The Effect of Cannabis Use on Health

LISS Panel Data in the Netherlands

Erasmus University Rotterdam

Erasmus School of Economics

Department of Health Economics

Supervisor: Prof. Dr. Ir. J.C. van Ours

Name: Melissa Heuchemer

Student number: 375813

E-mail address: 375813mh@student.eur.nl

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Abstract

Cannabis use is quasi-legalized in the Netherlands, which means that individuals can buy small quantities of cannabis in coffee shops. Cannabis use in the Netherlands lies above the average of the European Union and therefore, it is important to know the effect of cannabis use on health. The instrumental variable approach is used with religion, presence of a coffee shop and distance to a coffee shop as instruments. Both presence and distance are relevant instruments to test the endogeneity of cannabis use. Cannabis use is tested to be exogenous, which means that OLS gives better estimates than IV. It is found that using cannabis will lead to a decrease of the SAH score and that, overall, healthy individuals use cannabis.

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1. Introduction

Regulation of cannabis is a hot topic in the Netherlands. "De Tweede Kamer" recently voted for legalization, but we have to await the verdict of "De Eerste Kamer". As the parties voting for legalization do not have the majority in "De Eerste Kamer" the outcome is still uncertain. Do we want legalization of cannabis or not? Since 1976, the Netherlands has had a tolerance policy for soft drugs. This means that, under very strict conditions, coffee shops are allowed to sell small quantities of cannabis. However, cannabis production is still prohibited and only inhabitants of the Netherlands can buy cannabis[1]. Supporters of the legalization argue that legalization will be better for the economy and will reduce crime. However, opponents of legalization argue that it will be bad for population health and that it will lead to higher (societal) costs[2].

About 25% of the Dutch population (2.7 million citizens) has used cannabis at least once in their lifetime and the percentage of recent users (use in last year: 7.7% to 8.7%) and actual users is rising (use in last month: 4.5% to 5.3%). Furthermore, in 2015 over 10,000 individuals were addicted to cannabis (Trimbos-instituut, 2016). Even though the percentage of high school cannabis users decreased, the percentage of recent cannabis users lies above the average of the European Union (Trimbos-instituut, 2016). And even though the percentage of cannabis addicts is relatively low compared to hard drugs like heroine (1% compared to 3%), the social costs of cannabis addiction are almost as high as heroine addiction (1.5% compared to 1.6%) (RIVM, 2009). However, these costs may be higher in reality as few addicts seek professional help (Cunningham et al., 1993). Societal costs are usually divided into three categories: productivity, health and other costs (crime and treatment for example)[3].

Whether cannabis has a positive or negative effect on health is an ongoing debate in the literature. Using cannabis can have a positive effect on health, especially when looking at multiple sclerosis. When using cannabis, over 70% of the individual's report that pain, spasticity, and emotional problems are reduced (Consroe et al., 1997). However, cannabis is also associated with adverse effects. According to Rey and Tennant (2002), cannabis use is associated with schizophrenia later in life (Rey and Tennant, 2002). Cannabis is also known as a gateway drug, this means that the use of cannabis is likely to lead to the use of other drugs. Furthermore, using cannabis will increase the likelihood of drug dependence or drug use (Fergusson et al., 2006).

Cannabis can also lead to increased anxiety levels and/or depression (O'Shea et al., 2004). The effect of cannabis on cancer is not yet clear. For neck and head cancer, it is concluded that using cannabis increases the chance of getting cancer. However, an interaction between cannabis use and using alcohol and/or smoking is possible (Carriot and Sasco, 2000). Cannabis as a potential medicine for cancer is also researched; cannabis can decrease tumor growth for skin cancer (Sarfaraz et al., 2008). If cannabis use leads to an increase in health, opportunities await.

Establishing a causal effect between cannabis and health is difficult in the existing literature; therefore we can often only speak of negative or positive associations. In the literature, religion is often used as an instrument to establish a causal relation between cannabis and health, but it might not be a good instrument to establish a causal relation (French et al. 2001; Auld, 2005). As there are a lot of contradictions in the existing literature, more research is needed on this subject.

The aim of the study is to investigate whether the use of cannabis will lead to better or worse health using the instrumental variable approach. In this paper, new instruments will be introduced trying to establish a causal relationship. Trying to find a causal relation is

[1] https://www.rijksoverheid.nl/onderwerpen/drugs/inhoud/gedoogbeleid-softdrugs-en-coffeeshops
[2] https://www.jellinek.nl/vraag-antwoord/wat-zijn-argumenten-voor-en-tegen-legalisering/
[3] https://www.drugscience.org/Archive/bcr4/1Fed_costs.html

important as soft drugs are almost fully legalized in the Netherlands. Knowing the effects of cannabis on health is therefore becoming more important. If the effect of cannabis on health is known, further steps in politics can be taken. If cannabis has a positive effect on health, legalization and/or production of cannabis can be stimulated. If cannabis has a negative effect on health, stringent measures or education of the effects are needed. The research question is stated as follows:

What is the effect of cannabis use on health in the Netherlands?

The set-up for this paper is as follows. In section 2 a literature review is given. Section 3 provides some theory on health and cannabis. Section 4 provides the data and methodology used. In section 5, the results of the empirical model are presented. Section 6 concludes and section 7 presents limitations and gives some policy recommendations.

2. Literature review

Whether cannabis has an effect on health, may it be positive or negative, is a question many want to answer. But the effect of cannabis on health is, in many cases, not clear. One of the first to research the topic is W.B. O'Shaughnessy (1843), who tested the effects of Indian hemp, also known as cannabis, on the animal health system to understand whether it could help treat tetanus and convulsive diseases, for example epilepsy, for humans. He concluded that the use of hemp may be seen as a remedy for convulsive diseases, however, while in some cases after being given the hemp the patient was cured of tetanus, more research is needed (O'Shaughnessy, 1843).

In more recent years, the possible negative effect of cannabis on mental health became more important. When looking at the younger population (18-30 years), frequent cannabis users are linked to having a worse mental health compared to the non-frequent cannabis users, who are similar to the general population (Van der Pol et al., 2013). When looking at the adverse effects for individuals who have a mental disorder, we see that cannabis use leads to a higher chance of relapse and that it increases the symptoms of the disease (Johns, 2001). Especially, for a mental disorder like schizophrenia, where there exists a strong association with the use of cannabis. According to Allebeck et al. (1987), the risk of developing schizophrenia increased with higher cannabis consumption, where higher consumption means using cannabis more than 50 times.

When looking at the relation between cannabis and depression, it is concluded that there is exists a modest association between regular consumption of cannabis and depression. Such a relation does not exist when using cannabis irregularly. There is no evidence of a reverse relation; individuals who have depression will not use more cannabis (Degenhardt et al., 2003).

It is expected that the use of cannabis will have a direct negative effect on health. As drug use will lead to physical and psychological deterioration in the future when using the drugs from the age of 15 (Hansell and White, 1991). The most common direct effects are panic attacks and anxiety (Hall and Solowij, 1998). According to Robson (2001), cannabis use can have a positive effect on health. Especially for cancer or AIDS sufferers, cannabis can increase appetite and as a result lead to weight gain (Robson, 2001). Ashton (2002) concluded that cannabis could potentially play a role in treatments such as spastic disorders or in palliative care. However, cannabis is not a powerful predictor for physical health according to Vingilis et al. (1998).

The use of cannabis is associated with lower educational attainment levels. It could be the case that cannabis de-motivates students and they are therefore more likely to get lower grades or even drop out of school. It is also possible that cannabis can lead to a more unconventional lifestyle (Lynskey and Hall, 2000). When using a longitudinal study of 25 years, it is concluded that cannabis use in early adulthood is associated with lower educational levels, lower income and lower life satisfaction. Also, these individuals are more likely to be dependent on government aid (Fergusson and Boden, 2008).

The effect of cannabis on driving is also considered as cannabis can have adverse effects on performance and thus driving ability. Using cannabis is associated with more traffic accidents in the age group of 18-21, but these differences may be explained by group characteristics, as these individuals are not yet skilled drivers (Fergusson and Horwood, 2001). However, another study conducted by Bédard et al. (2007), concluded that cannabis does have a negative impact on driving when looking at the age group 20-49.

3. Theoretical Framework

To answer the research question, the definitions of cannabis and health must be explained.

Cannabis is a dried leaf of the cannabis sativa L plant. It is also known as weed or marijuana[4] and is quasi-legalized in the Netherlands. As mentioned before, quasi-legalization of cannabis means that the Dutch population can buy small quantities of cannabis at a coffee shop, but they are prohibited to grow it themselves.

According to the world health organization, further referred to as WHO, health is described as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity[5]". Also according to the WHO, mental health is described as " a state of well-being in which every individual realizes his or her own potential, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to her or his community[6]".

Health can be measured in three different ways. The first one is mortality or life expectancy. The disadvantage of this measure is that it does not take the quality of life into account. Therefore, the WHO developed summary measures that adjusted the life expectancy for health or disability. This measure gives us the number of years individuals are expected to live in full health. The second measure is morbidity or disability. This measures the extent of the disability a person suffers from as a consequence of a disease over time. A disability can be physical, mental, social or functional. Measures of morbidity include self-assessed health, restricted-activity days due to illness or biomarkers such as blood pressure. The last measure is disability-adjusted life expectancy (DALY), which is a combination of the first two measures (Folland et al., 2013). The DALY combines the time lived with a disease and the time that you lost due to early mortality. The time loss is weighted, and this reflects the decrease in functional capacity. Murray (1994) argues that the DALY method is superior to the methods that disregard the time spent in a state of disability. Others argue that the DALY method is flawed because of the weights and discounting (Anand and Hanson, 1995).

In this paper, the focus will be on the morbidity measure, self-assessed health, further referred to as SAH. Individuals are asked the question: "How would you describe your health, generally speaking?" Individuals then rate their health on a scale from 1-5, where 1 is having poor health and 5 is having excellent health.

The goal of an economist is to try to establish a causal effect instead of an association, as this may be suggestive. A causal relation means that the use of cannabis directly affects your health, as seen in Figure 3.1. OLS provides causal estimates when the zero conditional mean assumption is satisfied. This means that cannabis use is uncorrelated with the error term. The zero conditional mean assumption is violated when there is a functional form misspecification, reverse causality or omitted variable bias (Angrist and Krueger, 2001). In Figure 3.1, omitted variable bias is a problem when this variable influences both cannabis use and SAH. An example of an omitted variable would be education. Individuals with a lower educational attainment are associated with a higher cannabis intake (Lynskey and Hall, 2000). Education also influences SAH. Research has shown that there is a positive association between education and health (Ross and Wu, 1995). A variable that only influences cannabis is not seen as an omitted variable, as this would be a possible instrument to test the exogeneity of cannabis on SAH. Reverse causality would be the case when SAH has an effect on cannabis use.

[4] https://www.cannabisbureau.nl/medicinale-cannabis
[5] http://www.who.int/suggestions/faq/en/
[6] http://www.who.int/features/factfiles/mental_health/en/

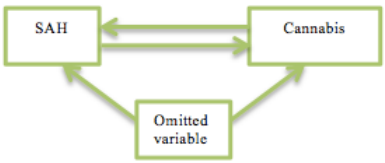

Figure 3.1: Causal Relation

The instrumental variable approach requires valid and relevant or strong instruments. With a valid and relevant instrument, IV is consistent, but when the instrument is not very significant, using IV can lead to very large standard errors (Angrist and Krueger, 2001). In practice, establishing a causal effect is proven to be difficult. To test whether cannabis is exogenous, instrumental variables can be used. Exogeneity means that the variables are determined outside the model and that the errors are uncorrelated with cannabis use. When cannabis use is endogenous, the zero conditional mean assumption of OLS is not satisfied, as cannabis use will then be determined within the model. Endogeneity is not a problem when cannabis use is only correlated with SAH or if the instrument is only correlated with cannabis use. An instrument is a variable that should not influence SAH, but will have an effect on cannabis. If the variable is endogenous, the instrument affects SAH. Equation 3.1 represents the first stage regression, where Z is the instrument and W are the included exogenous variables. If Z is significant it affects cannabis use. The first stage regression regresses cannabis use on Z and W, while using OLS to isolate the part of cannabis use that is uncorrelated with the error term, u, to obtain unbiased and consistent estimates of β_1

(3.1) $$Cannabis\ use_i = \pi_0 + \pi_1 Z_i + \pi_2 W_i + v_i$$

After the first stage regression the predicted value of cannabis use is obtained, $\widehat{\text{cannabis}}$ use. This way, the predicted value of cannabis use is uncorrelated with u_i. Equation 3.2 represents the second stage regression, where SAH is regressed on the predicted value of cannabis use and the included exogenous variables while using OLS. The beta of $\widehat{\text{cannabis}}$ use will give the causal effect.

