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The relationship between maternal smoking during pregnancy and obesity among German children

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Abstract

Maternal smoking during pregnancy is recognized as one of the most important risk factors for negative pregnancy outcomes, nevertheless it still happens nowadays. Maternal smoking can result in different birth and health outcomes compared to mothers that do not smoke during their pregnancy, such as childhood obesity. Obese children have a high chance of staying obese during childhood, which is worrying since obesity rates are rising rapidly worldwide. The consequences of increasing obesity rates are not only affecting obese people themselves with related chronic diseases but also whole societies with the economic burden it brings. It is relevant to gain scientific knowledge on maternal smoking during pregnancy as a predictor of childhood obesity so effective interventions can be made to prevent mothers from smoking during pregnancy and moreover, indirectly decreasing the number of obese children. This thesis is about the influence of maternal smoking during pregnancy on the risk of childhood obesity among German children. To provide answers, quantitative data from the KiGGS baseline study is used, which is a German health interview and examination survey for children and adolescents collected by the Robert Koch Institute. The findings indicate that the risk of childhood obesity is almost twice as high when mothers did smoke during pregnancy compared to mothers that did not smoke during pregnancy. The sex of a child did not affect the relationship between childhood obesity and maternal smoking, however, the age of the child and socioeconomic status of the mothers did. The older a child the more likely it is that the child is obese and has a mother that smoked during pregnancy. Socioeconomic status turns out to have an influence on the relationship between maternal smoking during pregnancy and childhood obesity as well. However, it depends on the different components of socioeconomic status to what extent it influences the relationship.

Key concepts: *childhood obesity, maternal smoking during pregnancy, life course approach, sex, age, socioeconomic status, Germany*

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Chapter 1: Introduction

1.1. Background

Since the 1950s and 1960s, it has been known that smoking is harmful to your health and causes a range of serious diseases (Cancer Council, n.d.). Despite that, the prevalence of smoking only began to decline after the mid-1990s (WHO, 2019; Ng et al., 2014). Especially smoking during pregnancy is recognized as one of the most important risk factors for negative pregnancy outcomes, however, it still happens (Cnattingius, 2003). Mothers that smoke during pregnancy are for example more likely to have a baby born premature or with a lower mean birth weight (Yerushalmy, 2014; O'Lane, 1963; Herriot et al., 1992). In addition to this, maternal smoking raises the risk of spontaneous abortions, and diseases and behavioral disorders in later life (Hair et al., 2015; Knopik et al., 2012). Furthermore, a study found a positive association between mothers that smoke during pregnancy and childhood obesity (Von Kries et al., 1999). The discovery of this negative health outcome is becoming an increasingly important issues since obesity rates are escalating worldwide (Prentice, 2005). Obesity brings some serious health issues and related costs with-it, not only for people themselves but for the whole society (Tremmel et al., 2017). It can result in the development of diseases such as diabetes, stroke, and certain forms of cancer (Konnopka et al., 2011). These diseases do not only emerge in the long term but can already appear during childhood (WHO, 2019; Al Mamun et al, 2006). A study of Germany's yearly costs in relation to overweightness and obesity in 2002, calculated that the direct costs amounted to €4,854 million and the indirect costs €5,019 million (Konnopka et al., 2011). An updated version of this study in 2008, showed that these costs increased significantly over 6 years (Lehnert et al., 2015). The indirect costs, for instance, increased to €8,150 million in 2008, whereof most for unpaid work (Lehnert et al., 2015). Since obese children have a high chance of staying obese during childhood, it is going to increase the prevalence of obesity, the related health issues forming an economic burden worldwide (Parsons, 1999; Tremmel et al., 2017).

Biro & Wien (2010) state that genetic, behavioral and environmental factors influence childhood obesity. However, other factors that might influence if a child becomes obese are less studied. Maternal smoking during pregnancy is one of these factors, since less research is done about this factor. Therefore, it is relevant to gain knowledge on the relationship between maternal smoking during pregnancy and childhood obesity. This way, effective interventions can be made to prevent mothers from smoking during pregnancy and moreover, indirectly decreasing the number of obese children and the economic burden it brings worldwide.

1.3. Research problem

This study aims to explore the relationship between maternal smoking during pregnancy and the risk of childhood obesity. The central question of this research is therefore as follows: *How does maternal smoking during pregnancy influences the risk of obesity among German children?*

Studies suggest that the sex and the age of a child can alter the risk of obesity on children (State of obesity, 2019; Liverstone, 2011). Next to this, socioeconomic status could also have an

influence on the smoking behaviour of the mother (Ebert & Fahy, 2007). This makes that there are several secondary questions that arise out of this central research question:

1) How does the sex of the child influence the effect of maternal smoking on the risk of childhood obesity?
2) How does the age of the child influence the effect of maternal smoking on the risk of childhood obesity?
3) How does socioeconomic status influence the effect of maternal smoking on the risk of childhood obesity?

1.3. Structure of the thesis

Chapter 2 of this thesis starts with a review of the literature relating to the life course approach, childhood obesity, maternal smoking, and demographic and socioeconomic factors. The conceptual model is demonstrated in chapter 2 as well. The methodology can be found in chapter 3, which will explain where the secondary data is from, how it is collected, analyzed and how it will be used. Chapter 4 provides the results of the quantitative analysis. These findings answer the central question and the secondary questions of this research. In the next chapter, these results will be connected with the literature in the discussion part. Next to this, the strengths and weaknesses of the research, and recommendations for further research will also be in chapter 4. Lastly, the conclusion will be drawn in chapter 5.

