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Income, Education and Nicotine Use: Investigating the Role of Socioeconomic Status in Electronic and Conventional Cigarette Usage

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Abstract

Smoking is a major public health issue worldwide, and it is especially prominent among the lower socioeconomic status groups (SES), as income and education both play a role in the smoking rate disparities. The market introduction of electronic cigarettes (e-cigarettes) has shifted individuals' health-related behaviors and decisions, raising concerns about the potential to exacerbate socioeconomic disparities in tobacco use. While it is well known that lower socioeconomic status group is associated with higher conventional cigarette use, evidence for the disparities in e-cigarette use remains inconclusive. As a result, this paper aim to investigate the relationship between socioeconomic status and electronic cigarette use, as well as how this effect differs from conventional cigarette use, using a logistic regression model with pooled cross-sectional data. This study finds a positive but non-significant association between income and e-cigarette use, as well as a negative association between education and e-cigarette use, though the strength of this negative association varies by education level. Furthermore, this paper finds that SES indicators have a stronger influence on electronic cigarette use than on conventional cigarette use, implying that the factors influencing electronic and conventional cigarette use differ. This differentiation is significant because it allows policymakers and government officials to tailor policies and interventions that target electronic and conventional cigarette usage separately in order to reduce smoking prevalence and improve public health.

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1. Introduction

Smoking is a major public health issue worldwide as its impact is detrimental to the body causing chronic health conditions, but it is also one of the leading causes of preventable death (CDC, 2022; World Health Organization, 2022). Smoking is a serious addiction that not only harms the user's health but also affects those who do not smoke. The economic consequences of smoking are complicated as they impose a burden on the country's economy and healthcare system, leading to a loss of productivity and human capital as a result of smoking-related death, which occurs in many developed countries (CDC, 2014). In the Netherlands, where smoking contributes to 9.4% of the disease burden, the tobacco problem costs the country €2.4 billion in healthcare expenditures each year and results in 20,000 deaths due to smoking-related diseases each year (Ministry of Health Welfare and Sport, 2019).

Despite the health effects of smoking, high smoking prevalence still exists in many countries. Looking at the global trend, an estimated 22.3% of the global population aged 15 and older use tobacco in some form (Ritchie & Roser, 2013). In the Netherlands, approximately 2.8 million people over the age of 18 smoked in 2020, but there was a slight decrease over time among adults who smoked in the Netherlands, from 25.7% in 2014 to 20.2% in 2020, and this rate includes both daily and occasional smokers (Trimbos Institute, 2020).

Furthermore, smoking continues to be prominent among lower socioeconomic status (SES) groups (Trimbos Institute, 2020). According to the World Health Organization, there is a significant difference in health outcome and behaviors between socioeconomic groups, with people with low SES being more likely to be less healthy, increasing their health risk (WHO, 2008). This is also reflected in the Netherlands, where daily smokers are more common among those with lower or middle levels of education, where smoking rates are 23.9% for both groups (Trimbos Institute, 2020). Chaloupka and Warner (2000) discuss the reasons for these disparities in smoking rates. Income, education, age, and gender all played a role in the disparities, indicating the importance of socioeconomic and demographic characteristics (Chaloupka & Warner, 2000). Furthermore, lower socioeconomic status (SES) individuals have limited access to healthcare and resources for smoking cessation, which explains why this smoking trend is prevalent in lower SES groups (Fernando et al., 2019; Mahdaviazad et al., 2022; Sahan et al., 2018; Tong et al., 2010).

On the other hand, the introduction of new and emerging tobacco products into the market, such as electronic cigarettes (e-cigarettes), has resulted in additional risky behaviors that individuals can engage in (Nitzkin, 2014). E-cigarettes are devices that simulate the sensation of smoking without the use of tobacco, but still contain a small amount of nicotine (Pepper & Brewer, 2014). Because of its unique features such as flavors and rechargeability, this product has grown rapidly in popularity in

recent years. Another factor contributing to its rising popularity is the fact that it does not rely on combustion, there is less chance of being exposed to the harmful tobacco particles produced by conventional cigarettes, which can have a negative impact on other risky health behaviors and serve as a gateway behavior to smoking (CDC, 2022; Pepper & Brewer, 2014). This can be seen in the Netherlands, where the share of people smoking e-cigarettes has increased from 3.5% in 2016 to 5.1% in 2021 (van Gelder, 2022). Though this number is low compared to conventional smoking, e-cigarette use could also lead to dual risky behavior, with people smoking both conventional and electronic cigarettes (Pepper & Brewer, 2014). Furthermore, the usage of electronic cigarette is particularly popular and higher among younger people, specifically those aged 18 to 24 (Trimbos Institute, 2020). Despite being marketed as a healthier alternative to smoking, e-cigarettes are not completely risk-free, as the health risks of using e-cigarettes are similar to those of conventional cigarettes, with users still being exposed to respiratory diseases, tumors, and cancers

As a result, many EU countries, including the Netherlands, are urging the development of comprehensive policies and regulatory frameworks to address the concerns surrounding e-cigarettes (Stoklosa et al., 2016). The Netherlands have adapted these policies through the Dutch Tobacco Act and National Prevention Agreement, aiming reduce tobacco consumption, and this applies to all kinds of tobacco products including both conventional and electronic cigarettes. Such policies include placing age limits on the purchase of tobacco products, plain packaging, advertisement bans, bans on flavored e-cigarettes, and increasing excise duty on tobacco products (Ministry of Health Welfare and Sports, 2019; Netherlands Enterprise Agency (RVO), 2019). Tobacco taxation policy is found to be the most effective to reduce smoking rates, but it disproportionately affects the low-income individuals (Chaloupka & Warner, 2000). Despite these efforts, socioeconomic disparities in smoking continue to exist, and that is why it is still crucial to examine the differential impact of how socioeconomic characteristics is related to electronic and conventional cigarette use as it can assist policymakers and the government in developing specific targeted strategies and policies for vulnerable groups.

