CAREER EFFECTS OF MENTAL HEALTH: EVIDENCE FROM AN INNOVATION IN TREATING BIPOLAR DISORDER*

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We use the approval of lithium as a maintenance treatment for bipolar disorder (BD) in Denmark in 1976 to investigate the career effects of mental health. Comparing people with and without BD, across cohorts with access to lithium at different ages and relative to people with other mental conditions, we find that access to treatment innovations increases labor market participation by 30 percent and earnings by 26 percent. These benefits operate largely through a reduction in the risk of disability, rather than through changes in occupation or educational achievement. Benefits are larger for people with less parental wealth.

KEYWORDS: MENTAL HEALTH, CAREERS, TREATMENT INNOVATIONS, AND BIPOLAR DISORDER

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One in eleven people suffers from a mental health disorder, such as depression, anxiety, schizophrenia, or bipolar disorder (BD).[1] These conditions may create severe costs for a person's career: They are associated with lost days of work (Kessler and Frank 1997; Kessler et al. 2006) and are among the leading causes of lost disability-adjusted years of life (WHO 2011). As a result, the welfare gains of treatment innovations could be very large.

Yet, the economic benefits of treatment innovations are difficult to quantify. First, both the incidence of mental health disorders and access to treatment can be related to family background, which also influences career outcomes. For example, people living in poverty may be more likely to suffer trauma, which can trigger mental health disorders (Persson and Rossin-Slater 2018; Adhvaryu, Fenske, and Nyshadham 2019), and they are less likely to receive treatment (Katz et al. 1997; Wang et al. 2005).[2] In addition, family disadvantage can undermine people's labor market success. The important role of family background for both a person's mental health and their career outcomes thus makes it difficult to identify the career effects of mental health disorders and treatments.

To address these empirical challenges and investigate the career effects of treatment innovations, we exploit an important change in the treatment of BD and compare people within families. In 1976, the Danish drugs authority approved lithium – a superior drug compared with previously available options – as the primary maintenance treatment for BD. To quantify the career effects of this change, we compare differences in labor market outcomes for people with BD with and without access to lithium in their 20s. To account for the role of family background, we further compare these two groups with their healthy siblings and with people with other mental health conditions, for which lithium is not used as the primary treatment. We find that access to improved treatment dramatically improved the careers of people with BD relative to their siblings, increasing their chances to participate in the labor market and helping them earn more.

BD is a severe disorder that affects over two million people in the United States and 0.6 percent of the population worldwide. It causes extreme shifts in mood, energy, and the ability to carry out day-to-day tasks.[3] Until 1976 it was primarily treated with sedatives, with limited effectiveness (López-Muñoz et al. 2018). In 1976, however, the treatment options for

[1] Vos et al. (2020) and https://ourworldindata.org/mental-health.
[2] Using data from the US National Comorbidity Study (NCS) and the Mental Health Supplement of the Ontario Health Survey, Katz et al. (1997) find that people with low incomes are less likely to receive mental health care than those with higher incomes, particularly in the United States. Using data from the US National Comorbidity Study Replication (NCS-R), Wang et al. (2005) confirm that, in the United States, people with lower incomes are less likely to receive treatment for mental health conditions.
[3] Vos et al. (2020).

BD improved dramatically with the approval of lithium as the primary treatment. This change initiated a revolution in treatment: Lithium consumption is associated with major reductions in rates of relapse (from 74 percent to 29 percent, Davis, Janicak, and Hogan 1999) and in the risk of suicide and hospitalizations for people with BD (Baldessarini, Tondo, and Hennen 1999; Tondo et al. 1999; Angst et al. 2005). These features make lithium the preferred maintenance treatment for BD to this day. Its approval was followed by advances in cognitive behavioral therapy (CBT; Cochran 1984) and the development of improved mood stabilizers, antidepressants, and antipsychotics, further expanding treatment options for people with BD. Our analyses investigate the joint effects of lithium and these additional treatment innovations.

To estimate the career effects of access to improved treatment, we use individual-level data on medical diagnoses, labor force participation, and earnings for the population of Denmark between 1995 and 2015. These data cover 3.1 million people born between 1940 and 1977, including over 34,000 people with BD and their siblings. A major advantage of these data is that we can link individuals to their siblings. This allows us to compare career outcomes of siblings with and without mental health disorders, fixing family background characteristics that could impact both people's labor market outcomes and their likelihood of having a mental health condition and receiving treatment for it.

To quantify the impact of improved treatment on people's careers, we compare differences in labor market outcomes for people with BD and their siblings for people who gained access to treatment at different ages. We start from simple difference-in-differences specifications, which compare differences in labor force participation and earnings for people with BD and their siblings across cohorts of people born before and after 1956, who were above and below the age of 20, respectively, when lithium was approved in Denmark in 1976. We choose age 20 as the cutoff for these tests because it is a typical age of onset for BD (Kessler et al. 2005). In complementary tests, we estimate differences by cohort.

Under the assumption that, in the absence of treatment innovations, differences in labor market outcomes between people with BD and their healthy siblings would have remained constant for people born before and after 1956, difference-in-differences estimates capture the causal effect of access to treatment innovations by age 20 on people's careers. Importantly, comparing differences in career outcomes for people with BD and their siblings allows us to control for unobservable factors that vary across families and may impact both a person's career and the incidence and treatment of BD.

With this identification strategy, we begin by studying the effects of BD and access to treatment innovations on labor force (non-)participation, and more specifically on the

probability of having no earnings in a given year. Compared with their siblings, people with BD who did not have access to treatment in their 20s were 1.5 times more likely to have no earnings. By comparison, people who did have access at age 20 were 1.03 times more likely to have no earnings. Taken together, these estimates imply that access to treatment at age 20 eliminated 34 percent of the gap in labor force participation for people with BD.

A potential threat to our empirical strategy is that the penalties associated with *all* mental health conditions – not just BD – may have declined for cohorts born after 1956, for reasons that are unrelated to improved treatments for BD. For example, a decline in the stigmatization of mental health disorders may have improved earnings for people with *any* mental health condition. We address this challenge by estimating a triple difference model, using people with other mental health conditions (such as depression, anxiety, and schizophrenia) as an additional control group. Specifically, this model estimates (i) the changes in outcomes of people with any mental health conditions (including BD) born after 1956 relative to before (and relative to their healthy siblings), which could be attributed to reasons other than lithium; and (ii) the additional change experienced by people with BD. Since lithium is almost uniquely used by people with BD,[4] the latter change can be attributed to the improved treatment for this condition.

Triple-difference estimates confirm our previous findings. Compared with people who did not have access to improved treatment at age 20, cohorts with access had a 30 percent smaller risk of zero earnings relative to their healthy siblings. In the remainder of the paper, we use triple-difference estimates as our preferred estimates.

To investigate the dynamics of the impact of access to improved treatment, we estimate differences in the risk of no earnings between people with BD and their siblings separately for groups of five cohorts, using those born between 1951 and 1955 as the reference group. Relative to the reference group, the difference in the likelihood of having zero earnings was significantly smaller for the 1956-60 cohorts, who entered their twenties 1-6 years after the approval of lithium. Consistent with further advances in treatment, this difference becomes progressively smaller for younger cohorts. Our identification strategy would be compromised if outcomes for people with BD started to improve before the approval of lithium in 1976. Notably, differences in the risk of zero earnings are indistinguishable and on a flat trend across

[4] When lithium is used for other mental health disorders, it is mostly described as an "add-on" rather than a primary treatment, e.g., to treat mania for people with schizophrenia (Leucht et al. 2015).

all cohorts who did not have access to treatment by age 20 (i.e., those born prior to 1956). These results support our identification assumption.

In addition to improving the chances that people with BD participate in the labor market, treatment innovations may also increase the earnings of people with BD. Conditional on having positive earnings, people with BD who did not have access to treatment at age 20 experienced a 43 percent earnings penalty compared with their healthy siblings; people who did have access, however, only experienced a 32 percent penalty, 26 percent smaller. Access to treatment also impacts the odds that people with BD have earnings in the top and bottom echelons of earnings. Compared with their siblings, people with BD without access to treatment innovations at age 20 were 1.3 times more likely to have earnings in the bottom decile of the earnings distribution and 41 percent less likely to have earnings in the top decile. Access to treatment reduces the probability of having earnings in the bottom decile by 30 percent and increases the probability of earnings in the top decile by 34 percent.

What explains these findings? We investigate three possible channels. First, access to improved treatment may reduce symptoms and allow people to participate in the labor market. We test this hypothesis by studying whether access to improved treatment changes the likelihood of receiving disability payments, a type of welfare support designed to help people who are not able to work full-time. We find that people with BD without access to treatment are a staggering 3.7 times more likely to receive disability pay compared with their healthy siblings. Access to improved treatments eliminates 71 percent of their excess likelihood of disability.

Second, access to treatment may make people more likely to sort into jobs that pay more. Our data, though, do not support this hypothesis. Access to treatment does not lead people to switch towards higher-paying jobs nor jobs with a strong managerial, social, or decision-making component (which have recently experienced a rapid growth, Deming 2017, 2021). Importantly, our estimates for baseline earnings penalties and the impact of treatment remain unchanged if we control for occupation or occupation-by-year fixed effects, indicating that occupational sorting cannot explain our findings.

Lastly, access to treatment might increase the odds that people with BD obtain a college degree, associated with higher earnings. We do not find any evidence of this: people with BD are not differentially likely to earn a college degree, and access to treatment does not impact these odds. A possible explanation for this finding is that educational choices are largely realized by age 20. This finding further supports the hypothesis that improvements in earnings occur primarily through an increase in a person's ability to work and productivity.

Next, we investigate whether the penalties from BD and the benefits from treatment differ across gender. Men and women face different risks of mental health conditions and often have very different careers; they could therefore benefit differentially from treatment innovations. In our data, women are 30 percent more likely to be diagnosed with BD and face larger career penalties from BD. Without access to treatment, women with BD are 165 percent more likely to have zero earnings, whereas men are 148 percent more likely. The benefits of access to treatment are comparable across genders, indicating that treatment does not mitigate baseline gender gaps in career outcomes.

The benefits from treatment may also differ across socioeconomic status (SES).[5] To investigate whether and how a person's SES influences the career effects of mental health, we estimate the penalties from BD and the impacts of access to improved treatment across the spectrum of SES using parental assets as a proxy for SES. Both the penalties associated with BD and the effects of access to improved treatment are smaller for people with high SES. Benefits from treatment are concentrated almost exclusively on people with parental assets in the three lowest quartiles of the distribution of SES. Lastly, treatment benefits could be related to the severity of the condition. Using the number of BD diagnoses as a measure of severity, we find that people who receive multiple diagnoses of BD experience larger penalties and benefit more from access to improved treatment.

Taken together, our estimates indicate that innovations in treatment for mental health conditions are associated with important economic gains. While BD only affects a small portion of the population, our estimates imply that universal access to treatment could save $120 million in wages per year, roughly 2 percent of total healthcare costs associated with mental health in Denmark (Appendix Table A8).

Our findings contribute to an emerging literature on the economic effects of mental health and its treatment, most of which has focused on depression. A first strand of this literature has used experiments in developing countries to study the impact of treatments such as psychotherapy and pharmacotherapy. For example, Angelucci and Bennett (2021) find that randomized pharmacotherapy treatments reduced depression severity among 1,000 depressed adults in India and increased human capital investments in their children. Investigating the impact of psychotherapy on 903 prenatally depressed mothers in Pakistan, Baranov et al. (2020) find that therapy reduced postpartum depression and improved women's mental health,

[5] Aizer and Currie (2014) show that children born to socioeconomically disadvantaged mothers have worse health outcome at birth. Katz et al. (1997) and Wang et al. (2005) find that people with low SES are less likely to use mental healthcare services.

financial empowerment, and parenting decisions in the medium term. Another strand has exploited quasi-experimental variation from a variety of sources, such as the expansion of insurance coverage of psychotherapy services in Denmark (Serena 2022), the introduction of black-box warnings for SSRI (Bütikofer, Kronin, and Skira 2020), geographic variation in spending on drug advertisements (Shapiro 2022), and physicians' propensity to prescribe drugs (Laird and Nielsen 2017).[6] We contribute to this literature in two ways. First, we use registry data and a major, large-scale discontinuity in treatment to identify the causal effect of pharmaceutical treatments on mental health. Second, we perform these analyses for BD, a common condition with severe symptoms that has been thoroughly researched in medicine and psychology (e.g., Kyaga et al. 2011; Kyaga et al. 2013) but has received little attention in economics to date.

