UNIVERSITY OF NOVA GORICA
GRADUATE SCHOOL

EFFECTS OF AIR POLLUTION WITH OZONE ON PRIMARY HEALTH CARE CONSULTATIONS FOR UPPER RESPIRATORY TRACT DISEASES IN CHILDREN IN KOPER MUNICIPALITY

Marija Maja REMS NOVAK

Master´s thesis

Mentor: Prof. Lijana Zaletel-Kragelj, MD PhD

Nova Gorica, 2013

UNIVERZA V NOVI GORICI
FAKULTETA ZA PODIPLOMSKI ŠTUDIJ

VPLIV ONESNAŽENOSTI ZRAKA Z OZONOM, NA POGOSTOST OBISKOV NA PRIMARNI RAVNI ZDRAVSTVENEGA VARSTVA ZARADI BOLEZNI ZGORNJIH DIHAL PRI OTROCIH V MESTNI OBČINI KOPER

Marija Maja REMS NOVAK

Magistrsko delo

Mentor: Prof. Lijana Zaletel-Kragelj, MD PhD

Nova Gorica, 2013

Dear mom,

Since you have been gone, I have made one of the bravest and very important decisions in my life – I decided for a study, the conclusion of which I now present. I devote it entirely to you, dear mom, and to everything you taught me - patience, persistence and diligence, which allowed me to complete it. Conclusion of the study will enable me an independent, better and friendlier future, in terms of both professional life and personal growth, as I proved once more that I am a strong personality who does not submit to any obstacle.

ABSTRACT

BACKGROUND. It has long been known that both, long-term exposure to higher concentrations of ozone and high peak exposure, is associated with increased adverse health effects, ranging from minor to major ones. The objective of the study was to assess the association between visits/consultations to the primary health care unit (the Community Health Centre Koper) due to respiratory diseases, and daily ozone concentrations in children from the Koper Municipality

METHODS. The study design was ecological time-trend with a single day as a unit of observation. Observed were 2010 and 2011 periods from April 1 through October 31, when ozone concentrations in the Koper Municipality are the highest. The study population was all children, aged 0-12 years, residing permanently or temporarily in the Koper Municipality, who visited the Community health centre Koper for any respiratory symptom. Poisson and logistic regressions were used as main methods of statistical analysis.

RESULTS. The main result of the study is the statistically significant association between daily occurrence of any consultation for asthma symptoms and ozone daily maximum 8-hr average concentration 70 $\mu g/m^3$ or exceeded, lag 4 (OR= 4.77; p =0.042).

CONCLUSION. We can conlude that there is an evidence of association between increased ozone levels and daily occurrence of any consultation for asthma symptoms in the Koper Municipality. Also we can conclude that with some improvements linkage of existing health and environmental data in Slovenia could be feasible in identifying the grounded need for public health action.

KEY WORDS: air pollution, ozone, respiratory diseases, asthma, ecological time-trend study, Poisson Regresion, logistic regression, Koper Municipality,

IZVLEČEK

OZADJE. Že dolgo je znano, da sta dolgotrajna izpostavljenost višjim koncentracijam ozona ali kratkotrajna izpostavljenost zelo visokim koncentracijam povezani s povečanimi škodljivimi učinki na zdravje, od relativno blagih, pa vse do hudih. Cilj raziskave je bil oceniti povezavo med obiski v primarni ravni zdravstvenega varstva zaradi bolezni dihal pri otrocih in dnevnimi koncentracijami ozona v Mestni občini Koper.

METODE. Raziskava je bila zasnovana kot ekološka raziskava časovnih trendov, z enoto opazovanja en dan. V letih 2010 in 2011 smo opazovali obdobje med 1. aprilom in 31. oktobrom, ko so običajno koncentracije ozona v Mestni občini Koper najvišje. Opazovana populacija so bili otroci, stari med 0 in 12 let, s stalnim ali začasnim prebivališčem v Mestni občini Koper, ki so obiskali Zdravstveni dom Koper, zaradi simptomov katere koli bolezni dihal. Kot glavni metodi statistične analize smo uporabili Poissonovo in logistično regresijo.

REZULTATI. Glavni rezultat raziskave je statistično značilna povezava med dnevnim številom obiskov zaradi simptomov astme in maksimalno dnevno 8-urno povprečno koncentracijo, ki je bila enaka ali je presegala 70 $\mu g/m^3$, s štiri dnevnim zamikom (RO=4,77; p=0,042).

ZAKLJUČEK. Zaključimo lahko, da obstajajo dokazi o povezavi med povečano koncentracijo ozona in dnevnim številom obiskov, zaradi simptomov astme v Mestni občini Koper. Zaključimo lahko tudi, da bi z nekaj izboljšavami povezovanje obstoječih zdravstvenih in okoljskih podatkov v Sloveniji lahko uporabljali v namen z dokazi podprtega javnozdravstvenega ukrepanja.

KLJUČNE BESEDE: onesnaženje zraka, ozon, bolezni dihal, astma, ekološka raziskava časovnih vzorcev, Poissonova regresija, logistična regresija, Mestna občina Koper

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

CHCK	Community Health Centre Koper
CI	Confidence Interval
DPABS	Društvo pljučnih in alergijskih bolnikov Slovenije - Pulmonary and Allergic Patients Association of Slovenia
EC	European Commision
EEA	European Environment Agency
EPA	Environment Protection Authority
GIS	Geographic Information System
GLM	Generalized Linear Model
ICD-10	International Classification of Diseases, version 10
IL	Illinois
IPHK	Institute of Public Health Koper
IRR	Incident Rate Ratio
KM	Koper Municipality
Max	Maximum
Min	Minimum
N	Number of units of observation
NASA	National Aeronautics and Space Administration
NO	Nitric Oxide
NO_2	Nitrogen dioxide
O	Oxygene atom
O_2	Oxygene
O_3	Ozone
OR	Odds Ratio

p	probability
PAH	Polycyclic Aromatic Hydrocarbons
PM	Particulate Matter
RO_2	atmospheric peroxides
SD	Standard Deviation
SEA	Slovenian Environment Agency
SI-STAT	Slovenian Statistical Portal
SPSS	Statistical Package for the Social Sciences
SRC	Slovenian Red Cross
U.S.	United States
UCLA	University of California Los Angeles
USA	United States of America
UV	Ultra Violet
VOCs	Volatile Organic Compounds
WHO	World Health Organization

1 INTRODUCTION

1.1 AIR POLLUTION

1.1.1 Definitions

Air pollution is a condition when the air we breathe contains substances (gases, dust, fumes or odour) in harmful quantities (quantities which could be harmful to the health or comfort of humans and animals or which could cause damage to plants and materials) (Environment Protection Authority (EPA) Victoria, 2012).

The substances that cause air pollution are called pollutants. Pollutants that are introduced into our atmosphere and directly pollute the air are called primary pollutants. Further pollution can arise if primary pollutants in the atmosphere undergo chemical reactions. The resulting compounds are called secondary pollutants (Environment Protection Authority (EPA) Victoria, 2012).

1.1.2 Health effects

Exposure to air pollution has been proven to be associated with a variety of adverse health effects. The health effects may range from subtle biochemical and physiological changes to wheezing, coughing, and difficulties in breathing, and aggravation of existing respiratory and cardiac conditions. Most of the recent evidence focuses on respiratory and cardiovascular effects (World Health Organization, Regional Office for Europe, 2001; World Health Organization, Regional Office for Europe, 2005b; Zanobetti et al., 2003; Mar et al., 2004; Pope et al., 2004; Neuberger et al., 2004; Moshammer et al., 2006; Neuberger et al., 2007; Orru et al., 2009; Lindgren et al., 2009; Stieb et al., 2009).

The most significant health impacts are now generally recognized to be fine particles and ground level ozone (European Environment Agency, 2011). There is a strong evidence that increased air pollution with particulate matter (PM_{10} and $PM_{2.5}$), and ozone (O_3), precipitates respiratory symptoms (Balmes, 1993; Stieb et al., 2002; World Health Organization, Regional Office for Europe, 2003; World Health Organization, Regional Office for Europe, 2005a; World Health Organization, Regional Office for Europe, 2005b Moura et al., 2008; Suwanwaiphatthana et al., 2010). Consequently, it increases emergency room visits and hospital admissions due to respiratory symptoms (Hajat et al., 1999; Wong et al., 1999; Gouveia et al., 2000; Braga et al., 2001; Lee et al., 2006; Wong et al., 2006; Myers et al., 2007; Babin et al., 2007; Strickland et al., 2010; Ji et al., 2011).

On the other hand, improvement of the quality of ambient air has been shown to improve the health of the exposed population groups (Neuberger et al., 2002).

1.2 POPULATION GROUPS VULNERABLE TO AIR POLLUTION

All population groups are affected by air pollution in different ways, however, some of them are more sensitive/vulnerable. On one hand, among them are children and elderly people, on the other hand, increasing amount of evidence suggests also that air pollution poses the biggest risk for people with health problems, including asthma and other lung diseases, and heart diseases.

Among the most susceptible population subgroups to air pollution are pre-school children (World Health Organization, Regional Office for Europe, 2005b; American Academy of Pediatrics, 2004; Tamburlini et al., 2002), particularly in terms of respiratory diseases (Schwartz, 2004). Already twenty years ago, Bobak and Leon (1992) reported that increasing levels of the most common air pollutants (particulate matter, ozone, nitrogen dioxide and sulfur dioxide) adversely affect the respiratory health of children. They have higher breathing rates than adults and therefore a higher intake of air pollutants per unit of body weight. They also spend more time outdoors than adults, thereby adding to their exposure potential (World Health Organization, Regional Office for Europe, 2005a; World Health Organization, Regional Office for Europe, 2005b; Schwartz, 2004). Evidence from a variety of studies suggests that exposure to air pollution increases the risk of acute respiratory illnesses in this population group, and admissions to hospital (Moura et al., 2008; Dietert et al., 2000; Giovannini et al., 2010).

As for ozone, several studies indicate positive association between higher concentrations of ozone in the air and negative health effects in children (Gouveia et al., 2000; Galan et al., 2003; Hwang et al., 2005; Babin et al., 2007; Myers et al., 2007; Lin et al., 2008a; Lin et al., 2008b). Furthermore, studies have reported that long-term exposure to ozone (even to relatively low concentrations) may reduce lung function in school children (Rojas-Martinez et al., 2007). Children living in an environment with frequently high ozone concentration and playing three or more sports were demonstrated to be a higher risk for developing asthma (McConnel et al., 2002).

1.3 AIR POLLUTION WITH OZONE

1.3.1 Definition and origin of ozone

Ozone (O_3) is a pale blue gas which is at a molecular level a molecule, composed of three oxygen atoms (Agencija Republike Slovenije za okolje, 2012a).

Ozone can be found in two layers of Earth's atmosphere – in the stratosphere (the stratospheric ozone) and in the troposphere (the tropospheric or ground-level or surface ozone). The O_3 in the stratosphere protects life on Earth from the sun's harmful ultraviolet radiation. On the contrary, the O_3 in the troposphere is a pollutant that poses a significant risk to human health, especially to health of children with asthma (U.S. Environmental Protection Agency, 2010). Formation of ozone in the stratosphere and troposphere is different:

- In the stratosphere O_3 is produced naturally by the process of photolysis of molecular oxygen (O_2) in which solar UV radiation of wavelength 240 nm and shorter breaks the O_2 bond and splits the molecule into two single oxygen atoms (Kupchella & Hyland, 1992; Wardle et al., 1997; NASA Goddard Earth Sciences Data and Information Services Center, 2012) (Equation 1.1.):

$$O_2 + h\upsilon(\lambda \leq 240nm) \rightarrow 2O \qquad \textbf{Equation 1.1}$$

  The free oxygen atoms can then combine with O_2 to form O_3 molecules:

$$O + O_2 \rightarrow O_3 \qquad \textbf{Equation 1.2}$$

- In the troposphere O_3 is not due to direct emissions, but is a secondary pollutant,. It is produced in a complex series of chemical reactions of its precursors, the primary pollutants (Kupchella & Hyland, 1992; Wardle et al., 1997). The source of highly reactive atomic oxygen (O) necessary for formation of O_3 is different than in stratosphere. Shortwave UV rays that cause splitting of the O_2 molecules in the stratosphere do not reach lower air masses in the troposphere. Nitrogen dioxide (NO_2) very effectively absorbs UV light that reaches the earth's surface, causing photolysis of NO_2 to nitric oxide (NO) and oxygen (O) (Equation 1.3).

$$NO_2 + h\upsilon(\lambda \leq 430nm) \rightarrow NO + O$$ **Equation 1.3**

Atomic oxygen (O) reacts with O_2 and forms O_3 (Equation 1.4):

$$O + O_2 \rightarrow O_3$$ **Equation 1.4**

Furthermore, NO produced by the initial photolysis reaction can react with O_3 and cause a reversion to NO_2 and O_2 (Equation 1.5)

$$NO + O_3 \rightarrow NO_2 + O_2$$ **Equation 1.5**

However, NO can revert to NO_2 by additional pathways, either by events that consume NO (e.g. the reaction of NO with atmospheric peroxides RO_2) (Equation 1.6), or enhance the production of NO_2 (Equation 1.7) (World Health Organization, Regional Office for Europe, 2006):

$$NO + RO_2 \rightarrow NO_2 + RO$$ **Equation 1.6**

$$2NO + O_2 \rightarrow 2NO_2$$ **Equation 1.7**

Both of these reactions prevent O_3 from reacting with NO and lead to accumulation of O_3 (Kupchella and Hyland 1992; World Health Organization, Regional Office for Europe, 2006). The result is photochemical pollution. In fact, the reaction of NO with atmospheric peroxides is the main cause of disturbance of the photochemical equilibrium. Atmospheric peroxides are formed by the oxidation of non-methane volatile organic compounds (VOCs). The concentration of ozone in troposphere depends on several factors, among which are sunshine intensity, concentrations of NO and VOCs, and the ratio of VOCs to NO (World Health Organization, Regional Office for Europe, 2006).

Surface ozone is a pollutant of growing concern in Europe (Amann et al., 2008).

1.3.2 Health effects of ozone

It has long been known that both, long-term exposure to higher concentrations of ozone and high peak exposure to ozone, is associated with increased adverse health effects, ranging from minor effects on the respiratory system to premature mortality (Gouveia et al., 2000; Galan et al., 2003; Babin et al., 2007; Myers et al., 2007; Lin et al., 2008a; Lin et al., 2008b). The most well known are (Commitee of the Environmental and Occupational Health Assembly of the American Thoracic Society, 1996; World Health Organization, Regional Office for Europe, 2005b; Diette et al., 2008; Amann et al., 2008):

- Inflammation of respiratory airways,
- Increased airway reactivity,
- Increased respiratory symptoms,
- Decreased lung function,
- Decreased exercise capacity,
- Increased medication use,
- Increased emergency room visits/hospitalizations, and
- Increased mortality.

Exposure to ozone can also make people more susceptible to respiratory infections and can aggravate pre-existing respiratory diseases - for example it can increase the risk of asthma exacerbation (Diette et al., 2008). Ozone can also cause irreversible changes in lung structure (Lippmann, 1989; World Health Organization, Regional Office for Europe, 2005b; Amann et al., 2008; Fortuol et al., 2011).

1.3.3 Exposure of human beings to ozone

Exposure to ozone is widespread. Since ozone is especially likely to reach unhealthy levels on hot sunny days in urban environments (European Environment Agency, 2007; Amann et al., 2008; U.S. Environmental Protection Agency, 2010), the most exposed are urban populations. However, unfortunately exposure is not necessarily very different for people living in rural areas (Bailey and Solomon, 2004), since ozone in the troposphere can also be transported long distances by wind (Amann et al., 2008). Even mountainous areas can experience high ozone levels.

