Dynamic Sequencing of Drug Treatments for ADHD Patients with Medicaid Coverage

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1 Introduction

The most recent National Survey of Children's Health reported that 9.5% of children aged 4-17 were diagnosed with attention deficit hyperactivity disorder (ADHD). More than a half of these children are reported as receiving medication treatment for the disorder. Although there is a strong belief that ADHD drugs are overprescribed, very little is known about the existing prescribing practices and physician learning process in ADHD treatment. In the Medical Expenditure Panel Survey (MEPS) 1996-2010 dataset, ADHD is one of the top-25 conditions by the number of prescriptions filled. The evidence suggests that children and teenagers diagnosed with ADHD face significant uncertainty regarding efficacy and severity of adverse effects of ADHD medications. The typical patient is prescribed between one and two different drugs before they find a suitable treatment. The switch from the initial choice occurs approximately within half a year.

Using South Carolina Medicaid claims data for 2003-2012, I will estimate a dynamic model of demand for ADHD drugs under uncertainty. Uncertainty comes from two sources: little evidence on newly introduced ADHD treatments and uncertainty about the response to treatment of a particular patient. In the model, highly heterogeneous patients learn about

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the efficacy of available treatments through experimenting. Their preferences are embedded into the preferences of their physician decision-maker.

This paper is an extension of Dickstein (2011). His analysis of depression drugs suggested that insurer copayment policies and drug promotions for the most efficient treatments can improve patient outcomes while minimizing insurer cost. In this paper, I explore whether these treatment protocols hold for ADHD drugs also. I will evaluate a number of prescribing practices accounting for physician preferences and patient heterogeneity in response to treatment for ADHD to explore the potential to develop better guidelines that can improve the quality of drug-patient matches, their health and at the same time reduce long-run costs to Medicaid.

2 Related Literature

This paper contributes to the literature on prescription drug demand under uncertainty. The quality of the so-called experience goods is imperfectly observed, so a consumer needs to learn about it from her experience, advertisement, or other consumers experiences. The ways the uncertainty is resolved are part of the major differences across research work.

Erdem and Keane(1996) and Ackerberg(2003) look at the effects of advertisement on consumer demand in the markets where there is uncertainty regarding product quality, which can be resolved with experience and outside information. Both empirical models are estimated using A.C. Nielsen, Inc. scanner panel data set. Erdem and Keane(1996) look at the sales of laundry detergent to estimate how changes in marketing strategy affect brand choice both in the short run and long run. They find that the intensity of promotion has small short-run effects, but is significant in the long run. Ackerberg(2003) examines sales of yogurt, where consumers also learn from experience and advertisement. However, they distinguish between the two potential effects of promotion: "informative" and "prestige" effects, where the latter affects both experienced and inexperienced consumers, while the former affects the demand of inexperienced consumers only. Ackerberg finds that consumers learn from their experience and informational component of advertisement. He does not find support for the hypothesis about the prestige effects of promotion. However, the informational effect of advertisement is estimated to be of a smaller value to consumers than the resources spent on it.

Early work on the demand for prescription drugs (Ellison et al.(1996), Berndt et al.(1997), and Hellerstein (1998)) does not feature consumer learning. Crawford and Shum(2005)

apply experience goods theory to anti-ulcer drugs. They argue that the patients and their doctors face uncertainty regarding the efficacy and severity of side effects of a drug in a particular patient before they try it. Then, prescription drug consumption becomes a complex matching problem, where the existing uncertainty is resolved through experimenting. The learning process in anti-ulcer prescriptions is the focus of this paper. Crawford and Shum(2005) specify the initial treatment choice and the process of updating beliefs using a bivariate Bayesian learning model of pharmaceutical demand.

The patient has two separate match values for each drug. They correspond to the two-dimensional patient heterogeneity: by symptomatic and curative effects. The symptomatic effect impacts a patients utility via diminishing side effects, and the curative effect impacts a patients probability of recovery. Notably, the former affects the patients current utility, while the probability of recovery affects the lifetime utility. In earlier learning models, like Erdem and Keane(1996) and Ackerberg(2003), the signals experience and advertising are defined to be relevant for the consumer current utility only.

The physician is assumed to be a perfect agent forher patient to avoid complications of the agency problem. Crawford and Shum(2005) assume that the patients are forward-looking and they select the sequence of drug treatments that maximizes their patients expected utility.

The authors measure the effects of uncertainty and learning in the demand for drugs. They find that learning reduces the costs of uncertainty in the anti-ulcer pharmaceutical market. Learning in this class of drugs occurs very quickly. Over two-thirds of patients resolve initial uncertainty and remain on their choice drug after the first prescription. To determine the costs of uncertainty, two counterfactuals are estimated. First, patients make the "best-case" scenario choice under complete information about their matching values. Second, the learning is eliminated by forcing the patients to stay on their first choice of treatment. Complete information results in about 9% higher average discounted utility over the baseline case with learning. If experimenting is not allowed, the average utility level drops 6% below the baseline case.