Our paper also speaks to the literature on the economic effects of treatment innovation, which has focused primarily on other types of disorders (outside of mental health). In this literature, Garthwaite (2012), finds that the removal of a branded Cox-2 inhibitor (Vioxx, used for the treatment of chronic pain) was associated with a decline in overall labor force participation and $19 billion in lost wages in the United States. Using data from Norway, Bütikofer and Skira (2018) show that the withdrawal of Vioxx increased sick days for individuals with joint pain and raised their probability of receiving disability benefits. We contribute to this literature by assessing the economic impacts of treatment innovations for mental health conditions.

More broadly, our findings relate to the literature on the causal effects of mental health on socioeconomic and labor market outcomes. Most of these studies have used survey data and are either correlational or observational.[7] In this paper, a large-scale quasi-experiment allows us to identify the causal impacts of mental health on outcomes. Administrative data on medical diagnoses linked to labor market outcomes, for individuals and their siblings, also enable us to track people over a longer time span and to account for family background.

In addition, our findings provide new evidence on the differential impact of mental health conditions and access to treatment across the spectrum of SES. Building on existing

[6] Investigating the effectiveness of psychotherapy, Serena (2022) finds that a 2008 Danish expansion in insurance coverage increased the use of therapy but had no effects on people's careers. Shapiro (2022) shows that increased spending on advertisement for anti-depressants in the US leads to more prescriptions and fewer lost days of work. Butikofer et al. (2020) document that the introduction of black box warnings for SSRIs in 2004 decreased antidepressant prescriptions and reduced labor supply. Exploiting quasi-random separations of individuals from their physicians, Laird and Nielsen (2017) find that physicians who are prone to prescribing mental health drugs has no discernable labor market effects on their patients.

[7] Correlational studies include Bartel and Taubman (1986); Goodman, Joyce, and Smith (2011); Hakulinen et al. (2019); Wang, Frank, and Glied (2022).

research on the effects of economic status on mental health (Haushofer and Shapiro 2016; Ridley et al. 2020; Ahammer, Grübl, and Winter-Ebmer 2020; Ahammer and Packham 2020), on the intergenerational persistence of mental health outcomes (Aizer and Currie 2014; Persson and Rossin-Slater 2018; Van den Bergh et al. 2015), and on the relationship between parents' earnings and children's mental health (Adhvaryu et al. 2019), we demonstrate that access to improved treatments can reduce inequality due to differences in mental health.

II. Data and Background on Mental Health Disorders

This section describes our data and summarizes relevant research from medicine and psychology on BD and its treatment, as well as on other mental health conditions. We link individual-level data on diagnoses and career outcomes from multiple public registries, which cover the population of Denmark between 1995 and 2015. We restrict our attention to people born in cohorts 1940 to 1977 who are between the ages of 20 and 60; this leaves us with 3,100,631 people observed between 1995 and 2015.[8]

A. Mental Health Diagnoses

Mental health diagnoses are drawn from the Central Psychiatric Register (*Landspatientregistret for Psykiatri Diagnoser*), which includes all mental health diagnoses from psychiatric departments in Denmark between January 1, 1995, and December 31, 2015. The register uses the World Health Organization (WHO)'s International Statistical Classification of Diseases and Related Health Problems (ICD-10) to classify mental health disorders.[9] Appendix Table A2 includes a detailed description of this classification.

For our analysis, we construct indicators for people with at least one diagnosis of BD, depression, and schizophrenia.[10] The following paragraphs describe each mental health condition and discuss treatments for BD.

Bipolar Disorder (*BD*) is a brain disorder that causes extreme shifts in mood, energy, and activity levels, limiting a person's ability to carry out day-to-day tasks. The National Institute of Mental Health (NIMH) and the American Psychiatric Association (APA) distinguish between two types of BD:

[8] These data are administered by Statistics Denmark. Appendix Table A1 describes the individual registries.
[9] See http://apps.who.int/classifications/icd10/browse/2016/en#/F30-F39.
[10] These variables are not mutually exclusive: each individual can be diagnosed with different disorders over his or her lifetime. Approximately 0.4 percent of the population received diagnoses for more than one type of disorder between 1995 and 2015.

- BD I is defined by at least one lifetime manic or mixed episode. Manic episodes are characterized by irritability, euphoria, a decreased need for sleep, increased activity, grandiose ideas, racing thoughts, impulsivity, and distractibility. For a diagnosis of BD I, manic episodes must last at least a week or require hospitalization. Mixed episodes combine symptoms of mania with simultaneous symptoms of depression for at least one week. Symptoms of depression are not necessary for a diagnosis of BD I.
- BD II is defined by a pattern of depressive and hypomanic episodes, without the full-blown manic episodes that are typical of BD I.

The ICD classification does not distinguish between BD I and II and only categorizes "Bipolar Disorder" and "Manic Episode." "Bipolar disorder" (diagnosis code ICD-10: F31) is described as "A disorder characterized by […] some occasions of an elevation of mood and increased energy and activity (hypomania or mania) and on others of a lowering of mood and decreased energy and activity (depression)." "Manic episode" (diagnosis code ICD-10: F30) is "A disorder […] which varies from carefree joviality to almost uncontrollable excitement, […] accompanied by increased energy, resulting in overactivity, pressure of speech, and a decreased need for sleep." The variable *BD* is an indicator for a diagnosis of BDI or BDII, captured by diagnosis codes ICD-10: F31 and ICD-10: F30. In our data, 34,315 people (1.1 percent) are diagnosed at least once with BD (Table 1). Worldwide, BD affects about 40 million people, most of whom remain untreated. Estimates of suicide risks equal 15 percent on average (Simpson and Jamison 1999).

Although the precise causes of BD are unknown, existing evidence points towards differences in the brain systems that regulate emotions and a dysregulation in the use of dopamine, a neurotransmitter that helps regulate reward-motivating behavior (Miklowitz and Johnson 2006).[11] The median age of onset for BD is 18 years (Kessler et al. 2005). We exploit this fact to compare people with and without access to treatment at age 20.

Lithium as a Treatment for BD Denmark's equivalent to the Federal Drug Administration, the *Lægemiddelstyrelsen*, approved the mood-stabilizer lithium as a "maintenance" treatment for BD in 1976 (Bech, Vendsborg, and Rafaelsen 1976).[12] As a treatment for BD, lithium is typically given in stages. The first is the acute treatment of an episode that has already

[11] Imaging studies of the brain have found that people with BD and their family members have less grey matter and lower levels of activity in the pre-frontal cortex, an area of the brain that is typically associated with moderating executive functions (Drevets et al. 1997; Krüger et al. 2006; Naranjo, Tremblay, and Busto 2001).
[12] Bech et al. (1976), Price and Heninger (1994), McInnis, Thomas, and Upjohn Woodworth (2014). The US FDA had approved lithium two years earlier, in January 1974.

developed. The second is maintenance treatment to delay and moderate future episodes and to reduce symptoms between episodes. Before 1976, treatment options for BD mostly consisted of sedatives (such as morphine, hyoscyamine, chloral hydrate, and barbiturates). These treatments, however, had limited efficacy (López-Muñoz et al. 2018).

Information on drug prescriptions comes from the Prescription Register (*Lægemiddeldatabasen)*, which includes all prescriptions from 1995 to 2015 from all doctors and hospitals in Denmark. One percent of all people had at least one lithium prescription, including 64 percent of those with at least one diagnosis of BD (Appendix Figure A5).

Complementary treatments in the form of psychosocial interventions ("therapy") and other drug treatments (such as antidepressants, anti-anxiety medications, and other types of mood stabilizers) also improved substantially after 1976. For example, interest in the application of cognitive behavioral therapy (CBT) began in the early 1980s (Cochran 1984), after the introduction of lithium.[13] Among all treatments, however, lithium has the strongest scientific record of controlling mania and preventing recurrences. Approximately 60%–70% of people with BD show remission of manic symptoms while on lithium (Goldberg and Harrow 2004). Lithium take-up is also associated with a significant reduction in the risk of hospitalization and with a 7-fold reduction in suicide rates for people with BD (Baldessarini et al. 1999; Tondo et al. 1999).

Other Mental Health Conditions Major depressive disorder, or *depression* for short, is a common and serious mental disorder that negatively affects how people feel, think, or act. Symptoms include sadness, a loss of interest in activities, trouble sleeping, a loss of energy, difficulties concentrating or making decisions, and thoughts of death or suicide. For a diagnosis of depression, symptoms must last for at least two weeks.

In our data, this condition is identified by diagnosis code ICD-10: F32: "[…] mild, moderate, severe or recurrent depressive episodes, [in which] the patient suffers from lowering of mood, reduction of energy, and decrease in activity." According to the WHO, depression affects 264 million people worldwide; in our data, 97,932 people (3.6 percent) received at least one diagnosis of depression between 1995 and 2015 (Table 1).[14]

[13] Recent approaches in CBT focus on psychoeducation and cognitive restructuring to challenge overly negative or positive cognitions. By 2005, the American FDA had approved four additional mood stabilizers for the treatment of BD: the anticonvulsant divalproex sodium (also known as valproate or valpro), the antipsychotic chloprozaine, the atypical antipsychotic olanzapine, and the anticonvulsant lamotrigine.

[14] World Health Organization Fact Sheet, April 2017 (http://www.who.int/mediacentre/factsheets/fs396/en/). In the National Comorbidity Study-Replication of 9,282 people in the continental United States, 16.2 percent had been affected by depression at least once and 6.6 percent within the 12 months prior (Kessler et al. 2003).

Anxiety is a condition characterized by feelings of tension; worried, recurring intrusive thoughts; and physical changes like increased blood pressure, sweating, trembling, dizziness, or a rapid heartbeat. In our data, this condition is identified by diagnosis codes ICD-10: F40-F43. These include phobic anxiety disorders, other anxiety disorders, obsessive-compulsive disorders, and reaction to severe stress disorders (such as post-traumatic stress disorder).[15] Because of high comorbidity, we combine diagnoses of depression and anxiety in a single indicator.

The variable *schizophrenia* is an indicator for having at least one diagnosis with code ICD-10: F20-F29: "Schizophrenia, schizotypal, delusional disorders and a larger group of acute and transient psychotic disorders." Schizophrenia involves problems with thinking (cognition), behavior, and emotions, with symptoms that include delusions, hallucinations, or disorganized speech.

The share of people with BD is stable across cohorts, with 1.2 percent for the 1946, 1954, and 1960 cohorts and 1.0 for the 1975 cohort, respectively (Appendix Figure A1). Rates of diagnosis for schizophrenia are also quite stable at around 1.5 percent, while rates of diagnosis for depression and anxiety decrease across cohorts, from 49 percent for the 1946 cohort to 46 percent for the 1954 cohort and 31 percent for the 1975 cohort (Appendix Figure A2).

B. Earnings and Disability

To calculate a person's *earnings,* we add income from wages and self-employment (Appendix Table A1). We convert earnings from Danish Kroner (DKK) to 2015 US dollars using the Danish CPI and the 2015 exchange rate. Individuals with positive earnings earn $52,297 on average, with a standard deviation of $82,413 (Table 1).

A separate variable measures *disability* receipt (*førtidspension*). People with disabilities apply for these benefits with their municipal government, which evaluates their ability to work (*ressource-forløb*), and assigns payments based on the severity of the disability and family status. People who receive disability payments can work part-time, earning up to an amount that depends on household structure, income, and wealth; if they earn more, they forfeit

[15] Anxiety disorders are defined as a "[…] group of disorders in which anxiety is evoked only, or predominantly, in certain well-defined situations that are not currently dangerous. […] The patient's concern may be focused on individual symptoms like palpitations or feeling faint and is often associated with secondary fears of dying, losing control, or going mad." Obsessive-compulsive disorders are those whose "[…] essential feature is recurrent obsessional thoughts or compulsive acts, […] ideas, images, or impulses that enter the patient's mind again and again in a stereotyped form.".

disability pay for that calendar year. Twelve percent of all people receive disability pay at least once during our sample period, including 17,497 people with BD (51 percent of all people with BD), 288,453 with depression or anxiety (23 percent), and 33,739 with schizophrenia (73 percent, Table 1).