Existing research has found a correlation between socioeconomic status and cigarette use. While it has been established that lower SES is associated with increased conventional cigarette use, data on electronic cigarette use is still limited. Most studies on SES and e-cigarette use have mainly focused on youth and adolescents as their main sample population, yielding various results. For example, Wang & Wu (2020) find that lower SES is associated with higher e-cigarette use among youth, whereas Azagba et al. (2023) finds no significant association between the two (Azagba et al., 2023; Wang & Wu, 2020). Meanwhile results from studies with adults as the primary sample population are inconclusive. Ooms et al. (2016) discovered that higher SES groups are more likely to use e-cigarettes while Kock et al. (2020) found that lower SES groups are more likely to use e-cigarettes (Kock, 2020;

Ooms et al., 2016). Furthermore, little research has been conducted to determine whether socioeconomic characteristics in e-cigarette use are similar to those observed in conventional cigarettes. Friedman & Horn (2019) examined this in the context of the United States and found that education and income is related to e-cigarette use are in contrast with conventional cigarette use, indicating that there is SES differential in electronic and conventional cigarette use (Friedman & Horn, 2019).

With regards to this, this study aims to find the association between socioeconomic status and the use of e-cigarettes, specifically looking from the perspective of income and education as it is the most significant indicator of socioeconomic characteristics (Fuchs, 2004). In line with this, the main research questions to be explored in this study are:

1. What is the association between socioeconomic status and e-cigarettes use?
2. How does the association between socioeconomic status and use of e-cigarettes differ from the association between socioeconomic status and use of conventional cigarettes?

The following are the objectives for this paper: (1) to assess the relationship between socioeconomic status (income and education) and e-cigarette use, and (2) to examine the extent to which socioeconomic disparities in e-cigarette use exist compared to conventional cigarette use. This study can help to gain a better understanding of how SES is associated to both conventional and electronic cigarette and to what extent does this SES differential exists between the two types of tobacco product. By doing so, it can shed a light on the population who are more likely to use e-cigarettes and allow policymakers to develop targeted policies and interventions for vulnerable groups and address the health disparities that exist between the different SES groups. Understanding the extent to which socioeconomic disparities differ in electronic and conventional cigarette use also allows the government and policymakers to develop policies that address the specific challenges associated with e-cigarette use. This contributes to a better understanding of the link between socioeconomic status and tobacco product use.

2. Literature Review

This section provides a comprehensive review of the existing literature on the socioeconomic inequalities in conventional and electronic cigarettes, as well as exploring the socioeconomic factors that contribute to the disparities between SES and cigarette use in both products.

2.1 Socioeconomic Status and Health-Related Behaviors

Maintaining a healthy lifestyle and having a high awareness of health-related behaviors and decisions is critical given that it is an investment in one's future and well-being, as these choices have a direct impact on an individual's health and the health of those around them. These behaviors are associated not only by a combination of personal reasons such as motivation and preference, but also external factors such as the socioeconomic characteristics of individuals (Cawley & Ruhm, 2011; Cutler & Glaeser, 2005). Health-related behaviors and decisions differ across socioeconomic statuses due to factors such as income and education. Socioeconomic status (SES) is a term used frequently in health economics research to refer to the social and economic factors that determine an individual's position in the social structure (Galobardes et al., 2006). There is a health disparity between people of low and high socioeconomic status, with people of higher SES being more likely to engage in healthy behavior and lifestyle choices (Contoyannis & Jones, 2004; Cutler & Glaeser, 2005; Petrovic et al., 2018).

Individual health behaviors are significantly associated socioeconomic characteristics like income and education. According to Fuchs (2004), there is a positive relationship between income and health outcomes because higher income individuals have better access to medical care, better quality food, shelter, and other goods and services that promote healthy behavior. The relationship between education levels and health outcome is similar, as higher educated people are more aware of and knowledgeable about health-promoting behaviors (Fuchs, 2004). Fuchs also stated that other underlying factors such as age, gender, health status, and marital status influence socioeconomic characteristics and health outcomes. Furthermore, other external factors such as leisure activities, support systems and social networks, and peer influences are also mentioned as being important to individuals' health-related behaviors (Contoyannis & Jones, 2004).

2.2 Socioeconomic Status and Cigarette Product Use

Given that smoking prevalence varies by country, socioeconomic status is one of the determinants of smoking behavior and tobacco product consumption in this context. Individuals with lower levels of education and income are more likely to smoke and will continue to smoke as they age (Christelis & Sanz-de-Galdeano, 2011). Differences in knowledge and attitudes towards health risks were also attributed to the differences of smoking rates between these groups (Hiscock et al., 2012).

Literature has shown that smoking is still relatively common among people of low socioeconomic status, implying that this group is at a much higher risk of tobacco use, resulting in smoking rate disparities (Fernando et al., 2019; John et al., 2012; Mahdaviazad et al., 2022; Sahan et al., 2018). Mahdaviazad et al. (2022) found that lack of education and low-income levels are the most significant factors associated with tobacco use (Mahdaviazad et al., 2022). Hiscock et al. (2012) argued in a comprehensive review of socioeconomic status and smoking that smoking prevalence is high among these groups due to a lack of support and motivation to quit, stronger addiction, and a lack of awareness of the potential harm of tobacco - all of which increase the risk of nicotine addiction (Hiscock et al., 2012).