1.4 REGULATIONS RELATING TO OZONE IN EUROPE AND SLOVENIA TO PROTECT PEOPLE'S HEALTH

Based on various scientific studies worldwide the World Health Organization (WHO) issues recommendations on appropriate air quality that do not cause adverse effects on health (Agencija Republike Slovenije za okolje, 2012a). Based on these recommendations, countries impose limits, target, long-term, warning and alert thresholds for concentrations of individual pollutants. The European Community in this regard issued on May 21, 2008, the Directive 2008/50/EC of the European Parliament and the Council of the European Union on ambient air quality and cleaner air for Europe (European Parliament and the Council of the European Union, 2008).

The requirements of the Directive 2008/50/EC are transposed in Slovenia's legal system in two legal documents:

- The Regulations on Ambient Air Quality (Vlada republike Slovenije, 2011), and
- The Rules on assessing ambient air quality (Ministrstvo za okolje in prostor Republike Slovenije, 2011).

These documents specify several different demarcation values for human beings: the limit value, target value, information threshold, alert threshold, and long-term objective of ozone concentrations in Slovenia (Vlada republike Slovenije, 2011; Ministrstvo za okolje in prostor Republike Slovenije, 2011, Šömen Joksić & Krek, 2008; European Parliament and the Council of the European Union, 2008):

- The "limit value" is defined as the level fixed on the basis of scientific knowledge, with the aim of avoiding, preventing or reducing harmful effects on human health and/or the environment as a whole, to be attained within a given period and not to be exceeded once attained,

- The “target value” is defined as the level fixed with the aim of avoiding, preventing or reducing harmful effects on human health and/or the environment as a whole, to be attained where possible over a given period,
- The “long-term objective” is defined as the level to be attained in the long term, save where not achievable through proportionate measures, with the aim of providing effective protection of human health and the environment.
- The “information threshold” is defined as the level beyond which there is a risk to human health from brief exposure for particularly sensitive sections of the population and for which immediate and appropriate information is necessary,
- The “alert threshold” is defined as the a level beyond which there is a risk to human health from brief exposure for the population as a whole and at which immediate steps are to be taken,

They also provide a way of measuring, quality assurance measurements, number of locations and information and reporting on the results of measurements.

According to above mentioned regulations these values for ozone in Slovenia are:

- The information threshold value for a one-hour average - 180 $\mu g/m^3$,
- The alert threshold for a one-hour average - 240 $\mu g/m^3$,
- The target value for maximum 8-hour average - 120 $\mu g/m^3$,

According to WHO guidelines the target value for maximum 8-hour average is even lower as defined in Directive 2008/50/EC (European Parliament and the Council of the European Union, 2008). Its value is set to 100 $\mu g/m^3$ (World Health Organization, 2006). This level provides, according to WHO, adequate protection of public health, though some health effects may occur below this level. Consequently, WHO also defines the baseline level value for maximum 8-hour average which is set to 70 $\mu g/m^3$ (the estimated background ozone level) (World Health Organization, 2006). Above this baseline level time-series studies indicate an increase in daily mortality in the range of 0.3–0.5% for every 10 $\mu g/m^3$ increment in 8-hour ozone concentrations (World Health Organization, 2006).

1.5 KOPER MUNICIPALITY AND AIR POLLUTION

In Slovenia, the Koper Municipality is considered as one of areas with a higher ozone air pollution. In fact in Slovenia the highest ozone concentrations occur in Primorska region

(Koper Municipality is a part of this region), especially in the situations when the wind blows from the south or south-west direction, what reflects the transfer of ozone across the border from Italy (Bolte, 2009; Agencija Republike Slovenije za okolje, 2012a).

The results of outdoor air quality measurements fot the Koper Municipality in the past have shown that, at least in summer months, the burdening through ozone is considerable in this area (Uršič et al., 2000; Agencija Republike Slovenije za okolje, 2005a; Agencija Republike Slovenije za okolje, 2005b; Planinšek, 2010). On many occasions the interim target for daily maximum 8-hour mean exceeded the national legally defined maximum value. Numerous exceedings of acceptable immission concentrations were discovered; with those in northeast part Dekani, showing exceedings of interim target for daily maximum 8-hour mean even on two occasions in one day. The measurements also pointed out the problem of air pollution with volatile organic compounds in that same area (Uršič et al., 2000). The latest report of the Slovenian Environment Agency (SEA) indicates that the Koper Municipality is highly charged with ozone pollution (Planinšek, 2010). This kind of air pollution is the problem in the entire southwest part of Slovenia (SI4 Region according to the SEA), which is located adjacent to industrial areas in northern Italy, which are the major source of air pollution, so this region is more sensitive to the cross-border transport of air pollution. In this area there operate three measurement stations – Nova Gorica, Koper and Otlica. The latest is intended to measure the ozone transport from Italy (predominantly from Padan Plain). In the period 2005-2009 PM_{10} concentration exceeded the upper assessment threshold in the Nova Gorica and Koper measurement stations. In some years the limit value in Nova Gorica was even exceeded. The upper assessment threshold was exceeded in the Koper Municipality (Planinšek, 2010). Concentrations of ozone in the area are the highest in Slovenia and in the period 2005-2009 they exceeded the target value in all three measurement locations of the SI4 Region (Planinšek, 2010). This is also supported by the measurements of the Regional Institute of Public Health Koper (Krek, 2007; Šömen Joksić et al., 2008; Šömen Joksić et al., 2011). Specific areas were evaluated for air quality due to ozone pollution based on passive sampling. The lowest concentrations were present along the coast and in locations burdened with traffic. Medium-high concentrations were present at higher elevations and in the interior of the land, while the highest were present in particular in higher elevations with characteristics of atmosphere opened towards the sea, and in locations that are not burdened with traffic (Šömen Joksić et al., 2008). In recent years, the evidence on the relationship between respiratory diseases in children and air pollution in the Koper Municipality accumulate (Eržen et al., 2003; Erlih and Eržen, 2010, Eržen et al., 2010). However, none of these studies has tried to link routine environmental and routine health data yet. Only one study has so far tried to link mortality data of total population, and air pollution with ozone (Šömen Joksić et al., 2011).

The problem was also perceived by the residents of Koper Municipality. In relation to air quality at the beginning of the second millennium there were many comments and warnings of residents, especially residents of some western and northern parts, describing episodes of heavy environmental pollution. They described the particular pollution by emissions with a distinct odour, dust and at the same time some health problems, which have occurred in people who were exposed to this perceived increase air pollution. They have been especially concerned about the high rate of respiratory diseases among population (Eržen et al., 2003). As a result, the authorities of Koper Municipality decided already 10 years ago to order the first study entitled »Examining the impact of the environment on the occurrence of certain diseases and increased mortality in the population of the Koper Municipality«, to tackle this problem, and which would give the first answers to these open questions (Eržen et al., 2003).

1.6 METHODS FOR STUDYING THE ASSOCIATION BETWEEN ENVIRONMENTAL AND HEALTH DATA

The so called "linkage methods for environment and health analysis" were proposed more than a decade ago by the World Health Organization (Briggs et al., 1996; Corvalan et al., 1997). The methodology was up to now used in several studies (Ostro et al., 1999; Galan et al., 2003; Lin et al., 2008a; Castro et al., 2007; Nastos et al., 2010; Giovannini et al., 2010; Wong et al., 2006; Lin et al., 2008b; Hajat et al., 2002). Temporal (time-series studies) as well as geographical patterns (geographical studies) of association between environmental and health data could be explored by these methods. From the epidemiological point of view these studies are known as ecological studies (Morgenstern, 1982; Walter, 1991; Morgenstern & Thomas, 1993; Morgenstern, 1998). Ecological studies are observational epidemiological studies that consider the characteristics of a disease and risk factors measured at the population level (Last, 2001; Bailey et al., 2005).

In a time-series studies, daily data are collected over a very short (i.e. 1-2 years) (Wong et al., 1999; Gouveia et al., 2000; Fusco et al., 2001; Neuberger et al., 2004; Moshammer et al., 2006; Vigotti et al., 2007; Ostro et al., 2007), short (i.e. 3-5 years or more) (Castellsague et al., 1995; Stedman et al., 1997; Gwynn et al., 2000; Hagen et al., 2000; Braga et al., 2001; Hajat et al., 2002; Galan et al., 2003; Zhang et al., 2006; Babin et al., 2007; Myers et al., 2007; Neuberger et al., 2007; Fraga et al., 2011), or longer (i.e. 6 years or longer) (Stieb et al., 1996; Vigotti et al., 1996; Burnett et al., 2001; Peel et al., 2005; Lee et al., 2006; Strickland et al., 2010) time periods. In exploring the ozone, some studies have been restricted to warm season of the year (e.g. April or May to September) because it was found that summer data produce the most significant association for ozone (Stieb et al. 1996; Stedman et al., 1997; Myers et al., 2007; Fraga et al., 2011). Limiting the period of observation to warm season of the year has the advantage of some factors being standardized in this way (e.g. influenza epidemic) (Fraga et al., 2011).

End points (observed outcomes) of public health interest could be consultations in emergency rooms or primary health care facilities (Castellsague et al., 1995; Stieb et al., 1996; Galan et al., 2003; Babin et al., 2007; Vigotti et al., 2007; Strickland et al., 2010; Fraga et al., 2011), hospital admissions (Katsouyanni et al., 1995; Vigotti et al., 1996; Anderson et al., 1997; Stedman et al., 1997; Wong et al., 1999; Gouveia et al., 2000; Gwynn et al., 2000; Hagen et al., 2000; Braga et al., 2001; Burnett et al., 2001; Fusco et al., 2001; Hajat et al., 2002; Lee et al., 2006; Myers et al., 2007; Ostro et al., 2007) or deaths (Spix et al., 1993; Katsouyanni et al., 1995; Vigotti et al., 1996; Gwynn et al., 2000; Conceicao et al., 2001; Gryparis et al., 2004; Zhang et al., 2006; Ostro et al., 2007; Neuberger et al., 2007) due to diseases in interest.

These responses are then usually explored/modelled by regression methods, more precisely by generalized linear models (GLMs) (Ren & Tong, 2008; De Souza Tadano et al., 2012), which are a union of linear and non-linear models, including Poisson and logistic regression models (Gouveia et al., 2000; Braga et al., 2001; Galan et al., 2003; Babin et al., 2007; Myers et al., 2007; Strickland et al., 2010), where one or more explanatory/confounding variables include air pollution, meteorology, and seasonality.

The air pollution variable of interest can be modelled either linearly or nonlinearly, using a variety of lags. In ozone studies, the explanatory variable of interest could be the 24-h average concentration (Katsouyanni et al., 1995; Stieb et al., 1996; Wong et al., 1999; Gwynn et al., 2000; Hagen et al., 2000; Braga et al., 2001; Conceicao et al., 2001; Fusco et al., 2001; Hajat et al., 2002; Ostro et al., 2007; Fraga et al., 2011), maximum 8-h average (Anderson et al., 1997; Stedman et al., 1997; Galan et al., 2003; Gryparis et al., 2004; Peel et al., 2005; Lee et al., 2006; Zhang et al., 2006;Babin et al., 2007; Strickland et al., 2010;), or maximum 1-h average (Castellsague et al., 1995; Katsouyanni et al., 1995; Anderson et al., 1997; Gouveia et al., 2000; Burnett et al., 2001; Gryparis et al., 2004; Myers et al., 2007), or several of them (Katsouyanni et al., 1995, Anderson et al., 1997; Gryparis et al., 2004, Myers et al., 2007). Observed lags could be 0 (current day's ozone is used as a predictor of current day's observed outcome) to 1 or 2 days (Katsouyanni et al., 1995; Burnett et al., 2001; Conceicao et al., 2001; Gryparis et al., 2004), or 3 up to 7 days (Castellsague et al., 1995; Stieb et al., 1996; Anderson et al., 1997; Wong et al., 1999; Gwynn et al., 2000; Braga et al., 2001; Fusco et al., 2001; Gryparis et al., 2004; Peel et al., 2005; Lee et al., 2006; Zhang et al., 2006; Myers et al., 2007; Ostro et al., 2007; Strickland et al., 2010). Some studies studied even more distant lags (Fraga et al., 2011).

The air pollution variable of interest is explored on its own or (much more frequently) in conjunction with other pollutants (co-pollutants). In the case of ozone studies among co-pollutants are mostly PM_{10}, NO_2, SO_2, and CO (Katsouyanni et al., 1995; Stieb et al., 1996; Anderson et al., 1997; Wong et al., 1999; Gouveia et al., 2000; Gwynn et al., 2000; Hagen et al., 2000; Braga et al., 2001; Burnett et al., 2001; Conceicao et al., 2001; Fusco et al., 2001; Hajat et al., 2002; Galan et al., 2003; Gryparis et al., 2004; Peel et al., 2005; Lee et al., 2006; Zhang et al., 2006; Neuberger et al., 2007; Strickland et al., 2010; Fraga et al., 2011). In some studies also pollen is included (Hajat et al., 2002; Galan et al., 2003; Babin et al., 2007; Strickland et al., 2010), and in some studies, in which longer time periods were observed, influenza epidemics (Spix et al., 1993; Katsouyanni et al., 1995; Vigotti et al., 1996; Anderson et al., 1997; Stedman et al., 1997; Hagen et al., 2000; Fusco et al., 2001; Lee et al., 2006; Neuberger et al., 2007; Vigotti et al., 2007).

Meteorology is modelled through a variety of different approaches. In ozone studies most often temperature and relative humidity are included (Spix et al., 1993; Stieb et al., 1996; Vigotti et al., 1996; Castellsague et al., 1995; Katsouyanni et al., 1995, Anderson et al., 1997; Stedman et al., 1997; Wong et al., 1999; Gouveia et al., 2000; Gwynn et al., 2000; Hagen et al., 2000; Braga et al., 2001; Burnett et al., 2001; Conceicao et al., 2001; Fusco et al., 2001; Hajat et al., 2002; Galan et al., 2003; Neuberger et al., 2004; Peel et al., 2005; Lee et al., 2006; Zhang et al., 2006; Neuberger et al., 2007; Vigotti et al., 2007; Fraga et al., 2011), while the wind parameters are rarely included (Katsouyanni et al., 1995).

Important potential confounding factors that may bias time series studies of air pollution in relation to morbidity or mortality are factors which vary on shorter or longer timescales. On shorter timescales important confounding factor could be calendar specific days (e.g. days of the week or holidays) (Lipfert, 1993; De Souza Tadano et al., 2012). For example, on weekends the number of hospital admissions could be lower than on weekdays and can also be lower during holidays. Weekly cycles may be expected in traffic related air pollutants or in those pollutants related to local industrial sources that operate with reduced emissions on weekends. Majority of ozone and other pollutant studies include days of the week and/or holidays as confounding factors (Katsouyanni et al., 1995; Vigotti et al., 1996; Anderson et al., 1997; Stedman et al., 1997; Gouveia et al., 2000; Gwynn et al., 2000; Hagen et al., 2000; Braga et al., 2001; Burnett et al., 2001; Fusco et al., 2001; Hajat et al., 2002; Gryparis et al., 2004; Neuberger et al., 2004; Lee et al., 2006; Neuberger et al., 2007; Ostro et al., 2007; Vigotti et al., 2007). In those studies studying the phenomena over several years throughout the year also confounding factors varying on longer timescales are added as confounders (e.g. season) (Katsouyanni et al., 1995; Anderson et al., 1997; Gouveia et al., 2000; Gwynn et al., 2000; Burnett et al., 2001; Conceicao et al., 2001; Galan et al., 2003; Gryparis et al., 2004; Peel et al., 2005; Zhang et al., 2006; Babin et al., 2007; Ostro et al., 2007).

Although ozone is a pollutant of growing concern in Europe (Amann et al., 2008), there have been performed so far relatively few time-series studies assessing the effects of current European surface ozone levels on children and adolescents' respiratory morbidity. Those that exist have been mainly conducted in large urban areas, and the estimated effects tend to be relatively small in magnitude (Fraga et al., 2011).