TABLE 1 – PEOPLE WITH MENTAL HEALTH CONDITIONS COMPARED WITH THE POPULATION

	All	BD	Depression/ Anxiety	Schizophrenia
All	3,100,631	34,315	1,257,412	46,148
born until 1956	1,285,417	15,135	624,023	16,431
born after 1956	1,815,214	19,180	633,389	29,717
W/ no earnings at least once	1,341,972	27,400	697,690	42,513
born until 1956	586,550	11,859	344,829	14,980
born after 1956	755,422	15,541	352,861	27,533
Average earnings ($)	52,297	37,350	47,748	24,752
	(82,413)	(47,722)	(47,064)	(27,889)
born until 1956	53,501	40,369	50,128	26,010
	(129,549)	(57,721)	(52,100)	(27,790)
born after 1956	51,728	35,944	46,277	24,386
	(45,628)	(42,192)	(43,599)	(27,907)
On disability at least once	379,270	17,497	288,453	33,739
born until 1956	225,478	8,985	168,728	13,227
born after 1956	153,792	8,512	119,725	20,512

Note: Counts of observations for individuals between the age of 20 and 60 from 1995 to 2015, in birth cohorts between 1940 and 1977; overall, with zero earnings and receiving disability payments. Average earnings are reported in 2015 US dollars ($). Standard errors in parentheses. The variables *BD*, *Depression/Anxiety*, and *Schizophrenia* equal 1 for individuals who have been diagnosed with these conditions at least once between 1995 and 2015. Diagnoses are available for calendar years between 1995 and 2015.

C. Family Identifiers and Parental Wealth

To control for unobservable factors that vary across families, we link each person to their siblings using their mother's or father's anonymized social security number as a family identifier. Family identifiers are available for 1.8 million people (58 percent of the population); 88 percent of all people and 87 percent of people with BD have at least one sibling.[16]

[16] Our main results remain robust when we exclude family fixed effects from all specifications and estimate them on the sample of all people, including those without a family identifier (Appendix Table A4).

Among people who can be linked with their parents, 71 percent have at least one parent who reported positive financial assets for at least one year between 1980 and 2015. For the remaining observations, we set parental assets to zero.[17] To define a person's position in the distribution of parental wealth, we calculate the percentile of parental assets for each year and assign the person to their parents' median percentile across all years.

*D. Job Descriptions: O*NET*

In our analysis we also test whether people with BD change the types of jobs they hold when they gain access to improved treatment. To classify job types, we link each person's occupation (recorded in the Danish administrative data using ISCO classifications) to detailed information about the characteristics of that occupation, which we take from O*NET. Sponsored by the US Department of Labor, O*NET is a survey database containing information on each occupation's required tasks, skills, competences, interests, and work context. With these data, we characterize five different "dimensions" of an occupation: management, decision-making, work under pressure, artistic work, and social skills. Each dimension is calculated as an occupation-specific average of the associated skills, interests, contexts, and activities, measured in levels and standardized to have mean zero and variance one. Appendix Table A3 details the construction of these variables.

II. PENALTIES FROM BD AND IMPACTS OF TREATMENT INNOVATIONS

This section estimates the effects of access to improved treatment options on the labor market outcomes of people with BD, including labor market participation, earnings, and the probability of receiving disability payments. Lithium, the most effective treatment for BD, was approved as a maintenance treatment for BD in 1976; its approval was followed by a series of further advances in the treatment of BD, including other medications (mood stabilizers, antidepressants, and antipsychotics) and cognitive behavioral therapy (CBT).

Since improved treatment for BD became available only in 1976, people in younger cohorts had access to treatment from a young age, while people in older cohorts remained untreated for a greater portion of their life.[18] Our baseline estimates use 20 as the reference age

[17] All results are robust to excluding individuals without information on parental assets from the analyses. Assets are reported by banks and other financial institutions.

[18] Early exposure is also associated with a higher likelihood of using lithium later in life. While the lack of prescription data before 1995 prevents us from measuring changes in lithium usage around the time of lithium approval, the data indicate that people with BD in younger cohorts are more likely to use lithium, controlling for age (Appendix Figure A5).

to define early access to treatment. People tend to be diagnosed with BD at that time (Kessler et al. 2005), and a person's early 20s are critical for a person's career (Kahn 2010; Oreopoulos, von Wachter, and Heisz 2012; Arellano-Bover forthcoming).[19]

A. Difference-in-Differences

To quantify the impact of access to improved treatment, we leverage differences in access to lithium across cohorts. For simplicity, we begin by comparing the difference in outcomes between people with BD and their siblings and for cohorts born after 1955, who had access to improved treatments when they turned 20, and older cohorts, who did not have access at that same age. Intuitively, the former should have had better access to a treatment for BD than the latter. We then relax this binary cohort categorization and estimate cohort-specific differences instead.

The difference in the excess probability of having no earnings in a given year, for people with BD relative to their siblings and between cohorts born after 1955 and older cohorts, is captured by β in the following equation:

$$(1) \quad P(earnings_{it} = 0) = \alpha\, BD_i + \beta\, BD_i * access_{c(i)} + \tau_t + F_i * \tau_t + \theta_{c(i)} + F_i * \theta_{c(i)} + \delta_{f(i)} + \varepsilon_{it}$$

where the dependent variable $P(earnings_{it} = 0)$ equals one if person i in cohort $c(i)$ earns zero in year t. The variable BD_i equals one for people who have been diagnosed with BD at least once and the variable $access_{c(i)}$ equals one for cohorts born after 1956, who had access to improved treatment at age 20. Year fixed effects τ_t control for changes in aggregate rates of employment and other forces that influence labor market participation over time. Cohort fixed effects $\theta_{c(i)}$ control for unobservable factors that vary across birth cohorts and may affect the labor market outcomes of people with and without BD. We include year and cohort fixed effects, alone and interacted with F_i (an indicator for women), to account for secular changes in labor market outcomes over time, which may differ by gender.

Family fixed effects $\delta_{f(i)}$ allow us to compare people with BD with their healthy siblings. If families with lower earnings or labor force participation have a higher rate of mental health disorders, a simple comparison of people with BD with the population may overstate the penalties from mental health disorders. Comparing people with BD with their siblings helps to

[19] Our data suggest that the age at onset is relatively stable across cohorts. The average lag between the year in which a person enters the sample and the year in which they receive the first BD diagnosis is equal to 9 for the 1956 cohort and 11 for the 1970 cohort (Appendix Figure A2).

account for family-specific factors that could act as triggers of the condition, influence its incidence, and impact the odds of a diagnosis and treatment.[20]

In equation (1), the parameter α captures the excess probability of having zero earnings for people with BD who did not yet have access to improved treatment at age 20, relative to their siblings. The parameter β measures how much this excess probability differs for people with BD who did have access to improved treatment by age 20. Under the assumption that, without changes in treatment, differences in labor market outcomes of people with and without BD would have remained stable across cohorts, estimates of β represent the causal effects of access to improved treatment on people with BD.

Investigating the Identification Assumption There are two main challenges to our empirical strategy. The first concerns the validity of the identification assumption. This assumption would be violated if the composition of people diagnosed with BD changed across cohorts, generating differences in labor market outcomes unrelated to access to improved treatments. For example, if people diagnosed in earlier cohorts had more severe symptoms on average compared with those diagnosed in later cohorts, we may observe improvements in labor market outcomes for people with BD over time even if treatments are ineffective, simply because later cohorts are less sick. While we cannot completely rule out this possibility, the data do not support it. If people with less severe symptoms became more likely to be diagnosed over time, the population share of people with BD should have increased across cohorts; instead, this share is stable at around 1 percent (Appendix Figure A1). Moreover, the characteristics of people with BD, such as comorbidities, parental wealth, levels of education, and gender are also stable across cohorts relative to the population (Appendix Figure A3).[21] Our results are also robust to retaining only data for the first 15 years when a cohort is observed (Appendix Table A6).

A second challenge arises because we can only observe diagnoses after 1995. This affects our definition of the subsample of people with BD: We cannot observe people who were ill enough to have died by 1995, and we might mistakenly assign people who were only diagnosed before 1995 to the control group. Both issues, though, would bias our estimates

[20] Mental health disorders can be triggered by abuse, neglect, the death of a parent, or other family-related stress (Mortensen et al. 2003; Persson and Rossin-Slater 2018). Low income is associated with an increased risk for manic and hypomanic symptoms (Bauer et al. 2011; Sareen et al. 2011; Hakulinen et al. 2019), and access to specialized mental health care is associated with socioeconomic status (Katz et al. 1997; Wang et al. 2005).
[21] To examine stability over time, we compare cohort-specific ratios of the share for people with BD and the population share of women, people with at least one college degree, people with at least one diagnosis of depression or schizophrenia, and quantiles of parental wealth (Appendix Figure A3).

towards zero. The inability to observe diagnoses before 1995 may also affect the identification assumption that outcome penalties from BD would have been comparable across cohorts in the absence of treatment. Specifically, since we cannot observe diagnoses for people in older cohorts at an early age, people with BD in older cohorts could be sicker and earn less because they have more severe symptoms, irrespective of access to treatment.

Reassuringly, our data indicate that, relative to the population, the composition of people diagnosed with BD at different ages is comparable across cohorts. Appendix Figure A4 shows observable characteristics of people with BD relative to the population, separately by age and cohort. These ratios are comparable across people whom we observe at different ages, both within and across cohorts.

TABLE 2 – OLS: BD, ACCESS TO TREATMENT, AND LABOR MARKET OUTCOMES

	P(Earnings=0)		ln(Earnings)			
	(1)	(2)	(3)	(4)	(5)	(6)
BD	0.170***	0.164***	-0.560***	-0.570***	-0.574***	-0.580***
	(0.009)	(0.009)	(0.034)	(0.034)	(0.030)	(0.031)
BD * access	-0.057***	-0.050***	0.178***	0.190***	0.186***	0.193***
	(0.009)	(0.009)	(0.036)	(0.036)	(0.032)	(0.032)
D, A, S	✓	✓	✓	✓	✓	✓
D/A/S * access		✓		✓		✓
Gender*cohort FE	✓	✓	✓	✓	✓	✓
Gender*year FE	✓	✓	✓	✓	✓	✓
Family FE	✓	✓	✓	✓	✓	✓
R-squared	0.354	0.354	0.302	0.323	0.955	0. 955
Mean Y	0.11	0.11	--	--	--	--
N	35371167	35371167	31628529	31404955	35371167	35371167
Sample	Full	Full	Earn>0	Earn>0	Full	Full

Standard errors in parentheses are clustered at the family level.
*** p<0.01, ** p<0.05, * p<0.1

Note: The dependent variable is an indicator for zero earnings (columns 1-2) or the natural logarithm of earnings, defined as the sum of wages and income from self-employment (columns 3-6). *BD* equals 1 for people who have been diagnosed with this condition at least once between 1995 and 2015. *Access* equals 1 for individuals born after 1956, who had access to lithium when they entered their 20s. *D*, *A*, and *S* are indicators for people who have ever received a diagnosis of depression, anxiety, and schizophrenia, respectively; *D/A/S* indicates people with at least one diagnosis of one of these conditions. All regressions include gender-by-cohort, gender-by-year, and family fixed effects. Columns 5-6 further control for interactions of *BD* and *BD * access* with an indicator for zero earnings. Data are available for calendar years 1995-2015. The sample is restricted to people between the ages of 20 and 60 in cohorts between 1940 and 1977, with family identifiers. Columns 3-4 report results for people with positive earnings.

People with Access in Their Early 20s Have Much Lower Risks of Zero Earnings

Overall, people with BD face an elevated risk of having no earnings at all. In the population, 42 percent of people have zero earnings in at least one year; for people with BD, this share is much higher at 80 percent (Table 1). Early access to improved treatment may allow people with BD to stay in the labor force, reducing their risks of no earnings.

Estimates of equation (1) confirm this hypothesis. An estimate of 0.170 for *BD* implies that people with BD and no access to improved treatment by age 20 are 17 percentage points more likely to have no earnings (Table 2, column 1, significant at 1 percent). Relative to a population share of 0.11, this estimate corresponds to a 1.5 times higher probability. An estimate for *BD* * *access* of -0.057 indicates that access to improved treatment by age 20 reduces this probability by 5.7 percentage points, or 34 percent (0.057/0.170) of the excess risk for people without access to improved treatments.