The introduction of electronic cigarettes (or e-cigarettes) into the market has altered people's health-related behaviors and decisions. This increases the tendency of individuals to engage in activity that risks their health (Nitzkin, 2014). This is concerning as e-cigarettes are marketed as a less harmful alternative to cigarettes and appear as a smoking cessation tool, though this does not completely mean a harm-free product (Pepper & Brewer, 2014). In addition, successful marketing, the flavor availability of e-cigarettes is also what attracted individuals, particularly adolescents, to use e-cigarettes (Hefner et al., 2019). The changing smoking landscape has raised concerns regarding the potential to widen the socioeconomic disparities in tobacco use.

While lower socioeconomic status is associated with increased conventional cigarette use, evidence for socioeconomic disparities in e-cigarettes use is inconclusive. Most studies that examine the impact of socioeconomic status on e-cigarette use tend to focus on adolescents as the primary population for study, with mixed results. Azagba et al. (2023) and Barrington-Trimis et al. (2015) show no significant association between socioeconomic status and youth e-cigarette use, suggesting that other factors may explain the rise of e-cigarette use among this population (Azagba et al., 2023; Barrington-Trimis et al., 2015). Wang & Wu (2020) also discovered that there is a socioeconomic disparity in e-cigarette use in low educated youths (Wang & Wu, 2020). This contrasts with the findings from Rennie et al. (2016), who found that adolescents with higher socioeconomic status are more likely to use e-cigarettes (Rennie et al., 2016). Previous research has yielded ambiguous results when examining socioeconomic disparities in adult e-cigarette use. E-cigarette use is higher among those in higher socioeconomic groups, particularly those with a higher level of education, and this trend is also visible throughout the European Union (Ooms et al., 2016; Pepper & Brewer, 2014). In contrast, several studies have found that lower socioeconomic status individuals are associated with higher use of e-cigarettes (Gagné & Brown, 2021; Kock et al., 2020).

Additionally, there is limited research that have been done on e-cigarette socioeconomic disparities compared to conventional cigarettes. According to my knowledge only one study has attempted to investigate this, but it was conducted in the United States. No similar studies have been conducted in the Netherlands. Friedman & Horn (2019) examined whether the socioeconomic gradients in electronic and conventional cigarette use are similar and reports that SES differentials exist and differ significantly between the two (Friedman & Horn, 2019).

2.3 Contribution

Socioeconomic disparities in nicotine consumption persist, with lower SES groups being more likely than higher SES groups to be exposed to the harms of tobacco use. While this conclusion has been well-documented in the literature, the result for the relationship between SES and e-cigarette use is inconclusive. Existing studies on socioeconomic status and e-cigarette usage have primary used youths and adolescents as the primary sample population. This paper fills a gap in the literature by investigating how socioeconomic disparities are related to e-cigarette use. This study will also take one step further to investigate whether the same socioeconomic characteristics associated with conventional cigarette is applied to electronic cigarette consumption. This is significant as e-cigarettes have gained its popularity as a less harmful alternative to the conventional cigarettes and by investigating these separately, a more nuanced understanding of how socioeconomic disparities occur with different types of cigarette products can be achieved, which can be critical in developing policies that address the specific challenges with e-cigarettes and conventional cigarettes separately can be achieved.

This study can help to examine which socioeconomic groups are more susceptible to e-cigarette use, which can help policymakers and government to better develop a targeted prevention program for the most vulnerable group. Examining the socioeconomic factors associated with e-cigarette use will help to address the health inequalities in society but also to understand the social and economic factors that influence why these individuals choose to smoke e-cigarettes. On the other hand, this study is economically relevant as it helps to identify the vulnerable population that are at higher risk of using e-cigarettes as socioeconomic disparities in smoking rates have implications for the healthcare costs. Consequently, this study can provide information to the policymakers and government in developing which targeted policies are most effective in reducing the disparities that exist between these groups.

2.4 Hypotheses

Based on the literature review and research questions above, I hypothesize the following:

1. Hypothesis 1: Lower socioeconomic status is associated with higher e-cigarette use

2. Hypothesis 2: The socioeconomic characteristic associated with electronic cigarette use is different to the association found with conventional cigarette use.

3. Data and Methodology

This section covers the data collection and methodology used to explore the association between socioeconomic status and conventional and electronic cigarette use. This section provides an in-depth explanation of the data collection, variables used, sample population and the empirical strategy used to analyze the results of the data.

3.1 Data Collection

This study employs an individual-level survey data in the Netherlands using a representative household sample. I used earlier collected data through the secondary data from the LISS (Longitudinal Internet Studies for the Social Sciences) panel administered by Centerdata (Tilburg University, The Netherlands). Individual and household characteristics are already provided by the LISS questionnaire. These data are then treated as a pooled cross section, taking data from several different waves of the LISS panel dataset between the year 2019-2022 (Wave 12 through Wave 15) using variables from the Health and Background Variables topics. In total, there is 701 people in the observation for e-cigarette users and 12,461 for conventional cigarette users. This number is derived from the number of individuals who have ever used electronic and conventional cigarette. The low number of observations for individuals who are current smokers of e-cigarettes, with only 201 observations across the dataset between waves 12 and 15, is the reason why I used the ever used for both products.