Ching(2010) builds an empirical model of demand for prescription drugs to study the role of aggregate learning and consumer heterogeneity in price sensitivity. The risk-averse consumers face uncertainty regarding newly introduced generic drugs' quality. Those consumers who are least price-sensitive are more likely to try a generic. After they try it, patients and their physicians disseminate information about their experience. The author models aggregate learning, where institutions like physician conferences and seminars, as well

as on-line stores with information on ranking, allow to aggregate consumers past experiences to update prior beliefs about the new product. Looking at generic drug introductions in two broad therapeutic classes, heart disease drugs and mental health drugs, Ching finds aggregate learning to be an important factor that explains the slow diffusion of generic drugs. Moreover, brand drug manufacturers are suggested to be forward-looking. They take into account consumers' initial pessimism in generics and their learning with time. Importantly, there is no advertisement or detailing effects in the model.

Dickstein(2011) builds upon Crawford and Shum(2005) to develop a dynamic model of demand under uncertainty for antidepressant medications. He relaxes perfect agency assumption and designs a new computational approach to accommodate a large set of available drug treatments. In contrast to Crawford and Shum(2005), Dicksteins data are comprised of employer-based commercial claims over 2003-2005. Patients are enrolled in a variety of plans with differential copayment rates. This allows Dickstein to study whether insurance cost-sharing policies and drug promotions can improve the efficiency of drug choice, measured by better patient outcome and lower long-run insurer costs. To answer the question, he estimates two sets of counterfactuals. In the first counterfactual, a series of copayment schemes is evaluated: uniform pricing applied across the border, uniform pricing applied to generic and brand drugs separately, and "value-based" insurance design that channels consumption into the most cost-effective drug classes. In the second counterfactual, the effects of advertisement are simulated. The author selects two antidepressants and adjusts their product-level fixed effects that proxy for promotion. Based on the estimation results, Dickstein argues that value-based policies that are built from observed quit rates can improve patient health, and promotion of cost-effective treatments is beneficial.

This paper is an extension of Dickstein(2011), although my primary data set resembles that of Crawford and Shum(2005). Dickstein's analysis of depression drugs suggested that policymakers can improve patient outcomes by either advertisements or lower prices for the most efficient treatments. I plan to explore whether these treatment protocols hold for ADHD drugs also. I will evaluate a number of prescribing practices accounting for patient heterogeneity in response to treatment for ADHD.

3 Background

3.1 ADHD

Attention-deficit/hyperactivity disorder (ADHD) is one of the most common mental conditions affecting children. It is often first diagnosed in school-aged children. The average age for children to be identified as having the condition is seven years old. The most recent National Survey of Children's Health reported that 9.5% of children aged 417 were diagnosed with ADHD. The National Comorbidity Survey Adolescent Supplement of 2001-2004 showed that 8.7% from a nationally representative sample of youth aged 13-18 years had ADHD, with males being three times more likely to be diagnosed than females. Approximately half of these cases were classified as severe ADHD (Merikangas et al., 2010). ADHD can also affect adults. The American Psychiatric Association (APA) estimates that 4.1% of adults in the U.S. have this disorder, with 1.7% of adults affected severely.[1]

More than half of these children are reported as receiving medication treatment for the disorder. Although there is a strong belief that ADHD drugs are overprescribed, very little is known about the existing prescribing practices and physician learning process in ADHD treatment (e.g. see Goldman et al., 1998). In the Medical Expenditure Panel Survey (MEPS) 1996-2010 dataset, ADHD is one of the top-25 conditions by the number of prescriptions filled. The IMS Institute for Healthcare Informatics (IMS) ranks ADHD 11th among therapeutic classes by U.S. spending in 2011.[2] Since 2007, expenditures on ADHD drugs increased from $4 billion to $7.9 billion in 2011. The market is likely to continue to grow as more adults are being recognized as having ADHD as well.

The description of the syndrome first appeared in 1902. Since then, its definition, categorization, and treatment practices have changed. The APA defines ADHD as a "brain condition" that is said to be present if either six or more of the inattention symptoms or six or more hyperactivity-impulsivity symptoms "have persisted for a least 6 months to a degree that is maladaptive and inconsistent with developmental level."[3]

Within the past several decades, ADHD has become one of the most studied childhood

[1] American Psychiatric Association website, http://www.psychiatry.org/adhd. Accessed on April 14th, 2013.

[2] IMS National Sales Perspectives, February 23, 2012.

[3] The American Psychiatric Association publishes the Diagnostic and Statistical Manual of Mental Disorders (DSM), where it sets criteria for the classification of mental disorders. It is the standard classification of mental disorders used by mental health professionals in the United States. The DSM consists of three major components: the diagnostic classification, the diagnostic criteria sets, and the descriptive text. The most current version is DSM-IV-TR of 2000. Next revision, DSM-5 is expected to come out in May 2013.

behavior disorders (Barkley, 2006). In part, it can be explained by a high potential for fruitful medical intervention. In the 1960s, it was shown that stimulant drugs have beneficial effects on both behavioral and cognitive aspects of the condition. More recently, new drugs were introduced, with the most recent being Kapvay and Intuniv in 2009. Development of both medications and therapies broaden the set of choices for managing a wide variety of mental issues united under the umbrella of ADHD. Most stimulant medications are now offered in a number of different strengths, forms and dosages. In treatment of children-patients form and dosage convenience are especially important.

Specific causes of ADHD are not fully understood. It was found that although ADHD runs in families, other factors like environment, biological proneness to the condition, and brain injury may play a role in the onset of the condition. Some studies also suggest that children whose mothers smoked, drank alcohol, or were exposed to extreme stress during pregnancy have an increased risk of ADHD.