In Slovenia, this methodology has not yet been very extensively used so far as well. One of the first studies of this type in Slovenia was conducted in the Nova Gorica region in 2007/2008 (Šimac, 2008).

2 AIM AND OBJECTIVES

The aim of the proposed study was to assess the feasibility of linkage of existing health and environmental data in Slovenia in the case of the Koper Municipality in identifying the grounded need for public health action.

The overall objective was to assess the association between visits/consultations to the primary health care unit (the Community Health Centre Koper) due to respiratory diseases, and daily ozone concentrations in children from the Koper Municipality. Specific goals were:

1. To show the temporal variability of the occurrence of respiratory diseases in the study area,
2. To show the temporal variability of the ozone concentrations in the study area, and
3. To estimate the relationship between respiratory disease visits/consultations to the primary health care unit in the observed population group, and the level of ozone concentration in the study area on the population level as a model for evidence-based design and implementation of cross-sectoral policies on the environment and health (evidence-based public health).

The main hypothesis was that an increased number of consultations for respiratory diseases in children in the Koper Municipality are associated with increased outdoor air concentrations of ozone.

3 MATERIALS AND METHODS

3.1 DESIGN OF THE STUDY

The study design was ecological time-trend study design (Morgenstern, 1982; Walter, 1991). The unit of observation was a single day of the observed period.

3.2 PERIODS OF OBSERVATION

Since the study was primarily interested in the association of ground-level ozone levels with respiratory diseases, especially with asthma-related medical consultations, the yearly study periods were restricted to the periods April 1 through October 31, when ozone concentrations in the observed area are the highest. Initially it was planned that this period would be observed only for the year 2011. In order for the results to be more reliable, the observation was extended to the year 2010. The data were thus obtained for the periods April 1 to October 31, 2010, and April 1 to October 31, 2011. Altogether, 428 days were observed (214 in the year 2010, and 214 in the year 2011).

3.3 STUDY AREA

The Koper Municipality is one out of 212 municipalities, and one out of 11 city municipalities in Slovenia. It is located in the south-west coastal region of Slovenia (Figure 3.1). In the north it borders Italy, and in the south Croatia (the length of borders: 124 km). In the northwest it borders the Adriatic Sea (the length of the coast: 17,6 km) (Mestna občina Koper, 2012). Due to the historical events it has a strong Italian minority. Consequently, the Municipality is bilingual.

The Municipality covers about 311 km^2, and it is ranked on the seventh place according its territory among the Slovenian municipalities. It is located between 0 (the sea level) and 1028 m (Mount Slavnik) of altitude. The entire territory is administratively divided into 23 local communities (Figure 3.2) (Mestna občina Koper, 2012).

Figure 3.1: The location of the Koper Municipality (KM) within other municipalities of Slovenia.

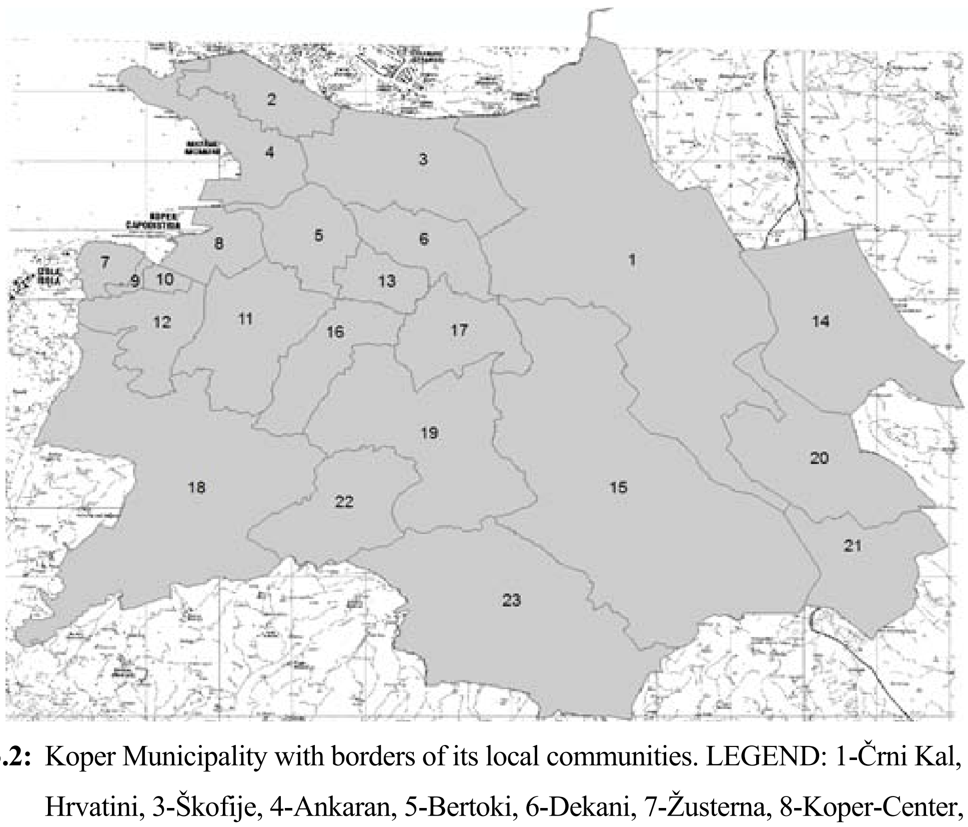

Figure 3.2: Koper Municipality with borders of its local communities. LEGEND: 1-Črni Kal, 2-Hrvatini, 3-Škofije, 4-Ankaran, 5-Bertoki, 6-Dekani, 7-Žusterna, 8-Koper-Center, 9-Za Gradom, 10-Semedela, 11-Škocjan, 12-Prisoje-Olmo, 13-Pobegi Čezarji, 14-Podgorje, 15-Gračišče, 16-Vanganel, 17-Sv. Anton, 18-Šmarje, 19-Marezige, 20-Zazid, 21-Rakitovec, 22-Boršt, and 23-Gradin.

At the end of 2008, the Municipality had approximately 51,300 residents (about 25,400 men and 25,900 women), and it was ranked according to its population on the fourth place among the Slovenian municipalities. There lived about 160 inhabitants per km^2 of the municipal area on average. Thus the density was greater than in Slovenia on average (100 inhabitants per km2) (Mestna občina Koper, 2012).

The climate is typically Mediterranean with mild winters and warm dry summers – the average summer temperature is 23.1 °C, while the average winter temperature is 2.3 °C. There is on average about 100 sunny and about 110 rainy days per year (Mestna občina Koper, 2012).

The main city is the city of Koper, with a population of about 23,500. It lies approximately five kilometres south of the border with Italy and 12 kilometres southwest of the Port of Trieste in Italy.

One of two largest economy branches in the Koper Municipality is transport with Port of Koper, one of the main connections between the markets of Central and Southeast Europe and the Mediterranean Sea (Port of Koper, 2012), in the central position. The second is tourism. In the region, a quarter of all overnight stays in the country were generated in 2009. Unfortunately, a side-effect of both branches is heavy traffic, especially from late spring to early autumn.

3.4 STUDY POPULATION

The study population was all children, aged 0-12 years, residing permanently (July 1, 2010: 5,965; July 1, 2011: 6,163) (Statistični urad Republike Slovenije, SI-STAT podatkovni portal, 2012), or temporarily (as tourists) in the Koper Municipality in the observed periods, who visited the Community Health Centre Koper (CHCK) for any respiratory symptom.

3.5 HEALTH DATA

Health data were obtained from health information systems of the CHCK for the periods April 1 to October 31, 2010 and April 1 to October 31, 2011.

CHCK is a health institution providing primary health care in Koper Municipality. In Slovenia, this level of health care is traditionally still mainly delivered through community health centres, which include services such as general practice, paediatrics, medicine for school children and adolescents, occupational medicine, pulmonary care, gynaecology, and dentistry. The rules of compulsory health care insurance entitle patients to select their own physician in primary health. The personal physicians for children in urban areas and in some small towns are paediatricians or school medicine specialists. Personal physicians represent the entrance point to the health system (gatekeeper). With his/her referral, the patient may enter the secondary and tertiary care (Albreht et al., 2009). CHCK provides primary health care at the primary level for most of inhabitants of Koper Municipality (Zdravstveni dom Koper, 2012). The visits/consultations could be in principles due to a newly discovered diagnosis, or acute exacerbation of chronic disease (first visits), due to the further consideration of the known (chronic) disease, which is not in the stage of acute deterioration (follow-up visits), or telephone or electronic consultations, re-prescription of drugs in chronic patients with a stable medical condition, issuing referrals for follow-up examination/consultation by a specialist, etc. (short visit). For the purpose of this study only first visits were considered.

The first visits/consultations of the following selected diagnoses according to the WHO International Classification of Diseases, version 10 (ICD-10) (World Health Organization, 2011) were observed:

- J00-J06 (acute upper respiratory tract infection),
- J10-J18 (influenza and pneumonia),
- J20-J22 (other acute lower respiratory tract infection),
- J30-J32 (other diseases of upper respiratory tract),
- J40-J46 (chronic lower respiratory tract disease).

The information gathered was:

- the number of children aged 0-12 years who for the first time visited CHCK due to all respiratory symptoms by day in the observed periods,
- the number of children aged 0-12 years who for the first time visited CHCK due to asthma symptoms by day in the observed periods.

3.6 ENVIRONMENTAL DATA

3.6.1 Data from the national automated network for monitoring air quality of the Republic of Slovenia

Data on the concentration of air pollutants in the smallest possible time interval were obtained from the measuring station in Koper/Markovec (located in the local community Žusterna), which is part of the fixed stations of the national automated network for monitoring air quality of the Republic of Slovenia, operated by the SEA for the periods April 1 to October 31, 2010, and April 1 to October 31, 2011. Figure 3.3 presents the location of the station. From this measurement station the following information was obtained:

- O_3 concentration (in µg/m^3),
- PM_{10} concentration (in µg/m^3),
- NO_2 concentration (in µg/m^3),
- meteorological parameters:
  - air temperature (in ºC),
  - relative humidity (as %),
  - wind direction (in angle degrees) and speed (m/s).

O_3, PM_{10}, and NO_2 concentrations were measured in accordance with the Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe with standard methods (Table 3.1) (European Parliament and the Council of the European Union, 2008).

Table 3.1: Methods used for determining concentrations of selected air pollutants at the Environment Agency of the Republic of Slovenia measuring station Markovec in the Koper Municipality.

Parameter	Standard	Method
O_3	SIST EN 14625:2005	Ultraviolet photometry
PM_{10}	SIST EN 12341:2000	Gravimetric
NO_2	SIST EN 1412:2005	Chemolumeniscence

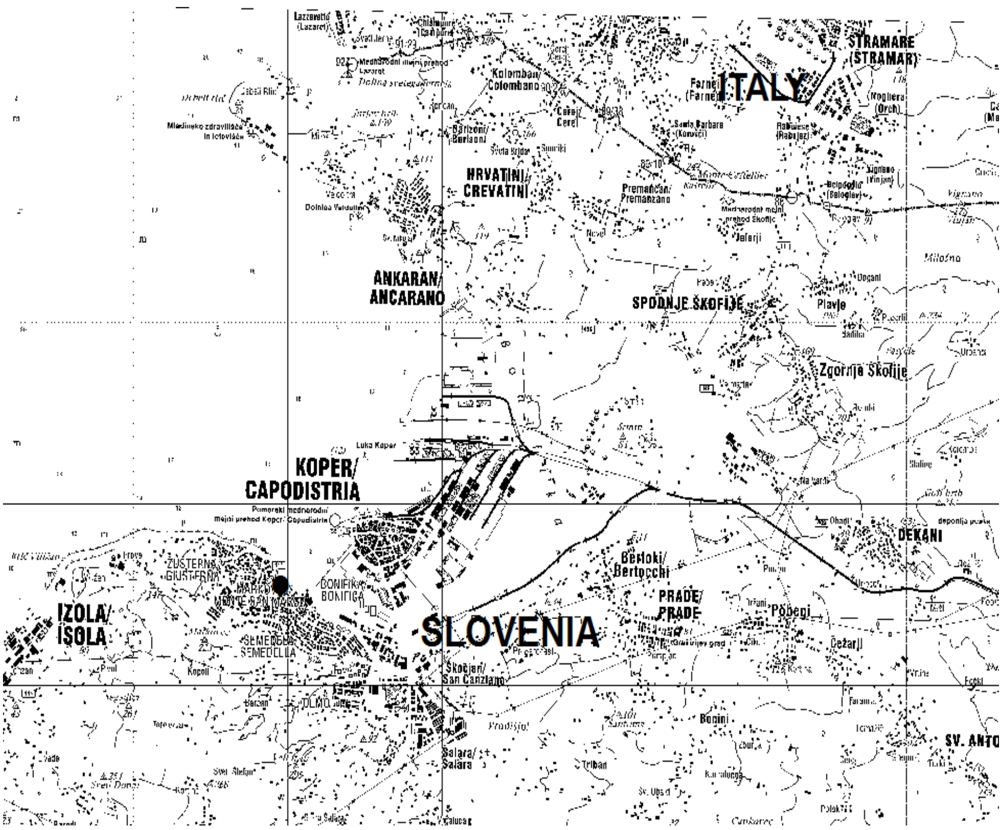

Figure 3.3: Location of the Environment Agency of the Republic of Slovenia measuring station Markovec in the Koper Municipality (●).

3.6.2 Data on pollen concentration from the Public Health Institute of the Republic of Slovenia

Data on pollen concentration (grains of pollen/m^3 over a 24-hr period) of different alergogenic plants (ragweed, wormwood, birch, hornbeam/hop hornbeam, chestnut, cypress family, beech, ash, olive tree, pine tree, plantain, plain tree, grass family, poplar, oak, willow, and nettle family) were obtained from the Public Health Institute of the Republic of Slovenia database (Inštitut za varovanje zdravja Republike Slovenije, 2012). The data were available for the measuring station in Koper only for the year 2010.

3.7 STATISTICAL METHODS

3.7.1 Variables in the analysis

3.7.1.1 Observed outcomes

Three health outcomes were considered:

1. A numerical indicator on the number of first consultations for all respiratory diseases (this indicator was used in description as well as in modelling),
2. A numerical indicator on the number of first consultations due to asthma symptoms (this indicator was only used in description),
3. A binary indicator as to whether or not any first consultation during a day were due to asthma-related symptoms, since the number of daily consultations due to asthma-related symptoms was small (this indicator was used in description as well as in modelling).

3.7.1.2 Explanatory factor

Ozone data were originally provided on an hourly basis (1-hr average in $\mu g/m^3$). The values were observed as provided; four other indicators, used in other similar studies, were designed as well:

1. A numerical indicator on 24-hr average.

   The indicator was calculated as the average of the 24 hourly values covering the period from the midnight of the day-1 to the midnight of the day n. When aggregating data and calculating statistical parameters the 75% criteria was used for checking validity (Vlada republike Slovenije, 2011), i.e. minimal number of valid data was 18 hourly averages per day.

2. A numerical indicator on daily maximum 8-hr average.

   Firstly, the 8-hr running averaged value for each hour was calculated as the average of the values for that hour and the 7 foregoing hours (averaging period) (e.g. the averaging period of hour 1 of day n was hour 17 of day n-1 until hour 1 of day n, and the averaging period of hour 24 of day n was hour 16 of day n until hour 24 of day n). When aggregating data the 75% criteria was used for checking validity

(Vlada republike Slovenije, 2011; European Parliament and the Council of the European Union, 2008), i.e. minimal number of valid data was 6 hourly averages per each averaging period. The daily maximum 8-hr average concentration (maximum daily 8-hr average from hourly running 8-hr) for a given calendar day was afterwards determined as the highest of the 24 possible 8-hour averages computed for that day. When aggregating data and calculating statistical parameters the 75% criteria was used for checking validity (Vlada republike Slovenije, 2011; European Parliament and the Council of the European Union, 2008), i.e. minimal number of valid data was 18 hourly running 8-hr averages.