3.2 Descriptive Statistics

Table 1 shows the descriptive statistics of the data. There are only 701 individuals (1.69% of the sample) who are ever e-cigarette users within the dataset. The remaining 98.31%, are 40,877 individuals who are categorized as non-e-cigarette users. Existing tobacco control policies in the Netherlands may contribute to this relatively low percentage of e-cigarette users. There are 12,461 individuals (29.97% of the population) who have ever smoke conventional cigarettes and 29,117 individuals (70.03% of the population) who does not smoke conventional cigarettes are observed. The education variable is categorized into six categories following the Dutch education system. The LISS panel dataset specify three gender categories available which are (1) male, (2) female and (3) others – but due to the low frequency of this third category (0.03% of the population), I dropped individuals in this category. Furthermore, to reduce the issue of multicollinearity, some categorical variables are simplified such as the health status and marital status variable. Marital status is simplified into three categories: (1) married, (2) separated/divorced/widowed and (3) never been married, whereas the health status is divided into two categories: (1) poor to moderate health status, and (2) good to excellent health status.

Table 1: Descriptive Statistics

Variables	N	Percentage/mean (SD)	Min.	Max.
E-cigarette Users				
E-cigarette users	701	1.69%		
Non-e-cigarette users	40,877	98.31%		
Log of Income	16,535	7.791 (0.7729)	0	14.324
Education				
Primary school	6,399	16.29%		
VMBO (intermediate secondary education)	6,876	17.50%		
HAVO/VWO (higher secondary education)	3,903	9.93%		
MBO (intermediate vocational education)	8,545	21.75%		
HBO (higher vocational education)	8,837	22.49%		
WO (university)	4,728	12.03%		
Age	19,604	54.504 (18.504)	16	99
Gender				
Male	9,096	46.41%		
Female	10,503	53.59%		
Marital Status				
Married	18,005	43.31%		
Separated/Divorced/Widowed	4,845	11.65%		
Never Married	18,727	45.04 %		
Health Status				
Poor to Moderate	2,796	11.02%		
Good to Excellent	22,579	88.98%		
Conventional cigarette user				
Conventional cigarette user	12,461	29.97%		
Non-conventional cigarette user	29,117	70.03%		

3.3 Dependent Variable

The main outcome variable in this study is individual's ever e-cigarette usage. It is a binary variable that takes the value of one if individual is an ever e-cigarette user and zero otherwise. The users of e-cigarettes are identified as individuals who answered the item "Have you ever smoked (even if it was a long time ago)?" with "yes" and responded "e-cigarettes" to the item "What do you smoke?" This data is derived from the LISS questionnaire from the health section of the dataset.

3.4 Independent Variable

The main independent variables in this study are socioeconomic indicators, in which this study will focus on two indicators which are income and education as Fuchs (2004) have argued that these indicators are significantly associated with smoking and overall risky behaviors. The study will use the personal gross monthly income in Euros available on the LISS panel dataset and this is a continuous variable. As for education, the study will refer to the level of education obtained by individuals according to the CBS Categories available in the LISS panel dataset as well. This is a categorical variable, and it is categorized into the following six categories: (1) primary school, (2) vmbo (intermediate secondary education), (3) havo/vwo (higher secondary education), (4) mbo (intermediate vocational education), (5) hbo (higher vocational education) and (6) wo (university)

3.5 Control Variables

Control variables such as age, gender, health status, and marital status are employed in this study. Fuchs (2004) argued that these factors affect both health outcome and socioeconomic status (Fuchs, 2004). Age is often associated with socioeconomic status as it can lead to individuals completing their education and entering the job market, therefore improving their socioeconomic status. On the other hand, smoking also correlates to health outcomes as smoking prevalence does vary across different age groups, with younger people tending to smoke more than older people.

Gender is also another variable that are associated with both health outcomes and socioeconomic status. Generally, women tend to have better health outcomes than men due to the differences in the health behaviors and biological factors. This is also reflected in the statistics that men smoke more than woman, and therefore have higher rates of getting smoke-related diseases, though primarily lung cancer (Trimbos Institute, 2020). Marital status is also correlated with SES, as the presence of a spouse is assumed to contribute to the health outcome. Williams and Umberson further argued that married people tend to do better in the marriage market (Williams & Umberson, 2004).

3.6 Conventional Cigarette Use

Conventional cigarette users are defined as individuals who responded "yes" to the item "Have you ever smoked (even if it was a long time ago)?" and responded "cigarettes (including rolling tobacco)" to the survey question "What do you smoke?" This is a binary variable that takes the value of one if individual is a conventional cigarette user and zero otherwise. By distinguishing between different smoking status of conventional and electronic cigarette, I allow for a better understanding of the different patterns of tobacco use and therefore, gaining a more comprehensive understanding of the relationship between SES and tobacco consumption.

3.7 Empirical Strategy

This study will employ pooled cross-sectional data from wave 12 through 15 of the LISS panel and using a logistic regression model. This model is the most appropriate to use as the dependent variable in this model is e-cigarette use, which is a binary variable that takes on the value of one if individual is an e-cigarette user and zero otherwise.

Since the coefficients indicated in a logistic regression do not provide a straightforward measure of the probability of cigarette use and only show the direction of the association, an additional estimation must be made through Average Marginal Effect (AME) to provide a more intuitive way of understanding the association between cigarette use and SES. This is done by calculating the average change in the probability of cigarette use associated with a one-unit change in income or education level.