ADHD is a behavioral disorder that adversely impacts many major life activities from childhood to adulthood. The condition is severe enough to be distressing for children, their families, and teachers. On average, children with ADHD display lower levels of intellectual and academic performance than non-disabled children. They are also more likely to develop a learning disability, to have delays in speech development, and to have lower working memory capacity. Individuals affected by the syndrome were also found to discount the future more heavily than unaffected individuals, to have problems with self-control and self-regulation, and to display riskier behavior, including more dangerous driving. Although there are no studies of the impact of ADHD on life expectancy, issues like more frequent accidents in childhood, auto accidents in adolescence and adulthood, higher crime rates, and use and abuse of substances all can be associated with reduced life expectancy.

If they are left untreated, ADHD sufferers are at a greater risk for potentially serious consequences. Individuals with ADHD, when compared to their unaffected peers, are found to be 32-40% more likely to drop out of school, to rarely complete college (5-10%), to have fewer or no friends (50-70%), to underperform at work (70-80%), to engage in antisocial activities (40-50%), and to use tobacco or illicit drugs more than normal. Furthermore, children growing up with ADHD are more likely to experience teen pregnancy (40%), STDs (16%), depression (20-30%), and personality disorders (18-25%) as adults (Barkley, 2006).

Although there is a consensus that ADHD is a disabling condition, there is little evidence and thus, agreement on diagnosing and treatment practices. Diagnosing ADHD is a subjective evaluation. In addition to the direct child examination, it involves parents and

teachers filling out questionnaires describing the patients behavior in different settings. The process is complicated by the diversity of ADHD manifestations and by frequently present comorbid conditions.

Children with ADHD are a heterogeneous group who are believed to have in common the characteristics of developmentally inappropriate levels of inattention, and in most cases hyperactivity-impulsivity. With time, the definition of ADHD subgroups will become more refined, but, as of today, there are only two diagnosing subcategories to describe different ADHD subpopulations.[4] ADHD has a number of serious comorbid disorders, and it shares symptoms with most of them. They include anxiety disorder, depressive disorder, bipolar I disorder, oppositional defiant and conduct disorders, and others.

3.1.1 Treatment

As for most mental disorders, there are three major treatment strategies: medications, behavioral therapy, or a combination of the two. Therapy usually consists of teaching parents and teachers how to provide positive feedback for desired behaviors and consequences for negative ones. Behavioral therapy alone was found to be less effective than pharmacological treatment alone, but no consensus exists on whether medications are inferior to the combination treatment (Barkley, 2006).

There are two major classes of ADHD medications: stimulant and non-stimulant drugs. Central nervous system stimulant medications have been used since the 1930s in treatment of behavioral disorders. Today they are the most commonly prescribed drugs to ADHD patients. Stimulants were found to improve the core symptoms of ADHD and to enhance behavioral, academic, and social functioning in about 50-95% of children treated.[5] Stimulants are likely to be recommended as the first step in treatment. If one stimulant does not work, another one may be tried. Children can respond differently to the stimulants, as well as to the other drugs less often used to treat ADHD. The drugs are sometimes, but not often, used in combination. There is little evidence that some stimulants are more efficient than others. There is also uncertainty about whether these benefits last longer than two years.

Table in figure 1 presents the information on branded status and pharmaceutical class

[4]ICD-9 codes for the Attention deficit disorder are 314.00 (Attention deficit, without hyperactivity) and 314.01 (Attention deficit, with hyperactivity). The American Psychiatric Association maps their classification into the ICD codes.

[5]Connor, Daniel F., et al. "Proactive and reactive aggression in referred children and adolescents" American Journal of Orthopsychiatry 74.2 (2004): 129-136. Spencer, Thomas, et al. "Pharmacotherapy of attention-deficit hyperactivity disorder across the life cycle." Journal of the American Academy of Child & Adolescent Psychiatry 35.4 (1996): 409-432.

of the medications approved by the Food and Drug Administration (FDA) for treatment of ADHD in children. Most stimulant drugs had seen their patent expire, and then generics came in. However, for neither of the non-stimulant drugs generic is available. For the Intuniv generic has been approved by the FDA but it is not commercially available until the brand-name patent expires in 2015. Non-stimulants are a newer class of drugs than stimulants. The latest two non-stimulants entered the market in 2009.

Figure 1: The FDA-approved pharmaceutical treatments of ADHD.

Active ingredient	Drug name	Brand	Generic	Stimulant
Amphetamine	Adderall IR	01.19.1960		Y
	Adderall XR	10.11.2001	06.22.2012	Y
Dextroamphetamine	Dexedrine	Prior to Jan 1, 1982	02.12.2001	Y
Dexmethylphenidate	Focalin	11.30.2001	06.08.2007	Y
	Focalin XR	05.31.2005	---	Y
Lisdexamfetamine	Vyvanse	02.23.2007	---	Y
Methylphenidate	Ritalin	12.05.1955	12.23.1977	Y
	Ritalin SR	03.31.1982	02.09.2001	Y
	Metadate ER	06.01.1988	02.09.2001	Y
	Methylin ER	05.09.2000	02.09.2001	Y
	Concerta	08.01.2000	12.28.2012	Y
	Metadate CD	04.03.2001	07.19.2012	Y
	Ritalin LA	06.05.2002	12.13.2011	Y
	Methylin oral solution	12.19.2002	07.23.2010	Y
	Methylin chewable tab	04.15.2003	---	Y
	Daytrana patch	04.06.2006	---	Y
Atomoxetine	Strattera	11.26.2002	---	N
Clonidine	Kapvay	09.29.2009	---	N
Guanfacine	Intuniv	09.02.2009	10.05.2012	N

