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Medical Adaptation to Academic Pressure: Schooling, Stimulant Use, and Socioeconomic Status

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Abstract

Despite the rise of medical interventions to address behavioral issues in childhood, the social determinants of their use remain poorly understood. By analyzing a dataset that includes the majority of prescriptions written for stimulants in the United States, we find a substantial effect of schooling on stimulant use. In middle and high school, adolescents are roughly 30 percent more likely to have a stimulant prescription filled during the school year than during the summer. Socioeconomically advantaged children are more likely than their less advantaged peers to selectively use stimulants only during the academic year. These differences persist when we compare higher and lower socioeconomic status children seeing the same doctors. We link these responses to academic pressure by exploiting variation between states in educational accountability system stringency. We find the largest differences in school year versus summer stimulant use in states with more accountability pressure. School-based selective stimulant use is most common among economically advantaged children living in states with strict accountability policies. Our study uncovers a new pathway through which medical interventions may act as a resource for higher socioeconomic status families to transmit educational advantages to their children, either intentionally or unwittingly.

Keywords

social stratification, social determinants of health, accountability, education

For the past 40 years, sociologists have documented the causes and consequences of the increasing medicalization of everyday life (Conrad 1992, 2007; Illich 1976; Timmermans and Buchbinder 2013). As a growing number of human ailments have become the target of medical intervention, scholars have recognized that the engines of medicalization have morphed over time. Doctors were once seen as the primary drivers of medicine's expansion, but recent studies argue that consumers, managed care companies, and the pharmaceutical industry jointly produce these outcomes (Conrad 2005).

While this literature has increased our understanding of medicalization, we know

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little about the mechanisms that produce steep socioeconomic gradients in the use of new medical interventions in childhood. Many new interventions are pharmaceuticals that promise to enhance human functionality and performance. Pharmaceuticals with these aims have existed for decades, but until relatively recently, children's use of them was limited (Conrad 2007). Given sociology's concern with the intergenerational transmission of advantage, the growing use of prescription psychotropic drugs in childhood deserves additional examination.

In this study, we focus on children's stimulant use. Stimulants act on the central nervous system to improve attention and concentration and are primarily used to treat attention deficit/hyperactivity disorder (ADHD). ADHD is the most common childhood psychiatric disorder and is characterized by a "persistent pattern of inattention and/or hyperactivity-impulsivity that is more frequently displayed and is more severe than is typically observed in individuals at comparable level of development" (DSM IV [American Psychiatric Association 2000]). Because no definitive biomarkers for ADHD exist, ambiguity accompanies diagnosis (Gathje, Lewandowski, and Gordon 2008). The difficulty and contextual sensitivity of diagnosing ADHD is reflected in prevalence estimates that exhibit considerable temporal and geographic variability. Nationally, more than 1 in 10 school-aged youth are diagnosed with ADHD (Visser et al. 2014). Between 2001 and 2010, ADHD prevalence increased 24 percent (Getahun et al. 2013). Increases in ADHD prevalence are matched by dramatically increased stimulant use. In 1996, an estimated 2.4 percent of children received a stimulant (Olfson et al. 2002). A decade later, 5.5 percent of middle school children had stimulant prescriptions.[1]

Among children and adolescents diagnosed with ADHD, stimulants consistently prove to be effective for treating ADHD symptoms and improving academic performance (Swanson, Baler, and Volkow 2011; Zoëga, Valdimarsdóttir, and Hernández-Díaz 2012). Activities ranging from note-taking, quiz performance, and homework completion (Evans et al. 2001) to working memory (Bedard et al. 2007) improve with use of stimulants, as do reading test scores, grade retention, and absenteeism (Barbaresi et al. 2007). Stimulants also enhance social standing among peers (Whalen et al. 1989) and improve overall social functioning (Abikoff et al. 2004). Importantly, use of stimulants in individuals *without* ADHD has been shown to improve memory and learning, and thus offers the opportunity for cognitive enhancement to all children (Smith and Farah 2011). The academic performance benefits that can accrue from stimulant consumption have led to widespread nonmedical stimulant misuse to improve academic performance (DeSantis, Noar, and Webb 2009; Wilens et al. 2008).

Our article provides a framework for understanding the social determinants of stimulant use in childhood; we have three major findings. First, by analyzing a unique dataset that includes the majority of stimulant prescriptions written in the United States during the 2007 to 2008 academic year, we find that children are considerably more likely to take prescription stimulants during the school year than in the summer. Despite the belief that "drug holidays," or planned periods of medication discontinuation around the academic calendar, are widespread, published prevalence estimates are scarce (Graham and Europeans Guidelines Group 2011). We show that school-based stimulant use does not exist prior to the onset of K–12 schooling and ends after it; we argue that the mismatch between children's academic and social behaviors and the schooling environment is a strong driver of stimulant prescriptions.

Second, we find that children from higher socioeconomic status (SES) families exhibit the largest differences between school year and summer stimulant use. At this effect's peak, higher-SES adolescents were 36 percent more likely to have their prescriptions filled during the school year than during the summer, compared with 13 percent for lower-SES children. There are at least two potential explanations for this finding. Because of income segregation (Reardon and Bischoff 2011), higher-SES children may see doctors who have different prescribing practices. Alternatively, higher-SES families might be more likely to use stimulant medications to help their children meet behavioral requirements of the school environment and succeed in school.

We adjudicate between these possibilities and conclude that differences between the prescribing practices of doctors seen by higher- versus lower-SES children do not drive the SES effect. The SES effect persists when we compare higher- and lower-SES children who see the same doctors. This suggests either that doctors give different recommendations to higher- and lower-SES children or that their families decide to pursue different courses of treatment. These differences also endure when we compare higher- and lower-SES children on the same medication-dose combination *and* seeing the same doctors, which further weakens the physician differential treatment explanation. In conjunction with the existing qualitative literature, our findings suggest that varying parental responses to academic pressure account for the patterns of stimulant use we observe.

Finally, we link these responses to academic pressure by exploiting between-state variation in educational accountability system stringency. We find the greatest selective stimulant use in states with more stringent accountability policies. Moreover, higher-SES children are more likely than their less advantaged peers to respond to accountability pressure through selective stimulant use. Selective stimulant use thus offers a new pathway through which medical interventions may act as a resource for higher-SES families to reproduce inequality, either intentionally or unwittingly.

Beyond these substantive findings, we make three larger contributions. We demonstrate that whether a child uses stimulants is affected by multiple social contexts: the time of the year, parents' socioeconomic status, and characteristics of the state educational environment. Second, we show that "demand-side medicine"—an umbrella term for a range of processes through which patients interface with the medical system and play a key role in determining their care—increases the opportunity for inter-institutional links to shape treatment choices. Finally, our findings contribute to the medical sociology literature by highlighting how socioeconomic status can act as a mechanism that generates health disparities that then cascade downstream to produce inequalities in other realms.[2]

THE EFFECTS OF SCHOOLING ON INDIVIDUAL LIVES

Social scientists have a long-standing interest in understanding how schooling shapes individual lives. Scholars have examined schooling's effects on aspirations (MacLeod 1995), non-cognitive skills (Jencks et al. 1972), cognitive skills (Downey, von Hippel, and Broh 2004), educational and occupational attainment (Blau and Duncan 1967), earnings (Murnane, Willett, and Levy 1995), marriage (Mare 1991), and health (Kitagawa and Hauser 1973).

Many of these studies identify longer-term effects of schooling; others attempt to determine whether schools exacerbate or attenuate cognitive inequality during childhood. Since the 1970s, the paradigmatic tradition for isolating the impact of schooling as an institution has relied on summer versus school-year comparisons. Researchers have exploited the seasonal nature of schooling to disentangle school and non-school influences on student outcomes. Heyns (1978), Alexander, Entwisle, and Olsen (2001), Downey and colleagues (2004), and Condron (2009) all demonstrate that poor students learn at rates similar to their more advantaged counterparts during the school year but fall back in the summer.

To date, the summer learning approach has not been widely deployed to study schools' effects on other outcomes. Because schools affect children in many ways beyond test scores, this is an important oversight. One notable exception is Von Hippel and colleagues' (2007) study on the effects of schooling on children's body mass index (BMI). By comparing BMI growth during the summer versus the school year, Von Hippel and colleagues determined that non-school environments have more of an influence than do school environments on obesity.

Multiple macro forces have contributed to increased performance pressure for U.S. children. Admission to the elite universities believed to offer access to higher-income jobs has become increasingly competitive (Espenshade and Radford 2009). Implementation of school accountability policies has made school more academic. Elementary mathematics instruction increased approximately 40 percent when the No Child Left Behind (NCLB) Act was implemented (Hannaway 2007), and schools now allocate less time to activities like art, physical education, and recess (Center on Education Policy 2007). Even kindergarten has become largely academic (Russell 2011). Test preparation activities increase when schools face more accountability pressure (Koretz 2008), and observations of classroom environments demonstrate decreased socio-emotional connection during the months when test preparation pressure is greatest (Plank and Condliffe 2013).