Estimates by Cohort The empirical specification in equation (1) implicitly assumes that the labor market penalties for people with BD, relative to their healthy siblings, are constant across cohorts with access to improved treatment at age 20 and older cohorts. To relax this assumption and explore the dynamic effects of treatment across cohorts, we estimate cohort-specific differences in the probability of zero earnings, captured by β_k in the equation:

$$(2) \qquad P(earnings_{it} = 0) = \alpha\, BD_i + \sum_k \beta_k\, BD_i\, \mathbf{1}(k\text{-}4 \leq c(i) \leq k) + \tau_t + F_i * \tau_t + \theta_{c(i)} + F_i * \theta_{c(i)} + \delta_{f(i)} + \varepsilon_{it}$$

Here, each parameter β_k captures the difference in the probability of zero earnings between people with BD born in cohorts k-4 to k (where k = 1945, 1950, 1960, 1965, 1970, 1975, and 1980) and their siblings. We normalize β_{1955} to be zero so that all these differences are expressed relative to the difference for the 1951-55 cohorts. Under the assumption that, without changes in treatment, differences in labor market outcomes of people with BD and their siblings would have remained stable across cohorts (the standard parallel trends assumption of difference-in-differences models), estimates of β_k for k>1955 represent the causal effects of access to improved treatment at age 20 on the labor market outcomes of people with BD. Estimates of β_k for $k<1955$ capture the differences in outcome penalties among cohorts who did not have access to treatment at age 20.

In line with the identifying assumption of parallel trends, estimates of β_k for $k<1955$ are always small in magnitude and indistinguishable from zero, ranging from -0.02 for the 1945-50 cohort (Figure 1, solid thin series, p-value equal to 0.33) to 0.02 for the 1940-45 cohort (p-value equal to 0.66). While the identifying assumption cannot be tested, these estimates show reassuring evidence of parallel pre-trends.

Estimates of β_k for $k>1955$ indicate that people who had access to treatment innovations earlier in life experienced a significantly smaller chance of having zero earnings. Compared with the 1951-55 cohort, penalties become significantly smaller starting from the 1956-60 cohort and continue to decline for younger cohorts. Specifically, the probability of having zero earnings is 3.0 percentage points smaller for cohorts born in 1956-60 (27 percent relative to an average of 11 percent for the population), 7.6 percentage points smaller for cohorts born in 1966-70 (69 percent), and 8.9 percentage points smaller for cohorts born in 1971-75 (81 percent, Figure 1).

The progressive decline in labor market penalties for BD across cohorts might reflect significant delays in the diffusion of drugs, as it typically takes physicians several years to adopt new treatments (Agha and Molitor 2018). It also reflects the fact that, following the "lithium revolution" of the mid-1970s, additional treatments became available for people with BD, whose effects might have compounded over time (see Table 2 of Lopez-Muñoz et al. 2018).

B. Triple Difference: Using People with Other Conditions as Controls

An additional challenge for our empirical strategy is that labor market outcomes might have changed over time (and across cohorts) for people with *any* mental health condition. This would confound our estimates of the impact of access to improved treatment. This change might have occurred, for example, due to the de-institutionalization of mental health care, the growth of community-based treatment centers (Geddes and Miklowitz 2013), changes in health insurance coverage,[22] and a reduction in the stigmatization of mental health disorders (Hinshaw and Stier 2008).[23] To control for time-varying factors affecting all people with mental health

[22] Mental health care in Denmark has undergone considerable change during the last decades, including an increase in outpatient treatment, a reduction in the number of hospital beds, and the establishment of community mental health centers (Danish Ministry of Health 2017). The Social Assistance Act of 1976 transferred psychiatric services from the state to local county responsibility. A Patients' Right law of 1992 prohibited treatment without consent and required providers to explain treatment options to patients (European Observatory on Health Care Systems 2001).

[23] In principle, evidence on the genetic drivers of mental health may mitigate stigmatization. Yet surveys show that stigmatization towards BD and other disorders has intensified since the 1950s (Phelan et al. 2000).

conditions, we use people with depression, anxiety, and schizophrenia as an additional control group:

$$(3) \qquad P(earnings_{it} = 0) = \alpha\, BD_i + \beta\, BD_i * access_{c(i)} + \alpha_M\, M_i + \beta_M\, M_i * access_{c(i)} + \tau_t + F_i * \tau_t + \theta_{c(i)} + F_i * \theta_{c(i)} + \delta_{f(i)} + \varepsilon_{it}$$

In this equation, the variable M_i equals one for people with at least one diagnosis of BD, depression, anxiety, and schizophrenia. The term $\alpha_M\, M_i$ captures the gap in the outcome variable between people with any mental health condition and the population born before 1956; the term $\beta_M\, M_i * access_{c(i)}$ measures the difference in this gap between cohorts born after 1955 and older cohorts. As a result, estimates of β capture differences in the probability of zero earnings, relative to healthy siblings, for people with BD and access to improved treatment at age 20 compared with people without access, *above and beyond* any changes experienced by people with any mental health condition. Even in the presence of secular changes in labor market experiences for all people with mental health conditions, estimates of β can be attributed to the approval of lithium as a maintenance treatment for BD, since this medication is prescribed primarily to people with BD.[24]

An estimate of 0.164 for *BD* implies that, relative to people with other mental health conditions, people with BD but without access to improved treatment by age 20 are 16.4 percentage points more likely to have no earnings, or 149 percent relative to the 11 percent population share (Table 2, column 2, significant at 1 percent). An estimate of -0.050 for *BD * access* confirms that access to improved treatment by age 20 reduces this probability by 5.0 percentage points, or 30 percent of the excess risk for people with no access.

We also estimate cohort-specific estimates β_k in the following equation:

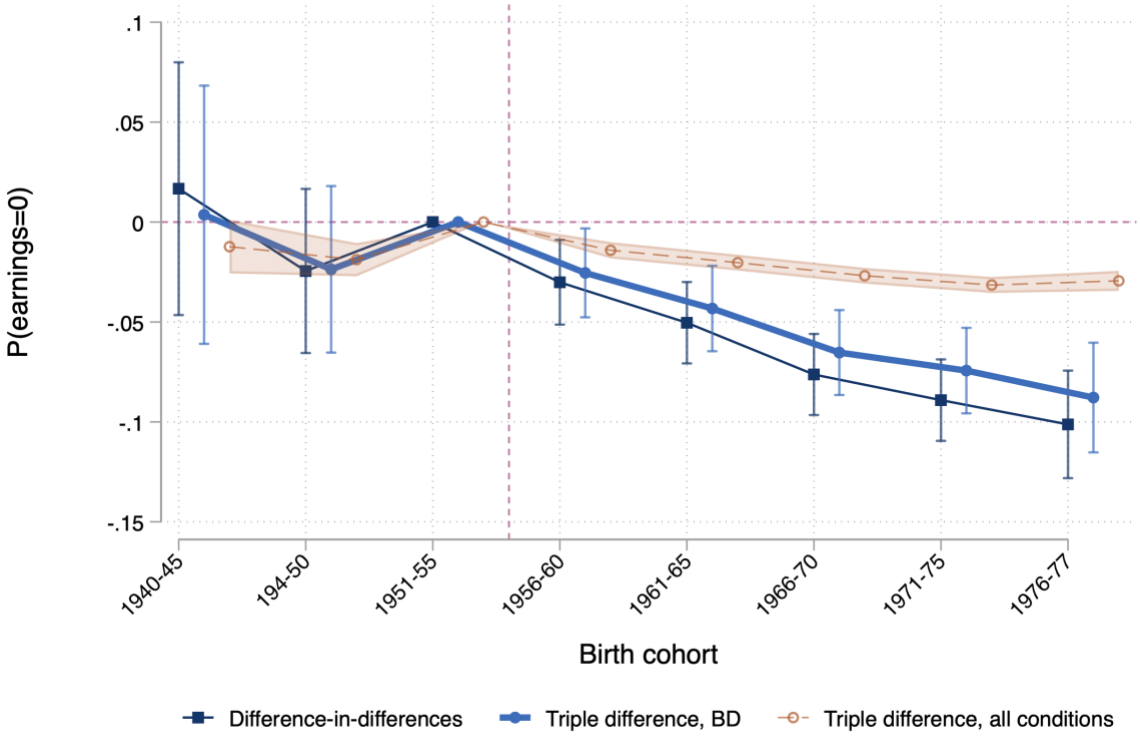
$$(4) \qquad P(earnings_{it} = 0) = \alpha\, BD_i + \sum_k \beta_k\, BD_i\, \mathbf{1}(k\text{-}4 \le c(i) \le k) + \alpha_M\, M_i + \sum_k \beta_{M,k}\, M_i\, \mathbf{1}(k\text{-}4 \le c(i) \le k) + \tau_t + F_i * \tau_t + \theta_{c(i)} + F_i * \theta_{c(i)} + \delta_{f(i)} + \varepsilon_{it}$$

[24] While lithium is sometimes prescribed as a treatment for schizophrenia, its use is not recommended because there is little evidence that it is an effective treatment (Leucht et al. 2015). If, however, lithium was a common and effective treatment for schizophrenia, our estimates of β would be biased towards zero.

As before, estimates of β_k for $k<1955$ (the solid bold series of Figure 1) are always small in magnitude and indistinguishable from zero, ranging from -0.02 for the 1946-50 cohort (p-value equal to 0.35) to 0.004 for the 1940-45 cohort (p-value equal to 0.93).

Estimates of β_k for $k>1955$, on the other hand, confirm that people with BD who had access to treatment innovations earlier in life experienced a significantly smaller chance of having zero earnings even compared with changes for people with other mental health disorders. Relative to the 1951-55 cohort, the probability of having zero earnings is 2.5 percentage points smaller for people with BD born in 1956-60 (or 18 percent compared with the population), 4.3 percentage points smaller for cohorts born in 1961-65 (31 percent), and 7.4 percentage points smaller for cohorts born in 1971-75 (53 percent, Figure 1, solid thin series).

FIGURE 1–OLS COHORT ESTIMATES: P(EARNINGS=0), PEOPLE W/BD AND OTHER CONDITIONS VS SIBLINGS



Note: OLS point estimates and 95 percent confidence intervals of the parameters β_k in equations (2) *(Difference-in-differences*) and (4) (*Triple difference, BD*) and $\beta_{M,k}$ in equation (4) (*Triple difference, all conditions*), obtained using an indicator for zero earnings as the dependent variable. Standard errors are clustered at the family level. The sample is restricted to individuals between 20 and 60 years of age, born between 1940 and 1977.

In equation (4), the parameters $\beta_{M,k}$ capture the difference in the probability of zero earnings between people with any mental health condition, born in cohort *k-4* to *k*, and their siblings. Estimates of these parameters (the dashed series in Figure 1) indicate that the risk of zero earnings progressively declines across cohorts. This is consistent with advances in treatments for conditions other than BD, such as cognitive behavioral therapy, antidepressants, antipsychotics, and other mood stabilizers. The decline, though, is significantly smaller compared with the additional decline experienced by people with BD. In addition, the decline starts at the beginning of the sample and there is no discontinuity in trends starting from the 1956-60 cohorts (as is the case for people with BD). These findings indicate that changes over time that affect all mental health conditions are unlikely to explain improved outcomes for people with BD after the approval of lithium.

The parallel trends assumption is untestable by construction. To examine the sensitivity of our estimates to possible violations of this assumption, we follow Rambachan and Roth (2021) and compare 95-percent confidence intervals of OLS estimates of the parameters β_k in equation (4), for k=1971-75 and k=1976-77, with estimates that allow for deviations from a linear trend up to an amount M. Appendix Figure A6 (panel (a)) shows sensitivity plots for $0 < M < \text{se}(\beta_k)$, where $\text{se}(\beta_k)$ is the standard error of β_k. All estimates remain large and statistically significant, supporting the identification assumption.

In our triple-difference specifications, we group people with depression, anxiety, and schizophrenia together into a single control group. In Appendix Figure A7 we probe the robustness of our estimates to this choice and re-estimate equation (4) using different sets of controls: only individuals with depression and schizophrenia (panels a and d), only people with depression (panels b and e), and only people with anxiety (panels c and f). Our estimates are robust to this choice, indicating that our results are not driven by the specific definition of control groups.