The following equation is used to determine the association between socioeconomic status and e-cigarette use:

(1) $ECIG_i = \beta_0 + \beta_1 . \log(INC_i) + \beta_2 . EDU_i + u_i$

(2) $ECIG_i = \beta_0 + \beta_1 . \log(INC_i) + \beta_2 . EDU_i + \beta_3 . X_i + u_i$

In the first equation, I aim to find the association between socioeconomic status and e-cigarette use while excluding the control variables. In the second equation, I added the control variables of age, gender, marital status, and health status. The control variables are included in the model to help minimize omitted variable bias, accounting for potential influences of other factors that may influence e-cigarette use. The specifications for the model above are as follows:

No.	Variables	Specification
1.	$ECIG_i$	Binary variable, one if individual is currently an e-cigarette user, zero otherwise
2.	$\log(INC_i)$	Log of income

3.	EDU_i	Categorical variable, highest education level with a diploma obtained by the individual
4.	X_i	Control variables (age, gender, marital status, health)
5.	u_i	Error term

Also, to test for the association between socioeconomic status and e-cigarette use as compared to conventional cigarette use, I first estimate the socioeconomic status on conventional cigarette use (see equation (3)) and then adding the control variables thereafter (see equation (4)).

(3) $CCIG_i = \beta_0 + \beta_1 . \log(INC_i) + \beta_2 . EDU_i + u_i$

(4) $CCIG_i = \beta_0 + \beta_1 . \log(INC_i) + \beta_2 . EDU_i + \beta_3 . X_i + u_i$

where the specifications are the same as model (1) and (2) but changing the outcome variable to $CCIG_i$, which is conventional cigarette user.

3.8 Assumptions

For the models that is developed above, these following assumptions are made:

1. Independence of observations: The variables in the dataset are independent of one another. This assumption is not fulfilled because the data is derived from the LISS panel and contains repeated observations of the same individuals over time, despite the fact that the data is treated as a cross-sectional. To account for this potential correlation, the logistic regression model will employ a clustered standard error at the individual level.
2. Model is an adequate fit: This assumption implies that the relationship between the outcome and the independent variables capture the relationship the data, which can be tested using the goodness-of-fit test and seeing the AIC and BIC value. The result from the goodness-of-fit test with e-cigarette use as the dependent variable, shows that the model is reasonably well-fitted to the data with a Hosmer Lemeshow chi-squared statistics of 14.95 and the p-value of 0.0602. This is also supported by the low AIC and BIC value, compared to other models that was tested. However, using the goodness-of-fit test with conventional cigarette use as the dependent variable, the result shows that the model is not well-fitted the data, violating this assumption. This can be seen from Hosmer Lemeshow chi-squared statistics of 51.32 and p-value of 0.000. See Table A1 and A2 in the appendix to see the full result of the test.
3. No Multicollinearity: The issue of multicollinearity rises when the independent variables are highly correlated to each other. After conducting the test, this assumption is fulfilled as there

is no high correlation between the independent variables. See Table A3 in the appendix to see the full result of the test.

4. No Perfect Separation: The issue of perfect separation rises when the dependent variable can be predicted by the independent variables resulting to an unreliable coefficient estimate. This assumption is fulfilled if the logistic model can run without any warning messages from Stata. After running the command for all of the equations, it is adequate to say that this assumption is fulfilled and there is no perfect separation issue in the data and in the models.
5. Adequate Sample Size: The dataset should have sufficient number of observations. The number of observations for e-cigarette use in this paper is very limited and small compared to non-e-cigarette use and conventional cigarette use.

4. Results

This section focuses on the previous section's results and estimation. Table 2 shows the estimation of a logistic regression model on the relationship of cigarette use to socioeconomic indicators income and education, with columns (1) and (2) focusing on electronic cigarette use as the dependent binary variable. Columns (3) and (4), on the other hand, focus on conventional cigarette use as the dependent binary variable. Table 3 shows the average marginal effect (AME) for logistic regression estimation using the same specifications as Table 2.

4.1 Association of Socioeconomic Status on E-Cigarette Use

To answer the first research question, "What is the association between SES and e-cigarette use?" I use a logistic regression model with a clustered standard error on individual level. Column (1) and (2) in Table 2 and Table 3 represent the findings for the first research question.

Focusing on the first SES indicator is income. The results shows that there is a positive association between income and electronic cigarette use. However, this result is not statistically significant both before and after controlling for other variables, suggesting that there is no association between income and the probability of electronic cigarette use. The association between education level and e-cigarette usage indicate that compared to primary school, individuals with higher levels of education are less likely to engage in e-cigarette use. However, the magnitude of this effect differs across different levels of education. VMBO-level education shows a negative association to e-cigarette use compared to primary school, with a coefficient of -0.596 and this is only significant at 0.1 level. With other levels of education such as HAVO/VWO and MBO, the result shows that there is no statistically significant association of education to e-cigarette use compared to primary school. On the other hand, individuals with higher levels of education (HBO and WO level) shows a statistically significant association with e-cigarette use. Referring to Table 3 for the Average Marginal Effect, this means that individuals with HBO and WO education levels on average have a lower probability of e-cigarette use of 3.8 percentage point and 5 percentage point ceteris paribus, respectively, compared to individuals with primary school education.

Moving to the control variables, there is a significant association between age and e-cigarette, insinuating that as individual ages, the probability of e-cigarette use would decrease. This result is significant even at 0.01 level. Moreover, compared to individuals who are married, it is also observed that individuals who are not married, separated, divorced, or widowed have higher probability of e-cigarette use. This association is also found significant. Nevertheless, there is no association between gender and health status on the chances of an e-cigarette use as the result shows an insignificant result.

