2011), and S_{it}denotes a binary indicator for mental health specialist use:

$$\Pr_{it}(S_{it} = 1) = \alpha_0 + \alpha_1 F_t + \gamma_1 X_{it} + \nu_{it} \ldots\ldots (1.1)$$

$$\Pr_{it}(C_{it} = 1) = \delta_0 + \boldsymbol{\delta_1} \hat{S} + \gamma_2 X_{it} + \varepsilon_{it} \ldots\ldots (1.2)$$

where $\hat{S}$ in equation (1.2) is the predicted probability of mental health specialist use from the first stage (equation 1.1).

The Probit-Probit 2SRI estimation takes the following,

$$\Pr(S_{it} = 1) = \Phi(\alpha_2 + \alpha_3 F_t + \gamma_3 X_{it} + \nu_{it}) \ldots\ldots (2.1)$$

$$\Pr_{it}(C_{it} = 1) = \Phi(\delta_2 + \boldsymbol{\delta_3} S_{it} + \delta_4 \hat{v}_{it} + \gamma_4 X_{it} + \varepsilon_{it}) \ldots\ldots (2.2)$$

where $\hat{v}_{it}$ in equation (2.2) is the predicted raw residuals from the first stage (equation 2.1), measured as the difference between predicted probability of $\Pr(S_{it} = 1)$ and the actual value of S_{it}. In equation (1)-(2), F_s denote a vector of instrumental variables. The vector C_{it} denote outcomes of interests for person *i* in year *t*, including binary indicators for any primary care visits during a year, annual lipid test, two A1c tests during a year, and annual eye exam. The probability of receiving guideline-concordant care or having any primary care visits is a function of mental health specialist use (S_{it}), and a vector of exogenous variables X_{it}, including patient demographics and comorbidities. The main parameters of interest are $\delta_1$and δ_3, the endogenous effect. If $\delta_1$and δ_3 are non-zero and statistically significant, interventions that change mental health specialist use would be predicted to spillover on primary care use and the probability of being guideline-concordant for diabetes care among individuals with co-occurring diabetes and depression.

If one could reasonably assume that the unobserved severity of chronic conditions or personal preferences do not vary during fairly short time periods, including person-level fixed effect would alleviate the endogeneity problem. Therefore, I estimated person-level fixed-effects with linear probability models. Alternatively, if most endogeneity was mostly caused by unmeasured time-variant personal preferences or disease severity, fixed effect estimation will not appropriately address this omitted-variable bias. Therefore, I also used instrument variables to estimate the local average treatment effect (LATE). LATE estimates generated from observational data often represent the average effect of treatment for patients with uncertainty in treatment choice, or so called "marginal individual," these are the patients who are most likely to have treatment decisions influenced by changes in the instruments (Angrist, Imbens, & Rubin, 1996; Chapman & Brooks, 2016). For the robustness of estimation, both 2SLS and 2SRI were estimated for each outcome. Two-Stage-Least-Squares were estimated both with and without person-level fixed effects, while the 2SRI models were only estimated cross-sectionally without fixed-effects as non-linear IV models including fixed effects tend to yield inconsistent estimation and therefore have different interpretations (Cameron & Trivedi, 2005). All resulting estimations for effect of mental health specialist care on outcome of interests (δ_1 in equation (1.2) and δ_3 (2.2)) are shown in Table 2.3 through Table 2.6. For easier comparison across naïve and IV models, results from LPM are presented when 2SLS is the presented, and results from probit models are presented when 2SRI is presented.

Specification tests were performed to assess the strength of the instrumental variables, over-identification restriction, and exogeneity. Strengths of different sets of instrument variables were tested with the first stage of 2SLS (LPM) or 2SRI (probit). All over-identifying tests and exogeneity tests were performed in LPM-FE models even when the preferred specification is

2SRI, as such tests are not available in a non-linear IV models. Sargan-Hansen's tests for over-identifying restriction were conducted to identify the most appropriate combination of instruments for each outcome. Finally, Wooldridge's score tests were conducted to test the exogeneity of mental health specialist use in all models.

Table 2.2 shows results from specification tests and level of identification. All instrument sets are strong predictors of mental health specialist use in the first stage of 2SLS or 2SRI estimation ($p<0.001$) (Table 2.2). The test statistics for the joint F-test reported in lipid test model and A1c test model are 67.01 and 83.50, and the Chi-square statistics in eye exam and primary care models are 53.83 and 52,92, showing the joint statistical significance of the proposed instruments in predicting mental health specialist use. Results from over-identification tests showed that mental health specialist use rate and HPDS mental health specialist supply together are jointly validly excluded from the second stage of estimating annual lipid test; mental health specialist use rate and Medicaid mental health specialist supply are jointly valid instruments for estimating A1c tests; HPDS mental health specialist supply and Medicaid mental health specialist supply are jointly valid instruments for estimating both probabilities of having an eye exam and any primary care visits. Additionally, the rejected exogeneity test in all specifications ($p<0.001$) indicates endogeneity of mental health specialist care.

Three sets of sensitivity analyses were conducted. First, to examine the influence of unmeasured depression severity, three depression care utilization variables from the prior year (lagged)--hospitalization for depression, having any antidepressant use, and having any psychotherapy-were included as covariates. Because of the reliance on prior year's data for this model, including lags excluded 29.32% of the original sample and reduced the estimation sample to 53,977. Results from analyses on this subsample are similar to the original results except both

estimates of mental health specialists on lipid and A1c tests from the 2SLS-fixed effect models became insignificant. Second, I restricted the estimation sample to individuals who were enrolled in Medicaid for at least 9 months during a year. This enrollment restriction excluded 16.79% of the original estimation sample, and the results are similar to the original estimates, in terms of the magnitude and significance. Additionally, it is possible that treatment choices for mental health specialist care between individuals with and without severe mental illness are heterogeneous. Therefore, separate analyses were also conducted on the subgroup without severe mental illness (sample size 51,950). Overall, results on all those different subsamples are very similar to those on the full sample and therefore are not separately reported but available upon request.

2.4 Results

Table 2.3 presents estimates of the differential effect of mental health specialist use on the expectation of receiving an annual lipid test. In Column (1) and (2), the LPM model and LPM fixed effect model both predict a positive association between mental health specialist use and receiving annual lipid test. Both the IV models with and without fixed effects (Column (3) and (4)), however, predict the effect in an opposite direction. The preferred specification (Column (4)) shows that, with endogeneity adjusted by valid instruments and person fixed effects, mental health specialist use is found to induce a significant 44.3 percentage point reduction in the expected probability of receiving an annual lipid test. The 2SLS without fixed effects model (Column (3)) also shows a similar negative differential effect. This result suggests that for a marginal individual who has co-occurring diabetes and depression and would increase their use of mental health specialist care due to the changes in either local preference or higher supply of mental health specialist, receiving mental health specialist care will decrease her

probability of receiving an annual lipid test for guideline-concordant diabetes management. Further, the differences in results from fixed effect models with IV and without IV (Column (3) and Column (4)) implied that the major causes of endogeneity in estimating receiving lipid tests are possibly time-variant. For individuals who were diagnosed with severe mental illness (bipolar disorder or schizophrenia) during the current year, the probability of receiving a lipid test increases by 3.6 percentage points compared to those without any severe mental illness.

Table 2.4 presents parameter estimation for effects of mental health specialist use and other controlled variables on expectation of receiving at least two A1c tests per year. The 2SLS with fixed effect models reports a significant negative effect with a magnitude of 31.5 percentage points (Column (4)). Note that similar to the lipid outcome model, result from IV models show the effect of mental health specialist care in the opposite direction of the effect reported by OLS model (Column (1)) and LPM fixed effect model (Column (2)). This result suggests that for an individual with co-occurring diabetes and MDD who would increase use of mental health specialist care due to the changes in either local preference or higher supply of mental health specialist, receiving mental health specialist care will decrease her probability of receiving at least two A1c tests during a year.

Table 2.5 shows results for estimating differential effect of mental health specialist as well as marginal effects of other variables on receiving annual eye exam. After adjusting for endogeneity with two instruments, the 2SRI model finds strong positive differential effects as 5.2 percentage points (Column (3)). Note that LPM fixed effect model in Column (2) also shows a significant positive effect of mental health specialist use. Overall, mental health specialist use increases probability of receiving an annual eye exam among those marginal individuals who would change their mental health specialist use for a change in local supply. Having any insulin

use or having any diabetic eye disease both increase probability of receiving an eye exam significantly. The number of diabetic complications is negatively affecting receiving an annual eye exam.

Table 2.6 presents the results of the impact of mental health specialist use and other controlled variables on the probability of having any primary care visits. In model 1 of Table 2.3, the naïve probit estimation shows that mental health specialist use is associated with 1.8 percentage point increase in probability of having any primary care visit. The LPM fixed effect model shows a slightly lower differential effect of mental health specialist use as 1.5 percentage points. The 2SRI estimation indicates mental health specialist use leads to a much larger positive differential effect as a 14.4 percentage point increase on probability of visiting a primary care provider. Overall, the mental health specialist use leads to a higher probability of having any primary care visits, and the effect is slightly smaller after the potential endogeneity is adjusted. Further, as 2SRI estimation shows, older age leads to decrease in probability of having any primary care visits, but the magnitude is fairly small as 0.2 percentage points. Additionally, being a male, an African American, and living in an urban area all decrease probability of having any primary care visits.

2.5 Discussion

Among patients with co-occurring diabetes and MDD, mental health specialist use decreased the probabilities of receiving two guideline-recommended primary care-based tests: annual lipid test and at least two A1c tests in a year, even after adjusting for diabetes complications and other co-morbidities. This implies that although such patients who go to a

mental health specialist also have higher likelihood of connecting with a primary care provider, they are less likely to be guideline-concordant on diabetes care at primary care.

There are several possible explanations for this surprising finding. First, it is possible that patients are substituting diabetes care with depression care. From a patient's perspective, treating MDD at mental health specialty might lead to less available time for diabetes follow-up care at primary care. A patient's limited time budget could lead to a crowding out effect of mental health specialty care on diabetes management. Further, although the current study shows that patients with mental health specialist care are more likely to visit a primary care physician, physician visits do not assure that patients receives recommended services. A provider may fail to follow the diabetes guideline by only responding to immediate concerns that a patient made the visit for. Alternatively, once an individual with co-occurring diabetes and MDD decides to seek mental health specialist care, the primary care physician might decide to address only one condition and the depression treatment or focus crowds out staying on diabetes quality metrics at primary care, as the competing demand model suggested (Nutting et al., 2000; Rost et al., 2000). Some ad hoc analyses on the number of primary care visits I conducted showed that mental health specialist care does not increase number of primary care visits among those with at least one primary care visit. This might imply that without additional number of visits, the dynamic and focus of primary care visits became a critical factor for receipt of guideline-concordant diabetes care.

Seeing a mental health specialist has been shown to increase the rate of having annual eye exam among individuals with co-occurring diabetes and depression. The utilization rate of an annual eye exam is low (17.6% for the general sample), consistent with what has been reported in other NC Medicaid populations (Domino et al., 2014; Olesiuk et al., 2016). There are several

pathways that could lead to this positive effect of mental health specialist. First, an eye exam is usually performed in a specialty setting that does not provide depression care. It is possible that mental health specialists provide better management of depression than primary care, and therefore increase a patient's willingness to visit an ophthalmology specialty. One might argue that individuals in an area with higher supply of mental health specialist usually have better access to other specialists and therefore are likely to visit those specialists; however, such an omitted-variable bias led by better access to other specialists has been minimized in instrumental variable analysis.

The instrumental variables results have important policy implications. First, increase in local supply of mental health specialist will increase mental health specialist use for MDD among Medicaid beneficiaries with co-occurring diabetes and depression. Such increase in mental health specialist use might increase probability of getting an annual eye exam, which is critical in preventing diabetic retinopathy. However, those health policies might succeed at the price of lower level of adherence to some primary care based diabetes care.

In light of the shortage of mental health specialists and the shifting of treatment modality, many studies have suggested that depression is a chronic illness that can be effectively treated in primary care settings (Ford et al., 2002). That does not necessary imply, however, that primary care providers are able to step in and fill the roles of absent mental health specialists. Future areas of research exist to what is the appropriate role of mental health specialist in treating depression, especially in primary care settings.

Overall, the present study implies that any policy aiming to increase mental health specialist use by increasing the local mental health specialist supply should consider this population's comprehensive care needs, especially among individuals with co-occurring diabetes

and depression. In the era of promoting personalized and patient-centered care, this study informs the need to further examine benefits of integrating behavioral healthcare and physical health care of individuals with multiple chronic conditions.