Although not approved for ADHD treatment, certain antidepressants and sleep-disorder medications are prescribed to patients off-label. For example, Provigil (sleep disorders); Wellbutrin (antidepressant); tricyclic antidepressants; Catapres and Tenex (short-acting forms of high blood pressure medicines); Abilify, Zyprexa, Seroquel, Risperdal, and Geodon (antipsychotics).

Table in figure 2 shows calculated market shares for each of the ADHD drugs. They are calculated as the number of prescriptions filled in the period from 1996 2010, using Medical Expenditure Panel Survey (MEPS) data. One of the oldest and most brand-populous class by active ingredient has the largest market share of about 35%. It also contains one of the

cheapest brand and generic medications. Adderall, another ADHD treatment that has been approved decades ago, takes about 19% of the market. Other active ingredients have rather modest market shares of less than 6%.

Figure 2: Market shares and price levels of ADHD drugs.

Active ingredient	Drug name	Market shares in MEPS, in %		Average price		
				B	G	Ingredient
Amphetamine	Adderall IR	8.23	18.46	291.00	91.86	197.83
	Adderall XR	10.23		276.83	180.33	
Dextroamphetamine	Dexedrine	0.86	0.86	252.33	72.40	139.88
Dexmethylphenidate	Focalin	0.79	3.44	87.67	66.00	145.36
	Focalin XR	2.65		227.60		
Lisdexamfetamine	Vyvanse	3.2	3.20	200.33		200.33
Methylphenidate	Ritalin	8.44	34.65	89.00	23.67	177.96
	Ritalin SR	0.57		99.00		
	Metadate ER	0.38			34.67	
	Methylin ER	0.52			57.00	
	Concerta	17.45		222.75	181.00	
	Metadate CD	1.87		242.83	144.20	
	Ritalin LA	2		185.75		
	Methylin oral solution	2.8				
	Methylin chewable tab			390.20	137.20	
	Daytrana patch	0.62		239.00		
Atomoxetine	Strattera	5.95	5.95	239.43		239.43
Clonidine	Kapvay	---	---	167.00		167.00
Guanfacine	Intuniv	0.06	0.06	222.75		222.75

Notes: Market shares were calculated using MEPS data for 1996-2010, by the number of prescriptions filled. Average price is calculated using Consumer Reports Best Buy Drugs (2012). "B" stands for brand, and "G" stands for generic drugs. Drug price is the average monthly cost of each drug.

3.1.2 Side effects and dosing convenience

ADHD medicines have a number of common side effects. For stimulant drugs they are low appetite, sleep problems, headache, irritability, jitteriness, and stomach pain. For the earliest non-stimulant medication Strattera the most common side effects are decreased appetite, dizziness, fatigue, mood swings, nausea, and upset stomach. It also has been linked to an increased risk of suicidal thoughts and behaviors in children and adolescents. For the newest non-stimulant drugs the associated side effects are sleepiness, tiredness, and small changes in blood pressure or heart rate. The side effects may be mild or in some cases severe enough to cause patients to discontinue their treatment.

All of the ADHD medicines have also been linked to rare cases of heart attack, stroke, and sudden death. To avoid complications, patients are typically started on low dosages, which are gradually increased if needed. Kapvay should also be gradually discontinued under a physicians supervision to avoid a sudden increase in blood pressure. Cascade et al.(2010) report that 156 out of 325 surveyed ADHD patients experienced at least one side effect, the most common being loss of appetite, sleep problems, and mood swings.

Side effects can vary by the age of the patient, with preschoolers often having stronger side effects.

3.1.3 Evidence from the Medical Expenditure Panel Survey (MEPS)

In order to evaluate my assumption regarding ADHD drugs being an example of experience good, I use MEPS data for 1996-2010. It is a set of comprehensive large-scale surveys of families and individuals, their medical providers, and employers across the U.S. MEPS has an overlapping panel design. Each individual passes through the five rounds of interviews over two calendar years. The publicly available data from the Household component include detailed information on health care utilization and expenditure, insurance coverage, medical conditions, and demographic characteristics of each individual. Most importantly, the survey includes a number of questions on prescription drugs purchased by the individual in every round. Each record in the prescription drugs file represents one purchased prescribed drug and includes the following:

- Detailed characteristics associated with the event (e.g., national drug code (NDC), medicine name, strength, form, etc.);
- Medical conditions associated with the drug (up to 3);
- Drugs therapeutic class(es);
- Drug cost and source(s) of payment.

I restrict the sample to the individuals who have a unique diagnosis ADHD, to avoid complications in cases of a number of concurrent conditions. Table in figure 3 reports summary statistics. From 1996 to 2010, there were about 40,000 prescriptions filled by the individuals diagnosed with ADHD. Over the two years in the sample, an average patient fills about 12 prescriptions, of which there are on average 2-3 different drugs and over 3 different forms and/or strengths.