When teachers face more pressure, they may be more concerned about maintaining control over the classroom environment and ensuring that students perform well on standardized tests (Plank and Condliffe 2013). Studies demonstrate that teachers are often the first party to recommend an assessment for ADHD (Sax and Kautz 2003; Snider, Busch, and Arrowood 2003). In qualitative studies, parents report not only a recommendation but pressure from teachers or school officials to consider medication. For example, in Brinkman and colleagues' (2009:583) study, one parent explained: "It was like the teachers were pushing me, pushing me. Get him meds, get him meds." In Cormier's (2012:350) study, a parent explained, "The school was telling us, 'He's belligerent and uncontrollable and you need to have him treated.'" We are aware of only one study examining the impact of accountability pressure on stimulant use, which determined that the presence of more stringent state accountability laws increased prescriptions for stimulant drugs (Bokhari and Schneider 2011). However, this study did not examine *how* stimulants were used; that is, whether stimulants were used consistently or only during the academic year, nor did it consider how SES might interact with accountability pressure to affect stimulant use.

Managing an increasingly demanding institution creates pressure for families to consider stimulants as a means of addressing these school-based demands. The importance of self-control, behavioral skills, and executive function—skills positively affected by stimulants—for educational success has received renewed attention in recent years. Traits not fully captured by test scores (often called non-cognitive skills) have substantial effects on educational and employment outcomes (Farkas 2003; Heckman and Rubenstein 2001). In some cases, psychologists have found that measures of self-discipline explain more than twice as much of the variance in adolescents' grades as do measures of IQ (Duckworth and Seligman 2005).

Children vary in their inherited and learned abilities to manage their own attention, to sit still when they are bored, and to concentrate on tasks that are not intrinsically interesting. Because higher-SES families adapt to extra-familial institutions by reflecting these demands in their childrearing practices (Lareau 2003), it is not surprising that families would attempt to help their children adapt to schooling demands by using stimulant medications to improve these competencies during the school year. A recent study found that children whose parents emphasized academic achievement were more than twice as likely as other children to begin taking stimulants (Fiks et al. 2013). In summary, a large body of literature demonstrates that state accountability policies shape classroom and school environments in ways that privilege attention-related skills. These accountability pressures and the academic environment they generate may produce medical adaption through selective stimulant use. Thus, our argument is not about parents attempting to improve their children's test scores; rather, we focus on how increased testing and accountability structures the academic environment for children in a way that generates pressure to utilize stimulants in response to schooling.

EVOLUTION OF PHYSICIANS' ROLE AND THE RISE OF DEMAND-SIDE MEDICINE

For most of the twentieth century, physicians enlarged their autonomy over the prices they commanded and the conditions under which they worked (Freidson 1970; Starr 1984). Nonetheless, early conceptions of the physicians' role portrayed doctors as acting only with the interest of the patient and the community in mind (Parsons 1951). In this view, doctors are agents of social control responsible for restoring deviant community members to reassume their normal social roles. The doctor-patient relationship was understood as paternalistic; it was the doctor's role to diagnose and treat, and the patient's role to submit to these recommendations and heal.

This understanding of the doctor-patient relationship has been supplanted by one in which doctors, while still maintaining some control because of information asymmetries, cannot dictate the terms of treatment alone (Hafferty and Light 1995; Pescosolido 2013). This shift is due to a number of social changes, including reductions in hierarchical relationships more generally, increases in the population's educational attainment, and increases in health information availability (Roter and Hall 2006). Mechanic (2006) describes a new ideal-type, "activated patients," who aggressively manage their own care, question doctors' authority, and request tests and procedures for which there is little evidence of medical benefit. Patients and doctors do not negotiate what treatment is desired or preferable in isolation, however. Demand can be institutionally and contextually generated.

This trend toward "demand-side medicine" has been driven, in part, by direct-to-consumer advertising of drugs, which was permitted beginning in 1997, and a growing class of health consumers (Conrad 2005). In the case of stimulants, pharmaceutical companies have engaged in a widespread "selling of attention deficit disorder" (Schwarz 2013). For example, one magazine advertisement for the drug Concerta features a mother saying, "Better test scores at school, more chores done at home, an independence I try to encourage, a smile I can always count on" (Schwarz 2013). These advertisements invite patients to "ask their doctor" if a particular treatment is right for them, and online materials that parents can bring to their child's doctor provide symptom checklists that mirror diagnostic criteria (Ebeling 2011). By giving patients and parents more power in medical decision-making, demand-side medicine also increases the possibility for key inter-institutional links—between family, medicine, and schooling—to shape treatment choices.

SOCIOECONOMIC STATUS AND DEMAND-SIDE MEDICINE

With the rise of demand-side medicine, there is more opportunity for social background to determine who is diagnosed and how they are treated. Socioeconomic gradients have been documented for a multitude of health outcomes, ranging from infant mortality to mental disorders (Link and Phelan 1995). The vast majority of conditions have a negative SES gradient, such that people with fewer resources are more likely to experience negative health. The prevalence and persistence of health gradients has given rise to the idea that socioeconomic status is itself a fundamental cause of health (Link and Phelan 1995). Rather than operating through a discrete mechanism for a given condition at a given time, socioeconomic status continuously acts through a multitude of mechanisms to create an enduring association between health and

SES (Lutfey and Freese 2005). When scientific and medical advances create opportunities for health improvements, they are more rapidly and extensively utilized by higher-SES individuals, leading health gradients to persist over time (Chang and Lauderdale 2009; King and Bearman 2011; Miech 2008).

Much of the research on health gradients focuses on upstream causes (Lutfey and Freese 2005; Miech 2008) rather than the downstream consequences. However, with the rise of demand-side medicine, we would expect to find an increasing number of downstream consequences. Relatively little attention has been given to whether differential use of medical interventions by socioeconomic status generates disparities in other realms. Using the case of selective stimulant use, we examine whether socioeconomic differences in medication utilization may spillover into the realm of education.

SELECTIVE STIMULANT USE AND DRUG HOLIDAYS

Despite anecdotal reports that stimulants are used selectively during the school year and that drug holidays are common, few studies empirically investigate the prevalence of drug holidays[3] or their appropriateness. According to the European Guidelines on Managing Adverse Effects of ADHD Medications,

> there is very little data on issues such as the extent of their [drug holidays] use; factors that predict use (e.g., child characteristics, parent and clinician beliefs, disorder progression, social structures and cultural norms); or their effectiveness in terms of either enhancing or reducing clinical effects or reducing side effects and their adverse consequences. (Graham and Europeans Guidelines Group 2011:30)

Evidence on the efficacy and safety of drug holidays is limited. In one study, researchers found that discontinuing stimulant use during weekends was weakly associated with fewer reports of insomnia and appetite suppression (Martins et al. 2004). Two additional studies tracking children and adolescents over longer periods found that stimulant holidays have no effect on height or weight (Spencer et al. 2006, 2007).

Notwithstanding the lack of clinical evidence, stimulant drug holidays are reportedly employed to reduce side effects, such as appetite suppression or insomnia, and minimize possible negative consequences of long-term use, such as height and weight reductions (Manos 2008). Anecdotally, a second motivation for taking periodic breaks from stimulant use is to try to prevent possible drug tolerance (Graham and Europeans Guidelines Group 2011). Third, clinicians or patients may schedule drug holidays to assess ADHD symptoms or to evaluate clinical need. Finally, parents sometimes discontinue medication during weekends and holidays to allow children to be "themselves" (Graham and Europeans Guidelines Group 2011).

While several rationales exist for periodic stimulant discontinuation, the Agency for Health Care Policy and Research's ADHD guidelines state that drug holidays "are not routinely recommended" (National Guideline Clearinghouse 2013). Similarly, the American Academy of Pediatrics' (AAP 2011:8) diagnostic and treatment guidelines assert that "the primary care clinician should recognize ADHD as a chronic condition and . . . should follow the principles of the chronic care model." Furthermore, the DSM-IV, psychiatry's diagnostic manual, requires that a child's symptoms cause impairments in two of three settings, where the main settings are home, school, and community. The notion of ADHD as a chronic condition that should be present in multiple domains is thus at odds with selective stimulant use during periods of schooling.

Stimulant holidays make an ideal test case to examine how schooling shapes health behaviors, in large part because there is a lack of consensus regarding their appropriateness. While many chronic diseases and disorders exhibit seasonal patterns (e.g., asthma), there is typically a known biological mechanism that can explain those patterns (e.g., the weather).

In contrast, ADHD is of unknown etiological origin. As a result, seasonal variation allows us to explore the role that social context may play in shaping patterns of stimulant use.

In the following analyses, we utilize the school calendar as an exogenous source of variation in schooling to understand how the use of stimulants arises from a complex negotiation among schools, physicians, parents, and children.

DATA AND METHODS

We analyze data from IMS LifeLink LRx Longitudinal Prescription database, which contains de-identified individual prescriptions from approximately 33,000 retail pharmacies, food stores, independent pharmacies, and mass retailers. The database covered over 60 percent of all U.S. retail prescriptions and 190,075,361 individuals in 2008. These data are geographically representative and are representative by sex, age, and insurance coverage.