Overall, the association between income and e-cigarette use shows a positive but insignificant result. This finding is supported from previous literature who reports a statistically insignificant association between income and e-cigarette use (Friedman & Horn, 2019). On the other hand, the association between education and e-cigarette use shows a negative association in general, suggesting that lower levels of education are associated with higher probability of e-cigarette use. However, this association is only significant for the least and most years of education, but not the middle level categories of education. This result contrasts with few existing studies who reports higher usage of e-cigarette among higher educated individuals (Ooms et al., 2016; Pepper & Brewer, 2014). With regard to the first hypothesis, lower socioeconomic status is associated with higher e-cigarette usage, the finding does not support the hypothesis for income as the SES indicator and cannot confirm this hypothesis due to the differing effects in education level.

4.2 Association of Socioeconomic Status on Conventional Cigarette Use

To answer the second research question, "How does the relationship between socioeconomic status and use of e-cigarettes differ from the relationship between socioeconomic status and use of conventional cigarettes?" First, it is important to know the association between socioeconomic status and conventional cigarette use. I refer to equation (3) and (4) as stated in section 3.7 to find the answer. First, I regress e-cigarette use on SES indicator using a logistic regression model with clustered standard error. The estimation result is presented in column (3) and (4) on Table 2 and Table 3.

There is a positive and significant association between income and conventional cigarette use, even after controlling for the variables, indicating that every one euro increases in income monthly is associated with a higher probability of conventional cigarette use by 6.9 and 3.8 percentage point, ceteris paribus, with and without controlling for the variables respectively. On the other hand, using education as a socioeconomic indicator, the result found that there is no significant association between lower levels of education (VMBO, HAVO/VWO and MBO) and the probability of conventional cigarette use. However, individuals with HBO and WO education level have a smaller probability of conventional cigarette use as compared to those in primary school. This implies that after controlling for the variables, the probability of conventional cigarette use decreases by 12.7 and 17.4 percentage point if individuals are in HBO and WO level of education respectively, when compared to primary school.

Similar to e-cigarette, there is a positive and significant association between age and conventional cigarettes as well as marital status and conventional cigarettes. However, the finding also shows that there is no association between gender and conventional cigarette, as well as health status, as the result yield statistically insignificant.

With income as the SES indicator, this finding contrast with decades of literature who found that lower SES is associated with higher conventional cigarette (Fernando et al., 2019; John et al., 2012; Mahdaviazad et al., 2022; Sahan et al., 2018). However, using education as the SES indicator, this finding is in line with the said papers that higher SES individuals reports lower probability of conventional cigarette usage.

Table 2: Logistic regression results of cigarette use on income and education

Dependent Variable	Electronic Cigarette Use		Conventional Cigarette Use	
	(1) Coefficient (Standard Error)	**(2) Coefficient (Standard Error)**	**(3) Coefficient (Standard Error)**	**(4) Coefficient (Standard Error)**
Income	0.065	0.093	0.303***	0.165***
	(0.1161)	(0.1634)	(0.04)	(0.063)
Education				
Primary school	*(Base)*	*(Base)*	*(Base)*	*(Base)*
VMBO	-0.596*	-0.537	0.025	-0.115
	(0.458)	(0.534)	(0.158)	(0.232)
HAVO/VWO	-0.139	-0.503	-0.127	-0.355
	(0.467)	(0.524)	(0.169)	(0.24)
MBO	-0.257	-0.750**	-0.112	-0.082
	(0.425)	(0.514)	(0.153)	(0.111)
HBO	-0.750**	-0.997***	-0.442***	-0.542**
	(0.447)	(0.519)	(0.155)	(0.223)
WO	-1.057***	-1.746***	-0.807***	-0.743***
	(0.918)	(0.627)	(0.167)	(0.236)
Age		-0.043***		0.0284***
		(0.01)		(0.002)
Marital Status				
Married		*(Base)*		*(Base)*
Separated/Divorced/		0.554**		0.129*
Widowed		(0.312)		(0.110)
Never Married		-0.35*		0.241***

		(0.31)		(0.09)
Gender				
Male		*(Base)*		*(Base)*
Female		-0.300*		0.0207
		(0.255)		(0.840)
Health Status				
Poor to Moderate		*(Base)*		*(Base)*
Good to Excellent		-0.612**		-0.092
		(0.380)		(0.144)
Constant	-3.86	-0.535	-2.58	-2.54
Wald chi2	9.32	38.00	92.94	178.68
Pseudo R-Squared	0.0096	0.0525	0.0139	0.0486
Observation	16,507	9,918	16,507	9,918

Note: In this table, (1) indicate Model 1, (2) indicate Model 2 with e-cigarette use as the dependent variable; (3) indicate Model 3 and (4) indicate Model 4 with conventional cigarette use as the dependent variable as stated on section 3.7; Standard errors are in parentheses; *p < 0.1, **p<0.05, ***<0.01

Table 3: Average marginal effect of cigarette uses on income and education

Dependent Variable	Electronic Cigarette Use		Conventional Cigarette Use	
	(1) AME (Standard Error)	**(2) AME (Standard Error)**	**(3) AME (Standard Error)**	**(4) AME (Standard Error)**
Income	0.0012	0.0024	0.069***	0.0384***
	(0.0022)	(0.004)	(0.009)	(0.014)
Education				
Primary school	*(Base)*	*(Base)*	*(Base)*	*(Base)*
VMBO	-0.0147	-0.0245	0.0062	-0.0268
	(0.0131)	(0.027)	(0.0384)	(0.0539)
HAVO/VWO	-0.004	-0.0232	-0.030	-0.0837