In the remainder of the paper, we focus on estimates from the triple-difference model using all three conditions (depression, anxiety, and schizophrenia) as controls. Difference-in-differences estimates yield similar results unless otherwise noted.

C. No Significant Effects of Treatment on Siblings

In addition to affecting people who are diagnosed, BD may also create spillovers for their siblings. For example, parents may shift resources away from healthy siblings towards children with BD. Moreover, even siblings who have never been diagnosed with BD may be affected

by a milder "subthreshold" form of BD (Mortensen et al. 2003; Krüger et al. 2006), which could impact their careers.[25]

To investigate the effects of BD on siblings, we compare healthy siblings of people with BD with the population, estimating the following specification:

$$(5) \quad P(earnings_{it} = 0) = \alpha\, BD_i + \beta\, BD_i * access_{c(i)} + \alpha_s\, BD\ sibling_i + \beta_s\, BD\ sibling_i * access_{c(i)} + \alpha_M\, M_i + \beta_M\, M_i * access_{c(i)} + \tau_t + F_i * \tau_t + \theta_{c(i)} + F_i * \theta_{c(i)} + \varepsilon_{it}$$

where $BD\ sibling_i$ equals one if person *i* has a sibling with BD.

OLS estimates of α_s and β_s confirm that BD creates negative spillovers for siblings of people with BD (Table 3). Healthy siblings of people with BD are 1.8 percentage points more likely than the population to have zero earnings, or 16 percent compared with an average share of 0.11 in the population (with an estimate of 0.018 for *BD sibling*, Table 3, column 2, significant at 1 percent). The estimated effects of access to treatment are positive, but small at 0.010 for *BD sibling * access* and only marginally significant (Table 3, column 2), possibly because parents continue to shift family resources to children with BD even when they benefit from treatment.

D. Impacts of BD and Its Treatment on Earnings

Our analyses so far have focused on labor market participation, measured by the probability of zero earnings. In this section we investigate whether and how BD and innovations in treating BD affect the earnings of people who are in the labor force.

Average Earnings First, we estimate earnings penalties for people with BD and investigate whether these penalties change with access to improved treatments. We substitute the natural logarithm of a person's earnings as the dependent variable in equation (3) and re-estimate the equation for the subsample of people with positive earnings.

Triple difference estimates reveal large earnings penalties for people with BD without access

[25] Analyses of US data indicate that people with a family history of BD are more likely to be affected by a milder form of (subthreshold) BD than the population (Judd and Akiskal 2003).

TABLE 3 — OLS: BD, ACCESS TO TREATMENT, AND LABOR MARKET OUTCOMES FOR PEOPLE WITH BD AND THEIR SIBLINGS

	P(Earnings = 0)		ln(Earnings)	
	(1)	(2)	(3)	(4)
BD	0.162***	0.158***	-0.491***	-0.517***
	(0.006)	(0.006)	(0.095)	(0.024)
BD * access	-0.046***	-0.041***	0.095***	0.127***
	(0.006)	(0.006)	(0.025)	(0.026)
BD sibling	0.019***	0.018***	-0.051***	-0.054***
	(0.005)	(0.005)	(0.016)	(0.016)
BD sibl. w/access	0.010*	0.010*	-0.040**	-0.037**
	(0.006)	(0.006)	(0.017)	(0.017)
D, A, S	✓	✓	✓	✓
D/A/S * access		✓		✓
Gender * cohort/year FE	✓	✓	✓	✓
Mean Y	0.11	0.11	--	--
R-squared	0.077	0.077	0.091	0.091
N	35371167	35371167	31404955	31404955

Standard errors in parentheses are clustered at the family level.
*** p<0.01, ** p<0.05, * p<0.1

Note: The dependent variable is an indicator for zero earnings (columns 1 and 2) and the logarithm of earnings, defined as the sum of all wages and income from self-employment (columns 3-4). *BD* equals 1 for people who have been diagnosed with this condition at least once between 1995 and 2015. *Access* equals 1 for individuals who were born after 1956 and thus had access to lithium, the main treatment for bipolar disorder, when they entered their 20s. *BD sibling* equals 1 for individuals with siblings with *BD*, and *BD sibling w/access* equals 1 for individuals with *BD* siblings born in cohorts after 1956. *D*, *A*, and *S* are indicators for people who have ever received a diagnosis of depression, anxiety, and schizophrenia, respectively. *D/A/S* indicates people with at least one diagnosis of one of these conditions. All regressions include gender-by-cohort and gender-by-year fixed effects. Diagnoses data are available for calendar years 1995-2015. The sample is restricted to individuals between the age of 20 and 65 in cohorts between 1940 and 1977, with family identifiers. Columns 3-4 report results for people with positive earnings.

to treatment; one-fourth of these penalties disappear with access to treatment. An estimate of -0.570 for *BD* implies that, conditional on having positive earnings, people with BD who did not have access to treatment earn 43 percent less than the population (exp(-0.570)-1=-0.43, Table 2, column 4, significant at 1 percent). Re-estimating equation (1) yields similar results (column 3). An estimate of 0.190 for *BD * access* (significant at 1 percent) indicates that people with BD who had access to improved treatments experienced an earnings penalty of only 32 percent compared with their siblings (exp(-0.570+0.190)-1=-0.32, significant at 1 percent). Treatment thus closes 26 percent of the earnings penalty associated with BD (1-0.32/0.43).

Columns 3 and 4 report estimates for the subsample of people with positive earnings, but the probability of positive earnings is itself affected by access to treatment. To jointly estimate the extensive and intensive margin effects of BD and treatment innovations on earnings, we modify equation (3) as follows:

$$
\begin{aligned}
(6) \qquad \ln(earnings_{it}) = {} & \alpha\, BD_i + \beta\, BD_i * access_{c(i)} + \gamma_1\, \mathbf{1}(earnings_{it} = 0) \\
& + \gamma_2\, BD_i * \mathbf{1}(earnings_{it} = 0) + \gamma_3\, \mathbf{1}(earnings_{it} = 0) * access_{c(i)} \\
& + \gamma_4\, BD_i * \mathbf{1}(earnings_{it} = 0) * access_{c(i)} + \alpha_M\, M_i + \beta_M\, M_i * access_{c(i)} \\
& + \tau_t + F_i * \tau_t + \theta_{c(i)} + F_i * \theta_{c(i)} + \varepsilon_{it}
\end{aligned}
$$

where $\mathbf{1}(earnings_{it} = 0)$ equals one if person *i* has zero earnings in year *t*.

Estimates of this equation confirm that people with BD who did not have access to treatment earn 44 percent less than their siblings: An estimate for *BD* equal to -0.580 implies an earnings difference of exp(-0.580)-1=-0.44. An estimate of *BD * access* equal to 0.193 implies an earnings difference of exp(-0.580+0.193)-1=-0.32 for people with BD and access to improved treatment compared with their siblings; this difference is 27 percent smaller than -0.44 (Table 2, column 6, both significant at 1 percent), which implies that access to treatment innovations closes 27 percent of the earnings gap between people with BD and their healthy siblings.

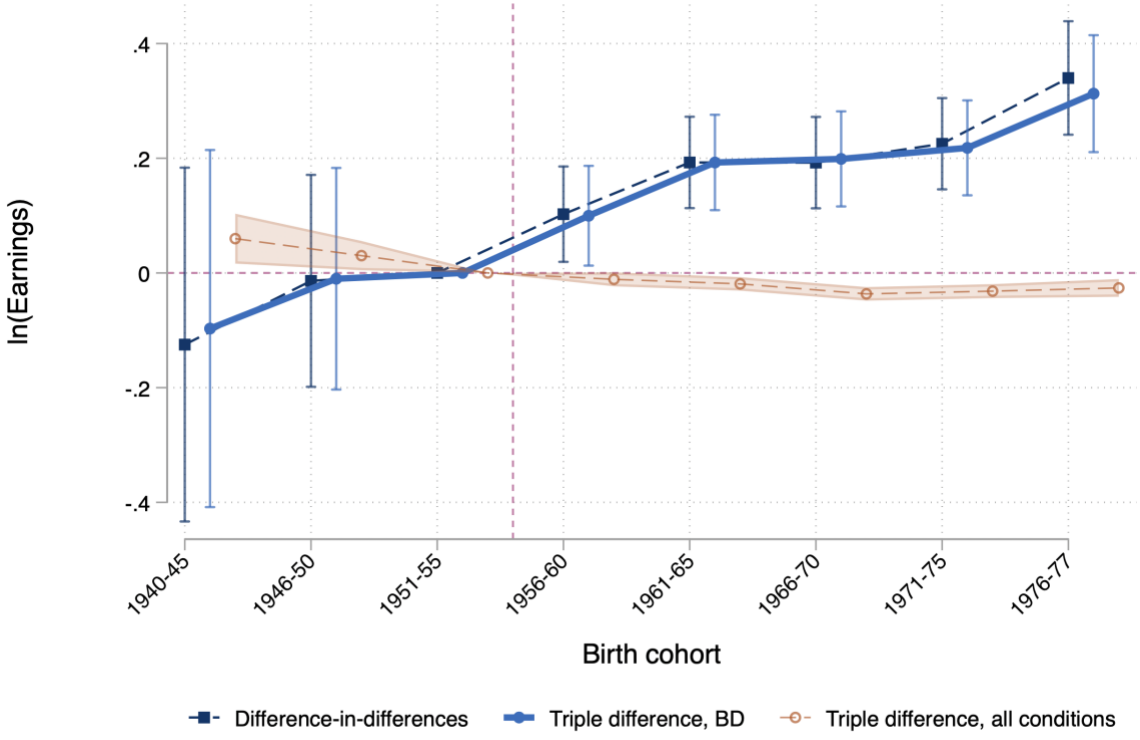
To investigate the dynamics of earnings effects across cohorts, we re-estimate equation (4) with the logarithm of earnings as the dependent variable. Estimates of β_k in this specification capture the difference in the earnings penalty (relative to healthy siblings) between people with BD born in cohorts *k-4* to *k* and those born in 1951-55.

Estimates of β_k for $k<1955$ are small in magnitude and indistinguishable from zero, ranging from -0.10 for the 1940-45 cohort (p-value 0.61) to -0.01 for the 1946-50 cohort (p-value 0.93, Figure 2, solid thick line; the solid thin line shows estimates of equation (2)). This indicates that earnings penalties were on a flat trend across cohorts without access to treatment by age 20, which supports the identification assumption of parallel trends.

Estimates of β_k for $k>1955$ indicate that people who had access to treatment innovations earlier in life experienced a significantly smaller earnings penalty. Compared with the 1951-55 cohort and with their healthy siblings, people with BD in the 1956-60 cohort have 11 percent higher earnings (with an estimate of β_k equal to 0.10, significant at 10 percent); people in the 1961-65 cohort have 21 percent higher earnings (with an estimate of β_k equal to 0.19,

significant at 1 percent); and people in the 1971-75 cohort have 24 percent higher earnings (with an estimate of β_k equal to 0.22, significant at 1 percent). These estimates confirm that having access to treatment innovations early in life mitigates the negative earnings impacts associated with BD. The fact that estimates are increasing over time is consistent with delays in the adoption of treatments (Agha and Molitor 2018).

FIGURE 2–OLS COHORT ESTIMATES: LOG EARNINGS, PEOPLE W/BD AND OTHER CONDITIONS VS SIBLINGS



Note: OLS point estimates and 95 percent confidence intervals of the parameters β_k in equations (2) *(Difference-in-differences*) and (4) (*Triple difference, BD*) and $\beta_{M,k}$ in equation (4) (*Triple difference, all conditions*), obtained using the natural logarithm of earnings as the dependent variable. Standard errors are clustered at the family level. The sample is restricted to individuals between 20 and 60 years of age, born between 1940 and 1977, with positive earnings.

Effects on the Probability of Extremely High and Low Earnings. So far, we have focused on the effects of BD and its treatments on average earnings. These estimates, though, might mask differences across the earnings distribution. On the one hand, BD may reduce earnings by increasing the risk of falling to the bottom of the earnings distribution; access to treatment may mitigate this risk. On the other hand, examples of extremely successful people with BD in business and the arts (e.g., Jamison 1993) suggest that BD might increase the odds of extremely high earnings.