(3.2) $$SAH_i = \beta_0 + \beta_1 \widehat{cannabis}\ use + \beta_2 W + u_i$$

If the coefficient of $\widehat{\text{cannabis}}$ use is significant, thus rejecting exogenous variation, there is an endogeneity problem (Nagler, 1999). This means cannabis use will be correlated with the error term and there are inconsistencies in the estimation of the betas. OLS will be biased and will not give a causal effect and thus you prefer IV. If the coefficient of $\widehat{\text{cannabis}}$ use is insignificant, there is exogenous variation and OLS is preferred, as IV is inefficient because it throws away a lot of variation (Arellano and Bover, 1995).

4. Data and Methodology

In this section, the data and the methods that are used will be discussed.

4.1. Data

In this paper, data of the LISS (Longitudinal Internet Studies for the Social sciences) panel administered by CentERdata is used (Tilburg University, The Netherlands)[7]. The LISS dataset consists of 7000 individuals over 4500 households. Only one member of the household provides data on the household, and all individuals are aged 16 and over. The panel members are randomly chosen from the population register and this means that the panel is a good representation for the entire population. The survey is longitudinal, which means that panel members are asked to answer the same questionnaire each year. Every year panel members are asked to answer additional questions in topics ranging from cannabis use to political views. These additional questions are only asked for one year (one single wave).

Data on health and some background variables are available for the years 2007-2014. For the cannabis variables (e.g. starting age, use), there is only data available for 2008, which is from the Alcohol and Drugs study.

Dependent Variable

Self-assessed health

The dependent variable will be the health variable, self-assessed health. Individuals are asked the question: "How would you rate your health generally speaking?" Then the individuals rate their health on a scale from 1 to 5, where 1 means having a poor health and 5 means having an excellent health. According to Table 4.1, the mean health score is 3.2; this means that most individuals rate their health between good and very good.

SAH	Percentage
1=Poor	1.0
2=Moderate	12.2
3=Good	60.5
4=Very Good	20.0
5=Excellent	3.3
Total %	**100.0 (N=5183)**
Mean SAH score	**3.2**

Table 4.1: Self-assessed health

Figure 4.1 reports the differences between males and females when rating their health. Females are more likely to report moderate or good health. Males are more likely to report very good or excellent health compared to females. The mean health score does not differ much between males and females; for males it is a score of 3.2 and females have a mean health score of 3.1 (see Appendix 1).

Figure 4.1: Reported SAH for Males and Females

When getting older, health deteriorates, as you will be more susceptible to diseases. This means that SAH will decrease when getting older. In Appendix 2, we see how many individuals reported a certain health state in the age category they belong to and this is graphically shown in Figure 4.1. In all age categories, most individuals rate their health as good. The younger individuals report more very good and excellent health and we see when individuals get older, poor, moderate, and good health are reported more often and less individuals rate their health as very good or excellent.

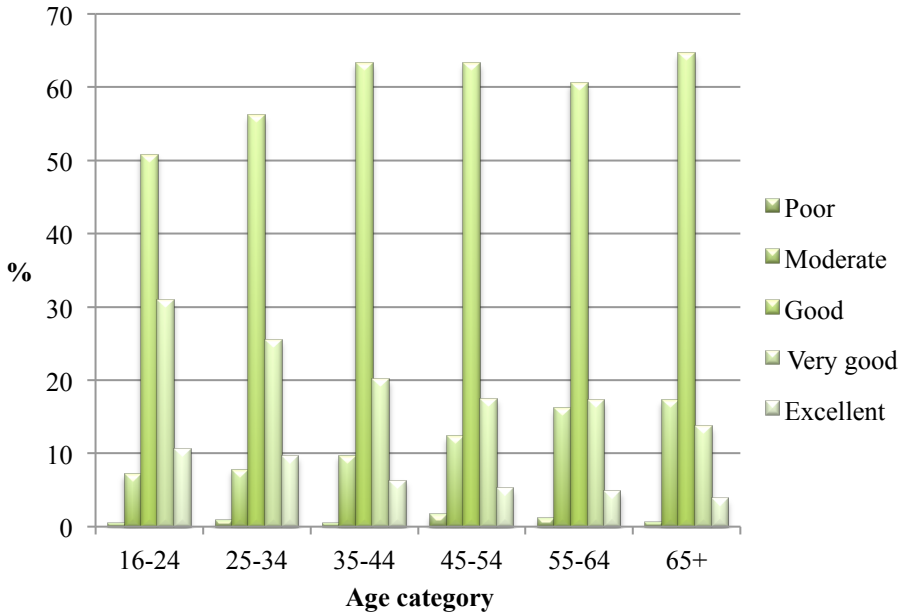

Figure 4.2: Reported SAH for Different Age Categories

Independent and Control Variables

Cannabis Use

Cannabis use is the only independent variable. The frequency of cannabis use is a categorical variable, as seen in Table 4.2, which will be 0 if you have never used cannabis or if you have not used cannabis over the last month and the variable will be 4 when you have used cannabis 6-7 days a week, on average, over the last month. In this sample, only 3.4% used cannabis in the last 30 days.

Frequency cannabis use	Percentage
0=Not once	96.6
1=< 1 day	0.9
2=1 day	0.9
3=2-5 days	0.9
4=6-7 days	0.8
Total N=4842	**100.00**

Table 4.2: Frequency Cannabis Use last month

In Table 4.3, the frequency of cannabis use is transformed into a binary variable, further referred to as cannabis use, where 0 means not having used cannabis and 1 means having used cannabis more than once over the last month.

Instead of measuring cannabis use over the last month, cannabis is measured as lifetime use. This means that it will be 0 if individuals have never used cannabis in their life and 1 if individuals have used cannabis at least once in their life. This variable is called ever used cannabis.

Smoking is a categorical variable where the individuals were asked if they had smoked the last 30 days. If the individual did smoke, they were asked how many days per week they had smoked, on average, over the past 30 days. If the variable is 0, this means that the person has never smoked or that the individual did not smoke over the last 30 days.

According to Table 4.3, only a small proportion (3.4%) of the sample used cannabis in the last 30 days. When looking at individuals who used cannabis at least once in their lifetime, this proportion grows to 22.6%. For smoking tobacco, 25.2% of the individuals in the sample smoked at least once in the last 30 days.

	Cannabis use	**Ever used cannabis**	**Smoking**
0=No	96.6	77.4	74.8
1=Yes	3.4	22.6	25.2
Total %	**100.0**	**100.0**	**100.0**
Total N=	**4842**	**4849**	**4844**

Table 4.3: Cannabis use last month, cannabis use ever and smoking tobacco last month.

Smoking daily is associated with an increased chance of using cannabis in the future (Lewinsohn et al., 1999). According to Table 4.4, 1089 individuals (22.6%) who did not use cannabis smoked tobacco and only 39 individuals (2.6%) used cannabis and did not smoke tobacco.

	Smoking tobacco		
Cannabis use	Not once	More than once	**Total**
Not once	74.0	22.6	**96.6**
More than once	0.8	2.6	**3.4**
Total %	**74.8**	**25.2**	**100.0**
Total N=	**3614**	**1214**	**4828**

Table 4.4: Using Cannabis and Smoking Tobacco Last Month

In Figure 4.3, the reported SAH when individuals used cannabis is shown compared to individuals who did not use cannabis. The data can be found in Appendix 3. There are only 156 individuals that reported cannabis use in the last month. Individuals who used cannabis reported slightly more poor and moderate health and less good, very good or excellent health compared to individuals who did not use cannabis. Furthermore, we can see that most individuals report a good health: 61% for individuals who did not use cannabis and 57% for individuals who did used cannabis in the last month.

Figure 4.3: SAH and Cannabis Use

Female

Gender is a binary variable, where 1 is male and 2 is female. It is expected that females have better self-assessed health compared to males, as males are more likely to use cannabis compared to females (Penning and Barnes, 1982). In the sample are slightly more females: 53.5% vs. 46.5% (see Appendix 4). 164 individuals reported that they used cannabis in the last 30 days and according to Figure 4.4, males are more likely to use cannabis compared to females: 63% vs. 37%.

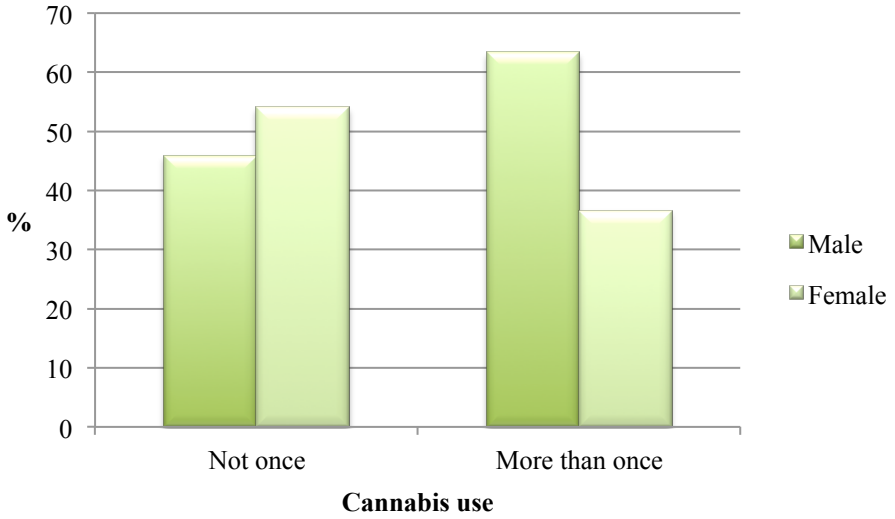

Figure 4.4: Gender and Cannabis Use

Age

The use of cannabis is not equally distributed among all ages, as the prevalence of cannabis use is highest in the age range of 20-24 years olds (Trimbos-instituut, 2016). This means that age has a possible non-linear effect. Age is therefore transformed into a categorical variable as seen in Table 4.5. Most individuals in the sample are between the ages 55-64, and as expected, most individuals who use cannabis are between the ages 16-24. There are slightly more females in the age categories 16-64, but in the age category 65^{+}, there are slightly more males.

	Gender	
Age	Male	Female
16-24	11.1	11.8
25-34	11.0	14.5
35-44	18.6	19.9
45-54	20.4	21.3
55-64	22.0	19.4
65+	16.9	13.1
Total %	**100.0**	**100.0**
Total N=	**2407**	**2774**

Table 4.5: Age Categories: Gender and Cannabis Use

Figure 4.5 shows what percentage of individuals in an age category used cannabis in the last 30 days. The figure can be read as follows. For the individuals who did not use cannabis, around 10% is between the 16 and 24 years old. For individuals who did use cannabis, 156 individuals, around 42% is between the 16 and 24 years old. See Appendix 5 for the table.

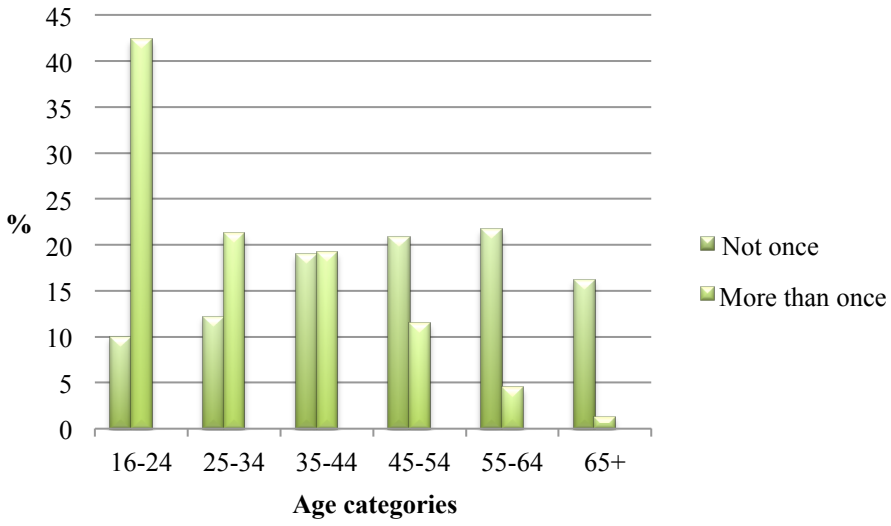

Figure 4.5: Cannabis Use with Age categories

Urban

Urban is a categorical variable, where 0 means living in a rural area and 4 means living in an extremely urban area. The area where individuals live can have a positive effect on the use of cannabis as large differences in drug use exist between areas (Wallace and Bachman, 1991; Wallace et al., 2003). Therefore, it is expected that individuals living in an urban area are more likely to report cannabis use. Most individuals live in a slightly, moderately or very urban area (see Appendix 6). Figure 4.6 shows in which areas individuals use cannabis. As mentioned earlier, 96.6% of the individuals indicated that they did not use cannabis in the last 30 days. The individuals, who did use cannabis, live in more urban areas. About 25% of the individuals who used cannabis live in an extremely urban area. In rural areas individuals are less likely to use cannabis (around 9%).