	(0.014)	(0.027)	(0.040)	(0.056)
MBO	-0.007	-0.0314	-0.027	-0.019
	(0.013)	0.0271	(0.037)	(0.052)
HBO	-0.0173	-0.038	-0.1036***	-0.127***
	(0.013)	(0.027)	(0.037)	(0.052)
WO	-0.021*	-0.050*	-0.179***	-0.174***
	(0.013)	(0.027)	(0.0385	(0.055)
Age		-0.043***		-0.0066***
		(0.01)		(0.0006)
Marital Status				
Married		*(Base)*		*(Base)*
Separated/Divorced/Widowed		0.002		0.0298
		(0.127)		(0.025)
Never Married		-0.008		0.056**
		(0.007)		(0.022)
Gender				
Male		*(Base)*		*(Base)*
Female		-0.0077		0.006***
		(0.255)		(0.0006)
Health Status				
Poor to Moderate		*(Base)*		*(Base)*
Good to Excellent		-0.020		-0.022
		(0.156)		(0.033)
Observation	16,507	9,918	16,507	9,918

Note: In this table, (1) indicate Model 1, (2) indicate Model 2 with e-cigarette use as the dependent variable; (3) indicate Model 3 and (4) indicate Model 4 with conventional cigarette use as the dependent variable as stated on section 3.7; Standard errors are in parentheses; *p < 0.1, **p<0.05, ***<0.01; Constant term and R-squared is not included in this table as this output is estimating the average marginal effect (AME) of independent variables on the dependent variable, not the overall model fit.

4.3 Differences in Socioeconomic Status Indicators on Electronic and Conventional Cigarette

To further answer the second research question, “How does the relationship between socioeconomic status and use of e-cigarettes differ from the relationship between socioeconomic status and use of conventional cigarettes?” I compared the coefficient estimates for each type of cigarette to compare the strength and significance of the association between electronic and conventional cigarette use with income and education respectively. From Table 2, it can be inferred that the way in which socioeconomic status is associated with electronic cigarette use differs compared to conventional cigarette use.

Though there is both a positive and negative association between income and education to both cigarette usage respectively, comparing just coefficient is not enough due to several reasons. First, the constant of both logistic regression models is different and may lead to misleading results. Second, there are large differences in sample sizes for both electronic and conventional cigarettes as there is a larger population of conventional cigarette users. Therefore, other methods need to be considered to analyze the magnitude of how income and education affects electronic and conventional cigarette use, such as coefficient plots.

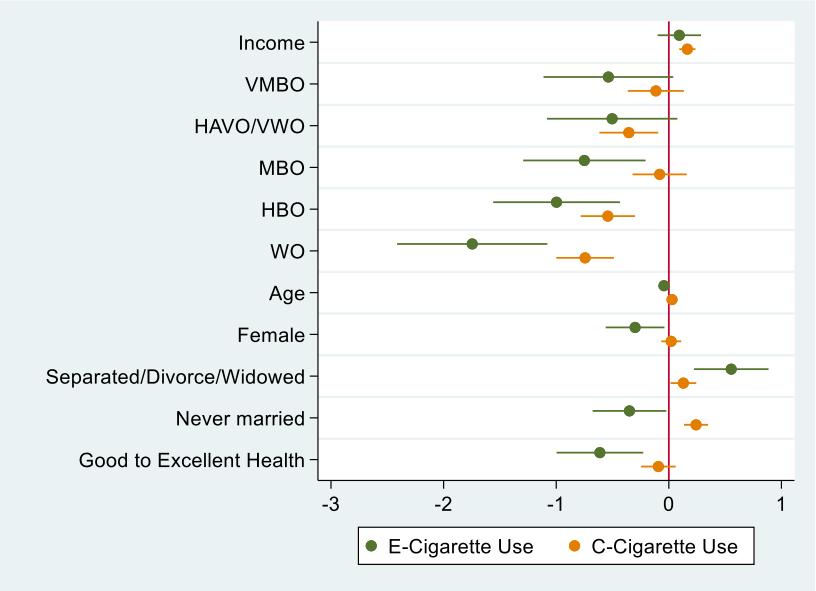
The coefficient plot for electronic and conventional cigarette use is shown in Figure 1. Income and education, the two socioeconomic status indicators, generally show the same direction of effect for both electronic and conventional cigarettes, with income being positive and education being negative. However, as longer lines in the plot show, income and education have a wider standard error on electronic cigarette use than conventional cigarettes. This implies that there is a SES differential between electronic and conventional cigarette use, and that the factors influencing electronic and conventional cigarette use may differ.

Possible explanations for the SES differential could be because of differences in time preferences, access to health information and knowledge, risk factors, perceptions of cigarette products (Dutra & Glantz, 2014; Friedman & Horn, 2019; Khwaja et al., 2007; Soneji et al., 2017; Zhuang et al., 2015). However, the mechanism to the differences of SES and other factors to electronic and conventional cigarette cannot be identified solely from the coefficient plot analysis.

