The Effect of Medical Treatment of Attention Deficit Hyperactivity Disorder (ADHD) on Foster Care Caseloads: Evidence from Danish Registry Data

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ABSTRACT

Since the early 2000s, foster care caseloads have decreased in most developed democracies, yet the causes of these declines remain, for the most part, a mystery. This paper uses administrative data from one of the countries that experienced a sharp decline in admissions to foster care over this period, Denmark, to show that increasing medical treatment of ADHD (primarily through the use of Ritalin) accounts for a substantial part of the decrease in Danish foster care caseloads. Indeed, according to our estimates, the decline in foster care caseloads over this period would have been 45% smaller absent increases in the medical treatment of ADHD. We also find that increased use of ADHD medication directly lowered the individual level risk of entering foster care for children, suggesting that our macro-level findings are not susceptible to the ecological fallacy, as would be the case absent the individual-level findings. Thus, while a host of factors such as parental behaviors and characteristics, welfare generosity, and the female imprisonment rate all shape foster care caseloads, future research should also be more attentive to the vital ways in which medical treatment aimed at addressing children's acute behavioral problems could also have a powerful effect on foster care caseloads. Yet previous research indicates that if the population-level of medical treatment of conditions such as ADHD exceeds a very low threshold even slightly higher rates of treatment could have deleterious population-level consequences

Toward the close of the 20th century, many developed democracies experienced profound growth in foster care caseloads (e.g., Department of Health 2000; Swann and Sylvester 2006). In the United States, for instance, the number of foster care caseloads increased from 276,000 in the mid-1980s to 568,000 by 1999 (Swann and Sylvester 2006:309). Since the early 2000s, however, foster care caseloads have decreased in many developed democracies, with a handful reporting rapid decreases in foster care caseloads (e.g., Fallesen, Emanuel and Wildeman 2013; Wildeman and Emanuel 2013). Yet the causes of these declines remain, for the most part, a mystery.

Researchers studying the predictors of foster care caseloads have tended to focus on two types of factors that shape foster care caseloads. First, they have focused on a range of negative parenting behaviors driven by a combination of poverty, unemployment, drug use and abuse, poor mental and physical health, homelessness, single motherhood, and age, among other things (Barbell and Freundlich 2001; Cunningham and Finlay 2013; Paxson and Waldfogel 1999; 2002; for a recent review, see Wildeman and Waldfogel Forthcoming). Second, they have focused on policies such as welfare generosity, criminal justice policy, or adoption subsidies (e.g., Berger and Waldfogel 2004; Bitler, Gelbach and Hoynes 2006; Buckles 2013; Paxson and Waldfogel 2003; Swann and Sylvester 2006; Andersen and Wildeman forthcoming; for a recent review, see Wildeman and Waldfogel Forthcoming). Taken together, these strands of research show that macro-level factors such as increases in the imprisonment rate and declines in welfare generosity and micro-level factors such as poor socioeconomic background and drug abuse have a profound effect both on foster care caseloads and on the risk of placement for individual children. The strands of research do, however, are very poor job of explaining the recent decrease in foster care rates (especially when considering that the decrease persisted through the financial crisis from 2008 and onwards).

Yet parents are only one side of the foster care equation, and the state policies that affect them are but one more. A third side of the equation is children with significant enough emotional and behavioral problems that it makes parenting them very difficult, even absent other significant obstacles to pro-social parenting, such as poverty (Barbell and Freundlich 2001). Children entering foster care present far higher levels of anxiety, attention deficit hyperactivity disorder (ADHD), conduct disorder or oppositional defiant disorder, depression, mania, and posttraumatic stress disorder than do other children (McMillen et al. 2005). They are also more likely to score within the clinical range of the Child Behavior Checklist than are other children, with older children in foster care scoring the highest (Achenbach 1993; Burns et al. 2004). Yet, although the children who eventually end up in foster care disproportionately present symptoms of—and are diagnosed with—serious behavioral and mental health problems, relatively little research has considered how shifts in the behavioral problems of children could affect foster care caseloads.

Medical sociologists have long studied, how physicians have used medical treatment of ADHD and similar diagnoses to control deviant behavior (e.g, Conrad 1975; 1992), yet no one has studied how medical treatment of ADHD affects children's risk of entering foster care. Instead, research have approached medicalization of behavioral problems from a critical point of view, conceptualizing medicalization as way of controlling deviance created by poor functioning institution, such as the educational system (Conrad, 1982). Nevertheless, recent studies on medical treatment of ADHD have found that when a very small part of the child population are diagnosed and/or treated for ADHD (as is the case in e.g. Denmark), it leads to decreased strain in families (Kvist, Nielsen and Simonsen, 2013) and less risky behavior among children (Dalsgaard, Nielsen and Simonsen 2013b). In contrast, studies of population with higher medicalization rates have found that treating children on the margin has negative effects on learning and behavioral issues (Currie, Stabile and Jones, 2013). The discordant findings indicate that the effect of medical treatment of behavioral problems could vary depending on how strict or lapse the threshold for when to treat children is.

In this paper, we provide a test of how behavioral problems affect foster care rates, and in so doing propose to expand the discussion of the factors that shape foster care caseloads by testing the effects of medical treatment of ADHD (primarily through the use of Ritalin) on foster care caseloads. In order to provide this test, we use annual medical, child welfare, and population data on all Danish municipalities from 1998 to 2010 to examine whether the increased medical treatment of ADHD with prescription drugs like Ritalin (beginning in the late 1990s) caused foster care caseloads to decrease in Denmark. We also examine the effect of the rise in use ADHD medication on children's individual level risk of being in foster care and, in so doing, help alleviate the well-founded concerns about the ecological fallacy that would be present absent this individual-level test.

The results of our analysis suggest that medical treatment of ADHD has substantial effects on both foster care caseloads and the risk of entering foster care for individual children. Moreover, the results suggest that further interventions (both medical and non-medical) designed to address children's behavioral and mental health problems may diminish foster care caseloads and risk of entering foster care dramatically. Taking observable municipality characteristics, year fixed effects, and municipality fixed effects into account, we show that fully 45 percent of the marked decrease in foster caseloads was attributable to increased use of ADHD medication. In comparison, in their seminal article on the causes of the increase in foster care caseloads in the United States, Swann and Sylvester (2006) found that the increase in female imprisonment accounted for 31 percent of the increase in US foster care caseloads between 1985 and 2000. On the individual level, a child's risk of entering foster care decreased 0.7 percentage points when the share of children medicated with Ritalin (and other similar drugs) increased 1 percentage point, a dramatic individual-level response that further buttresses our macro-level findings.

Parental behaviors and characteristics, welfare generosity, and the female imprisonment rate all shape foster care caseloads. Nevertheless, our results indicate that future research should also be more attentive to the various ways in which medical treatment aimed at addressing children's acute behavioral problems could also have a powerful effect on foster care caseloads.