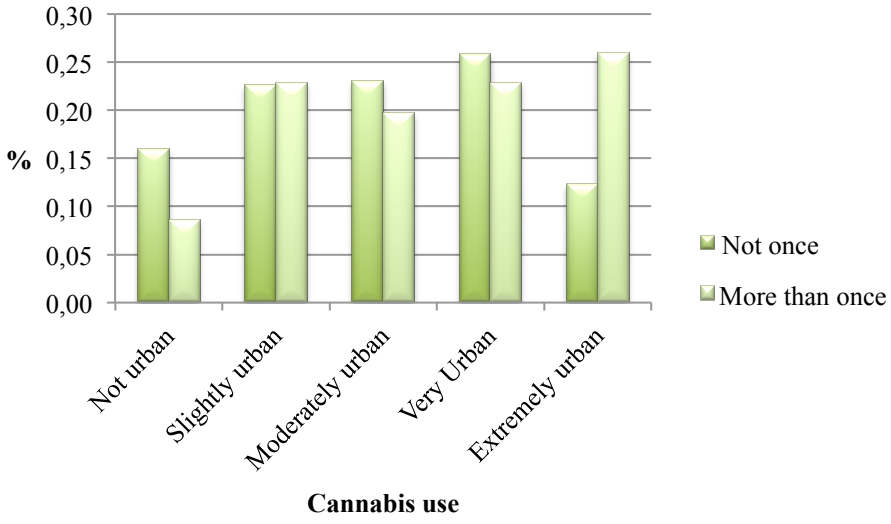

Figure 4.6: Urbanity and Cannabis Use

Migrant

Large differences exist between ethnic or racial groups with regards to drug use (Wallace and Bachman, 1991; Wallace et al., 2003). It is therefore expected that individuals with a Dutch background are more likely to report cannabis compared to individuals with a migrant background. 0 means having a Dutch background and 1 having a migrant background.

Migrants are individuals with a 1st and 2nd generation western and non-western background. In the sample there are far more individuals with a Dutch background (89.9% vs. 10.1%). 118 individuals indicated that they used cannabis in the last 30 days, see Table 4.6, and 103 of those individuals (87.3% of the cannabis users have a Dutch background. The Dutch cannabis users account for 2.5% of the total sample, whereas non-Dutch cannabis users account for 0.4% of the total sample.

	Cannabis use		
Migrant	Not once	More than once	**Total**
No	87.4	2.5	**89.9**
Yes	9.7	0.4	**10.1**
Total %	**97.1**	**2.9**	**100.0**
Total N=	**3959**	**118**	**4077**

Table 4.6: Migrant and cannabis use

Education

Whether an individual has a low or high educational attainment level can influence cannabis use. Past research shows that lower educated individuals reported higher cannabis use in the last year, but if we look at the 30-day use, higher-educated individuals indicated a higher cannabis intake (Williams and Hagger-Johnson, 2017). Table 4.7 shows the Educational attainment levels. For example, you will only fall into the category HBO if you actually finished your education and have your diploma. Individuals, who have not yet completed their education, have not yet started any education or have other diplomas belong in the category other. According to Table 4.10, most individuals have a VMBO diploma followed by a MBO and HBO diploma. When looking at the percentages instead of the frequency, it can be seen that 3.2% of the individuals with a WO diploma use cannabis, 4.0% of the individuals with a MBO diploma, and 3.7% of the individuals with a primary diploma.

	Cannabis use		
Education	Not once	More than once	**Total**
Primary	4.3	0.2	**4.5**
VMBO	25.4	0.7	**26.1**
HAVO/VWO	10.5	0.7	**11.2**
MBO	22.4	0.9	**23.3**
HBO	22.6	0.5	**23.1**
WO	7.6	0.2	**7.8**
Other	3.8	0.2	**4.0**
Total %	**96.6**	**3.4**	**100.0**
Total N=	**4678**	**164**	**4842**

Table 4.7: Highest Education with Diploma and cannabis use

Specific Diseases *(Asthma, Arthritis, Cancer, Alzheimer)*

Using cannabis can alleviate specific diseases such as asthma, arthritis, cancer, and Alzheimer (Abrams and Guzman, 2015; Campbell and Gowran, 2007; Stokes et al., 2000; Wright et al., 2006; Ziment and Tashkin, 2000). Table 4.8 shows the individuals with a specific disease and whether they use cannabis or not. For example, 129 individuals have asthma in the sample and 4 of those individuals used cannabis more than once in the last month.

Specific disease	Cannabis use		Total %	Total N=
	Not once	More than once		
Asthma	96.9	3.1	**100.0**	**129**
Arthritis	98.3	1.7	**100.0**	**238**
Cancer	97.9	2.1	**100.0**	**48**
Alzheimer	87.5	12.5	**100.0**	**8**

Table 4.8: Specific Diseases and cannabis use

Instruments

There is reason to believe that cannabis use is not exogenous, but endogenous. This means that cannabis use is likely to be determined by variables included in the model. With an instrument it can be tested whether cannabis use is exogenous or endogenous.

Religion

Whether you are religious or not can influence the decision to try cannabis, as religious individuals are less likely to use cannabis compared to non-religious individuals because of beliefs or use being prohibited (Wallace et al., 2003). According to Engs and Mullen (1999), more consistent results can be found when dividing individuals into categories of the attention they give to religious matters instead of, for example, dividing individuals into Catholics and Protestants. The question that is asked is if he/she devotes attention to religious matters, the categories can be found in Table 4.9. 2.7% of the believers used cannabis in the last month compared to 3.8% of the non-believers.

Religion	Cannabis use		Total
	Not once	More than once	
Absolutely not	22.6	1.0	**23.6**
Not	22.1	0.7	**22.8**
Slightly	16.0	0.5	**16.5**
A bit	15.5	0.4	**15.9**
Yes	12.1	0.3	**12.4**
Absolutely	8.6	0.2	**8.8**
Total %	**96.9**	**3.3**	**100.0**
Total N=	**4644**	**162**	**4806**

Table 4.9: Religion

Coffee shop

D_shop is a binary variable and it describes whether there was a cannabis shop in the municipality of the respondent in 1999, this is further referred to as presence coffee shop (Palali and Van Ours, 2013). Distance is a binary variable, which describes the distance to the nearest coffee shop in kilometers according to the following equation:

$$(4.1) \quad Distance = D\_shop + (1 - D\_shop) \times Distance$$

If there is a coffee shop in the municipality, the distance is 1. If there is no coffee shop in the municipality, presence of a coffee shop is 0 and the distance is the distance to the nearest coffee shop in the nearest municipality, this is shown in Table 4.10. The distance from your municipality to a municipality that has a coffee shop ranges from 3.1 kilometers to 44.5 kilometers. This can be seen in Appendix 7.

	Presence coffee shop		
Distance	0	1	**Total**
1.0	1.8	51.2	**53.0**
>1.0	46.3	0.7	**47.0**
Total %	**48.1**	**51.9**	**100.0**
Total N=	**3959**	**118**	**4260**

Table 4.10: Distance and presence of a coffee shop

The table can be read as follows: 2179 individuals have a coffee shop in the municipality and 1972 individuals have no coffee shop in the municipality and have to travel more than 3.1 kilometers to the nearest municipality with a coffee shop. The entire Table of distance and presence of coffee shop can be found in Appendix 7. When distance to a coffee shop is 1 kilometer and there is no coffee shop in the municipality, the distance to the nearest municipality with a coffee shop is 1 kilometer. The distance to a coffee shop is a time varying variable that changes if the number of coffee shops in the municipality drops to zero or when the municipality introduces a coffee shop. This is only the case for a few individuals in the sample (Palali and Van Ours, 2013).

4.2. Methodology

Equation

Whether cannabis use has a direct effect, negative or positive, on health is the question. For the equation of interest, equation (4.1), OLS is used as it makes it easier to interpret the parameter estimates compared to using a probit model.

$$H_i = \beta_0 + \beta_1 X_i + \gamma C_i + u_i \qquad (4.1)$$

where

H_i is self assessed health for individual i
X_i are the characteristics for individual i
C_i is cannabis use for individual i

Cannabis use may be influenced by individual characteristics, for example: gender, education, and age. In equation (4.2), the relation between cannabis use and these individual characteristics is shown.

$$C_i = \alpha_1 + \beta_1 X_i + \delta S_i + v_i \qquad (4.2)$$

where

C_i is cannabis use for individual i
X_i are the characteristics for individual i
S_i is the instrument for cannabis use for individual i

2sls

To see whether there is a causal effect, the instrumental variable approach will be used. An instrument randomizes the data to make sure that the relationship between cannabis and health is not due to heterogeneity and reverse causality. Cannabis use may not be exogenous as variables such as age and gender may influence cannabis use and SAH. From Figure 4.2, we can see that when you are getting older, you will report a lower SAH and from Figure 4.5, it can be seen that when you are getting older, you are less likely to use cannabis. From

Figure 4.1, it seems that males report a higher SAH and from Figure 4.4 it seems that males are more likely to use cannabis. This means that cannabis use may not be exogenous but endogenous. To test for this, the instrumental variable approach is used.

From the first stage regression it can be concluded whether the instrument is relevant or not: if the instrument is significant in the first stage regression, the instrument is associated with using more cannabis, and in turn, is relevant.

Religion is often used in the literature as an instrument for cannabis use, as being religious has a significant negative relationship with drug use (French et al., 2001; Zavala and French, 2003; Roebuck et al., 2004). However, researchers are concerned about the potential endogeneity of religion as religion might be correlated with unobserved personal characteristics (Auld, 2005).

In this paper, two alternative instruments will be introduced and tested. The instruments are presence of a coffee shop and Distance to a coffee shop. When you live in a municipality where they have a coffee shop you might be more inclined to try cannabis or have a higher intake of cannabis, as it is easily accessible. However, it is highly unlikely that the presence of a coffee shop has a direct impact on health.

According to Palali and Van Ours (2013), there seems to be a relation between distance to a coffee shop and the intake of cannabis for the younger individuals. More than 50% of the sample lives in a municipality with a coffee shop. When the distance to a coffee shop is less than 5 kilometers, 40% of the individuals used cannabis at least once in their lifetime. When the distance to a coffee shop is more than 20 kilometers only 16.9% used cannabis at least once in their lifetime. For the older individuals there did not seem to be a relation. Distance to a coffee shop influences cannabis intake, as a higher distance decreases the chance of using cannabis, but it is unlikely that the distance to a coffee shop influences your SAH.

Sensitivity analysis

A sensitivity analysis is necessary to determine the robustness or uncertainty of the model and/or the findings (Saltelli et al., 2010).

First, some restrictions on age and migrant status will be tested to see the effect on cannabis use. Also smoking cigarettes will be added to see whether this has an effect on cannabis use. According to Palali and Van Ours (2013), at a certain age, individuals will not try new things, where the crucial age is between 15 and 25. Therefore an age criteria is used, where we will only look at individuals aged 16-24. Research has shown that individuals with a migrant background are less honest and are more likely to underreport when completing a questionnaire (Carballo and Nerukar, 2001). Therefore, only the individuals with a Dutch background will be included in the baseline analysis, to see whether including migrants changes the outcome variables, cannabis use and SAH, all individuals will be taken into account in the sensitivity analysis.

To test the robustness of cannabis use, cannabis use as a dependent variable will be replaced by frequency of cannabis use, ever using cannabis, and smoking cigarettes. Cannabis use will be replaced by the frequency of cannabis use to see whether using cannabis every day will have a stronger effect on health than using cannabis once a week. The variable cannabis use will be replaced by ever having used cannabis to see whether there is a difference in long-term effects. In the literature, cannabis use over the past 30 days is used as an indicator for long-term cannabis use. However, only 164 out of 4842 (3.4%) individuals reported that they used cannabis in the last 30 days. When changing the question to “Have you ever used cannabis?” 1098 out of 4849 (22.6%) individuals indicated that they used cannabis. This might be a better indicator for SAH. Furthermore, the variable smoking cigarettes will be used instead of cannabis use to see if they yield the same result. If they have the same result, it might be that smoking cigarettes might explain the relationship between cannabis and health.

For the sensitivity analysis for SAH, the same restrictions and variables will be tested. If the instrumental variable becomes insignificant in the equation of cannabis use (the

first stage regression), the instrument is not a good instrument and this restriction will not be tested with SAH (second stage regression).