While this paper is able to address many analytical issues in estimating the effect of mental health specialist use on diabetes care, several limitations are acknowledged. First, caution should be made when interpreting this study's findings, as instrument variable analysis applies to "marginal individual." In the context of this study, marginal individuals are those Medicaid beneficiaries whose increased use of mental health specialist care was influenced by the changes in either local preference or higher supply of mental health specialist. The study results will not apply to individuals who change their behavior due to other reasons. Second, my analysis only focuses on Medicaid enrollees, and is not generalizable to adults that may be uninsured or have other types of insurance. Also, although every effort has been made to identify clinical information through diagnosis and procedure coding, some of the observed differences between recommended and actual care might have been explained with clinical information not available in claims data sets (Kerr et al., 2003). For example, glycemic level is not observed in claims data. Individuals with good glycemic control might be less likely to be advised by their primary care providers for follow-up diabetes checks. Without such information, the negative effect of mental health specialist care could be over-estimated. Finally, it is not possible to follow all types of recommendations specified in the guidelines for my analysis, as certain services, such as foot exams, were not billed separately from physician visits. Nevertheless, even with the limitations of the study, the evidence is still relatively strong, showing that mental health specialist use could influence preventive diabetes care among those with co-occurring diabetes and MDD.

2.6 Conclusion

In this paper, I use an instrumental variables/fixed effects methodology that compares outcomes of diabetes care between Medicaid beneficiaries who did or did not visit a mental health specialist for their MDD. Overall, this study found that with mental health specialist supply and local mental health specialist use as instruments, mental health specialist care decreases the probability of receiving regular lipid test and two regular A1c checks, but increases the probability of having at least one primary care visit and getting an annual eye exam. These effects hold true even when the analyses were conducted on several different restricted subsamples.

This is an opportune time to examine the "spillover" effects of mental health specialist care and quality of care among individuals with multiple chronic conditions, as the Patient Protection and Affordable Care Act provides new opportunities for integrating behavioral healthcare and physical health care of individuals with multiple chronic conditions (US Department of Health and Human Services, 2010). As the number of patients with multiple chronic conditions in the US will grow substantially and mental health specialty supply is predicted to remain low, this study addresses the most critical aspect of the mental health specialist care issues among a specific complex patient population and brings important policy implications. Findings from this study suggest that for North Carolina Medicaid beneficiaries with co-occurring diabetes and MDD, seeking treatment from mental health specialists might lead to a higher level of receiving any eye exam but a lower level of guideline-concordant diabetes care in other two indicators. This implies that any policy aiming to improve mental health care delivery also needs to consider the spillover effect of mental health care on other co-occurring conditions. This implication is important as comorbidity between diabetes and MDD is

common (Moussavi et al., 2007; Wells, Rogers, Burnam, Greenfield, & Ware, 1991). Specifically, people with MDD had 25%-50% higher prevalence of diabetes than general population (Wells et al., 1991). Future areas of research exist to carefully evaluate whether patients with multiple chronic conditions would benefit more from mental health specialist care in a coordinated, comprehensive, and patient-centered care setting. Findings will inform policy programs designed to allocate mental health specialist care more efficiently and to reform mental health care delivery in North Carolina as well as nationwide.

Table 2.1 Summary Statistics on Annual Observations

	All (NT=76,369)	Mental Health Specialist Use		
		Yes (NT=23,832)	No (NT=52,537)	P-value¶
Outcome				
Any Primary care visit (%)	72.62	86.43	66.36	<0.001
Any lipid test annually (%)	58.04	67.04	53.96	<0.001
Two or more A1c tests annually (%)	39.59	47.68	35.92	<0.001
Any eye exam annually (%)	17.62	27.49	13.14	<0.001
Patient Characteristics				
Age	44.81	44.59	44.91	<0.001
Female (%)	77.67	78.08	77.49	0.073
Race				<0.001
African American (%)	41.49	42.67	40.96	
White (%)	51.82	52.18	51.66	
Other race (%)	6.91	5.42	7.59	
Urban (%)	78.58	79.89	78.01	<0.001
Number of months of Medicaid Enrollment (1-12)	10.68	11.38	10.36	<0.001
Clinical Characteristics				
Total number of diabetes complication (0-9)	0.52	0.53	0.52	0.005
Total number of diabetes complication, exclude diabetic eye disease (0-8)	0.29	0.27	0.30	<0.001
Diabetic eye disease (%)	23.60	26.61	22.23	<0.001
Gangrene (%)	2.47	2.66	2.38	0.022
Debridement (%)	2.22	2.19	2.24	0.650
Amputation (%)	0.78	0.72	0.81	0.186
Chronic renal failure (%)	6.06	6.22	5.99	0.228
End Stage Renal Disease, ESRD (%)	0.90	0.71	0.99	<0.001
Myocardial infarction (%)	3.89	3.55	4.05	0.001
Congestive heart failure (%)	9.13	7.99	9.65	<0.001
Stroke (%)	3.18	2.68	3.41	<0.001
Any insulin use (%)	30.38	32.08	29.60	<0.001

	All (NT=76,369)	Mental Health Specialist Use		
		Yes (NT=23,832)	No (NT=52,537)	P-value¶
Severe mental illness (%)	20.19	40.20	11.11	<0.001

¶ Chi-square tests were performed for categorical variables and T-tests were performed for continuous variables. Severe mental illness includes schizophrenia and bipolar disorder.

Table 2.2 Results of specification tests and level of identification

Outcome variable	Level of identification and Instruments	Strengths of the instruments ♯	Overidentification test §	Endogeneity test¶	Preferred IV specifications
Lipid test	Overidentified. IV: MHS use rate, HPDS MHS supply	F(2, 76296)=67.01**	χ_1^2 (1)=1.04	χ_1^2 (1)=6.95**	2SLS-FE
A1c test	Overidentified. IV: MHS use rate, Medicaid MHS supply	F(2, 76296)=83.50**	χ_1^2 (1)=0.13	χ_1^2 (1)=5.54*	2SLS-FE
Eye exam	Overidentified. IV: Medicaid MHS supply, HPDS MHS supply	χ_2^2 (2)=53.83**	χ_1^2 (1)=0.529	χ_1^2 (1)=75.89**	2SRI-raw
Any PCP visit	Overidentified. IV: Medicaid MHS supply, HPDS MHS supply	χ_2^2 (2)=52.92**	χ_1^2 (1)=2.00	χ_1^2 (1)=199.66**	2SRI-raw

2SLS: Two stage least square. 2SRI-raw: Two stage residual inclusion with raw residuals. FE: fixed effect. MHS: mental health specialist. HPDS: North Carolina Health Profession Data System. # F-statistic for LPM first stage and Chi^2 for Probit first stage. § Sargan-Hansen's test is performed with 2SLS-FE. ¶Wooldridge's score test was conducted with 2SLS-FE. *p<=0.05. **p<0.01

Table 2.3 Selected Average Marginal Effect Estimations on Probability of Receiving Annual Lipid Test

	(1) LPM	(2) LPM FE	(3) 2SLS	(4) 2SLS FE
Any Mental health specialist visit	0.0253**	0.0136**	-0.404**	-0.443*
	(0.0046)	(0.0053)	(0.115)	(0.185)
Age	0.00210**	0.002	0.00157**	0.011
	(0.00016)	(0.044)	(0.00020)	(0.047)
Female	0.0079*		0.0118**	
	(0.0039)		(0.0042)	
Race (Reference: White)				
African American	-0.043**		0.041**	
	(0.003)		(0.004)	
Other race	-0.009		-0.015*	
	(0.006)		(0.007)	
Urban	0.0006	0.004	0.0072	0.008
	(0.0038)	(0.012)	(0.0044)	(0.013)
Number of months of Medicaid Enrollment (1-12)	0.03329**	0.02996**	0.0348**	0.0325**
	(0.00057)	(0.00087)	(0.0071)	(0.0014)
Any insulin use	-0.0102*	0.0393**	-0.0142**	0.0400**
	(0.0044)	(0.0071)	(0.0048)	(0.0076)
Total number of diabetes complication (0-9)	0.0243**	0.014**	0.0257**	0.0156**
	(0.0028)	(0.003)	(0.0030)	(0.0034)
Severe mental illness	0.0114	0.0132	0.036**	0.036**
	(0.0068)	(0.0085)	(0.010)	(0.013)
Sample Size (NT)	76,369	76,369	76,369	76,369
Number of unique individuals (N)	22,392	22,392	22,392	22,392
R-squared/Pseudo-R-squared	0.22		0.13	
Fixed Effect F-statistic (Ho: all u_i=0)		1.62**		1.42**

MHS: mental health specialist. LPM: linear probability model. FE: fixed effect. 2SRI: two stage residual inclusion. In all models, other control variables not reported include year dummy variables (2006-2011) and CDPS indicators (58 dummy variables). Robust standard errors are estimated in all linear models. Severe mental illness includes schizophrenia and bipolar disorder. *p<=0.05 **p<0.01

Table 2.4 Selected Average Marginal Effect Estimations on Probability of Receiving Two A1c Tests in A Year

	(1) LPM	(2) LPM FE	(3) 2SLS	(4) 2SLS FE
Any Mental health specialist visit	0.0283**	0.0257**	-0.220*	-0.315*
	(0.0044)	(0.0050)	(0.096)	(0.151)
Age	0.00234**	0.021	0.00202**	0.028
	(0.00015)	(0.041)	(0.00020)	(0.043)
Female	0.0234**		0.0257**	
	(0.0037)		(0.0039)	
Race (Reference: White)				
African American	-0.0272**		-0.0262**	
	(0.0032)		(0.0033)	
Other race	0.0023		-0.001	
	(0.0062)		(0.006)	
Urban	0.0019	-0.001	0.0057	0.001
	(0.0037)	(0.011)	(0.0040)	(0.012)
Number of months of Medicaid Enrollment (1-12)	0.02461**	0.02288**	0.025450**	0.0248**
	(0.00040)	(0.00081)	(0.00058)	(0.0012)
Any insulin use	0.0948**	0.0980**	0.0924**	0.0986**
	(0.0047)	(0.0066)	(0.0049)	(0.0069)
Total number of diabetes complication (0-9)	0.0086**	0.0042	0.0093**	0.0052
	(0.0028)	(0.0029)	(0.0028)	(0.0031)
Severe mental illness	-0.0114	-0.0134	0.0029	0.004
	(0.0065)	(0.0080)	(0.0087)	(0.011)
Sample Size (NT)	76,369	76,369	76,369	76,369
Number of unique individuals (N)	22,392	22,392	22,392	22,392
R-squared/Pseudo-R-squared	0.29		0.25	
Fixed Effect F-statistic (Ho: all u_i=0)		1.73**		1.60**

MHS: mental health specialist. LPM: linear probability model. FE: fixed effect. 2SLS: two stage least square. In all models, other control variables not reported include year dummy variables (2006-2011) and CDPS indicators (58 dummy variables). Robust standard errors are estimated in all linear models. Severe mental illness includes schizophrenia and bipolar disorder. *p<=0.05 **p<0.01

Table 2.5 Selected Average Marginal Effect Estimations on Probability of Receiving Annual Eye Exam

	(1) Naïve Probit	(2) LPM FE	(3) 2SRI-raw
Any Mental health specialist visit	0.0142**	0.0201**	0.052**
	(0.0032)	(0.0042)	(0.014)
Age	0.00003	0.015	0.00008
	(0.00011)	(0.034)	(0.00011)
Female	0.0102**		0.0098**
	(0.0028)		(0.0028)
Race (Reference: White)			
African American	0.0005		0.0004
	(0.0024)		(0.0024)
Other race	-0.0148**		-0.0141**
	(0.0046)		(0.0047)
Urban	-0.0146**	0.014	-0.0153**
	(0.0027)	(0.010)	(0.0027)
Number of months of Medicaid Enrollment (1-12)	0.00827**	0.00356**	0.00798**
	(0.00057)	(0.00068)	(0.00055)
Any insulin use	0.0094**	0.0215**	0.0097**
	(0.0029)	(0.0055)	(0.0028)
Total number of diabetes complication (0-8)	-0.0057*	-0.0036	-0.0055
	(0.0027)	(0.0039)	(0.0028)
Any diabetic eye disease	0.2312**	0.2931**	0.2307**
	(0.0021)	(0.0031)	(0.0021)
Severe mental illness	-0.0128**	-0.0069	-0.0149**
	(0.0045)	(0.0066)	(0.0045)
Sample Size (NT)	76,369	76,369	76,369
Number of unique individuals (N)	22,392	22,392	22,392
R-squared/Pseudo-R-squared	0.36		0.36
Fixed Effect F-statistic (Ho: all u_i=0)		1.07**	

MHS: mental health specialist. LPM: linear probability model. FE: fixed effect. 2SRI: two stage residual inclusion. In all models, other control variables not reported include year dummy variables (2006-2011) and CDPS indicators (58 dummy variables). Robust standard errors are estimated in fixed effect model. Standard errors are estimated with delta-method for differential effect estimation in 2SRI model. Severe mental illness includes schizophrenia and bipolar disorder. *p<=0.05 **p<0.01

Table 2.6 Selected Average Marginal Effect Estimations on Probability of Having Any Primary Care Visit

	(1) Naïve Probit	(2) LPM FE	(3) 2SRI-raw
Any Mental health specialist visit	0.0180**	0.0151**	0.144**
	(0.0039)	(0.0046)	(0.016)
Age	-0.00185**	-0.062	-0.00163**
	(0.00014)	(0.037)	(0.00013)
Female	0.0369**		0.0357**
	(0.0034)		(0.0033)
Race (Reference: White)			
African American	-0.0497**		-0.0455**
	(0.0030)		(0.0030)
Other race	-0.0113*		-0.010*
	(0.0056)		(0.005)
Urban	-0.0421**	-0.013	-0.0417**
	(0.0032)	(0.010)	(0.0033)
Number of months of Medicaid Enrollment (1-12)	0.02599**	0.02492**	0.01903**
	(0.00058)	(0.00074)	(0.00048)
Any insulin use	-0.0135**	0.0357**	-0.0099*
	(0.0036)	(0.0060)	(0.0040)
Total number of diabetes complication (0-9)	0.0190**	0.0149**	0.0194**
	(0.0022)	(0.0027)	(0.0025)
Severe mental illness	0.0259**	0.0099	0.0254**
	(0.0053)	(0.0073)	(0.0064)
Sample Size (NT)	76,369	76,369	76,369
Number of unique individuals (N)	22,392	22,392	22,392
R-squared/Pseudo-R-squared	0.30		0.30
Fixed Effect F-statistic (Ho: all u_i=0)		1.69**	

MHS: mental health specialist. LPM: linear probability model. FE: fixed effect. 2SRI: two stage residual inclusion. In all models, other control variables not reported include year dummy variables (2006-2011) and CDPS indicators (58 dummy variables). Robust standard errors are estimated in fixed effect model. Standard errors are estimated with delta-method for differential effect estimation in 2SRI model. Severe mental illness includes schizophrenia and bipolar disorder. *p<=0.05 **p<0.01.