BACKGROUND

Foster Care in Denmark

Danish foster care caseloads have been remarkably stable over the last 100 years (Ebsen and Andersen 2010), with roughly 1 percent of all Danish children in foster care any given day. The comparative rate for American children in 2010 was 0.55 percent (U.S. Department of Health and Human Services 2011). The cumulative risk of entering foster care has, however, decreased for Danish children since around 2000 (Fallesen, Emanuel, and Wildeman 2013), whereas the share of children in foster care at any given time has been stable, indicating a decline in first admissions to foster care but a slight increase in duration of exposure to foster care. Figure 1a shows the development of the cumulative risk of foster care for Danish children from 1998 until 2010. While a child in 2000 had a cumulative risk of 0.06 of entering foster care at some point in his or her childhood, the risk had decreased to below 0.03 in 2010. The drop is also evident in foster care caseloads (shown in Figure 1b), although with a slight delay because of children who have already entered foster care. Overall, the annual foster care caseload in Denmark has decreased over the same period that the cumulative risk of entering foster care decreased.

[Figure 1 about here.]

In Denmark, foster care is a social service program aimed at providing children with a substitute living arrangement if social services deems the children's parents unable to provide proper care for their children or a child's parents no longer feel capable of providing proper care for them. Local municipalities manage foster care, with social workers and representatives of the municipal government having the final say in whether or not to instigate a foster care placement. Between 85 and 90 percent of Danish foster care placements are instigated with parental consent (Andersen 2010), and the risk of first time entry is highest among teenagers, followed by infants (Fallesen, Emanuel and Wildeman 2013). The use of voluntary placements and high share of first timers among teenagers stand in stark contrast to the United States, where infants have by far the highest risk of entering foster care (Wildeman and Emanuel 2013) and where parental consent is considered relevant only when the parent requests the placement (which is relatively rare).

As in other developed democracies, children from disadvantaged social backgrounds disproportionately enter foster care in Denmark. Danish children in foster care are more likely to come from single-parent families, their mothers are more likely to be on disability pension, welfare, or unemployment benefits, and their parents are more likely to have had contact with the criminal justice system (Andersen and Wildeman 2013; Ejrnæs, Ejrnæs and Frederiksen 2010). Danish children in foster care are also markedly more likely to suffer from a host of behavioral and mental health disorders such as ADHD (Egelund and Laustsen 2009). A similar American study found that up to 75% of children in foster care received the ADHD diagnoses prior to their placement, suggesting behavioral problems may precipitate placement (McMillen et al. 2005).

Foster Care and Medicalization as Forms of Social Control

Psychiatrists and pediatricians started to use the diagnosis ADHD in 1987 with the introduction of a new version of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-III R). Yet pediatricians have described similar conditions as far back as 1902, and stimulant treatment for symptoms consistent with what we would now call ADHD dates back to 1930s (CDC 2013).[1] Sociological researchers began to study medicalization of "hyperkinetic" children in the 1970s (Conrad 1975), building upon the theories of social control and deviance (e.g. Becker 1963, Erikson 1966, Foucault 1965). The tradition viewed medicalization as a depoliticization and individualization of social problems through medical social control prescribed by an expert system of medical professionals, medical technology, and pharmaceutical companies (e.g. Conrad 1998; 2005). Over-medicalization can have severe negative consequences because it re-labels and sickens normal responses to adverse situations (see e.g. Horwitz and Wakefield 2007). Yet it is still better to exert some medical social control rather than none at all—especially, if the alternative is to lock patients up instead of using medical treatment (Frank and Glied 2005) or allowing behavioral problems to go unchecked until other (and more total) technologies of control becomes necessary. An example of a more invasive technology is foster care, which perhaps is the strongest measures the state can use to intervene against families.

Foster care emerged as a technology of social control to handle the social problem posed by unattended children during the 16th and 17th centuries' urbanization of European cities (Foucault 2007, pp. 306-7). In the U.S., foster care measures emerged from civic society in the late 19th century rather than as a governmental measure, with a dual focus on preventing abuse

[1] Using names such as minimal brain dysfunction (DSM-I in 1952), hyperkinetic reaction of childhood (DSM-II in 1968), and attention-deficit disorder (DSM-III in 1980).

and curtail children from becoming delinquent (Myers 2008). Although society's view on children has changed drastically since the first foster care institutions (Zelizer 1985), foster care is still a technology used to control, curtail, and remedy unwanted behavior among children and their parents.

The medical treatment of behavioral issues and the use of foster care are both technologies that parents, medical professional, and social services can deploy to address the needs of children with behavioral issues. Whereas social services only can instigate medical treatment after they have placed a child in foster care, parents and medical professional can instigate medical treatment of behavioral issues earlier in a childhood trajectory, thereby curtailing behavioral issues that, had the issues gone unchecked, would later lead to a foster care placement.

ADHD Treatment as a Protective Factor

Because suffering from ADHD appears to be a contributing cause to foster care placement, the increasing treatment of ADHD might cause fewer children to enter foster care, provided it directly (and beneficially) affects their behavior. Earlier studies of the effect of medical treatment of ADHD on behavior partly corroborate this hypothesis, as medical treatment of ADHD causes children suffering from ADHD to have fewer emergency room visits and to commit less crime (Dalsgaard, Nielsen and Simonsen 2013b), to do better in school (Scheffler et al. 2009), and leads to a substantial decrease in traffic accidents once the children reach adulthood (Chang et al. 2014).

Yet, despite some clear benefits of medical treatment of ADHD for children with severe symptoms, other research shows harmful effects of overprescribing. In one especially provocative study, Currie, Stabile, and Jones (2013) show that increasing the share of a child population that receives ADHD medication can lead to poorer educational attainment among boys and higher levels of emotional problems among girls when a large number of children in the population were already medicated for ADHD. On balance, therefore, it seems that the benefits of medical treatment of ADHD are most pronounced in a positive direction when very few children in the population are medicated. Beyond this initial point, the effects may even change course. As we show in detail below, it might be that the U.S. is on the other side of such a tipping point compared to Denmark.

Although analyses of the effects of medical treatment of ADHD on children's behavioral outcomes provide suggestive evidence of a link between medical treatment of ADHD and foster care placement, there is a host of possible confounders that an analysis must account for to c demonstrate a causal relationship. First, children whose families have low SES, who were low birth weight babies, and who had mothers who smoked during pregnancy, for instance, are markedly more likely both to be diagnosed with ADHD and to be placed in foster care at some point (e.g. Ejrnæs, Ejrnæs and Frederiksen 2010; Langley et al. 2007; Swanson et al. 2007). To convincingly demonstrate a causal link between medical treatment of ADHD and foster care caseloads, therefore, we would ideally have macro-level analyses (to show how population-level shifts in ADHD medication shape foster care caseloads) and micro-level analyses (to show that we fully adjust for individual-level factors shaping ADHD diagnosis and foster care placement).

Second, social services might be less inclined to place a child in foster care if the child already receives medical treatment for ADHD. In such a case, it would not be treatment of behavioral issues that drove the decrease in foster care, but merely the labelling effect of a diagnosis. Yet, a host of recent studies indicates that treating ADHD with Ritalin might have substantial impact on child and family characteristics know to affect the risk of entering foster care. Kvist, Nielsen and Simonsen (2013) show that parents with children with ADHD experience more strain on their relationship and have lower labor supply when controlling for confounding genetic factors. Lack of labor market attachment and family instability are both predictors of future foster care placement (e.g., Berger and Waldfogel 2004). If treatment of ADHD is effective, it would lead to more stable family conditions thereby lowering the risk of children entering foster care. Medical treatment of ADHD also limits risky behavior. As previously mentioned, studies find that medical treatment directly affects children's frequency of emergency room visits (Dalsgaard, Nielsen and Simonsen 2012) and adults' involvement in traffic accidents (Chang et al. 2014). Overall, treatment with drugs such as Ritalin directly affects behavior. Additionally, social services are not involved in whether or not children receives the ADHD diagnosis. Thus, there is little chance that a labelling effect drives the relationship between medical treatment of ADHD and entrance into foster care.