To investigate the effects of BD and its treatment on a person's position in the earnings distribution, we re-estimate equation (3) with indicators for earnings at the top and bottom of the distribution as the dependent variable. These estimates indicate that access to treatment innovations greatly reduces a person's risks of low earnings and increases their probability of high earnings. People with BD have a 13 percentage-point higher risk of earnings in the bottom decile compared with their siblings and people with other mental health conditions (or a 1.3 times higher risk, estimate for *BD* in Table 4, column 2, significant at 1 percent). Access to improved treatment reduces this risk by 30 percent (with an estimate for *BD* * *access* equal to -4.0 percentage points, Table 4, column 2, significant at 1 percent). Access to treatment also increases the probability that a person with BD has earnings in the top decile by 34 percent compared with their siblings (*BD* = -4.1 percentage points and *BD* * *access* = 1.4 percentage points, Table 4, column 8, significant at 1 percent). Results are similar in specifications without controls for other mental health conditions (columns 1 and 7), and in specifications with the probability of earnings in the top and bottom quartiles as the outcome variable (columns 4 and 6).

III. Possible Mechanisms: Disability, Occupational Sorting, and Educational Attainment

Access to treatment innovations reduces the huge penalties that people with BD suffer in terms of labor force participation and earnings. We now examine three possible explanations for these effects: changes in the risk of disability, occupational sorting, and educational attainment.

A. Disability

An elevated risk of zero earnings suggests that symptoms of mental health disorders may prevent people from participating in the labor force. According to the WHO (2011), mental illness is the leading cause of lost disability-adjusted life years (DALYs) worldwide, accounting for more than one-third of years lost due to non-communicable diseases (also Ormel et al. 2008).[26] In the United States, mental illness accounts for over half of the rise in disability receipt after 1990 for men (Duggan and Imberman 2009). In our data, the share of people who

[26] In a survey of 253 people with BD, Suppes et al. (2001) found that 57 percent of respondents were unable to work, and another 9 percent held part-time jobs. In self-reported data from the World Health Organization's Health and Work Performance Questionnaire (HPQ), BD and depression are associated with 65.5 and 27.2 excess lost workdays per worker, respectively (Kessler et al. 2006). Projecting these estimates to the US labor force suggests that 225.0 million workdays are lost to depression each year, and 96.2 million are lost to BD.

TABLE 4 – OLS: BD, ACCESS TO TREATMENT, AND THE PROBABILITY OF EXTREME EARNINGS

	Bottom 10%		Bottom 25%		Top 25%		Top 10%	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
BD	0.129***	0.132***	0.151***	0.132***	-0.087***	-0.092***	-0.039***	-0.041***
	(0.008)	(0.008)	(0.010)	(0.008)	(0.010)	(0.010)	(0.008)	(0.008)
BD * access	-0.036***	-0.040***	-0.031***	-0.040***	0.025**	0.032***	0.010	0.014*
	(0.008)	(0.009)	(0.011)	(0.009)	(0.010)	(0.010)	(0.008)	(0.008)
D, A, S	✓	✓	✓	✓	✓	✓	✓	✓
D/A/S * access		✓		✓		✓		✓
Gender * cohort FE	✓	✓	✓	✓	✓	✓	✓	✓
Gender * year FE	✓	✓	✓	✓	✓	✓	✓	✓
Family FE	✓	✓	✓	✓	✓	✓	✓	✓
R-squared	0.226	0.226	0.317	0.296	0.419	0.419	0.387	0.387
Mean of Dep. Var.	0.10	0.10	0.25	0.25	0.25	0.25	0.10	0.10
N	31404955	31404955	31404955	31404955	31404955	31404955	31404955	31404955

Standard errors in parentheses are clustered at the individual level. *** p<0.01, ** p<0.05, * p<0.1

Note: The dependent variable equals 1 for individuals with earnings in the bottom 10 percent (columns 1-2), bottom 25 percent (columns 3-4), top 25 percent (columns 6-7), and top 10 percent (columns 7-8) of the earnings distribution; earnings are defined as the sum of all wages and income from self-employment. *BD* equals 1 for people who have been diagnosed with this condition at least once between 1995 and 2015. *Access* equals 1 for individuals born after 1956, who had access to lithium when they entered their 20s. *D/A/S* indicates people with at least one diagnosis of one of these conditions. All regressions include cohort, year, and family fixed effects. All regressions include cohort, year, and family fixed effects. The sample is restricted to people between 20 and 60 years of age, between 1995 and 2015 and in birth cohorts 1946-1977, with family identifiers and positive earnings.

receive disability payments is much higher for people with BD, with a staggering 51 percent compared with just 12 percent in the population.

Access to improved treatments may enable people with BD to work and reduce the likelihood of disability. Examining depression, Shapiro (2022) finds that encouraging people to take drugs for depression through advertising leads them to miss fewer days at work. Garthwaite (2012) shows that the removal of Vioxx (a nonsteroidal anti-inflammatory drug) from the market was associated with a 0.35 percentage point decline in overall labor force participation. If treatments for BD are similarly effective, they may reduce the risk that people with BD receive disability pay.

TABLE 5 – OLS: BD, ACCESS TO TREATMENT, DISABILITY, AND TOTAL INCOME

	P(disability)		ln(total income)	
	(1)	(2)	(3)	(4)
BD	0.202***	0.222***	-0.155***	-0.209***
	(0.010)	(0.010)	(0.026)	(0.026)
BD * access	-0.121***	-0.157***	0.052*	0.153***
	(0.010)	(0.010)	(0.027)	(0.028)
D, A, S	✓	✓	✓	✓
*D/A/S** access		✓		✓
Gender * cohort FE	✓	✓	✓	✓
Gender * year FE	✓	✓	✓	✓
Family FE	✓	✓	✓	✓
Mean Y	0.06	0.06	--	--
R-squared	0.427	0.427	0.228	0.229
N	35371167	35371167	35371167	35371167

Standard errors in parentheses are clustered at the individual level.

*** p<0.01, ** p<0.05, * p<0.1

Note: The dependent variable is an indicator for individuals with positive disability payments (columns 1-2) and the logarithm of total income, calculated as the sum of earnings, disability, and other welfare payments (columns 3-4). *BD* equals 1 for people who have been diagnosed with this condition at least once between 1995 and 2015. *Access* equals 1 for individuals born after 1956, who had access to lithium when they entered their 20s. *D*, *A*, and *S* are indicators for people who have ever received a diagnosis of depression, anxiety, and schizophrenia, respectively; *D/A/S* indicates people with at least one diagnosis of one of these conditions. All regressions include gender-by-cohort, gender-by-year, and family fixed effects. The sample is restricted to individuals between the ages of 20 and 60 in birth cohorts 1940-1977, with family identifiers.

To examine whether treatment innovations reduced the likelihood of disability for people with BD, we re-estimate equation (3) with an indicator for disability as the dependent variable. These estimates show that people with BD who did not have access to improved treatments by age 20 have a vastly higher probability of disability. Compared with their

siblings, their likelihood of receiving disability pay in a given year is 22 percentage points or nearly 3.7 times higher (with an estimate for *BD* equal to 0.222, Table 5, column 2, significant at 1 percent, compared with an average share of people with disability equal to 0.06). Access to improved treatments greatly reduces this likelihood: The odds of disability associated with BD are 16 percentage points smaller for cohorts with treatment by age 20, equivalent to 71 percent of the baseline probability for people with BD (with an estimate of -0.157 for *BD * access*, Table 5, column 2, significant at 1 percent).

Impacts on Total Income By providing payments to people who cannot work, disability pay reduces the impact of missed earnings on their total income. We investigate effects on total income by estimating models with the sum of earnings, disability, and other welfare payments as the outcome variable.

Triple-difference estimates indicate that people with BD and without access to treatment have 19 percent less total income than their healthy siblings (-0.209, Table 5, column 4, significant at 1 percent), less than one-half of the 43 percent earnings penalty (Table 2). An estimate of 0.153 for *BD * access* (significant at 1 percent) indicates that people with access to treatment innovations suffer only a 5 percent total income penalty compared with their siblings (exp(-0.209+0.153)-1=-0.05). This implies that access to treatment innovations closes nearly three quarters (74 percent, 1-0.05/0.19) of the total income penalty associated with BD.

B. Occupational Sorting

A second, possible explanation for the change in labor market penalties is that improvements in mental health may change the types of jobs that people with BD have. In the absence of treatment, people with BD might be limited to occupations that are compatible with their symptoms. If, for example, symptoms such as mania or depression preclude people with BD from performing non-routine tasks, they may be restricted to jobs with routine tasks that pay lower wages.[27]

To investigate occupational sorting as a mechanism for reduced earnings, we perform three tests. First, we calculate the median earnings for each occupation and year and re-estimate equation (3) using the log of median earnings of each person's occupation as the dependent variable. An estimate for *BD* = -0.019 indicates that, compared with their siblings and with

[27] A recent literature has highlighted how unstructured occupations and those that have a strong social and decision-making component have been growing faster than all others (Autor, Levy, and Murnane 2003; Deming 2017, 2021).

people with other conditions, people with BD and without access to treatment hold jobs that pay 2 percent less (Appendix Table A7, column 1, significant at 1 percent), just a small fraction of the 43 percent earnings penalty we estimated using individual-level earnings. Thus, occupational sorting cannot explain the baseline earnings penalties for people with BD. Moreover, a virtually zero estimate for *BD * access* indicates that the benefits of treatment do not operate through a reshuffling across occupations, from lower-paying to higher-paying jobs (-0.006, Appendix Table A7, column 1).

Second, we test whether access to treatment makes people more likely to select into jobs with a strong managerial, decision-making, pressure, artistic, or social component. We use standardized measures of these job dimensions from O*NET as the dependent variable in equation (3). These estimates indicate that people with BD and without access to treatment at age 20 have jobs with a 0.05 standard deviations (sd) lower managerial component (Appendix Table A7, column 2, significant at 5 percent) and 0.04 sd lower decision-making component (Appendix Table A7, column 3, significant at 5 percent). Access to treatment does not change the intensity of these components in the jobs held by people with BD. We also find that people with BD (with or without access to treatments), do not hold jobs that are significantly different in pressure, or in their artistic or social components compared with their siblings and compared with people with other conditions.

Third, we check whether the earnings results presented in columns 3-6 of Table 2 change if we control for occupation or occupation-by-year fixed effects. If our earnings results were explained, all or in part, by occupational sorting, estimates of *BD* and *BD * access* should become smaller. Instead, they remain robust (Appendix Table A7, columns 7 and 8). This further confirms that, rather than an improvement in the type of occupation, the relative earnings increase experienced by people with BD and access to treatment at age 20 are likely due to an improvement in their productivity and wages, within occupations.

C. Educational Attainment

Lastly, we explore the possibility that the positive effects of treatment on labor market outcomes may be driven by an increase in educational attainment. Access to treatment at age 20 may make people with BD more likely to complete college, which in turn improves earnings. To test this, we check whether college attainment is higher for people with BD who had access to treatment by age 20, compared with people without access and relative to their siblings and people with other mental health conditions.

Our findings do not support this hypothesis. We do not find significant differences between people with BD without access to treatment at age 20 and either their siblings, or people with other conditions (with an estimate for *BD* =0.008, Appendix Table A8, column 2, p-value equal to 0.50). If anything, people with BD and access to treatment are less likely to attend college (with an estimate of *BD* * *access* equal to -0.027, Appendix Table A8, column 2). This suggests that treatment might begin to influence people's lives at a point in time when educational decisions are already made, and that changes in disability and the types of jobs that people with BD and access can get are more likely channels behind the main effects compared with educational attainment.

IV. Who Benefits More From Medical Innovations?

Population data on mental health diagnoses and earnings reveal large benefits from treatment. In this section, we examine whether these benefits are larger for some subgroups of affected people. We focus on three dimensions of heterogeneity: gender, a person's socioeconomic status (SES), measured by their parents' position in the distribution of wealth, and the severity of the condition.

A. Gender

Women are at a higher risk for BD compared with men. In our data, 1.3 percent of all women receive at least one diagnosis of BD; this share is 1.0 percent for men. At the same time, women are less likely to participate in the labor market, and when they do, they earn less than their male counterparts. In Denmark, 12 percent of women report zero earnings in any given year (compared with 9 percent of men). Women who report positive earnings earn $43,182 on average, compared with $60,633 for men. Differences in labor market experiences and BD incidence across gender may thus lead to differences in the career impacts of access to improved treatment.