Chapter 2: Theoretical framework

2.1. Life course approach

The life course approach in health as suggested by Kuh and Ben-Shlomo (2004), looks at health and disease risks by associating them with physical or social factors that appear during different periods in life. The time and timing components are important when considering the links between exposures and outcomes during an individual life course, across generations, and on population-level trends (Lynch & Smith, 2005). Time is significant because (chronic) diseases develop over time. For example, cancer has a long latency period; and again, timing is important. Because in a particular stage of life, when an exposure appears, it can be crucial to interpreting its later effects (Lynch & Smith, 2005). This approach states that certain exposures, in particular during in-utero, are linked to the growth and development of the fetus but also to health and behaviour later in life (Knopik et al., 2012). According to Kuh and Ben-Shlomo (2004), critical periods of growth and development in-utero or early infancy are important. During these periods is the body system very sensitive to the environment, which results in chronic diseases and risk factors being easily biologically programmed (Barker, 1998). This means that influences from the outside can lead for example to irreversible metabolic effects or excess weight gain that develop later in life (Kuh & Shlomo, 2004; Gillman, 2004).

2.2. Childhood obesity

For years, childhood malnutrition was the biggest threat for health especially in lower income countries, however, nowadays the opposite of this is affecting the world (Poobalan & Aucott, 2016). The World Health Organization (WHO) is now dealing with this new pandemic of overweightness and obesity and related diseases and burdens this brings with it (Prentice, 2005). Obesity is described as “abnormal or excessive fat accumulation that presents a risk to health” (WHO, 2018). The prevalence of obesity has been more than doubled since 1980 worldwide (Bhurosy & Jeewon, 2014). In Europe alone, the prevalence of obesity has been tripled since 1980 and is still on the rise. Over 2.1 billion people were overweight in 2014, whereof half a billion were obese. This comes down to almost 30% of the global population being overweight and this rate is increasing every year (Tremmel et al., 2017; Bhurosy & Jeewon, 2014). In 2016, more than 340 million children in the age of 5 to 17 and nearly 41 million children younger than 5 years were overweight or obese (WHO, 2018). In Germany, 2,9% of children aged 3-6 years, whereof 2,5% boys and 3,3% girls (WHO, 2013). 6,4% aged 7-10 were obese, whereof 7,0% boys and 5,7% girls (WHO, 2013). The risk of becoming obese is mainly growing with age, which is concerning since people are aging in most of Europe (Van Vliet-Ostaptchouk et al, 2014). Nearly 7% of the healthcare budgets in European countries are obesity-related diseases (Van Vliet-Ostaptchouk et al, 2014). For example, in 2014 when the costs of obesity appraise to be 2.0 trillion US Dollars globally (Tremmel et al., 2017). When the obesity rates are increasing like they are doing now, the healthcare costs will rise even more (Tremmel et al., 2017). Moreover, the morbidity and mortality from the noncommunicable diseases as a result of obesity will raise and cause a burden for health systems, the costs and the wider society (Van Vliet-Ostaptchouk et al, 2014). This makes the obesity epidemic one of the big challenges of the 21st century related to public health,

especially since overweight or obese children have a high risk of staying obese in later life (Wang & Lim, 2012; Parsons, 1999).

There are several factors that contribute to the obesity epidemic of children and adolescents. The rising prevalence of obese children is a result of the complex interaction between genetic, behavioral and environmental factors (Biro & Wien, 2010). Genes prefer to store excess calories as fat, especially when the environment changes fast and therefore decrease the energy consumption and increases the energy intake (Chung & Leibel, 2008). However, most studies emphasize behavioral and environmental factors as determinants for childhood obesity. The majority of the studies state that rising obesity rates are mostly the result of an imbalance in calories consumed and calories burned. There is an increase in the availability and affordability of foods and drinks that are high in saturated fats, sugars in addition to large portion sizes (Biro & Wien, 2010). The consumption of snacks has also increased over the years, which adds to the energy intake of children (Jahns et al., 2001). Physical activity is one of the important ways to prevent obesity and other chronic diseases (Warburton et al., 2006). However, a decline in physical activity by European children is noticed, especially by girls and those of older age (Van Vliet-Ostaptchouk et al, 2014; Konnopka et al., 2011). Ebbeling et al. (2002) reported that children who had the least physical activity or watched the most television were overweight the most. They also found that for each hour per day when children do moderate-to-vigorous physical activity, their obesity risk lowers by 10%. This was associated with especially a change in BMI for girls. Next to this, for each hour per day children watch television or play video games, the risk of obesity raises with 12% (Ebbeling et al., 2002). However, this was associated with BMI change of both girls and boys. Watching television is associated with weight gain because it displaces physical activity and increases food consumption. Especially since children tend to eat energy-dense foods while watching and they are exposed to commercials about mostly unhealthy foods (Ebbeling et al., 2002). Examples of environmental factors that are related to increase in the prevalence of obesity are anxiety, abuse, depression, and family stress (Vamosi et al., 2010). These factors are probably related because of the adrenal axis and stress-related eating patterns (Vamosi et al., 2010). Maternal smoking during pregnancy also could be one of the environmental factors as mentioned earlier.

2.3. Maternal smoking

Since the fetal stage is a highly vulnerable period during the life course, health behaviour of a mother during pregnancy can influence the health and behaviour of the fetus and in later life. Moreover, multiple studies show that tobacco smoke exposure during in-utero is one of the most dangerous environmental risk factors during pregnancy (Huang et al., 2017; Knopik et al., 2012). It gives different birth outcomes compared to women who do not smoke during pregnancy (Knopik et al., 2012). It raises the risk of perinatal mortality, miscarriage, and sudden infant death syndrome (Huang et al., 2017). It is more likely that mothers who smoke during pregnancy give birth to a premature baby than for those who do not (Yerushalmy, 2014). The mean birth weight and height of babies whose mothers are smoking during pregnancy is lower than for non-smoking mothers (Reeves & Bernstein, 2008; Ino, 2010). Maternal smoking during pregnancy also impacts cognitive functions. It negatively impacts memory, problem-solving, speech and language, school performance, and many more cognitive functions (Knopik et al., 2012). Oken et al. (2008) found

that the risk of overweightness for children whose mothers smoked during pregnancy in comparison to children of non-smoking mothers increased by 50%. Von Kries et al. (2002) reported a higher percentage of children with obesity versus not having obesity for mothers that smoked during pregnancy. One explanation for this is mentioned by Ino (2010), who found that maternal smoking during pregnancy can cause low birth weight and these low birth weight newborns often have a faster 'catch-up growth' than normal-weight newborns and then develop obesity in childhood.