The Rise of Ritalin

Medical treatment of ADHD, though dating back to the 1930s, has risen dramatically since the late 1990s. Figure 2 shows the number of children in Denmark and the U.S. per 1,000 children who filled at least one prescription for Ritalin, Strattera, or other medications used to treat ADHD.[2] The U.S. shares are substantially larger than the Danish shares. Studies estimate that the share of U.S. children receiving medical treatment for ADHD in 2007 was between 30 children (Zuvakas and Vitielo 2012) and 40 children (Visser et al. 2013) per 1,000 children. The Danish

[2] This includes amphetamine (N06BA01), dexamphetamine (N06BA02), dextromethamphetamine (N06BA03), methylphendiate (N06BA04), atomoxetine (N06BA09), dexmethylphendiate (N06BA11), and lisdexamfetamine (N06BA12). Some of these drugs are also used to treat children with autism spectrum disorders (ASD). Dalsgaard, Nielsen and Simonsen (2013a) show that 16 percent of Danish children with ASD receive one of these medications.

share was just above five in 1,000 in the same year. In general, the long tradition of medicating children with hyperkinetic disorders in the U.S. compared to other countries is evident in Figure 2.

The share of children receiving medication increased moderately in both countries until the mid-2000s, after which the rate increased much more rapidly. In 1998, for instance, less than one Danish child in 1,000 filled a prescription for ADHD medication; the corresponding share in 2013 was more than 11 children per 1,000. Furthermore, the distribution of the increase in the rate of ADHD medication usage is not even across age. Children under the age of six experienced the smallest shift, and children aged 10 and older experienced the largest increase in Denmark (Dalsgaard, Nielsen and Simonsen 2013a).

[Figure 2 about here.]

There is also substantial geographical variation in ADHD medication usage. Figure 3 shows the number of children who filled a prescription for ADHD medication across Danish municipalities for the years 1998, 2004, and 2010. While the intensity maps mirror the overall rise in medication use across the time, they also show that there are substantial differences between municipalities in the same period. This is in line with the literature on geographical variation in the adoption of medical technologies (see Nattinger et al. 1992; Gelijns and Rosenberg 1994 for a general discussion and Bruckner et al. 2012; Dalsgaard, Nielsen and Simonsen 2012 for discussion on geographical variation in the use of ADHD medication).

[Figure 3 about here.]

DATA

Foster Care Caseloads

All Danish municipalities have reported all instances of instigation or conclusion of a foster care case to Statistics Denmark since 1977. Because these data originate from administrative registers used in the processing of all foster care cases and undergo a thorough control before Statistics Denmark makes themavailable to researchers, the data have very high validity, and there is no sample selection or attrition issues because data include all Danish foster care children (Statistics Denmark 2013).

The dependent variable used in our study is the logarithm of the annual foster care caseload rates for each Danish municipality measured each year from 1998 to 2010. We drop 16 observations of municipalities with less than 100 children in a given year. We log-transform foster care caseloads because the variable is highly skewed. However, all results are robust to using an untransformed version of the variable (results available upon request). We measure the foster care caseload rate as the number of children in foster care during the year per 1,000 children from age 0 to age 17 living in the municipality. Table 1 reports summary statistics for the foster care caseloads, as well as the explanatory variables discussed in the next subsection.

[Table 1 about here.]

Measuring Medical Treatment of ADHD

We obtain data on prescribed drugs used to treat ADHD from the Danish medical database. All pharmacies have since 1997 reported all redeemed prescriptions to Statistics Denmark (See Johannesdottir et al. 2012 for a detailed description of these data). It is possible to link redeemed prescriptions to individuals through their social security numbers. Because customers or patients must supply their social security numbers in order to obtain their prescriptions, these data are highly reliable (as was the case with foster care caseloads). Through the population register, we can isolate all prescriptions redeemed by or for individuals ages 0-17 for each municipality. We measure the ADHD medication rate as number of children per 1,000 children that have redeemed at least one prescription for medicine used to treat ADHD.

Other Explanatory Factors

In the macro-level portion of the analysis, we control for female and male incarceration rates, the share of the municipal population who are receiving welfare benefits, unemployment level, and average household income, all of which have been linked to foster care caseloads in previous research (e.g., Berger and Waldfogel 2004; Bitler, Gelbach and Hoynes 2006; Buckles 2013; Paxson and Waldfogel 2003; Swann and Sylvester 2006; Andersen and Wildeman forthcoming).

We account for individual level risk factors by including average age of children in the municipality, the share of Non-Western immigrants and descendants, the share of mothers who are employed, the share of missing, deceased, or unknown fathers, and average sibship size. We also control for municipality fixed effect to capture between-municipality differences in the way social services and schools operate, and average constant traits among inhabitants.

EMPIRICAL APPROACH

Macro-level Model

Our macro-level sample consists of annual observations of foster care caseloads, ADHD medication rates, and a set of covariates. The data have a panel format with annual observations (t) nested within municipalities (j). We regress the log of foster care caseloads measured as the number of children in foster care per 1,000 children on the number of children per 1,000 medicated for ADHD, a set of municipality characteristics, and municipality fixed effects[5] and year fixed effects. The underlying assumption is that once we account for varying and fixed municipality characteristics, the variation in ADHD medication rates is caused by stochastic variation in the diffusion of the use of Ritalin and similar drugs throughout municipalities. This leads to the following macro-level model:

$$\log(Caseload)_{jt} = \sum_{j=1}^{J} Municipality_j + \sum_{t=1998}^{2010} Year_t + \delta ADHD_{jt} + \boldsymbol{X\beta_{jt}} + \varepsilon_{jt} \quad (1)$$

where $\mathbf{X\beta}$ is the set of time-varying covariates, and δ captures the effect of ADHD medication rates on foster care caseloads.

As previously discussed, the increase in ADHD medication usage was limited to older children. It follows then that since children below the age of 5 almost never receive medical treatment for ADHD, they would only contribute statistical noise to our analysis. Therefore, we also estimate equation 1 using only foster care caseloads and ADHD treatment share for children aged 6 to 17. If the rise in ADHD medication caused foster care caseloads to drop, we should expect to see a more pronounced and statistically significant effect when only examining the limited age group. As shown in Figure A1 in appendix, the rise of ADHD medication rates was around 25 percent higher when limiting the sample to children ages 6 to 17.

A last set of issues of concern is whether social services chose to treat children for ADHD because social services did not place in foster care (reverse causality). As discussed previously there is little evidence that this will be the case. Nevertheless, if the drop in foster care caseload rates led to more children receiving medication or if a common factor affected foster care

[5] A number of municipalities merged in 2007, as evident from Figure 3. The number of municipalities went from 271 to 98. To account for this we include fixed effects for municipalities both before 2007 and from 2007 on.

caseloads negatively and ADHD medication rates positively, that would seriously bias our estimate. To examine whether reverse causality or confounding drive our results, we also estimate a model using one year lagged ADHD rates as our predictor of interest. We also include two and three year lagged variables as controls for the municipality-specific trend in ADHD prescription, but the predictor of interest is the one year lagged.