3. A binary indicator as to whether or not daily maximum 8-hr average achieved or exceeded the according to WHO 8-hour average baseline level for maximum 8-hour average of 70 μg/m^3 (the estimated background ozone level) (World Health Organization, 2006).
4. A binary indicator as to whether or not daily maximum 8-hr average achieved or exceeded the 8-hr average target value for maximum 8-hour average of 120 μg/m^3 (World Health Organization, 2006),
5. A numerical indicator on daily maximum 1-hr average.

   At this level (hourly values) the data were provided by the SEA. When aggregating data and calculating statistical parameters SEA is obliged to use the 75% criteria for checking validity (Vlada republike Slovenije, 2011; European Parliament and the Council of the European Union, 2008), i.e. minimal number of valid data should be for 45 minutes per hour. The daily maximum 1-hr average concentration for a given calendar day was afterwards determined as the highest of the 24 possible 1-hour averages for that day.

In all ozone variables, lags of zero to five days from exposure to the consultation day (lag 0, lag 1, lag 2, lag 3, lag 4, and lag 5 days, respectively) were examined to determine the amount of time between exposure and effect. Since the environmental data were provided by the SEA only for the period of observation (April 1 to October 31, 2010, and April 1 to October 31, 2011), the lags were also determined for that period. This resulted in slightly shorter time series when lags were observed.

3.7.1.3 Covariates

Some important covariates/confounders were considered, as proposed for such kind of studies (De Souza Tadano et al., 2012):

1. Other pollutants:

    - A numerical indicator on 24-hr average concentration of PM_{10} (in µg/m^3). The indicator was calculated as the average of the 24 hourly values covering the period from the midnight of the day-1 to the midnight of the day n. When aggregating data and calculating statistical parameters the 75% criteria was used for checking validity (Vlada republike Slovenije, 2011), i.e. minimal number of valid data was 18 hourly averages per day.

    - A numerical indicator on 24-hr average concentration of NO_2 (in µg/m^3). The indicator was calculated as the average of the 24 hourly values covering the period from the midnight of the day-1 to the midnight of the day n. When aggregating data and calculating statistical parameters the 75% criteria was used for checking validity (Vlada republike Slovenije, 2011), i.e. minimal number of valid data was 18 hourly averages per day.

    - A numerical indicator on 24-hr average pollen concentration of allergogenic plants (as number of grains/m^3). In the present study only the pollen concentration of very highly and highly allergogenic plants (birch, cypress family, grass family, olive tree, ragweed, and wormwood) was considered (Inštitut za varovanje zdravja Republike Slovenije, 2012). For the purpose of analysis, the number of pollen particles of all the above mentioned plants was merged to one numerical indicator.

    In PM_{10} and pollen concentration, lags of zero to five days from exposure to consultation day (lag 0, lag 1, lag 2, lag 3, lag 4, and lag 5 days, respectively) were examined to determine the amount of time between exposure and effect.

2. Meteorological factors:

    - A numerical indicator on 24-hr average temperature,
    - A numerical indicator on 24-hr average relative humidity,
    - A numerical indicator on 24-hr average wind direction. The indicator was transformed to a categorical indicator. The angle degrees were grouped as

follows: north: 0.1-22.5 and 337.6-360.0; north-east: 22.6-67.5; east: 67.6-112.5; south-east: 112.6-157.5; south: 157.6-202.5; south-west: 202.6-247.5; west: 247.6-292.5; north-west: 292.6-337.5) (this indicator was only used in description),

- A numerical indicator on 24-hr average wind speed (this indicator was only used in description),

3. Seasonal factors:

- A numerical indicator on the year of data collection,
- A binary indicator as to whether or not a single day is a workday or weekend day,
- A binary indicator as to whether or not a single day is a day of holidays (summer holidays and other work-free days).

Meteorological and seasonal factors were used in analysis, as proposed for such kind of studies (De Souza Tadano et al., 2012), as background covariates.

3.7.2 Methods of data description

3.7.2.1 Description of distributions

The distributions of values of count outcome variables for health data were presented by bar charts and described by non-parametric typical statistical values (Min, Max, and 25th, 50th and 75th percentiles), since these distributions were highly skewed.

The distributions of values of other numerical variables were presented by histograms and described by parametric and non-parametric typical statistical values (Mean, SD, Min, Max, and 25th, 50th and 75th percentiles). In highly skewed distribution of pollen only non-parametric typical statistical values (Min, Max, and 25th, 50th and 75th percentiles) were used.

The distributions in binary data were presented by frequency distribution tables.

3.7.2.2 Sequence plots

The changing trends over time were presented by using sequence plots (Morgenstern, 1982; Walter, 1991; Morgenstern and Thomas, 1993). On graphs presenting time trends of ozone indicators, demarcation values for human beings defined in the legislation or recommended by WHO were added as reference lines:

- Ozone - target value for maximum 8-hour average of 120 μg/m^3 (Vlada republike Slovenije, 2011; European Parliament and the Council of the European Union, 2008),
- Ozone - baseline level for maximum 8-hour average of 70 μg/m^3 (the estimated background ozone level) (World Health Organization, 2006),
- Ozone – information threshold for 1-hour average of 180 μg/m^3 (Vlada republike Slovenije, 2011; European Parliament and the Council of the European Union, 2008).

3.7.2.3 Wind and pollution roses

The distribution of wind direction (the percentage of the days the wind blew from north, north-east, east, south-east, south, south-west, west or north-west directions during the observation period) and the distribution of wind speed as a function of wind direction was presented by using the wind rose (Franek & DeRose, 2003).

The pollution rose was constructed to indicate the frequency of measured or predicted levels of ozone as observed pollutant, as a function of wind direction (Franek & DeRose, 2003).

3.7.3 Methods of relationship analysis

3.7.3.1 Univariate analysis

Univariate relationship analysis was performed only as simple univariate correlation analysis between explanatory (O_3) and other pollution factors, and between other pollution factors. The analysis was performed by using Pearson or Spearman correlation method (whenever pollen was involved in analysis). Results are presented as a part of description of data.

3.7.3.2 Multivariate analysis

Multivariate association between observed outcomes and a particular form of explanatory variable was analysed by using Poisson and logistic regression models, both frequently used in epidemiology (Parodi and Bottarelli, 2006; Szklo and Nieto, 2007; Verma, 2009), including environmental epidemiology (Myers et al., 2007; De Souza Tadano et al., 2012). Both methods are members of a family of generalized linear models (Coxe et al., 2009).

1. The number of consultations due to all respiratory diseases was modelled using Poisson regression (Vittinghoff et al., 2005; Parodi and Bottarelli, 2006; Szklo and Nieto, 2007; Coxe et al., 2009; Verma, 2009; De Souza Tadano et al., 2012).

   Poisson regression is a regression technique used when the outcome is a count variable (Coxe et al., 2009; Verma, 2009) or a rate (Parodi and Bottarelli, 2006; Szklo and Nieto, 2007; Verma, 2009).

   When the outcome variable is a count variable this model is mathematically expressed as (Equation 3.1):

   $$\ln(\hat{\mu}) = \ln(count) = a + b_1 x_1 + b_2 x_2 + \ldots + b_n x_n$$ **Equation 3.1**

   In this equation $\hat{\mu}$ is the predicted count on the outcome variable given the specific values on predictors ($x_1, x_2, \ldots x_n$). The interpretation of regression coefficient for individual predictor b is that it is an increase in the *ln count* of the outcome variable per unit increase in the individual predictor adjusted for all other variables in the model. Antilogarithm of b is interpreted as ratio of counts, and is interpreted as an increase in the *count* of the outcome variable per unit increase in the individual predictor adjusted for all other variables in the model.

   When the outcome variable is a rate (e.g. counts/person-time) this model is mathematically expressed as (Equation 3.2):

   $$\ln(\lambda) = \ln(rate) = a + b_1 x_1 + b_2 x_2 + \ldots + b_n x_n$$ **Equation 3.2**

   In this equation λ is the predicted rate given the specific values on predictors ($x_1, x_2, \ldots x_n$). The interpretation of regression coefficient for individual predictor b is that it is an increase in the *ln rate* of the outcome variable per unit increase in the individual predictor adjusted for all other variables in the model. Antilogarithm of b is interpreted as ratio of rates (rate ratio or relative rate), and is interpreted as an increase in the *rate* of the outcome variable per unit increase in the individual predictor adjusted for all other variables in the model.

In computer programmes this end interpretable result of Poisson regression procedure is often generally referred as incidence rate ratio (IRR) (UCLA Academic Technology Services, Statistical Consulting Group, 2012b), regardless of whether the outcome variable is a count or a rate.

2. The binary indicator as to whether or not any consultations during a day were due to asthma-related symptoms was modelled using logistic regression (Hosmer and Lemeshow, 2000; Szklo and Nieto, 2007; Verma, 2009).

   Logistic regression is a regression technique used when the outcome is a categorical variable. When the outcome is a binary variable, as it is in the present study, the binary logistic regression is used. The model for multiple binary regression is mathematically expressed as (Equation 3.3):

$$\ln\left(\frac{p(x)}{1-p(x)}\right) = \ln(odds) = \operatorname{logit} = a + b_1 x_1 + b_2 x_2 + ... + b_n x_n$$ **Equation 3.3**

   In this equation $(p(x)/1-p(x))$ is the predicted *odds* (the ratio of the probability of an event's occurring to the probability of its not occurring) given the specific values on predictors ($x_1, x_2, ...x_n$). The interpretation of regression coefficient for individual predictor b is that it is an increase in the *ln odds* (*logit*) of the outcome variable per unit increase in the individual predictor adjusted for all other variables in the model. Antilogarithm of b is interpreted as ratio of odds (odds ratio or relative odds), and is interpreted as an increase in the *odds* of the outcome variable per unit increase in the individual predictor adjusted for all other variables in the model.

   In computer programmes this end interpretable result of logistic regression procedure is referred as odds ratio (OR) (UCLA Academic Technology Services, Statistical Consulting Group, 2012a; Hosmer and Lemeshow, 2000).

In both cases all forms of explanatory variable were examined. Also in both cases the same covariates/potential confounders were included to adjust for different effects. The modelling procedure was in both cases performed in two stages:

1. Uni-pollutant models.

   In the first stage, single pollutant models were obtained by adding the single exposure variable (all indicators on ozone, PM_{10}, NO_2, and pollen concentration) to a core covariate model that included all selected meteorological and seasonal factors (background covariates) considered in the study (temperature, relative humidity, year of data collection, workday or weekend day, holiday or not). These models were determined in order to obtain the best lag of exposure variable to be potentially included in the multi-pollutant model. In the process of determination, biological plausibility, e.g. the direction of relationship between the outcome and explanatory variable/covariate/confounding variable (only positive association was considered as sensible in terms of literature and acceptable to enter the multi-pollutant model), as well as statistical significance of this relationship, were considered. Results of all tests with a p-value of 0.05 or less were considered as statistically significant. However, a p-value 0.250 or less was considered acceptable for entering a variable into the multi-pollutant model (borderline significance) (Hosmer and Lemeshow, 2000).

2. Multi-pollutant models.

   In the second stage, models that included best lags of all pollutants considered in the study (ozone, PM_{10}, NO_2, and pollen concentration) as well as meteorological and seasonal factors were defined. Since the pollen concentrations were available only for the year 2010, two models were defined. The first model was the model without pollen concentration considered (the model was defined on data for both years of observation, 2010 and 2011). The second model was the model with pollen concentration included (the model was defined only on data for the year 2010).

   Direct and stepwise methods of building the models were used (Hosmer and Lemeshow, 2000). In the first step, the direct method with considering all the best variants and lags of the explanatory factor/covariates chosen in uni-pollutant models as suitable to enter the multi-pollutant model/models was applied. Afterwards, the stepwise method was applied to let the statistical programme itself choose the most important variables to enter the final multi-pollutant model. In the event that ozone was not chosen to be in the final model, this variable was forced to enter by using again the direct method of building the models.

3.7.4 Statistical software

For all statistical analyses SPSS (Statistical Package for the Social Sciences) for Windows Version 18.0 (SPSS Inc., Chicago, IL, USA), while for generation of figures SPSS, GIS (Geographic Information System) and Excel programs were used. The analyses, including generation of figures of location of Koper Municipality, were performed at the Chair of Public Health at Faculty of Medicine, University of Ljubljana.

3.8 ETHICAL CONSIDERATIONS

In the phase of the preparation and execution of the study as well as in the phase of data analysis, the criteria for maintaining the confidentiality of personal information according to the Personal Data Protection Act were taken into consideration. In the Community Health Centre Koper there was an appointed person responsible for the preparation of the data. All data were depersonalized and provided for use in analysis in aggregate form.

The study protocol was approved by the Ethical Committee of the Republic of Slovenia in 2012.

4 RESULTS

4.1 DATA DESCRIPTION

4.1.1 Number of consultations for respiratory diseases

4.1.1.1 Consultations for all respiratory tract diseases symptoms

In the analysis data for all 428 days were included.

The distribution of the number of daily consultations for all respiratory tract diseases is presented in Figure 4.1, while selected statistical typical values of this distribution are presented in Table 4.1.

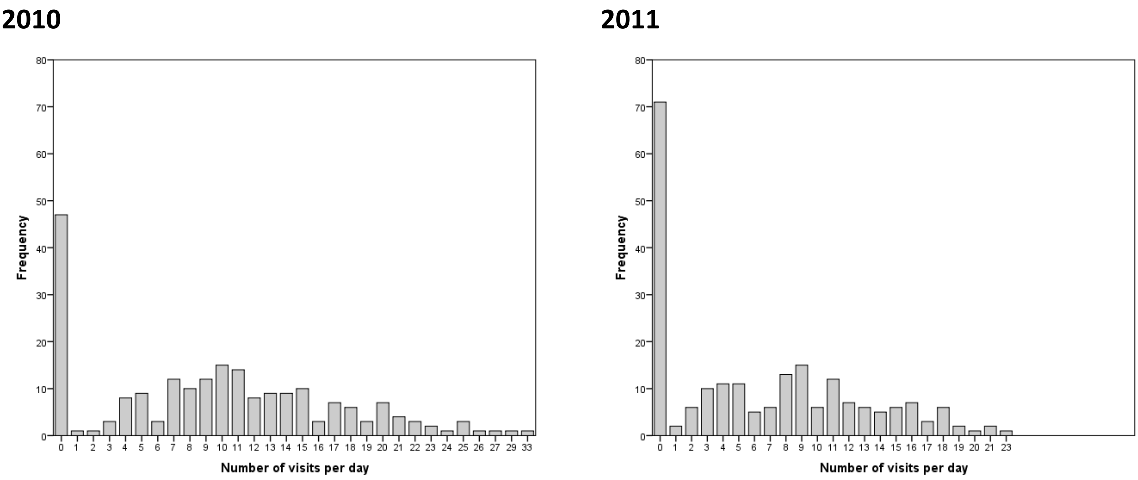

Figure 4.1: The distribution of the number of daily consultations for all respiratory tract diseases in children in the Koper Municipality, Slovenia, from April 1 to October 31, 2010, and April 1 to October 31, 2011.

Table 4.1: Selected statistical typical values of the distribution of the number of daily consultations for all respiratory tract diseases in children in the Koper Municipality, Slovenia, from April 1 to October 31, 2010, and April 1 to October 31, 2011.

		Percentiles			
Year	**Min**	**25th**	**50th**	**75th**	**Max**
2010	0	4	10	14.25	33
2011	0	0	5	11	23

In the year 2010 there were 47/214 (22.0%) days with no consultations for respiratory tract diseases while in the year 2011 there were 71/214 (33.2%) such days (Figure 4.1).

Altogether there were 3416 visits for all respiratory tract diseases in the observed period (2054 in 2010 and 1362 in 2011).