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CHAPTER 3. STUDY 2: THE EFFECT OF MENTAL HEALTH SPECIALIST CARE ON GUIDELINE-CONCORDANT DEPRESSION CARE OF ADULTS WITH CO-OCCURRING MAJOR DEPRESSIVE DISORDER AND DIABETES

3.1 Introduction

Major depressive disorder (MDD), a serious mood disorder associated with significant reductions in physical and social functioning, is one of the most prevalent mental disorders in the US (National Institute of Mental Health, 2015). With an estimated 16.1 million adults affected by a depressive disorder in a given year, MDD accounted for 6.7% of all adults in the US (National Institute of Mental Health, 2015). The prevalence of MDD is higher among individuals with diabetes than among those without diabetes with approximately 10% of adults with diabetes having co-occurring MDD, and those with diabetes have a twofold-increased odds of developing MDD compared to individuals without diabetes (Moussavi et al., 2007; Rubin, Ciechanowski, Egede, Lin, & Lustman, 2004). Prior literature has shown that treating MDD improved both depression outcomes and diabetic outcomes such as glycemic control (W. J. Katon, Von Korff, et al., 2004; P J Lustman, Freedland, Griffith, & Clouse, 2000; Patrick J Lustman, Griffith, Clouse, & Kenneth, 1997; Patrick J Lustman, Griffith, Freedland, Kissel, & Clouse, 1998). A more recent systematic review further indicated that either psychotherapy or pharmacotherapy had a moderate effect on depression symptoms and a small to moderate effect on glycemic control (W. Katon, Maj, & Sartorius, 2011). However, the proportion of individuals with MDD receiving recommended treatment is still suboptimal. For individuals with MDD but without other co-morbid conditions, a 2002 survey found that only 71.7% of patients received at least 84 days of antidepressant treatment, the recommended minimum length of treatment (Pincus, 2002).

Treatment utilization rates are even lower among those with co-morbid diabetes. For example, results from a population study found that among insured patients with both diabetes and MDD diagnoses, only 32.8% had received either an adequate dose of an antidepressant during at least 90 days or at least 4 psychotherapy visits during a year (W. J. Katon, Simon, et al., 2004).

Either mental health specialists or primary care providers can provide depression care. Mental health specialists include prescribers such as psychiatrists and psychiatric nurse practitioners, as well as non-prescribers, such as psychologists, social workers, family and marriage therapists, and counselors. Individuals diagnosed with major depressive disorder are recommended to receive antidepressant medication, psychotherapy, or a combination of the two modalities (American Psychiatric Association, 2010). However, the treatment modality has been shifting towards more pharmacotherapy during the last decade, especially after the introduction of selective serotonin reuptake inhibitors (SSRI), a class of antidepressant medications with equal efficacy but lower toxicity from prior antidepressants (Olfson et al., 2002). For example, among Florida Medicaid beneficiaries, the percentage of adults with MDD who received antidepressants increased from 65.1% to 75.2% between 1996 to 2005, and the percentage who received psychotherapy for decreased from 56.6% % to 37.5 % during the same time period (Fullerton, Busch, Normand, McGuire, & Epstein, 2011). Coupled with the lack of access to mental health specialists in many areas and the growing ability of primary care providers in managing depression with pharmacotherapy, this treatment modality change has further led to the shifting of depression care utilization from mental health specialists, to primary care settings (Pirraglia, Stafford, & Singer, 2003). Research using the National Health and Nutrition Examination Survey found that during 2005-2006, only 39% of all Americans with severe depressive symptoms reported having seen a mental health professional within a year, and this

statistic dropped to 35% during 2009-2012 (Pratt & Brody, 2008, 2014). Similar findings were also reported among older adults in the US (Akincigil et al., 2011)

Whether mental health specialist care provides better quality of depression treatment has long been a major interest of research. In 1990, Mechanic argued that psychiatric services provided in the primary care sectors may be inappropriate for some patients (Mechanic, 1990), but he also recognized the need for further research to enhance knowledge in this research area (Mechanic, 1990). Many studies have provided estimates of effect of mental health specialist care on rates of adherence to depression treatment among individuals with depression. In the Medical Outcomes Study, a quasi-experimental study, patients with MDD or depressive symptoms seen by psychiatrists had higher rates of detection and better guideline-concordant care utilization, measured by antidepressant use and counseling, than those treated by primary care physicians (Sturm, Meredith, & Wells, 1996). In an analysis of the National Comorbidity Survey, 29% of individuals with MDD seen by mental health specialists received combination therapy (medication and four or more mental health visits), while only 13.8% of those seen by general physicians received the same care, and this difference was higher for persons with greater severity of illness (Katz, Kessler, Lin, & Wells, 1998). Finally, another quasi-experimental study that utilized telephone survey examined appropriate care, defined as use of either appropriate psychotropic medication or counseling during the prior year, among individuals with MDD and anxiety disorders. The study results showed a much higher proportion of not receiving appropriate care in those with primary care visits only than in either those with mental health specialist visits only or with both types of visits (80.5%, 11.4%, and 10.1%) (A. S. Young, Klap, Sherbourne, & Wells, 2001). Note that this study did not separate care for MDD from care for anxiety disorders (A. S. Young et al., 2001). These studies, however, did not

control for the selection bias into mental health specialist care. Further, these studies were mostly focused on individuals with MDD only.

The objective of this study is to examine whether the mental health specialist care for MDD affects the receipt of guideline-concordant depression care among a population with co-morbid diabetes. The current study addresses the gap in the literature with two major strengths. First, this study is focused on individuals with co-occurring MDD and diabetes instead of those with MDD only. Second, we control for the selection bias into depression treatment modality via both person-level fixed effects and instrumental variable methodology in order to compare the outcomes of depression care between Medicaid beneficiaries who made different treatment choices on mental health specialist use. To the best of my knowledge, there have been no other observational studies examining the effect of mental health specialists on guideline-concordant depression care for individuals with co-occurring diabetes.

3.2 Method

3.2.1 Conceptual framework

As prior evidence has shown, the marginal benefits of mental health specialist care on health could be higher than that of primary care, as mental health specialist care was found associated with a higher probability of receiving guideline-concordant depression care in many settings (Katz et al., 1998; Sturm et al., 1996; A. S. Young et al., 2001). However, this positive effect might be reduced by other factors among individuals with co-occurring diabetes, while those individuals often visit primary care providers for diabetes care. The marginal cost of depression care provided by a mental health specialist is usually higher than depression care provided by their primary care providers, even among well-insured Medicaid populations, due to

greater time and travel costs for treatment. The higher marginal cost, in turn, may reduce the probability of depression care with a mental health specialist. In sum, although the marginal benefits of depression care provided by mental health specialists on health are potentially higher than that provided by primary care providers, the marginal costs of mental health specialist visits could be higher too. Therefore, the net change on marginal return of mental health specialist care is ambiguous and requires empirical investigation.

3.2.2 Statistical analysis

Mental health specialist use is subject to potential endogeneity, since decisions to visit a mental health specialist could be heavily driven by severity of illness, personal preferences, or other unobservable factors that would also affect antidepressant use or psychotherapy visits. Therefore, person-level fixed effect and instrumental variable specifications were used to mitigate endogeneity bias. The person-level fixed effect will alleviate the endogeneity problem if the unobserved severities of chronic conditions or personal preferences do not vary during a fairly short period of time. On the other hand, if the endogeneity was mostly caused by unmeasured time-variant factors, instrumental variable estimation will result in consistent estimates. Overall, one might argue that those who prefer seeing a mental health specialist might be more willing to be adherent to depression treatment as well. With person-fixed effect and instrument variable estimation, however, the bias led by unobserved personal preferences on mental health specialist care and depression care overall should have been eliminated. Two-Stage-Least-Squares with person-level fixed effect (2SLS-FE) specification is used to estimate the local average treatment effect (LATE) of mental health specialist use on the quality of depression care received. The LATE estimates in this study represent the average effect of mental health specialist use for a “marginal individual” whose decisions on mental health

specialist use are most likely influenced by changes in the instruments (Angrist, Imbens, & Rubin, 1996; Chapman & Brooks, 2016). The choice to methods for the binary dependent variables with a binary endogeneous variable could vary, however, as 2SLS would be the biased. Therefore, probit-probit Two-Stage-Residual-Inclusion (2SRI) with raw residuals is also estimated. The standard errors around the marginal effects were estimated via bootstrapping with 1000 iterations. The 2SRI models were estimated cross-sectionally without fixed-effects as non-linear instrumental variable models including fixed effects tend to yield inconsistent estimation and therefore have different interpretations (Cameron & Trivedi, 2005).

Two sets of sensitivity analyses were conducted. First, I restricted the estimation sample to individuals who were enrolled in Medicaid for at least 90 days during the first four months of the episode, referred to here as the continuously enrolled. This enrollment restriction excluded 3.94% of the original estimation sample, and the results are similar to the original estimates, in terms of the magnitude and significance. Second, it is possible that treatment choices for mental health specialist care between individuals with and without severe mental illness are heterogeneous. Therefore, separate analyses were also conducted on the subgroup without severe mental illness anytime during the year when the depression episode occurred (n= 35,369). As the results are also very similar to those on the full sample, they are not separately reported but are available upon request.

3.2.3 Data

3.2.3.1 Estimation sample and episode creation

The data in this study come from the North Carolina Medicaid Analytic Extracts (MAX) from 2006-2011. These data files contain enrollment information and final action claims for all Medicaid fee-for-service beneficiaries in North Carolina. An adult beneficiary is included if she

had at least one inpatient or at least two outpatient diagnoses of diabetes and MDD during the study period (International Classification of Disease version 9 [ICD-9] code: 250.XX 357.2X, 362.0X, 366.41 for diabetes and 296.2X, 296.3X, 300.4X, 311.XX for MDD (The Healthcare Effectiveness Data and Information Set, n.d.). Individuals with Medicaid and Medicare dual coverage were excluded due to the potential for incomplete information on healthcare and prescription drug utilization. Finally, individuals were excluded if they were in one of the five (of 100) counties where mental health services were carved-out during this time period, as mental health care utilization for such patients were incomplete in MAX files.

Following the previous literature, we identified depression treatment episodes among this estimation sample (Busch et al., 2006; Donohue et al., 2004; Teh et al., 2010). An index event to begin an observed episode of depression treatment consisted of one of the following: an outpatient visit with a MDD diagnosis, an inpatient stay with a MDD diagnosis, or an antidepressant prescription. The episode start date is either the first service beginning date if the episode starts with an outpatient visit or an inpatient stay, or the first medication prescribed date if the episode starts with an antidepressant prescription, after at least a 60-day gap from a prior episode. An episode is considered terminated when an individual has a gap of at least 60 days in depression treatment including antidepressant prescriptions, outpatient visits with a diagnosis of MDD, a psychotherapy visit with a diagnosis of MDD, or hospitalization with a diagnosis of MDD. In order to identify the receiving of appropriate depression care, the acute phase of an episode is defined as the first 114 days and the first 84 days after the index event began for observing antidepressant use and psychotherapy use, respectively. This definition follows the Healthcare Effectiveness Data and Information Set and is consistent with other prior studies (Schoenbaum et al., 2002; Teh et al., 2010; The Healthcare Effectiveness Data and Information

Set, n.d.). Episodes with long-term care facility service use were excluded because those beneficiaries are less likely to receive outpatient visit claims during those episodes. To avoid censoring problems in examining lengths of an episode, I excluded episodes that began during the first 60 days of 2006. I also excluded episodes with acute phases that ended after December 31, 2011.

The final estimation sample includes 17,787 unique persons with co-occurring diabetes and MDD during 2006-2011 (Table 3.1). The average age was 45, 22% of the sample were male, 41% were African American, and 79% lived in an urban area. This estimation sample contributed 43,822 depression episodes to the analysis, with 10,715 unique individuals having more than one episode during the study period.