A lot of research is done on cannabis with regards to mental illnesses. In the sensitivity analysis, *SAH* will be replaced by *Anxiety* and *Depression*. By doing this, we can estimate the effect of cannabis on mental illnesses as well and see if there are significant differences between *SAH* and *Anxiety/Depression* when using cannabis.

Whether you should use OLS or an ordered/probit model for categorical dependent variable, is an ongoing debate. The dependent variable, self-rated health is ordered on a scale from 1 to 5. The probit and logit models assume that the categorical dependent variable is a linear function of the explanatory variables (Noreen, 1988).

OLS makes it easier to exploit differences within individuals and interpret the parameter estimates, whereas with a logit or probit model, you cannot say anything about the magnitude of the parameters. The average marginal effects command for logit or probit models calculates the average marginal effects of the whole sample. This means that it calculates the marginal effects for every individual and takes the average (Noreen, 1988). For binary dependent variables, logistic regressions are better at predicting the probability of an attribute (Pohlmann and Leitner, 2003). According to Noreen (1988), OLS regressions perform just as well as using a logit or probit model when having more than two categories.

However, a sensitivity analysis with an ordered probit model will be included to see if the same results are achieved.

5. Results

In this chapter, the results of the analysis will be discussed. First the baseline results will be presented with the results of the instrumental variable approach and this is followed by the results of the sensitivity analysis.

5.1. Equations of Interest

The results of the equations of interest will be presented while using OLS. First the results of the first stage regression will be presented and this will be followed by the results of the second stage regression.

Cannabis Use

Equation (4.2), also known as the first stage regression, is used to estimate which variables affect the use of cannabis. The results are presented below in Table 5.1.

Table 5.1: OLS with Cannabis Use as Dependent Variable

VARIABLES	(1)	(2)	(3)	(4)
Female	-0.020***	-0.021***	-0.020***	-0.022***
	(0.007)	(0.007)	(0.007)	(0.007)
Age				
25-34	-0.095***	-0.096***	-0.095***	-0.092***
	(0.022)	(0.022)	(0.022)	(0.022)
35-44	-0.109***	-0.110***	-0.109***	-0.106***
	(0.021)	(0.021)	(0.021)	(0.021)
45-54	-0.116***	-0.116***	-0.116***	-0.113***
	(0.021)	(0.021)	(0.021)	(0.021)
55-64	-0.135***	-0.137***	-0.136***	-0.134***
	(0.020)	(0.020)	(0.020)	(0.020)
65+	-0.138***	-0.140***	-0.139***	-0.137***
	(0.020)	(0.020)	(0.020)	(0.020)
Education				
VMBO	0.006	0.005	0.005	0.007
	(0.014)	(0.014)	(0.014)	(0.014)
HAVO/VWO	-0.010	-0.011	-0.011	-0.010
	(0.019)	(0.019)	(0.019)	(0.019)
MBO	-0.004	-0.004	-0.004	-0.005
	(0.015)	(0.015)	(0.015)	(0.015)
HBO	-0.013	-0.012	-0.013	-0.012
	(0.014)	(0.014)	(0.014)	(0.014)
WO	-0.022	-0.023	-0.023	-0.022
	(0.016)	(0.016)	(0.016)	(0.016)
Other	-0.001	-0.000	-0.002	0.002
	(0.019)	(0.019)	(0.019)	(0.019)
Urban				
Slightly urban	0.010	0.009	0.009	0.010
	(0.008)	(0.008)	(0.008)	(0.008)
Moderately urban	0.003	0.003	-0.000	0.016*
	(0.009)	(0.010)	(0.010)	(0.008)
Very Urban	-0.000	0.002	-0.003	0.018**
	(0.011)	(0.012)	(0.013)	(0.008)
Extremely urban	0.013	0.018	0.010	0.036***
	(0.015)	(0.015)	(0.016)	(0.013)
Specific diseases				
Asthma	-0.016	-0.016	-0.016	-0.017
	(0.014)	(0.014)	(0.014)	(0.014)
Arthritis	0.017	0.018	0.017	0.018
	(0.012)	(0.012)	(0.012)	(0.012)
Cancer	0.016	0.016	0.016	0.014
	(0.030)	(0.030)	(0.030)	(0.030)
Alzheimer	0.126	0.125	0.125	0.126
	(0.133)	(0.132)	(0.133)	(0.132)
Presence coffee shop	0.025***	-	0.019**	-
	(0.009)		(0.010)	
Distance coffee shop	-	-0.001**	-0.001	-
		(0.001)	(0.001)	
Religion	-	-	-	0.002
				(0.002)
Constant	0.155***	0.177***	0.165***	0.154***
	(0.026)	(0.029)	(0.029)	(0.027)
Observations	3,017	3,017	3,017	3,000
R-squared	0.064	0.063	0.064	0.060

Notes: (i) Output for Equation (4.2): First Stage Regression, with Cannabis Use as dependent variable. (ii) Column (1) with presence of a coffee shop in the municipality, Column (2) with Distance to a coffee shop, Column (3) with presence of a coffee shop and Distance to a coffee shop, and Column (4) with Religion. (iii) Coefficient and Robust Standard Errors in Parentheses. (iii) *** p<0.01, ** p<0.05, * p<0.1.

According to Column (1) in Table 5.1, females use 2.0% less cannabis compared to males. When getting older, you are less likely to use cannabis, as all age categories are relative to the age category 16-24. When you are 65^{+} you use 13.8% less cannabis compared to individuals aged 16-24. A higher educational attainment level is associated with less cannabis use compared to primary education. However, there is one exception: VMBO; this level of education is associated with higher use of cannabis compared to primary education (+0.6%). As expected, individuals living in an urban area are more likely to use cannabis compared to individuals living in a rural area. An interesting observation is that individuals living in a very urban area are less likely to use cannabis compared to individuals living in a rural area, but this effect is negligible. Individuals with asthma are less likely to use cannabis, whereas individuals with arthritis, cancer and Alzheimer's are more likely to use cannabis; individuals with Alzheimer's use 12.6% more cannabis than individuals with no disease. Individuals who live in a municipality with a coffee shop are more likely to use cannabis compared to individuals who live in a municipality with no coffee shop.

The constant can be interpreted as follows: a Dutch male aged 16-24 who has a primary education, lives in a rural area and has no specific disease has a 15.5% chance of using cannabis.

However, not all parameters are significant, especially in the categories: Education, Urban, and Specific diseases. For these categories, a test for joint significance is conducted to see whether the categories are significant together. From Table 5.2 (1), it can be concluded that the categories for Education, Urban, and Specific diseases are not jointly significant and therefore cannot explain much.

Parameter	(1) P-value	(2) P-value
Education	0.2787	0.2921
Urban	0.5654	0.5828
Specific diseases	0.2349	0.2359

Table 5.2: Wald Test for Joint Significance Parameters (1)=Presence Coffee Shop, (2)=Distance to a Coffee Shop.

In Table 5.1 (2), presence of a coffee shop is replaced with distance to a cannabis shop. The results do not change that much, except for Urban. With distance to a cannabis shop, individuals living in a more urban area compared to a rural area are more likely to use cannabis. From Column (2) in Table 5.1, you can see that there is a significant negative effect of distance of a coffee shop on cannabis intake.

In Table 5.1 (3), the presence of a cannabis shop and the distance to a cannabis shop are both included. When living in a moderately urban area, individuals are less likely to use cannabis compared to individuals living in a rural area. Furthermore, the presence of a cannabis shop becomes significant at a 5% significance level and the distance to a cannabis shop becomes insignificant at a 10% significance level.

In Table 5.1 (4), Religion is added to the equation. The only changes compared to the presence of a coffee shop is that almost all categories of urban become significant, which means that living in a more urban area increases cannabis use. However, religion is insignificant at 10% significance level.

SAH

Equation (4.1) is used to estimate the effect of cannabis on self-assessed health. The results can be found in Table 5.3 (1). Table 5.3 (2) reports the results when using presence of a coffee shop in the municipality and Table 5.3 (3) when using Distance to a coffee shop as instrument. Presence in combination with distance to a coffee shop and religion will not be used as an instrument as these where insignificant at a 10% significance level in the first stage regression. This means that these are irrelevant instruments.

According to Table 5.3 (1), using cannabis more than once a week for the past month has a significant negative effect on SAH, compared to individuals who did not use cannabis over the past month. Females report a lower SAH compared to males, although this is not

significant. As is expected, the older you get, the lower the reported SAH. The age effect is greatest at the age category 55-64, and becomes smaller again in the age category 65+. For The age category 65^{+}, the SAH score will decrease by 0.34 on a scale of 1-5 compared to individuals' aged 16-24. All educational attainment levels above primary education report higher SAH. An interesting observation is that individuals living in a slightly, very and extremely urban area report lower SAH compared to living in a rural area, whereas individuals living in a moderately urban area report higher SAH. However, these are not significant. As expected, individuals with a specific disease report lower SAH compared to individuals who do not have these illnesses, with the largest negative effect on SAH being Alzheimer's, which lowers the SAH score by 0.92 compared to individuals who do not have Alzheimer's.

The constant can be interpreted as follows: a Dutch male aged 16-24, who does not use cannabis, has a primary education, lives in a rural area and has no specific disease has a score of 3.3 on a scale of 1-5 for SAH. This means he has a good health.

Table 5.3: SAH as Dependent Variable

VARIABLES	(1) OLS	(2) 2SLS	(3) 2SLS
Instrument	-	Presence Coffee shop	Distance Coffee shop
Cannabis use	-0.206**	-2.411	-1.492
	(0.091)	(1.673)	(1.782)
Female	-0.016	-0.062	-0.043
	(0.028)	(0.045)	(0.046)
Age			
25-34	-0.136**	-0.344**	-0.257
	(0.064)	(0.172)	(0.179)
35-44	-0.237***	-0.475**	-0.376*
	(0.058)	(0.190)	(0.200)
45-54	-0.332***	-0.586***	-0.480**
	(0.056)	(0.199)	(0.211)
55-64	-0.356***	-0.655***	-0.531**
	(0.057)	(0.231)	(0.245)
65+	-0.335***	-0.640***	-0.513**
	(0.059)	(0.235)	(0.248)
Education			
VMBO	0.186***	0.200***	0.194***
	(0.064)	(0.072)	(0.067)
HAVO/VWO	0.196***	0.174*	0.183**
	(0.074)	(0.089)	(0.082)
MBO	0.205***	0.199***	0.201***
	(0.068)	(0.076)	(0.071)
HBO	0.342***	0.317***	0.327***
	(0.067)	(0.077)	(0.073)
WO	0.440***	0.394***	0.413***
	(0.085)	(0.099)	(0.096)
Other	0.072	0.076	0.074
	(0.090)	(0.098)	(0.092)
Urban			
Slightly urban	-0.017	0.009	-0.002
	(0.041)	(0.047)	(0.046)
Moderately urban	0.053	0.088*	0.073
	(0.042)	(0.052)	(0.052)
Very Urban	-0.006	0.033	0.017
	(0.042)	(0.057)	(0.055)
Extremely urban	-0.018	0.058	0.026
	(0.052)	(0.084)	(0.083)
Specific diseases			
Asthma	-0.375***	-0.412***	-0.396***
	(0.076)	(0.082)	(0.081)
Arthritis	-0.430***	-0.390***	-0.406***
	(0.054)	(0.065)	(0.064)
Cancer	-0.546***	-0.515***	-0.528***
	(0.156)	(0.178)	(0.167)
Alzheimer	-0.921**	-0.641	-0.757*
	(0.396)	(0.431)	(0.423)
Constant	3.292***	3.637***	3.494***
	(0.094)	(0.275)	(0.293)
Observations	3,017	3,017	3,017
R-squared	0.094		0.023

Notes: (i) Output for Equation (4.3). (ii) (1)=OLS (2)=Presence coffee shop in municipality, (3)=Distance to coffee shop as instrument. (iii) Coefficient and robust standard errors in parentheses. (iv) *** p<0.01, ** p<0.05, * p<0.1.

Not all coefficients for urban, and education are significant when using OLS. Therefore, a Wald test is conducted. The results of the Wald test can be found in Table 5.4.

Parameter	P-value
Urban	0.3822
Education	0.0000

Table 5.4: Wald Test for Joint Significance Parameters

From Table 5.4, it can be concluded that the categories of education are jointly significant. The categories of urban are jointly insignificant. Education does have an effect on SAH, but for urban there does not seem to be an effect.

2SLS

To test whether there is a causal relation between cannabis and health, two instruments will be tested. The first instrument that will be tested is presence of a coffee shop and the second one will be the distance to a coffee shop.

First Stage Regression

From the result of the first stage regression, Table 5.1 column 1 and 2, it can be concluded that presence to cannabis shop and distance to cannabis shop are both relevant instruments as they both are significant at 5%.