Figure 3: Summary statistics on ADHD medications, MEPS 1996-2010.

	N obs.	Mean	St. dev.	Min	Max
N Rx filled	39,088				
N Rx filled, per person/drug	6,085	9.07	6.47	1	40
N Rx filled, per person	3,337	11.71	11.19	1	107
N different drugs filled by an individual	39,088	2.51	1.66	1	10
N different NDCs filled by an individual	39,088	3.31	2.26	1	17

Notes: Sample includes individuals with a single diagnosis, ICD9=314. "Rx" stands for prescription drug; "NDC" stands for National Drug Code.

In other words, consistent with clinical evidence, empirical evidence suggests that children and teenagers diagnosed with ADHD face significant uncertainty regarding the efficacy and severity of adverse effects of ADHD medications. The typical patient is prescribed between one and two different drugs before he or she finds a suitable treatment. The switch from the initial choice occurs approximately within half a year. Figure 4 presents the entire distribution of the number of different drugs prescribed to the patients with ADHD. About 80% of individuals try three different medications.

On average, six prescriptions are needed to resolve uncertainty regarding patient-drug match. Table in figure 5 presents summary statistics on the persistence of the patient in her first, second, and later choices. Interestingly, independently of whether the drug was picked early in the treatment course or later on, the average spell (number of prescriptions taken before the switch) is still equal to six prescriptions. However, as Figure 6 shows, for about 50% of patients three prescriptions are sufficient to resolve uncertainty.

In sum, empirical evidence using MEPS points at significant uncertainty physicians and their patients have regarding drug-patient match.

3.2 Medicaid

Medicaid is a means-tested health program that was created in 1965 and is funded jointly by federal government and the states. The target population is low-income families, disabled, aged, and blind individuals, and pregnant women. Under broad federal guidelines, each state manages its own Medicaid program. They are required to cover a number of mandatory benefits, but they have significant freedom when deciding on the optional benefits provision. In general, the states have a say on the type, amount, duration, and scope of services provided by their Medicaid program. The provision of prescription drugs' coverage

Figure 4: Number of different drugs filled, MEPS 1996-2010.