Nevertheless, estimates of the prevalence of maternal smoking during pregnancy are mostly based on reports that mothers filled in themselves (Cnattingius, 2004). Therefore, it is likely to be underestimated. Especially since increasing negative attitudes towards maternal smoking in pregnancy (Cnattingius, 2004). A study that used biochemical tests of urine samples after mothers self-reported they did not smoke, yet the researchers found that in 3% of these samples smoking was indicated. Furthermore, in the same study, 11% of the non-smoking mothers refused permission for the urine tests which can indicate that many of them probably smoked (Huang et al, 2017).

2.4. Demographic and socioeconomic factors

The possibility of being obese as a young adult raises with the age of the obese child (Whitaker et al., 1997). Obese as an 18-year-old results in being a strong predictor for staying this later during adulthood. This is slightly less, but still a strong predictor for a 13-year-old obese child. However, this is only a moderate for children with obesity under 13 years of age (Livingstone, 2001). A study in the United States in 2015-2016, reported 13,9% of children in the age group 2-5 years were obese. This percentage increased to 18,4% for the age group 6-11 years and 20,6% for the age group 12 to 19 years (State of obesity, 2019). They also found that boys aged 2-19 years were slightly more obese than girls. However, according to another study, boys are less likely to be obese than girls because they are more physically active (Liverstone, 2011). So, there is some disagreement about which sex is more obese.

Gillman (2004) uses the life course approach to illustrate that the prevention of obesity should start early in life. Since maternal smoking is one of the risk factors in-utero, it is important to know what the characteristics are of mothers that smoke during pregnancy. A study by Laws et al. (2006) states that around the year 2006 smoking during pregnancy is still common, with 20-30% of women doing this. Smoking and socioeconomic status are closely related (Ebert & Fahy, 2007). Mothers who smoke during pregnancy are more likely to be poor, less educated and showing poorer health-promoting behaviour than women who do not smoke in pregnancy (Haslam & Lawrence, 2004; Knopik et al, 2012). Unemployed women smoke more cigarettes than employed women especially when they work full-time (Lee et al., 1991). Adults with the occupational status of managers and professionals were least likely to smoke (10%). Next to this, a study found that women who stopped smoking during pregnancy were more often employed (37,2%) than unemployed (20%) (McLeod et al., 2003). Another study found that smoking was more likely with pregnant women that were unemployed, unmarried and had a lower household income (Gillman et al., 2008). Having a lower family-income is also an important predictor for maternal smoking (Winkleby et al., 1992; Al Mamun et al. (2006). People with lower socioeconomic status generally

eat less healthy, because it is less affordable for them and therefore have higher obesity levels than people with higher socioeconomic status (Prättälä et al., 2009). Furthermore, when mothers are less economically stable, smoking is reported as a relief of anxiety and depression (Haslam & Lawrence, 2004). Gillman et al. (2008) also found a significant relationship between maternal smoking and less than high school education. Al Mamun et al (2006) found that age is related to maternal smoking next to socioeconomic status. They found that smoking mothers during pregnancy were of a younger age than mothers who did not smoke during pregnancy. Overall, there is a decrease in smoking especially around maternal age (Cnattingius, 2004). In the US in 1965, 38% of women smoked in the age group of 18-24 and 44% in the age group of 25-44. In 2000, these percentages decreased to 25% and 23% (USDHHS, 2002).

2.7. Conceptual model

This conceptual model in Figure 1 is derived from the theoretical framework. Maternal smoking during pregnancy is one of the other factors that could influence childhood obesity (Von Kries et al., 1999). Maternal smoking during pregnancy is mostly influenced by socioeconomic status, especially occupation, income, and education level (Al Mamun et al (2006). The low occupation status of the mother can also lead to maternal smoking (Lee et al., 1991). Next to this, a low (family-) income can lead to maternal smoking during pregnancy (Winkleby et al., 1992). The prevalence of maternal smoking is highest for mothers with the least years of education (Gillman et al., 2008). Next to this, the sex and the age of the child could play a role in developing childhood obesity (State of Obesity, 2019; Liverstone, 2011).

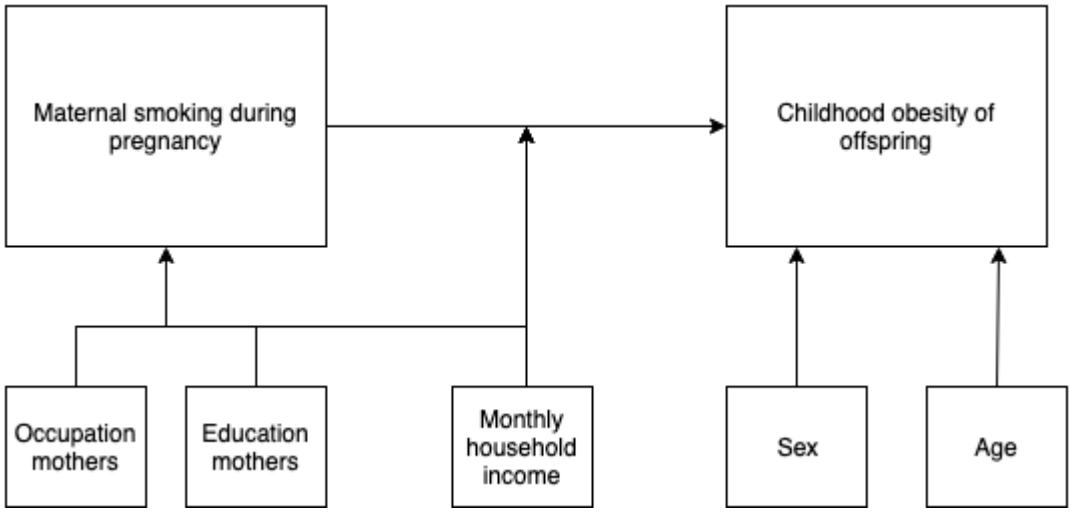

Figure 1: Conceptual model.