There are different methods to validate whether an instrument is weak. According to the rule of thumb of Staiger and Stock (1997), an instrument is weak if the F-statistic of the first stage is less than 10. Stock and Yoko (2005) provided an improvement to the rule of thumb of Staiger and Stock and said if the minimum eigenvalue statistic exceeds the critical value, that the instrument is not weak. The 5% Wald test has rejection rates of 10%, 15%, 20% and 25%.

The Staiger and Stock rule of thumb and the Cragg-Donald Wald statistic can be found in Table 5.5.

Instrument	F-statistic	Eigenvalue	10%	15%	20%	25%
Presence coffee shop	7.58	10.33	16.38	8.96	6.66	5.53
Distance to a coffee shop	5.90	7.27	16.38	8.96	6.66	5.53

Table 5.5: Tests for Weak Instrument

When using the rule of thumb, presence of a coffee shop in the municipality is seen as a weak instrument, but if we look at the Cragg-Donald Wald statistic at 15%, it can be concluded that it is not a weak instrument. Distance to a coffee shop, according to the rule of thumb, is seen as a weak instrument. However, at 20% of the Cragg-Donald Wald statistic, the null hypothesis of a weak instrument can be rejected.

Second Stage Regression

In the second stage regression the adjusted explanatory variable cannabis is used with the instrument to see whether cannabis use is still exogenous to the outcome variable, SAH. OLS is violated if cannabis is correlated with the error, cannabis use will then we endogenous. If the coefficient of cannabis has changed in magnitude, it can be concluded that there is no more heterogeneity or reverse causality. The results of the second stage regression can be found in Table 5.3, columns 2 and 3. Further results of the second stage regression will be discussed in the sensitivity analysis.

5.2. Sensitivity Analysis

In the sensitivity analysis, the results of cannabis use, equation (4.2), will be discussed. This is followed by the results of the equation of interest: SAH, equation (4.1).

Cannabis Use

In column (1) of Table 5.6, the base scenario of cannabis use is shown. This column is the same as Table 5.1 (1). In the base scenario, age is divided into categories and all ages are taken into account. According to Palali and Van Ours (2013), the crucial age for cannabis intake ranges from 15-25 years old. Therefore an age restriction of 16-25 is imposed. In column (2) the results of this restriction are shown. Especially in the categories of education sign changes in the coefficients are seen. Whereas with the baseline (1), individuals with a VMBO have a higher chance of using cannabis compared to having a Primary diploma, with the age restriction this is reversed. Furthermore, individuals aged 16-24 with a specific disease, are less likely to use cannabis compared to individuals who do not have a specific disease. Alzheimer's is omitted, as it is highly unlikely that an individual aged 16-24 has this disease and nobody in this dataset has Alzheimer's at this age. When imposing the age restriction, the variable presence of a coffee shop becomes insignificant at a 10% level.

In the base scenario, only individuals with a Dutch background are included. In column (3), the results are shown when migrants are included in the regression. When comparing the baseline (1) with column (3), it can be concluded that it almost follows the baseline. However, a sign change is visible with individuals with a VMBO diploma; these individuals are less likely to use cannabis compared to individuals with a primary education, and individuals having another type of education are more likely to use cannabis compared to individuals with a Primary education.

In column (4), whether you smoke cigarettes is included to see if smoking cigarettes increases the chance of using cannabis. There are some sign changes, especially in the categories of education. When having a higher education, you are less likely to use cannabis compared to having a Primary education diploma, except for a WO diploma; these individuals are less likely to use cannabis.

In this paper, the aim is to estimate the long-term effect of cannabis on health using the variable cannabis use as a binary dependent variable. To see whether this is a good fit, cannabis use is changed to frequency of cannabis use (column 5), ever used cannabis (column 6), and smoking cigarettes (column 7). When changing the dependent variable to frequency of cannabis use in column (5), some sign changes are visible. Individuals with a MBO diploma and other type of diploma are more likely to use more cannabis compared to individuals with a Primary education diploma. Individuals living in a moderately urban area are less likely to use more cannabis compared to individuals living in a rural area.

From column (6), it can be seen that there are quite some sign changes. The magnitude of the coefficients has also increased. When looking at the age categories, individuals aged 25-34 are more likely to use cannabis compared to individuals aged 16-24. An interesting observation is that almost all educational levels have a sign change. When you have a higher educational attainment, you are more likely to use cannabis at least once in your life compared to having a Primary education, where individuals with a WO diploma have the highest chance of using cannabis. When cannabis use is replaced by if you ever used cannabis, the variable presence of a coffee shop becomes insignificant at 10% significance level.

Concluding that cannabis has a negative effect on health might be a premature conclusion as smoking might be the underlying factor. Lewinsohn et al. (1999) reported that smoking daily increases the chances of using cannabis in the future. This way smoking and not cannabis intake might be the cause of deteriorating health. In column (7), the results are shown where smoking cigarettes replace cannabis use as a dependent variable. Where it is expected that almost all coefficients have the same sign, the opposite is true. Where with cannabis intake, increasing age leads to a lower chance to use cannabis, with smoking the chance increases with age. An interesting observation is that individuals living in rural areas are more likely to smoke compared to living in an urban area, as the opposite is true for cannabis. Also, as educational attainment level rises, the chance of smoking reduces. Where with cannabis intake, individuals with a MBO diploma were more likely to use cannabis, with smoking they are less likely to smoke compared to individuals with a Primary diploma.

Where individuals with cancer were more likely to use cannabis, the opposite is the case with smoking. Furthermore, when replacing cannabis use by smoking cigarettes, the variable presence of a coffee shop becomes insignificant at 10%.

Table 5.6: Sensitivity Analysis for Cannabis Use

VARIABLES	(1) OLS	(2) Age	(3) Migrant	(4) Smoke cigarettes	(5) Frequency cannabis	(6) Ever used cannabis	(7) Smoking cigarettes
Female	-0.020***	-0.036	-0.019***	-0.017***	-0.062***	-0.095***	-0.049***
	(0.007)	(0.023)	(0.006)	(0.006)	(0.018)	(0.015)	(0.016)
Age							
25-34	-0.095***	-	-0.094***	-0.098***	-0.166***	0.097**	0.038
	(0.022)		(0.021)	(0.022)	(0.055)	(0.038)	(0.035)
35-44	-0.109***	-	-0.105***	-0.111***	-0.199***	-0.005	0.010
	(0.021)		(0.020)	(0.020)	(0.052)	(0.034)	(0.032)
45-54	-0.116***	-	-0.114***	-0.119***	-0.222***	-0.079**	0.026
	(0.021)		(0.020)	(0.020)	(0.050)	(0.032)	(0.032)
55-64	-0.135***	-	-0.134***	-0.136***	-0.277***	-0.190***	-0.006
	(0.020)		(0.019)	(0.020)	(0.048)	(0.031)	(0.032)
65+	-0.138***	-	-0.138***	-0.131***	-0.287***	-0.288***	-0.108***
	(0.020)		(0.019)	(0.019)	(0.049)	(0.029)	(0.032)
Education							
VMBO	0.006	-0.113	-0.008	0.011	0.037	0.036	-0.069*
	(0.014)	(0.229)	(0.016)	(0.014)	(0.029)	(0.024)	(0.042)
HAVO/VWO	-0.010	-0.268	-0.030	0.001	-0.018	0.069**	-0.149***
	(0.019)	(0.223)	(0.020)	(0.019)	(0.041)	(0.034)	(0.047)
MBO	-0.004	-0.212	-0.017	0.007	0.006	0.023	-0.132***
	(0.015)	(0.223)	(0.017)	(0.015)	(0.032)	(0.027)	(0.043)
HBO	-0.013	-0.237	-0.026	0.003	-0.017	0.073***	-0.193***
	(0.014)	(0.223)	(0.016)	(0.015)	(0.030)	(0.027)	(0.042)
WO	-0.022	-0.237	-0.037**	-0.001	-0.063*	0.137***	-0.275***
	(0.016)	(0.225)	(0.018)	(0.017)	(0.033)	(0.042)	(0.048)
Other	-0.001	-0.259	0.002	0.009	0.022	0.053	-0.125**
	(0.019)	(0.224)	(0.023)	(0.020)	(0.051)	(0.039)	(0.057)
Urban							
Slightly urban	0.010	0.012	0.012	0.014*	0.036*	0.032	-0.047*
	(0.008)	(0.019)	(0.008)	(0.008)	(0.020)	(0.021)	(0.025)
Moderately urban	0.003	0.039	0.002	0.005	-0.002	0.026	-0.033
	(0.009)	(0.024)	(0.008)	(0.009)	(0.021)	(0.023)	(0.028)
Very Urban	-0.000	0.017	-0.002	0.004	-0.002	0.049*	-0.050*
	(0.011)	(0.031)	(0.011)	(0.011)	(0.029)	(0.025)	(0.029)
Extremely urban	0.013	0.069	0.020	0.008	0.042	0.122***	0.068*
	(0.015)	(0.047)	(0.015)	(0.015)	(0.041)	(0.033)	(0.037)
Specific diseases							
Asthma	-0.016	-0.038**	-0.010	-0.014	-0.032	-0.043	-0.030
	(0.014)	(0.018)	(0.015)	(0.014)	(0.041)	(0.037)	(0.042)
Arthritis	0.017	-0.004	0.013	0.017	0.075*	0.050**	0.002
	(0.012)	(0.019)	(0.011)	(0.011)	(0.043)	(0.023)	(0.033)
Cancer	0.016	-0.065**	0.011	0.018	0.025	0.008	-0.020
	(0.030)	(0.029)	(0.025)	(0.031)	(0.060)	(0.051)	(0.074)
Alzheimer	0.126	-	0.105	0.113	0.232	0.101	0.170
	(0.133)		(0.118)	(0.128)	(0.265)	(0.151)	(0.167)
Presence coffee shop	0.025***	0.041	0.023***	0.024***	0.074***	0.024	0.021
	(0.009)	(0.028)	(0.009)	(0.009)	(0.024)	(0.018)	(0.021)
Migrant	-	-	0.002	-	-	-	-
			(0.010)				
Smoking cigarettes	-	-	-	0.078***	-	-	-
				(0.010)			
Constant	0.155***	0.264	0.164***	0.118***	0.318***	0.346***	0.480***
	(0.026)	(0.220)	(0.028)	(0.025)	(0.059)	(0.045)	(0.057)
Observations	3,017	353	3,367	3,012	3,017	3,021	3,019
R-squared	0.064	0.093	0.060	0.104	0.045	0.123	0.035

Notes: (i) Output Sensitivity Analysis for Cannabis Use (ii) Coefficient and robust standard errors in parentheses. (iii) *** p<0.01, ** p<0.05, * p<0.1.

SAH

In Table 5.7, the results of the sensitivity analysis for SAH are reported. This is a sensitivity analysis on the IV method. The results are compared to the base, which is shown in Table 5.7 (1), and in all the analyses the presence of a coffee shop is used as an instrument. From the results of the sensitivity analysis for cannabis use, it is concluded that the presence of a coffee shop does not influence cannabis use when imposing an age restriction. Furthermore, the presence of a coffee shop in the municipality also does not influence whether you ever used cannabis or whether you smoke cigarettes or not. Because of this, these variables will not be taken into account in the sensitivity analysis for SAH.

For all analyses, except for the age restriction, the coefficient of cannabis use becomes more negative. If the IV method gives considerably larger results than OLS, the instrument of presence of a coffee shop determines SAH directly or through some omitted variable. This means that presence of a coffee shop might not be a valid instrument.