Because our goal was to examine temporal patterns of stimulant use among school-aged children and adolescents, we limited our analyses to the 3,995,270 patients 20 years old and younger who filled 15,742,249 stimulant prescriptions[4,5] between September 1, 2007 and August 31, 2008. To avoid censoring issues, we further restricted our analysis to the 22.3 percent (929,631/3,995,270) of these patients who had at least one stimulant prescription filled in the six months prior to and subsequent to our study period. This ensured that patients who disappear from our dataset, aged out of our analysis, or discontinued stimulants altogether were not erroneously coded as not filling a prescription. For each of the 929,631 patients in our study population, we created a variable equal to one if the patient had a prescription filled in a given week and zero otherwise. This yielded a total of 48,340,812 person-weeks for the 929,631 patients included in our sample during the 52-week study period, which extended from September 1, 2007 to August 31, 2008. A total of 7,544,457 prescriptions were written by 273,593 physicians during the period. Of the prescriptions in our analysis, 92 percent were written for a 30-day supply and 98 percent were for 30 days or fewer. Thus, our results cannot be explained by variation in prescription supply.

Each prescription in the LRx database contains the patient's sex, patient's year of birth, the payment source (cash, Medicaid, or private insurance), the date dispensed, the medication for which the prescription was written, and the strength of the prescription. Using an encrypted prescriber identification number, we linked prescriptions to information about the physicians, including the three-digit zip code in which physicians practiced and their specialty. Both physicians and patients can be tracked longitudinally using their unique identification numbers.

Central to our analysis is the role of socioeconomic status in explaining patterns of selective stimulant use. We use insurance status—private or public insurance—as a proxy for socioeconomic status. We refer to children and adolescents covered by private insurance as "higher socioeconomic status." In contrast, we refer to children and adolescents covered by public insurance, either Medicaid or the Children's Health Insurance Program, as "lower socioeconomic status." In 2008, 59.6 percent of children under age 18 were covered by private insurance, 30.3 percent were covered by public insurance, and 10.2 percent were uninsured (American Academy of Pediatrics 2009). While there is variability in income eligibility for public insurance by state, in 2009, 45 states provided public insurance to children up to or above 200 percent of the federal poverty level ($36,620 per year for a family of three). As income increases, rates of private insurance also increase (American Academy of Pediatrics 2009). Insurance status thus provides a reasonable proxy for socioeconomic status. In all models, lower socioeconomic status is the reference group.

Descriptive Analyses

Our first descriptive analysis tests for a temporal pattern consistent with selective stimulant use during the school year. To do so, we plotted the percent of adolescents who had a 30-day stimulant prescription filled by week. We then stratified the graph by socioeconomic status to assess whether selective stimulant use varied by socioeconomic status.

To examine whether school-year increases could be either an artifact of the data or reflect more general temporal patterns in prescription use (e.g., taking extended summer holidays or doctors' offices closing), we created the same plots for anti-seizure medications. In addition, we exploited variation in school closing dates to see if stimulant use decreased earlier in states with early school closings. To do this, we used data on school closing dates and categorized states as "early close" if over 75 percent of schools in the state closed prior to June 1 and "late close" if over 75 percent of schools closed after June 15th (Market Data Retrieval 2012). We then used logistic regression to predict the probability of having a prescription filled in the period from June 1st to 15th for early- and late-close states.

Baseline Models

To analyze temporal patterns of stimulant use, we estimated a baseline logistic regression for school-aged children and adolescents. The dependent variable in all our analyses is whether a patient had a prescription filled in a given week controlling only for the holiday periods. Our primary independent variable of interest is the dummy variable "school week," which was set to one for the weeks encompassing September 1, 2007 through May 31, 2008, excluding holidays.

Because we expected that fill rates might decline during holiday periods, due to either patients taking shorter drug holidays or office closures and travel disruptions, we included a control dummy variable for two weeks surrounding the Thanksgiving holiday and the three weeks encompassing Christmas and New Year's Eve. After obtaining a baseline estimate of increased use in the school year, we then estimated logistic regressions stratified by socioeconomic status for each age controlling only for holidays to observe where increases in school-year use varied by socioeconomic status and age. Because children under age five rarely use stimulants, observations in this age group are pooled to obtain reliable estimates.

Based on previous research, we anticipated that several patient and prescriber characteristics might influence both the overall rate at which patients' stimulant prescriptions were filled, as well as whether patients selectively used stimulants during the school year. We thus included several covariates in our models. We anticipated that patient's sex might be associated with use patterns because sex is associated with overall stimulant use (Olfson et al. 2002). In addition to coding children covered by public insurance as lower socioeconomic status and those with private insurance as higher socioeconomic status, we included a dummy variable for patients paying with cash. Cash payments could indicate that a patient is not insured or underinsured, or the prescription may have been filled outside of the insurance coverage refill window or formulary plan. Because the meaning of cash payment is ambiguous, we included it as a control but do not provide a substantive interpretation of results. For patients who had multiple payment methods throughout the study period, we included a multi-payment dummy variable. We also included dummy variables for the most common physician specialties that prescribe stimulants in our dataset: pediatrics, general medicine, and psychiatry. Previous research finds that adherence to diagnostic and treatment guidelines varies considerably by specialty (Handler and DuPaul 2005).

To examine the main effect of these independent variables on overall fill rates, as well as whether they moderated school-year utilization rates, our analyses include all of the independent variables and an interaction between the independent variables and school year. Except where noted, all models are logistic regressions with robust standard errors clustered by both physician and patient

(Cameron, Gelbach, and Miller 2008). To facilitate interpretation of these results, we often estimated predicted probabilities using Stata's prvalue command, which computes the conditional probability of being in each level of the response variable and sets other covariates to their mean (Long and Freese 2005). When reporting predicted probabilities, standard errors are clustered by patient except where noted. This in no way alters our results, given the large number of observations in the dataset.

Parents and Physician Practice Variation

A key question in our study is how much influence physicians have over the decision to increase stimulant use during the school year. We first examine this by including physician fixed-effects in our baseline models. These models control for unobserved time-invariant features of physicians. Physician fixed-effects models examine within-physician patterns of school-based selective stimulant use, which allows us to begin to disentangle the importance of physicians' practice styles and familial decision-making. Of particular interest is whether SES effects persist once we examine children of different socioeconomic status who see the same doctors. This allows us to adjudicate between two possible explanations for any observed effects of socioeconomic status. On one hand, school-based selective stimulant use might be more common among higher-SES children because these children are more likely to see physicians who favor stimulant holidays. Alternatively, a greater propensity to increase stimulant use during the school year among higher-SES children could arise because higher-SES families are more likely to selectively use stimulants irrespective of their doctor's practice style. If differences by socioeconomic status persist even when we make comparisons within the same doctor using physician fixed-effects, our results would suggest that patients and families are playing a key role in shaping their own medical care.

School Accountability, Performance Pressure, and Socioeconomic Status

After assessing the degree to which patient characteristics shape patterns of stimulant use, we considered how institutional incentives, such as school accountability policies, may contribute to selective stimulant use. We used state ratings from the Standards, Assessments, and Accountability section of Education Week Research Center's (2008) *Quality Counts* report to establish accountability strength. A number of other studies of accountability strength have used this measure. The score includes measures of the degree to which clear and specific academic content standards have been adopted in all core subjects, the rigor of the assessment system, how well state standards align with state tests, and the degree to which the state holds schools accountable for their performance (including whether the state assigns ratings to schools beyond those required by NCLB, and the extent to which high and low school performance is linked to specific rewards and sanctions). To facilitate interpretation of the coefficients, we created a dummy variable for states that received a grade of B or higher, indicating they had relatively more stringent standards, assessments, and accountability policies. The average state grade was a B, and 25 states met this criteria. This variable allowed us to assess the relationship between school accountability scores and stimulant fill rates. We then interacted the dummy with the school variable to assess whether students residing in states with stringent accountability policies were more likely to increase stimulant use during the school year. As a robustness check, we also estimated these models using continuous accountability scores and the numerical mean (rather than letter grade) as the point of dichotomization. In all analyses of state accountability policies, we restricted our sample to 9- to 14-year-olds; these children are likely in grades 3 through 8, the grades in which testing is mandated by NCLB.

We then assessed whether socioeconomic status moderated the accountability–stimulant use relationship. Of particular interest was whether higher-SES students responded differently to stringent accountability policies than did students with fewer economic resources. To do this, we first estimated a model that included a three-way interaction between higher socioeconomic status, school week, and state accountability scores. We then stratified our models by socioeconomic status and generated predicted probabilities by payment type and accountability strength. All models that include state accountability strength were estimated with standard errors clustered by prescriber and state.

Robustness Checks

Four issues might influence the likelihood that a youth would discontinue stimulants when not in school: cost, diagnostic heterogeneity, symptomatic severity, and side effects. One simple possibility is that discontinuation in the summer may be a cost-saving strategy or necessity. To assess this possibility, we classified each prescription by whether the medication retained exclusivity (i.e., brand-name medication) or whether generic forms of the drug were available. Of all prescriptions written for stimulants to persons 20 years and younger, 38.3 percent were for generic medications. Patient utilization of generic versus non-generic medications was also stable. Among patients who had at least one prescription filled for a generic medication, 81 percent solely had prescriptions for generic medications filled, suggesting some sensitivity to price. To examine whether price sensitivity may influence prescription fill patterns, we examined only patients who consistently had generic prescriptions filled throughout the analysis period. We also included physician fixed-effects in these models to account for the possibility that physicians may have different preferences for generic medications or may work for an integrated delivery network with a generics-first policy. If our results are similar for medications with and without generic alternatives, then it is unlikely financial considerations alone are driving our results.