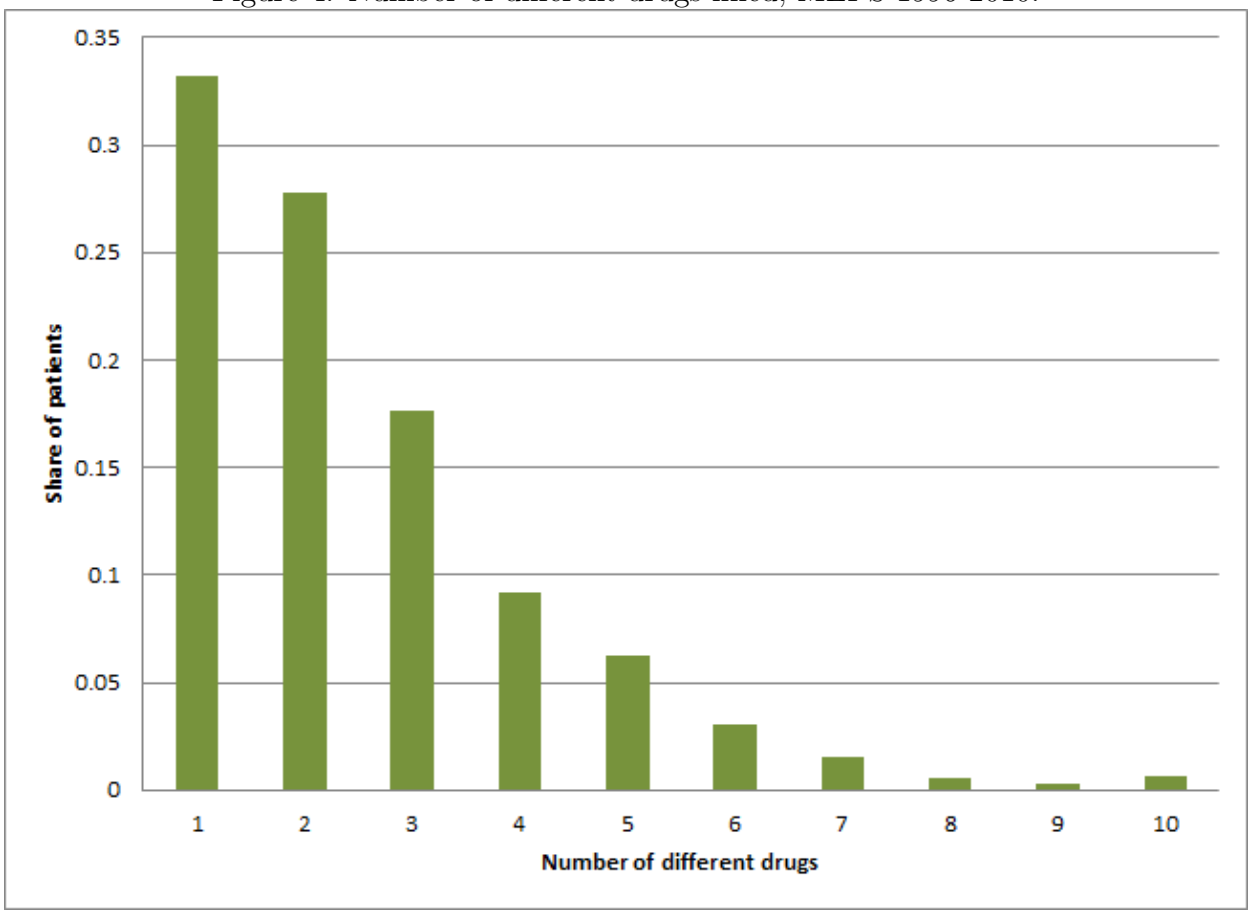


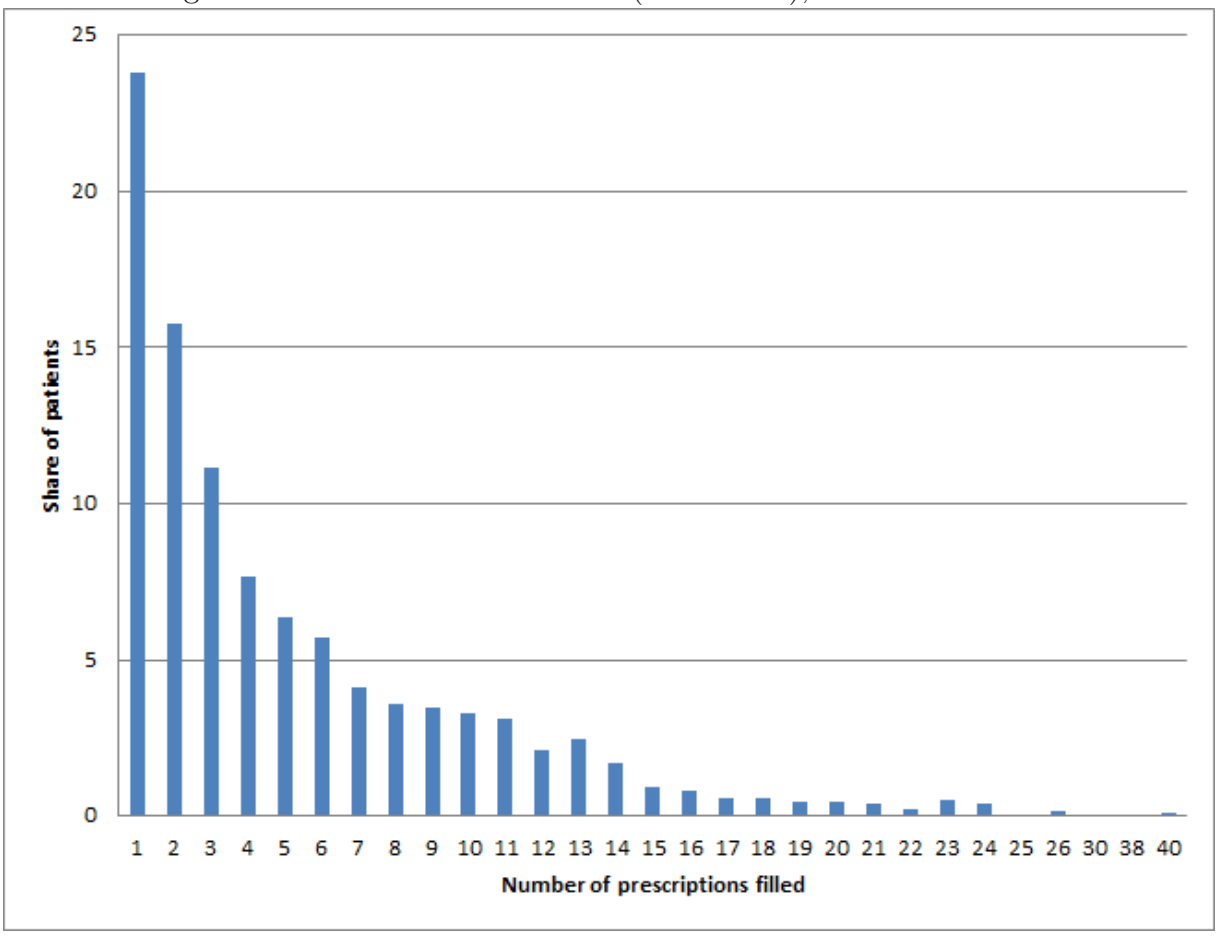
Figure 5: Choice persistence, MEPS 1996 - 2010.

	N obs.	Mean	St. dev.	Min	Max
Persistence of 1st choice, all	3,661	6.32	5.92	1	40
Persistence of 1st choice, if no switch	1,762	7.37	6.51	1	40
Persistence of 1st choice, if switched	1,899	5.35	5.11	1	40
Persistence of 2nd choice	1,416	6.52	5.58	1	37
Persistence of 3rd choice	583	6.64	5.49	1	26
Persistence of 4th choice	244	6.68	5.11	1	31

is an optional benefit that is currently offered by all states.

Among other program parameters, the states decide on whether to charge premiums for enrollment and whether to have cost-sharing provisions for the enrollees, but their amount is capped by federal regulation. In most states, certain population groups, including children

Figure 6: Persistence of 1st choice (if switched), MEPS 1996-2010.



are exempt from out-of-pocket spending provisions. In SC, children and young adults (under age 19) face zero copayment for the prescription drugs. In addition to the cost-sharing provisions, Medicaid prescription drug coverage typically includes conditions on preferred generic versus brand, mail-order versus pharmacy drugs.