Individual Level Risk

Whereas our macro-level model provides a strong test of the association between ADHD medication rates and foster care caseloads, the model remains vulnerable to the ecological inference problem (e.g., Drake et al., 2003). Thus, without also including a rigorous individual-level test of the relationship between medical treatment of ADHD and foster care placement, we cannot be certain that changes in medical treatment of ADHD drove the decrease in foster care caseloads. In order to provide such a test, we use a randomly drawn 10 percent longitudinal sample of all Danish children aged 6 to 17 from 1998-2010. We do have the entire child population available, but the sheer size of data pose too high computational demands. The random draw still leaves us with 1,449,221 observations. The outcome variable for these analyses is whether a child was in foster care any time a given year. We use a one year lagged indicator on municipal ADHD load (calculated at the individual level to take movement between municipalities into account), individual level information on parental characteristics and include municipality fixed effects. The individual level characteristics include age dummies for the child, dummy for whether mother was in employment the given, dummy for whether mother had experienced divorce, dummy for whether father was dead or immigrated, dummy for whether mother was dead or immigrated, and parental income calculated at the 2003 level. The municipal level characteristics include annual unemployment level, welfare dependency take up, female incarceration rates, and male incarceration rates. We obtained all data from Statistics Denmark. Table A1 in the appendix presents all sample statistics.

The individual level models assess the impact of increased ADHD medication use on the average risk of entering foster care. If medical treatment of ADHD directly affects the risk of being in foster care, the individual level effect of increases in ADHD medication on foster care risk should align closely to the estimated caseload level effect. In addition, the individual level data allows us to remove individual level fixed effects (such as genetic background and cohort).

When we use individual level fixed effect models, we control for birth cohort. Because year fixed effects are a linear combination of age and birth year, we end up with an APC (age-period-cohort) issue – we cannot control for age, period, and cohort, and still get proper identification, unless we restrict certain parameters or use proxies (see Winship and Harding 2008).

Our main variable of interest, prevalence of ADHD medication, is mainly a function of time (i.e., municipalities increase use of medication over time, but at different rates). ADHD-medication load is the mechanism through which time affects the risk of entering foster care. One solution to this problem is to eliminate time from the model. Then, identification of ADHD-medication on foster care risk relies on within-child, between-child and between-municipality differences. Including time as a linear term allows us to use the within-municipality variation, giving us better identification of the effect. This gives the individual level model:

$$Foster\ Care_{it} = \sum_{j=1}^{J} Municipality_j + \varphi Year_t + \delta ADHD_{it-1} + \boldsymbol{X\beta_{it}} + \boldsymbol{Z\gamma_{jt}} + \alpha_i + \varepsilon_{it} \quad (2)$$

Foster care$_{it}$ is equal to 1 if child *i* is in foster care at any time in year *t* and 0 otherwise. *Year*$_t$ is the linear time term, *ADHD*$_{it-1}$ is the ADHD-medication rate for the municipality the child lived in in year *t*-1, $\boldsymbol{X\beta_{it}}$ is the set of child characteristics, and $\boldsymbol{Z\gamma_{it}}$ is the set of municipality characteristics. Identification of the causal effect of ADHD-medication rate on the individual level risk of entering foster care relies on the variation of the lagged difference of ADHD-medication between and within children and between and within municipalities.

A different approach would be to use a hierarchical model that captures cohort and individual level effects as random parameters. This would give us more information on the cohort effect, but we already know from Figure 1a that entrance rates into foster care is decreasing between cohorts, and the additional information gained from modelling this explicitly are of little interest for the present study. In addition, we also have no interest in testing the effect of individual level constant traits such as gender or ethnicity (see Yang and Land 2008 for discussion). Thus, we use fixed effect models.

RESULTS

We first present results from the macro-level model that examines the relationship between ADHD medication rates and foster care caseloads, both measured at the municipal level and using variation within and between municipals to obtain causal inference. We then submit our results to a number of robustness test that takes into account (a) the fact that only children above a certain age are likely to receive medical treatment for ADHD; and (b) that time trends and ADHD medication rates are heavily intertwined. Last, we examine how ADHD medication rates affected the individual level risk of being in foster care to address the ecological inference. In the micro-level analysis we again rely on municipal differences in prescription rates, but also account for individual level fixed effects and use lagged measures of ADHD medication to further address issues of simultaneity bias.

Results from Macro-level Sample

Table 2 reports the results from the macro-level model. Column 2 shows that there is a strong negative relationship between foster care caseloads and rate of children treated for ADHD when controlling for municipal level covariates. When not controlling for neither municipal or time fixed effects, we find that an increasing medication rates with one additional child per 1,000 leads to a 2.9 percent decrease in foster care caseloads (translates into a 29 percent decrease per 1 percentage point increase in ADHD medication rates).

[Table 2 about here.]

When we include municipality fixed effects in the model (column 3), the negative relationship remains between ADHD medication and foster care caseloads remain. Most other covariates decrease in size when controlling for municipal fixed effects. There is, however, one exception. Log to the share of immigrants changes sign from negative to positive, which indicates that municipalities with high levels of immigrants have lower foster care rates, but that a change in immigrant population share within a municipality is associated with increase in foster care caseloads.

When we control for the year fixed effects, but not for municipality fixed effect (column 4), the association between medication rate and foster care caseloads remains negative but becomes statistically insignificant. As discussed earlier, we do expect multicollinearity between time and ADHD medication rates—the use of medication increased and spread over time in a monotone way, so time fixed effects will capture some of the variation that is actually increase in ADHD medication rates. At the same time, the result in column 4 does not rely on the geographical variation in the spread of medical technologies, but merely places this in the error term. That is, we get lower bound estimates when we control for time fixed effects.

When we control for both the time trend and the municipality fixed effects (column 5), ADHD is negatively and significantly associated with foster care caseloads. Though the parameter estimate for ADHD is only 0.005, it is important to remember that (a) we are dealing with a lower bound estimate; and (b) the number of children who received medical treatment for ADHD rose from less than one out of 1,000 in 1998 to almost 12 out of 1,000 in 2010. For each extra child per 1,000 children who receive medication for ADHD foster care caseloads drops 0.5 percent in a given municipality if we assume a constant semi-elasticity. From this, we find as a lower bound estimate that increase in ADHD medication rates from 1998 to 2010 caused a five percent decrease in foster care caseloads.

Results from age-limited sample

As discussed earlier, the increase in the use of medications such as Ritalin was not constant across age groups (Dalsgaard, Nielsen and Simonsen 2013a). Children between age zero and five almost never receive medication for ADHD and did not experience any rise in their medication rates. The youngest group of children then only contributed statistical noise to the results presented in Table 2. Therefore, we redo our macro-level analysis only examining the foster care caseloads and ADHD medication rates for children ages 6 to 17.

