



Patients with Autism Spectrum Disorder in the Minnesota Medical Cannabis Program

Experience of Enrollees During the First Six Years

Oct. 1, 2026

Patients with Autism Spectrum Disorder in the Minnesota Medical Cannabis Program: Experience of Enrollees During the First Six Years

Office of Cannabis Management
Division of Medical Cannabis
PO Box 64034
St. Paul, MN 55164

cannabis.info@state.mn.us

<https://mn.gov/ocm/>

To obtain this information in a different format, email cannabis.info@state.mn.us.

Table of contents

Executive summary	4
Background	4
Objective	4
Methods	4
Results	4
Conclusions	6
1. Introduction	6
Cannabis and autism spectrum disorder	8
2. Description of patients enrolled	9
Qualifying condition	9
Additional qualifying conditions	9
Gender and age	10
Race and ethnicity	11
Geographic distribution	12
3. Medical cannabis use patterns	13
Description of purchased products	13
Route of administration (ROA)	15
THC:CBD ratio	16
4. Benefits	19
Benefit received from medical cannabis	19
Standard eight symptoms	20
Aberrant behavior checklist second edition	26
5. Adverse side effects	32
Commonly reported side effects	33
Common side effects by severity	34
Severe side effects	34
6. Conclusion	35
Appendix A. Additional tables	36
References	37

Executive summary

Background

Autism spectrum disorder (ASD) is a neurodevelopmental disorder that is characterized by sustained social impairments in reciprocal social communication and interactions as well as repetitive behaviors, interests or activities (American Psychiatric Association, 2022). Patients with ASD may experience co-occurring conditions like anxiety, depression and sleep problems. Cannabis is hypothesized to aid patients with these conditions and reduce behavioral symptoms.

Objective

This report aims to investigate patient experience in Minnesota's medical cannabis program among patients qualified for ASD. Patient experience includes medical cannabis product purchasing, standard eight symptom improvement, adverse side effects, and improvement in behavioral symptoms in a subset of patients.

Methods

This report includes patients who enrolled for the first time between Aug. 1, 2018, and July 31, 2024, listing ASD as a qualifying condition. Data used in this report come from patient certification information, medical cannabis purchasing records and the patient self-evaluation (PSE). During the timeframe covered in this report, Minnesota patients were required to fill out a PSE before each medical cannabis purchase. The PSE asks patients to rate their experience of eight standard symptoms during the prior 24 hours, on a severity scale from 0 to 10. The standard eight symptoms include anxiety, lack of appetite, depression, disturbed sleep, fatigue, nausea, pain, and vomiting. In this report, a $\geq 30\%$ decrease in symptom score from baseline score was considered a clinically significant change. The PSE also asks patients to report any adverse side effects and rate their severity.

In addition to the standard eight symptoms, patients under the age of 26 were asked to complete the Aberrant Behavior Checklist Second Edition (ABC-2), a questionnaire indicating the presence and severity of behaviors associated with ASD. The ABC-2 measures behaviors in the following domains: irritability, hyperactivity, lethargy, repetitive behaviors and inappropriate speech. Unlike the PSE, it was optional to take the ABC-2 questionnaire. Program enrollment and 10-week follow-up ABC-2 scores were compared to investigate changes in behaviors after starting medical cannabis.

Results

A total of 1,811 first-time patients enrolled in Minnesota's medical cannabis program and listed ASD as a qualifying condition between Aug. 1, 2018, and July 31, 2024. Of these enrolled patients, 90.8% (n = 1,645) purchased medical cannabis. This report focuses on patients who made at least one medical cannabis purchase.

Almost three-quarters of this cohort self-identified as male (n = 1,189; 72.3%) compared to female (n = 393; 23.9%). The average age of patients at program enrollment was 20 years (standard deviation: 11.8 years). More than three-quarters of patients self-identified as white (n = 1,227; 77.6%), followed by two or more races (n = 122; 7.4%).

Anxiety was the most common symptom reported among patients, with 88.3% reporting moderate to severe scores at program enrollment (score ≥ 4). Among these patients, 34.3% were able to reduce their anxiety score by $\geq 30\%$ within four months of starting medical cannabis and maintain that reduction for an additional four months. Patients also reported similar improvements in disturbed sleep (37.3%), fatigue (34.4%), and depression (41.3%) scores.

In analyses using the ABC-2 questionnaire, 46 patients completed both the baseline and 10-week follow-up ABC-2 questionnaires. Among these patients, there was a statistically significant (p-value < 0.05) decrease in scores in all domains between baseline and follow-up. A decrease in ABC-2 score corresponds to decreased presence and/or severity of behaviors in a given domain. These results are from a very small sub-sample (3.9%) of the eligible patient population and may be overrepresented by patients who saw benefit from medical cannabis.

The above analyses of patient benefits after using medical cannabis do not compare to a control group of patients not using medical cannabis, and do not account for other treatments used by patients. More research is needed to investigate medical cannabis and autism spectrum disorder.

The law restricts purchase of medical cannabis flower products to patients over the age of 21. Patients under 18 years old must have a parent or legal guardian purchase medical cannabis products on their behalf. Medical cannabis purchasing data were analyzed for each patient during their first year in the program. This included 18,102 sales transactions, consisting of 47,071 products purchased. Products are classified by their route of administration (how a product enters the body) and THC and CBD content. For patients under the age of 18, the most common route of administration for purchased products was enteral, which are eaten or swallowed and absorbed through the gastrointestinal tract. Products in this category include pills, capsules, gummies, and oral solutions and account for 85.3% of all products purchased for that age group. For patients over the age of 18, inhalation products like cannabis flower and vaping products were the most commonly purchased, accounting for 68% of all products purchased by that age group. Patients under the age of 18 mainly purchased balanced or high CBD:THC products, while adult patients purchased high THC:CBD products.

Only 20% of patients reported an adverse side effect on their PSE. More than half reported one unique side effect (59.8%), with 89.7% reporting three or fewer unique side effects within their first year of medical cannabis purchases. Almost three-quarters of side effects reported were mild (n = 926; 72.6%), and the most commonly reported side effect was dry mouth. Only 5.8% of reported side effects were severe, and the most commonly reported severe side effect was anxiety. *The PSE may not capture all severe adverse side effects.*

Conclusions

Medical cannabis patients qualified for ASD reported reduced anxiety and a sub-set of patients reported reduced presence/severity of behavioral symptoms after starting medical cannabis. However, since all patients utilized medical cannabis, this report cannot compare the effectiveness in symptom relief to a control or placebo group. More research is needed to further elucidate this relationship.

This report informs patients, health care practitioners, and other citizens of Minnesota on the reported impact of medical cannabis on patients with ASD. Additionally, this report adds to the scientific literature and knowledge base on medical cannabis and may be used by lawmakers to make policy decisions.

1. Introduction

In May 2014, Minnesota became the 23rd state to create a medical cannabis program. Distribution of cannabis products to qualified enrolled patients began July 1, 2015. Patients are enrolled in state's medical cannabis program through a health care practitioner who certifies their qualifying medical condition. Once in the program, patients work with medical cannabis pharmacists and certified medical cannabis consultants at the medical cannabis dispensary to determine a route of administration and dose that works for their symptoms.

Minnesota's medical cannabis program is distinct from those in nearly all other states because the Office of Cannabis Management is required to study and learn from the experience of participants.

Minnesota's online registry integrates information from patients, certifying health care practitioners and manufacturers, and continuously captures program data. Data elements from the registry have been selected to create a de-identified research dataset for reporting and research. This report draws on aspects of that research dataset to describe the experience of patients newly enrolled in the program for autism spectrum disorder between Aug. 1, 2018, and July 31, 2024, which were the first six years that autism spectrum disorder was recognized as a qualifying condition for Minnesota's medical cannabis program.

Autism spectrum disorder (ASD) is a neurodevelopmental disorder that is characterized by sustained social impairments in reciprocal social communication and interactions; and repetitive behaviors, interests, or activities (American Psychiatric Association, 2022). These core symptoms of ASD present in early childhood and limit everyday functioning (American Psychiatric Association, 2022). The word "spectrum" is used to define ASD since the disorder manifests itself in diverse ways, depending on varying symptom severity, the individual's developmental level, and chronological age (American Psychiatric Association, 2022). The Diagnosis and Statistical Manual of Mental Disorders, Fifth Edition, Text Revision (DSM-5-TR) is the 2022 update to the American Psychiatric Association's classification and diagnostic tool. In the U.S., the DSM serves as the primary authority for psychiatric diagnosis. Several disorders have been incorporated into the DSM definition of ASD—Kanner's autism and Asperger's disorder, among others (American Psychiatric Association, 2022). To be diagnosed with ASD, a person needs to fulfill the following criteria (American Psychiatric Association, 2022):

1. Persistent deficits in social communication and interaction across multiple contexts, as manifested by all of the following:
 - a. Deficits in social-emotional reciprocity, ranging, for example, from abnormal social approach and inability to have normal back-and-forth conversation; to reduced sharing of interests, emotions, or affect; to failure to initiate or respond to social interactions.
 - b. Deficits in nonverbal communicative behaviors used for social interaction, ranging, for example, from poorly integrated verbal and nonverbal communication; to abnormalities in eye contact and body language or deficits in understanding and use of gestures; to a total lack of facial expressions and nonverbal communication.
 - c. Deficits in developing, maintaining, and understanding relationships, ranging, for example, from difficulties adjusting behavior to suit various social contexts; to difficulties in sharing imaginative play or in making friends; to absence of interest in peers.
 - d. Note: These criteria can be currently occurring or have occurred in the patient's past. Examples are illustrative, not exhaustive.
2. Restricted, repetitive patterns of behavior, interests, or activities, as manifested by at least two of the following:
 - a. Stereotyped or repetitive motor movements, use of objects, or speech (e.g., repetitive hand flapping, lining up toys or flipping objects, delayed or immediate parroting of others' speech, idiosyncratic phrases).
 - b. Insistence on sameness, inflexible adherence to routines, or ritualized patterns of verbal or nonverbal behavior (e.g., extreme distress at small changes, difficulties with transitions, rigid thinking patterns, greeting rituals, need to take same route or eat same food every day).
 - c. Highly restricted, fixated interests that are abnormal in intensity or focus (e.g., a child who is extremely attached to a spoon, an adult who spends hours rewriting specific phrases).
 - d. Extremely exaggerated or dulled reactions to sensations or unusual interest in sensory aspects of the environment (e.g., apparent indifference to pain/temperature, adverse response to specific sounds or textures, excessive smelling or touching of objects, visual fascination with lights or movement).
 - e. Note: These criteria can be currently occurring or have occurred in the patient's past. Examples are illustrative, not exhaustive.
3. Symptoms must be present in the early developmental period. Though, symptoms may not become fully apparent until social demands exceed limited capacities. Symptoms may also be masked by learned strategies in later life.
4. Symptoms cause clinically significant impairment in social, occupational, or other important areas of current functioning.
 - a. These disturbances are not better explained by intellectual disability (intellectual developmental disorder) or global developmental delay. Intellectual disability and ASD frequently co-occur. Social communication should be below what is expected for general developmental level, in order to make comorbid diagnoses of ASD and intellectual disability.