Estimates of equation (3) estimated on the sub-population of women indicate that women with BD and no access to improved treatment at age 20 are 19.8 percentage points (165 percent of the population share) more likely to receive no earnings in any given year compared with their siblings (Table 6, column 1, significant at 1 percent). Access to treatment reduces this probability by 5.8 percentage points, or 29 percent of the baseline probability. Men with BD and no access have a smaller likelihood of no earnings, 13.3 percentage points (148 percent of the population share) relative to siblings. Access to treatment reduces this likelihood by 5.7

percentage points, or 43 percent (Table 6, column 2, significant at 1 percent). These results imply that, even if the absolute impact of treatment is indistinguishable across genders (as is evident from a small and indistinguishable estimate for *BD * female * access* in column 3 of Table 6), the relative impact is smaller for women because they have a higher baseline probability.

TABLE 6 – OLS: BD, ACCESS TO TREATMENT, AND CAREER OUTCOMES BY GENDER

	P(earnings = 0)			ln(Earnings)		
	Women	Men	All	Women	Men	All
	(1)	(2)	(3)	(4)	(5)	(6)
BD	0.198***	0.133***	0.142***	-0.576***	-0.494***	-0.575***
	(0.013)	(0.011)	(0.009)	(0.049)	(.044)	(.038)
BD * access	-0.058***	-0.057***	-0.065***	0.171***	0.153***	0.204***
	0.013	(0.012)	(0.010)	(0.051)	(0.047)	(0.040)
BD * female			0.046***			0.007
			(0.013)			(0.054)
BD * female * access			0.019			-0.025
			(0.014)			(0.056)
D, A, S	✓	✓	✓	✓	✓	✓
D/A/S * access	✓	✓	✓	✓	✓	✓
Gender * cohort FE	✓	✓	✓	✓	✓	✓
Gender * year FE	✓	✓	✓	✓	✓	✓
Family FE	✓	✓	✓	✓	✓	✓
R-squared	0.351	0.352	0.322	0.322	0.955	0. 955
Mean Y	0.12	0.09	0.11	--	--	--
N	35371167	35371167	35371167	31404955	31404955	31404955

Standard errors in parentheses are clustered at the family level.

*** p<0.01, ** p<0.05, * p<0.1

Note: The dependent variable is an indicator for zero earnings (columns 1-3) or the natural logarithm of earnings, defined as the sum of wages and income from self-employment (columns 4-6). Columns 1 and 4 are estimated on women; columns 2 and 5 are estimated on men. *BD* equals 1 for people who have been diagnosed with this condition at least once between 1995 and 2015. *Access* equals 1 for individuals born after 1956, who had access to lithium when they entered their 20s. *Female* indicates women. *D*, *A*, and *S* are indicators for people who have ever received a diagnosis of depression, anxiety, and schizophrenia, respectively; *D/A/S* indicates people with at least one diagnosis of one of these conditions. All regressions include gender-by-cohort, gender-by-year, and family fixed effects. Columns 5-6 further control for interactions of *BD* and *BD * access* with an indicator for zero earnings. Data are available for calendar years 1995-2015. The sample is restricted to people between the ages of 20 and 60 in cohorts between 1940 and 1977, with family identifiers. Columns 4-6 report results for people with positive earnings.

The impact of treatment on earnings is also comparable across gender, both in absolute and relative terms. Women with BD and no access to improved treatment at age 20 earn 44

percent less compared with their siblings (estimate of *BD* equal to -0.576, exp(-0.576)-1=-0.44, table 6, column 4, significant at 1 percent). Access to treatment closes 25 percent of this gap. Men with BD and no access to improved treatment earn only 39 percent less compared with their siblings, and access to treatment closes 26 percent of this gap (Table 6, column 5). Taken together, these results indicate that access to improved treatment for BD, while effective in improving the careers of both men and women, does not affect the gender gap in earnings and labor market participation.

B. The Benefits of Treatment are Largest for People with Low Parental Wealth

Existing research has documented a strong link between SES and the incidence of mental health conditions. For example, adverse health shocks in utero or during childhood have been linked to mental health disorders in adults (McClellan, Susser, and King 2006; Neugebauer, Hoek, and Susser 1999, Van den Bergh et al. 2005; Persson and Rossin-Slater 2018; Adhvaryu et al. 2019).[28] Moreover, SES influences access to treatment. Katz et al. (1997) and Wang et al. (2005) show that low-income urban populations in the United States are less likely to receive appropriately targeted treatment for mental health conditions. Unequal access to care may be due to the monetary costs of treatment or to informal barriers and stigmatization. In our empirical setting, health care is essentially free, allowing us to shut down monetary costs and isolate the influence of other factors.

We investigate whether the benefits of treatment differ across the distribution of parental wealth by interacting *BD* and *BD * access* in equation (3) with *TopW* and *BottomW*, indicators for parental assets in the top and bottom quartile, respectively:

$$
\begin{aligned}
(7) \qquad & \text{P}\,(earnings_{it}=0) = \alpha\, BD_i + \beta\, BD_i * access_{c(i)} + \eta_{0,bottom}\, BottomW_i \\
& + \alpha_{bottom}\, BD_i * BottomW_i + \beta_{bottom}\, BD_i * BottomW_i * access_{c(i)} + \eta_{0,top}\, TopW_i \\
& + \alpha_{top}\, BD_i * TopW_i + \beta_{top}\, BD_i * TopW_i * access_{c(i)} \\
& + \alpha_M\, M_i + \beta_M\, M_i * access_{c(i)} + \tau_t + F_i * \tau_t + \theta_{c(i)} + F_i * \theta_{c(i)} + \delta_{f(i)} + \varepsilon_{it}
\end{aligned}
$$

[28] McClellan et al. (2006) and Neugebauer et al. (1999) show that maternal exposure to famine increases rates of schizophrenia and anti-social behavior among children. Van den Bergh et al. (2005) and Persson and Rossin-Slater (2018) show that in-utero exposure to maternal stress and anxiety increase the incidence of mental health conditions during adulthood. Adhvaryu et al. (2019) use variation in the price of cocoa in Ghana to show that children who are exposed to negative wealth shocks in utero have lower mental health outcomes as adults. Examining the effects of income shocks on adults, Gardner and Oswalt (2007) find that lottery winners in Britain experience improvements in well-being and that larger wins are followed by stronger improvements.

OLS estimates indicate that the benefits from treatment are significantly smaller for people with parental wealth in the top quartile. An estimate of -0.065 for *BD * access* indicates that treatment innovations reduce the odds of zero earnings by 6.5 percentage points for people

TABLE 7 – OLS: BD, ACCESS TO TREATMENT, AND CAREER OUTCOMES, BY PARENTAL WEALTH

	P(no earnings)		ln(Earnings)	
	(1)	(2)	(3)	(4)
BD	0.193***	0.187***	-0.634***	-0.645***
	(0.025)	(0.025)	(0.094)	(0.094)
BD * access	-0.072***	-0.065***	0.249***	0.262***
	(0.025)	(0.025)	(0.095)	(0.095)
< 25 pctile (*BottomW*)	0.026***	0.026***	-0.054***	-0.054***
	(0.003)	(0.003)	(0.009)	(0.009)
BD * < 25 pctile	-0.020	-0.019	0.063	0.064
	(0.026)	(0.026)	(0.098)	(0.098)
Access * < 25 pctile	-0.001	-0.001	0.001	0.001
	(0.002)	(0.002)	(0.007)	(0.007)
BD * < 25 pctile * access	0.017	0.016	-0.086	-0.088
	(0.026)	(0.026)	(0.100)	(0.100)
>= 75 pctile (*TopW*)	-0.011**	-0.011**	0.061***	0.061***
	(0.005)	(0.005)	(0.015)	(0.015)
BD * >= 75 pctile	-0.171***	-0.170***	0.495***	0.496***
	(0.044)	(0.044)	(0.158)	(0.158)
Access * >= 75 pctile	0.002	0.002	-0.017	-0.017
	(0.004)	(0.004)	(0.012)	(0.012)
BD * >= 75 pctile * access	0.132***	0.131***	-0.407***	-0.408***
	(0.045)	(0.045)	(0.160)	(0.160)
D, A, S	✓	✓	✓	✓
D/A/S * access		✓		✓
Gender * cohort FE	✓	✓	✓	✓
Gender * year FE				
Family FE	✓	✓	✓	✓
Mean of Dep. Var.	0.14	0.14	--	--
R-squared	0.354	0.354	0.323	0.323
N	35371167	35371167	31628529	31628529

Standard errors in parentheses are clustered at the individual level.
*** p<0.01, ** p<0.05, * p<0.1

Note: The dependent variable is an indicator for zero earnings (columns 1-2) or the natural logarithm of earnings, defined as the sum of wages and income from self-employment (columns 3-4). *BD* equals 1 for people who have been diagnosed with BD at least once. *Access* equals 1 for individuals born after 1956, who had access to treatment innovations at age 20. *D*, *A*, and *S* are indicators for people who have ever received a diagnosis of depression, anxiety, and schizophrenia, respectively. *D/A/S* indicates people with at least one diagnosis of one of these conditions. The variable *< 25 pctile* (*>= 75 pctile*) equals 1 for individuals whose parents have median assets below the 25th percentile (above the 75th percentile). Information on parents' assets is available for years 1986 to 2010 and for 38 percent of the sample. All regressions include gender-by-cohort, gender-by-year, and family fixed effects. Data are

available for calendar years 1995-2015; they include people between the age of 20 and 60 in birth cohorts 1940-1977, with family identifiers. Columns 3-4 report results for people with positive earnings.

Although based on a smaller subsample, our estimates suggest that family wealth plays an important role in shaping the career effects of mental health conditions. High levels of parental wealth appear to shield individuals with BD from the most severe effects of the disorder. When universal health insurance eliminates financial barriers to treatment, people with less wealth benefit most from access to treatment. Combined with existing evidence on disparate access to mental health treatment across the spectrum of SES, these results suggest that mental health might be an important driver for the persistence of low SES across generations, documented by Boserup, Kopczuk, and Kreiner (2013) for Denmark and Chetty et al. (2014) for the United States.

C. Penalties Are Larger for People with More Severe Forms of BD, but Benefits from Treatment Are Not

Next, we assess whether the labor market penalties and the benefits from treatment vary with the intensity of BD, measured by the number of diagnoses that a person receives. People with only one diagnosis may have just experienced a single episode and therefore are less sick, while people with multiple diagnoses have experienced many episodes of BD. On average, people with BD receive 2.4 diagnoses between 1995 and 2015, with a median of 2 diagnoses.

To test whether earnings penalties and benefits from treatment are related to the number of diagnoses, we estimate:

$$(8) \quad P\,(earnings_{it}=0) = \alpha_1 BD_i + \beta_1 BD_i * access_{c(i)} + \alpha_2 \#\,BD\ episodes_i + \beta_2 \#\,BD\ episodes_i * access_{c(i)} + \alpha_M M_i + \beta_M M_i * access_{c(i)} + \tau_t + F_i * \tau_t + \theta_{c(i)} + F_i * \theta_{c(i)} + \delta_{f(i)} + \varepsilon_{it}$$

where $\#\,BD\ episodes_i$ is the number of BD episodes experienced by individual *i*.

OLS estimates of equation (8) show that, relative to their siblings, even people with just a single diagnosis suffer earnings penalties from BD; however, the size of these penalties is larger for people with more diagnoses. People with a single diagnosis of BD who did not have access to treatment innovations at age 20 are 1.1 times more likely to earn zero (with an estimate of 0.157 for *BD* and compared with a 14 percent population share, Table 8, column 2,

significant at 1 percent). On top of this, each additional diagnosis of BD is associated with an additional 2.7 percentage point increase in the probability of zero earnings (with an estimate of 0.027 for *# BD episodes*, significant at 1 percent). For the median person with BD, this implies a 1.5 times higher chance of zero earnings ((0.157 + 2 * 0.027)/0.14=).

The benefits of treatment are also larger for people with more diagnoses. For people with just one diagnosis, access to treatment eliminates 21 percent of the excess likelihood of having zero earnings (with an estimate of -0.033 for *BD * access*, Table 8, column 2, significant at 1 percent). An estimate of -0.006 for *# BD episodes * access* indicates that the benefits from treatment increase by 0.6 percentage points with each additional diagnosis (Table 8, column 2, significant at 5 percent).