Table 3 presents results the older age sample. Column 2 reports the result from the model without municipality fixed effects and time effects. The parameter estimate for ADHD medication rates are substantially lower (-0.017) than what we observed in Table 2 (-0.027). The difference is, however, a function of variable specification. Because no children below the age of six receives medical treatment, it menas that when we calculate the ADHD medication share for the full sample, this group contributes to the denominator but not to the numerator. Thus, we get higher ADHD medication shares when only examining children ages 6 to 17. Contrastingly, children enter foster care at all ages (though substantially more before turning six and in their teens), so we do not change the foster care caseloads in a similar fashion.

Because we roughly reduce the denominator for the ADHD share with one-third when we disregard the youngest group of children, we should also expect the parameter estimate to decrease with one-third (because the ADHD share becomes numerically, but not substantially, higher). This is exactly what we find, when comparing the estimates in column 2 across Table 2 and 3.

The parameter estimates for ADHD become smaller for the first three models presented in columns 2-4. The ADHD estimate for the model that includes both municipality fixed effects and time effects are however identical to the one found in Table 2, but more significant. Because we estimate the ADHD parameter in using higher ADHD rates than those used in Table 2, it translates into a higher impact of ADHD medication on foster care caseloads when we only focus on children ages 6 to 17. The age group experienced a rise in ADHD medication from just below 1 in 1,000 in 1998 to more than 15 in 1,000 in 2010 (see Figure A1 in appendix). Assuming a constant elasticity across the increase ADHD medication, we calculate that under this lower bound specification increased ADHD medication caused approximately a 7.5 percent decrease in foster care caseloads.

The fact that we find higher and more statistically significant results after controlling for municipality fixed and time effects demonstrates that including younger children only contribute statistical noise, as we hypothesized. Thereby, the results gives credence to the argument that increased use of ADHD medication *directly* affected foster care caseloads for children (who are ages 6-17).

[Table 3 about here.]

Sensitivity analyses

To address issues of reverse causality and confounding, we estimate the model using one, two, and three year lagged ADHD treatment share. All models shown include municipality fixed effects and time effects. We calculate the lagged caseloads at the individual level before aggregating them, thereby taking into account that parts of the child population might move between municipalities from year to year. Table 4 shows the lagged results. Columns 2 to 4 show the results for the one year lagged ADHD variable for the full sample. The point estimates are similar to those in Table 2 but insignificant. Columns 5 to 7 show results for the one year lagged ADHD variable for the sample of children age 6 to 17. The point estimates are similar to those shown in Table 3 and significant on the ten percent level. Overall, results become weaker when using one year lagged ADHD medication rates, but are ultimately in support of the general conclusion even when also controlling for two and three year lagged ADHD medication rates.

[Table 4 about here.]

Predicting caseload change

In order to examine how much of the overall change in foster care caseload rates that changes in ADHD medicine can account for we also calculate foster care caseloads for 2010 but with 1998 level rates of medication use and then compare this counterfactual change in foster care caseloads to the change in foster care caseloads predicted by our model. When comparing the differences in changes we find that the dramatic rise in ADHD medication use from 1998 to 2010 accounts for fully 45 percent of the changes in foster care caseloads in the same period.

Time trends and model specifications

Time effects may however bias the estimate of ADHD medication share towards zero because of foster care reentry and retention rates. When the cumulative risks of foster care drops, it leaves room in the foster care system for higher retention rates of children already in the system, which is the case with regard to foster care in Denmark (Fallesen, Emanuel & Wildeman 2013). In addition, the ADHD medication share is partly a function of time, so including time fixed effect could cause multicollinearity. This would also make the estimates biased toward zero. Assuming a constant time effect, changes in ADHD medication rates might account for as much as a 32 percent drop in foster care caseloads. Using a first difference approach instead of municipality fixed effect places the estimate at 25 percent. Using lagged ADHD medication rate and a first difference model gives a predicted 29 percent drop in caseloads.

Overall, models including time effects provide a lower bound estimate of the drop attributable to the rise in ADHD medication share, while models without the time effect provide an upper bound estimate. Yet, no matter whether time effects are included or not the rise in medical treatment of ADHD has had a substantial effect on the size of Danish foster care caseloads, causing a 5 percent to 29 percent decrease in caseloads, and explaining up to 45 percent of the decrease in Danish foster care caseloads since 1998.

Micro-level results

Although our macro-level estimations provide robust results that indicate that ADHD medication rates negatively impacted foster care caseloads, the macro-level results is still vulnerable to ecological inference issues. To address the issue, we also estimate individual level fixed effect models regressing an indicator of whether a child was in foster care a given year on ADHD medication rates in the child's municipality and a set of controls. We identify the effect of increased use of ADHD medication using within- and between-individual and municipality variation and a one year lagged measure of ADHD medication load. We assume that variation in one year lagged ADHD medication load is exogenous once we have taken individual and municipality characteristics into account. Given our macro-level findings, we limit the sample to children ages 6-17.[7]

[Table 5 about here.]

Table 5 shows the results of the individual level fixed effect regressions. A rise in ADHD medication load causes a significant decrease in the risk of entering foster care when we only control for individual fixed effect, municipality fixed effects, and linear time trend (column 2). The estimate expresses the effect of an increase of one child per 1,000 receiving medical treatment for ADHD on the probability of being in foster care when not controlling for time varying observables. For every one child per 1,000 receiving medical treatment, the risk of being

[7] We also run the micro-level model for only children ages 0-5. If the ADHD measure is capturing a different underlying process that generally led to lower foster care rates, we should see a negative association between ADHD medication rates and foster care rates for this group as well. The results (not shown here but available from the author) find no significant association between ADHD medication rates and the risk of being in foster care for children ages 0-5.

in foster care drops with 0.08 percentage points. Controlling for municipality level and family level characteristics does not substantially lower the estimate. Increasing the share of children medicated for ADHD by one percentage point causes a 0.07 percentage point decrease in the individual level risk of being in foster care the subsequent year. Calculating the individual level effect based on the increase in the use of ADHD medication among children ages 6-17 from 1998 to 2010 (from a municipal average of just below 1 in 1,000 to above 15 in 1,000) translates into a decrease in the risk of being in foster care of 1.05 percentage points. Measured against the share of children in the micro-level sample who was in foster care in 1998, we then calculate that increased use of ADHD medication caused a 33 percent decrease in the foster care risk of children ages 6-17 by 2010. We also estimated Bayesian tipping point models across the distribution of share of ADHD medicated to examine whether the effect decreases or even changes as ADHD medication shares increase, but we find no evidence of Denmark having reached a tipping point for the negative effect of ADHD medication rates on children's individual level foster care risk.[8]

The individual level result dovetails nicely with the estimated macro-level results on alternative time specification, giving credence to the argument that the macro-level model with time fixed effects indeed does provide a lower bound estimate of the impact of ADHD medication on foster care caseloads.