Cannabis and autism spectrum disorder

The endocannabinoid system, comprised of endogenous (produced in the body) cannabinoids, regulates nerve cells and may play a role in behavioral functioning (Holdman et al., 2022; Karhson et al., 2018). Recent studies investigating the endocannabinoid system found children with autism spectrum disorder have lower levels of some endogenous cannabinoids compared to neurotypical children (Aran, Eylon, et al., 2019; Karhson et al., 2018). This difference in endogenous cannabinoids is the basis for using cannabis as a therapeutic agent for patients with ASD. Cannabis is hypothesized to aid those with ASD by reducing behavioral symptoms, hyperactivity, sleep problems, and anxiety.

Few clinical trials using cannabinoids as a therapeutic agent in patients with ASD have been published. The vast majority of these studies are conducted with pediatric patients using either a high CBD ratio or CBD-only therapeutic agent. One randomized trial in children and adolescents found patients treated with high CBD (with a 20:1 ratio of CBD to THC) whole-plant extract had improved disruptive behavior scores compared to placebo treatment (Aran et al., 2021). However, total scores for the Home Situation Questionnaire-ASD, a scale measuring noncompliant behavior, were not different between treatment and placebo (Aran et al., 2021). Another randomized control trial using the same CBD-dominant treatment to investigate the effects of cannabinoids and sleep in children with ASD did not find a difference in child sleep-habit questionnaire scores between treatment and placebo (Schnapp et al., 2022). In another randomized control trial among children 5 to 11 years old using a 9:1 CBD:THC treatment, researchers found significant results for social interaction, psychomotor agitation, anxiety, number of meals in a day, and concentration after 12 weeks (Silva et al., 2024). A double-blind clinical trial of boys with autism spectrum disorder found Epidiolex (a plant-derived CBD treatment) was not effective in reducing a broad range of behaviors compared to placebo. They additionally noted that there was a strong placebo effect in this study (Trauner et al., 2025).

Other studies investigating the effects of cannabis on behavioral symptoms in patients with ASD have been published, though these studies do not compare to a placebo control group. One such study in children with ASD treated with CBD found a decrease in self-injury and rage attacks, hyperactivity symptoms, and sleep problems in a majority of patients after treatment (Barchel et al., 2019). Another study found after treatment with CBD-dominant cannabis, behavior outbreaks were improved in 61% of patients (Aran, Cassuto, et al., 2019).

There are few studies conducted in medical cannabis patients with ASD. One study of 74 patients in the United Kingdom Medical Cannabis Registry found significant improvement in general health-related quality of life and sleep one month and again three months after beginning medical cannabis treatment (Erridge et al., 2022). Sustained changes in quality of life and sleep were observed at six months (Erridge et al., 2022). A follow-up study conducted on these patients enrolled in the United Kingdom Medical Cannabis Registry found cannabis-based medical product use was associated with improvements in anxiety, sleep, and health-related quality of life 18 months after starting treatment (Aggarwal et al., 2026).

Overall, existing data investigating the effects of cannabis on autism spectrum disorder are limited, with some studies suggesting there may be some benefit to using cannabis in treating ASD-related symptoms and behaviors.

2. Description of patients enrolled

Qualifying condition

Between Aug. 1, 2018, and July 31, 2024, 1,811 patients enrolled in Minnesota’s medical cannabis program with autism spectrum disorder (ASD) as a qualifying condition. Follow-up data were gathered on the enrollees who registered by July 31, 2024, until a year later, July 31, 2025, for this study. Of those that enrolled in the program, 90.8% (n = 1,645) purchased medical cannabis. This report focuses on these patients.

Additional qualifying conditions

Patients may enroll in Minnesota’s medical cannabis program with multiple qualifying conditions; 18.4% (n = 302) of enrolled patients with ASD reported additional qualifying conditions. Most commonly, post-traumatic stress disorder (9.9%; n = 163), chronic or intractable pain (5.0%; n = 83), and seizures (3.2%; n = 53) (Table 2.1) were indicated along with ASD.

Table 2.1. Count of additional qualifying conditions

Additional qualifying conditions	n (number of patients)	% of patients
Post-traumatic stress disorder	163	9.9%
Chronic or intractable pain	83	5.0%
Seizures	53	3.2%
Tourette syndrome	20	1.2%
Severe and persistent muscle spasms	19	1.2%
Obstructive sleep apnea	19	1.2%
Other condition	26	1.6%

Gender and age

Almost three-quarters of patients who enrolled under the ASD qualification identified as male (72.3%; n = 1,189), compared to female (23.9%; n = 393), while 3.8% (n = 63) preferred not to answer. This 3:1 male to female gender ratio is seen across studies in patients with ASD. The gender disparity we see in patients is due, in part, to the difficulty in identifying ASD in females (Loomes et al., 2017; Shaw et al., 2025). In the overall medical patient registry, 53% of patients identify as male (*Minnesota Medical Cannabis Dashboard*, 2024).

The average age of patients at enrollment was 20 years old (standard deviation: 11.8 years). The youngest patient was 2 years old, while the oldest was 75 years old at enrollment (Figure 2.2, Figure 2.3). Patients qualified for ASD are younger, on average, compared to the overall medical cannabis patient population. The average age in the overall patient population is 45.7 years old (*Minnesota Medical Cannabis Dashboard*, 2024).

Figure 2.2. Age and gender distribution of patients

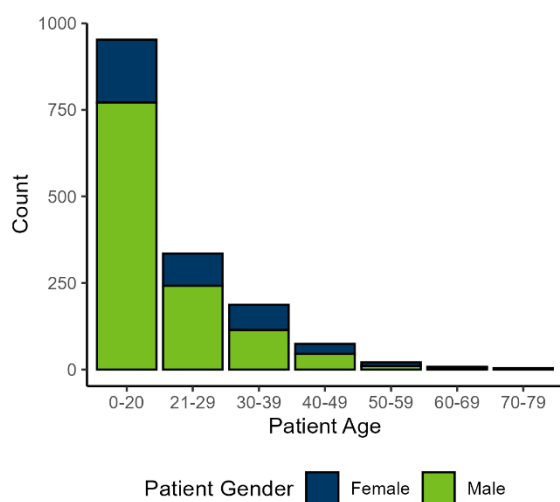
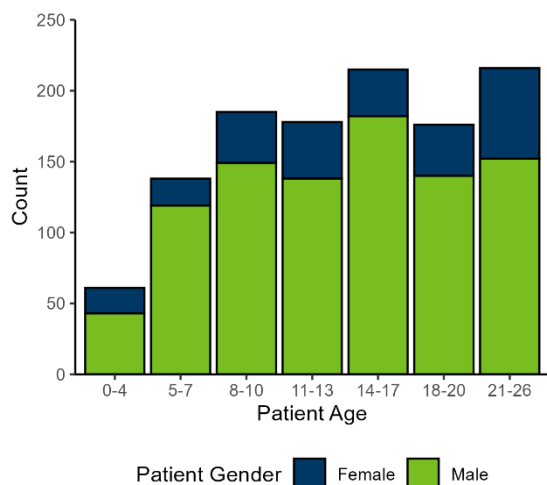


Figure 2.3. Age distribution of patients under the age of 26 at enrollment



Race and ethnicity

Patients with ASD identified primarily as white (77.6%; n = 1,227), followed by two or more races (7.4%; n = 122); Black, African, or African American (5.4%; n = 89); Asian (2.4%; n = 39); and American Indian or Alaska Native (0.8%; n = 13). About 5% (5.5%; n = 91) identified as Hispanic ethnicity (Table 2.2). The race breakdown of patients qualified with ASD is similar to the overall Medical Cannabis Registry (*Minnesota Medical Cannabis Dashboard, 2024*).

Table 2.2. Demographic characteristics of patients. A) Gender. B) Race. C) Ethnicity.

A) Gender characteristics of patients

Gender	n (number of patients)	% (percent of patients)
Male	1,189	72.3%
Female	393	23.9%
Prefer not to answer	63	3.8%
Total	1,645	100%

B) Race characteristics of patients

Race	n (number of patients)	% (percent of patients)
White	1,277	77.6%
Black, African, or African American	89	5.4%
American Indian or Alaska Native	13	0.8%
Asian	39	2.4%
Hawaiian or other Pacific Islander	2	0.1%
Two or more races	122	7.4%
Other race	21	1.3%
No answer or unknown	76	4.6%
Total	1,645	100%

C) Ethnicity characteristics of patients

Ethnicity	n (number of patients)	% (percent of patients)
Hispanic	91	5.5%
Non-Hispanic	1,492	90.7%
No answer or unknown	56	3.4%
Total	1,645	100%

Geographic distribution

When registering for Minnesota's medical cannabis program, patients provide their home address to verify Minnesota residency. The general geographic distribution of patients was examined using patient-reported ZIP codes; the first three digits of ZIP codes compose a prefix which corresponds to an approximate geographic region. The U.S. Postal Service assigns to each prefix labels that match the major city within the region and approximate surrounding cities; these region labels are shown in Table 2.3, along with the count of patients living in the corresponding ZIP codes. The majority of patients with ASD are located in the Twin Cities metro ZIP region: 41.2% in Minneapolis, 30.7% in St. Paul, 5.8% in the Duluth region, 5.1% in the St. Cloud region, 4.7% in the Rochester region, and 4.3% in the Mankato region (Table 2.3).

Table 2.3. Patients by ZIP code region (first three number prefixes).

ZIP code region	ZIP code prefixes	Count (%)
St. Paul	550, 551	505 (30.7)
Minneapolis	553, 554, 555	678 (41.2)
Duluth	556, 557, 558	95 (5.8)
Rochester	559	78 (4.7)
Mankato	560, 561	71 (4.3)
Willmar	562	26 (1.6)
St. Cloud	563	84 (5.1)
Brainerd	564	40 (2.4)
Detroit Lakes, Bemidji, Grand Forks	565, 566, 567	61 (3.6)

3. Medical cannabis use patterns

There is no standard medical cannabis treatment for symptoms and co-occurring conditions associated with ASD. Health care practitioners, medical cannabis pharmacists, or medical cannabis consultants may recommend routes of administration (ROA) (inhalation, enteral, oromucosal, or topical) or dosage, but ultimately, it is the patient (or patient's legal guardian) who decides what product to purchase. It is advised to "start low and go slow," meaning patients are advised to start with a low dose of cannabinoids (e.g., THC and CBD) and increase slowly as needed to address symptoms.

Flower products (i.e., cannabis flower or prerolls) are not available to patients under the age of 21. Additionally, patients under the age of 18 must have a parent or legal guardian purchase and pick up their medical cannabis. For patients under 18, all medical cannabis purchasing decisions are made by the patient's parent or legal guardian. Patients aged 18 to 20 can buy medical cannabis for themselves, except for flower products.

Patients do not report how they use medical cannabis to the medical cannabis program. Therefore, the program does not have data on frequency of use or quantity used per use. This report will describe medical cannabis products purchased by patients from licensed medical cannabis dispensaries.

Description of purchased products

Purchasing data for medical cannabis are captured by Minnesota's medical cannabis program. For this report, purchasing data were extracted for all patients qualified for ASD enrolled for the first time between Aug. 1, 2018, and July 31, 2024. Purchasing data analysis in this report describes all purchases made within their first year in the program. The query provided a dataset of:

- 18,102 sales transactions
- 47,071 products purchased
- 1,645 patients represented

Products included in this dataset were categorized according to their ROA (descriptions below, Box 3.1) and the ratio of THC to CBD contained in the product. THC:CBD ratios ranged from products very high in THC to CBD to those very high in CBD to THC, as well as everything in between. As of this report, products that include raw cannabis flower (e.g., ground flower, flower, preroll products) do not include THC or CBD concentration in milligrams and cannot be classified by THC:CBD ratio in the same way as other products. Instead, they are classified according to relative values of THC and CBD by percent of product weight.