3.2.3.2 Key measures

The dependent variables are three measures of guideline-concordant depression care during the acute phase of a depression episode. The adequate antidepressant use is defined as whether an individual had at least 84 days coverage of antidepressant prescription during the first 114 days of a depression treatment episode. This definition follows the Healthcare Effectiveness Data and Information Set (The Healthcare Effectiveness Data and Information Set, n.d.). Consistent with other studies for guideline-concordant depression care (Schoenbaum et al., 2002; Teh et al., 2010), the adequate psychotherapy use is defined as whether an individual had at least 4 psychotherapy visits during the first 84 days of a depression treatment episode. If any hospitalization occurs during the acute phase of the episode, the length of the acute phase was extended in adjustment for the days of hospitalization. Finally, guideline-concordant depression care, the major outcome of interest, is defined as either having adequate psychotherapy use or adequate antidepressant use during a depression episode.

Mental health specialist use is the key independent variable in this study. It is defined as whether an individual had visited a mental health specialist during the acute phase of a depression treatment episode. A mental health specialist visit was identified as an outpatient claim with the provider type coded as a mental health specialist, consisting of a psychiatrist, psychologist, psychological associate, mental health nurse practitioner, licensed clinical social worker, mental health HMO, Assertive Community Treatment Team, or Critical Access Behavioral Health Agencies. Overall, 36 % of the episodes in this study had at least one mental health specialist visit during the acute phase.

3.2.3.3 Other control variables

Other control variables included patient demographics, other psychiatric co-morbidities, diabetes complications, and other co-morbidities during the year when the depression treatment episode began. Patient demographics included age, gender, and race. Age was measured at the beginning of the episode. Race was categorized as Caucasian, African American, and other races. Rural residence, which was found to be negatively associated with the number of mental health visits (Lambert, Agger, & Hartley, 1999), was defined as with a binary indicator. Rural area is defined according to Rural-Urban Commuting Areas (RUCAs). The RUCA codes classify U.S. census tracts using measures of population density, urbanization, and daily commuting (United States Department of Agriculture Economic Research Service, 2016). As census tracts are not available in MAX data, RUCA codes were identified with zipcode in this study. Area with RUCA codes less than 4 is defined as rural.

Further, I controlled for comorbid conditions that might affect both the probabilities of mental health specialist use and depression care receipt. I included binary indicators for severe mental illness, including bipolar disorder and schizophrenia, as individuals with those conditions

might be more likely to use both mental health specialist care and receive any psychotherapy or pharmacotherapy. For diabetes, I created an index of diabetic complications following Bethel and colleagues (2007), defined as the total number of diabetes complications as identified in the claims data. The index ranges zero to eight by calculating the number of complications among the following: diabetic eye disease (low vision or blindness), chronic renal failure, ESRD, gangrene, debridement, and amputation, myocardial infarction, congestive heart failure, and stroke (Bethel, Sloan, Belsky, & Feinglos, 2007). Additionally, a separate binary indicator for any insulin use is also included in the model, as insulin use typically indicates more severe diabetes (Gamble, Simpson, Eurich, Majumdar, & Johnson, 2010; B. A. Young et al., 2008).

Finally, general co-morbidities identified through Chronic Illness and Disability Payment System (CDPS) are also included in all analyses. There are twenty major categories of diagnoses in CDPS (version 6.0), and most of the major categories are further divided into several subcategories according to the degree of the increased expenditures associated with the diagnoses (Kronick, Gilmer, Dreyfus, & Lee, 2000). Overall, there are 58 binary indicators for all CDPS subcategories controlled in all current analyses. All the comorbidities are identified during the beginning year of a depression treatment episode.

3.2.3.4 Instrumental variables

Three variables were identified as potential instruments to correct the endogeneity: a local preference-based variable determined by the utilization pattern of mental health specialist use among Medicaid beneficiaries at the county-level (Basu, Heckman, Navarro-Lozano, & Urzua, 2007), the total number of licensed mental health specialists in each county from North Carolina Health Professions Data System (HPDS) (Richman, Fraher, & Gaul, 2015), and the total number of mental health specialists accepting Medicaid patients. As valid instruments,

those instruments should only affect depression care outcomes through mental health specialist use and otherwise be independent of guideline-concordant depression care. The first instrument, mental health specialist use rate, is defined as the proportion of all Medicaid beneficiaries who had any mental health specialist use during the year at the county-level. The variation in local treatment selection is possibly through a historical practice style, which is plausibly independent of underlying health, preferences and outcomes of the patients (Basu et al., 2007). The full Medicaid sample regardless of diagnosis was used to generate variables reflecting total number of Medicaid beneficiaries enrolled by county as well as the proportion of beneficiaries with at least one mental health specialist visit at county-level.

The second instrument, HPDS supply, is a mental health specialist supply measure, defined as the total number of psychiatrists and psychologists in a county, comes from North Carolina Health Professions Data System (HPDS) (Richman et al., 2015). In theory, the supply of mental health specialists affects depression care through affecting mental health specialist use only. Due to data availability in HPDS, this measure includes only psychiatrists and psychologists, the two major types of mental health specialist (Richman et al., 2015). Nevertheless, this measure is likely to reflect the availability of mental health specialist services more generally, as indicated by the high correlation between number of psychiatrists, psychologists, and other specialists at the county level (Ellis, Konrad, Thomas, & Morrissey, 2009).

The third measure, Medicaid mental health specialist supply, is defined as the number of mental health specialists that had seen at least one Medicaid beneficiary in a year at the county-level. A Medicaid provider is identified with a unique provider identifier that had at least one claim for a Medicaid beneficiary in a year. The unique identifiers used are state-assigned

Medicaid billing identifiers prior to 2009 and National Provider Identifier (NPI) beginning 2009. The Medicaid mental health specialist supply is measured as the total number of Medicaid mental health specialists with some Medicaid-billed claims in a year at county-level. Note that a provider could be counted more than once as she might be identified from different counties in a year. The full sample regardless of diagnosis was used to identify Medicaid mental health specialist. All three instruments are appended to the analysis file during the year when a depression episode began.

3.2.4 Specification tests

Specification tests were performed to assess the strength of the instrumental variables, the over-identifying restriction, and the exogeneity of mental health specialist use. The instruments were highly predictive of mental health specialist use in the first stage of 2SLS estimation. The test statistics for the joint F-test on all three instruments from the first stage of 2SLS were greater than 10 ($F(3, 43748)=31.36$, $p<0.001$), showing the joint statistical significance of the proposed instruments in predicting mental health specialist use (Staiger & Stock, 1997; Stock, Wright, & Yogo, 2002). Additionally, Sargan-Henson's test was conducted with the 2SLS-FE specification to test the over-identifying restriction with the three instruments. The results showed that this instrument set passed the test of overidentification in all three models ($\chi\_2\text{^}2$ =3.74, 0.87, and 0.53 for antidepressant, psychotherapy, and guideline-concordant depression care models). Finally, the endogeneity of mental health specialist use was tested in each 2SLS-FE model. The test results, however, failed to reject the null hypothesis that mental health specialist use is endogeneous, implying that FE specification without IVs might be more efficient. Results from non-IV and IV estimation are all reported. As exogeneity is not

rejected in IV specifications, results from linear probability models are also presented. All the analyses and specification tests were conducted with Stata 13 (Stata Corp, Texas).

3.3 Results

On average, nearly 39% of the episodes in the current analysis had adequate antidepressant use with a filled prescription for an antidepressant medication for at least 84 days during the acute phase, but only less than 11% of the episodes had adequate psychotherapy with at least four visits during the first 84 days following the index event for depression (Table 3.1). On average, 43% of episodes had guideline-concordant depression care with either adequate antidepressant use or adequate psychotherapy use.

Table 3.2 presents estimates of the differential effect of mental health specialist use on the expectation of receiving adequate antidepressant care for depression. The LPM (column (1)) predicts that episodes with mental health specialist use are associated with 20.5 percentage point increase on probability of adequate antidepressant use. The LPM-FE (column (2)) also predicts mental health specialist use leads to a 19.4 percentage point increase on probability of adequate antidepressant use. The 2SLS-FE specification (column (3)) further predicts a positive effect by 21.0 percentage points; however, with a much larger standard deviation estimated from the 2SLS-FE specification, this effect is insignificant at the 5% level. Note that results from the exogeneity test with this 2SLS-FE specification also failed to reject exogeneity. Being one year older or female increased the probability of adequate antidepressant use by 0.3% and 2.7%, respectively ($p<0.01$). African Americans and other minorities are significantly less likely to receive adequate antidepressant care by 11.5% and 4.2%, respectively ($p<0.01$). Individuals with

more diabetes complications during the episode year are more likely to receive adequate antidepressants by1.7% in both LPM-FE and 2SLS-FE specifications ($p<0.01$).

Table 3.3 presents estimated effects of mental health specialist use and other controlled variables on the expectation of receiving at least four psychotherapy visits during the first 84 days of a depression episode. The LPM models report a significant positive effect with a magnitude of 24.0 percentage points (Column (1)). The LPM-FE model (Column (2)) and 2SRI model (Column (3)) also show the same significant positive effect of mental health specialist care on receiving adequate psychotherapy. The preferred 2SRI specification reports a differential effect of mental health specialist use as 15.4 percentage points. This result suggests that for an individual with co-occurring diabetes and MDD who would increase use of mental health specialist care due to the changes in either local preference or higher supply of mental health specialist, receiving mental health specialist care will increase her probability of receiving at least four psychotherapy during the acute phase of a MDD episode by 15.4 percentage points. African American and other race are significantly less likely to receive adequate psychotherapy by 2.3% and 2.4% ($p<0.01$), even after controlling for the regional supply of mental health specialists. Individuals with one additional diabetes complication during the episode year are more likely to receive adequate psychotherapy by 0.6 percentage points ($p<0.01$).

The final LPM model reports that mental health specialist use is significantly associated with a 28.4 percentage points higher probability of receiving guideline-concordant depression care (Table 3.4, Column (1)). After adjusting for the endogeneity led by unobservable time-invariant factors, the LPM-FE model further predicts a significant and slightly smaller effect as 26.5 percentage points. After adjusting for the endogeneity with instruments, however, the effect became larger as 34.4 percentage points but insignificant at the 5% level with a p-value of 0.166.

Note that results from the exogeneity test with this 2SLS-FE specification also failed to reject exogeneity. Overall, among individuals with co-occurring diabetes and MDD, mental health specialist care increases the probability of receiving guideline-concordant depression care during the acute phase of depression. Additionally, being female is more likely to receive guideline-concordant depression are by 2.7% ($p<0.01$), while African American and other minorities are less likely to receive such care by10.8% and 4.4% ($p<0.01$).

3.4 Discussion

This study found a relatively low rate of guideline-concordant depression care during acute phase of depression treatment episodes among individuals with co-occurring depression and diabetes. On average, only 43% of the analyzed episodes had evidence of guideline-concordant depression care. This utilization rate is lower than what have been reported for those with MDD only, which ranged in prior research from 44.2% to 71.7% (Pincus, 2002; Schoenbaum et al., 2002; Teh et al., 2010), and is slightly higher than the utilization rate among those with co-occurring MDD and diabetes another study reported as 32.8% (W. J. Katon, Simon, et al., 2004).

Mental health specialist care is found to increase the likelihood of receiving guideline-concordant care among those with co-occurring diabetes. Specifically, this effect is positive even among those who are likely receiving diabetes care from their primary care providers. While prior studies on individuals with MDD have demonstrated that mental health specialist care might provide better quality of depression care than primary care (Katz et al., 1998; Sturm et al., 1996; A. S. Young et al., 2001), the current study builds on upon this literature and provide new estimates on a more specific population with complex healthcare needs. Further, the positive

effect of mental health specialist care holds true across different specifications. These robust findings imply the benefit of mental health specialist care on improving quality of depression care, despite the potential higher relative cost for visiting a mental health specialist in this more primary care based population.

The instrumental variable estimation also brings important policy implications. The results suggest that improvement in quality of depression care could be achieved by increasing local supply of mental health specialists, and future policies should aim to trigger supply increase. For example, the Psych NP-NC program in North Carolina was launched in 2004 to recruit and educate nurses with prescriptive authority so that they can return to their home community or county to provide essential psychiatric and mental health assessment and treatment, including prescription of psychotropic medications and psychotherapies (Soltis-Jarrett, 2011). The program has been successful in targeting a total of 67 counties and graduating 74 new psychiatric nurses during 2004-2011(Soltis-Jarrett, 2011). Another way to increase mental health specialist use in this population is to increase the number of providers participating in Medicaid. Given the current limited supply, telepsychiatry is a potential solution for more mental health specialists to deliver certain forms of depression care to Medicaid beneficiaries. Psychiatric consultation and follow-up delivered by telepsychiatry has been found to produce clinical outcomes equivalent to those achieved by same services provided through face to face, with 10% less cost (O'Reilly et al., 2007). However, exploratory analysis in these data shows that utilization rates of telepsychiatry are still less than 1% in both Medicaid beneficiaries with co-occurring MDD and diabetes as well as all Medicaid beneficiaries in North Carolina. Future targeted efforts are needed in identification and dissemination of evidence-based telepsychiatry models.