A child may be covered under Medicaid if they are a U.S. citizen or a permanent resident. A child may be eligible for Medicaid regardless of the eligibility status of its parents or guardians. Thus, a child can be covered by Medicaid based on its individual status even if its parents are not eligible. Similarly, if a child lives with someone other than a parent, she may still be eligible based on its individual status.

In addition to the Medicaid program, the states run the Childrens Health Insurance Program (CHIP). It provides coverage to children whose family income is too high to qualify for Medicaid, but too low to afford private health insurance. Currently, SC runs a com-

bined Medicaid-CHIP program. And individuals whose income is below 150% of the Federal Poverty Level (FPL) are eligible for Medicaid in SC. Individuals, whose income is below 200% of the FPL are eligible for CHIP.

In SC, 892,583 individuals, about 20% of the state population, was enrolled in Medicaid in FY2009. The majority of enrollees (62%) are female and half of the enrollees are children (52%). The overall program spending in SC was $5.2 billion, 4% of which was spent on prescription drugs.

Medicaid coverage may start retroactively for up to three months prior to the month of application, if the individual would have been eligible during the retroactive period had she applied then. Coverage generally stops at the end of the month in which a person no longer meets the requirements for eligibility.

Medicaid is similar to Medicare in that there is a traditional "fee for service" and also managed care programs. Most states received a waiver from the federal government and offer their enrollees to select a private health plan that receives a fixed monthly premium from the state.

4 Data

4.1 SC Medicaid claims data

The primary data I will use are SC Medicaid claims data. This data set has information on all SC enrollees and their respective in-patient, out-patient, and pharmacy claims. For this paper, I will use the pharmacy and physician visits data, as well as the information on the enrollee, her demographic characteristics, income, and family when available. I will use data on the Medicaid enrollees who have been diagnosed with ADHD (ICD-9 codes 314.00 and 314.01) at the age of 3-19 years old, over the period of ten years from 2003 to 2012. Given the statistics on ADHD incidence in general population, I expect to have about 50,000 children and young adults in my sample. The data on claims come from the SC Office of Research and Statistics (ORS), and the data on Medicaid coverage are provided by the Medicaid subcontractor Magellan Medicaid Administration. Appendix B contains the names of the fields that have been requested from the SC ORS.

4.2 Thomson Reuters MarketScan Databases Claims Data

In addition to the SC Medicaid claims data, I requested a commercial data set. It contains individual-level information on physician visits and drug claims from large employers, managed care organizations, hospitals, and Medicare and Medicaid programs. This data set is valuable for two reasons: there is variation in insurance coverage of the enrollees, and they face differential copayment rates for prescription drugs covered under the plan.

5 Model

I follow Dickstein(2011) in building a theoretical model. The dynamic model of demand under uncertainty consists of two parts: the model of initial drug choice and the learning mechanism. The physician evaluates her patients, makes a diagnosis based on her priors about the efficacy and potential side effects of a particular drug. After the patient tries the drug, she reports back to the physician. After observing her patient's health outcome, the physician updates her prior and makes a decision of whether to switch the treatment, keep the patient on the first choice, or discontinue the treatment.

5.1 Initial Choice Model

The initial choice model is built and estimated to form the prior physician's beliefs about the available treatment strategies. Although physician is the one making prescription choice, she takes into account her patient's utility. Patients care about the out-of-pocket drug costs they face, treatment efficacy, side effects, and dosing convenience. Since children and young adults covered by Medicaid face zero copayment rates, I do not include drug price in the patient's utility.

$$U_{ijt}^{Patient} = a_i X_{ijt}^{Patient} + b Z_{ij}^{Patient}$$

where i indexes individual, j - drug, and t - year. Following Dickstein(2011) I include drug efficacy, side effects and dosing convenience with random effects (X_{ijt}), and branded drug status with fixed effects (Z_{ij}) that are constant over time.

Physicians care about their patients to a degree γ. They are also concerned with drugs' side effects because of the malpractice risk and are influenced by advertisement. Product fixed effects capture both effects. Since Medicaid requires the doctors justify their choice of drug if a brand instead of generic medication is prescribed, I include branded status and

prior-approval requirement into the physician's utility. Following Dickstein's argument, I also assume that the drug cost enters the physician's utility function, although more evidence is needed on Medicaid operations to support this hypothesis. The drug cost enters the utility with random coefficient and all other effects as fixed effects.

$$\begin{aligned} U_{ijt}^{Physician} &= c_i X_{ijt}^{Physician} + dZ_{ijt}^{Physician} + \gamma U_{ijt}^{Patient} + \varepsilon_{ijt} \\ &= (\gamma a_i, c_i) X_{ijt} + (\gamma b, d) Z_{ijt} + \varepsilon_{ijt} \\ &= \beta_i' X_{ijt} + \alpha' Z_{ijt} + \varepsilon_{ijt} \end{aligned}$$

where ε_{ijt} is an idiosyncratic extreme value error term that captures time-varying unobservables.