Chapter 3: Methodology

3.1. Data

To explore the relationship between childhood obesity and maternal smoking during pregnancy, data from the KiGGS baseline study was used. KiGGS is the German health interview and examination survey for children and adolescents. This data is collected by The Robert Koch Institute (RKI), which is the German government's central scientific institution in the field of biomedicine (RKI, 2017). The baseline study is a combined cross-sectional and longitudinal study that was collected from 2003 to 2006 and contains a variety of data collected about 8985 boys and 8656 girls aged between 0 and 17 years old from Germany (KiGGS, 2019). The data is collected in the same structure used in a successful 1998 survey (KiGGS, 2019). The core survey is where the benchmark health information is collected from the complete sample of children and adolescents. The rest of the data is divided into three modules in which they use subject-specific methods of collecting the data (KiGGS, 2019). The Environmental Survey involves a personal interview, measurement of noise pollution and hearing impairment, and the analysis of drinking water, dust and air samples from home. Next to this, urine and blood samples are tested for substances related to environmental health. The Mental Health module is using the benchmark health information related to behavioral problems and subjective wellbeing. They also use interviews for certain parts. For the motor functions/ physical activity, the children and adolescents will be asked about what they physically do and tested on skills like strength. Next to these modules, parents fill in a questionnaire about information like vaccinations (KiGGS, 2019).

3.2. Data analysis

The database of KiGGS presents a variety of variables to measure the determinants of child health and development. However, this research will focus on the relationship between maternal smoking during pregnancy and childhood obesity. Maternal smoking during pregnancy is a binary variable, which has the answer options yes and no. There were multiple variables that could have been used to measure childhood obesity. Nevertheless, this thesis uses the Kromeyer-Hauschild reference system instead to measure obesity. The concepts of overweightness and obesity that this Kromeyer-Hauschild reference system uses, are determined based on the 90th and the 97th percentile of the body mass index (Moreno et al., 2011). By using these percentiles, this method makes up for the disadvantage the pure use of BMI has with using data of children. Especially, since the Kromeyer-Hauschild method has been designed for children living in Central Europe (Moreno et al., 2011).

Childhood obesity is the dependent variable and maternal smoking during pregnancy the independent variable. Both variables are nominal and binary. Therefore, a binary logistic regression is used to see if there is a relationship between the two with $p<0.05$. Sex, age, and socioeconomic status are used as control variables. Sex is a binary variable and age is an ordinal. The age group 0-2 is not in the regression because infants cannot be classified as obese at such a young age. Therefore, the age group 3-6 years is used as reference category. Socioeconomic status is a complex concept that consists of multiple variables that can be analyzed and is mostly explained as "a combination of financial, occupational and education influences" (Winkleby et al.,

1992). Back in the days, researchers were often combining variables. Nowadays, it is more common to analyze these as separate variables because studies state that each variable gives a different dimension of socioeconomic status. For example, education normally does not change through adulthood or will change because of poor health in adulthood, where occupation and income do (Zhu et al., 1996; Winkleby et al., 1992). The variables occupational status (nominal), monthly household income (ordinal), and education of the mother (ordinal) are used to determine socioeconomic status. Table 1 describes how the different variables are structured.

Variable	**Number of cases**	**Number of missing cases**	**Options**	**Number**	**Percentage**
Maternal smoking during pregnancy	17088	552	Yes	2910	17,0%
			No (reference)	14178	83,0%
Childhood obesity (>97 Kromeyer-Hauschild)	14178	2894	Yes	904	6,1%
			No (reference)	13842	93,9%
Sex child	17640	0	Male (reference)	8985	50,9%
			Female	8655	49,1%
Age group child	17640	0	0-2 years	2805	15,9%
			3-6 years (reference)	3875	22,0%
			7-10 years	4148	23,5%
			11-13 years	3076	17,4%
			14-17 years	3736	21,2%
Occupational status mother	16637	1003	Housewife (reference)	2212	13,3%
			Unskilled worker	1094	6,6%
			Semiskilled	981	5,9%
			Skilled worker	2160	13,0%
			Forewoman/crew leader	126	0,8%
			Self-employed farmer	80	0,5%
			Self-employed academician	534	3,2%
			Other self-employed (small company)	414	2,5%
			Other self-employed (large company)	56	0,3%
			Assisting at family company	495	3,0%
			Industrial worker	66	0,4%

			Employee with simple activity	1553	9,3%
			Employee with qualified activity	4719	28,4%
			Employee with highly qualified activity	940	5,7%
			Employee with leadership tasks	80	0,5%
			Lower-grade civil servant	47	0,3%
			Middle-grade civil servant	270	1,6%
			Upper-grade civil servant	337	2,0%
			Higher-grade civil servant	141	0,8%
			Other	332	2,0%
Monthly household income	16552	1088	<500€ (reference)	194	1,2%
			500-<750€	498	3,0%
			750-<1000€	1658	10,0%
			1250-<1500€	1239	7,5%
			1500-<1750€	1188	7,2%
			1750-<2000€	1601	9,7%
			2000-<2250€	1726	10,4%
			2250-<2500€	1843	11,1%
			2500-<3000€	2571	15,5%
			3000-<4000€	2409	14,6%
			4000-<5000€	982	14,6%
			<=5000€	643	3,9%
Education mother	17295	345	No degree (reference)	480	2,8%
			Lower secondary education	3603	20,8%
			Medium secondary education	5125	29,6%
			Vocational secondary education	1313	7,6%
			Vocational secondary education	2820	16,3%
			Polytechnic secondary education	3577	20,7%
			Other	377	2,2%

Table 1: Descriptive variables.

Chapter 4: Results

4.1. Descriptive statistics

In this database, 6.1% of all children have obesity according to the Kromeyer-Hauschild method. This comes down to 904 children. There are 2910 mothers that filled in that they have smoked in pregnancy, which comes down to 17,0%. Figure 2 shows the percentages of obese children based on different age groups and divided into male and female. The percentages between the two sexes are very equal. The age group 3-6 years has less obese children than the other age groups. The number of obese children in the older three age groups is quite similar.