Diagnostic heterogeneity could also produce heterogeneity in selective stimulant use. The International Statistical Classification of Diseases and Related Health Problems-IX (ICD-9) (Centers for Disease Control and Prevention 2010) distinguishes between three subtypes of ADHD: "Attention deficit disorder . . . without mention of hyperactivity, predominantly inattentive type" (314.00), attention deficit disorder "with hyperactivity" (314.01), and a combination of both. The primary distinction between these subclassifications is whether ADHD manifests mainly through hyperactivity or inattention. One could argue that inattention would be more pronounced and would require more treatment during the academic year, whereas behavioral problems arising from hyperactivity would remain constant and necessitate treatment throughout the year. One might anticipate our results would arise solely from increased school-year use among children diagnosed with the inattentive subtype of ADHD and thus have limited generalizability. To examine whether diagnostic heterogeneity accounts for the temporal patterns we observe, we included ADHD ICD-9 classifications in a robustness check.

To obtain diagnoses, we combined the IMS LRx Lifelink database with IMS's Medical Claims database. The Medical Claims Database contains data on procedures and diagnoses for office visits to roughly 100,000 unique physicians. While it is possible to link the two datasets using patient IDs common to both, only 15 percent of patients in the LRx dataset have at least one medical claim. The office visit captured in the Medical Claims file could be for any reason, not necessarily related to ADHD. Of the 929,631 children and adolescents in our dataset, we were able to obtain a Medical Claims file with an ADHD diagnostic code for approximately 8 percent of patients. We included these diagnostic classifications along with the variables in our baseline model to examine whether diagnostic heterogeneity could account for our results or limit their generalizability.

Third, we wanted to examine whether different temporal patterns were observed for patients with differing levels of symptomatic severity. If ADHD medications are being used selectively to aid in school performance during the school year, rather than to treat ADHD as a chronic condition, we would expect to see the largest rise in stimulant use during the school year among the least severe cases. To test this, we used age-adjusted drug-specific prescription strength as a proxy for patient severity. Here, we assume that if two children are the same age and sex and are taking the same medication on the same schedule, on average, the one on the higher dose likely has more severe symptoms.[6] Clinicians typically titrate dose until optimal symptom reduction or patient "normalization" is achieved. It is well established that symptomatic impairments diminish as stimulant dose increases (Greenhill 2000; Stein et al. 2003). Given the strong association between symptomatic presentation and dose, children and adolescents on lower stimulant doses are more likely to be higher-functioning and less symptomatically impaired. Moreover, increasing stimulant dose reduces overt ADHD behaviors but does not improve academic performance (Sprague and Sleator 1977; Tannock et al. 1989). Academic functioning improves with stimulant initiation, but greater gains do not accrue as the dose increases (Tannock et al. 1989). If children and adolescents are using stimulants to enhance school performance, rather than having more general and severe symptomatic impairments in multiple domains as required by the DSM, we would expect them to be on a lower dose of the medication.

For each medication, we calculated the minimum, modal, and maximum dose received by all patients in each age group. We then empirically classified each child by whether they were on the minimum, maximum, modal, or other dose of medication for their age. However, changes in dose and switching between medications are fairly common. To avoid complications from dose titration and medication switching, in this analysis we examine only patients who received the same medication and dose for all prescriptions filled during our analysis period. Because these are the most consistent and persistent users in our dataset, estimates among these groups may be downwardly biased. In our analysis, 25.9 percent (240,897/929,631) of children and adolescents had prescriptions filled only for the same medication-dose combination. Only in analyses stratified by dose do we subset to this population. Of this subset, 13 percent received the minimum dose-medication combination for their age group, 39.6 percent the modal dose, and 26.9 percent the maximum dose. Using these classifications, we re-estimated our baseline models, stratifying by dose, with and without physician fixed-effects.

Fourth, a commonly cited reason for taking stimulants only during the school year is to minimize the side effects of stimulant medications, particularly weight loss and slowed growth (Klein 1988; Xia 2013). One alternative explanation for our findings is that selective stimulant use is not a response to schooling, but a response to the negative side effects arising from stimulant use. In the absence of severe side effects, children would be medicated year-round. Following this argument, any findings related to socioeconomic status could be explained by the fact that higher-SES parents or their physicians have better access to information about the possible negative consequences of stimulant use and how to manage them. In explaining any results related to accountability measures, however, it is hard to imagine how side effects would differ by accountability regime.

To assess the extent to which our findings might be explained by a desire to minimize the possible side effects of stimulant use, we utilized differences in the adverse effects profiles of medications used to treat ADHD. The majority of medications used to treat ADHD are stimulants. Decreased appetite, weight loss, headaches, and delayed sleep onset are the most common side effects associated with stimulant use (Medical Lettter 2011). While there is some evidence that stimulant use may result in modest reductions in expected height and weight, data remain inconclusive and the matter is widely debated (Charach et al. 2006; Swanson et al. 2007). In contrast to stimulants, atomoxetine is a selective norepinephrine reuptake inhibitor and the first non-stimulant medication approved to treat ADHD. A study following youth taking atomoxetine for up to five years found no long-term effects on growth (Spencer et al. 2007). In addition, it can take atomoxetine four to eight weeks to begin working, unlike stimulants which have a rapid onset (College of Psychiatric and Neurologic Pharmacists 2013). Given that atomoxetine does not have the same potential to arrest growth and weight gain, has a diminished effect on appetite when compared to stimulants, and requires several weeks to achieve maximal effectiveness, we would not expect to see large temporal variation in atomoxetine use if potential side effects and optimal usage were driving our analyses. To test this possibility, we re-estimated our baseline models for patients treated only with atomoxetine.

Finally, our estimate of differences in school year versus summer stimulant use are likely lower-bound estimates because we limit our analysis to persistent users. Limiting our analysis to patients who had at least one prescription filled in the six months prior and subsequent to our analysis period is important, because our analysis is susceptible to censoring bias and rates of stimulant discontinuation are high. Analyses examining stimulant persistence found that 44 percent of patients discontinued stimulants within 10 months (Firestone 1982) and only 43 percent had persistent use over the course of a school year (Sanchez et al. 2005). Thus, our study, which focuses on persistent stimulant users, likely produces lower-bound estimates of the schooling effect. To assess patterns of use among less persistent users, we relaxed our censoring restrictions and analyzed 1,439,934 patients who had at least one prescription filled in the six months after our study period but did not have a prescription filled prior to the study period.[7]

RESULTS

Figure 1a reveals a temporal pattern consistent with school-induced stimulant use. On average, 16.6 percent of families filled a stimulant prescription in a given week during the school year compared to 13.3 percent during the summer months. School-year stimulant use was 25 percent higher than summer use.

Stimulant use also declines during shorter school holidays. During the Thanksgiving week, prescription fills averaged 13.6 percent. In the three weeks surrounding Christmas and New Year's Eve (not shown), rates averaged 8.4 percent. A 17 percent fill rate in weeks during the school year suggests the average family is filling a prescription every 41 to 42 days. This is approximately the number of days between fills we would expect if children are largely taking stimulants during the school week and not over the weekend. Patterns of stimulant use thus map neatly onto the school calendar as well as the school week. Moreover, as Figure 1b illustrates, higher-SES children are more likely to increase stimulant use during the school year relative to the summer. In addition, the slightly lower fill rate among higher-SES children during the school year suggests this group may be more likely than their less advantaged peers to discontinue stimulant use during the weekend.[8]

We do not see a similar temporal pattern for anti-seizure medications. Anti-seizure medication fill rates differed by less than 1 percent during the school year compared to the summer months.[9] Accordingly, the increased use we observe during the school year for stimulants is unlikely to arise from more general seasonal prescription filling habits.