Table 5.7: Sensitivity Analysis for SAH

VARIABLES	(1) OLS	(2) 2SLS	(3) 2SLS Migrant	(4) 2SLS Smoke cigarettes	(5) 2SLS Interaction	(6) 2SLS Frequency cannabis use
Cannabis use	-0.206**	-2.411	-2.146	-2.515	-18.231	-0.813
	(0.091)	(1.673)	(1.708)	(1.794)	(29.603)	(0.543)
Female	-0.016	-0.062	-0.070*	-0.061	-0.068	-0.063
	(0.028)	(0.045)	(0.042)	(0.042)	(0.079)	(0.045)
Age						
25-34	-0.136**	-0.344**	-0.332*	-0.354*	-0.442	-0.251**
	(0.064)	(0.172)	(0.171)	(0.189)	(0.582)	(0.112)
35-44	-0.237***	-0.475**	-0.437**	-0.488**	-0.692	-0.375***
	(0.058)	(0.190)	(0.185)	(0.205)	(0.779)	(0.122)
45-54	-0.332***	-0.586***	-0.560***	-0.601***	-0.799	-0.488***
	(0.056)	(0.199)	(0.199)	(0.218)	(0.794)	(0.131)
55-64	-0.356***	-0.655***	-0.606***	-0.670***	-0.888	-0.555***
	(0.057)	(0.231)	(0.233)	(0.248)	(0.869)	(0.160)
65+	-0.335***	-0.640***	-0.608**	-0.649***	-0.905	-0.540***
	(0.059)	(0.235)	(0.239)	(0.237)	(0.917)	(0.163)
Education						
VMBO	0.186***	0.200***	0.198***	0.204***	0.001	0.216***
	(0.064)	(0.072)	(0.067)	(0.075)	(0.324)	(0.070)
HAVO/VWO	0.196***	0.174*	0.165*	0.183**	-0.055	0.184**
	(0.074)	(0.089)	(0.093)	(0.089)	(0.357)	(0.081)
MBO	0.205***	0.199***	0.177**	0.206***	-0.019	0.213***
	(0.068)	(0.076)	(0.075)	(0.077)	(0.366)	(0.070)
HBO	0.342***	0.317***	0.314***	0.328***	0.095	0.334***
	(0.067)	(0.077)	(0.080)	(0.076)	(0.380)	(0.070)
WO	0.440***	0.394***	0.347***	0.407***	0.029	0.396***
	(0.085)	(0.099)	(0.105)	(0.094)	(0.601)	(0.093)
Other	0.072	0.076	0.151*	0.084	-0.028	0.097
	(0.090)	(0.098)	(0.089)	(0.100)	(0.298)	(0.094)
Urban						
Slightly urban	-0.017	0.009	0.004	0.013	-0.012	0.013
	(0.041)	(0.047)	(0.047)	(0.051)	(0.075)	(0.047)
Moderately urban	0.053	0.088*	0.088*	0.091*	0.062	0.079*
	(0.042)	(0.052)	(0.049)	(0.054)	(0.078)	(0.048)
Very Urban	-0.006	0.033	0.033	0.037	0.091	0.031
	(0.042)	(0.057)	(0.051)	(0.062)	(0.205)	(0.054)
Extremely urban	-0.018	0.058	0.031	0.056	0.150	0.060
	(0.052)	(0.084)	(0.088)	(0.079)	(0.277)	(0.082)
Specific diseases						
Asthma	-0.375***	-0.412***	-0.437***	-0.412***	-0.532**	-0.399***
	(0.076)	(0.082)	(0.077)	(0.082)	(0.264)	(0.079)
Arthritis	-0.430***	-0.390***	-0.414***	-0.388***	-0.482***	-0.369***
	(0.054)	(0.065)	(0.059)	(0.067)	(0.116)	(0.074)
Cancer	-0.546***	-0.515***	-0.482***	-0.513***	-0.074	-0.534***
	(0.156)	(0.178)	(0.153)	(0.181)	(0.953)	(0.168)
Alzheimer	-0.921**	-0.641	-0.719*	-0.637	-0.939**	-0.756**
	(0.396)	(0.431)	(0.370)	(0.428)	(0.375)	(0.376)
Migrant	-	-	-0.068	-	-	-
			(0.046)			
Smoke cigarettes	-	-	-	0.058	-0.289	-
				(0.144)	(0.261)	
Interaction cigarettes and cannabis	-	-	-	-	17.861	-
					(29.256)	
Constant	3.292***	3.637***	3.627***	3.627***	4.167***	3.524***
	(0.094)	(0.275)	(0.294)	(0.234)	(1.288)	(0.196)
Observations	3,017	3,017	3,367	3,012	3,012	3,017
R-squared	0.094					
Endogeneity test	-	0.132	0.213	0.124	0.125	0.148

Notes: (i) Output Sensitivity Analysis for SAH. (ii) Column (1)=OLS. (2)=base scenario with presence of coffee shop as instrument, (3)=all individuals in sample, (4)=adding smoking cigarettes to regression, (5) adding interaction between smoking tobacco and using cannabis, (6)=changing cannabis use from binary variable to categorical variable, frequency of cannabis use. (iii) Coefficient and robust standard errors in parentheses. (iv) *** p<0.01, ** p<0.05, * p<0.1.

In all columns in Table 5.7, the magnitude has changed significantly for cannabis use; the coefficient becomes more negative. Therefore, the coefficients are likely to be biased and inconsistent. This means that the causal interpretation of the coefficient is not valid (Winship and Radbill, 1994). The coefficient for cannabis use becomes insignificant when using the

instruments and this means that there is no endogeneity problem and/or the instrument might not be precise. To verify this, an endogeneity test is conducted and the results can be found in Table 5.7 (Endogeneity test). The null hypothesis of exogeneity cannot be rejected as the p-value exceeds 0.05. Cannabis use is therefore an exogenous regressor and OLS is preferred as IV is inefficient. OLS will give unbiased and consistent estimates of the slope coefficient and the intercept coefficient.

Mental Health

Cannabis use is exogenous; this means that IV will give imprecise and biased estimates. To compare SAH with feeling anxious and depressed, OLS will be used. As usual, column (1) of Table 5.8 reports the results when using SAH as dependent variable.

Table 5.8: Sensitivity Analysis OLS; SAH vs. Mental health

VARIABLES	(1) SAH	(2) Anxiety	(3) Depression
Cannabis use	-0.206**	-0.105	0.055
	(0.091)	(0.116)	(0.130)
Female	-0.016	0.222***	0.124***
	(0.028)	(0.037)	(0.038)
Age			
25-34	-0.136**	-0.433***	-0.091
	(0.064)	(0.084)	(0.084)
35-44	-0.237***	-0.555***	-0.302***
	(0.058)	(0.077)	(0.077)
45-54	-0.332***	-0.622***	-0.180**
	(0.056)	(0.075)	(0.075)
55-64	-0.356***	-0.621***	-0.304***
	(0.057)	(0.075)	(0.075)
65+	-0.335***	-0.669***	-0.453***
	(0.059)	(0.080)	(0.077)
Education			
VMBO	0.186***	-0.307***	-0.132
	(0.064)	(0.111)	(0.099)
HAVO/VWO	0.196***	-0.226*	-0.026
	(0.074)	(0.124)	(0.113)
MBO	0.205***	-0.255**	-0.139
	(0.068)	(0.113)	(0.102)
HBO	0.342***	-0.354***	-0.230**
	(0.067)	(0.112)	(0.101)
WO	0.440***	-0.268**	-0.097
	(0.085)	(0.128)	(0.120)
Other	0.072	-0.386***	-0.142
	(0.090)	(0.147)	(0.142)
Urban			
Slightly urban	-0.017	-0.023	0.068
	(0.041)	(0.056)	(0.056)
Moderately urban	0.053	-0.010	0.083
	(0.042)	(0.058)	(0.058)
Very Urban	-0.006	0.058	0.034
	(0.042)	(0.058)	(0.055)
Extremely urban	-0.018	0.119	0.094
	(0.052)	(0.072)	(0.071)
Specific diseases			
Asthma	-0.375***	0.274**	0.269**
	(0.076)	(0.117)	(0.126)
Arthritis	-0.430***	0.221**	0.138*
	(0.054)	(0.091)	(0.083)
Cancer	-0.546***	0.642***	0.546**
	(0.156)	(0.205)	(0.214)
Alzheimer	-0.921**	0.693**	1.493**
	(0.396)	(0.323)	(0.585)
Constant	3.292***	2.660***	2.143***
	(0.094)	(0.145)	(0.134)
Observations	3,017	3,017	3,017
R-squared	0.094	0.071	0.042

Notes: (i) Output Sensitivity Analysis for SAH. (ii) Column (1)=base scenario SAH, (2)=anxiety as dependent variable, (3)=depression as dependent variable. (iii) Coefficient and robust standard errors in parentheses. (iv) *** p<0.01, ** p<0.05, * p<0.1.

Column (2) of Table 5.9 shows the results when using anxiety as dependent variable. A Dutch male aged 16-24 who has a Primary education diploma, lives in a rural area and has no specific disease has a score of 2.7 of anxiety on a scale from 1-6. This means that this

individual seldom to sometimes feels anxious. Cannabis use decreases the anxiety score by 0.1.

Column (3) of Table 5.8 shows the results when using depression as dependent variable. A Dutch male aged 16-24 who has a Primary education diploma, lives in a rural area and has no specific disease has a score of 2.1 of feeling depressed on a scale from 1-6. This means that this individual seldom feels depressed. Using cannabis increases the depression score by 0.6.

Oprobit Model

In Table 5.9, an oprobit model is used instead of OLS for equation 4.1. In the first column the oprobit model can be found. However, as we can only say something about the sign and significance of the oprobit model, the marginal effects are calculated for poor, moderate and excellent SAH. These results can be found in Table 5.9 column 2-4.

For the oprobit model, estimated probabilities can be calculated. A Dutch male aged 16-24 with a primary education diploma who lives in a rural area, has no specific disease and who uses cannabis, has the following estimated probability for belonging in the category poor health:

$$P(Y=j|x_{\text{cannabis use}})=\Phi\left(\tau_j-\beta_j x_{\text{cannabis use}}\right)-\Phi(\tau_{j-1}-\beta_{j-1}x_{cannabis\ use})$$

where Φ is the cumulative distribution of the normal distribution and τ_j is cut off point j.

$$P(Y=1|x_{\text{cannabis use}})=\Phi(-1.31+0.32)-\Phi(-2.65+0.32)$$

When calculating the cumulative distribution of the normal distribution, this means that for the Dutch male, the estimated probability that this individual belongs to the category moderately healthy is 14.9%. For this Dutch male, the probability of belonging in category poor health is 1.0% and in excellent health is 4.0%

For the oprobit model for poor health, Table 5.9 (2), on average, using cannabis increases the probability of reporting poor health by 0.8 percentage points compared to individuals who do not use cannabis. Effect is significant at a 5% significance level. For good health, Table 5.9 (3), on average, using cannabis increases the probability of reporting good health by 3.5 percentage points compared to individuals who did not use cannabis. For Excellent health, Table 5.9 (4), on average, using cannabis decreases the probability of reporting excellent health by 3.9 percentage points compared to individuals who did not use cannabis.

Table 5.9: Ordered Probit Model

VARIABLES	(1)	(2) Poor health	(3) Good health	(4) Excellent health
Cannabis use	-0.315**	0.008**	0.035**	-0.039**
	(0.137)	(0.004)	(0.016)	(0.017)
Female	-0.027	0.001	0.003	-0.003
	(0.042)	(0.001)	(0.005)	(0.005)
Age				
25-34	-0.204**	0.002**	0.045**	-0.036**
	(0.093)	(0.001)	(0.021)	(0.017)
35-44	-0.345***	0.005***	0.067***	-0.056***
	(0.084)	(0.001)	(0.018)	(0.015)
45-54	-0.488***	0.008***	0.082***	-0.073***
	(0.082)	(0.002)	(0.018)	(0.014)
55-64	-0.530***	0.001***	0.085***	-0.077***
	(0.084)	(0.000)	(0.018)	(0.015)
65+	-0.493***	0.008***	0.082***	-0.073***
	(0.088)	(0.002)	(0.018)	(0.015)
Education				
VMBO	0.294***	-0.011**	-0.006	0.025***
	(0.101)	(0.005)	(0.005)	(0.007)
HAVO/VWO	0.312***	-0.011**	-0.008	0.027***
	(0.115)	(0.005)	(0.007)	(0.009)
MBO	0.332***	-0.012**	-0.010	0.029***
	(0.106)	(0.005)	(0.006)	(0.008)
HBO	0.533***	-0.015***	-0.038***	0.056***
	(0.105)	(0.005)	(0.009)	(0.009)
WO	0.660***	-0.017***	-0.063***	0.077***
	(0.129)	(0.005)	(0.019)	(0.016)
Other	0.124	-0.005	0.002	0.009
	(0.141)	(0.006)	(0.003)	(0.011)
Urban				
Slightly urban	-0.034	0.001	0.004	-0.004
	(0.061)	(0.002)	(0.007)	(0.007)
Moderately urban	0.075	-0.002	-0.010	-0.010
	(0.063)	(0.001)	(0.008)	(0.008)
Very Urban	-0.022	0.001	0.002	-0.003
	(0.064)	(0.002)	(0.007)	(0.008)
Extremely urban	-0.039	0.001	0.004	-0.005
	(0.078)	(0.002)	(0.008)	(0.009)
Specific diseases				
Asthma	-0.593***	0.014***	0.067***	-0.073***
	(0.119)	(0.004)	(0.014)	(0.015)
Arthritis	-0.683***	0.017***	0.077***	-0.084***
	(0.087)	(0.003)	(0.012)	(0.012)
Cancer	-0.849***	0.021***	0.095***	-0.105***
	(0.243)	(0.007)	(0.029)	(0.031)
Alzheimer	-1.438**	0.035**	0.162**	-0.178**
	(0.639)	(0.016)	(0.074)	(0.079)
Cut 1	-2.652***			
	(0.159)			
Cut 2	-1.313***			
	(0.143)			
Cut 3	0.514***			
	(0.142)			
Cut 4	1.440***			
	(0.143)			
Observations	3,017	3,017	3,017	3,017

Notes: (i) Oprobit for SAH. (ii) Column (1)=Ordered probit, (2)=Oprobit marginal effects for poor health, (3)= Oprobit marginal effects for good health, (4) Oprobit margingal effects for excellent health. (iii) Coefficient and robust standard errors in parentheses. (iv) *** p<0.01, ** p<0.05, * p<0.1.