TABLE 8 – OLS: BD, ACCESS TO TREATMENT, AND CAREER OUTCOMES, BY INTENSITY OF THE CONDITION

	P(earnings = 0)		ln(Earnings)	
	(1)	(2)	(3)	(4)
BD	0.212***	0.157***	-0.603***	-0.477***
	(0.008)	(0.008)	(0.033)	(0.033)
BD * access	-0.037***	-0.033***	0.093***	0.128***
	(0.009)	(0.009)	(0.061)	(0.035)
# BD episodes	0.028***	0.027***	-0.136***	-0.135***
	(0.002)	(0.002)	(0.014)	(0.013)
# BD episodes * access	-0.006**	-0.006**	0.035**	0.034**
	(0.003)	(0.003)	(0.014)	(0.014)
D, A, S	✓	✓	✓	✓
D/A/S * access		✓		✓
Gender * cohort	✓	✓	✓	✓
Gender * year FE	✓	✓	✓	✓
Family FE	✓	✓	✓	✓
Mean of Dep. Var.	0.14	.014	--	--
R-squared	0.335	0.344	0.301	0.307
N	35371167	35371167	31,404,955	31,404,955

Standard errors in parentheses are clustered at the individual level.
*** p<0.01, ** p<0.05, * p<0.1

Note: The dependent variable is an indicator for receiving zero earnings each year (columns 1-2) or the natural logarithm of earnings, defined as the sum of wages and income from self-employment (columns 3-4). *BD* equals 1 for people who have been diagnosed with this condition at least once between 1995 and 2015. *Access* equals 1 for individuals born after 1956, who had access to lithium at age 20 or earlier. The variable *# BD episodes* counts diagnoses of BD between 1995 and 2015. *D*, *A*, and *S* are indicators for people who have ever received a diagnosis of depression, anxiety, and schizophrenia, respectively. *D/A/S* indicates people with at least one diagnosis of one of these conditions. All regressions include gender-by-cohort, gender-by-year, and family fixed effects. The sample is restricted to people between the ages

of 20 and 60 in birth cohorts 1940-77, with family identifiers. Columns 3-4 report results for a subsample of people with positive earnings.

People with more frequent episodes also experience larger earnings penalties compared with siblings. People with a single diagnosis of BD have 38 percent lower earnings than their healthy siblings (with an estimate for *BD* = -0.477, Table 8, column 4, significant at 1 percent). Access to treatment eliminates 24 percent of this penalty (with an estimate of *BD* * *access* = 0.128 and an associated 29 percent of the earnings penalty: exp(-0.477+0.128) -1=-0.29 for people with access). Each additional diagnosis of BD is associated with an additional 13 percent loss in earnings (with an estimate for # *BD episodes* = -0.135, significant at 1 percent). This implies a 53 percent earnings penalty compared with siblings for people with a median number of diagnoses (exp(-0.477-2*0.135) -1=-0.53). An estimate of 0.034 for *# BD episodes* **access* indicates that the benefits from treatment are equivalent to a 3 percent higher salary for each additional diagnosis (Table 8, column 4, p-value equal to 0.98). For the median person with BD, this implies a reduction of 21 percent of the initial earnings penalty (exp(-0.477 + 2 *(-0.135) + 0.128 + 2*0.034)-1=0.42, 1-0.42/0.53=0.21).

V. Benchmark Comparisons with Other Mental Health Disorders

Our analyses have exploited a drastic change in the availability of treatment options for BD to investigate the career effects of mental health and treatment innovations. Without such changes in treatment, the economic effects of mental health and treatment innovations are difficult to identify. In fact, causality may operate in the oppositive direction if negative labor market shocks trigger mental health episodes (Ahammer et al. 2020; Ahammer and Packham 2020).[29] We can, however, use registry data to estimate the labor market penalties associated with other mental health disorders and compare them with the penalties associated with BD. While these penalties cannot be interpreted as causal, they can serve as a benchmark to gauge the potential gains from innovations in treatment innovations more broadly.

A. Differences in the Probability of No Earnings

We begin by estimating the difference in the likelihood of having no earnings between people with BD, depression/anxiety, and schizophrenia and their healthy siblings. We estimate:

[29] Ahammer et al. (2020) show that downsizing has negative effects on mental health of non-laid off employees, who might be fearing for their jobs. Ahammer and Packham (2020) compare unemployed workers with and without access to unemployment benefits and find that the latter have worse mental health outcomes.

(9) $$P(earnings_{it} = 0) = \beta_1 BD_i + \beta_2 DA_i + \beta_3 S_i + \tau_t + F_i * \tau_t + \theta_{c(i)} + F_i * \theta_{c(i)} + \delta_{f(i)} + \varepsilon_i$$

where the indicator variables DA_i and S_i equal one for people who have been diagnosed with depression/anxiety or schizophrenia, respectively, at least once. In this specification, the parameters β_1, β_2, and β_3 represent the earnings penalties associated with each condition, relative to their healthy siblings.

OLS estimates of equation (9) imply that BD occupies a middle position between depression/anxiety and schizophrenia. People with depression or anxiety are 8.2 percentage points more likely to have no earnings each year compared with their siblings (59 percent relative to the population mean, Table 9, column 1, significant at 1 percent). People with BD are 12.1 percentage points, or 86 percent, more likely; people with schizophrenia are 37.2 percentage points or 266 percent more likely (Table 9, column 1, significant at 1 percent).

TABLE 9 – OLS: MENTAL HEALTH CONDITIONS AND CAREER OUTCOMES

			Earnings in			
	P(Earn=0)	ln(Earn)	Top 10%	Top 25%	Bottom 25%	Bottom 10%
	(1)	(2)	(3)	(4)	(5)	(6)
BD	0.121***	-0.404***	-0.028***	-0.064***	0.098***	0.126***
	(0.003)	(0.011)	(0.002)	(0.003)	(0.003)	(0.003)
Depr/Anxiety	0.082***	-0.248***	-0.034***	-0.076***	0.051***	0.094***
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Schizophrenia	0.372***	-1.302***	-0.037***	-0.095***	0.309***	0.294***
	(0.003)	(0.015)	(0.002)	(0.003)	(0.004)	(0.004)
Cohort FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Family FE	✓	✓	✓	✓	✓	✓
Mean Y	0.14	--	0.10	0.25	0.25	0.10
R-squared	0.353	0.312	0.368	0.391	0.222	0.210
N	35371167	31628529	31628529	31628529	31628529	31628529

Standard errors in parentheses are clustered at the individual level.
*** p<0.01, ** p<0.05, * p<0.1

Note: The dependent variable is an indicator for people with zero earnings (column 1); the natural logarithm of earnings, defined as the sum of all wages and income from self-employment (column 2); and indicators for individuals having earnings in the top 10 percent (column 3), top 25 percent (column 4), bottom 25 percent (column 5), and bottom 10 percent (column 6) of the earnings distribution. The variables *BD*, *Depression/Anxiety*, and *Schizophrenia* equal 1 for individuals who have been diagnosed with these conditions at least once between 1995 and 2015. Diagnoses data are available for calendar years 1995-2015. All regressions include cohort, year, and family fixed effects. The sample is restricted to individuals aged between 20 and 60 born in cohorts 1940-1977, with family identifiers;

columns 2-6 refer to individuals with positive earnings.

B. Average Earnings Penalties

Next, we investigate whether mental health disorders are associated with lower earnings. OLS estimates of equation (9) show vast earnings penalties for all three mental health disorders; estimates for BD again fall between the estimates for depression/anxiety and schizophrenia. People with depression or anxiety earn 22 percent less (with an estimate of -0.248, Table 9, column 2, significant at 1 percent). People with BD earn 33 percent less (significant at 1 percent), and people with schizophrenia earn 73 percent less (significant at 1 percent).

C. Differences in the Probability of Extremely High or Low Earnings

People with mental health disorders are significantly less likely to have earnings in the top echelons of the income distribution and more likely to fall into the bottom quantiles. All three estimates fall in a similar range, between 28 and 37 percent. People with depression or anxiety are 3.4 percentage-point (34 percent) less likely to be in the top 10 percent of the earnings distribution compared with their siblings (Table 9, column 3, significant at 1 percent). Similarly, people with BD are 2.8 percentage points (28 percent) less likely to reach the top earnings decile, and people with schizophrenia are 3.7 percentage points (37 percent) less likely (column 3, significant at 1 percent). Examining the top 25 percent of earnings corroborates these patterns (column 4).

People with BD are also 12.6 points (126 percent relative to the population mean) more likely to be in the bottom 10 percent of earnings compared with their siblings (Table 9, column 6, significant at 1 percent). Estimates are similar for depression/anxiety (with a 9.4 percent higher probability compared with their siblings, significant at 1 percent) and much larger for schizophrenia (a 294 percent higher probability compared with their siblings, significant at 1 percent). Examining the bottom 25 percent of earnings yields similar results (column 5).

D. Benchmark Estimates for Other Mental Health Disorders

These estimates reveal enormous earnings penalties for mental health conditions, beyond BD. Compared with BD, depression is more prevalent (affecting 3.6 percent of the population) while schizophrenia is less prevalent (affecting 1.5 percent of the population) but more debilitating and associated with larger economic losses.

The absence of exogenous variation in treatment prevents us from estimating the causal impact of treatment for these disorders. We can, however, use estimates for BD to estimate the benefits from treatments for depression/anxiety and schizophrenia if a similarly effective treatment were to be found. In Appendix Table A9, we estimate the total wage increases that universal access to treatment for these conditions would deliver if treatment could close 26 percent of the earnings penalties for all three conditions. This calculation indicates that universal access to for BD could save nearly $120 million in wages per year, or 2 percent of the total (direct and indirect) healthcare costs associated with mental health in Denmark (using estimates of healthcare costs reported by Santini et al. 2021).[30] If universal access to treatment were extended to all conditions, it could save almost $4 billion in wages per year, roughly 80 percent of all mental healthcare costs.

VI. CONCLUSIONS

This paper has used registry data on mental health diagnoses, earnings, and disability and a major innovation in the treatment of BD to investigate the career effects of mental health and improved treatments. Using the approval of lithium as an effective maintenance treatment for BD in 1976, we estimate the impact of access to improved treatment on people's labor force participation and earnings. Comparing differences in outcomes between people with BD and (i) their healthy siblings and (ii) people with other mental health conditions, across cohorts with and without access to treatment innovations in their 20s, we find that access to treatment reduces the likelihood of zero earnings by one-third. In addition, access to treatment closes one-fourth of the earnings penalties from BD. Our analyses of disability pay suggest that a dramatic reduction in the likelihood of disability is a major driver for these benefits.

These results imply that policies that improve and expand access to mental health treatments could create major economic and social benefits by increasing earnings, reducing the risk of low earnings, and mitigating the risk of disability. In the United States, estimates from the National Comorbidity Survey (NCS-R) indicate that one in three people with BD remains untreated (Kessler et al. 2003).[31] Expansions in Medicaid coverage have increased access to psychotropic prescriptions for mental illness by 22 percent (Maclean et al. 2019). Our

[30] Santini et al. (2021) estimate that Denmark incurs approximately $962.4 million in total direct costs and $3.9 billion annually in total indirect costs from mental health problems.

[31] Even when people are treated, the quality of treatment is highly uneven. In the NCS-R, more than one-third of all people with BD were treated by mental health professionals who are not psychiatrists (35.4 percent, Kessler et al. 2003), even though a striking 73 percent in general medical treatment received the wrong drugs (compared with an also large 43 percent in specialist treatment). See also Kessler, Merikangas, and Wang (2007).

findings suggest that such changes have major welfare effects: Access to treatment for BD could save $120 million in lost wages.

Our results also suggest that parental wealth plays an important role in shaping the career impact of mental health and that people whose parents are less wealthy benefit the most from access to treatment. For example, the effect of access to treatment on labor force participation is much larger for people with BD with parents in the lowest three quartiles of financial assets compared with the top quartile. It is important to remember that Denmark offers universal health care; our results therefore estimate the benefits of access to treatment in a context where the financial costs of treatment are minimal. In countries where access to mental health care treatment is costly, such as the United States, the distributional impact of mental health – and the potential benefits of expanding access to treatment – is likely to be greater.

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