Another important point is that substantial racial disparities were found in the rates of receiving adequate antidepressant use, receiving adequate psychotherapy use, and receiving overall guideline-concordant depression care. African Americans and other minorities are less likely to receiving any adequate depression treatment even after all other important factors are controlled. This finding is consistent with what has been reported in another Medicaid population (OR=1.04 for not receiving guideline-concordant depression care) (Teh et al., 2010) and consistent with the disparities for African-Americans and other minorities in utilization of mental health services in representative US population (Cook, Doksum, Chen, Carle, & Alegría, 2013; Cook, McGuire, & Miranda, 2007). This study also found that female beneficiaries have higher likelihood of receiving appropriate depression care during the acute phase of a depression episode, although the effect is much smaller than what have been reported in a prior study that examined life-time depression care utilization (OR: 1.89) (Galbaud du Fort, Newman, Boothroyd, & Bland, 1999). This observed gender difference could be explained by the notion that women are more likely to seek professional help for psychiatric problems (Henderson, Evans-Lacko, & Thornicroft, 2013).

Although many studies have suggested that MDD is a chronic illness that can be effectively treated in primary care settings (Ford et al., 2002), the current study finds that, mental health specialist care could still improve rates of receiving guideline-concordant depression care, even among individuals with co-occurring diabetes and MDD who could be more primary-care based due to diabetes management. This positive effect implies the possibility that the clinical significance of mental health specialist care on quality of depression care still outweighs the potential high marginal cost of visiting a mental health specialist in this specific population. Further, our instrumental estimation suggests that such improvement in quality of depression

care could be achieved by increasing local supply of mental health specialists. Future research is encouraged to identify and evaluate appropriate policies to trigger such changes, especially in areas with severe shortage of mental health specialist.

While this paper is able to address many of the relevant issues in estimating the effect of mental health specialist use on depression care, several limitations are acknowledged. First, this study was only focused on Medicaid enrollees and services reimbursed by Medicaid; therefore, we could not observe depression treatment services provided outside of Medicaid, and our results might not be generalizable to adults who are uninsured or have other types of insurance. Additionally, it is not possible to address the quality or the content of psychotherapy or mental health specialist visit due to data limitations. Finally, due to the lack of clinical information in claims data, clinical outcomes of this study population were not observable. Future areas of research, therefore, exist to carefully evaluate whether such improvement in quality of depression care would alleviate depression symptoms and overall health status.

Better understanding of the effect of mental health specialist care on the receipt of quality care for depression among Medicaid beneficiaries with co-occurring diabetes and MDD will allow for more targeted efforts on health policy to improve treatment and outcomes for this population. As the number of patients with multiple chronic conditions in the US grows substantially and the supply of mental health specialists is predicted to remain low (Anderson, 2010; Thomas, Ellis, Konrad, Holzer, & Morrissey, 2009), this study brings important policy implications for a specific complex population. Findings will also inform policy programs designed to allocate mental health specialist care more efficiently in North Carolina as well as nationwide.

Table 3.1 Summary Statistics

Individual Level Characteristics	All (N=17,787)
Female (%)	74.66
Race	
Caucasian (%)	52.28
African American (%)	41.05
Other race (%)	6.87
Living in a rural area (%)	21.03
Average number of episodes observed per person (1-17, SD)	2.44 (1.74)

Acute-Phase Depression Episode Level Characteristics		Mental Health Specialist Use		
N	All (43,822)	Yes (15,749)	No (28,073)	P-value §
Depression Care Outcome				
At least 84 days of antidepressant during first 114 days (%)	38.67	50.04	32.29	<0.001
At least 4 psychotherapy during first 84 days (%)	10.96	26.45	2.28	<0.001
Guideline-concordant depression care (%)	42.55	47.53	35.92	<0.001
Episode Characteristics				
Age at the beginning of an episode (years, SD)	43.920 (0.054)	43.766 (0.089)	44.008 (0.068)	0.031
Number of days of Medicaid enrollment within the first 4 Months (0-124, SD)	117.87 (15.91)	119.59 (11.10)	116.90 (17.98)	<0.000
Clinical Characteristics ¶				
Total number of diabetes complication (0-9, SD)	0.5550 (0.0039)	0.5316 (0.0061)	0.5683 (0.0050)	0.009
Diabetic eye disease (%)	25.70	27.28	24.81	<0.001
Gangrene (%)	2.51	2.25	2.66	0.008
Debridement (%)	2.35	2.10	2.49	0.010
Amputation (%)	0.98	0.79	1.09	0.003
Chronic renal failure (%)	6.25	5.94	6.42	0.047
End Stage Renal Disease, ESRD (%)	1.00	0.74	1.15	<0.001
Myocardial infarction (%)	4.37	3.76	4.72	<0.001
Congestive heart failure (%)	8.94	7.29	9.87	<0.001
Stroke (%)	3.40	3.02	3.62	0.001
Any insulin use (%)	32.30	30.92	33.08	<0.001
Severe mental illness (%)	19.29	33.49	11.32	<0.001

Guideline-concordant depression care: At least 84 days of antidepressant and/or at least 4 psychotherapy visits. ¶Clinical characteristics are measured during the year when the episode began. §Chi-square tests were performed for categorical variables and T-tests were performed for continuous variables. Severe mental illness includes schizophrenia and bipolar disorder.

Table 3.2 Selected Average Marginal Effect Estimations on Probability of Receiving ≥84 Days of Antidepressant

	(1) LPM	(2) LPM-FE	(3) 2SLS-FE
Any Mental health specialist visit during an episode	0.2053**	0.1944**	0.21[a]
	(0.0053)	(0.0071)	(0.24)
Age at the beginning of an episode	0.00300**	0.0151	0.0133
	(0.00023)	(0.0093)	(0.0235)
Female	0.0266**		
	(0.0056)		
Race (Reference: Caucasian)			
African American	-0.1153**		
	(0.0048)		
Other race	-0.0415**		
	(0.0094)		
Living in a rural area	-0.0054	-0.0112	-0.0112
	(0.0054)	(0.0197)	(0.0197)
Number of days of Medicaid enrollment within the first 4 Months	0.003525**	0.00343**	0.00339**
	(0.000086)	(0.00020)	(0.00051)
Any insulin use	0.0081	0.0456**	0.0452**
	(0.0062)	(0.0120)	(0.0128)
Total number of diabetes complication (0-9)	0.0227**	0.0166**	0.0165**
	(0.0038)	(0.0053)	(0.0054)
Severe mental illness	0.0294**	0.022	0.022
	(0.0091)	(0.014)	(0.015)
Sample Size (N)	43,822	43,822	43,822
Number of unique individuals (N)	17,787	17,787	17,787
R-squared	0.12		

LPM: linear probability model. 2SLS: two stage least square. FE: fixed effect. Other control variables not reported include year dummy variables (2006-2011) and CDPS indicators (58 dummy variables). Robust standard errors are estimated with delta-methods. Severe mental illness includes schizophrenia and bipolar disorder. **p<0.01. a: P>|z|= 0.380

Table 3.3 Selected Average Marginal Effect Estimations on Probability of Receiving ≥4 Psychotherapy

	(1) LPM	(2) LPM-FE	(3) 2SRI
Any Mental health specialist visit during an episode	0.2403**	0.1859**	0.154**
	(0.0041)	(0.0040)	(0.042)
Age at the beginning of an episode	-0.00006	-0.00437	-0.00010
	(0.00014)	(0.00521)	(0.00014)
Female	0.0106**		0.0093**
	(0.0034)		(0.0033)
Race (Reference: White)			
African American	-0.1083**		-0.0234**
	(0.0048)		(0.0029)
Other race	-0.0212**		-0.0242**
	(0.0052)		(0.0064)
Living in a rural area	0.0029	0.0005	0.0016
	(0.0033)	(0.0110)	(0.0034)
Number of days of Medicaid enrollment within the first 4 Months	0.000582**	0.00050*	0.00169**
	(0.000047)	(0.00011)	(0.00019)
Any insulin use	-0.0042	-0.0042	-0.0063
	(0.0036)	(0.0067)	(0.0038)
Total number of diabetes complication (0-9)	0.0049*	0.0026	0.0056*
	(0.0023)	(0.0030)	(0.0023)
Severe mental illness	-0.0039	0.0054	-0.0031
	(0.0066)	(0.0079)	(0.0051)
Sample Size (NT)	43,822	43,822	43,822
Number of unique individuals (N)	17,787	17,787	17,787
R-squared	0.12		

LPM: linear probability model. 2SRI: two stage residual inclusion. FE: fixed effect. Other control variables not reported include year dummy variables (2006-2011) and CDPS indicators (58 dummy variables). Robust standard errors are estimated in linear models with delta-methods. Standard errors for 2SRI were bootstrapped with 1000 iterations. Severe mental illness includes schizophrenia and bipolar disorder. *p<=0.05 **p<0.01

Table 3.4 Selected Average Marginal Effect Estimations on Probability of Receiving Guideline-concordant Depression Care

	(1) LPM	(2) LPM-FE	(3) 2SLS-FE
Any Mental health specialist visit during an episode	0.2835**	0.265**	0.344a
	(0.0053)	(0.007)	(0.248)
Age at the beginning of an episode	0.00290**	0.0127	0.006
	(0.00023)	(0.0095)	(0.024)
Female	0.0266**		
	(0.0056)		
Race (Reference: White)			
African American	-0.1083**		
	(0.0048)		
Other race	-0.0438**		
	(0.0094)		
Living in a rural area	-0.0065	-0.013	-0.013
	(0.0053)	(0.020)	(0.020)
Number of days of Medicaid enrollment within the first 4 Months	0.003683**	0.00350**	0.00335**
	(0.000090)	(0.00020)	(0.00052)
Any insulin use	0.0081	0.0431**	0.0416**
	(0.0061)	(0.0122)	(0.0131)
Total number of diabetes complication (0-9)	0.0218**	0.0173**	0.0170**
	(0.0038)	(0.0054)	(0.0055)
Severe mental illness	0.0075	0.015	0.014
	(0.0091)	(0.014)	(0.015)
Sample Size (NT)	43,822	43,822	43,822
Number of unique individuals (N)	17,787	17,787	17,787
R-squared	0.12		

LPM: linear probability model. 2SLS: two stage least square. FE: fixed effect. Other control variables not reported include year dummy variables (2006-2011) and CDPS indicators (58 dummy variables). Robust standard errors are estimated with delta-methods. Severe mental illness includes schizophrenia and bipolar disorder. **p<0.01. a: P>|z|= 0.166

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CHAPTER 4. STUDY 3: DOES MENTAL HEALTH SPECIALIST USE AFFECT EMERGENCY DEPARTMENT VISITS AND HOSPITALIZATIONS OF ADULTS WITH CO-OCCURRING DIABETES AND MAJOR DEPRESSIVE DISORDER?

4.1 Background

The growing use of emergency department (ED) services and inpatient care has become a leading cost driver in the US health care system (Schuur & Venkatesh, 2012). Nationally, the annual number of hospital admissions increased by 15.0% between 1993 to 2006 (Schuur & Venkatesh, 2012), and the annual number of ED visits also increased by 23.1% between 1997 and 2007 (Tang, Stein, Hsia, Maselli, & Gonzales, 2010). Further, individuals with multiple chronic conditions are higher utilizers of such tertiary care. A prior study analyzing Medical Expenditure Panel Survey (MEPS) in 2009 found that the likelihood of having at least one hospital stay or at least one ED visit significantly increased among individuals with more than one chronic condition (Machlin & Soni, 2013).

Diabetes and major depressive disorder (MDD) are two of most common chronic conditions that tend to co-occur and affect each other's courses (Ali, Stone, Peters, Davies, & Khunti, 2006; Eaton, Armenian, Gallo, Pratt, & Ford, 1996; Katon, Maj, & Sartorius, 2011; Moussavi et al., 2007; Pratt & Brody, 2014a). Individuals with diabetes are higher utilizers of ED and inpatient care than those without diabetes (Dall et al., 2008; Zhou et al., 2015). Major depressive disorder is shown to be associated with increased risk of obesity, glycemic level, diabetic complications including diabetic retinopathy, nephropathy, neuropathy, microvascular complications, and higher mortality among individuals with diabetes (De Groot et al., 2001; Eaton et al., 1996; Egede et al., 2005; Knol et al., 2006; Lustman et al., 2000; Pratt & Brody,

2014a). Further, MDD leads to higher ED and inpatient care use compared with those who were not depressed among those with diabetes (Ciechanowski, Katon, & Russo, 2000; Davydow et al., 2013; Himelhoch, Weller, Wu, Anderson, & Cooper, 2004; Hutter, Schnurr, & Baumeister, 2010; Kalsekar et al., 2006). Among Medicare beneficiaries with diabetes, Himelhoch and colleagues found MDD almost doubled the likelihood of using ED services (from 36% to 65%), and doubled the likelihood of having inpatient admissions (from 34% to 66%) (Himelhoch et al., 2004). With the increasing prevalence of diabetes and MDD, the high ED and inpatient services use attributed to the population with co-occurring diabetes and MDD has been an emerging public health challenge.