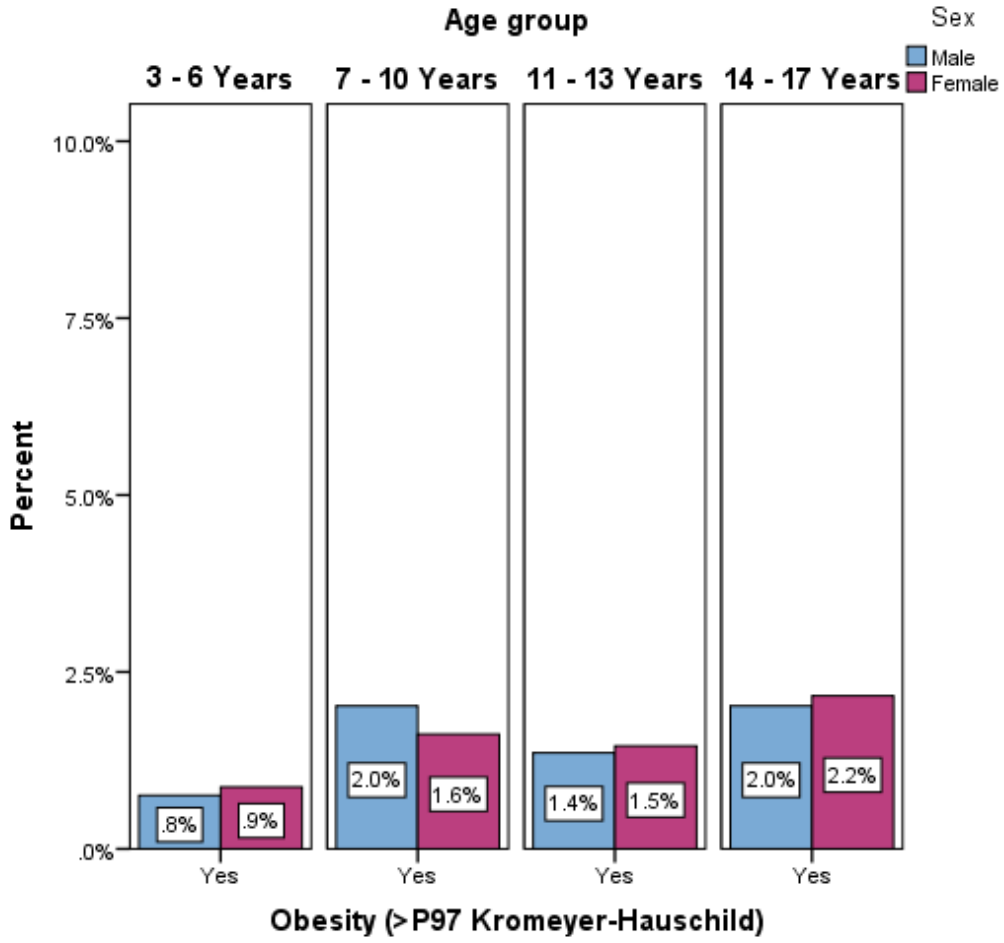

Figure 2: Childhood obesity percentages in different age groups and sex.

4.2. Maternal smoking resulting in childhood obesity

To examine a potential relationship between childhood obesity according to the Kromeyer-Hauschild method and maternal smoking during pregnancy, a binary logistic regression in SPSS is executed as seen in table 2. Firstly, a $p<0.05$ is found, which means that there is a significant relationship between childhood obesity and maternal smoking during pregnancy. The test gave a positive B of 0,663 and an exponent B of 1,940. The first statistic (B) describes that compared to mothers that do not smoke during pregnancy, mothers that do smoke during pregnancy have a

bigger chance of having an obese child. The exponent B of 1,940 means that the risk of childhood obesity is 1,940 times more likely when the mother did smoke during pregnancy compared to when a mother did not smoke during pregnancy.

	B	S.E.	Sig.	Exp(B)
Maternal smoking during pregnancy (No= reference)	0,663	0,084	0,000	1,940

Table 2: Binary logistic regression childhood obesity and maternal smoking during pregnancy

Figure 3 also shows that when a mother smokes during pregnancy the risk is higher that her child will have obesity than that her child is not obese since it shows that when mothers smoke 27,2% of the children have obesity compared to 16,3% that do not have obesity when the mother smoked during pregnancy.

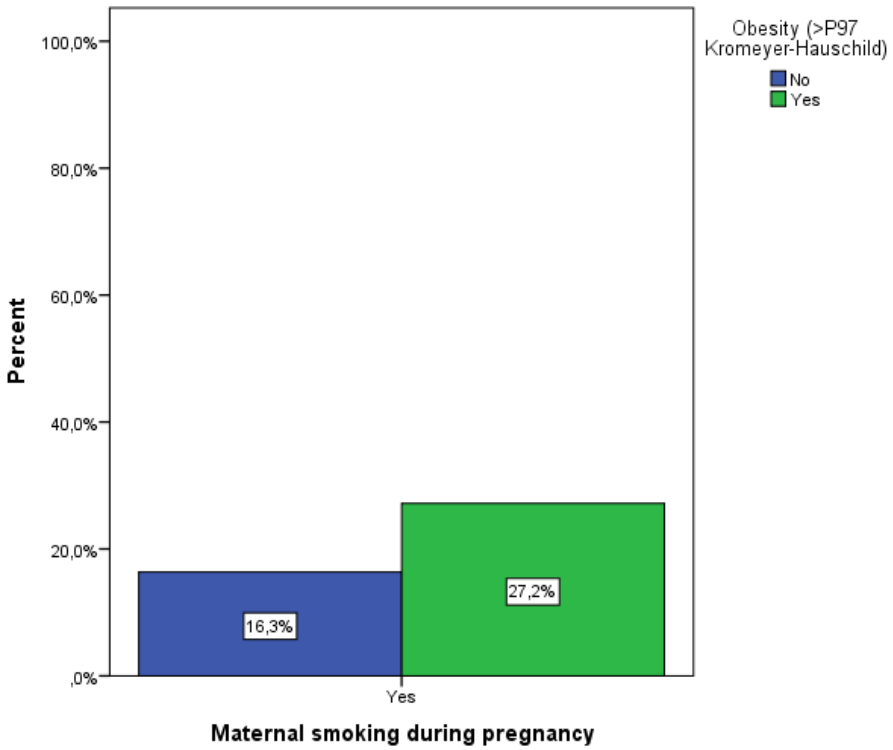

Figure 3: Bar-chart childhood obesity and maternal smoking during pregnancy.