Box 3.1. Categories to describe medical cannabis products purchased by patients

Medical cannabis products categorized by THC:CBD content ratio:

- **Very high THC to CBD:** 100:1 or higher
- **High THC to CBD:** > 4:1 up to 99:1
- **Balanced:** 1:1 up to 4:1
- **High CBD to THC:** ≥ 1:1 up to 99:1
- **Very high CBD to THC:** 100:1 or higher

Medical cannabis flower products categorized by relative values of THC and CBD (values measured as % of product weight):

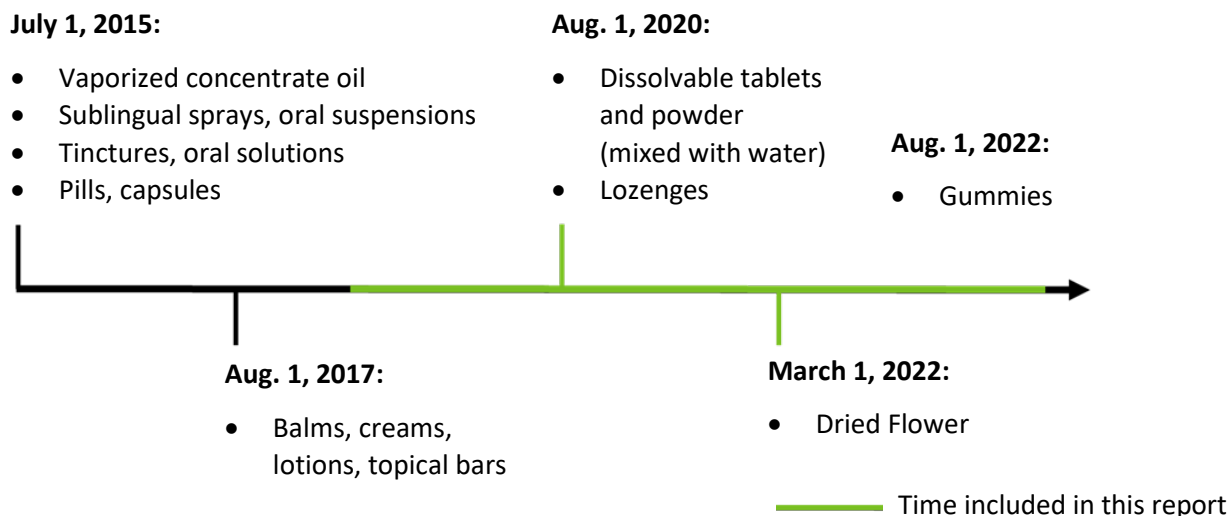
- **High THC:** > 15%
- **Medium THC:** 5 to 15%
- **Low THC:** < 5%
- **High CBD:** > 10%
- **Medium CBD:** 1 to 10%
- **Low CBD:** < 1% or trace amount

Product routes of administration (ROA):

- **Enteral:** Entry through the gastrointestinal tract via swallowing (i.e., capsules, oral solutions)
- **Inhalation:** Entry through lungs (i.e., vaporized oils, smoked flower)
- **Oromucosal:** Absorbed through cheek/oral mucosa (i.e., sublingual sprays and tinctures)
- **Topical:** Applied to body surface (i.e., balms)

Product delivery methods available through Minnesota’s medical cannabis program are decided on by the Office of Cannabis Management through a petition process. Cannabis product availability has evolved throughout the time covered by this report. A timeline of product availability is shown in Figure 3.1.

Figure 3.1. Timeline of product availability in Minnesota’s medical cannabis program

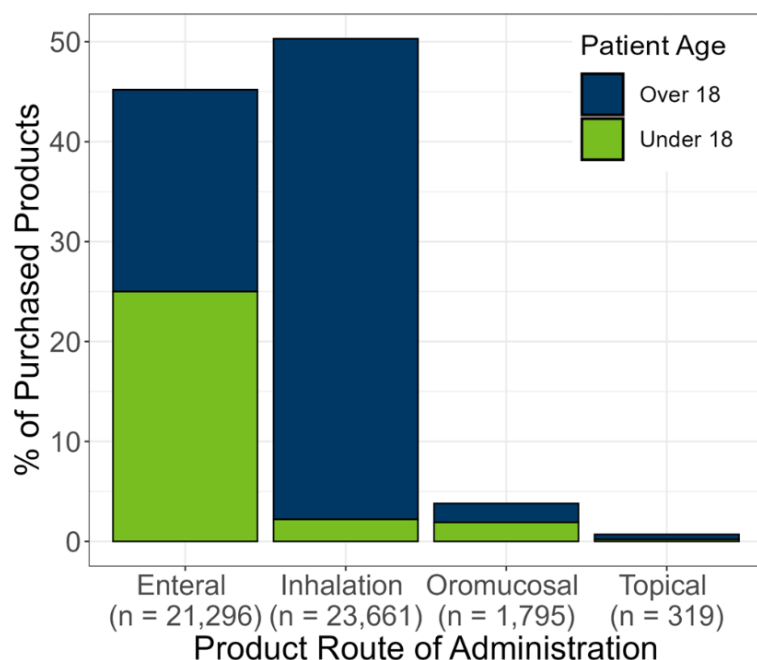


In Minnesota's medical cannabis program, patients under the age of 18 cannot purchase medical cannabis products. Instead, a parent or legal guardian must purchase products on their behalf. Additionally, patients under the age of 21 cannot purchase dried flower products. Among patients with ASD, 47.7% (n = 785) were under the age of 18 at enrollment. These patients account for less than one-third of products purchased (n = 13,799; 29.3%).

Route of administration (ROA)

Analysis of medical cannabis products are by ROA and THC:CBD ratio as defined in Box 3.1. Half of all products purchased were inhalation products (n = 23,661; 50.3%), followed by enteral products (n = 21,296; 45.2%). Nearly 5% of all products purchased were oromucosal (n = 1,795; 3.6%), or topical (n = 319; 0.7%) (Figure 3.2). Among patients under 18 years old, enteral products were the most commonly purchased, accounting for 85.3% (n = 11,766) of all products purchased for that age group. For patients over the age of 18, inhalation products were the most commonly purchased (22,640; 68.0%) (Figure 3.2).

Figure 3.2. Product transactions categorized by product's intended route of administration and patient age



THC:CBD ratio

Enteral products

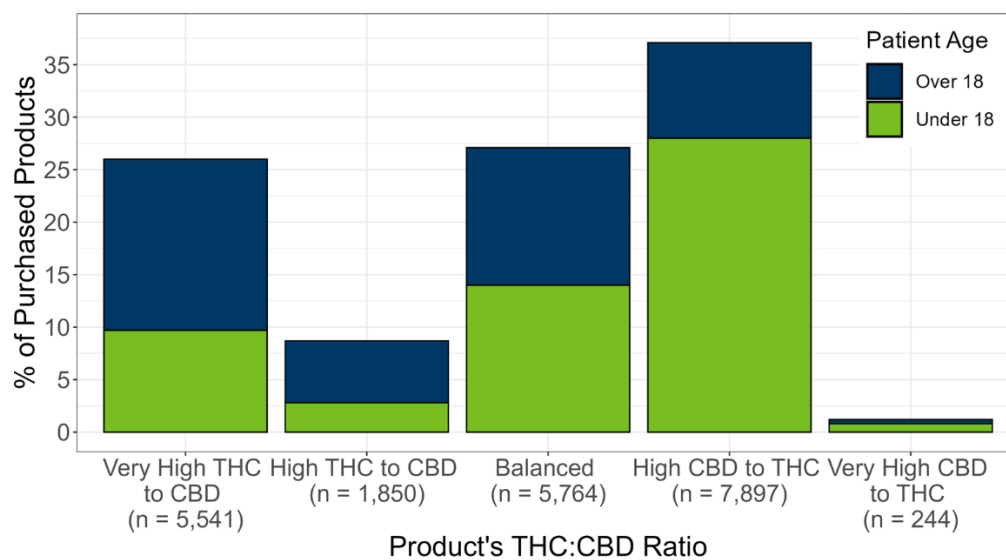
Oral solutions were the most popular enteral products, accounting for 41.1% of all enteral products purchased. The next most popular products were tablets and capsules (39.6%), and gummies and chews (19.0%). Patients under 18 years old primarily purchased oral solutions or suspensions and capsules or tablets, while patients over 18 primarily purchased capsules or tablets and gummies or chews (Table 3.1).

Patients under the age of 18 primarily purchased high CBD to THC (52.1%) or balanced (25.3%) enteral products. Only 22.6% of enteral products purchased by patients under the age of 18 were high or very high THC to CBD. Patients over the age of 18 purchased more high or very high THC to CBD products (49.6%) (Figure 3.3).

Table 3.1. Number and proportion of enteral product purchases by product type and patient age. Proportions shown are column proportions.

Product type	Under 18 years old	Over 18 years old	Total
Capsule or tablet	3,854 (32.8%)	4,578 (48%)	8,432 (39.6%)
Edible oil (RSO oil)	0 (0%)	48 (0.5%)	48 (0.2%)
Gummy or chew	1,192 (10.1%)	2,862 (30.0%)	4,055 (19.0%)
Oral solution/suspension	6,720 (57.1%)	2,041 (21.4%)	8,761 (41.1%)
Total	11,766 (100%)	9,529 (100%)	21,296 (100%)

Figure 3.3. Enteral product transactions categorized by product's THC:CBD ratio and patient age



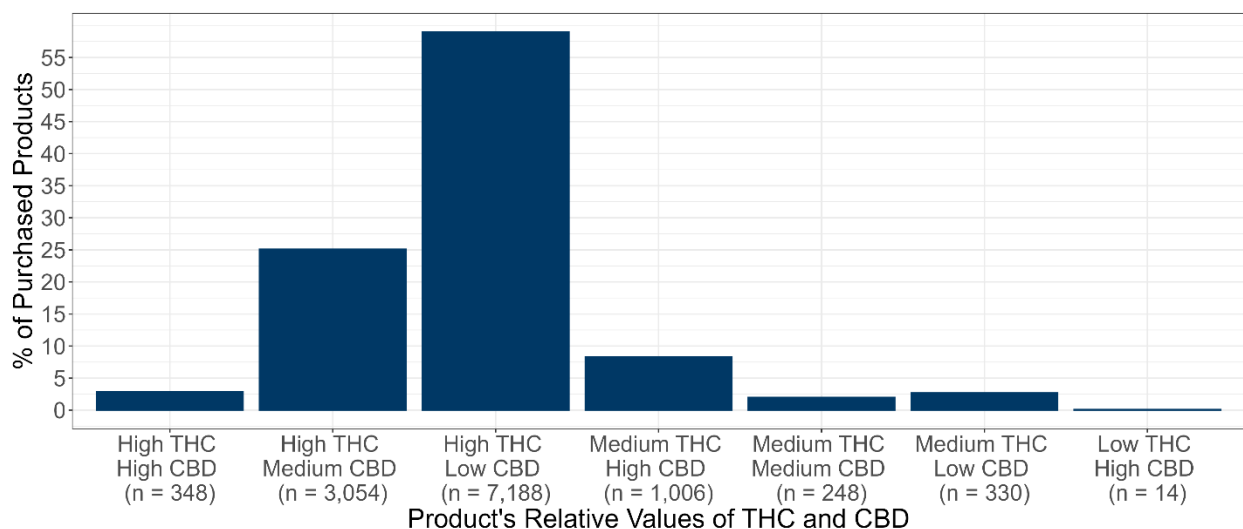
Inhalation products

Inhalation products sold in Minnesota's medical cannabis program fall into two groups: flower products and vaporization products. Dried flower products were added as an approved delivery method March 1, 2022 (Figure 3.1) and make up 51.5% of all inhalation products purchased by patients with ASD. Flower products are not available for patients under 21 years old. Flower products purchased include flower (73.1%) and prerolls (26.9%).