While MDD is now commonly treated in primary care, many individuals with MDD are seen by mental health specialists, including prescribers, such as psychiatrists and psychiatric nurses, and other non-prescribers, such as psychologists, licensed clinical social workers, family and marriage therapists, and counselors. However, over half of U.S. counties have shortages of mental health specialists (Merwin, Hinton, Dembling, & Stern, 2003), and about three-quarters of U.S. counties were estimated to have a severe shortage of psychiatrists (Thomas, Ellis, Konrad, Holzer, & Morrissey, 2009). Guidelines have suggested that individuals diagnosed with major depressive disorder be treated with antidepressant medication, psychotherapy, or a combination of the two modalities (American Psychiatric Association, 2010). The treatment of MDD, however, has been shifting towards more pharmacotherapy at primary care settings since the 1990s (Akincigil et al., 2011; Ng, Bardwell, & Camacho, 2002; Olfson et al., 2002; Wang et al., 2005). Research using the National Health and Nutrition Examination Survey found that during 2009-2012, only 35% of all Americans with severe depressive symptoms reported having seen a mental health specialist within a year (Pratt & Brody, 2014b).

Whether mental health specialist care provides better quality of depression treatment has long been a major interest of research. Some literature has indicated mental health specialist care improves the quality of depression care over other providers among those with MDD only (Katz, Kessler, Lin, & Wells, 1998; Sturm, Meredith, & Wells, 1996; A. S. Young, Klap, Sherbourne, & Wells, 2001). Patients with MDD seen by psychiatrists were found to have better guideline-concordant care utilization, measured by antidepressant use and counseling, than those treated by primary care physicians in the quasi-experimental Medical Outcomes Study (44% vs 21% for antidepressant use, 87% vs 37% for counseling) (Sturm & Wells, 1995). In an analysis of the National Comorbidity Survey, a higher proportion of individuals (29%) with MDD seen by mental health specialists received medication and four or more mental health visits than those seen by general physicians only (13.8%) (Katz et al., 1998).

Depression severity is associated with higher ED and inpatient care utilization among those with diabetes (Ciechanowski et al., 2000). The higher utilization might be resulted from an objective worsening glucose control or an increased risk of diabetic complications associated with MDD. (De Groot, Anderson, Freedland, Clouse, & Lustman, 2001; Lustman et al., 2000; Richardson, Egede, Mueller, Echols, & Gebregziabher, 2008). It might be also a result of a lack of adequate outpatient care for diabetes or MDD (Oster & Bindman, 2003). In theory, therefore, improvement in depression symptoms through better quality of outpatient depression care could lead to lower ED and inpatient care utilization. However, there is only limited evidence on the differences in outcomes of individuals with MDD treated in primary care settings and mental health specialty. Results from a recent clinical trial showed that identical remission and response rates were achieved in primary and specialty settings when identical care is provided (Gaynes et

al., 2008). Regardless, there is still very limited empirical evidence on changes in ED and hospitalizations associated with mental health specialist care.

The objective of this study is to examine whether the use of mental health specialists for depression care affects ED visits and hospitalizations. The current study builds on previous research to provide further evidence of the role of mental health specialist care on ED visits and hospitalizations by addressing the gap in the literature with two major strengths. First, this study is focused on individuals with co-occurring MDD and diabetes instead of those with MDD only or with diabetes only. Second, the selection bias into depression treatment modality is controlled via both instrumental variable methods and panel-data analysis in order to compare the utilization outcomes between those who made different treatment choices on mental health specialist use. To the best of my knowledge, this study is the first to model mental health specialist use as endogenous with both instrumental variables and panel-data specifications to determine the effect of mental health specialist care on ED visits and hospitalizations in this specific population.

4.2 Method

4.2.1 Conceptual framework

Two types of providers for depression care are considered: mental health specialists and primary care providers. The depression care provided by mental health specialists would affect ED visits and hospitalizations differently than depression care provided by primary care providers, but the differential treatment effect could be in opposite directions.

ED visit and inpatient service use are reflective of a patient's health status. Intuitively, for patients with confirmed diagnoses of diabetes and MDD, outpatient care could be considered

preventive care and lead to better health reflected by less avoidable emergency and inpatient service use. Therefore, we need to examine the health production function. Assuming that an aggregate health production function could be expressed as

$$H = h(D_1(G,S), D_2(G,S); E) \ldots\ldots (1)$$

Where *G* is primary care physician visit count and *S* is a mental health specialist visit count. *E* is the consumer's predetermined stock of knowledge or human capital exclusive of health capital. D_1 is quality of *diabetes* care, and D_2 is quality of *depression* care. The total marginal contributions to health of different types of provider visit are

$$\frac{dh}{dS} = h_{D_1}\frac{\partial D_1}{\partial S} + h_{D_2}\frac{\partial D_2}{\partial S} \ldots\ldots (2a)$$

$$\frac{dh}{dG} = h_{D_1}\frac{\partial D_1}{\partial G} + h_{D_2}\frac{\partial D_2}{\partial G} \ldots\ldots (2b)$$

We would like to compare between $\frac{dh}{dS}$ and $\frac{dh}{dG}$ (left-hand sides of 2a and 2b.) If $\left(\frac{\partial h}{\partial S} - \frac{\partial h}{\partial G}\right) > 0$, or $\frac{\partial h}{\partial S} > \frac{\partial h}{\partial G}$, then mental health specialists are more efficient than primary care providers in terms of their marginal contribution to health. Efficient providers are defined as those that provide care with fewer inputs (i.e. visits, duration of treatment, or medications) than an inefficient provider but achieve the same outcome (Lindrooth et al., 2006; Newhouse, 1996)

Take the difference between $\frac{dh}{dS}$ and $\frac{dh}{dG}$ and organize similar terms,

$$\frac{dh}{dS} - \frac{dh}{dG} = h_{D_1}\left(\frac{\partial D_1}{\partial S} - \frac{\partial D_1}{\partial G}\right) + h_{D_2}\left(\frac{\partial D_2}{\partial S} - \frac{\partial D_2}{\partial G}\right) \ldots\ldots (2c)$$

We know $h_{D_1} > 0$, $h_{D_1} > 0$. If $\left(\frac{\partial D_1}{\partial S} - \frac{\partial D_1}{\partial G}\right)$ is assumed to be negative, or $\frac{\partial D_1}{\partial S} < \frac{\partial D_1}{\partial G}$, which says the marginal contribution to quality of *diabetes* care of a primary care visit is larger than that of a mental health specialist visit, then the sufficient condition for $\left(\frac{dh}{dS} - \frac{dh}{dG}\right) > 0$ is

$\left(\frac{\partial D_2}{\partial S} - \frac{\partial D_2}{\partial G}\right) > 0$. While $\left(\frac{\partial D_2}{\partial S} - \frac{\partial D_2}{\partial G}\right) > 0$ does not guarantee $\left(\frac{\partial h}{\partial S} - \frac{\partial h}{\partial G}\right) > 0$, comparing $\frac{dh}{dS}$ and $\frac{dh}{dG}$ is subject to empirical investigation. However, as literature documented, I argue that $\left(\frac{\partial D_2}{\partial S} - \frac{\partial D_2}{\partial G}\right)$ is likely to be greater than zero and large and the difference between $\frac{\partial D_1}{\partial S}$ and $\frac{\partial D_1}{\partial G}$ is likely to be small in magnitude even if it is negative. Thus I hypothesize that $\left(\frac{\partial h}{\partial S} - \frac{\partial h}{\partial G}\right) > 0$, or $\frac{h_S}{h_G} > 1$, the marginal benefit to health (measured by ED and inpatient care) of mental health specialist use with respect to primary care use is greater than one. In sum, mental health specialist care could decrease ED/hospitalization by increasing the marginal returns to depression care on health. While depression severity is associated with higher ED and inpatient care (Ciechanowski et al., 2000; Gonzalez et al., 2008), the higher quality associated with mental health specialist care could lead to lower ED and inpatient care. Therefore, the marginal return to mental health specialist care on health production could be higher than that of primary care, and thus could lead to lower ED and inpatient care.

However, it is also possible that mental health specialist care crowds out diabetes care due to the emphasis on depression issues in preventive outpatient care (Lin, 2017). The crowding-out effect could lead to lower adherence to diabetes care, worse general health outcomes, and therefore, higher all-cause ED/hospitalization utilization. Therefore, the effect of mental health specialist visits on ED/hospitalizations is ambiguous a priori and an important empirical question.

4.2.2 Empirical specifications

Mental health specialist use is subject to potential endogeneity since decisions to visit a mental health specialist could be heavily driven by severity of illness, personal preferences, or other unobservable factors that could also affect ED and inpatient utilization. To estimate the

effect of mental health specialist use, two different empirical strategies were employed. First, the potential endogeneity of mental health specialist care was addressed by adopting an instrumental variable approach. Further, panel-data analyses were conducted to explicitly account for within-person correlation and time-invariant latent heterogeneity. Outcomes of interest include both the probabilities of having any ED/hospitalizations and the total counts of ED visits /hospitalization days.

4.2.2.1 Any ED visits/hospitalization days

The choice of methods for the binary dependent variables with a binary endogeneous variable could vary depending on the rarities of outcomes and treatment. As Two-Stage-Least-Square (2SLS) could be biased, probit-probit Two-Stage-Residual-Inclusion (2SRI) models with raw residuals were also estimated. The standard errors around the marginal effects were estimated via bootstrapping with 1000 iterations. Further, to control for time-invariant unobservable factors, Two-Stage-Least-Square (2SLS) specifications with person-level fixed effect were also estimated. The 2SRI models were estimated without fixed-effects as non-linear instrumental variable models including fixed effects tend to yield inconsistent estimation (Cameron & Trivedi, 2005), but was estimated with Generalized Estimating Equations (GEE) to account for correlation between different observations within the same individual.

4.2.2.2 Total ED visits/hospitalization days

The effects of mental health specialist care on total ED visits and hospitalization days were estimated with GEE models with negative binomial distributions, taking into account the correlation among different observations across years for the same patient. To further mitigate potential endogeneity of mental health specialist care, instrumental variables were used in GEE

models with 2SRI-raw residuals. The standard errors around the marginal effects of all instrumental variable models were estimated via bootstrapping with 1000 iterations.

4.2.2.3 Specification tests

Specification tests were performed to assess the strength of the combination of the three proposed instrumental variables, over-identification restrictions, and exogeneity. The strength of the three instrumental variables was tested in the first stage of 2SRI (probit). The Chi-square test statistic in the first stage was 159.09, showing the joint statistical significance of the three proposed instruments in predicting mental health specialist use ($p<0.001$). Further, Sargan-Hansen's tests for over-identifying restrictions and Wooldridge's score tests for exogeneity were performed in 2SLS-FE models even the preferred specification is 2SRI, as such tests are not available in a non-linear IV models. The results showed that the three instruments are jointly validly excluded from the second stage for each outcome. The exogeneity of mental health specialist use was rejected for the any ED visit/ hospitalizations outcomes ($p<0.001$) but not the number of ED visits/hospitalization days ($p=0.103$ for ED visits and $p=0.230$ for hospitalization days). Accordingly, results from all instrumental variable models are presented even though mental health specialist care might be only endogenous to the first part of the outcome.

4.2.2.4 Robustness check

Three sets of robustness checks were conducted. First, in order to examine the influence of unmeasured health status, the number of ED visits and number of hospitalization days from the prior year (lagged) were included as covariates under the assumption that prior hospitalization and ED visits could represent health status that are associated with mental health specialist care and current ED and hospitalizations (Davydow, Zivin, & Langa, 2014). Because of the reliance on prior year's data for this model, including lags excluded 29.32% of the original

sample and reduced the estimation sample to 53,977 observations. Second, it is possible that treatment effects of mental health specialist care between individuals with and without severe mental illness are heterogeneous. Therefore, separate analyses were also conducted on the subgroup without severe mental illness (sample size 51,950). Finally, the estimation sample was restricted to individuals who were enrolled in Medicaid for at least 9 months during a year (sample size 64,197). Results on all those subsamples are very similar to those on the full sample. Therefore, they are not separately reported but available by request from the corresponding author.

4.2.3 Data

4.2.3.1 Estimation sample

The data in this study come from the North Carolina Medicaid Analytic Extracts (MAX) from 2006-2011. These data files contain enrollment information and final action claims including outpatient care, emergency room visits, and hospitalization. The estimation sample was restricted to adult beneficiaries aged 18 or older with at least one inpatient or at least two outpatient diagnoses of diabetes and MDD during the study period (International Classification of Disease version 9 [ICD-9] code: 250.XX 357.2X, 362.0X, or 366.41 for diabetes and 296.2X, 296.3X, 300.4X, or 311.XX for MDD. Data were collapsed to annual summaries reflecting the total utilization in the year. A person-year is included if the beneficiary had at least one month of Medicaid enrollment in that year. Person-years with Medicaid and Medicare dual coverage were excluded due to the potential for incomplete information on healthcare utilization. Person-years with long-term care facility service use were excluded because those beneficiaries are less likely to receive outpatient visit claims. Finally, individuals were excluded if they were in one of the five (of 100) counties where mental health services were carved-out during this time period,

as mental health care utilization for such patients were incomplete in MAX files. The final estimation sample includes 22,392 unique persons with co-occurring diabetes and MDD during 2006-2011, contributing 76,369 person-years to the analysis.