4.3. Control variables sex and age

To investigate sex differences, it is tested whether it made a difference if the obese child was a boy or a girl. Table 3 shows a binary logistic regression, which gave a p>0,005, sex of a child is therefore not a significant addition to the model. The Exp(B) of childhood obesity and maternal smoking did not change and stayed 1,940. This means that being a boy or girl (sex) does not influence the relationship between childhood obesity and maternal smoking during pregnancy.

	B	S.E.	Sig.	Exp(B)
Maternal smoking during pregnancy (No= reference)	0,663	0,084	0,000	1,940
Sex (Male= reference)	-0,014	0,074	0,854	0,986

Table 3: Binary logistic regression childhood obesity and maternal smoking during pregnancy, incl. sex.

Next to this sex, age was also looked at as a variable affecting the relationship between childhood obesity and maternal smoking during pregnancy. In the age group 3-6 years 3,1% has obesity, 6,5% in the age group 7-10, 6,8% in the age group 11-13 and lastly, 8,3% in the age group 14-17. Figure 4 demonstrates the percentages of children that have mothers that smoked during pregnancy and do or do not have obesity, divided into four different age groups. Of the three oldest age groups, more children have obesity than do not have obesity when their mother smoked during pregnancy.

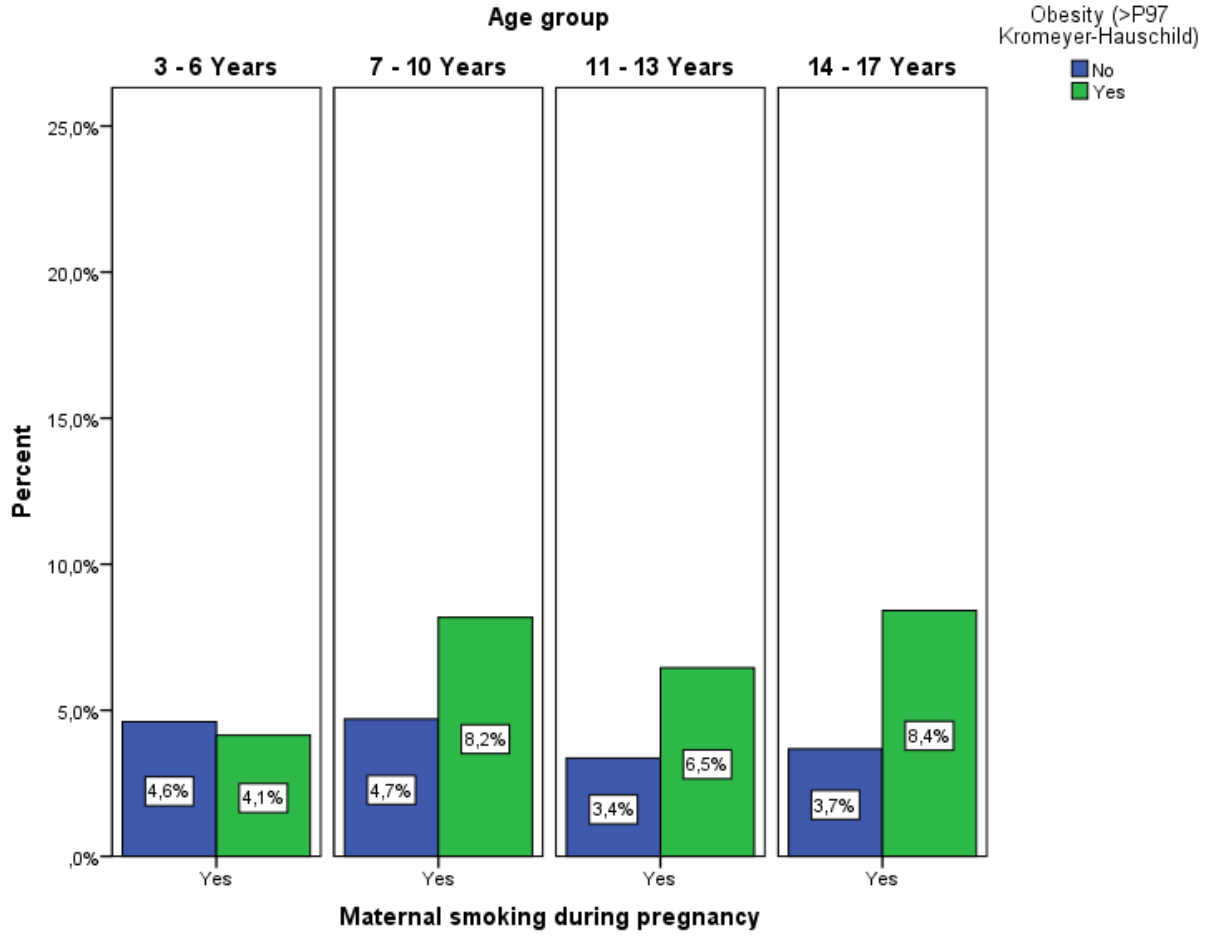

Figure 4: Bar-chart childhood obesity and maternal smoking divided into age groups.

Adding the variable age to the model turns out to be a significant improvement of the model with p<0,005. Table 3 shows the binary logistic regression when the variable age is included and that it is has a significant effect on the relationship between childhood obesity and maternal smoking. The B's are positive and become higher the older the age group. This means that the chance of

childhood obesity is becoming higher the older the children are, compared to the age group 3-6 years old (reference). The Exp(B)'s are growing the older the age group as well. Indicating, that the likelihood of having obesity when a mother smokes during pregnancy is growing with age. As an example, it is 2,788 times more likely that children from the age group 14-17 years old are obese compared to children from the age group 3-6 years old. Moreover, age has an effect on the relationship between childhood obesity and maternal smoking. Exp(B) even increased slightly when the variable age is added to the regression. Therefore, age makes it even more likely that a child has obesity than not has obesity when a mother smoked during pregnancy.