To further examine the extent to which schooling might be driving stimulant use, we exploited variation in the school calendar and stratified our analysis by states with an early close date (prior to June 1st) versus a late close date (June 15th). Of central interest was whether the odds of filling a prescription between June 1st and June 15th would differ between the two groups. After controlling for the rest of the summer recess and holidays, the odds of filling a prescription between June 1st and June 15th compared to the

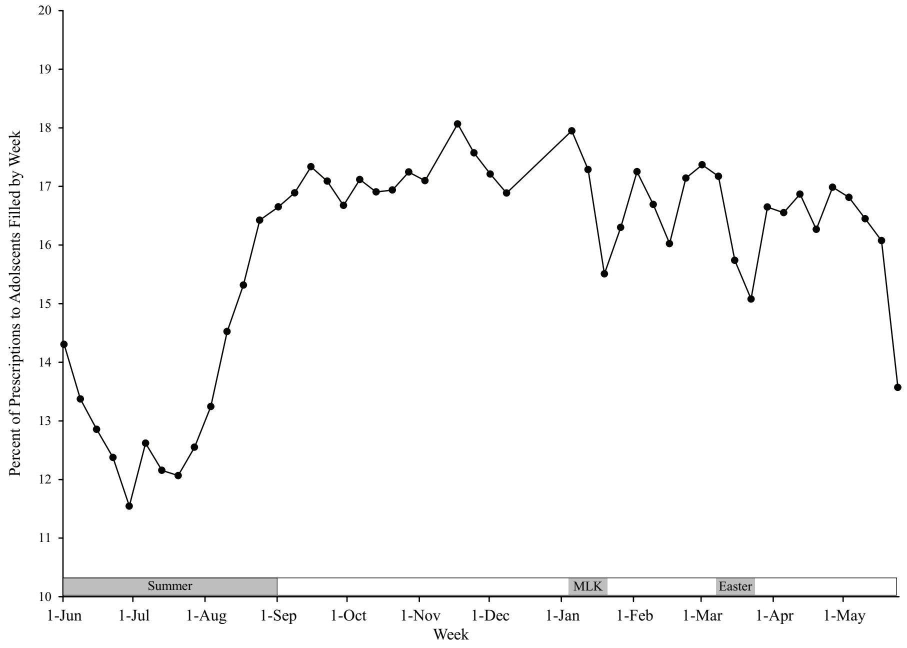

Figure 1a. Percent of Youth Age 5 to 17 Years with a Filled 30-Day Prescription by Week
Note: Thanksgiving and December holidays omitted. Authors' calculations based on data from IMS LifeLink Information Assets.

school year were .82 in early-close states and .93 in late-close states ($p < .001$). Recall that our classifications are based on over 75 percent of schools closing by the cut-off date, so observing some reduction in late closing states is to be expected. Based on these findings, stimulant use appears to respond precisely to the temporal patterning of the academic calendar.

Turning from the descriptive graphs presented earlier to the baseline models, the odds of having a stimulant prescription filled increased by 25 percent for all school-aged children during the school year (OR: 1.24; $p < .001$). In middle and high school, adolescents were approximately 30 percent more likely to have a stimulant prescription filled during the school year than during the summer (OR: 1.29; $p < .001$). School-based selective stimulant use varied not only by age but also by socioeconomic status. As shown in Figure 2, which plots the odds of a stimulant prescription being filled during the school year by age, school-based selective stimulant use was most common during middle and high school. Among children 5 years and younger, there was a small difference between prescription fill rates during the school year and the summer. However, as children enter the school system, the odds they will have a prescription filled during the school year relative to the summer increase. Selective school-year stimulant use peaks during the ages when mandated educational accountability testing occurs, roughly ages 9 to 14. At age 18, when high school ends, the odds of having a prescription filled during the school year begin to diminish. Among adults age 20 and older, the probability of filling a prescription during the school year is equivalent to the probability of filling a prescription during the summer.

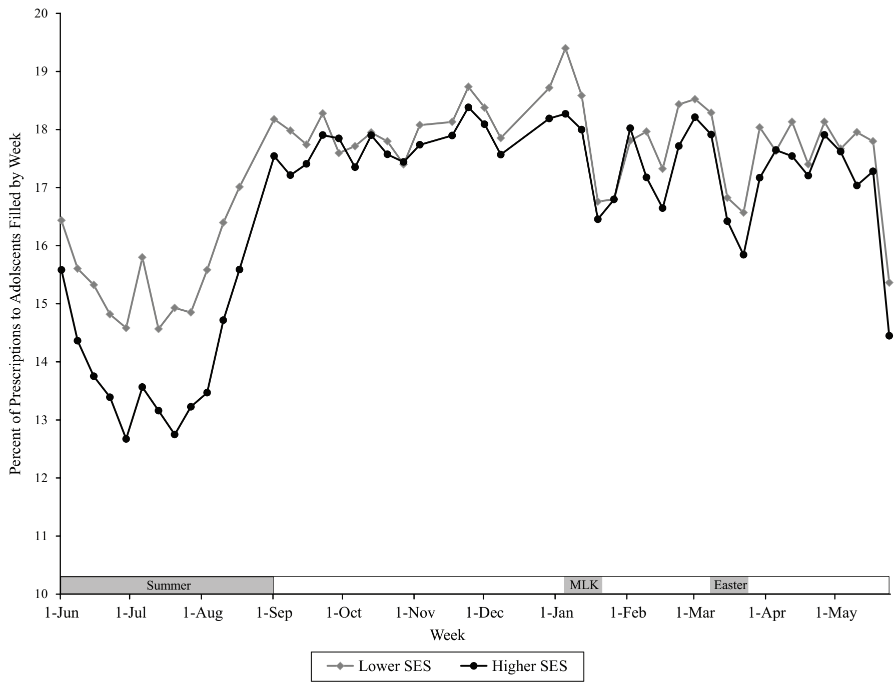

Figure 1b. Percent of Youth Age 5 to 17 Years with a Filled 30-Day Prescription by Week and Socioeconomic Status
Note: Thanksgiving and December holidays omitted. Authors' calculations based on data from IMS LifeLink Information Assets.

Moreover, higher-SES children were much more likely than their less advantaged peers to selectively use stimulants during the school year. At the peak of this difference, a higher-SES student was 36 percent more likely to have a prescription filled during the school year than in the summer. In contrast, the odds of a prescription fill during the school year increase by 13 percent for a lower-SES student of the same age. Age and socioeconomic status are thus important for selective stimulant use.

Turning to Table 1, which includes covariates that might affect our results, higher-SES children remain more likely than their lower-SES peers to selectively have prescriptions filled during the school year. The odds ratio for the interaction term between higher SES and school year for 5- to 10-year-olds was 1.08 ($p < .001$), for 11- to 15-year-olds it was 1.14 ($p < .001$), and for 16- to 20-year-olds it was 1.11 ($p < .001$). Note that the coefficient for the effect of higher-SES patients is less than one. One possibility is that higher-SES children are also more likely than their less advantaged peers to take drug holidays on weekends. While relatively economically disadvantaged children were more likely than their higher-SES peers to have a prescription filled in any given week, children and adolescents of higher socioeconomic status were substantially more likely to increase their frequency of stimulant use during the school year.

Disentangling Parental and Physician Practices

The SES effects we observe could arise because patients with different socioeconomic backgrounds tend to see different doctors with different practice styles. To examine the degree to which physician practice styles influence the likelihood that a patient will increase stimulant use during the school year, we included physician fixed-effects in our

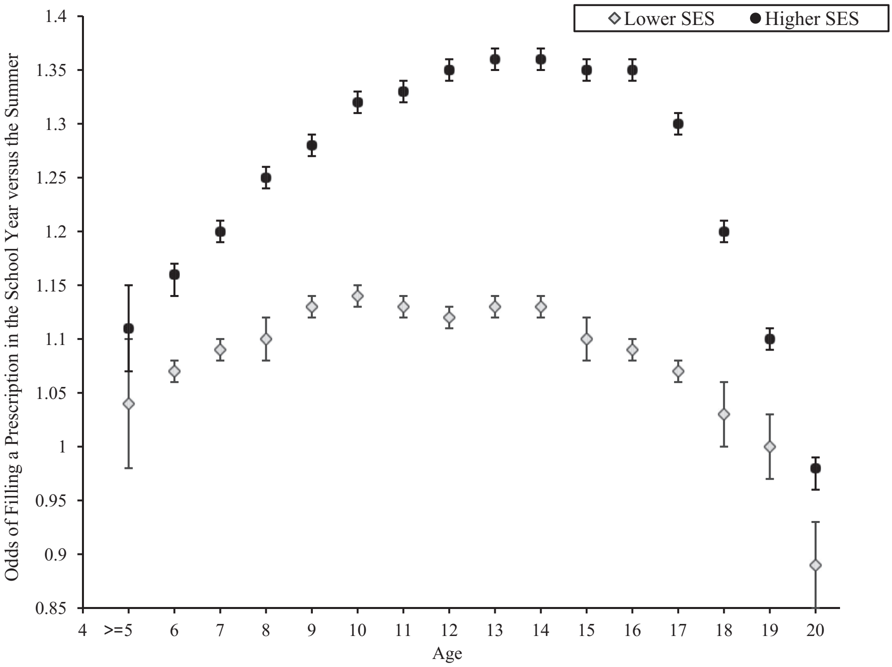

Figure 2. Odds of Filling a Stimulant Prescription during the School Year Compared to the Summer by Age, Stratified by Socioeconomic Status
Note: Baseline models estimated with data from IMS LifeLink Information Assets controlling only for holidays.

model. If stable physician characteristics or practice styles account for the observed differences in selective stimulant use, then the parameter estimates in models with physician fixed-effects should significantly differ from models that do not include physician fixed-effects. Table 2 shows that inclusion of physician fixed-effects had little effect on families' overall propensity to fill a prescription during the school year compared to our baseline models. The magnitude of changes in school-year fill rates compared to our baseline models was small. With inclusion of physician fixed-effects, the odds of a 5- to 10-year-old having a prescription filled in the school year relative to the summer decreased from 1.08 to 1.07. We also see a small difference for 11- to 15-year-olds and 16- to 20-year-olds. Among 11- to 15-year-olds, the odds ratio for school year in the fixed-effects model was 1.20 compared to 1.25 in the model without fixed effects. These results, which control for time-invariant physician variation in prescribing stimulants, suggest that patients and parents play an important role in determining their own treatment. In addition, the higher-SES–school-year interaction terms were similar in the models with and without physician fixed-effects, suggesting that socioeconomic status primarily expresses itself through patients and parents, not through physician practice styles or characteristics.