DISCUSSION

Previous research on the predictors of foster care caseloads has mostly focused on parenting behaviors and policy changes. In this paper, we have addressed a third dimension: the

[8] Result available upon request.

effect of child behavior on foster care caseloads. Children in foster care have much higher propensity for exhibiting behavioral problems than children in the general population, and ADHD is one of the most common disorders diagnosed prior to entering foster care for the first time. If prevalence of behavioral problems in itself contributes to foster care caseload rates, better treatment of children exhibiting problem behavior might then decrease the need for placing children in foster care.We have shown that increased medical treatment of ADHD – one of the most prevalent forms of problem behavior among children who enter foster care – significantly and substantially lowered foster care rates in Denmark. Fully 45 percent of the change in foster care caseloads from 1998 to 2010 is attributable to the rise in use of medication to treat children with ADHD based on results from our preferred model specification. Furthermore, even in arguably our most conservative macro level model (25 percent) and our micro level model (33 percent), we find pronounced effects of increases in ADHD medication on the decrease in foster care caseloads in Denmark. To consider the magnitude of these effects, in their seminal analysis of US foster care caseloads, Swann and Sylvester (2006) showed that increases in the female imprisonment rate, the factor that most strongly drove the increase in foster care caseloads, accounted for 31 percent of the foster care boom in the US from the mid-1980s to 2000. Moreover, medical treatment is not the only option when it comes to treating ADHD. Some form of cognitive-behavioral therapy often accompanies medical treatment (e.g. Semple et al. 2010). By focusing on prescriptions, we are therefore not capturing the entire rise in treatment of ADHD but only the rise in medical treatment. Our estimates of treatment rates are therefore conservative because we do not capture the full range of ADHD treatment options.

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Table 1 Descriptive Statistics for Danish Municipalities, 1998-2010

Variable	Mean	S.D.
Foster care caseload per 1,000 children	26.214	12.694
ADHD medicated per 1,000 children	2.923	3.446
Age of children	8.543	0.383
Non-Western immigrants/descendants	0.031	0.032
Working mother	0.811	0.051
Missing father	0.017	0.007
Sibship	1.837	0.120
Household income in 10,000 DKK[9]	41.016	5.583
Unemployed	0.016	0.015
Welfare dependency	0.143	0.025
Female incarcerations per 1,000 females	0.568	0.419
Male incarcerations per 1,000 males	5.057	2.009
N	2853	

[9] Calculated at 2003-level.

Table 2 Regression Results from Macro-Level Model for Foster Care Caseloads for All Children

	Model 1	Model 2	Model 3	Model 4
ADHD medicated per 1,000	-0.027***	-0.028***	-0.001	-0.005*
children	(0.002)	(0.002)	(0.003)	(0.002)
Log of Nonwestern immigrant	-0.135***	0.126***	-0.167***	-0.020
per 1,000	(0.012)	(0.017)	(0.013)	(0.017)
Male incarceration per 1,000	0.020***	0.011***	0.021***	0.004
	(0.005)	(0.003)	(0.005)	(0.003)
Female incarceration per 1,000	0.017	0.017	0.026	0.006
	(0.019)	(0.012)	(0.017)	(0.010)
Household income	0.008***	0.006	0.001	0.007
	(0.002)	(0.006)	(0.002)	(0.006)
Share dependent on welfare	6.408***	12.078***	3.186***	3.784***
	(0.517)	(0.758)	(0.515)	(0.813)
Unemployment rate	0.001	0.004	-0.009	0.000
	(0.006)	(0.004)	(0.006)	(0.004)
Average age of children	0.222***	0.086**	0.200***	0.104**
	(0.023)	(0.030)	(0.026)	(0.033)
Average sibship	0.405***	0.246***	0.853***	-0.299
	(0.068)	(0.045)	(0.125)	(0.187)
Employed mother	-0.970***	-0.632*	-1.318***	-1.972***
	(0.244)	(0.253)	(0.251)	(0.290)
Divorced mother	5.605***	3.343***	7.542***	2.286***

	(0.516)	(0.631)	(0.584)	(0.598)
Father unknown, dead, or emigrated	1.376	0.352	1.212	2.730*
	(1.199)	(1.403)	(1.170)	(1.320)
Fixed effects		X		X
Time effects			X	X
N	2853	2853	2853	2853

Standard errors in parentheses $^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3 Regression Results from Macro-Level Model for Foster Care Caseloads for Children Age 6 to 17

	Model 1	Model 2	Model 3	Model 4
ADHD medicated per 1,000	-0.017***	-0.016***	0.000	-0.005**
children	(0.002)	(0.002)	(0.002)	(0.002)
Log of Nonwestern immigrant	-0.140***	0.152***	-0.168***	-0.019
per 1,000	(0.013)	(0.017)	(0.013)	(0.018)
Male incarceration per 1,000	0.019***	0.013***	0.020***	0.005
	(0.005)	(0.003)	(0.005)	(0.003)
Female incarceration per 1,000	0.001	0.005	0.018	-0.006
	(0.019)	(0.012)	(0.018)	(0.010)
Household income	0.009***	0.013*	0.004+	0.004
	(0.002)	(0.006)	(0.002)	(0.007)
Share dependent on welfare	6.828***	11.280***	3.003***	3.394***
	(0.514)	(0.772)	(0.516)	(0.836)
Unemployment rate	-0.000	0.001	-0.008	-0.000
	(0.007)	(0.004)	(0.006)	(0.004)
Average age of children	0.116**	-0.184***	0.293***	0.078+
	(0.039)	(0.039)	(0.045)	(0.045)
Average sibship	0.433***	0.215***	0.875***	-0.149
	(0.069)	(0.046)	(0.123)	(0.196)
Employed mother	-0.764**	-0.492+	-1.116***	-1.847***
	(0.248)	(0.256)	(0.254)	(0.297)

Divorced mother	6.757***	5.133***	8.237***	2.808***
	(0.510)	(0.600)	(0.574)	(0.608)
Father unknown, dead, or	0.456	-1.675	1.219	2.530+
emigrated	(1.201)	(1.404)	(1.185)	(1.357)
Fixed effects		X		X
Time effects			X	X
N	2853	2853	2853	2853

Standard errors in parentheses. + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4 Results from Macro-Level Model for Foster Care Caseloads with Lagged ADHD Variable

	Full sample	Full sample	Full sample	Age 6-18	Age 6-18	Age 6-18
ADHD year-1	-0.004	-0.005	-0.005	-0.004^{+}	-0.006^{+}	-0.006^{+}
	(0.003)	(0.004)	(0.004)	(0.002)	(0.003)	(0.003)
ADHD year-2		0.002	-0.002		0.003	0.001
		(0.005)	(0.006)		(0.004)	(0.004)
ADHD year-3			0.007			0.005
			(0.006)			(0.004)
N	2853	2853	2853	2853	2853	2853

Standard errors in parentheses $^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