	B	**S.E.**	**Sig.**	**Exp(B)**
Maternal smoking during pregnancy (No= reference)	0,680	0,085	0,000	1,974
Sex (Male= reference)	-0,011	0,075	0,878	0,989
Age group 3-6 (=reference)			0,000	
Age group 7-10	0,733	0,121	0,000	2,082
Age group 11-13	0,822	0,125	0,000	2,277
Age group 14-17	1,025	0,119	0,000	2,788

Table 2: Binary logistic regression childhood obesity and maternal smoking during pregnancy, incl. sex and age groups

4.5. Control variable socioeconomic status

Next to sex and age, it is tested whether the variable socioeconomic status is affecting the relationship between childhood obesity and maternal smoking during pregnancy. Socioeconomic status consists of three factors, namely the occupational status of the mother, monthly household income and education of the mother. Appendix 1 shows the binary logistic regression including all the different control variables. The socioeconomic status factors have an effect on the relationship between childhood obesity and maternal smoking, with $p<0,005$. Exp(B) decreased from 1,940 to 1,532, which makes that after adding all the control variables, it is 1,532 times more likely that childhood obesity is present when a mother did smoke during pregnancy compared to when mothers did not smoke. For the variable occupational status, unskilled worker significantly differs from a housewife (reference category). This indicates that the chance of unskilled workers have obese children is 38,7% higher than housewives have. All the other occupations are not significantly different from housewife; however, they can still be different from a housewife, just not significantly. Moreover, only the monthly household incomes 2000-2250€, 3000-4000€, and 4000-5000€ show a significant difference with the reference category monthly household income <500€. Households in these three categories have a 44,5%, 48,8%, and 65,1% lower chance to have obese children than households in the reference category <500€. All the other categories do not present a significant difference with <500€. Outstanding is that none of the education categories differ significantly from the reference category no degree when it comes to the risk of childhood obesity.

Chapter 5: Discussion

5.1. Main findings

This research found a positive relationship between maternal smoking during pregnancy and childhood obesity. Next to this, 27,2% of the children had obesity compared to 16,3% that not had obesity when the mother smoked during pregnancy. Similar results have been presented by Von Kries et al. (2002), who also described a positive association between maternal smoking and childhood obesity. They found a higher percentage of obese children with mothers that smoked during pregnancy compared to mothers that did not smoke during pregnancy. A potential explanation for this could be that maternal smoking during pregnancy can cause low birth weight and these low birth weight newborns often have a faster 'catch-up growth' than normal-weight newborns and then develop obesity in childhood (Ino, 2010). The results of this thesis are corresponding with the theory, however, Cnattingius (2004) found that the percentage of smoking mothers during pregnancy is often underestimated because mothers have filled in the reports themselves and mostly are aware of the negative attitudes towards this behaviour. Huang et al., (2017) found at least 3% of mothers that had smoke indicated in their urine, and so they lied when they filled in that they did not smoke during pregnancy. Therefore, the percentage of smoking mothers is probably underestimated in the KiGGS database as well, because the questionnaires were filled in by the mothers themselves.

The theory suggested that in Germany in 2013, 2,9% of children aged 3-6 years (2,5% boys and 3,3% girls) and 6,4% aged 7-10 (7,0% boys and 5,7% girls) were obese (WHO). In the KiGGS database, these percentages are almost equal with 3,1% of the obese children aged 3-6 years and 6,5% obese children aged 7-10 and therefore an accurate reflection of the total obese children in Germany aged 3-6 and 7-10. Next to this, in the first age group 6,3% are obese boys and 7,0% obese girls and in the second age group 16,6% obese boys and 12,9 obese girls. The discovery that there are more obese girls in the first age group compared to obese boys and more obese boys than obese girls in the second age group is similar to the 2013 percentages of the World Health Organization. However, in the KiGGS database from 2003/2006 are especially the percentages of the age group 7-10 notable higher than in 2013 findings of the World Health Organization. This is corresponding with a study in the United States in 2015-2016, where they also found increasing percentages with increasing age (State of obesity, 2019). Unfortunately, there was no precise literature to compare the other two age groups with the total German obese children aged 11-13 and 14-17. A potential explanation for why more children are obese in older age groups is that there is a decline noticed in physical activity among European children of older age (Van Vliet-Ostaptchouk et al., 2014; Konnopka et al, 2011). They probably play more games and watch more television than children of a younger age, which decreases the physical activity level even more and increases the food consumption since children tend to eat energy-dense foods while watching television (Ebbeling et al., 2002). Next to this, since older age groups have more mothers that smoked during pregnancy, it could be that since the 1990s tobacco use decreased substantial and with this the younger the child the lower the chance that the mother smoked, especially during pregnancy (Salihu & Wilson, 2007).

Ebert & Fahy (2007) found that smoking and socioeconomic status are closely related, this is in line with the results from the thesis, where an effect on the relationship between childhood obesity and maternal smoking during pregnancy was found. Haslam & Lawrence (2004) found that smoking mothers during pregnancy were more likely to be less educated and poor. A possible explanation for this could be that mothers that smoke during pregnancy show poorer health-promoting behaviour than women who do not smoke in pregnancy since it is commonly known that maternal smoking is unhealthy for yourself and your infant (Haslam & Lawrence, 2004). Furthermore, the findings present that the chance that unskilled workers obese children have is 38,7% higher than for housewives. These two categories are in general the lowest paid or even not paid jobs. Moreover, the monthly household incomes 2000-2250€, 3000-4000€, and 4000-5000€ have a lower chance to have obese children than households in the reference category <500€. These categories probably can afford to workout often, to buy healthier and mostly, more expensive food and have therefore less chance on obese children in comparison with the households in the lower income categories (Prättälä et al., 2009).