5.2 Learning mechanism

After the patient tries a drug, she reports back to the physician. The physician observes her patient's health outcome, and decides whether to continue the first-choice treatment, switch the treatment, or discontinue the treatment. This decision is made upon updating the prior belief on the drug efficacy and its side effects on the specific patient. The prior belief is updated using Bayes' learning model.

Total individual utility can be written down as a linear model (adopted from Dickstein, 2011).

$$y_{ijt} = f_{ijt} + v_{ij} + W_{it}$$

where f_{ijt} contains all fixed components that do not need updating, they are known at the start of treatment and there is no uncertainty associated with them. They include drug fixed effects, branded status, cost, and prior-approval list status. v_{ij} is a variable component of the utility function and it is being updated in every period. v_{ij} can be parameterized as $v_{ij} = U_j \times \beta_i$, where U_j includes all known characteristics of drug j (efficacy, side effects profile, dosage convenience), and β_i is a vector that describes each patient's heterogeneous reaction to the drug characteristics. The vector β_i has a normal prior distribution with the mean being initial choice parameter estimates. This distribution is updated every period using Bayesian updating process.

W_{it} is a random shock observed by the patient alone. It could include any personal circumstances that affect health outcome but are unobserved by either physician or econo-

metrician. W_{it} is distributed normally with mean zero and variance σ_W^2.

6 References

1. Ackerberg, D. A. (2003). Advertising, learning, and consumer choice in experience good markets: an empirical examination*. International Economic Review, 44(3), 1007-1040.

2. Barkley, Russell A., and Kevin R. Murphy. Attention-deficit hyperactivity disorder: A clinical workbook. Vol. 2. Guilford Publication, 2006.

3. Berndt, E. R., Bui, L. T., Lucking-Reiley, D. H., & Urban, G. L. (1996). The roles of marketing, product quality, and price competition in the growth and composition of the US antiulcer drug industry. In The economics of new goods (pp. 277-328). University of Chicago Press.

4. Cascade, E., Kalali, A. H., & Wigal, S. B. (2010). Real-World Data on: Attention Deficit Hyperactivity Disorder Medication Side Effects. Psychiatry (Edgmont), 7(4), 13.

5. Ching, A. T. (2010). Consumer learning and heterogeneity: Dynamics of demand for prescription drugs after patent expiration. International Journal of Industrial Organization, 28(6), 619-638.

6. Consumer Reports Best Buy Drugs (March, 2012). Evaluating Prescription Drugs Used to Treat: Attention Deficit Hyperactivity Disorder (ADHD).

7. Crawford, G. S., & Shum, M. (2005). Uncertainty and learning in pharmaceutical demand. Econometrica, 73(4), 1137-1173.

8. Dickstein, M. J. (2011). Efficient provision of experience goods: Evidence from antidepressant choice. Harvard, unpublished.

9. Ellison, S. F., Cockburn, I., Griliches, Z., & Hausman, J. (1997). Characteristics of demand for pharmaceutical products: an examination of four cephalosporins. The RAND Journal of Economics, 426-446.

10. Erdem, T., & Keane, M. P. (1996). Decision-making under uncertainty: Capturing dynamic brand choice processes in turbulent consumer goods markets. Marketing Science, 15(1), 1-20.

11. Goldman, Larry S., et al. "Diagnosis and treatment of attention-deficit/hyperactivity disorder in children and adolescents." JAMA: the journal of the American Medical Association 279.14 (1998): 1100-1107.

12. Hellerstein, J. K. (1998). The importance of the physician in the generic versus trade-name prescription decision. The Rand journal of economics, 108-136.

13. Merikangas, Kathleen Ries, et al. "Lifetime prevalence of mental disorders in US adolescents: Results from the National Comorbidity Study-Adolescent Supplement (NCS-A)." Journal of the American Academy of Child and Adolescent Psychiatry 49.10 (2010): 980.

A Appendix

A.1 Appendix A: ADHD Symptoms (APA)

ADHD is diagnosed when six (or more) of the following symptoms from either section have persisted for at least six months to a degree that is maladaptive and inconsistent with developmental level.

- Inattention

    1. often fails to give close attendtion to details or makes careless mistakes in school, work, or other activities
    2. often has difficulty sustaining attention in tasks or play activities
    3. often does not seem to listen when spoken to directly
    4. often does not follow through on instructions and fails to finish schoolwork, chores, or duties in the workplace (not due to oppositional behavior or failure to understand instructions)
    5. often has difficulty organizing tasks and activities

6. often avoids, dislikes, or is reluctant to engage in tasks that require sustained mental effort (such as schoolwork or homework)
7. is often easily distracted by extraneous stimuli
8. is often forgetful in daily activities

- Hyperactivity

1. often fidgets with hands or feet or squirms in seat
2. often leaves seat in classroom or in other situations in which remaining seated is expected
3. often runs about or climbs excessively in situations in which it is inappropriate (in adolescents or adults, may be limited to subjective feelings of restlessness)
4. often has difficulty playing or engaging in leisure activity quietly
5. is often "on the go" or often acts as if "driven by a motor"
6. often talks excessively

- Impulsivity

1. often blurts out answers before questions have been completed
2. often has difficulty awaiting turn
3. often interrupts or intrudes on others (e.g., butts into conversations or games)

A.2 Appendix B: SC Medicaid Claims Data Layout.