As a result, this finding lends support to the second hypothesis, which states that "the socioeconomic characteristics associated with electronic cigarette use differ from those associated with conventional cigarette use." According to the empirical evidence of this paper, while the association between socioeconomic status indicators and cigarette use is similar, the magnitude and significance of the impact differs for electronic and conventional cigarettes. This evidence supports the

findings of Friedman and Horn (2018), who discovered differences in SES between electronic and conventional cigarette use.

Figure 1: Coefficient Plot of E-Cigarette and C-Cigarette Use



Note: The lines show 95% confidence intervals

5. Discussion and Conclusion

This study investigates the relationship between socioeconomic status and e-cigarette use, comparing how SES differences differ from conventional cigarette use using income and education as SES indicators. The purpose of this paper is to provide answer to the following research questions: (1) What is the relationship between socioeconomic status and e-cigarette use? (2) How does the relationship between socioeconomic status and use of e-cigarettes differ from the relationship between socioeconomic status and use of conventional cigarettes? This paper attempts to answer the research questions using the LISS panel dataset and a logistic regression model for estimation, with data being treated as a pooled cross-sectional data.

The findings of this paper have implications for understanding the factors that influence electronic and conventional cigarette use. First, this study finds a positive but insignificant relationship between income and electronic cigarette use. The insignificant relationship between income and electronic cigarette use may imply that other factors other than income may drive electronic cigarette use in the Netherlands. Second, the study discovered that people with higher levels of education are less likely to use e-cigarettes. The negative association, as well as the differing effects in education levels and e-cigarette use, emphasizes the importance of taking different levels of education into account when analyzing the relationship between socioeconomic indicators and e-cigarette use. The findings of this paper cannot confirm the first hypothesis due to the insignificant association of income and e-cigarette usage and the differing effects of education level and e-cigarette usage. Third, the paper reports a significant difference between socioeconomic indicators and electronic cigarette use, and that SES indicators have a stronger influence on electronic cigarette use than on conventional cigarette use. This emphasizes the importance of distinguishing between the specific characteristics and determinants of electronic cigarette use and conventional cigarette use. This suggests that SES differential for e-cigarette use differs significantly from those for conventional cigarette use, supporting the second hypothesis.

Overall, the findings of this paper contribute to existing tobacco research by providing a better understanding of socioeconomic status and tobacco use in the Netherlands. The finding from this paper suggests that there is a need to differentiate the specific factors that is associated with both cigarettes use separately as the magnitude and significance of SES on electronic and conventional cigarette use differ. The reason for the differences in SES factors associated with both electronic and conventional cigarette is because of differences in time preference, risk factors and perception of cigarette products. Acknowledging this variation can help to develop policies and interventions that address the unique characteristics of electronic and conventional cigarette users separately.

The findings of this paper, however, have some limitations. To begin, the sample size in this paper is relatively small for e-cigarette usage, with only 701 observations from the LISS panel dataset. Second, the measure for electronic and conventional cigarette usage in this paper uses ever-cigarette user rather than current-cigarette user. This is due to the dataset's being even smaller observation for current electronic cigarette use, and in order to have a sufficient amount of observation, I used ever-cigarette user as the measure for this. Third, this thesis employs a logistic regression model with a pooled cross-sectional data, which has some drawbacks. The nature of the pooled cross-sectional data makes it impossible to determine causality and can only determine the association between dependent and independent variables. This method also limits the ability to track changes in SES and cigarette consumption over time. There is also a violation of the independence assumption because this data is derived from multiple waves of the LISS panel dataset, implying that the same individuals exist over time. Finally, this paper may suffer from endogeneity because some variables that influence income, education, and both electronic and conventional cigarette usage may be excluded from the model.

There are some important takeaways for future research in this area. It may be interesting to investigate the mechanism by which differences in socioeconomic status influence electronic and conventional cigarette use, as this may aid in gaining a better understanding of tobacco usage among socioeconomic groups and the factors that influence it. Furthermore, future research could look for changes in e-cigarette usage over time using different types of data, such as panel data, and different estimation methods, such as fixed effect. This can result in more reliable and internally valid estimates. Including more control variables in this method of analysis, which affects both income and education, as well as electronic and conventional cigarettes, allows for a less biased estimation.

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Appendix

Table A1: Goodness-of-Fit Test with e-cigarette use as the main variable

Hosmer-Lemeshow Test	
No. of observations	9,918
No. of groups	10
Hosmer-Lemeshow chi2(8)	14.95
Prob > chi2	0.0602
Akaike Information Criterion and Bayesian Information Criterion	
df	7
AIC	2386.561
BIC	2436.975

Table A2: Goodness-of-Fit Test with conventional cigarette use as the main variable

Hosmer-Lemeshow Test	
No. of observations	9,918
No. of groups	10
Hosmer-Lemeshow chi2(8)	51.32
Prob > chi2	0.0000
Akaike Information Criterion and Bayesian Information Criterion	
df	7
AIC	13144.19
BIC	13194.61

Table A3: Testing the multicollinearity assumption

	Income	Education	Age	Gender	Marital Status	Health Status
Income	1.000					
Education	0.4412	1.0000				
	(0.000)					
Age	0.0647	0.0199	1.000			
	(0.000)	(0.033)				
Gender	-0.3313	-0.0658	-0.1084	1.000		
	(0.000)	(0.000)	(0.000)			
Marital	-0.1012	-0.2733	-0.5106	0.0433	1.000	
Status	(0.0000)	(0.000)	(0.000)	(0.000)		
Health	0.0904	0.0808	-0.1188	-0.0231	0.0155	1.0000
Status	(0.000)	(0.000)	(0.000)	(0.013)	(0.0590)	