Manufacturers do not report milligrams of THC and CBD in their flower products; instead, they report an approximate percentage of THC and CBD by product weight. Therefore, these products could not be categorized by THC:CBD ratio and are instead categorized by relative values of THC and CBD (Box 3.1).

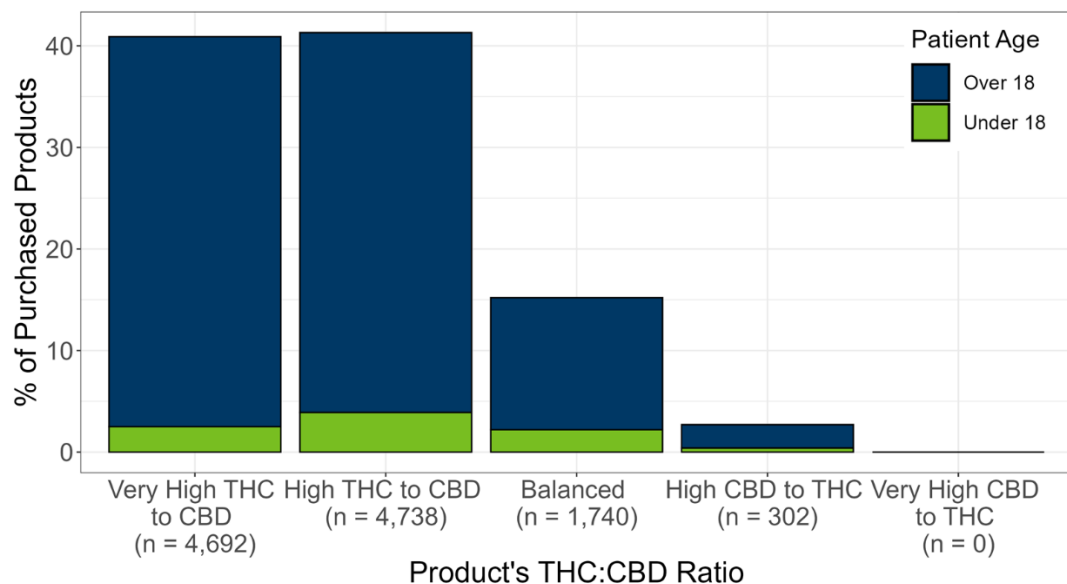
A majority of flower products purchased had high THC/low CBD (59.0%), followed by high THC/medium CBD (25.1%) and medium THC/high CBD (8.3%) products (Figure 3.4).

Figure 3.4. Inhalation flower product transactions organized by relative values of the THC and CBD



Patients over 18 years old account for 91.0% of all vaporization product purchases. Among vaporization products, high THC:CBD ratio products were most commonly purchased (n = 4,738; 41.3%), closely followed by very high THC:CBD (n = 4,692; 40.9%), and balanced THC:CBD products (n = 1,740; 15.2%). Only 2.6% (n = 302) vaporization products purchased were high CBD:THC. Trends were similar between patients over and under the age of 18 (Figure 3.5).

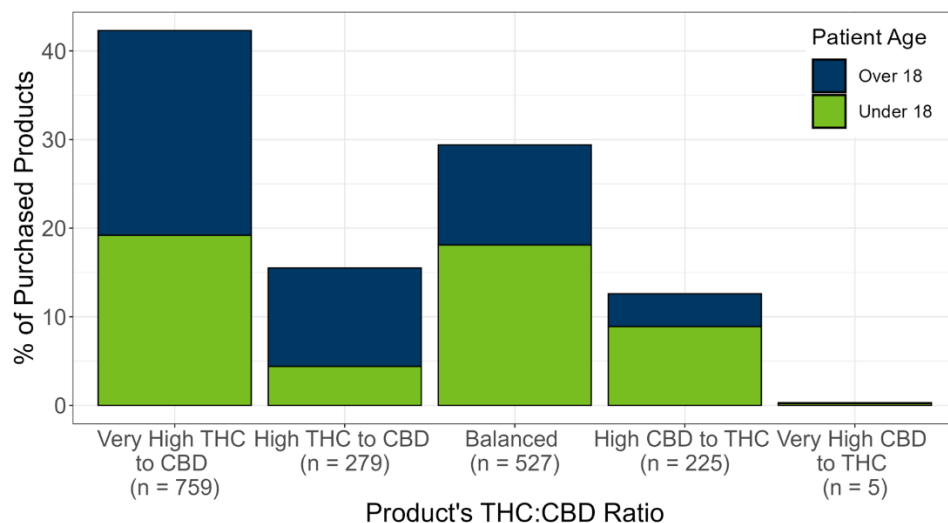
Figure 3.5. Inhalation vaporization product transactions organized by product's THC:CBD ratio and patient age



Oromucosal products

Patients under 18 years purchased half of all oromucosal products (50.8%). Oromucosal products include lozenges (16.0%), sublingual sprays (67.4%), and tinctures (16.5%). A majority of oromucosal products were very high THC:CBD ratio (42.3%), followed by balanced THC:CBD ratio (29.4%) and high THC:CBD ratio (15.5%) products. Majority CBD products made up 12.8% of all oromucosal sales (Figure 3.6).

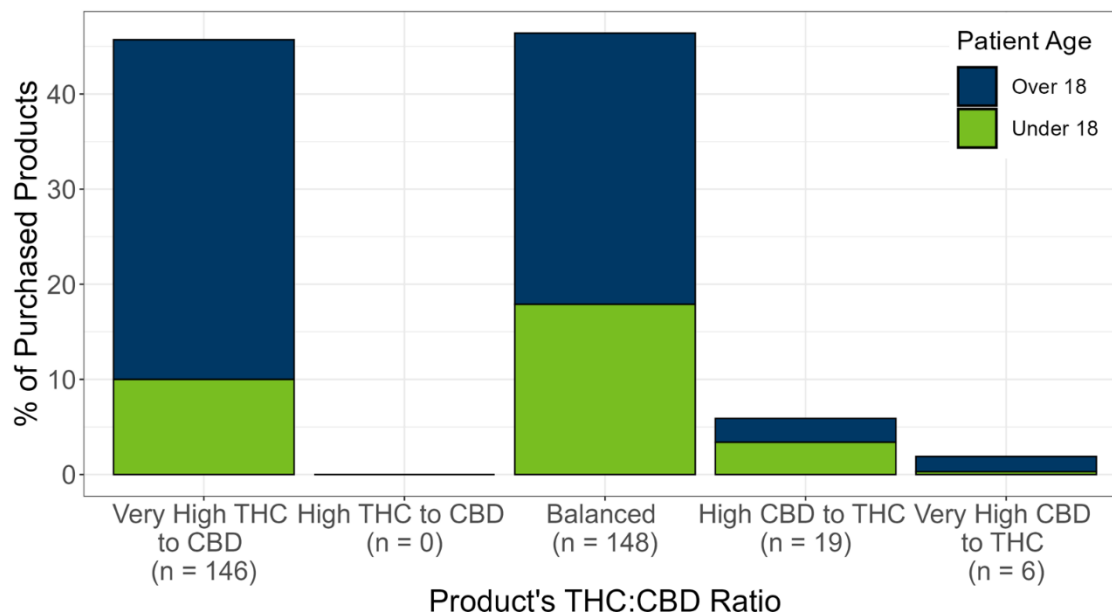
Figure 3.6. Oromucosal product transactions categorized by product's THC:CBD ratio and patient age



Topical products

Topical medical cannabis products, which constitute fewer than 1% of all products purchased, include balms (43.6%), bars (15.7%), and gel creams (40.8%). Patients over 18 years old purchase 68.3% of all topical products. Almost half of purchased topical products had a very high THC:CBD ratio (49.3%), followed by balanced products (44.4%). Majority CBD products accounted for 6.3% of all topical products purchased (Figure 3.7).

Figure 3.7. Topical product transactions categorized by product's THC:CBD ratio and patient age



4. Benefits

Benefit received from medical cannabis

During the timeframe covered in this study, all patients enrolled in Minnesota's medical cannabis program must complete a patient self-evaluation (PSE) before each medical cannabis purchase. The PSE asks patients about their symptoms and concerns about medical cannabis to facilitate a discussion with their medical cannabis pharmacist or medical cannabis consultant before making their next purchase. Patients are also asked in the PSE about new medications, a set of eight standard symptoms, side effects, and any perceived benefits from using medical cannabis.

Below are a sample of quotes from patients qualified for ASD and caregivers in Minnesota's medical cannabis program when asked about the benefits of medical cannabis.

- *"Medical cannabis has helped me deal with so many aspects of my disorder. From being able to eat food in the morning without being sick to being an addition to therapy and the like."*
- *"It feels like my autistic anxiety has calmed down a bit. It helps me sleep a little better. Numbs the depression pain a little."*
- *"[Patient] seems happier, smiles more and will engage in an activity more easily."*

- “Decrease in anxiety, decrease in aggressive behavior, decrease in self-injurious behavior, sleeping much better, decrease in seizures, better appetite.”
- “Medical cannabis has eased social anxiety as well as anxiety that I have in the workplace. It has allowed me to be a better student, friend and employee to my peers.”

Standard eight symptoms

As part of the PSE, all patients, regardless of their certified condition(s), receive a set of eight symptom questions which are answered on a 0 – 10 numerical rating scale (NRS), with zero indicating absence of the symptom and 10 indicating that the symptom is as bad as the patient can imagine (see Box 4.1). Therefore, higher scores indicate greater symptom severity. Scores greater than or equal to four indicate moderate to severe symptoms. Patients are asked to rate their symptom severity over the *past 24 hours*.

Box 4.1. Listing of the standard eight symptom measures that all patients answer, including the response options available to patients.