The temporal pattern of consultations for all respiratory tract diseases symptoms by day of study for both years is presented in Figure 4.2.

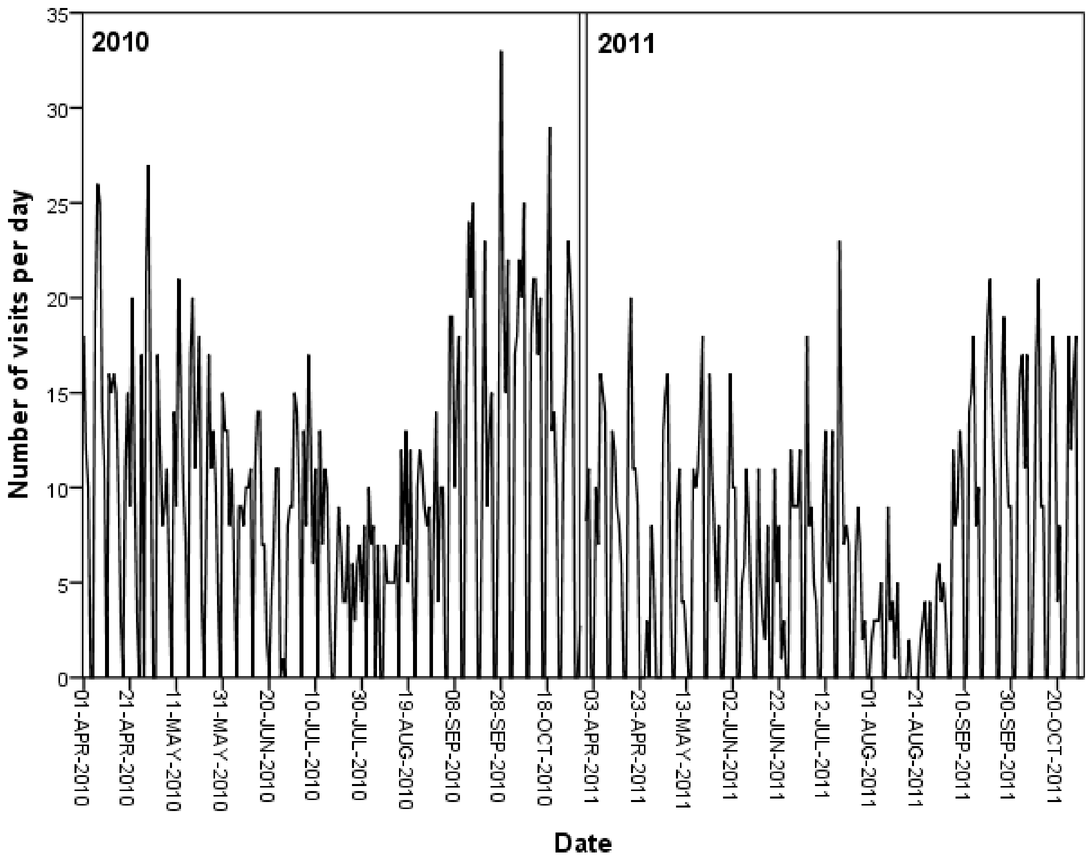

Figure 4.2: Temporal pattern of consultations for all respiratory tract diseases symptoms in children in the Koper Municipality, Slovenia, by day of study, from April 1 to October 31, 2010, and April 1 to October 31, 2011.

From Figure 4.2, it can be seen that the number of daily consultations for all respiratory tract diseases in 2010 was the highest in September and the lowest in the second part of July. In 2011, the number was the highest in September again, while the lowest was in August.

4.1.1.2 Consultations for asthma symptoms

In the analysis data for all 428 days were included.

The distribution of the number of daily consultations for asthma-related symptoms is presented in Figure 4.3, while selected statistical typical values of this distribution are presented in Table 4.2.

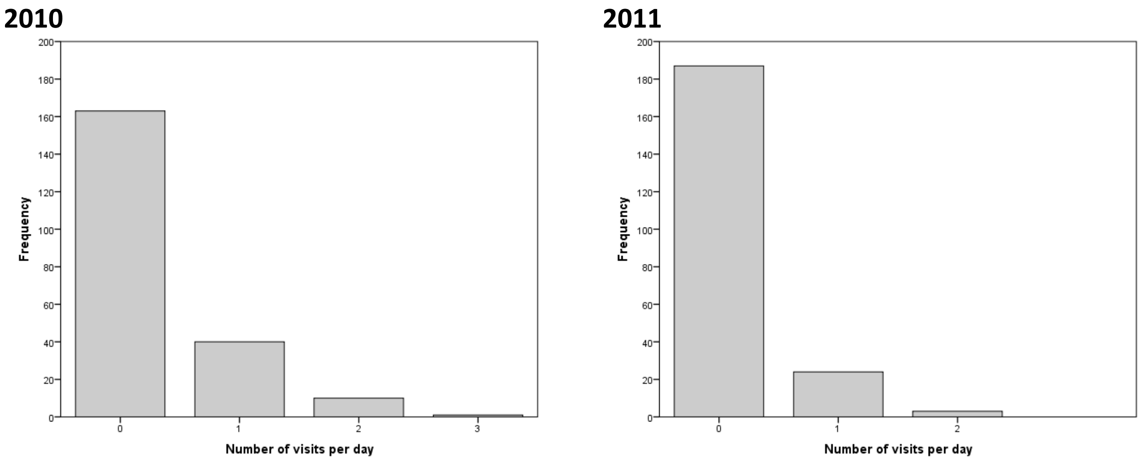

Figure 4.3: The distribution of the number of daily consultations for asthma-related symptoms in children in the Koper Municipality, Slovenia, from April 1 to October 31, 2010, and April 1 to October 31, 2011.

Table 4.2: Selected statistical typical values of the distribution of the number of daily consultations for asthma-related symptoms in children in the Koper Municipality, Slovenia, from April 1 to October 31, 2010, and April 1 to October 31, 2011.

		Percentiles			
Year	**Min**	**25th**	**50th**	**75th**	**Max**
2010	0	0	0	0	3
2011	0	0	0	0	2

In the year 2010 there were in total 163/214 (76.2%) days with no consultations for asthma-related symptoms and 51/214 with any consultation, while in the year 2011 there were in total 187/214 (87.4%) days with no consultations for asthma-related symptoms and 27/214 with any consultation (Figure 4.3).

Altogether there were 93 visits for asthma-related symptoms in the observed period (63 in 2010 and 30 in 2011).

The temporal pattern of consultations for asthma-related symptoms by day of study for both years is presented in Figure 4.4.

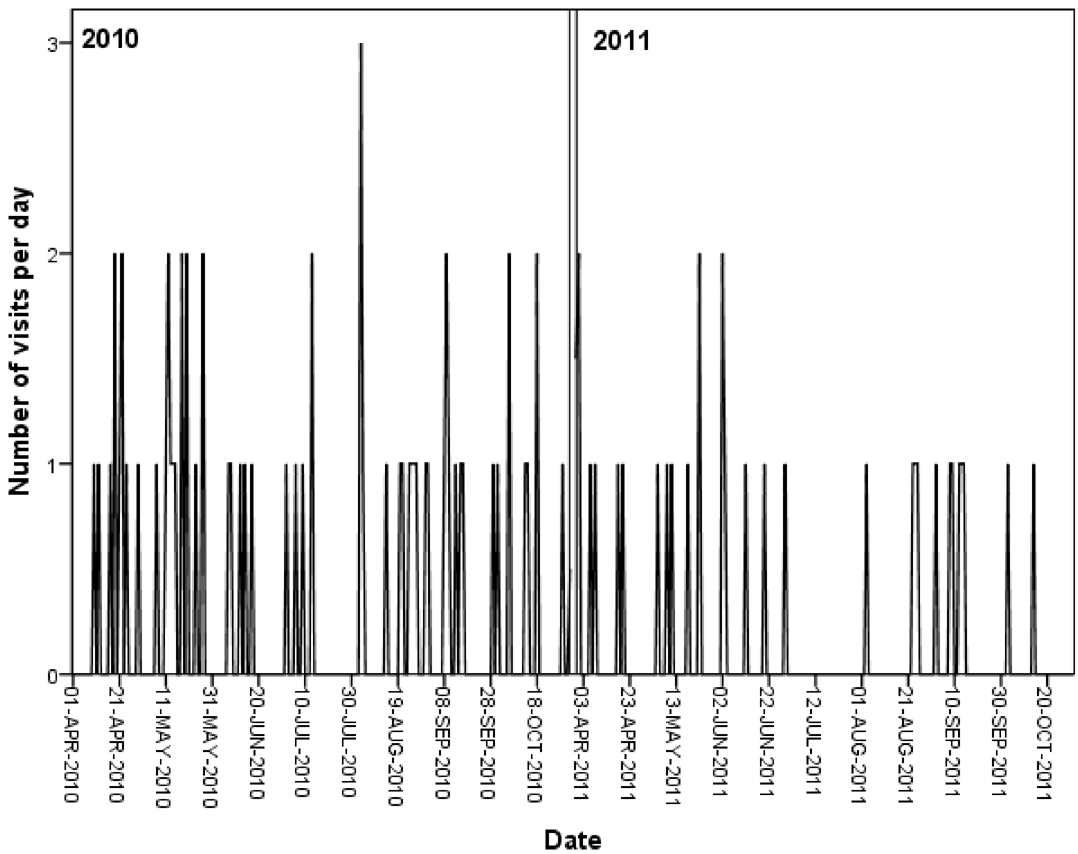

Figure 4.4: Temporal pattern of consultations for asthma-related symptoms in children in the Koper Municipality, Slovenia, by day of study, from April 1 to October 31, 2010, and April 1 to October 31, 2011.

From Figure 4.4, it can be seen that the number of daily consultations for asthma-related symptoms in 2010 was the highest in April and May, and the lowest in the second part of July. In 2011, the number was the highest in April and May, while it was the lowest in July.

4.1.2 Ozone

4.1.2.1 24-hr average concentration

In the analysis data for 424 days were included, 210 days from the year 2010 and 214 from 2011.

The distribution of the daily 24-hr average concentration of ozone (μg/m^3) is presented in Figure 4.5, while selected statistical typical values of this distribution are presented in Table 4.3.

2010 **2011**

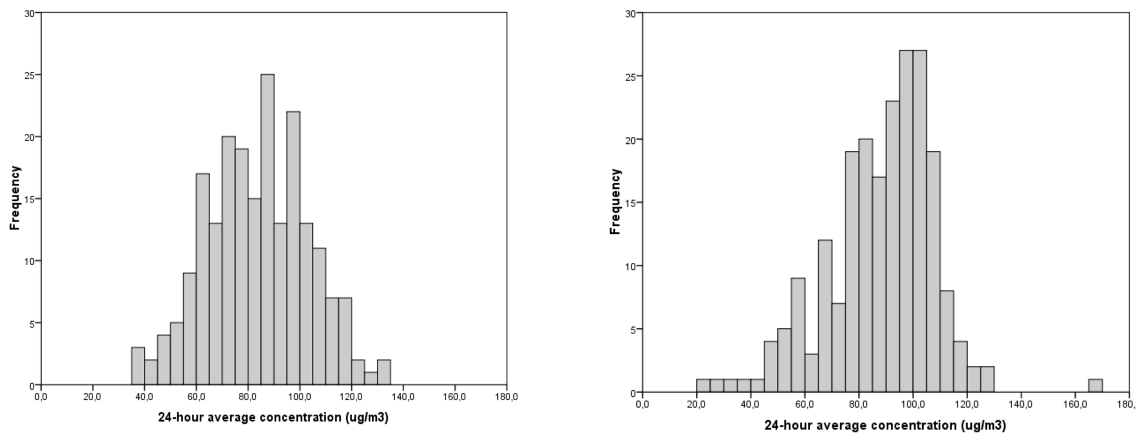

Figure 4.5: The distribution of the daily 24-hr average concentration of ozone (μg/m^3) in the Koper Municipality, Slovenia, from April 1 to October 31, 2010, and April 1 to October 31, 2011.

Table 4.3: Selected statistical typical values of the distribution of the daily 24-hr average concentration of ozone (μg/m^3) in the Koper Municipality, Slovenia, from April 1 to October 31, 2010, and April 1 to October 31, 2011.

				Percentiles			
Year	**Mean**	**SD**	**Min**	**25th**	**50th**	**75th**	**Max**
2010	83.39	19.58	37.30	93.56	83.65	97.90	132.20
2011	88.25	19.62	23.60	77.48	91.65	101.31	166.50

The temporal pattern of the daily 24-hr average concentration of ozone (μg/m^3) by day of study for both years is presented in Figure 4.6.

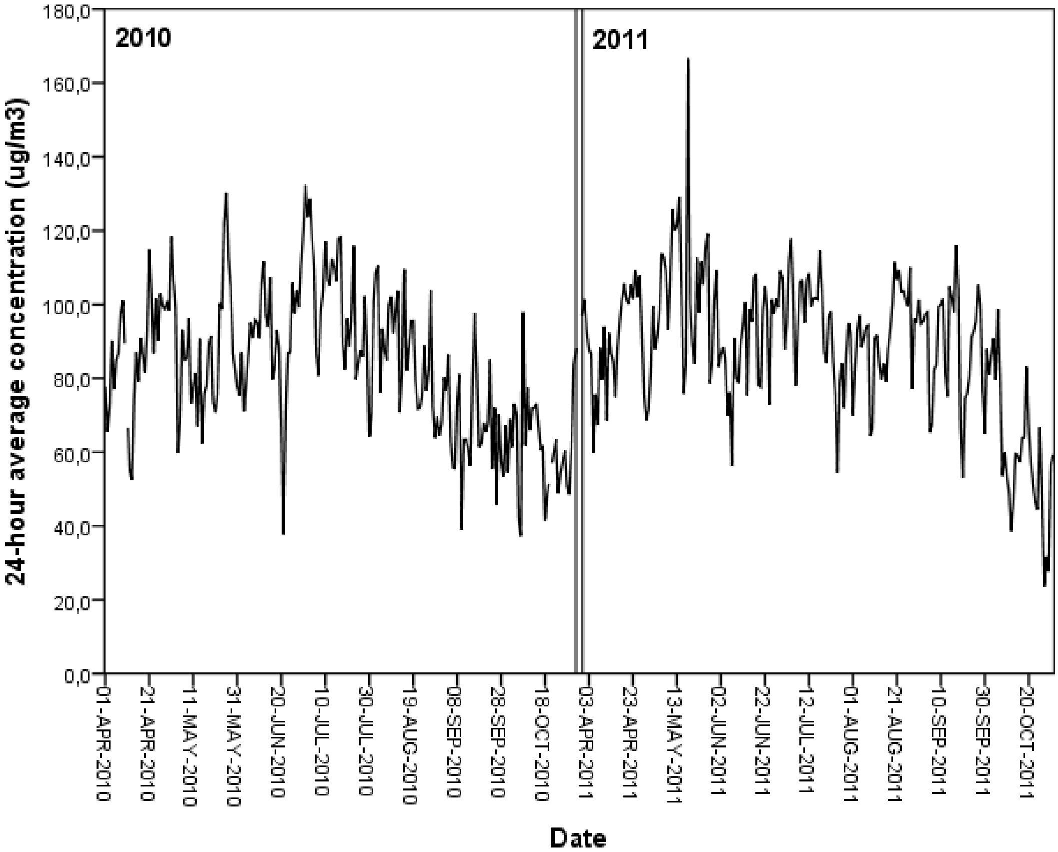

Figure 4.6: Temporal pattern of the daily 24-hr average concentration of ozone (µg/m^3) in the Koper Municipality, Slovenia, by day of study, from April 1 to October 31, 2010, and April 1 to October 31, 2011.

From Figure 4.6, it can be seen that the overall trend of daily 24-hr average concentration of ozone was upward from April to July, and then downward from July to October. In 2010, the concentration was the highest in the second part of June and the first part of July, and the lowest in the second part of October. In 2011, the concentration was the highest in May, while it was the lowest in October.