We believe this finding is consistent with a number of studies in the qualitative literature that find parents see themselves as the ultimate arbitrators of their children's medication (Brinkman et al. 2009; Coletti et al. 2012; Cormier 2012). For example, Coletti and colleagues' (2012:233) study of parents of ADHD diagnosed children found that "parent ideas of partnership were characterized by equality with physicians, who were seen as providing expertise so that a parent could make a treatment decision." Similarly, Singh (2005) reports that all interviewees faced a dilemma over whether to medicate their children on the weekends. As one mother, Beth, stated (quoted in Singh 2005:42):

Table 1. Factors Associated with the Odds of Filling a Stimulant Prescription in a Given Week

	Ages 0 to 4		Ages 5 to 10		Ages 11 to 15		Ages 16 to 20	
Any Stimulant Prescription	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
School Year	1.08	(.99, 1.18)	1.23***	(1.22, 1.24)	1.25***	(1.24, 1.26)	1.13***	(1.12, 1.15)
Higher SES x School Year	1.03	(.96, 1.11)	1.08***	(1.08, 1.09)	1.14***	(1.13, 1.14)	1.11***	(1.10, 1.12)
General Practice x School Year	.92	(.80, 1.05)	1.04***	(1.03, 1.05)	1.03***	(1.02, 1.04)	.97***	(.96, .98)
Psychiatrist x School Year	1.00	(.92, 1.07)	.92***	(.92, .93)	.90***	(.90, .91)	.92***	(.91, .93)
Multiple Payments x School Year	.99	(.91, 1.06)	1.02***	(1.01, 1.03)	1.04***	(1.04, 1.05)	1.04***	(1.02, 1.05)
Multiple Doctors x School Year	.98	(.91, 1.04)	.92***	(.92, .93)	.91***	(.91, .91)	.94***	(.93, .95)
Male x School Year	1.03	(.97, 1.10)	1.01***	(1.01, 1.02)	1.03***	(1.02, 1.03)	1.05***	(1.05, 1.06)
Cash x School Year	1.07	(.71, 1.60)	1.30***	(1.23, 1.37)	1.27***	(1.22, 1.32)	1.01	(.97, 1.06)
Higher SES	1.02	(.94, 1.11)	.93***	(.92, .94)	.86***	(.85, .86)	.82***	(.81, .83)
General Practice	1.08	(.94, 1.25)	.92***	(.91, .93)	.93***	(.93, .94)	.99*	(.97, 1.00)
Psychiatrist	1.09	(.99, 1.20)	1.20***	(1.19, 1.21)	1.27***	(1.26, 1.28)	1.24***	(1.23, 1.26)
Multiple Payments	1.32***	(1.21, 1.43)	1.15***	(1.15, 1.16)	1.13***	(1.12, 1.14)	1.10***	(1.08, 1.11)
Multiple Doctors	1.42***	(1.31, 1.53)	1.38***	(1.37, 1.38)	1.41***	(1.40, 1.42)	1.38***	(1.37, 1.40)
Male	1.03	(.96, 1.11)	1.01***	(1.01, 1.02)	1.00	(1.00, 1.01)	.98***	(.97, .99)
Cash	.70	(.49, 1.00)	.48***	(.45, .52)	.53***	(.50, .56)	.65***	(.61, .69)
Holiday	.63***	(.59, .68)	.61***	(.60, .61)	.61***	(.61, .61)	.62***	(.61, .62)
N Patient Weeks	105,820		16,629,600		22,158,136		9,447,256	

Note: Omitted categories are lower socioeconomic status and pediatrician. Exponentiated coefficients. 95% confidence intervals in parentheses. Authors' calculations based on data from IMS LifeLink Information Assets.
*$p < .05$; **$p < .01$; ***$p < .001$ (two-tailed tests).

Table 2. Factors Associated with the Odds of Filling a Stimulant Prescription in a Given Week with Physician Fixed-Effects

	Ages 0 to 4		Ages 5 to 10		Ages 11 to 15		Ages 16 to 20	
Any Stimulant Prescription	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
School Year	1.07	(.96, 1.19)	1.20***	(1.18, 1.21)	1.20***	(1.19, 1.21)	1.08***	(1.07, 1.10)
Higher SES x School Year	1.03	(.94, 1.13)	1.09***	(1.08, 1.10)	1.15***	(1.14, 1.16)	1.12***	(1.11, 1.14)
Multiple Payments x School Year	.98	(.88, 1.09)	1.02***	(1.01, 1.03)	1.05***	(1.04, 1.06)	1.04***	(1.02, 1.06)
Multiple Doctors x School Year	.98	(.91, 1.06)	.94***	(.94, .95)	1.03***	(1.02, 1.03)	.97***	(.96, .98)
Male x School Year	1.04	(.95, 1.13)	1.01***	(1.00, 1.02)	1.03***	(1.02, 1.03)	1.06***	(1.05, 1.07)
Cash x School Year	1.05	(.70, 1.59)	1.33***	(1.25, 1.42)	1.29***	(1.23, 1.36)	1.03	(.97, 1.09)
Higher SES	1.05	(.88, 1.24)	.90***	(.90, .91)	.84***	(.83, .85)	.83***	(.82, .84)
Multiple Payments	1.35***	(1.14, 1.59)	1.12***	(1.11, 1.13)	1.09***	(1.09, 1.10)	1.09***	(1.07, 1.10)
Multiple Doctors	1.44***	(1.24, 1.68)	1.38***	(1.37, 1.39)	1.40***	(1.40, 1.41)	1.37***	(1.36, 1.39)
Male	.98	(.88, 1.09)	1.02***	(1.01, 1.02)	1.01*	(1.00, 1.01)	.97***	(.97, .98)
Cash	.16	(.04, .74)	.48***	(.46, .51)	.54***	(.51, .56)	.64***	(.61, .68)
Holiday	.63***	(.59, .68)	.61***	(.60, .61)	.61***	(.61, .61)	.61***	(.61, .62)
Physician Fixed-Effects	Yes		Yes		Yes		Yes	
N Patient Weeks	105,407		16,612,621		22,138,061		9,439,787	

Note: Models estimated with data from IMS health. Omitted categories are third-party insurance and pediatrician. Exponentiated coefficients. 95% confidence intervals in parentheses. Authors' calculations based on data from IMS LifeLink Information Assets.
*$p < .05$; **$p < .01$; ***$p < .001$ (two-tailed tests).

> Why should we drug him on the weekend? The question [whether or not to use medication on weekends] drives me nuts, drives me crazy. . . . I know half of me wants him to be successful and do well and blah, blah but the other half of me is like who the heck am I pleasing here? He is fine the way he is. It's the weekend for god's sake. He doesn't have to be successful now.

As Beth's quote makes clear, she believes the choice of whether to medicate her child during non-school periods is her choice to make as a parent and academic pressure influences her decision.

School Accountability, SES, and Selective Stimulant Use

After establishing that SES and the school calendar shape patterns of selective stimulant use, we wanted to assess whether school-year increases in stimulant use were higher in states with more stringent accountability policies.[10] Of particular interest was whether higher-SES students are more likely than their less advantaged peers to respond to strict accountability policies by selectively using stimulants during the school year. As Model 1 in Table 3 shows, students in states with more stringent accountability policies were more likely than their peers living in states with weaker policies to selectively use stimulants during the school year (OR 1.04; $p < .01$).

Having established that increases in stimulant use during the school year were greater among children living in states with relatively strict accountability policies, we further wanted to assess whether responses to accountability pressure differed by SES. The three-way interaction between school year, higher SES, and accountability regime shown in Model 2 in Table 3 indicates that higher-SES students living in states with more stringent accountability policies were more likely than their peers to selectively use stimulants during the school year (OR: 1.03; $p < .01$). Alternative specifications of the three-way interaction with a continuous accountability score (OR: 1.02; $p = .03$) or using the numeric mean as a cut point (OR: 1.02; $p = .02$) produced similar results.[11]

To facilitate interpretation of the three-way interaction, Table 4 shows models stratified by payment type, and Figure 3 presents graphs of the predicted probabilities from the models. Higher-SES children were more likely than their lower-SES peers to increase stimulant use during the school year, particularly in states with strict accountability regimes. The disproportionate increase in stimulant use during the school year in strict accountability regimes was driven almost entirely by higher-SES students. Thus, higher-SES children are more likely than their less advantaged peers to use stimulants when and where academic pressure is intense.