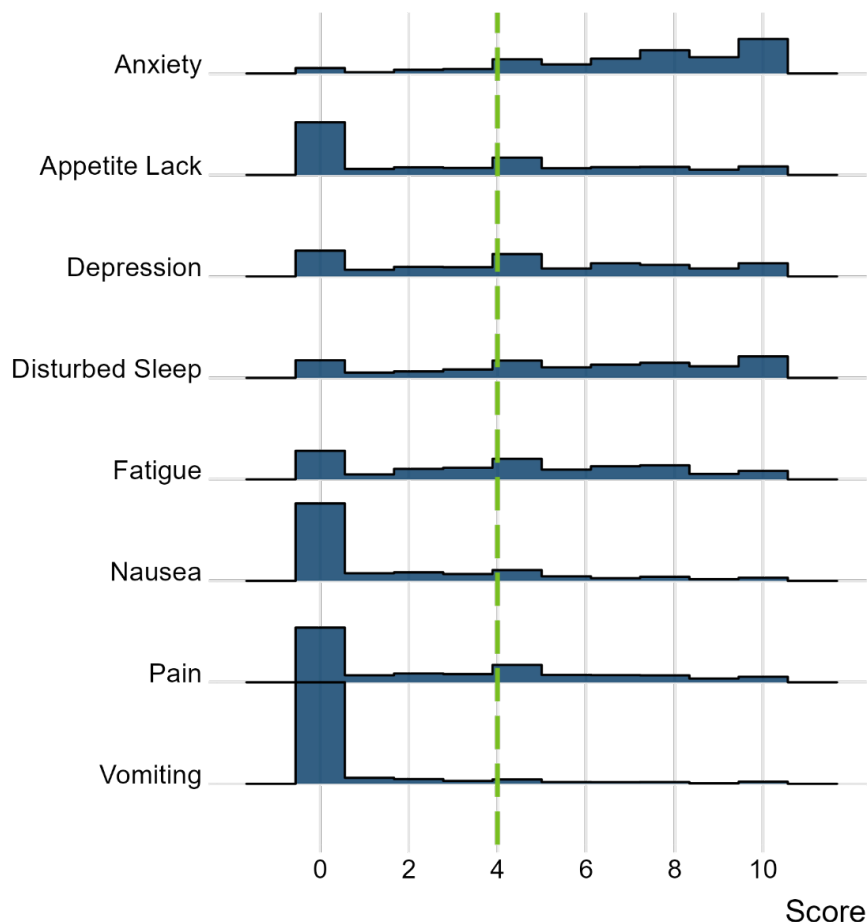
Standard eight symptom measures:											
• Anxiety										• Fatigue	
• Lack of appetite										• Nausea	
• Depression										• Pain	
• Disturbed sleep										• Vomiting	
Response options (0 – 10 NRS):											
0	1	2	3	4	5	6	7	8	9	10	
Symptom not present										Symptom as bad as one can imagine	

The threshold of $\geq 30\%$ reduction on a scale from 0 – 10 was chosen for the standard eight symptoms because this threshold has been documented in clinical trials to represent clinically meaningful change—especially for pain reduction. Examples of $\geq 30\%$ change include moving from a score of 10 to a score of 7, from 9 to 6, from 8 to 5, from 7 to 4, etc.

Symptoms at enrollment in Minnesota’s medical cannabis program

At enrollment, 1,450 (88.3%) of patients qualified for ASD reported experiencing moderate to severe anxiety (Table 4.1). The average anxiety score at enrollment was 7.28 (standard deviation: 2.74) (Table A1, in the Appendix). The next most common symptoms with moderate to severe scores were disturbed sleep (70.2%; $n = 1,154$), depression (59.8%; $n = 982$), and fatigue (56.2%; $n = 924$) (Table 4.1). Average scores for all standard eight symptoms are found in Table A1. There were some differences in symptom scores at enrollment between pediatric and adult patients. Adult patients (over 18 years old) reported higher scores (worse severity) for lack of appetite, depression, fatigue, nausea, pain, and vomiting, compared to patients under 18 at enrollment. However, anxiety and disturbed sleep scores at baseline were similar between age groups (Table A1).

Figure 4.1. Distribution of standard eight symptom scores at enrollment. A score of four or greater indicates that the symptom is of moderate to severe intensity.



Changes in symptoms

Among all patients with ASD with moderate to severe anxiety at baseline, 57.0% (n = 826) reported a $\geq 30\%$ reduction in anxiety score within four months of first medical cannabis purchase (Table 4.1A). Among those patients who reported a $\geq 30\%$ reduction in anxiety score, 67.4% (n = 498) maintained that improvement for at least four months after initial improvement (Table 4.1A). Overall, 34.3% of patients with moderate to severe anxiety score were able to achieve and maintain $\geq 30\%$ reduction in anxiety score (Table 4.1A). Similarly, 37.3% of patients with moderate to severe disturbed sleep scores and 34.4% of patients with moderate to severe fatigue were able to achieve and maintain $\geq 30\%$ reduction in baseline scores (Table 4.1A). Depression scores saw greater improvement. Among all patients with moderate to severe depression score at baseline, 63.4% (n = 623) reported $\geq 30\%$ reduction in depression score within four months of first medical cannabis purchase (Table 4.1A). Among all patients who saw improvement in depression score, 73.7% (n = 406) were able to maintain that improvement for at least four months after initial improvement (Table 4.1A). Overall, 42.9% of patients with moderate to severe depression score were able to achieve and maintain $\geq 30\%$ reduction in depression score (Table 4.1A).

Proportions of patients able to achieve and maintain $\geq 30\%$ reduction in symptom scores were similar between pediatric and adult patients for anxiety (33.5% vs 35.1%), depression (41.3% vs 41.4%), and fatigue (35.3% vs 33.9%) (Table 4.1B-C). A higher proportion of adult patients were able to achieve and maintain $\geq 30\%$ reduction in baseline disturbed sleep score at 40.2%, compared to 34.1% of pediatric patients (Table 4.1B-C).

In summary, a proportion of patients qualified for ASD report to have reached clinically meaningful improvements in various symptoms, some of which are commonly reported in this population such as anxiety, depression, and sleep disturbances. These observations, however, are tempered by some limitations. One limitation observed in this population is that many patients are under 18 years old and therefore a parent or other adult may be filling out the PSE on their behalf. These PSE data are a mix of third-party reporting and self-reporting of symptom intensity. Another limitation is the lack of information about other medications and treatments patients are using. These results on symptom changes assume medical cannabis treatment is the only change over the study period, which may not be the case.

Time in the medical cannabis program

Proportions of patients achieving and maintaining symptom relief discussed above are based on the number of patients at baseline. This is a conservative estimate of symptom relief as it assumes no loss to follow-up in the eight months after first medical cannabis purchase. Among all patients qualified for ASD, 7.4% ($n = 122$) only purchased medical cannabis one time. More than two-thirds (68.5%; $n = 1,125$) of patients purchased medical cannabis for more than eight months, which is the length of follow-up time in this report (Table 4.2). Length of participation in the medical cannabis program was slightly different between pediatric and adult patients. The proportion of adult patients at enrollment who stayed in the program for more than eight months was higher than among patients under the age of 18 (73.8% vs 62.6%) (Table 4.2). Medical cannabis patients may leave the program for any reason at any time. Patients leaving the program might formally remove themselves from the medical cannabis registry, or many simply stop purchasing medical cannabis and not re-enroll in the program. In previous surveys, patients cite the cost of medical cannabis, inaccessibility of medical cannabis dispensaries, and ineffectiveness of symptom management as major reasons for leaving the program.

Table. 4.1. Standard eight symptoms benefits in patients with autism spectrum disorder. A) Among all patients (n = 1,643). B) Among patients under 18 years old at enrollment (n = 783). C) Among patients 18 years and older at enrollment (n = 860).

A) Among all patients (n = 1,643)

Standard eight symptom measure	n (%) of patients reporting at moderate to severe levels at baseline	n (%) of patients with ≥ 30% symptom improvement within four months, among those who had moderate to severe levels at baseline	Number of patients with data in four-month period following initial ≥ 30% symptom improvement	n (%) of patients who achieved ≥ 30% symptom improvement that maintained it for at least four months	% of patients that both achieved ≥ 30% symptom improvement and retained that degree of improvement for at least four months
Anxiety	1450 (88.3)	826 (57.0)	739	498 (67.4)	34.3%
Appetite lack	694 (42.2)	451 (65.0)	406	298 (72.9)	42.9%
Depression	982 (59.8)	623 (63.4)	551	406 (73.7)	41.3%
Disturbed sleep	1154 (70.2)	700 (60.7)	627	431 (68.7)	37.3%
Fatigue	924 (56.2)	530 (57.4)	464	318 (68.5)	34.4%
Nausea	347 (21.1)	237 (68.3)	208	153 (73.6)	44.1%
Pain	625 (38.0)	334 (53.4)	301	198 (65.8)	31.7%
Vomiting	157 (9.6)	106 (67.5)	95	82 (86.3)	52.2%

B) Among patients under 18 years old at enrollment (n = 783)

Standard eight symptom measure	n (%) of patients reporting at moderate to severe levels at baseline	n (%) of patients with ≥ 30% symptom improvement within four months, among those who had moderate to severe levels at baseline	Number of patients with data in four-month period following initial ≥ 30% symptom improvement	n (%) of patients who achieved ≥ 30% symptom improvement that maintained it for at least four months	% of patients that both achieved ≥ 30% symptom improvement and retained that degree of improvement for at least four months
Anxiety	684 (87.4)	399 (58.3)	342	229 (67.0)	33.5%
Appetite lack	299 (38.2)	191 (63.9)	168	125 (74.4)	41.8%
Depression	395 (50.4)	263 (66.6)	223	163 (73.1)	41.3%
Disturbed sleep	534 (68.2)	341 (63.9)	294	182 (61.9)	34.1%
Fatigue	343 (43.8)	214 (62.4)	179	121 (67.6)	35.3%
Nausea	107 (13.7)	77 (72.0)	66	53 (80.3)	49.5%
Pain	219 (28.0)	131 (59.8)	118	83 (70.3)	53.9%
Vomiting	59 (7.5)	43 (72.9)	39	32 (82.1)	54.2%

C) Among patients 18 years and older at enrollment (n = 860)

Standard eight symptom measure	n (%) of patients reporting at moderate to severe levels at baseline	n (%) of patients with ≥ 30% symptom improvement within four months, among those who had moderate to severe levels at baseline	Number of patients with data in four-month period following initial ≥ 30% symptom improvement	n (%) of patients who achieved ≥ 30% symptom improvement that maintained it for at least four months	% of patients that both achieved ≥ 30% symptom improvement and retained that degree of improvement for at least four months
Anxiety	766 (89.1)	427 (55.7)	397	269 (67.8)	35.1%
Appetite lack	395 (45.9)	260 (65.8)	238	171 (71.8)	43.3%
Depression	587 (68.3)	360 (61.3)	328	243 (74.1)	41.4%
Disturbed sleep	620 (72.1)	359 (57.9)	333	249 (74.8)	40.2%
Fatigue	581 (67.6)	316 (54.4)	285	197 (69.1)	33.9%
Nausea	240 (27.9)	160 (66.7)	142	100 (70.4)	41.7%
Pain	406 (47.2)	203 (50.0)	183	115 (62.8)	28.3%
Vomiting	98 (11.4)	63 (64.3)	56	50 (89.3)	51.0%

Table 4.2. Length of time in Minnesota’s medical cannabis program by age at enrollment.