Correlation analysis between daily 24-hr average concentration of O_3 (µg/m^3) and PM_{10} 24-hr average concentrations (µg/m^3) showed only weak positive correlation (r=0.246). However, this correlation was statistically significant ($p \leq 0.001$).

4.1.2.2 Daily maximum 8-hr average concentration

In the analysis data for 423 days were included, 209 days from the year 2010 and 214 from 2011.

The distribution of the daily maximum 8-hr average concentration of ozone (μg/m^3) is presented in Figure 4.7, while selected statistical typical values of this distribution are presented in Table 4.4.

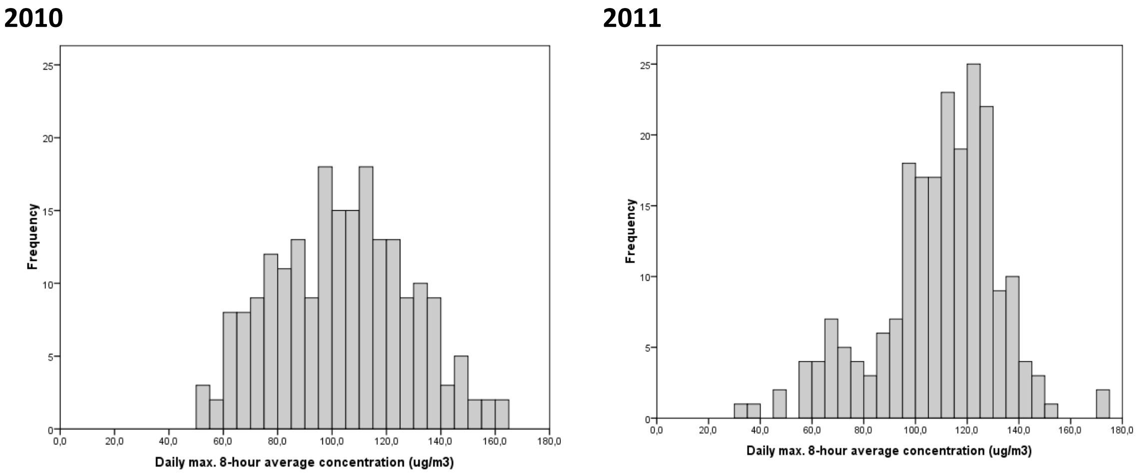

Figure 4.7: The distribution of the daily maximum 8-hr average concentration of ozone (μg/m^3) in the Koper Municipality, Slovenia, from April 1 to October 31, 2010, and April 1 to October 31, 2011.

Table 4.4: Selected statistical typical values of the distribution of the daily maximum 8-hr average concentration of ozone (μg/m^3) in the Koper Municipality, Slovenia, from April 1 to October 31, 2010, and April 1 to October 31, 2011.

				Percentiles			
Year	**Mean**	**SD**	**Min**	**25th**	**50th**	**75th**	**Max**
2010	103.47	24.69	52.20	84.72	103.83	121.52	161.60
2011	108.62	23.31	32.60	97.24	111.56	124.09	173.20

The temporal pattern of the daily maximum 8-hr average concentration of ozone by day of study for both years is presented in Figure 4.8. From this figure it can be seen that the overall trend of daily maximum 8-hr average concentration of ozone was upward from April to June or July, and then downward from June or July to October. In 2010 concentration was the highest in the second part of June and the first part of July and the lowest in the second part of October. In 2011 the concentration was the highest in the middle of May, while it was the lowest in October.

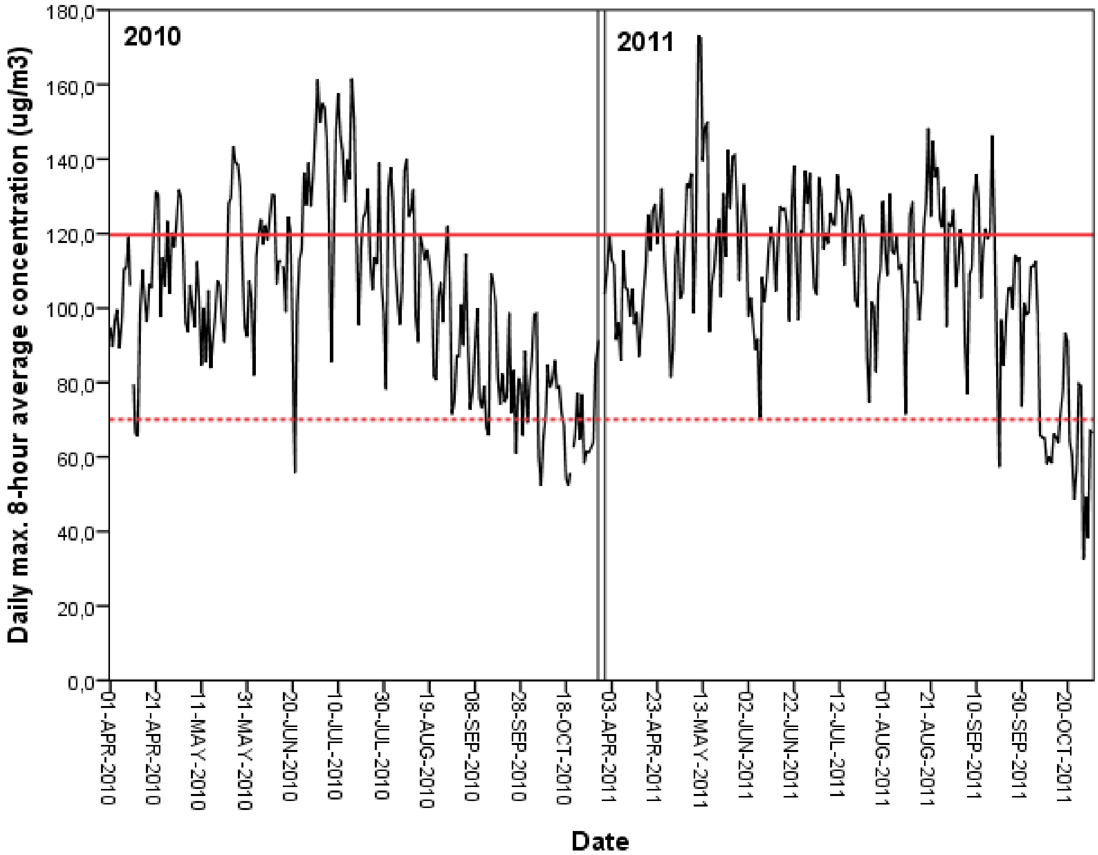

Figure 4.8: Temporal pattern of the daily maximum 8-hr average concentration of ozone (μg/m^3) in the Koper Municipality, Slovenia, by day of study, from April 1 to October 31, 2010, and April 1 to October 31, 2011. LEGEND: — = target value for maximum 8-hour average of 120 μg/m^3 (Vlada republike Slovenije, 2011; European Parliament and the Council of the European Union, 2008); - - - = baseline level for maximum 8-hour average of 70 μg/m^3 (the estimated background ozone level) (World Health Organization, 2006).

In the year 2010 there were in total 188/209 (90.0%) days in the observed period on which 8-hr average achieved or exceeded the WHO 8-hour average baseline level of 70 μg/m^3, while in 2011 there were 195/214 (91.1%) such days (Figure 4.8).

In the year 2010 there were in total 55/209 (26.3%) days in the observed period on which 8-hr average achieved or exceeded the 8-hr average target value of 120 μg/m^3, while in 2011 there were 76/214 (35.5%) such days (Figure 4.8).

4.1.2.3 Daily maximum 1-hr average concentration

In the analysis data for 424 days were included, 210 days from the year 2010 and 214 from 2011.

The distribution of the daily maximum 1-hr average concentration of ozone (μg/m^3) is presented in Figure 4.9, while selected statistical typical values of this distribution are presented in Table 4.5.

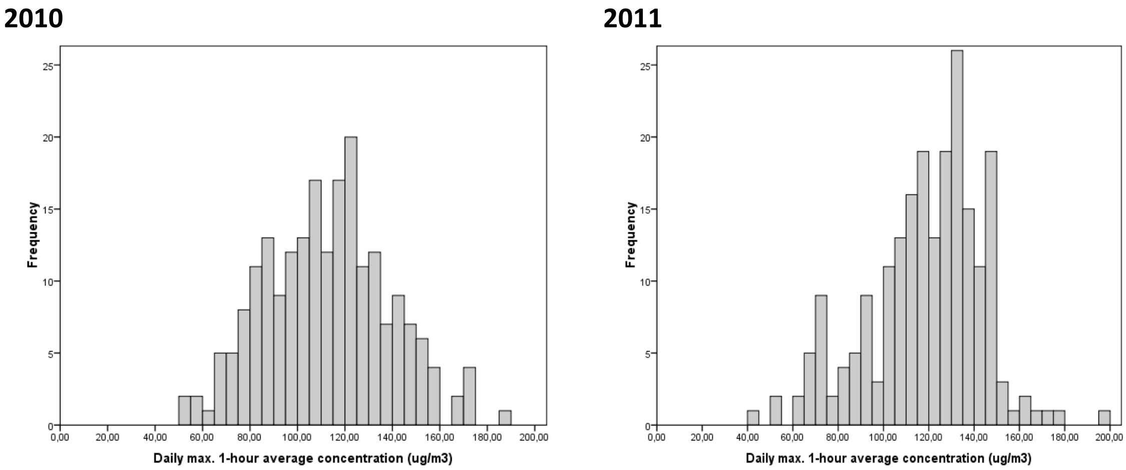

Figure 4.9: The distribution of the daily maximum 1-hr average concentration of ozone (μg/m^3) in the Koper Municipality, Slovenia, from April 1 to October 31, 2010, and April 1 to October 31, 2011.

Table 4.5: Selected statistical typical values of the distribution of the daily maximum 1-hr average concentration of ozone (μg/m^3) in the Koper Municipality, Slovenia, from April 1 to October 31, 2010, and April 1 to October 31, 2011.

				Percentiles			
Year	**Mean**	**SD**	**Min**	**25th**	**50th**	**75th**	**Max**
2010	112.29	26.31	50.10	93.56	113.23	129.10	189.55
2011	118.86	25.38	41.10	104.99	122.48	135.28	198.80

The temporal pattern of the daily maximum 1-hr average concentration of ozone by day of study for both years is presented in Figure 4.10. From this figure it can be seen that the overall trend of the daily maximum 1-hr average concentration of ozone was upward from April to July, and then downward from July to October. This trend was less explicit in

2011. In 2010, the concentration was the highest in the second part of June and the first part of July, and the lowest in the second part of October. In 2011, the concentration was the highest in May, while it was the lowest in October.

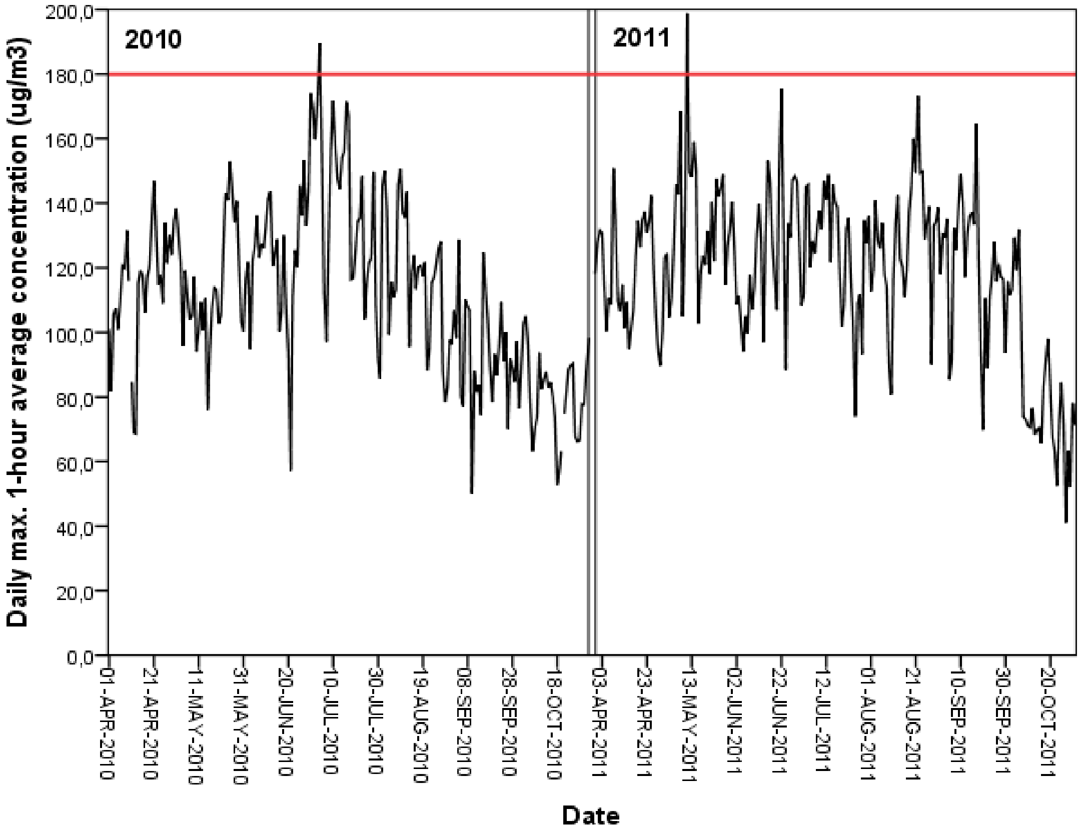

Figure 4.10: Temporal pattern of the daily maximum 1-hr average concentration of ozone (μg/m^3) in the Koper Municipality, Slovenia, by day of study, from April 1 to October 31, 2010, and April 1 to October 31, 2011. LEGEND: ─ = information threshold for 1-hour average of 180 μg/m^3 (Vlada republike Slovenije, 2011; European Parliament and the Council of the European Union, 2008).

In 2010 and 2011 the 1-hr average warning limit value of 180 μg/m^3 was exceeded on only one day (Figure 4.10).

4.1.3 Covariates

4.1.3.1 PM_{10} 24-hr average concentration

In the analysis, data for 411 days were included, 203 days from the year 2010 and 208 from 2011.

The distribution of PM_{10} 24-hr average concentration (μg/m^3) is presented in Figure 4.11, while selected statistical typical values of this distribution are presented in Table 4.6.

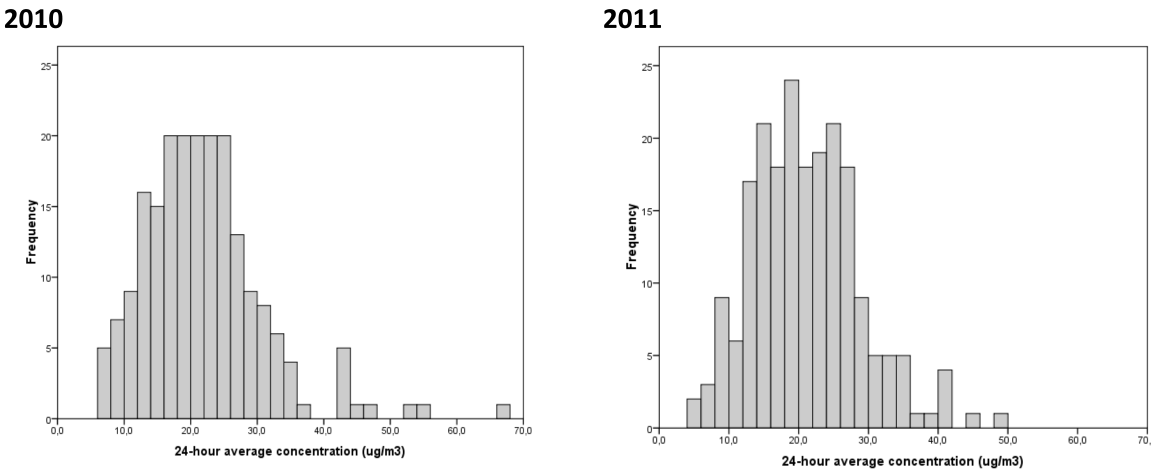

Figure 4.11: The distribution of the PM_{10} 24-hr average concentration (μg/m^3) in the Koper Municipality, Slovenia, from April 1 to October 31, 2010, and April 1 to October 31, 2011.