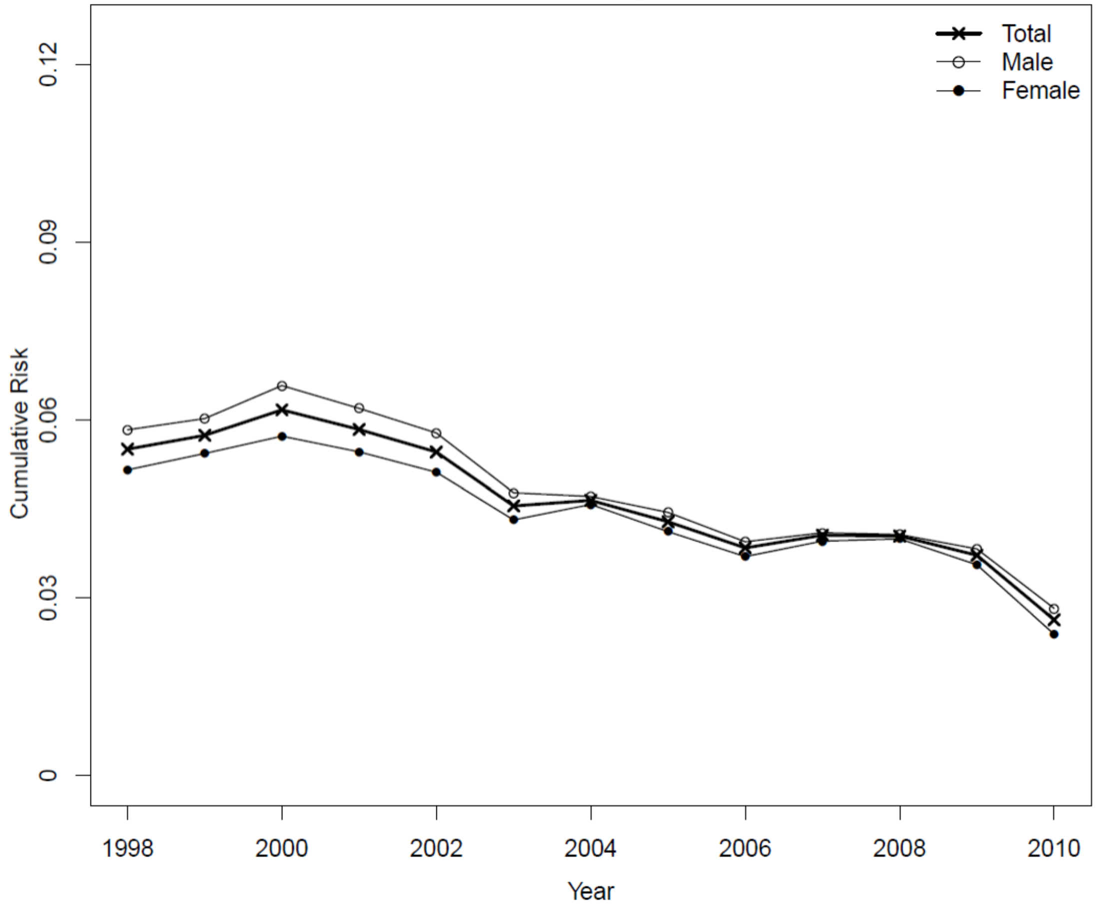
Table 5 Individual Level Fixed Effect Regression Results for Children Age 6 to 17

	FE 1	FE 2	FE 3
Share of children treated	-0.0008***	-0.0007***	-0.0007***
for ADHD at year-1	(0.000)	(0.000)	(0.000)
Share dependent on		0.163***	0.156***
welfare		(0.016)	(0.016)
Unemployment rate		0.005***	0.004***
		(0.001)	(0.001)
Male incarceration per		0.359***	0.352***
1,000		(0.095)	(0.095)
Female incarceration per		0.483	0.485
1,000		(0.335)	(0.335)
Father missing			-0.007**
			(0.002)
Mother missing			-0.021**
			(0.008)
Mother employed			-0.003***
			(0.000)
Mother divorced			0.007***
			(0.000)
Parents' gross income			-0.0001***
			(0.000)

N	1449221	1449221	1449221

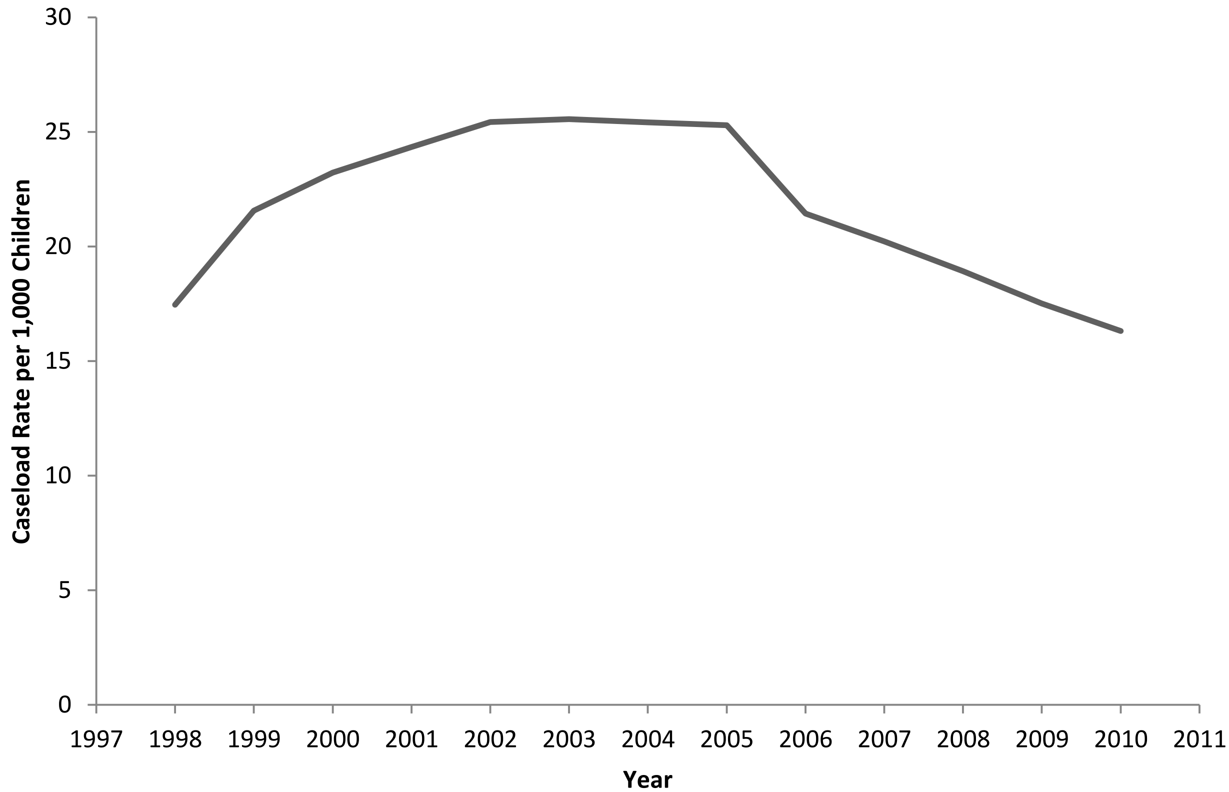
Municipality dummies and time trend not shown. Standard errors in parentheses $^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Fig. 1a Cumulative Risk of Foster Care Placement by Age 18, all Children by Sex