Time between first and last purchase	All ASD Patients (n = 1,643)	Patients Under 18 Years Old (n = 783)	Patients Over 18 Years Old (n = 860)
Only purchased one time	122 (7.4%)	61 (7.8%)	61 (7.1%)
Less than one month	63 (3.8%)	39 (5%)	24 (2.8%)
One to four months	176 (10.7%)	105 (13.4%)	71 (8.3%)
Four to eight months	159 (9.7%)	90 (11.5%)	69 (8%)
Eight to 12 months	196 (11.9%)	86 (11%)	110 (12.8%)
More than 12 months	929 (56.5%)	404 (51.6%)	525 (61%)

Aberrant behavior checklist second edition

In addition to the PSE, patients qualified for ASD were asked to complete an additional optional research survey. Between August 2018 and July 2023, all patients qualified for ASD under the age of 26 at enrollment were asked to complete the Aberrant Behavior Checklist Second Edition (ABC-2) at enrollment and again 10 weeks after their first medical cannabis purchase. The age cutoff of 26 was chosen because the ABC-2 is only validated for patients under 26 years old. The ABC-2 is a widely used standardized questionnaire measuring behaviors, including scales measuring irritability, hyperactivity, lethargy, repetitive behaviors and inappropriate speech (Aman et al., 1985). The ABC-2 score indicates the presence and severity of behaviors in a given domain. A decrease in score corresponds to decreased presence and/or severity of aberrant behaviors. Participation in the ABC-2 survey was optional for all eligible patients, unlike the PSE. Patients were mailed physical copies of the survey; completed surveys were mailed back to staff at the Division of Medical Cannabis.

Among all patients under 26 years old (n = 1,170), 46 (3.93%) were included in the analysis below. To be included in the analysis, patients must have ABC-2 data at both baseline and 10 weeks. As this was an optional mail-in survey, some patients did not complete the follow-up survey at exactly 10 weeks. To include as many patients as possible, we included patients who filled out the follow-up survey eight to 20 weeks after the initial survey. The gender breakdown was similar among those who were and were not included in the final analysis (78.3 vs 77.8% male). The age of patients included in the analysis was younger than those not included (12.65 vs. 15.3 years). More than 90% (n = 42; 91.3%) of the participants in the analysis sample self-identified their race as white, compared to 75.3% (n = 845) of those that were not included (Table 4.3). The sample included in the below analysis skews younger and has a larger proportion of white participants compared to the total eligible population. The below results are not generalizable to the total population due to these differences.

Table 4.3. Demographic characteristics of patients who were and were not included in ABC-2 analysis.
A) Gender. B) Age. C) Race.

A) Gender characteristics of patients who were and were not included in ABC-2 analysis

Gender	N (%) not included in analysis	N (%) included in analysis
Female	208 (19.9)	10 (21.7)
Male	815 (77.8)	36 (78.3)
Prefer not to answer	24 (2.3)	0 (0.0)
Total	1124 (100)	46 (100)

B) Age characteristics of patients who were and were not included in ABC-2 analysis

Demographic characteristic	Mean (SD) not included in analysis	Mean (SD) not included in analysis
Patient age	15.31 (7.41)	12.65 (5.27)

C) Race characteristics of patients who were and were not included in ABC-2 analysis

Race	n (%) not included in analysis	n (%) included in analysis
American Indian or Alaska Native	10 (0.9)	0 (0.0)
Asian	31 (2.8)	2 (4.3)
Black, African or African American	76 (6.8)	1 (2.2)
Hawaiian or other Pacific Islander	1 (0.1)	0 (0.0)
White	845 (75.3)	42 (91.3)
Multiple race	90 (8.0)	0 (0.0)
No answer	47 (4.2)	1 (2.2)
Other race	17 (1.5)	0 (0.0)
Unknown	5 (0.4)	0 (0.0)
Total	1124 (100)	46 (100)

Distribution of reported ABC-2 scores at baseline and follow-up are shown in Figure 4.2. ABC-2 scores at baseline and follow-up were non-normally distributed (Figure 4.2). Therefore, the paired Wilcoxon Signed-Rank test was conducted to compare sub-scores at baseline and follow-up. Median and interquartile range for baseline and 10-week follow-up scores are shown in Table 4.4. There was a statistically significant decrease in scores (indicating improvement) between baseline and 10-week follow-up for all ABC-2 subscales (Table 4.5).

Because only a small percentage (3.93%) of eligible patients completed the ABC-2 survey at both time periods, there is likely response bias in this sample. Patients who were included in the analysis may have seen improvement in symptoms and therefore may be more likely to continue to participate in the medical cannabis program and fill out the follow-up survey. Having to mail back the surveys may have been a barrier for patients; in the future, these surveys will be available electronically, like the PSE. Additionally, this analysis does not compare to a control group or control for potential confounding factors. This analysis does not control for other treatments used by patients and assumes the change in scores is due to medical cannabis use. As such, more research is needed to study the impact of medical cannabis treatment on symptoms of ASD.

The report continues on the next page.

Figure 4.2. Histograms of ABC-2 subscale scores at baseline and 10-week follow-up

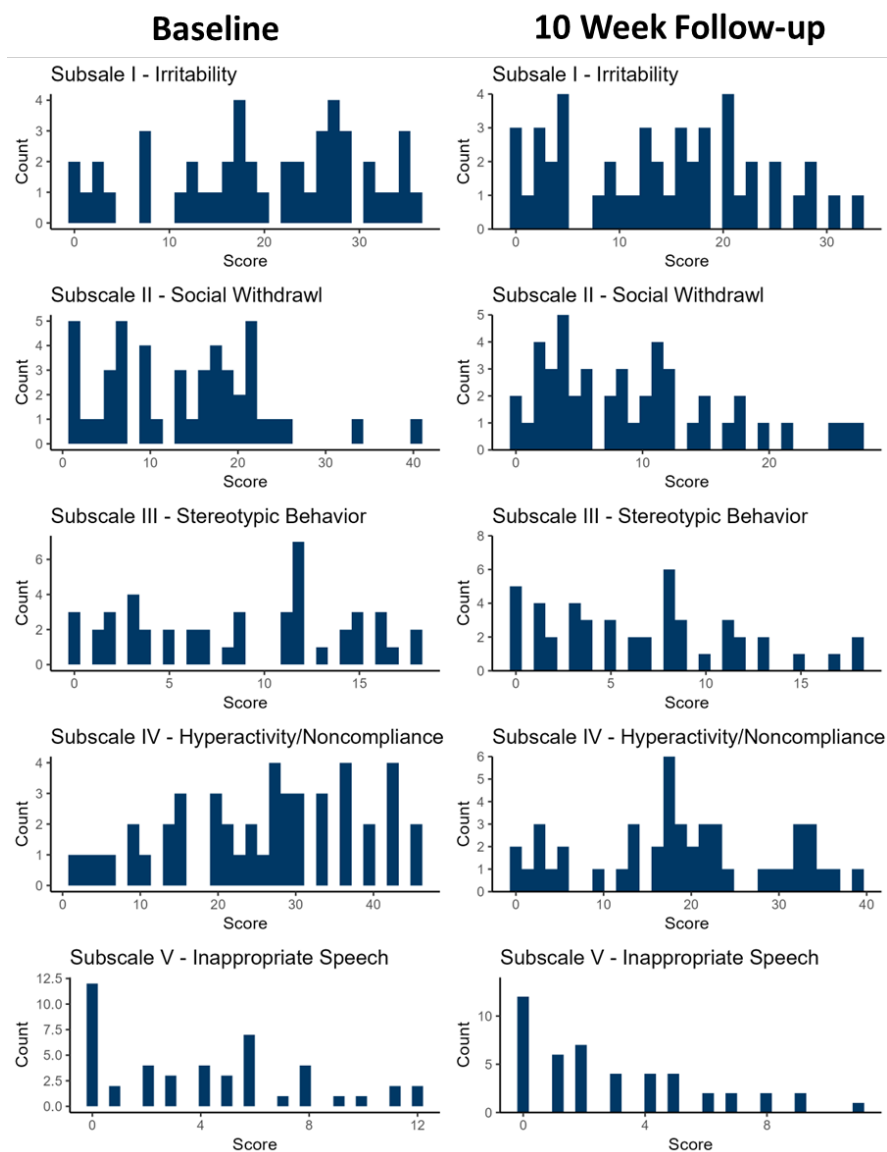


Table 4.4. Median and interquartile range (IQR) for ABC-2 scores at baseline and 10-week follow-up

ABC-2 subscale	Baseline median [IQR]	Ten-week follow-up median [IQR]
Subscale I - Irritability	21.00 [13.25, 27.00]	14.50 [5.00, 20.00]
Subscale II - Social withdrawal	14.50 [7.00, 19.75]	8.00 [4.00, 12.00]
Subscale III - Stereotypic behavior	9.00 [3.25, 12.75]	6.50 [3.00, 9.75]
Subscale IV - Hyperactivity/noncompliance	27.50 [16.00, 35.50]	19.00 [14.00, 27.00]
Subscale V - Inappropriate speech	4.00 [0.25, 6.00]	2.00 [0.25, 5.00]

Table 4.5. Paired Wilcoxon Signed-Rank Test results comparing baseline and follow-up ABC-2 scores

ABC-2 subscale	n	Location shift 95% confidence interval	(Pseudo) median	P-value
Subscale I - Irritability	46	5.0, 9.0	7.00	<0.001
Subscale II - Social withdrawal	46	3.0, 7.5	5.50	<0.001
Subscale III - Stereotypic behavior	46	1.0, 3.5	2.50	0.001
Subscale IV - Hyperactivity/noncompliance	46	5.0, 9.0	7.00	<0.001
Subscale V - Inappropriate speech	46	1.0, 2.5	2.00	<0.001

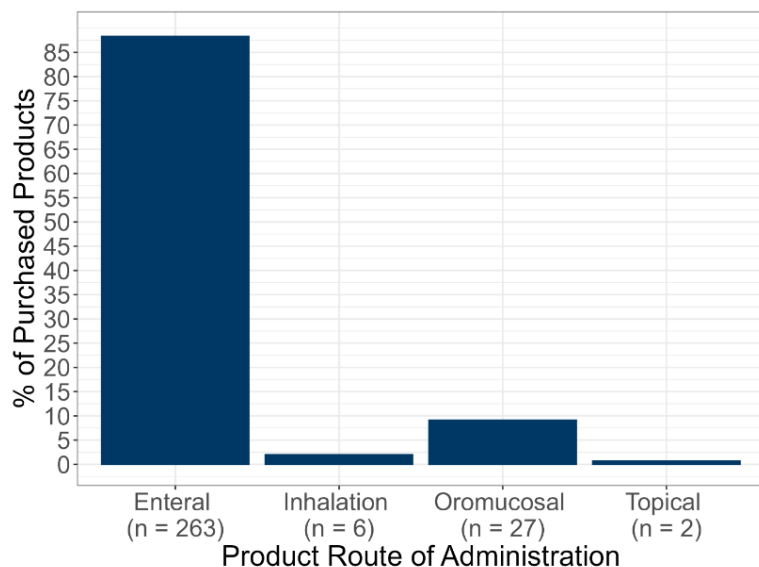
Products purchased by ABC-2 analysis sample

Medical cannabis purchasing data were reviewed for products purchased by the sample of patients who completed the ABC-2 questionnaire as described above. The review pulled medical cannabis products purchased before completing the follow-up ABC-2 questionnaire, with the following results:

- 175 sales transactions
- 298 products purchased
- 46 patients represented

The vast majority of products purchased by patients in the ABC-2 sample were enteral (n = 263; 88.3%) (Figure 4.3). Of these products, 76.8% (n = 202) were oral solutions, and the remaining 23.2% (n = 61) were capsules or tablets.