6. Conclusion

Cannabis is easily accessible in the Netherlands, as it is quasi-legalized. Individuals can buy small quantities of cannabis legally in a coffee shop but are not allowed to produce it themselves. Earlier research does not provide a clear picture whether cannabis use has adverse health effects. Negative health effects of cannabis use are the risk of dependency, an increasing risk of cardiovascular diseases, and an impaired respiratory function (Hall and Degenhardt, 2009). Cannabis use can have positive health effects when individuals are really sick, especially when having a disease such as cancer (Sarfaraz et al., 2008). Individuals who have ever used cannabis have an increased risk of psychotic outcomes (Moore et al., 2007). Daily use of cannabis is even associated with a fivefold increase of feeling depressed and anxious (Patton et al. 2002).

The research question was if cannabis use has an effect, either positive or negative, on health. To find a causal effect between cannabis use and health is proven to be difficult as cannabis use may be endogenous. To test for this, the instrumental variable approach is conducted. The instrument used in the literature, religion, was found to be irrelevant and the two newly introduced instruments; presence and distance to a coffee shop were found to be relevant, but whether they are strong or weak instruments is debatable. When there is a coffee shop in the municipality, individuals have a 2.5% higher chance to use cannabis. With an increasing distance to a coffee shop, individuals are less likely to use cannabis.

When using the instruments, there was an enormous effect on the coefficient of cannabis use. Where cannabis use decreases the health score by 0.2 with OLS, with the IV method it decreases the health score by 2.4 on a health scale from 1-5. This leads to the belief that cannabis use might not be endogenous but exogenous. Cannabis use was tested to be an exogenous regressor and thus satisfies the zero conditional mean condition of OLS.

When using OLS, it can be concluded that your health score that is rated on a scale from 0 to 5, will decrease with 0.2 when you use cannabis. Smoking cigarettes and using cannabis may be correlated, as smoking will increase the change of using cannabis by 7.8%. However, with smoking, the older you get the higher the change of smoking until you reach the age of 55. Furthermore, the education effect is much larger and you are more likely to smoke when living in a rural area. It seems that cannabis use and smoking cigarettes can be seen separately, which means than cannabis use does not depend on smoking cigarettes. This is supported by the correlation (0.22), which means only a weak correlation exists between smoking and using cannabis.

If self-assessed health is replaced by mental health, the results are ambiguous. When using cannabis, the anxiety score of 2.7 will decrease by 0.1, holding all else equal. When using cannabis, the depression score of 2.1 will increase by 0.06. However, these effects are not significant. These results are in accordance with Moore et al. (2007), who concluded that outcomes for anxiety and depression were less consistent.

With the oprobit model, the same conclusions as the OLS model can be made for cannabis use on SAH. Holding all else equal, the probability of belonging in the category good health when using cannabis is 63.7%.

To conclude, cannabis use is exogenous. However, individuals who use cannabis are overall healthy individuals who will report a lower health score than individuals who did not use cannabis.

7. Discussion and Recommendations

Some shortcomings and recommendations for future research will be discussed here.

The dataset is the first shortcoming. The LISS provides a representative sample for the Dutch population from 2007 onwards. However, the data for cannabis use is only available for 2008. In earlier research, long-term effects of cannabis use are measured through the 30-day use. In this dataset there were, however, only a few individuals who used cannabis in the past month, which led to small and/or insignificant coefficients. Williams and Hagger-Johnson (2017) reported that higher educated individuals have a higher cannabis intake in the last 30-days but indicated a lower cannabis intake in the last year, compared to lower educated individuals. In this research, when looking at the last 30-days, higher educated individuals use less cannabis compared to the lower educated individuals and when we look at the question whether they ever used cannabis, we see that the higher educated had a higher chance to use cannabis compared to the lower educated. Lynskey and Hall (2000) support the claim that higher educated individuals have a lower chance of using cannabis compared to the lower educated individuals in the last 30 days.

The second shortcoming is the use of the instruments. The presence of a coffee shop is data from 1999 and as the cannabis data is from 2008, this might be problematic. In these 9 years, coffee shops might be relocated, closed or opened. Palali and Van Ours (2012) concluded that this might not be a problem as they compared the number of coffee shops in 1999 with 2007. According to Bieleman et al. (2012), while the number of coffee shops decreased and the number of municipalities decreased as well, the municipalities with a coffee shop remained the same. It is also possible that a municipality had 2 coffee shops and nowadays only has 1 coffee shop. Another remark on the use of the instruments is that the current home address is taken into account. It might be the case that individuals tried cannabis when they were in college and were living in the city where there are coffee shops. When looking at the cannabis use in the last 30 days this is not a problem, except when the individual moved from a city with a coffee shop in that time period to a municipality without a coffee shop. Municipalities with a coffee shop might be the municipalities where individuals are less healthy. Another reason could be that these municipalities are more urban. With urban areas, individuals report lower SAH and this would mean that the urbanity of a municipality explains the SAH and not the distance or the presence of a coffee shop. The distance to a coffee shop might also not be a good instrument as Palali and Van Ours (2012) conclude that the distance effect is only visible for younger individuals. In this research, it is mostly young individuals who use cannabis and this means that the availability or the distance to a coffee shop plays a significant role in the accessibility of cannabis, as they do not have the transportation to travel to another municipality.

The presence and the distance to a coffee shop play significant roles in the accessibility of cannabis, especially for young individuals and as we saw, cannabis leads to a decrease in health. This means that the government must play a role to decrease the accessibility of cannabis for young individuals. One possible solution would be that the number municipalities with coffee shops should decrease, this way there would be no coffee shop in the municipality and the distance to a coffee shop increases, which will lead to a decrease of using cannabis because of decreasing accessibility. Another policy recommendation could be that the government educates high school students about the adverse effects of cannabis on your health, to discourage cannabis use. The government could also take it a step further and educate parents or legal guardians. When they get educated on the adverse effects of cannabis use, they can discourage their children to use cannabis or they can monitor their children.

For future research more data on cannabis use is recommended. Cannabis use and health in 2008 is measured, but as most of the individuals (about $^1/_3$) are young, they might be in the experimental phase in life and have used cannabis in the last month. If the questionnaire had been repeated in 2009, it could be the case that these individuals now

indicate that they have used cannabis at least once in their life but did not use cannabis in the last 30 days. Furthermore, data on how many times they have used cannabis in their entire life is necessary. There is a big difference whether you used cannabis once in your life or you used it daily for a couple of years.

8. List of the Literature References

Abrams, D.I., and Guzman, M. (2015). Cannabis in Cancer Care. *Clinical Pharmacology & Therapeutics, 97,* pp. 575-586

Allebeck, P., Andréasson, S., Engströ., and Rydberg, U. (1987). Cannabis and Schizophrenia a Longitude Study of Swedish Conscripts. *The Lancet, 2*(8574), pp. 1483-1486.

Anand, S., and Hanson, K. (1995). Disability-Adjusted Life Years: a Critical Review. *Journal of Health Economics, 16,* pp. 685-702.

Angrist, J.D., and Krueger, A.B. (2001). Instrumental Variables and the Search for Identification: From Supply and Demand to Natural Experiments. *Journal of Economic Perspectives, 15*(4), pp. 69-85.

Arellano, M., and Bover, O. (1995). Another Look at the Instrumental Variable Estimation of Error-Components. *Journal of Econometrics, 68*, pp. 29-51.

Ashton, H. (2002). Cannabis or health? Current opinion in psychiatry, 15(3), pp. 247-253.

Auld, M.C. (2005). Smoking, Drinking, and Income. *Journal of Human Resources, 40*(2), pp. 504-518

Bédard, M., Dubois, S., and Weaver, B. (2007). The Impact of Cannabis on Driving. *Canadian Journal of Public Health, 98*(1), pp. 6-11.

Bieleman, B., Nijkamp, R., and De Bak, T. (2012). Coffeeshops in Nederland. Aantallen en Gemeentelijk Beleid 1999-2011. Groningen: Intraval.

Campbell, V.A., and Gowran, A. (2007). Alzheimer's Disease; Taking the Edge off With Cannabinoids? *British Journal of Pharmacology, 152*(5), pp. 655-662.

Carballo, M., and Nerukar, A. (2001). Migration, Refugees, and Health Risks. *Emerging Infectious Diseases, 7*(3), pp. 556-560.

Carriot, F., and Sasco, A.J. (2000). Cannabis and Cancer. *Revue d'épidémiologie et de Santé Publique, 48*(5), pp. 471-483.

Consroe, P., Musty, R., Rein, J., Tillery, W., and Pertwee, R. (1997). The Perceived Effects of Smoked Cannabis on Patients with Multiple Sclerosis. *Eur Neurol, 38*, pp. 44-48.

Cunningham, J.A., Sobell, L.C., Sobell, M.B., Agrawal, S., and Toneatto, T. (1993). Barriers to Treatment: Why Alcohol and Drug Abusers Delay or Never Seek Treatment. *Addictive Behaviors, 18*(3), pp. 347-354.

Degenhardt, L., Hall, W., and Lynskey, M. (2003). Exploring the Association Between Cannabis Use and Depression. *Addiction, 98*(11), pp. 1493–1504.

Engs, R.C., and Mullen, K. (1999). The Effect of Religion and Religiosity on Drug Use Among a Selected Sample of Post Secondary Students in Scotland. *Addiction Research, 7*(2), pp. 149-170.

Farell, A.D, Kung, E.M., White, K.S., and Valois, R.F. (2000). The Structure of Self-Reported Aggression, Drug Use, and Delinquent Behaviors During Early Adolescence. *Journal of Clinical Child Psychology, 29*(2), pp. 282-292.

Fergusson, D.M., and Boden, J.M. (2008). Cannabis Use and Later Life Outcomes. *Addiction, 103*(6), pp. 969-976.

Fergusson, D.M., Boden, J.M., and Horwood, L.J. (2006). Cannabis Use and Other Illicit Drug Use: Testing the Cannabis Gateway Hypothesis. *Addiction, 101*(4), pp. 556-569.

Fergusson, D.M., and Horwood, L. (2001). Cannabis Use and Traffic Accidents in a Birth Cohort of Young Adults. *Accident Analysis & Prevention, 33*(6), pp. 703-711.

Folland, S., Goodman, A.C., and M. Stano. 2013. The Economics of Health and Health Care. Pearson New International Edition, 7th edition. Pearson Education Inc.

French, M.T., Roebuck, M.C., and Alexandre, P.K. (2001). Illicit Drug Use, Employment, and Labor Force Participation. *Southern Economic Journal, 68,* pp. 349-368.

Hall, W., and Degenhardt, L. (2009). Adverse Health Effects of Non-Medical Cannabis Use. *The Lancet, 374*(9698), pp. 1383-1391.

Hall, W., and Solowij, N. (1998). Adverse Effects of Cannabis, *The Lancet, 352*(9140), pp. 1611-1616.

Hansell, S., and White, H. R. (1991). Adolescent Drug Use, Psychological Distress, and Physical Symptoms. *Journal of Health and Social Behavior,* 32, pp. 288–301.

Johns, A. (2001). Psychiatric Effects of Cannabis. *The British Journal of Psychiatry, 178*(2), pp. 116-122.

Lewinsohn, P.M., Rhode, P., and Brown, R.A. (1999). Level of Current and Past Adolescent Cigarette Smoking as Predictors of Future Substance Use Disorders in Young Adulthood. *Addiction, 94*(6), pp. 913-921.

Lynskey, M., and Hall, W. (2000). The Effects of Adolescent Cannabis Use on Educational Attainment: a Review. *Addiction, 95*(11), pp. 1621-1630).

Moore, T.H.M., Zammit, S., Lingford-Hughes, A., Barnes, T.R.E., Jones, P.B., Burker, M., and Lewis, G. (2007). Cannabis Use and the Risk of Psychotic or Affective Mental Health Outcomes: a Systematic Review. *The Lancet, 370*(9584), pp. 319-328.

Murray, C.J.L. (1994). Quantifying the Burden of Disease: the Technical Basis for Disability-Adjusted Life Years. *Bulletin of the World Health Organization, 72,* pp. 429-445.

Nagler, J. (1999). Notes on Simultaneous Equations and Two Stage Least Squares Estimates.