4.2.3.2 Key measures

The outcomes of interest are ED visits and hospitalization days. Both the presence and counts of ED visits and hospitalization days were measured. Number of ED visits is defined as the total number of visits a patient made to an Emergency room for all causes during a year. This measure does not include ED visits that led to inpatient stays at the same facility. The average rate of having any ED visits is 69.5%. The average number of ED visits per year is 3.3 (Table 4.1).

Number of hospitalization days is defined as the total number of hospitalization days for all causes during a year. The average rate of having any hospitalization is 36.28% during 2006-2011(Table 4.1). The average number of hospitalization days is 4.2 (Table 4.1).

Mental health specialist use is the key independent variable in this study. It is defined as a binary indicator of whether an individual had any visits to a psychiatrist, a psychologist, a psychological associate, a mental health nurse practitioner, a licensed clinical social worker, a mental health HMO, an Assertive Community Treatment Team, or any Critical Access Behavioral Health Agency. On average, 31.6% of the annual observations in this study had at least one mental health specialist visit during a year (Table 4.1).

4.2.3.3 Other control variables

Other important control variables included patient characteristics, diabetes complications, other psychiatric co-morbidities, and other co-morbidities. Patient characteristics include age, gender, and race and living in a rural area. Rural area is defined according to Rural-

Urban Commuting Areas (RUCAs). The RUCA codes classify U.S. census tracts using measures of population density, urbanization, and daily commuting (United States Department of Agriculture Economic Research Service, 2016). As census tracts are not available in MAX data, RUCA codes were identified with zipcode in this study. Areas with RUCA codes lower than 4 are defined as rural. Among the estimation sample, the average age was 45, 22% were male, 41% were African American, 79% lived in an urban area, and the average enrollment in a calendar year was 11 months (Table 4.1).

For diabetes, nine major complications were identified and an index of diabetic complications was created accordingly, defined as the sum of the number of diabetes complications each year. Following Bethel and colleagues (2007), those diabetes complications included diabetic eye disease (low vision or blindness), chronic renal failure, ESRD, gangrene, debridement, amputation, myocardial infarction, congestive heart failure, and stroke (Bethel, Sloan, Belsky, & Feinglos, 2007). Any insulin use for diabetes was identified and included separately in the model, as insulin use typically indicates more severe diabetes associated with both higher outpatient and inpatient care utilization (Gamble, Simpson, Eurich, Majumdar, & Johnson, 2010; B. A. Young et al., 2008). Binary indicators for bipolar disorder and schizophrenia were included in the model, as individuals with those conditions might be more likely to use both mental health specialist care, ED, and inpatient care.

Additionally, general co-morbidities were also included in all analyses, as the combination of generic and diabetes-specific measures should lead to greater predictive power on probability of receiving different types of healthcare utilization (Maciejewski, Liu, & Fihn, 2009). The Chronic Illness and Disability Payment System (CDPS) was applied to identify general co-morbidities during the year. There are twenty major categories of diagnoses in CDPS

(version 6.0), and most of the major categories are further divided into several subcategories according to the degree of the increased expenditures associated with the diagnoses (Kronick, Gilmer, Dreyfus, & Lee, 2000). Binary indicators for all 58 subcategories for current year were included in the model.

4.2.3.4 Instrumental variables

Three variables were identified as potential instruments: the proportion of mental health specialist use among Medicaid beneficiaries at the county-level, the total number of licensed mental health specialists in each county from North Carolina Health Professions Data System (HPDS) (Richman, Fraher, & Gaul, 2015), and the total number of mental health specialists accepting Medicaid patients generated from the MAX data. As valid instruments, those variables should only affect depression care outcomes through mental health specialist use and otherwise be independent of ED visits/hospitalizations. The first instrument, mental health specialist use rate, is defined as the proportion of all Medicaid beneficiaries who had any mental health specialist use during the year at the county-level. The variation in local treatment selection is possibly through the historical practice style, which is plausibly independent of underlying health, preferences and outcomes of patients (Basu, Heckman, Navarro-Lozano, & Urzua, 2007). The full Medicaid sample regardless of diagnosis was used to generate variables reflecting total number of Medicaid beneficiaries enrolled by county as well as the proportion of beneficiaries with at least one mental health specialist visit at county-level.

The second instrument, HPDS supply, is defined as the total number of psychiatrists and psychologists in a county, and comes from North Carolina Health Professions Data System (HPDS) (Richman et al., 2015). In theory, the supply of mental health specialists affects depression care through affecting mental health specialist use only. Due to data availability in

HPDS, this measure includes only psychiatrists and psychologists, the two major types of mental health specialists (Richman et al., 2015). Nevertheless, this measure could reflect the availability of mental health specialist services more generally, if there is a high correlation among the number of psychiatrists, psychologists, and other specialists at the county level (Ellis, Konrad, Thomas, & Morrissey, 2009).

The third measure, Medicaid mental health specialist supply, is defined as the number of mental health specialists that had seen at least one Medicaid beneficiary in a year at the county-level. A Medicaid provider was identified from unique provider identifiers that had at least one claim for a Medicaid beneficiary in a year. The unique identifiers used are state-assigned Medicaid billing identifiers prior to 2009 and National Provider Identifier (NPI) beginning 2009. The Medicaid mental health specialist supply was measured as the total number of Medicaid mental health specialists with at least one Medicaid-billed claim in a year at county-level. Note that a provider seeing patients in multiple counties could be counted more than once. The full sample regardless of diagnosis was used to identify Medicaid mental health specialists. All three instruments were merged to the analytical file by county and year.

4.3 Results

4.3.1 ED visits

Any ED visits. Estimates of the differential effects of mental health specialist use on the expectation of having any ED visits are presented on the first row through Column (1) to (3) in Table 4.2. The naïve probit model (Column (1)) predicts a positive association of 0.87 percentage points ($p<0.05$) between mental health specialist use and having any ED visits. This effect became insignificant, however, in both the 2SLS model with fixed effect and 2SRI-GEE

model (Column (2) and (3)). The preferred 2SRI with GEE specification (Column (3)) shows that, with endogeneity adjusted by valid instruments, mental health specialist use is found to reduce 3.0 percentage point in the expected probability of having ED visits in a year, but this effect is not statistically significant (p=0.541).

Number of ED visits. After adjusting for endogeneity, the GEE model (Column (4)) shows a significant negative effect of mental health specialist use on the number of ED visits by 0.37 ($p<0.01$) in the full estimation sample. This result suggests that for an individual with co-occurring diabetes and MDD who would increase use of mental health specialist care due to the changes in either local utilization pattern or higher supply of mental health specialist, receiving mental health specialist care will lead to 0.37 fewer ED visits during a year.

4.3.2 Hospitalization days

Any hospitalizations. Parameter estimation for effects of mental health specialist use on expectation of having any hospitalizations per year are presented through Column (1) to (3) in Table 4.2. The naïve probit model (Column (1)) predicts a positive association of 4.3 percentage points ($p<0.01$) between mental health specialist use and having any hospitalizations. Both the 2SLS model with fixed effect and 2SRI with GEE model (Column (2) and Column (3)), however, predict the effect in an opposite direction. The preferred 2SRI-GEE specification (Column (3)) shows that, with endogeneity adjusted by valid instruments, mental health specialist use is found to induce a significant 7.0 percentage point decrease in the expected probability of having any hospitalizations in a year ($p<0.01$). This result suggests that for a *marginal individual* who has co-occurring diabetes and MDD and would increase their use of mental health specialist care due to the changes in either local preference or higher supply of

mental health specialist, receiving mental health specialist care will significantly decrease her probability of having any hospitalizations.

Number of hospitalization days. With instrumental variable methods, the GEE-IV model on the full sample (Column (7)) shows that mental health specialist use will induce a decrease on the number of hospitalization days by 0.73, but this effect is not statistically significant (p=0.236).

4.4 Discussion

Mental health specialist care was found to reduce the overall number of ED visits significantly among adult Medicaid beneficiaries with co-occurring diabetes and MDD. The reduction in ED visits might have resulted from better depression management through outpatient care provided by mental health specialty, as MDD could worse symptoms of other medical chronic conditions. The preferred specification showed that mental health specialist use had no significant effect on the probability of having ED visits. An exploratory analysis was further conducted to investigate the effect of mental health specialist care on ED visits for MDD, and the results showed that mental health specialist use significantly decreased the probability of having any ED visits with a MDD diagnosis. However, such ED visits only represented a very small proportion (<9%) of the all-cause ED visits in the estimation sample, implying that this measure might not accurately identify ED visits for MDD.

Among those with co-occurring diabetes and MDD, individuals visited mental health specialists were less likely to incur hospitalizations during the same year, although mental health specialist care had no significant effect on the number of hospitalization days either in those with non-zero hospitalizations or in the full estimation population. There are plausible scenarios in

which an outpatient visit leads to the detection and successful treatment of a crisis that, if left untreated, would result in hospitalization. If mental health specialists provide better detection and treatment for such crisis during a patient's outpatient visit than a primary care provider, this difference could lead to the reduction in probability of hospitalizations.

The instrumental variable estimation also brings important policy implications. The results suggest that decrease in ED/hospitalization utilization might be achieved by increasing the local supply of mental health specialists. Therefore, future policies could target efforts at increasing such supply. An example is the Psych NP-NC program in North Carolina launched in 2004. This program recruits and educates nurses so that they are able to provide prescriptions of psychotropic medications and psychotherapies when returning to their home community (Soltis-Jarrett, 2011). The program has been successful in targeting a total of 67 counties in NC and graduating 74 new psychiatric nurses during 2004-2011(Soltis-Jarrett, 2011). Further studies are required to better understand the nature of such supply effect and to determine the effect of specific efforts to increase supply of mental health specialist on reducing ED/hospitalization use as well as improving overall population health.

This study found that among Medicaid beneficiaries with co-occurring diabetes and MDD, 69.4% had at least one ED visit during a year. This is higher than what have been reported for those either with MDD or diabetes only, which ranged from 36.0% to 42.9% during a year (Himelhoch et al., 2004; Lee et al., 2008), and similar to the utilization rate as 65.0% among Medicare beneficiaries (Himelhoch et al., 2004). The average number of ED visits is 3.3, slightly larger than the average number among individuals with diabetes and co-morbid MDD in another study which utilized 1996 Medical Expenditure Panel Survey (MEPS), reported as one ED visit in a year (Egede, Zheng, & Simpson, 2002). However, the study population was very

different from the present study as about one-third of their estimation sample were adults aged 65 or more; therefore, the results might not apply to the present study population.

This study found that 36.3% of the study population had at least one hospitalization during a year. This utilization rate, however, is much lower than what has been reported in a prior study as 66.0% among Medicare beneficiaries with diabetes and MDD (Himelhoch et al., 2004). This could be due to the fact that the current study population experienced fewer co-morbid chronic conditions than general Medicare beneficiaries. The average number of hospitalization days is 4.2, higher than the average number among those with diabetes only during 2010-2011, reported as 1.45 by another study utilizing Medical Expenditure Panel Survey (MEPS) (Zhou et al., 2015).

Several limitations are acknowledged. First, caution should be made when interpreting this study's findings, as instrument variable analysis applies to the "marginal individual." In the context of this study, marginal individuals are those Medicaid beneficiaries whose increased use of mental health specialist care was influenced by the changes in higher supply of mental health specialists. The study results will not apply to individuals who change their behavior due to other reasons. Second, my analysis only focuses on Medicaid enrollees, and is not generalizable to adults that may be uninsured or have other types of insurance. Finally, this study did not examine expenditures associated with ED and hospitalizations outcomes. It is possible that reduced healthcare use does not guarantee reduced expenditures.

While the number of patients with multiple chronic conditions in the US has grown substantially from 24 % in 2001 to 28% in 2006 (Anderson, 2010), the increasing use of ED and inpatient care attributed to those chronic conditions has also become a leading cost driver in the US health care system (Schuur & Venkatesh, 2012). Findings from this study suggest that for

individuals with co-occurring diabetes and MDD, policies that aims to reduce ED and inpatient care utilization could target increasing access to mental health specialist care in this population. Strategies for such increased access to care can be achieved through either increasing the supply of licensed mental health specialists in the community or increasing participation in Medicaid among current mental health specialists. This study also sheds light on the potential benefits of mental health specialist care on reducing ED and hospitalization utilization in other complex population with mental health care needs. Future research exists, therefore, to carefully examine the impact of mental health specialist care in other populations with different combinations of co-occurring mental health and physical conditions.