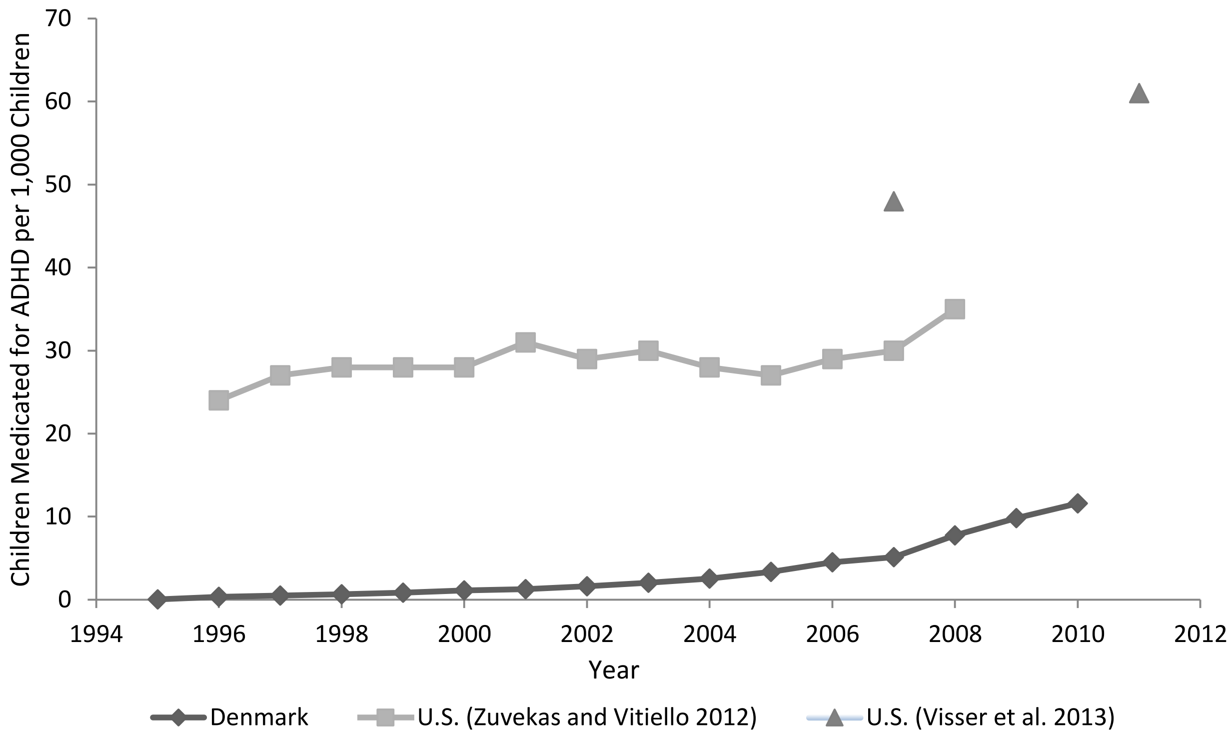
Source: Fallesen, Emanuel and Wildeman (2013)

Fig. 1b Average Number of Foster Care Caseloads per 1,000 Children



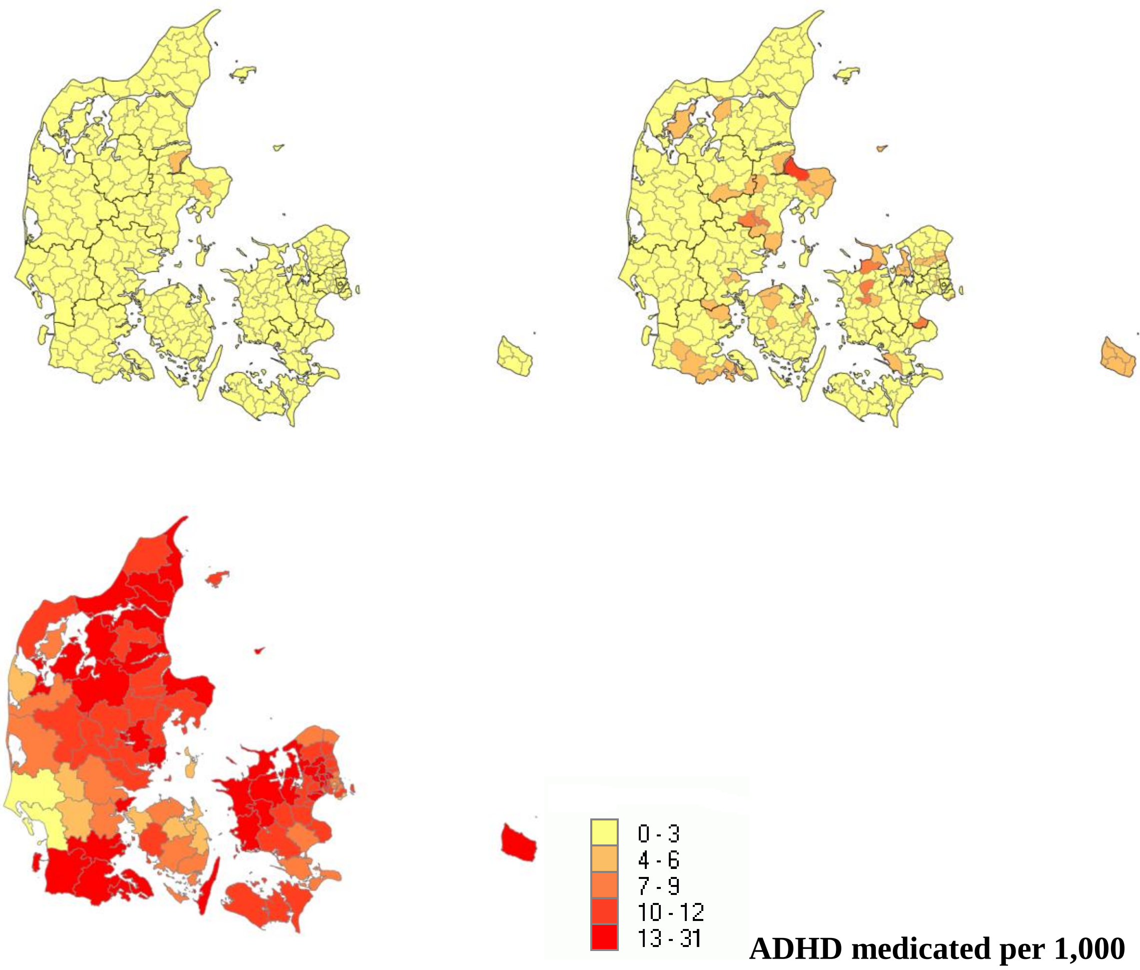
Source: Statistics Denmark.

Fig. 2 Average number of Receivers of ADHD Medication per 1,000 Children



Source: Statistics Denmark; Zuvekas and Vitiello (2012); Visser et al. (2013)

Fig. 3 Municipal Variation in Average Number of ADHD medicated per 1,000 Children - 1998, 2004, 2010



APPENDIX

Table A1 Summary Statistics for Individual Level Sample

Variable	Mean	S.D.
In foster care	0.023	0.149
ADHD medicated per 1,000 children for year-1	3.22	3.365
Age	8.378	5.132
Working mother	0.802	0.399
Divorced mother	0.103	0.304
Missing father	0.017	0.128
Missing mother	0.002	0.041
Parental income in 10,000 DKK[10]	58.074	39.348
Municipal unemployment level	0.150	0.111
Municipal welfare dependency	0.137	0.023
Female incarcerations per 1,000 females in municipality	0.001	0.000
Male incarcerations per 1,000 males in municipality	0.006	0.002
N	1449221	

[10] Calculated at 2003-level.

Figur A1 Average number of Receivers of ADHD Medication per 1,000 Children in Denmark