Table 4.6: Selected statistical typical values of the distribution of the PM_{10}-24-hr average concentration (μg/m^3) in the Koper Municipality, Slovenia, from April 1 to October 31, 2010, and April 1 to October 31, 2011.

				Percentiles			
Year	**Mean**	**SD**	**Min**	**25th**	**50th**	**75th**	**Max**
2010	21.830	9.1324	7.1	15.500	20.900	26.000	67.8
2011	21.110	7.7415	5.7	15.425	20.550	25.700	48.3

The temporal pattern of the PM_{10} 24-hr average concentration by day of study for both years is presented in Figure 4.12. From this figure it can be seen that the PM_{10} 24-hr average concentration in 2010 was the highest at the end of June, in the first part of July and at the beginning of October, and the lowest at the beginning of April. In 2011, hardly any temporal pattern could be seen.

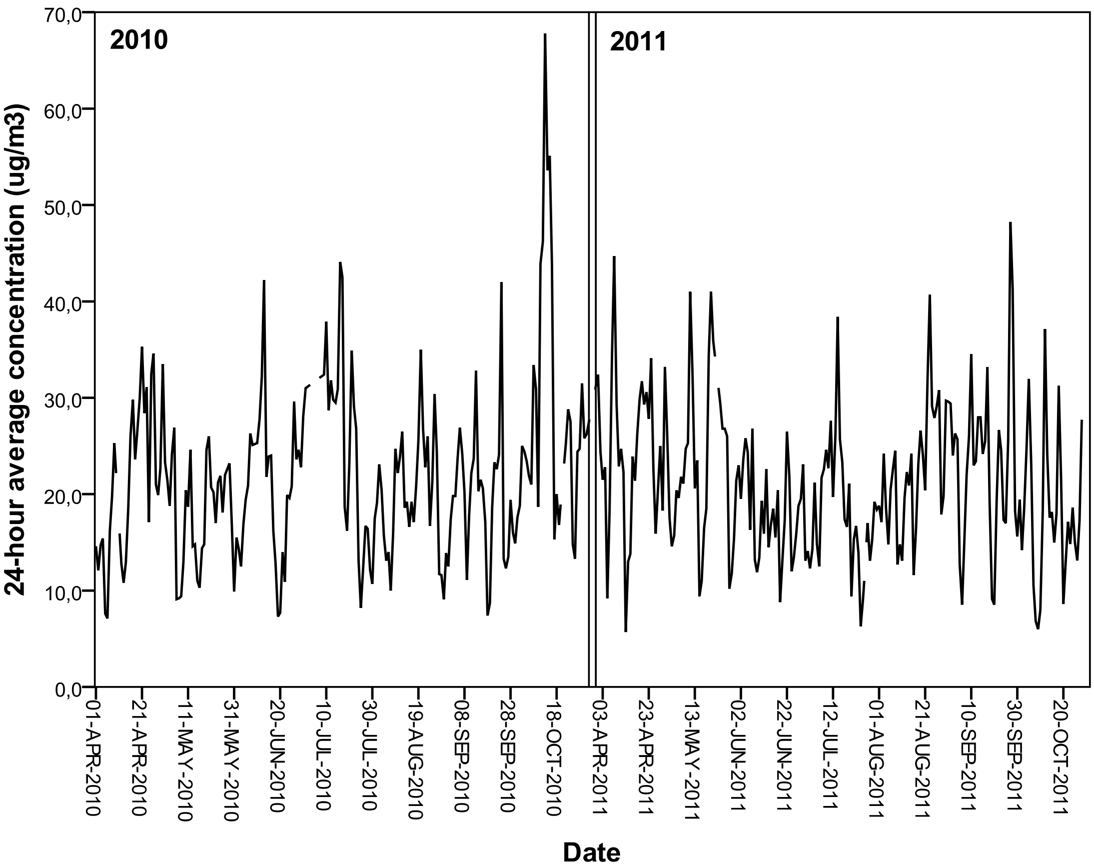

Figure 4.12: Temporal pattern of the PM_{10} 24-hr average concentration ($\mu g/m^3$) in the Koper Municipality, Slovenia, by day of study, from April 1 to October 31, 2010, and April 1 to October 31, 2011.

Correlation analysis between PM_{10} 24-hr average concentrations ($\mu g/m^3$) and daily 24-hr average concentration of O_3 ($\mu g/m^3$) showed only weak positive correlation ($r=0.246$). However, this correlation was statistically significant ($p\leq0.001$). Correlation analysis between PM_{10} 24-hr average concentrations ($\mu g/m^3$) and NO_2 24-hr average concentrations ($\mu g/m^3$) showed moderate positive correlation ($r=0.444$), which was statistically significant ($p\leq0.001$). Correlation analysis between PM_{10} 24-hr average concentrations ($\mu g/m^3$) and daily average pollen concentration (number of particles/m^3) showed weak positive correlation as well ($\rho=0.151$), which was also statistically significant ($p=0.032$).

4.1.3.2 NO_2 24-hr average concentration

In the analysis, data for 414 days were included, 203 days from the year 2010 and 211 from 2011.

The distribution of the NO_2 24-hr average concentration (μg/m^3) is presented in Figure 4.13, while selected statistical typical values of this distribution are presented in Table 4.7.

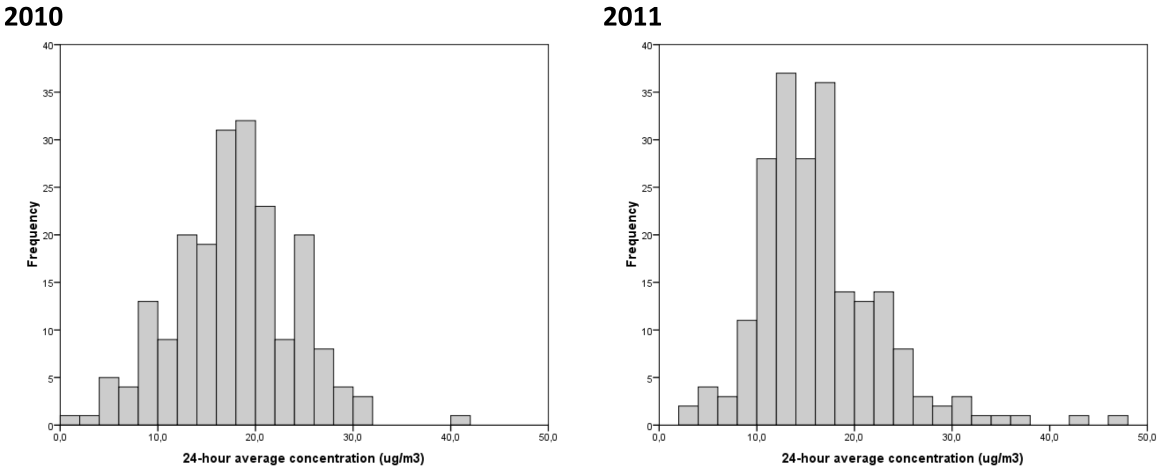

Figure 4.13: The distribution of the NO_2 24-hr average concentration (μg/m^3) in the Koper Municipality, Slovenia, from April 1 to October 31, 2010, and April 1 to October 31, 2011.

Table 4.7: Selected statistical typical values of the distribution of the NO_2 24-hr average concentration (μg/m^3) in the Koper Municipality, Slovenia, from April 1 to October 31, 2010, and April 1 to October 31, 2011.

				Percentiles			
Year	**Mean**	**SD**	**Min**	**25th**	**50th**	**75th**	**Max**
2010	17.711	6.0554	1.9	13.600	17.800	21.400	41.6
2011	16.324	6.3990	2.8	12.300	15.324	19.500	46.7

The temporal pattern of the NO_2 24-hr average concentration by day of study for both years is presented in Figure 4.14.

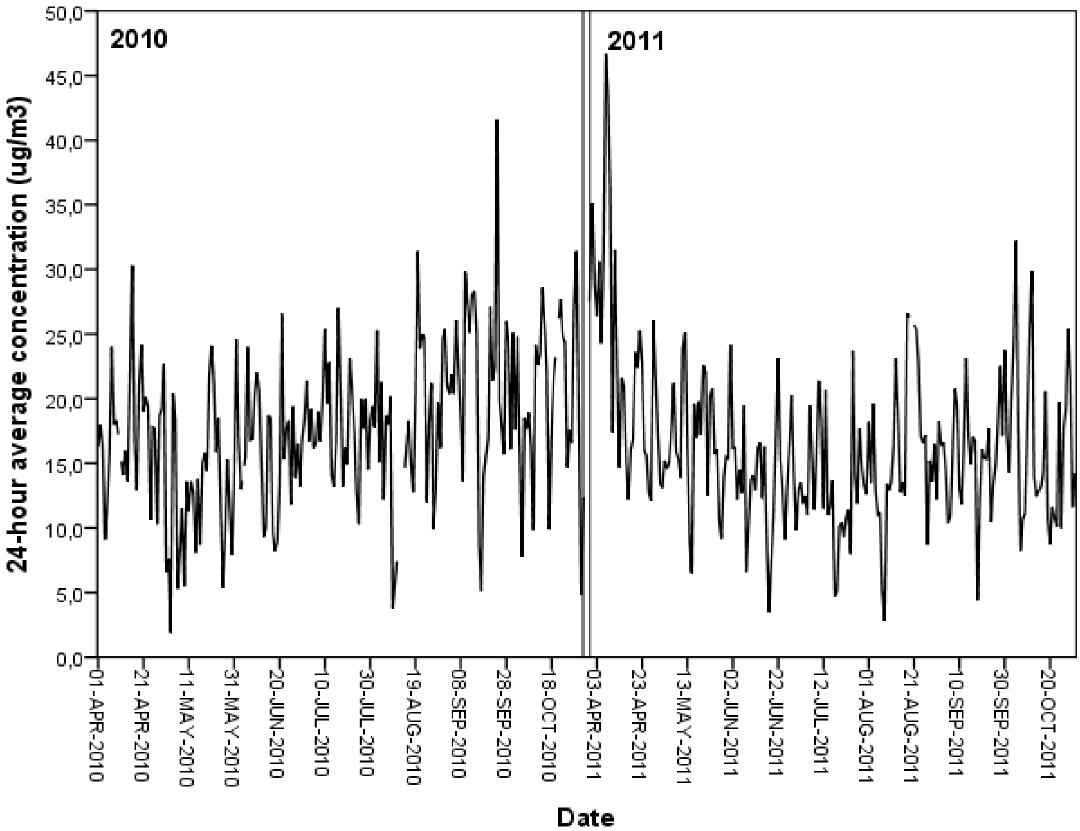

Figure 4.14: Temporal pattern of the NO_2 24-hr average concentration (μg/m^3) in the Koper Municipality, Slovenia, by day of study, from April 1 to October 31, 2010, and April 1 to October 31, 2011.

From Figure 4.14, it can be seen that the NO_2 24-hr average concentration in 2010 was the highest in the middle of September and the lowest at the end of May. In 2011, the concentration was the highest in the first part of April, while it was the lowest in the first part of August.

Correlation analysis between NO_2 24-hr average concentrations (μg/m^3) and daily 24-hr average concentration of O_3 (μg/m^3) showed only weak negative correlation ($r=-0.234$). However, this correlation was statistically significant ($p\leq0.001$). Correlation analysis between NO_2 24-hr average concentrations (μg/m^3) and PM_{10} 24-hr average concentrations (μg/m^3) showed moderate positive correlation ($r=0.444$), which was statistically significant ($p\leq0.001$).

4.1.3.3 Daily average pollen concentration

In the analysis, only data for 214 days from the year 2010 were included.

The distribution of the daily average pollen concentration (number of particles/m^3) is presented in Figure 4.15, while selected statistical typical values of this distribution are presented in Table 4.8.

2010 **2011**

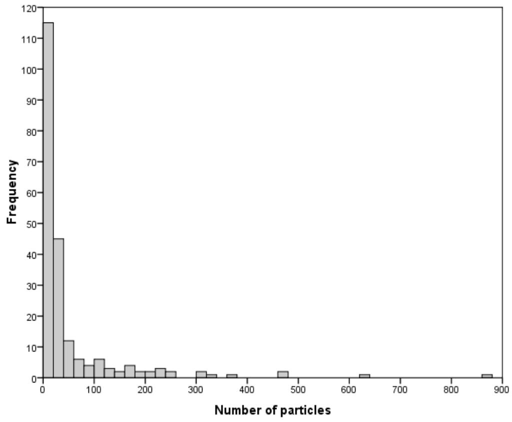

Figure 4.15: The distribution of the number of daily average pollen concentration (number of particles/m^3) in the Koper Municipality, Slovenia, from April 1 to October 31, 2010.

Table 4.8: Selected statistical typical values of the distribution of the daily average pollen concentration (number of particles/m^3) in the Koper Municipality, Slovenia, from April 1 to October 31, 2010.

Year	Min	Percentiles			Max
		25th	**50th**	**75th**	
2010	0	6	16	42	860
2011	/	/	/	/	/

For the total observed period the total count of pollen particles/m^3 was 11,192.

The temporal pattern of the daily average pollen concentration by day of study for the year 2010 is presented in Figure 4.16.

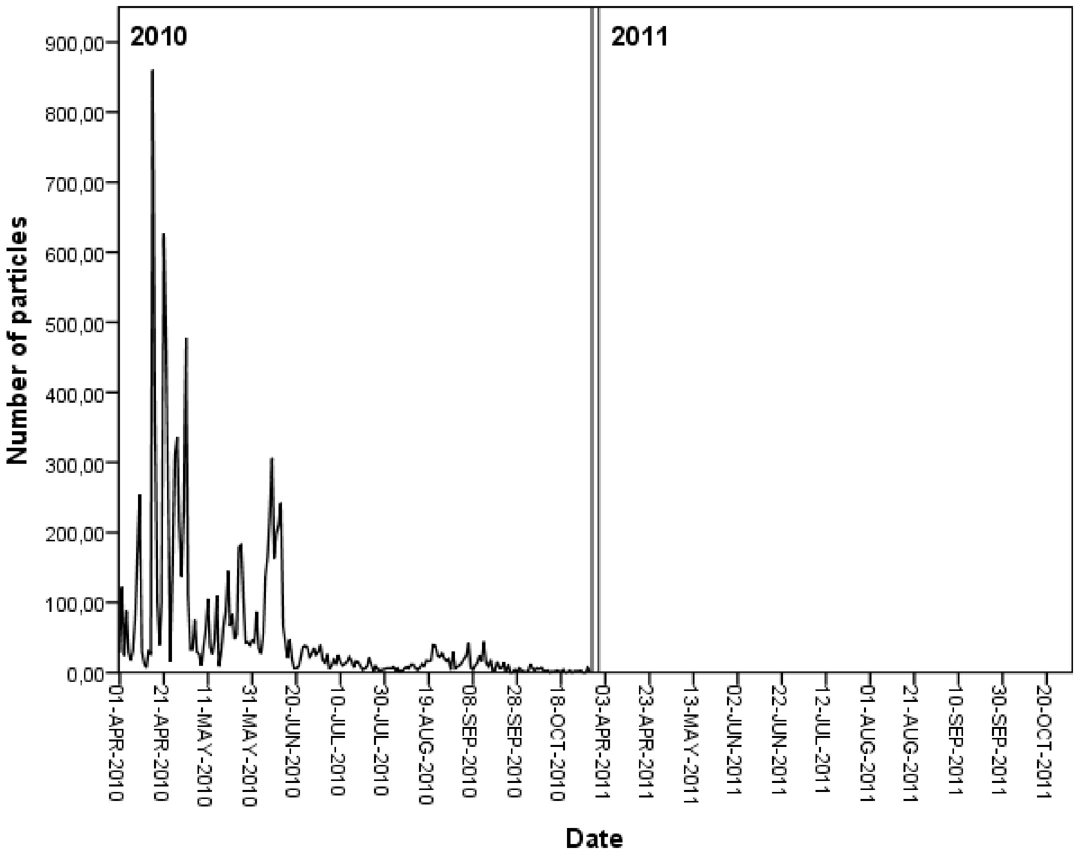

Figure 4.16: Temporal pattern of the daily average pollen concentration (number of particles/m^3) in the Koper Municipality, Slovenia, by day of study, from April 1 to October 31, 2010.