Robustness Checks

Four factors that could also influence our results but have not yet been considered are cost, diagnostic heterogeneity, symptomatic severity, and side effects. Cost considerations could affect all patients in different ways due to unobservable variance in co-pay structures, price sensitivity, and the like. Accordingly, we examined the role of cost by sub-setting our data to generic prescriptions. If cost was an important factor in temporal patterns of stimulant use, we would expect models for much cheaper generic medications to differ substantially from our baseline models. While we see slightly higher school-year increases among patients who had only generic prescriptions filled, these results do not meaningfully differ from our baseline models, which assuaged our concerns that cost considerations may by influencing the results we report.[12]

Diagnostic heterogeneity could also influence our results. Because ADHD manifests in two subtypes, primarily attention or hyperactivity, we wanted to ensure that our results were generalizable across conditions. To examine the sensitivity of our results to diagnostic heterogeneity, we estimated an additional set of models that controlled for a

Table 3. Factors Associated with the Odds of Filling a Stimulant Prescription in a Given Week with State-Level Accountability Measures

	Model 1		Model 2	
	OR	95% CI	OR	95% CI
Strict Accountability x School Year x Higher SES			1.03***	(1.01, 1.04)
Strict Accountability x School Year	1.04**	(1.02, 1.07)	1.03**	(1.01, 1.05)
Higher SES x School Year	1.11***	(1.10, 1.13)	1.11***	(1.10, 1.13)
School Year	1.22***	(1.19, 1.25)	1.23***	(1.20, 1.26)
General Practice x School Year	1.04***	(1.02, 1.05)	1.04***	(1.02, 1.05)
Psychiatrist x School Year	.91***	(.90, .92)	.91***	(.90, .92)
Multiple Payments x School Year	1.03***	(1.02, 1.04)	1.03***	(1.02, 1.04)
Multiple Doctors x School Year	.91***	(.90, .92)	.91***	(.90, .92)
Male x School Year	1.02***	(1.02, 1.03)	1.02***	(1.02, 1.03)
Strict Accountability	.90***	(.86, .94)	.90***	(.86, .95)
Higher SES	.89***	(.87, .91)	.89***	(.87, .92)
General Practice	.92***	(.90, .94)	.92***	(.90, .94)
Psychiatrist	1.25***	(1.23, 1.27)	1.25***	(1.23, 1.27)
Multiple Payments	1.15***	(1.12, 1.18)	1.15***	(1.12, 1.18)
Multiple Doctors	1.39***	(1.37, 1.42)	1.39***	(1.37, 1.42)
Male	1.00	(1.00, 1.01)	1.00*	(1.00, 1.01)
Holiday	.61***	(.60, .62)	.61***	(.60, .62)
Higher SES x Strict Accountability			.99	(.96, 1.02)
N Patient Weeks	28,065,492		28,065,492	

Note: Omitted categories are third-party insurance and pediatrician. Exponentiated coefficients. 95% confidence intervals in parentheses. Standard errors clustered by state and prescriber. Authors' calculations based on data from IMS LifeLink Information Assets.
$^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$ (two-tailed tests).

patient's diagnosis. These results found slightly smaller increases in stimulant use during periods of schooling for patients with a sole diagnosis of ADHD with hyperactivity. However, inclusion of controls for diagnostic heterogeneity did not have a substantial impact on the results or conclusions from our other analyses.[13]

Turning to analyses examining symptomatic severity, children and adolescents on the *weakest* medication doses were the *most* likely to have higher stimulant fill rates during the school year. Among 5- to 10-year-olds on minimum dose prescriptions, the odds of having a prescription filled were 54 percent higher in the school year than in the summer.[14] Among 5- to 10-year-olds on the highest medication doses for their age, the odds of having a prescription filled differed by 17 percent between the two periods. Depending on dose intensity, which we interpret as a proxy for symptomatic severity, there was more than a three-fold difference in the propensity to increase stimulant use during the school year. Similarly, 11- to 15-year-olds on low doses were 72.3 percent more likely to have a prescription filled during the school year than when school was not in session. Among young adults, the odds of filling a stimulant prescription in the school year did not differ substantially across dose categories. For school-age children and adolescents, school effects have the greatest impact on stimulant use of the least impaired children.

The importance of socioeconomic status varied considerably by patient symptomatic severity. The school-year–higher-SES interaction term was strongest for children and

Table 4. Factors Associated with the Odds of Filling a Stimulant Prescription in a Given Week Stratified by Payment Type

	Medicaid		Third Party	
	OR	95% CI	OR	95% CI
School Year	1.21***	(1.18, 1.23)	1.36***	(1.35, 1.38)
Strict Accountability x School Year	1.02***	(1.01, 1.03)	1.05***	(1.02, 1.08)
General Practice x School Year	1.03**	(1.01, 1.06)	1.04***	(1.03, 1.05)
Psychiatrist x School Year	.94***	(.92, .95)	.89***	(.88, .90)
Multiple Doctors x School Year	.93***	(.92, .95)	.90***	(.89, .91)
Male x School Year	1.02***	(1.01, 1.03)	1.02***	(1.02, 1.03)
Strict Accountability	.88***	(.82, .94)	.90***	(.86, .94)
Generalist	.92***	(.90, .94)	.93***	(.92, .95)
Psychiatrist	1.16***	(1.14, 1.17)	1.31***	(1.30, 1.32)
Multiple Doctors	1.36***	(1.34, 1.38)	1.45***	(1.44, 1.46)
Male	.99	(.98, 1.00)	1.01***	(1.00, 1.02)
Holiday	.61***	(.60, .62)	.60***	(.60, .61)
N Patient Weeks	5,151,016		17,368,156	

Note: Exponentiated coefficients. 95% confidence intervals in parentheses. Difference in strict accountability x school year coefficients significant at $p = .04$. Standard errors clustered by state and prescriber. Authors' calculations based on data from IMS LifeLink Information Assets.
*$p < .05$; **$p < .01$; ***$p < .001$ (two-tailed tests).

adolescents taking the weakest stimulant dosages. The predicted probability of having a low-dose prescription filled among higher-SES adolescents was 64.2 percent higher in the school year than during the summer. Among lower-SES adolescents on the weakest medications, fill rates were 35 percent higher during the school year. In contrast, among adolescents of the same age group on the highest medication doses, the probability of having a prescription filled during a school week compared to a summer week increased 23.8 percent among higher-SES students compared to 14 percent among lower-SES adolescents.[15]

In summary, sensitivity analyses examining the importance of symptomatic severity and school-based selective stimulant use yield two important findings. First, increased stimulant use during the school year is most common among children and adolescents on the lowest medication doses who likely have the least severe ADHD symptoms and are most diagnostically ambiguous. This suggests that students who are the least impaired are the most likely to change their prescription-taking behavior in response to changes in the school environment. In addition, socioeconomic status expressed itself most strongly on children with the least severe ADHD symptoms who are most diagnostically ambiguous. Note, however, that stimulant holidays are still observed for children and adolescents on the highest doses of stimulant medications.

To explore the potential role that side effects might play in explaining our results, we examined whether we could observe temporal variation in stimulant use among children and adolescents medicated with atomoxetine. Given that atomoxetine has a different mechanism of action and different side effect profile, we would not expect to see drug holidays for this prescription. This is especially true given that it takes several weeks for the drug to achieve maximal effectiveness. However, even among atomoxetine users, we observe increased use during the school year compared to the summer, although these effects were smaller than those observed for stimulants (OR 1.22; $p < .001$). Because

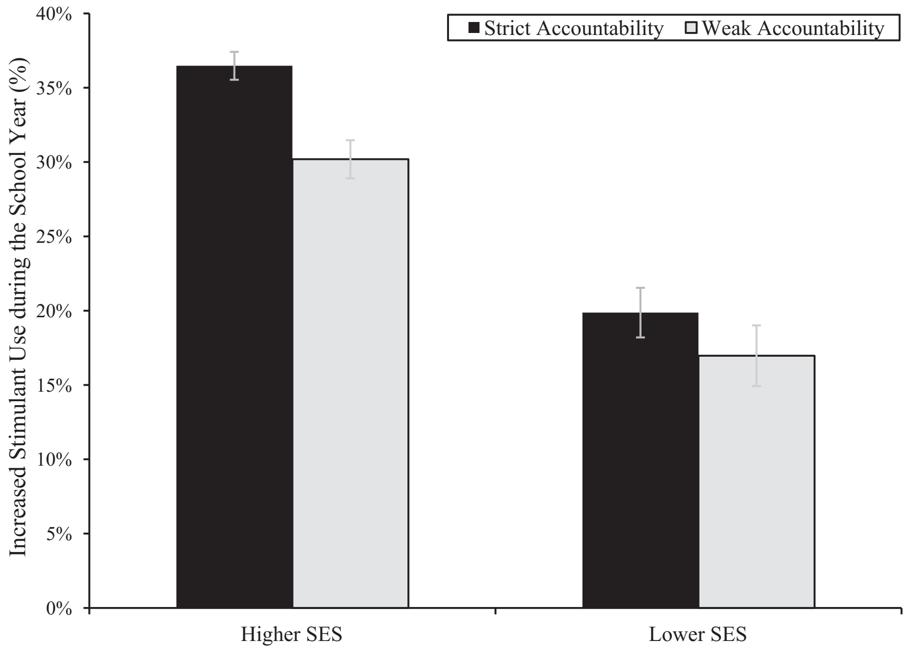

Figure 3. School Year Increase in Stimulant Use by Accountability Regime and Payment Type for Test-Age Children

Note: Predicted probabilities from models generated with data from IMS LifeLink Information Assets shown in Table 4.

we observe increases in use during the school year for a medication with a different side effect profile than stimulants—a medication that should not be discontinued and restarted according to clinical guidelines—it seems unlikely that our results are simply capturing a desire to reduce side effects. Moreover, if a desire to reduce side effects accounted for the findings we present, side effects would have to differ by accountability regime.