Figure 4.3. Product transactions by ABC-2 analysis sample categorized by product's intended route of administration



In this sample, all patients were under the age of 21, so no flower products were purchased. Therefore, we can compare the THC:CBD ratio of all products. A majority of products purchased were high CBD:THC (n = 163; 54.7%), followed by balanced products (n = 86; 28.9%). Only 15.4% of products purchased had a high or very high THC:CBD ratio (n = 46) (Figure 4.4, Figure 4.5).

Figure 4.4. Product transactions by ABC-2 analysis sample categorized by product's THC:CBD ratio

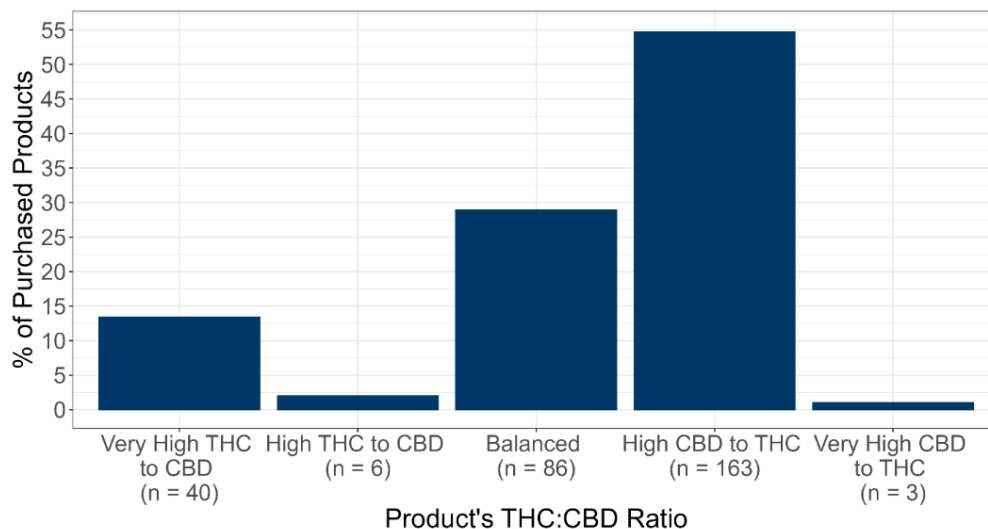
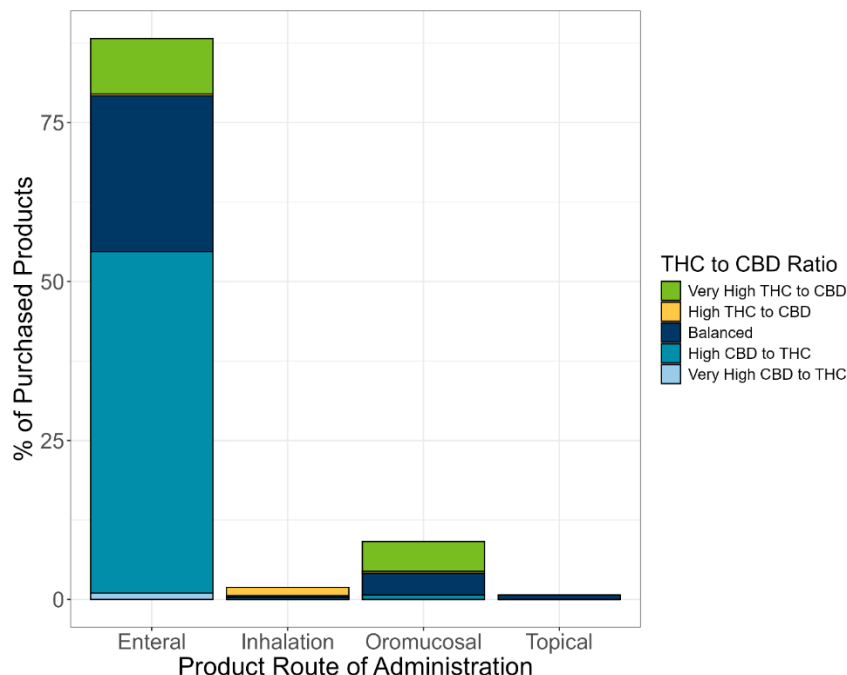


Figure 4.5. Product transactions by ABC-2 analysis sample categorized by product's intended route of administration and THC:CBD ratio



5. Adverse side effects

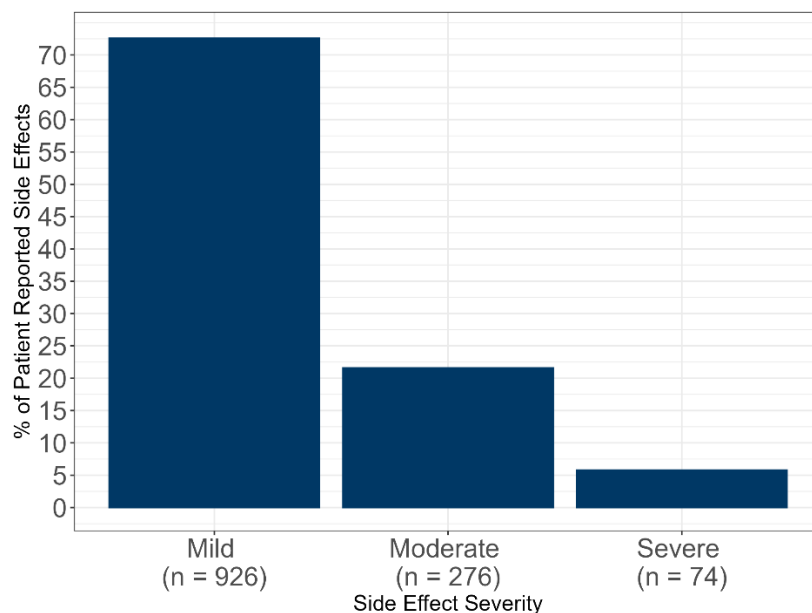
In addition to reporting benefits of medical cannabis and rating condition symptoms, the PSE is used to report adverse side effects of using medical cannabis. When completing the PSE, a patient can include any adverse side effects experienced. At the medical cannabis dispensary, patients can discuss these side effects and any other concerns with the medical cannabis pharmacist or medical cannabis consultant. At the time of this study, the PSE was required before each medical cannabis purchase. Patients can choose from 31 side effect options (e.g., anxiety, dry mouth, headache) or write in an unlisted side effect under “other.” Each adverse side effect is rated by the patient as mild, moderate, or severe. Mild is defined as symptoms do not interfere with daily activities. Moderate is defined as symptoms may interfere with daily activities. Severe is defined as symptoms interrupt usual daily activities.

For this report, side effect data from the PSE was extracted for all patients qualified for ASD enrolled for the first time between Aug. 1, 2018, and July 31, 2024. This report describes all purchases that occurred within the first year of enrollment. This query reflects:

- 1,276 patient-reported side effects
- 321 (19.5%) patients

Of patients reporting side effects in a PSE (n = 321), more than half reported one unique side effect (n = 192; 59.8%), with 89.7% reporting three or fewer unique side effects within one year of their first medical cannabis purchase. A vast majority of the reported side effects were mild (n = 926; 72.6%), 21.6% were moderate (n = 276), and only 5.8% were reported to be severe (n = 74) (Figure 5.1).

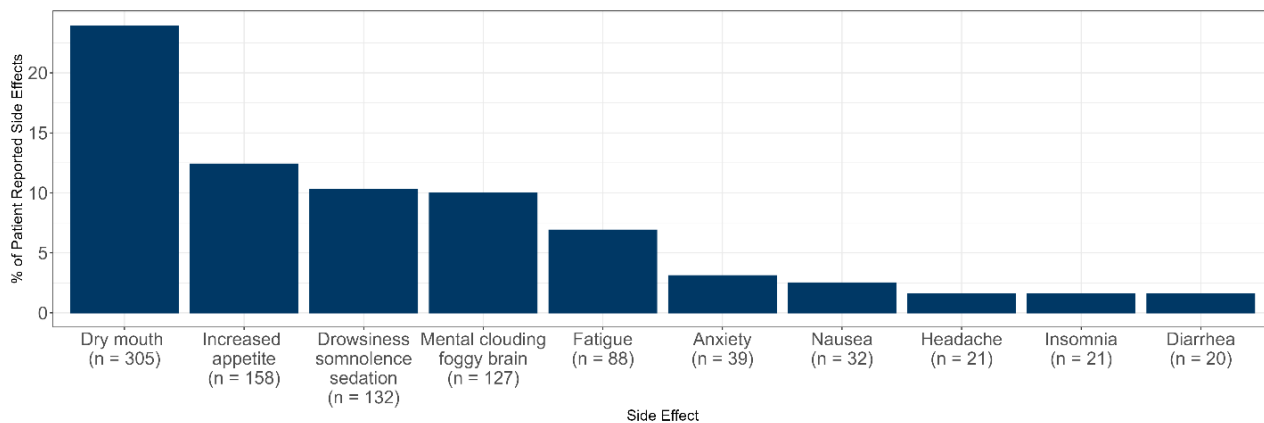
Figure 5.1. Severity of patient-reported side effects



Commonly reported side effects

The most reported side effect was dry mouth, accounting for 23.9% (n = 305) of all reported side effects. Other commonly reported side effects included increased appetite, drowsiness/somnolence/sedation, and mental clouding or brain fog. Figure 5.2 illustrates the top 10 patient-reported side effects.

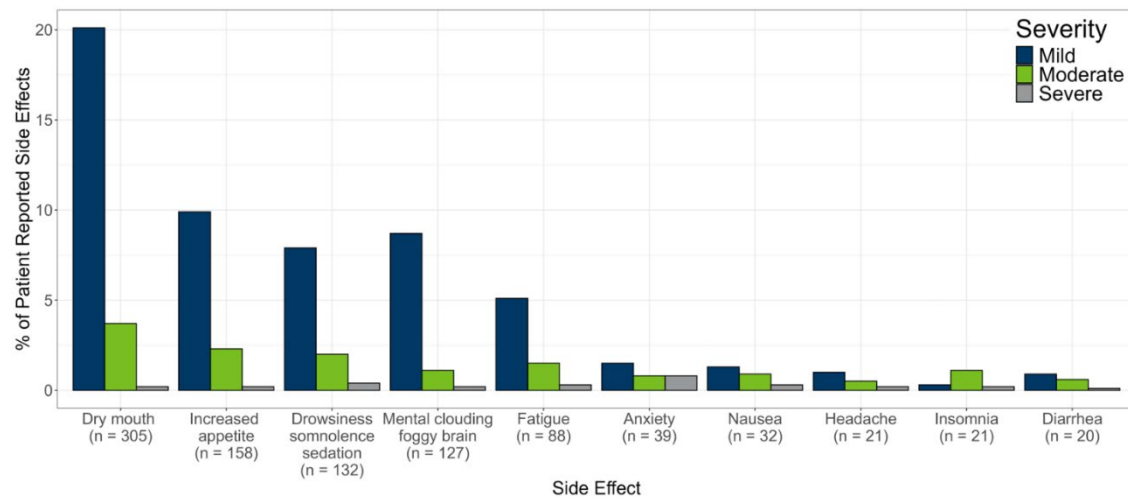
Figure 5.2. Top 10 patient-reported adverse side effects



Common side effects by severity

Among the top 10 most reported side effects, most were mild, followed by moderate and few were severe (Figure 5.3).