5.2. Reflection

This thesis uses data KiGGS baseline study. Although using secondary data has the great benefit that it is already collected and thus saves up a lot of time, it also has its limitations. For example, this was the case with the variables age of the children and the age of the mother that were not ratio variables, but variables divided into specific groups. Which made it hard to test whether maternal age would make a difference for the relationship between maternal smoking and childhood obesity, which is suggested by some researchers. Next to this, only a small part of childhood obesity is related to maternal smoking during pregnancy. There are multiple other reasons for the development of childhood obesity as Wiro and Bien (2010) describe, however they are not tested in this thesis because of practical reasons. Furthermore, limited theory is available about the combination of childhood obesity and maternal smoking during pregnancy, which made it sometimes hard to discuss the data in the context of the theory.

5.3. Recommendations

Further research on childhood obesity is needed. It would be recommended to include more variables since there are multiple reasons for obesity development in childhood, like psychical activity and eating habits. This subject is especially interesting because the prevalence of childhood obesity is growing, and obese children are likely to stay obese for the rest of their lives. This is not beneficial at all since obesity is an economic burden and causes other health issues not only physically but also mentally.

Maternal smoking during pregnancy is another subject that needs further and more up-to-date research. A lot of studies about maternal smoking date from half a century ago and although it now is commonly known that maternal smoking is very unhealthy for the infant and the mother, it still happens nowadays. In today's studies, maternal smoking is mostly a control variable or a small part of the study; not the main subject of the study. On the contrary, childhood obesity may only be a small part of all the outcomes of maternal smoking during pregnancy gives.

It is also interesting to dig deeper into socioeconomic status since for example income is important in what a person can (not) afford and how this affects a person and/or a family's eating habits and (active) lifestyle.

Chapter 6: Conclusion

In this thesis, the influence of maternal smoking during pregnancy on the risk of childhood obesity among German children is analyzed. The results state that it is 1,940 times more likely that a child is obese than not obese when a mother smoked during pregnancy. While it does not make any difference if the obese child is a boy or a girl, it does when it comes down to different age groups. In fact, age also increases the relationship between childhood obesity and maternal smoking during pregnancy by a small margin. The older the child, the higher risk that the child is obese and that its mother smoked during pregnancy, which can be related to the fact that oldest children in the database have mothers that were smoking because it was more common than for the mothers of the younger children or that in general older children are less active and watch more television or games than younger children. Next to this, socioeconomic status turns out to have an influence on relationship between childhood obesity and maternal smoking during pregnancy as well. Nevertheless, it does not affect the relationship as much as age does. Oftentimes, the mothers who work the lowest paid jobs have the most chance of having obese children, with this, some of the higher monthly household incomes have the least risk of obese children. The higher paid jobs can presumably find it easier afford to workout, to buy healthy, mostly expensive food and have therefore less chance on obese children in comparison with the households with lower incomes. Moreover, mothers that smoke during pregnancy show poorer health-promoting behaviour than women who do not smoke in pregnancy since it is commonly known that maternal smoking is unhealthy for yourself and your infant.

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Appendix 1: Binary logistic regression

	B	S.E.	Sig.	Exp(B)
Maternal smoking during pregnancy (NO= reference)	,426	,089	,000	1,532
Sex (Male= reference)	-,010	,075	,890	,990
Age group 3-6 (Reference)			,000	
Age group 7-10	,716	,122	,000	2,046
Age group 11-13	,788	,127	,000	2,200
Age group 14-17	1,005	,121	,000	2,733
Occupational status mother: housewife (reference)			,158	
Occupational status mother: unskilled worker	,327	,149	,028	1,387
Occupational status mother: semi-skilled worker	-,019	,167	,910	,981
Occupational status mother: skilled worker	,048	,145	,742	1,049
Occupational status mother: forewoman/ crew-leader	-,043	,438	,922	,958
Occupational status mother: self-employed farmer	,403	,446	,366	1,497
Occupational status mother: self-employed academician	-,292	,291	,316	,747

Occupational status mother: self-employed (small company)	-,058	,267	,829	,944
Occupational status mother: self-employed (large company)	,611	,493	,215	1,843
Occupational status mother: assisting at family company	,348	,215	,106	1,416
Occupational status mother: industrial worker	-1,169	1,020	,252	,311
Occupational status mother: employee with simple activity	-,127	,160	,427	,881
Occupational status mother: employee with qualified activity	-,199	,139	,153	,819
Occupational status mother: employee with highly qualified activity	,155	,218	,478	1,167
Occupational status mother: employee with leadership tasks	,208	,535	,698	1,231
Occupational status mother: lower-grade civil servant	,159	,619	,798	1,172
Occupational status mother: middle-grade civil servant	,244	,322	,449	1,276
Occupational status mother: upper-grade civil servant	-,164	,412	,691	,849
Occupational status mother: higher-grade civil servant	-,098	,613	,873	,906

Occupational status mother: other	-,050	,318	,875	,951
Monthly household income: <500 (Reference)			,000	
Monthly household income: 500-750	,018	,335	,957	1,018
Monthly household income: 750-1000	-,159	,305	,602	,853
Monthly household income: 1250-1500	-,097	,310	,754	,908
Monthly household income: 1500-1750	-,160	,313	,609	,852
Monthly household income: 1750-2000	-,386	,310	,214	,680
Monthly household income: 2000-2250	-,787	,319	,013	,455
Monthly household income: 2250-2500	-,586	,313	,061	,556
Monthly household income: 2500-3000	-,523	,306	,088	,593
Monthly household income: 3000-4000	-,671	,313	,032	,511
Monthly household income: 4000-5000	-1,053	,365	,004	,349
Monthly household income: >5000	-,558	,368	,129	,572
Education mother: no degree (Reference)			,001	

Education mother: lower secondary education	,076	,208	,714	1,079
Education mother: medium secondary education	-,247	,216	,253	,781
Education mother: polytechnic secondary education	-,109	,249	,663	,897
Education mother: vocational secondary education	-,233	,222	,296	,792
Education mother: gymnasium	-,109	,316	,731	,897