Noreen, E. (1988). An Empirical Comparison of Probit and OLS Regression Hypothesis Tests. *Journal of Accounting Research, 26*(1), pp. 119-133.

O'Shaughnessy, W. B. (1843). On the Preparations of the Indian Hemp, or Gunjah: Cannabis Indica Their Effects on the Animal System in Health, and their Utility in the Treatment of Tetanus and other Convulsive Diseases. *Provincial Medical Journal and Retrospect of the Medical Sciences*, *5*(123), pp. 363–369.

O'Shea, M., Singh, M.E., Mcgregor, L.S., and Mallet, P.E. (2004). Chronic Cannabinoid Exposure Produces Lasting Memory Impairment and Increased Anxiety in Adolescent but not Adult Rats. *Journal of Psychopharmacology, 18*(4), pp. 502-508.

Palali, A., and Van Ours, J. (2013). Distance to Cannabis-Shops and Age of Onset of Cannabis Use. *CentER Discussion Paper, 2013*(048).

Patton, G.C., Coffey, C., Carlin, J.B., Degenhardt, L., Lynskey, M., and Hall, W. (2002). Cannabis Use and Mental Health in Young People: Cohort Study. *BMJ, 325*, pp. 1195-1198.

Penning, M., and Barnes, G.E. (1982). Adolescent Marijuana Use: A Review. *International Journal of the Addictions, 17*(5), pp. 749-791.

Pohlmann, J.T., and Leitner, D.W. (2003). A Comparison of Ordinary Least Squares and Logistic Regression. *The Ohio Journal of Science, 103*(5), pp. 118-125.

Saltelli, A., Annoni, P., Azzini, I., Campolongo, F., Ratto, M., and Tarantola, S. (2010). Variance Based Sensitivity Analysis of Model Output. Design and Estimator for the Total Sensitivity Index. *Computer Physics Communication, 181*(2), pp. 259-270.

Sarfaraz, S., Adhami, V.M., Syed, D.N., Afaq, F., and Mukhtar, H. (2008). Cannabinoids for Cancer Treatment: Progress and Promise. *Cancer Research, 68*(2), pp. 339-342.

Staiger, D., and Stock, J.H. (1997): Instrumental Variables Regression with Weak Instruments. *Econometrica*, 65, 557–86

Stokes, J.R., Hartel, R., and Ford, L.B. (2000). Cannabis (hemp) Positive Skin Tests and Respiratory Symptoms. *Annals of Allergy, Asthma & Immunology, 85*(3), pp. 238-240.

Trimbos-instituut. (2016). *Jaarbericht 2016.* Retrieved from: https://assets.trimbos.nl/docs/24dd30ba-464f-4dcd-a740-20ac058d310b.pdf

Rey, J.M., and Tennant, C.C. (2002). Cannabis and Mental Health, *British Medical Journal, 325*(7374), pp. 1183-1184.

RIVM, (2009). *Ranking van Drugs: Een Vergelijking van de Schadelijkheid van Drugs.* Retrieved from: http://www.rivm.nl/dsresource?objectid=8875d55b-eb92-42e2-9e7c-c914dcd171fd&type=org&disposition=inline

Robson, P. (2001). Therapeutic Aspects of Cannabis and Cannabinoids. *The British Journal of Psychiatry, 172*(2), pp. 107-115.

Roebuck, M.C., French, M.T., and Dennis, M.L. (2004). Adolescent Marijuana Use and School Attendance. *Economics of Education Review, 23*(3), pp. 133-141.

Ross, C.E., and Wu, C. (1995). The Links Between Education and Health. *American Sociology Review, 60*(5), pp. 719-734.

Van der Pol, P., Liebregts, N., de Graaf, R., ten Have, M., Korf, D. J., van den Brink, W., and van Laar, M. (2013), Mental Health Differences Between Frequent Cannabis Users With and Without Dependence and the General Population. *Addiction, 108*, pp. 1459–1469.

Wallace, J.M., and Bachman, J.G. (1991). Explaining Racial/Ethnic Differences in Adolescent Drug Use: The Impact of Background and Lifestyle. *Social Problems, 38*(3), pp. 333- 357.

Wallace, J.M., Bachman, J.G., O'Malley, P.M., Schulenberg, J.E., Cooper. S.M., and Johnston, L.D. (2003). Gender and Ethnic Differences in Smoking, Drinking and Illicit Drug Use Among American 8th, 10th and 12th Grade Students, 1976-2000. *Addiction, 98*(2), pp. 225-234.

Wallace, J.M., Brown, T.N., Bachman, J.G., and LaVeist, T.A. (2003). The Influence of Race and Religion on Abstinence From Alcohol, Cigarettes and Marijuana Among Adolescents. *Journal of Studies on Alcohol, 64*(6), pp. 843-848.

Williams, J., and Hagger-Johnson, G. (2017). Childhood Academic Ability in Relation to Cigarette, Alcohol and Cannabis Use From Adolescence Into Early Adulthood: Longitudinal Study of Young People in England (LSYPE). *BMJ Open, 7*(2).

Winship, C., and Radbill, L. (1994). Sampling Weights and Regression Analysis. *Sociological Methods & Research, 23*(2), pp. 230-257.

Wright, S., Ware, M., and Guy, G. (2006). The Use of a Cannabis-Based Medicine (Sativex) in the Treatment of Pain Caused by Rheumatoid Arthritis. *Pheumatology, 45*(6), pp. 781.

Zavala, S.K., and French, M.T. (2003). Dangerous to Your Health. The Role of Chronic drug Use in Serious Injuries and Trauma. *Medical Care, 41,* pp. 309-322.

Ziment, I., and Tashkin, D.P. (2000). Alternative Medicine for Allergy and Asthma. *Journal of Allergy and Clinical Immunology, 106*(4), pp. 603-614.

9. Appendix

Appendix 1: Reported SAH by Gender

	Gender	
SAH	Male	Female
Poor	1.1	0.8
Moderate	11.0	13.2
Good	58.9	62.1
Very good	22.0	18.2
Excellent	7.0	5.7
Total %	**100.0 (N=2408)**	**100.0 (N=2775)**
Mean SAH score	**3.2**	**3.1**

Appendix 2: Self-assessed health at Different Age Categories in Percentages

SAH	16-24	25-34	35-44	45-54	55-64	65+
Poor	0.5	0.9	0.5	1.7	1.2	0.6
Moderate	7.2	7.8	9.7	12.3	16.2	17.3
Good	50.8	56.2	63.3	63.3	60.6	64.6
Very Good	30.9	25.5	20.2	17.5	17.2	13.7
Excellent	10.6	9.6	6.3	5.2	4.8	3.8
Total %	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Total N=	**593**	**666**	**1000**	**1083**	**1066**	**773**

Appendix 3: SAH and Cannabis Use

	Cannabis use	
SAH	Not once	More than once
Poor	0.9	1.9
Moderate	12.1	18.6
Good	60.9	57.1
Very Good	19.9	17.9
Excellent	6.2	4.5
Total %	**100.0**	**100.0**
Total N=	**4647**	**156**

Appendix 4: Gender and Cannabis Use

	Cannabis use		
Gender	Not once	More than once	**Total %**
Male	45.9	63.4	**46.5**
Female	54.1	36.6	**53.5**
Total %	**100.0 (96.6)**	**100.0 (3.4)**	**100.0**
Total N=	**4678**	**164**	**4842**

96.6% of the individuals in the sample indicated that they did not use cannabis in the last 30 days and 3.4% of the individuals did use cannabis more than once. 46.5% of the individuals are male and 53.5% are female.

Appendix 5: Age Categories and Cannabis Use

	Cannabis use	
Age	Not once	More than once
16-24	10.0	42.3
25-34	12.2	21.2
35-44	19.0	19.2
45-54	20.9	11.5
55-64	21.7	4.5
65+	16.2	1.3
Total %	**100.0**	**100.0**
Total N=	**4645**	**156**

Appendix 6: Urbanity and Cannabis Use

	Cannabis use		
Urban	Not once	More than once	**Total % living in an area**
Not urban	16.0	8.6	**15.8**
Slightly urban	22.7	22.8	**22.7**
Moderately urban	23.1	19.8	**22.9**
Very Urban	25.8	22.8	**25.8**
Extremely urban	12.4	25.9	**12.8**
Total %	**100.0 (96.6)**	**100.0 (3.4)**	**100.0**
Total N=	**4670**	**162**	**4832**

96.6% of the individuals in the sample indicated that they did not use cannabis in the last 30 days and 3.4% of the individuals did use cannabis more than once. 15.8% of the individuals live in a rural area and 12.8% lives in an extremely urban area.

Appendix 7: Entire Table for Table 4.10.

	Presence coffee shop		
Distance coffee shop	0	1	**Total**
1.0	76	2179	2255
3.1	5	0	5
3.8	9	0	9
4.0	12	0	12
4.2	6	0	9
4.4	12	0	12
4.9	8	0	8
5.0	6	0	6
5.3	4	0	4
5.4	7	0	7
5.7	20	0	20
6.1	14	0	14
6.2	2	0	2
6.5	8	1	9
6.7	20	0	20
6.8	27	0	27
6.9	26	0	26
7.0	4	0	4

7.1	14	0	14
7.2	2	0	2
7.3	26	0	26
7.5	31	0	31
7.6	4	0	4
7.8	26	0	26
7.9	7	0	7
8.0	42	0	42
8.1	14	0	14
8.2	5	0	5
8.3	2	0	2
8.4	4	0	4
8.5	27	0	27
8.6	14	0	14
8.7	17	0	17
8.8	5	0	5
8.9	10	0	10
9.0	15	0	15
9.3	11	0	11
9.4	18	0	18
9.5	16	0	16
9.6	1	0	1
9.7	17	0	17
9.8	17	0	17
9.9	21	0	21
10.0	20	0	20
10.1	48	0	48
10.2	27	0	27
10.3	5	0	5
10.4	8	0	8
10.6	9	0	9
10.7	18	0	18
10.8	22	0	22
10.9	12	0	12
11.0	14	0	14
11.2	28	0	28
11.2	28	0	28
11.3	4	0	4
11.4	9	0	9
11.5	16	0	16
11.7	6	0	6
11.8	9	0	9
11.9	14	0	14
12.0	3	0	3
12.1	1	0	1
12.2	7	0	7

12.3	21	0	21
12.4	29	0	29
12.6	17	0	17
12.7	29	0	29
12.8	24	4	28
12.9	19	0	19
13.0	29	0	29
13.1	7	0	7
13.3	3	0	3
13.4	15	0	15
13.5	8	0	8
13.6	22	0	22
13.7	5	0	5
13.8	26	0	26
13.9	8	0	8
14.0	8	0	8
14.1	26	0	26
14.2	20	0	20
14.3	15	0	15
14.4	15	0	15
14.5	3	0	3
14.6	4	0	4
14.7	5	0	5
14.8	20	0	20
15.0	2	0	2
15.1	35	0	35
15.2	6	0	6
15.3	5	0	5
15.4	13	0	13
15.5	7	0	7
15.6	12	0	12
15.8	8	0	8
16.1	9	0	9
16.3	2	0	2
16.5	9	0	9
16.6	14	0	14
17.0	11	0	11
17.1	13	0	13
17.3	13	0	13
17.4	8	0	8
17.7	45	0	45
17.8	5	0	5
17.9	17	0	17
18.1	2	0	2
18.2	23	0	23
18.3	16	0	16

18.6	3	5	8
18.8	5	0	5
18.9	2	0	2
19.0	19	0	19
19.1	14	0	14
19.2	25	0	25
19.3	1	0	1
19.4	28	1	29
19.7	5	0	5
19.9	18	0	18
20.2	13	0	13
20.3	11	0	11
20.5	7	0	7
20.8	1	0	1
21.0	1	0	1
21.1	1	0	1
21.3	1	0	1
21.4	17	0	17
21.5	10	0	10
21.7	6	0	6
22.3	5	0	5
22.5	3	0	3
22.6	1	0	1
22.8	11	0	11
23.2	32	0	32
23.6	2	0	2
24.0	5	0	5
24.1	3	0	3
24.2	6	0	6
24.4	10	0	10
24.6	2	0	2
25.1	7	0	7
25.5	21	0	21
25.8	12	0	12
26.0	5	0	5
26.1	15	0	15
26.3	1	0	1
26.4	15	0	15
27.0	15	0	15
27.1	1	0	1
27.8	8	0	8
28.0	4	0	4
28.2	16	0	16
28.6	4	0	4
31.5	2	22	24
32.0	3	0	3

32.2	20	0	20
33.6	3	0	3
34.1	1	0	1
36.2	6	0	6
36.4	6	0	6
36.5	4	0	4
37.6	1	0	1
37.7	4	0	4
42.4	7	0	7
44.5	2	0	2