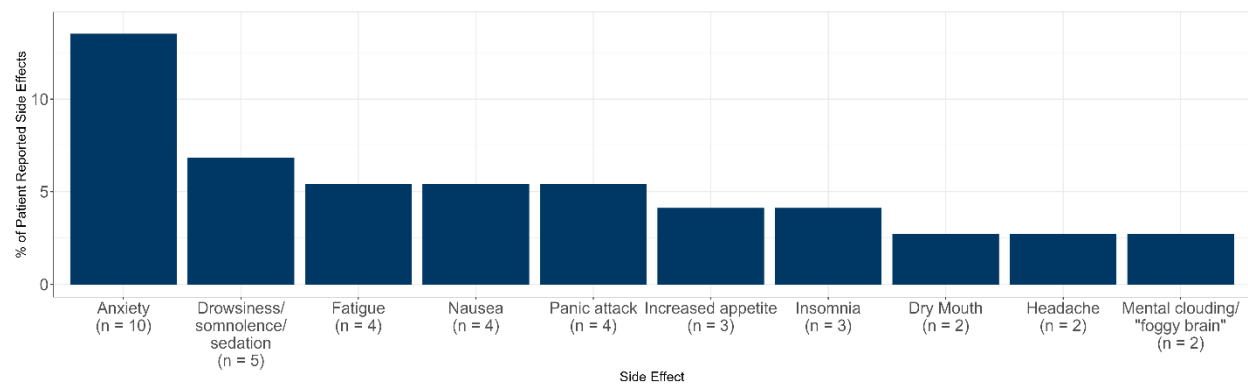
Figure 5.3. Top 10 patient-reported side effects, by severity



Severe side effects

Through the PSE, 74 side effects were reported as severe by 51 patients. Anxiety was the most common severe side effect (n = 10, 13.5%), followed by drowsiness/somnolence/sedation (n = 5, 6.8%), fatigue (n = 4, 5.4%), nausea (n = 4, 5.4%), and panic attack (n = 4, 5.4%) (Figure 5.4).

Figure 5.4. Top 10 patient-reported severe side effects



A major limitation of these data is a lack of follow-up data due to the PSE being administered at purchase. For example, the office would have no record of the last side effect if the patient decided not to purchase again after experiencing an undesirable reaction to medical cannabis. Therefore, under-reporting of moderate to severe side effects through PSEs is likely. Patients, caregivers, and healthcare practitioners may report side effects directly to the medical cannabis manufacturer, which would be outside of the office's data set. Another notable methodology limitation is that many patients in this cohort are young children or may have limited communication skills and may not be able to accurately report side effects.

6. Conclusion

This report provides insight into medical cannabis purchasing, symptom benefits, and adverse side effects in patients qualified for Minnesota's medical cannabis program with ASD. There were differences in patient purchasing needs by age group: patients under the age of 18 prefer CBD-dominant enteral products while those over the age of 18 prefer THC-dominant inhalation products. Only one-fifth of patients reported any adverse side effects from taking medical cannabis. Patients were able to achieve and maintain symptom relief after starting medical cannabis. However, because all patients utilized medical cannabis, we cannot compare the effectiveness in symptom relief to a control or placebo group. More research is needed to further elucidate this relationship. This report informs patients, health care practitioners, and Minnesotans on the impact of medical cannabis on patients with ASD. Additionally, this report adds to the scientific literature and knowledge base on medical cannabis and may be used by lawmakers to make policy decisions.

Appendix A. Additional tables

Table A.1. Mean and standard deviation standard eight symptom scores at baseline by age group.

Standard eight symptom	Patient age < 18	Patient age ≥ 18	Total
n	783	860	1643
Anxiety [mean (SD)]	7.22 (2.84)	7.34 (2.63)	7.28 (2.74)
Appetite lack [mean (SD)]	2.92 (3.44)	3.57 (3.50)	3.26 (3.48)
Depression (mean [SD])	3.93 (3.45)	5.31 (3.26)	4.65 (3.42)
Disturbed Sleep [mean (SD)]	5.52 (3.49)	5.80 (3.36)	5.66 (3.42)
Fatigue (mean [SD])	3.46 (3.27)	5.17 (3.10)	4.36 (3.29)
Nausea (mean [SD])	1.11 (2.30)	2.30 (2.99)	1.73 (2.75)
Pain (mean [SD])	2.12 (2.97)	3.63 (3.33)	2.91 (3.25)
Vomiting [mean (SD)]	0.65 (1.88)	1.00 (2.28)	0.83 (2.11)

References

- Aggarwal, A., Erridge, S., Varadpande, M., Clarke, E., McLachlan, K., Coomber, R., Asghar, M., Bhoskar, U., Crews, M., De Angelis, A., Imran, M., Kamal, F., Korb, L., Mwimba, G., Sachdeva-Mohan, S., Shaya, G., Rucker, J. J., & Sodergren, M. H. (2026). UK Medical Cannabis Registry: A Clinical Outcomes Analysis for Autism Spectrum Disorder. *Neuropsychopharmacology Reports*, 46(3), e70146. <https://doi.org/10.1002/npr2.70146>
- Aman, M. G., Singh, N. N., Stewart, A. W., & Field, C. J. (1985). The aberrant behavior checklist: A behavior rating scale for the assessment of treatment effects. *American Journal of Mental Deficiency*, 89(5), 485–491.
- American Psychiatric Association. (2022). *Diagnostic and Statistical Manual of Mental Disorders: DSM-5-TR* (Fifth Edition, Text Revision). American Psychiatric Association. <https://psychiatryonline.org/doi/book/10.1176/appi.books.9780890425787>
- Aran, A., Cassuto, H., Lubotzky, A., Wattad, N., & Hazan, E. (2019). Brief Report: Cannabidiol-Rich Cannabis in Children with Autism Spectrum Disorder and Severe Behavioral Problems-A Retrospective Feasibility Study. *Journal of Autism and Developmental Disorders*, 49(3), 1284–1288. <https://doi.org/10.1007/s10803-018-3808-2>
- Aran, A., Eylon, M., Harel, M., Polianski, L., Nemirovski, A., Tepper, S., Schnapp, A., Cassuto, H., Wattad, N., & Tam, J. (2019). Lower circulating endocannabinoid levels in children with autism spectrum disorder. *Molecular Autism*, 10, 2. <https://doi.org/10.1186/s13229-019-0256-6>
- Aran, A., Harel, M., Cassuto, H., Polyansky, L., Schnapp, A., Wattad, N., Shmueli, D., Golan, D., & Castellanos, F. X. (2021). Cannabinoid treatment for autism: A proof-of-concept randomized trial. *Molecular Autism*, 12, 6. <https://doi.org/10.1186/s13229-021-00420-2>

Barchel, D., Stolar, O., De-Haan, T., Ziv-Baran, T., Saban, N., Fuchs, D. O., Koren, G., & Berkovitch, M. (2019). Oral Cannabidiol Use in Children With Autism Spectrum Disorder to Treat Related Symptoms and Co-morbidities. *Frontiers in Pharmacology*, 9, 1521. <https://doi.org/10.3389/fphar.2018.01521>

Erridge, S., Kerr-Gaffney, J., Holvey, C., Coomber, R., Barros, D. A. R., Bhoskar, U., Mwimba, G., Praveen, K., Symeon, C., Sachdeva-Mohan, S., Sodergren, M. H., & Rucker, J. J. (2022). Clinical outcome analysis of patients with autism spectrum disorder: Analysis from the UK Medical Cannabis Registry. *Therapeutic Advances in Psychopharmacology*, 12, 20451253221116240. <https://doi.org/10.1177/20451253221116240>

Holdman, R., Vigil, D., Robinson, K., Shah, P., & Contreras, A. E. (2022). Safety and Efficacy of Medical Cannabis in Autism Spectrum Disorder Compared with Commonly Used Medications. *Cannabis and Cannabinoid Research*, 7(4), 451–463. <https://doi.org/10.1089/can.2020.0154>

Karhson, D. S., Krasinska, K. M., Dallaire, J. A., Libove, R. A., Phillips, J. M., Chien, A. S., Garner, J. P., Hardan, A. Y., & Parker, K. J. (2018). Plasma anandamide concentrations are lower in children with autism spectrum disorder. *Molecular Autism*, 9, 18. <https://doi.org/10.1186/s13229-018-0203-y>

Loomes, R., Hull, L., & Mandy, W. P. L. (2017). What Is the Male-to-Female Ratio in Autism Spectrum Disorder? A Systematic Review and Meta-Analysis. *Journal of the American Academy of Child and Adolescent Psychiatry*, 56(6), 466–474. <https://doi.org/10.1016/j.jaac.2017.03.013>

Minnesota Medical Cannabis Dashboard. (2024, September 9). Division of Medical Cannabis. <https://mn.gov/ocm/dmc/data-reports/data-projects/cannabis-dashboard.jsp>

Schnapp, A., Harel, M., Cayam-Rand, D., Cassuto, H., Polyansky, L., & Aran, A. (2022). A Placebo-Controlled Trial of Cannabinoid Treatment for Disruptive Behavior in Children and Adolescents

with Autism Spectrum Disorder: Effects on Sleep Parameters as Measured by the CSHQ.

Biomedicines, 10(7), 1685. <https://doi.org/10.3390/biomedicines10071685>

Shaw, K. A., Williams, S., Patrick, M. E., Valencia-Prado, M., Durkin, M. S., Howerton, E. M., Ladd-Acosta, C. M., Pas, E. T., Bakian, A. V., Bartholomew, P., Nieves-Muñoz, N., Sidwell, K., Alford, A., Bilder, D. A., DiRienzo, M., Fitzgerald, R. T., Furnier, S. M., Hudson, A. E., Pokoski, O. M., ... Maenner, M. J. (2025). *Prevalence and Early Identification of Autism Spectrum Disorder Among Children Aged 4 and 8 Years—Autism and Developmental Disabilities Monitoring Network, 16 Sites, United States, 2022*. 74(2).

Silva, E. A. da, Medeiros, W. M. B., Santos, J. P. M. D., Sousa, J. M. M. de, Costa, F. B. da, Pontes, K. M., Borges, T. C., Espínola, C., Andrade E Silva, A. H., Nunes, E. L. G., Alves, N. T., Rosa, M. D. da, & Albuquerque, K. L. G. D. de. (2024). Evaluation of the efficacy and safety of cannabidiol-rich cannabis extract in children with autism spectrum disorder: Randomized, double-blind, and placebo-controlled clinical trial. *Trends in Psychiatry and Psychotherapy*, 46, e20210396. <https://doi.org/10.47626/2237-6089-2021-0396>

Trauner, D., Umlauf, A., Grelotti, D. J., Fitzgerald, R., Hannawi, A., Marcotte, T. D., Knight, C., Smith, L., Paez, G., Crowhurst, J., Brown, A., Suhandynata, R. T., Lund, K., Menlyadiev, M., & Grant, I. (2025). Cannabidiol (CBD) treatment for severe problem behaviors in boys with autism: A randomized clinical trial. *Journal of Autism and Developmental Disorders*, 10.1007/s10803-025-06884-y. <https://doi.org/10.1007/s10803-025-06884-y>