Table 4.1 Summary Statistics on Annual Observations

	All (NT=76,369)	Mental Health Specialist Use		
		Yes (NT=23,832)	No (NT=52,537)	P-value¶
Outcome				
Any ED visits (%)	69.47	75.25	66.85	<0.001
Number of ED visits (mean)	3.255	4.091	2.876	<0.001
Standard Errors	(0.020)	(0.043)	(0.022)	
Any hospitalizations (%)	36.28	40.83	34.22	<0.001
Number of hospitalization days (mean)	4.15	5.278	3.633	<0.001
Standard Errors	(0.0053)	(0.082)	(0.046)	
Patient Characteristics				
Age	44.81	44.59	44.91	<0.001
Female (%)	77.67	78.08	77.49	0.073
Race				<0.001
African American (%)	41.49	42.67	40.96	
White (%)	51.82	52.18	51.66	
Other race (%)	6.91	5.42	7.59	
Rural (%)	21.42	21.11	22.99	<0.001
Number of months of Medicaid Enrollment (1-12)	10.68	11.38	10.36	<0.001
Clinical Characteristics				
Total number of diabetes complication (0-9)	0.52	0.53	0.52	0.005
Total number of diabetes complication, exclude diabetic eye disease (0-8)	0.29	0.27	0.30	<0.001
Diabetic eye disease (%)	23.60	26.61	22.23	<0.001
Gangrene (%)	2.47	2.66	2.38	0.022
Debridement (%)	2.22	2.19	2.24	0.650
Amputation (%)	0.78	0.72	0.81	0.186
Chronic renal failure (%)	6.06	6.22	5.99	0.228
End Stage Renal Disease, ESRD (%)	0.90	0.71	0.99	<0.001
Myocardial infarction (%)	3.89	3.55	4.05	0.001

	All (NT=76,369)	Mental Health Specialist Use		
		Yes (NT=23,832)	No (NT=52,537)	P-value¶
Congestive heart failure (%)	9.13	7.99	9.65	<0.001
Stroke (%)	3.18	2.68	3.41	<0.001
Any insulin use (%)	30.38	32.08	29.60	<0.001
Severe mental illness (%)	20.19	40.20	11.11	<0.001

¶ Chi-square tests were performed for categorical variables and T-tests were performed for continuous variables. Severe mental illness includes schizophrenia and bipolar disorder.

Table 4.2 Differential Effect of Mental Health Specialist Care on ED Visits and Hospitalization Day

	Any service use			Total service use
	(1) Probit	(2) 2SLS-FE	(3) 2SRI-GEE	(4) 2SRI-GEE
ED visit	0.0087*	-0.21	-0.030	-0.37**
Standard errors	(0.0044)	(0.14)	(0.049)	(0.13)
P-value	0.047	0.130	0.541	0.006
Sample Size (N)	76,369	76,369	76,369	76,369
Number of unique individuals (N)	22,392	22,392	22,392	22,392
Hospitalization days	0.043**	-0.05	-0.070**	-0.73
Standard errors	(0.004)	(0.15)	(0.014)	(0.61)
P-value	<0.001	0.731	<0.001	0.236
Sample Size (N)	76,369	76,369	76,369	76,369
Number of unique individuals (N)	22,392	22,392	22,392	22,392

2SLS-FE: Two stage least square with person-level fixed effect. 2SRI: Two stage residual inclusion with raw residuals. GEE: General Estimating Equations. In all models, other control variables not reported include year dummy variables (2006-2011) and CDPS indicators (58 dummy variables). Standard errors are estimated with delta-method for differential effect estimation in Probit and 2SLS-FE. Standard errors are estimated with bootstrapping methods with 1000 iterations for 2SRI-GEE. *p<=0.05 **p<0.01

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CHAPTER 5. DISCUSSION

The objective of this study was to examine the effect of the mental health specialist care on healthcare utilization of adult Medicaid beneficiaries with co-occurring diabetes and major depressive disorder (MDD) in North Carolina. This study examined the effect of mental health specialist care on guideline-concordant diabetes care (Chapter 2), guideline-concordant depression care (Chapter 3) and, the emergency department (ED) and hospitalization care utilization (Chapter 4). North Carolina Medicaid claims data (MAX) were used to analyze outcomes of healthcare utilization with appropriate specifications, including person-level fixed effect (Chapter 2-4), Instrumental variable method (Chapter 2-4), and Generalized Estimating Equations (Chapter 4). In this final chapter, the study findings are summarized and their implications for policy, limitations, and future research on mental health specialist care are discussed.

5.1 Summary of Study Findings

The main findings of this dissertation could be summarized as the following. First, mental health specialist care affects guideline-concordant diabetes care in two different directions among individuals who would change their treatment choices due to changes in local supply of mental health specialists. It improves adherence level of annual eye exam and likelihood of having visited a primary care provider, but it decreases adherence level of annual lipid test and two A1c tests during a year, two important primary care-based preventive check-ups. Second, mental health specialist care leads to higher adherence level to guideline-

concordant depression care, measured as at least 84 days covered antidepressant prescription or four psychotherapy visits during the acute phase of a depression treatment episode. Finally, mental health specialist care reduces the overall number of all-cause ED visits and the probability of having any all-cause hospitalizations. Therefore, among adults with co-occurring diabetes and MDD, mental health specialist care improves quality of depression care, but might reduce quality of diabetes care at primary care. Further, it also reduces tertiary care utilization through decreasing both the overall number of ED visits and the likelihood of hospitalizations.

5.2 Implications

The availability of providers to care for patients is the foundation for all health care delivery. Unfortunately, many areas in the US continue to have shortages of health care professionals, especially for mental health care. As mental health specialty supply is predicted to remain low, how to efficiently allocate mental health workforce among those with mental health care needs has became a critical policy issue. The high level of unmet need as well as the high cost among individuals with co-occurring mental health and physical conditions suggest that this population deserves increased attention. It is important to examine the role of mental health specialists in caring for this population as well as how mental health specialist care affects other types of healthcare utilization.

This dissertation study addresses the most critical aspect of the mental health specialist care issues among a specific complex patient population and brings important policy implications. Overall, despite the fact that primary care providers have been more engaged in providing depression care, mental health specialist care is found to generally improve healthcare utilization outcomes among adults with co-occurring diabetes and MDD. Specifically, mental

health specialist care could improve quality of depression care and reduce ED and inpatient care utilization. This implies the possibility that the clinical significance of mental health specialist care could still outweigh the potential high marginal cost of visiting a mental health specialist in this specific population. Policies aiming to improve healthcare utilization outcomes in this population could target at improving access to mental health specialist care through increasing licensure workforce or Medicaid participation among mental health specialists.

The negative effect of mental health specialist care on some primary care-based quality indicators for diabetes care, however, implies that any policy aiming to improve mental health care delivery also needs to address the spillover effect of mental health care on other co-occurring physical conditions. Study results suggest that due to potentially limited available resources or competing demand during a primary care visit, healthcare demand for one chronic condition might crowd out demand for another condition. As individuals with multiple chronic conditions tend to present greater challenges to achieving quality goals designing for those with a single condition (Werner, Greenfield, Fung, & Turner, 2007), future policies should focus on developing a comprehensive care model that addresses specific quality performance in this population.

5.3 Limitations

Specific limitations for have been addressed in each of the previous chapter. Overall, this dissertation is subject to several potential limitations. First, Medicaid claims data does not have information on the severity of symptoms (mental health or physical health), and the ability to describe a beneficiary's clinical severity based on claims data is restricted (Iezzoni, 1990). Although this study controlled comorbidities in different forms, it id not provide answers to

questions specific to severity of symptoms. For example, this study cannot examine weight change or MDD severity after a patient sees a specialist. However, with understanding of the effect of mental health specialist care on overall health built from this study, future research with primary data collection or Medical record abstractions to collect severity of symptoms or clinical outcomes could help researches to further study the effect of mental health specialist care on disease-specific severity among this population.

Second, the provider licensure data is available for limited number of categories of mental health specialist. Although HPDS is an excellent dataset with richer NC workforce information than other available data sources, it is still lacking information of some types of mental health specialists. For example, information of counselors, social workers, and family and marriage therapists are not available as of this writing. However, psychologists and psychiatrists are two most important types of shortage among all mental health providers and deserve major attention. This study will still answer important policy questions even without weighting in supply information of some other types of provider.

Third, the county-level supply of Medicaid provider is measured as the number of Medicaid mental health specialist in a year at county-level. However, this measure is subject to potential bias. A provider could be counted more than once as she might be identified from different counties in a year and could lead to overestimated numbers of providers. Further, the unique id used was state-assigned Medicaid billing identifiers prior to 2009 and National Provider Identifier (NPI) beginning 2009. Medicaid billing identifiers are more likely to be practices, while NPI are more likely to be clinicians. Therefore even when the actual supply stays stable over years, it may still show an increasing trend during the study period with those two different identifier systems.

5.4 Next Steps

As this dissertation was focused on adult Medicaid beneficiaries in North Carolina, implications yielded from the study results might only apply to this specific population. For example, study findings might not be generalizable to Medicare beneficiaries, as the elderly population with multiple chronic conditions might occur higher ED and hospitalization utilization than their younger counterparts. Further, individuals with different combinations of physical and mental health conditions might have different treatment choices for mental health care than those with co-occurring diabetes and MDD. Future areas of research, therefore, exist to carefully examine choices for mental health care as well as to determine the effect of mental health specialist care on other populations with different insurance types, different demographics, or different combinations of chronic conditions.

In the spirit of promoting integration between behavioral healthcare and medical care, a natural extension to the current study would be to evaluate whether patients with mental health and physical health chronic conditions benefits more from mental health specialist care in a coordinated, comprehensive, and patient-centered care setting. Those models that adapted the patient-centered multidisciplinary approach include medical home models, community health teams, and primary care and behavioral health integration models (US Department of Health and Human Services, 2010). Research interests have emerged with regard to the impacts of such models on quality of care among individuals with co-occurring mental and physical chronic conditions. For example, a recent study has found that medical home enrollment is generally associated with greater likelihood of receiving guideline-concordant diabetes care for Medicaid enrollees with diabetes and schizophrenia (Olesiuk et al., 2016). Future research should carefully

evaluate the role of mental health specialists in those models, as well as impacts of those models on mental health specialist use and other healthcare utilization of individuals with mental health and other physical conditions.

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APPENDIX: SELECTED AVERAGE MARGINAL EFFECT ESTIMATIONS ON ED VISITS AND HOSPITALIZATION DAYS

Appendix Table 1 Selected Average Marginal Effect Estimations on ED visits

	(1)	(2)
	Any ER visit	Total ED visit
	2SRI-GEE	GEE-IV
Any Mental health specialist visit	0.0008	-0.37**
	(0.0015)	(0.13)
Age	-0.00689**	-0.0895**
	(0.00014)	(0.0024)
Female	0.0304**	-0.062
	(0.0037)	(0.058)
Race (Reference: Caucasian)		
African American	0.0392**	0.026
	(0.0032)	(0.050)
Other race	-0.0070	-0.283**
	(0.0060)	(0.092)
Living in a rural area	-0.0076	-0.052
	(0.0035)	(0.050)
Number of months of Medicaid Enrollment	0.00495**	0.2226**
	(0.00056)	(0.0078)
Any insulin use	0.0269**	0.185**
	(0.0043)	(0.042)
Total number of diabetes complication	0.0298**	0.207**
	(0.0029)	(0.019)
Severe mental illness	0.0547**	0.421**
	(0.0069)	(0.052)
Sample Size (N)	76,369	76,369
Number of unique individuals (N)	22,392	22,392

2SRI-raw: Two stage residual inclusion with raw residuals. GEE: General Estimating Equations. IV: Instrumental variable method. In all models, other control variables not reported include year dummy variables (2006-2011) and CDPS indicators (58 dummy variables). Standard errors are estimated with bootstrapping methods with 1000 iterations for 2SRI and GEE-IV. *p<=0.05 **p<0.01

Appendix Table 2 Selected Average Marginal Effect Estimations on Hospitalization days

	(1) Any hospitalization	(2) Total hospitalization days
	2SRI-GEE	GEE-IV
Any Mental health specialist visit	-0.069**	-0.727
	(0.014)	(0.614)
Age	-0.00205**	-0.0624**
	(0.00015)	(0.0083)
Female	-0.0216**	-1.27**
	(0.0035)	(0.16)
Race (Reference: White)		
African American	0.0056	0.40**
	(0.0031)	(0.14)
Other race	0.0103	0.96*
	(0.0059)	(0.46)
Living in a rural area	-0.0031	-0.57**
	(0.0036)	(0.17)
Number of months of Medicaid Enrollment	-0.01168**	-0.276**
	(0.00059)	(0.026)
Any insulin use	0.0554**	1.35**
	(0.0041)	(0.16)
Total number of diabetes complication	0.0663**	1.542**
	(0.0025)	(0.093)
Severe mental illness	0.1063**	2.98**
	(0.0060)	(0.23)
Sample Size (NT)	76,369	76,369
Number of unique individuals (N)	22,392	22,392

2SRI-raw: Two stage residual inclusion with raw residuals. GEE: General Estimating Equations. IV: Instrumental variable method. In all models, other control variables not reported include year dummy variables (2006-2011) and CDPS indicators (58 dummy variables). Standard errors are estimated with bootstrapping methods with 1000 iterations for 2SRI and GEE-IV. *p<=0.05 **p<0.01