Finally, the estimates of increased stimulant use during the school year that we report likely represent lower-bound estimates. To minimize potential censoring issues, we restricted our analysis to patients who had at least one prescription filled in the six months prior to and six months subsequent to our analysis period. These restrictions ensured that our analyses capture the same patients throughout the study period and that our results are not subject to biases arising from new patients entering the dataset or, more importantly, that patients who drop out of our dataset or discontinue stimulants all together are not included in our analysis. The patients included in our analysis are thus persistent stimulant users. To assess the effect that restricting our analysis to relatively persistent users has on our results, we relaxed our censoring conditions and only required patients to have a prescription filled in the six months subsequent to our analysis period to guarantee that our analyses were not biased by patients dropping out of the dataset. These models produced significantly higher estimates of stimulant use increases during the school year. Among this population of less persistent users, the odds of having a prescription filled during the school year compared to the summer varied from a high of 2.03 ($p < .001$) among 11- to 15-year-olds to 1.49 ($p < .001$) among 5- to 10-year-olds. Put differently, in middle school, stimulant use *more than doubled* during the school year.

DISCUSSION

In our study, one in three children engaged in school-based stimulant use—that is, increasing stimulant medications during the academic year. This practice was more common among children and adolescents of higher socioeconomic status. We provided evidence that schooling has a direct effect on how often families fill children's stimulant prescriptions. In states with more stringent accountability policies, we observed greater selective stimulant use. These effects persisted even when we made comparisons *within* the same doctor. Higher-SES families were more likely than lower-SES families seeing the same physician to selectively use stimulants during the school year. Collectively, our findings suggest that economically advantaged families are more likely than their less advantaged peers to use stimulants in response to academic performance pressure. Thus, school-based selective stimulant use offers a new pathway through which medical interventions may act as a resource for higher-SES families to transmit educational advantages to their children.

Our study has several limitations. First, while we use variation in the school year to understand how academic pressure influences when and how stimulants are used, our data do not allow us to examine overall levels of stimulant use by SES. Ideally, we would have had more refined data on socioeconomic status and the distribution of the underlying population by SES. This would allow us to refine our analyses that use insurance coverage as a proxy for SES, as well as look at levels of stimulant use. In addition, our data do not allow us to assess the relative weight of different rationales for higher-SES families' increased likelihood of using stimulants during the school year. Nor can we assess the role that teachers play in shaping patterns of stimulant use. Future qualitative work should examine how families from different backgrounds think about, and make use of, stimulant medications.

We are unable to directly tie academic performance to patterns of stimulant use and estimate the advantage gained by higher-SES children. While we believe the medical literature provides evidence that stimulants produce at least short-term academic and behavioral advantages that translate into advantages in school, the long-term effects of stimulant use are less clear. Some studies suggest there are no positive longer-term effects, and there may even be negative longer-term effects (Greenhill, Pliszka, and Dulcan 2001). Given that use of stimulants by patients with more mild symptoms is a relatively new phenomenon, this question may remain unanswered for some time.

Finally, there is no consensus in the medical literature about the "true" rate of ADHD in the population or the appropriate stimulant use rate, but we can estimate that the increase in school-year stimulant use (or decreased summer use) has large cost and policy implications. On one hand, if stimulant use did not increase during the school year, the reduced costs would translate to $175.61 per child—145 percent more than per capita State Mental Health Agency expenditures.[16] In the aggregate, increased stimulant use during the school year amounts to $544.4 million dollars. To help benchmark the magnitude of that expenditure, this is more than New Hampshire, Nebraska, and New Mexico spent on mental health combined in 2008. Alternatively, decreased use during the summer could be viewed as a shortfall in medication provision, which would cost $64.72 per patient or $200.6 million to resolve. Both of these scenarios have important policy and ethical implications.

Our study also suggests a number of fruitful areas of exploration to improve sociology's understanding of how health is a resource through which parents may, intentionally or unwittingly, reproduce advantage. The sociology of education has a long history of examining the extra-school strategies that families pursue to help their children succeed academically. These include additional tutoring and "shadow education" (Buchmann, Condron, and Roscigno 2010), enrollment in extracurricular and summer activities (Chin and Phillips 2004), and exposure to experiences that build cultural capital (Lareau 2003). At present, higher-SES families spend $7,500 more a year on these endeavors than do lower-SES families (Duncan and Murnane 2011), and achievement gaps between the wealthy and the poor have grown substantially (Reardon 2011). As with many other practices through which parents do not necessarily intend to reproduce advantage—such as holding children out of kindergarten for an additional year so they are among the oldest in their class, which is most prevalent among higher-SES families—selective stimulant use may be an adaptation to performance pressures from schools that nonetheless have this consequence. Study of out-of-school strategies that reproduce educational advantage should thus be extended to the medical realm.

While a large body of work within medical sociology has investigated the role of socioeconomic status in generating persistent gradients in health outcomes (Link and Phelan 1995; Lutfey and Freese 2005), relatively little attention has been devoted to understanding how differential use of health technologies by different socioeconomic groups may extend to other realms. However, differential utilization of health-enhancing technologies could generate further inequalities in the domains of work, education, and sport (Bahrke, Yesalis, and Brower 1998; Greely et al. 2008). We need to understand when and under what conditions the enhancement of health may generate or perpetrate inequalities into different social realms. The rise of demand-side medicine increases the possibility that inter-institutional linkages will lead to downstream disparities.

A key sociological insight is that we cannot understand individual biographies without reference to the multiple institutions that structure individual lives. The study of medical interventions, which act on what many see as their most individual attribute, the body, is particularly vulnerable to an overly individualized and atomized view of medical intervention use. Our article reveals how the linked demands of the institutions that govern individuals' everyday lives shape families' and doctors' decisions about the use of stimulant medication in childhood.

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Notes

1. For overall utilization levels by age, see Figure S1 in the online supplement (http://asr.sagepub.com/supplemental).
2. We would like to thank an anonymous reviewer for calling this to our attention.
3. Published estimates of drug holidays are scarce. To our knowledge, the only published estimate of the prevalence of drug holidays among children and adolescents was a survey of 28 parents of children with ADHD living near Amsterdam. The authors found that 65 percent of parents reported no or less drug use on weekends and holidays (Hugtenburg, Heerdink, and Tso 2007). In addition, a survey found that approximately one-fifth of adult patients had structured medication interruptions; of these, 56 percent were patient initiated (Faraone et al. 2004.)
4. We use the term stimulant to refer to all stimulant medications approved to treat ADHD, as well as atomoxetine, which was the only non-stimulant medication approved for treatment of ADHD during our study period. The full list of medications is available upon request.
5. Because our data arise from pharmacy claims, we can examine only filled prescriptions.
6. Symptomatic severity correlates with minimal effective dose but "weight was not a major factor in predicting effective dose" (Newcorn, Stein, and Cooper 2010:187). While the superiority of weight-adjusted titration is widely debated in the clinical trials literature, it is rarely used in clinical practice (Greenhill 2000).
7. It is necessary to continue to require a prescription fill after our study period to minimize possible biases arising from patient attrition from our dataset.
8. Our data do not allow us to examine *overall* levels of stimulant use by SES. Recent studies have found either no relationship between stimulant use and parental income (Zuvekas and Vitiello 2012)

or slightly higher use among more economically advantaged children (Olfson, He, and Merikangas 2013). These findings stand in contrast to a large body of work documenting higher rates of ADHD among lower-SES youth, suggesting there is a disconnect between stimulant use and ADHD diagnosis (Visser et al. 2010) that may be related to socioeconomic status. Future work examining what accounts for these disparate findings, as well as what role academic pressure may play in explaining this puzzle, is needed.

9. Results available upon request.
10. Our analysis focuses on patterns of stimulant use by accountability regime, rather than levels of stimulant use. However, research by Bokhari and Schneider (2011) found that if all states shifted to strict accountability laws, an additional 655,252 children would be diagnosed with ADHD and treated with stimulants.
11. Models with state accountability variables cluster standard errors by state and physician. For the complete set of models, see Table S1 in the online supplement.
12. For full results, see Table S2 in the online supplement.
13. For full models, see Table S3 in the online supplement.
14. For graph of odds ratios, see Figure S2 in the online supplement.
15. Full models available upon request.
16. The absolute rate of fills in any given week would be approximately 23 percent if all families in our sample were filling prescriptions every 30 days and fills were uniformly distributed across a 30-day month. That is, the probability of filling on any given day is 1/30, so that across a week, the probability of filling is 1/30 x 7 = .23. The observed probability of filling on any given day in a week during the school year is (1/42) x 7 = .167, and during the summer it is (1/52) x 7 = .134. Put differently, families fill a prescription roughly every 42 days during the school year and every 52 days during the summer. This translates into 8.3 fills per year based on a three-month summer and nine-month school year. If use held at summer fill rates, we would expect to see 7.0 (365/52) fills per year. Multiplying the difference of 1.3 fills per year by the annual average prescription cost reported in our data yields an annual cost of $175.61 per child. With 3.1 million stimulant users age 5 to 17 years, the aggregate cost is $544.4 million. Data on State Mental Health Agency expenditures is from fiscal year 2008 as reported by the Kaiser Family Foundation (2013).

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