From Figure 4.16 it can be seen that the daily average pollen concentration in 2010 was the highest in April (45.9% of total count of pollen grains), precisely in the second part of it. In May (21.8% of total count of pollen grains) and in June (21.2% of total count of pollen grains) the concentrations were still relatively high. More precisely, the concentration has decreased at the end of April and has started to rise again at the beginning of May and reached the second peak, which was lower than the first one in April, in the first part of June. In July (3.5% of total count of pollen grains), August (3.6% of total count of pollen grains) and September (3.1% of total count of pollen grains) the concentrations were much lower. However, another small rise in concentration was present from the middle of August to the middle of September. The concentrations were the lowest in October (0.8% of total count of pollen grains).

With regard to the structure of the pollen grains, in April 79.1% of all pollen was on account of the cypress family pollen, 9.0% on account of the birch tree pollen, 8.8% on account of the olive tree pollen, and 3.2% on account of the grass family pollen. In May the structure was much different: 42.9% of all pollen was on account of the grass family pollen, 33.7% on account of the olive tree pollen, and 23.3% on account of the cypress family pollen. Only 0.1% of all pollen was on account of the birch tree pollen. In June the most important alergogenic plant was the olive tree: 58.5% of all pollen was on account of the olive tree pollen. In addition 37.4% on account of the grass family pollen, and only 4.1% on account of the cypress family pollen. In July the most important alergogenic plant family was the grass family. 89.2% of all pollen was on account of the grass family pollen. In addition, 8.8% of all pollen in July was on account of the cypress family pollen, and only 1.3% on account of the olive tree pollen. In July also grains of the wormwood appeared. 0.8% of all pollen in July was already on account of the wormwood pollen. In August grains of the ragweed appeared, and 34.4% of all pollen in August was on account of the ragweed pollen. However, the majority (41.3%) of all pollen in August was on account of the grass family pollen. In addition, 20.9% of all pollen in August was on account of the wormwood pollen. Only 3.4% of all pollen in August was on account of the cypress family pollen. In September the situation was slightly similar to the situation in August: 47.1% of all pollen was on account of the grass family pollen, 43.7% on account of the ragweed pollen, 5.1% on account of the wormwood pollen, and 4.0% on account of the cypress family pollen.

Correlation analysis between pollen concentration (number of particles/m^3) and PM_{10} 24-hr average concentrations ($\mu g/m^3$) daily average showed weak positive correlation ($\rho=0.151$). The correlation was also statistically significant ($p=0.032$).

4.1.3.4 Daily temperature average

In the analysis, data for 426 days were included, 212 days from the year 2010 and 214 from 2011.

The distribution of the daily temperature average (degrees Celsius) is presented in Figure 4.17, while selected statistical typical values of this distribution are presented in Table 4.9.

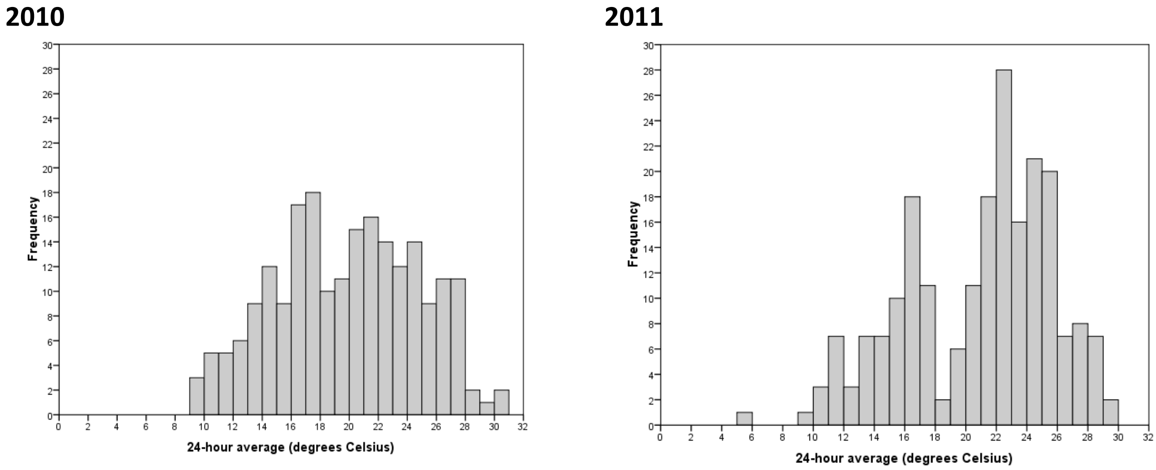

Figure 4.17: The distribution of the daily temperature average (degrees Celsius) in the Koper Municipality, Slovenia, from April 1 to October 31, 2010, and April 1 to October 31, 2011.

Table 4.9: Selected statistical typical values of the distribution of the daily temperature average (degrees Celsius) in the Koper Municipality, Slovenia, from April 1 to October 31, 2010, and April 1 to October 31, 2011.

				Percentiles			
Year	**Mean**	**SD**	**Min**	**25th**	**50th**	**75th**	**Max**
2010	19.80	4.90	9	16.03	20.00	23.60	31
2011	20.83	4.86	5	16.87	22.05	24.61	30

The temporal pattern of the daily temperature average by day of study for both years is presented in Figure 4.18.

From Figure 4.18 it can be seen that the overall trend of daily temperature average was upward from April to June or August, and then downward to October.

In 2010, the temperature was the highest in the middle of July and the lowest at the beginning of April and the end of October. In 2011, the daily temperature average was the highest in the second part of June and at the beginning of July, and then again in the second part of August, while it was the lowest at the end of April.

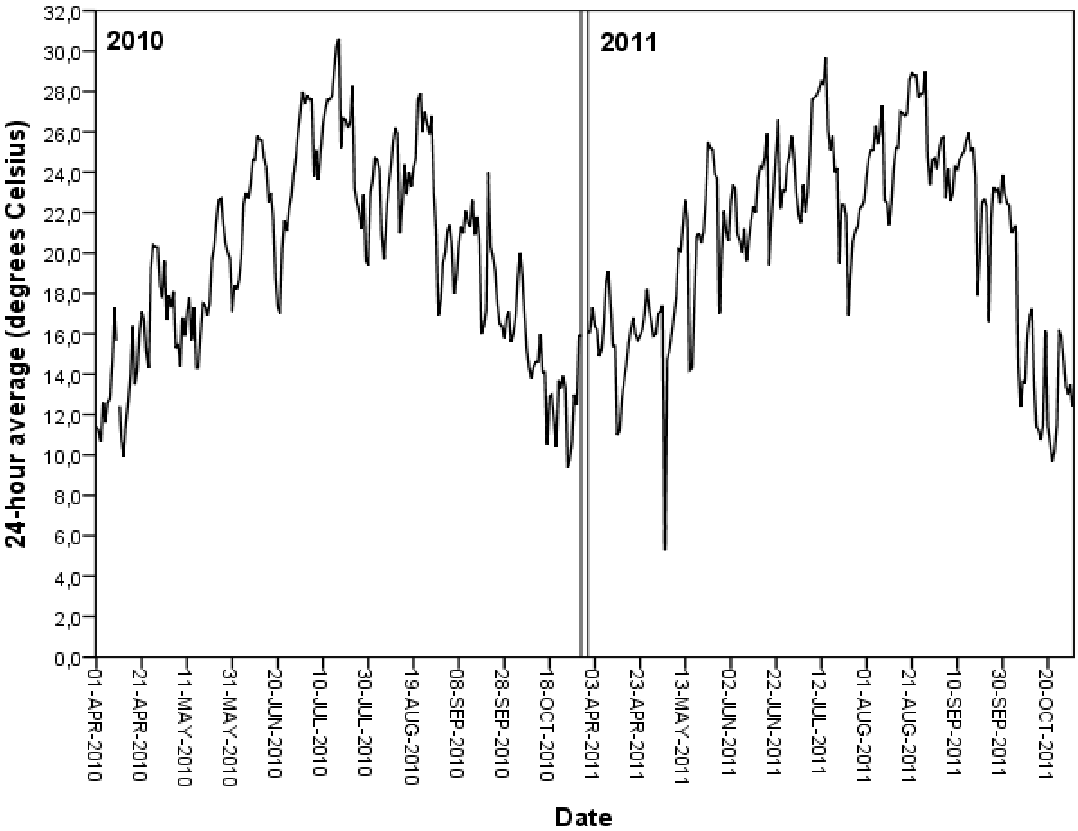

Figure 4.18: Temporal pattern of the daily temperature average (degrees Celsius) in the Koper Municipality, Slovenia, by day of study, from April 1 to October 31, 2010, and April 1 to October 31, 2011.

4.1.3.5 Daily relative humidity average

In the analysis, data for 426 days were included, 212 days from the year 2010 and 214 from 2011.

The distribution of the daily relative humidity average (%) is presented in Figure 4.19, while selected statistical typical values of this distribution are presented in Table 4.10.

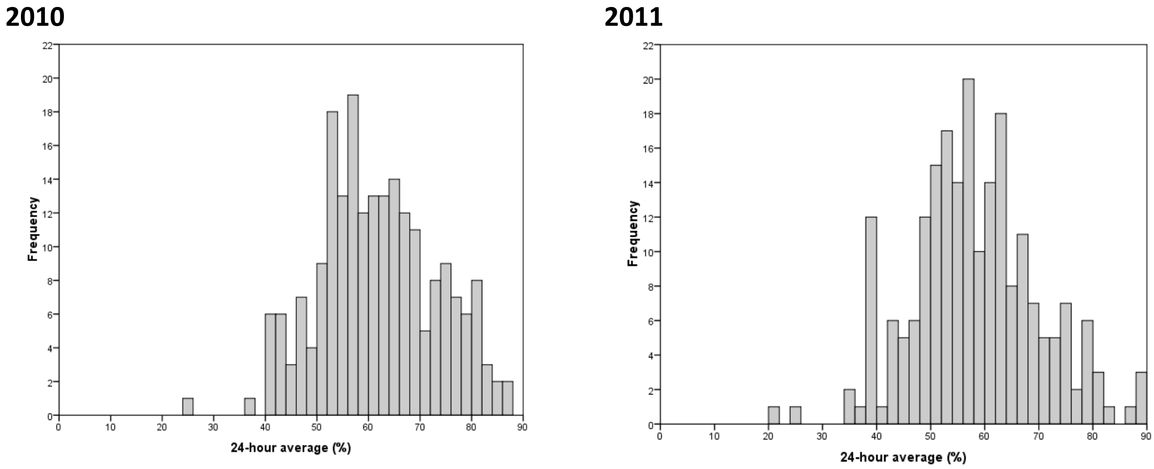

Figure 4.19: The distribution of the daily relative humidity average (%) in the Koper Municipality, Slovenia, from April 1 to October 31, 2010, and April 1 to October 31, 2011.

Table 4.10: Selected statistical typical values of the distribution of the daily relative humidity average (%) in the Koper Municipality, Slovenia, from April 1 to October 31, 2010, and April 1 to October 31, 2011.

				Percentiles			
Year	**Mean**	**SD**	**Min**	**25th**	**50th**	**75th**	**Max**
2010	61.76	11.40	24	53.53	61.15	69.55	87
2011	58.04	11.81	21	50.58	57.00	65.23	89

The temporal pattern of daily relative humidity average by day of study for both years is presented in Figure 4.20. From this figure it can be seen that the daily relative humidity average in 2010 was the highest in the second part of May and at the end of September, and the lowest in the second part of April. In 2011, the daily relative humidity average was the highest at the end of October, while it was the lowest at the end of April.

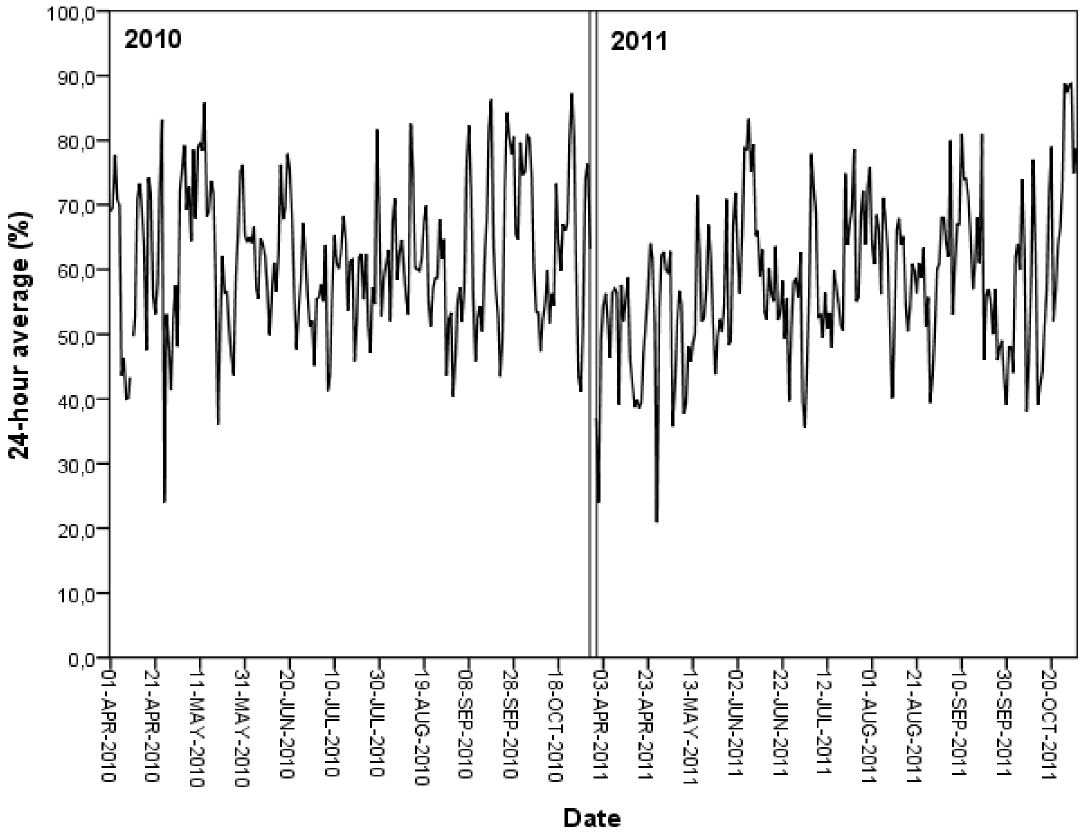

Figure 4.20: Temporal pattern of the daily relative humidity average (%) in the Koper Municipality, Slovenia, by day of study, from April 1 to October 31, 2010, and April 1 to October 31, 2011.

4.1.3.6 Daily average wind direction and average wind speed

In the analysis, data for 426 days were included, 212 days from the year 2010 and 214 from 2011.

The distribution of the daily average wind direction (the direction from which the wind is blowing to the Koper Municipality) is presented in Figure 4.21. From this figure it can be seen that in observed period in 2010 wind direction was predominantly south followed by the south-west winds. In 2011 situation was similar - wind direction was predominantly south-west followed by the south winds (Figure 4.21).

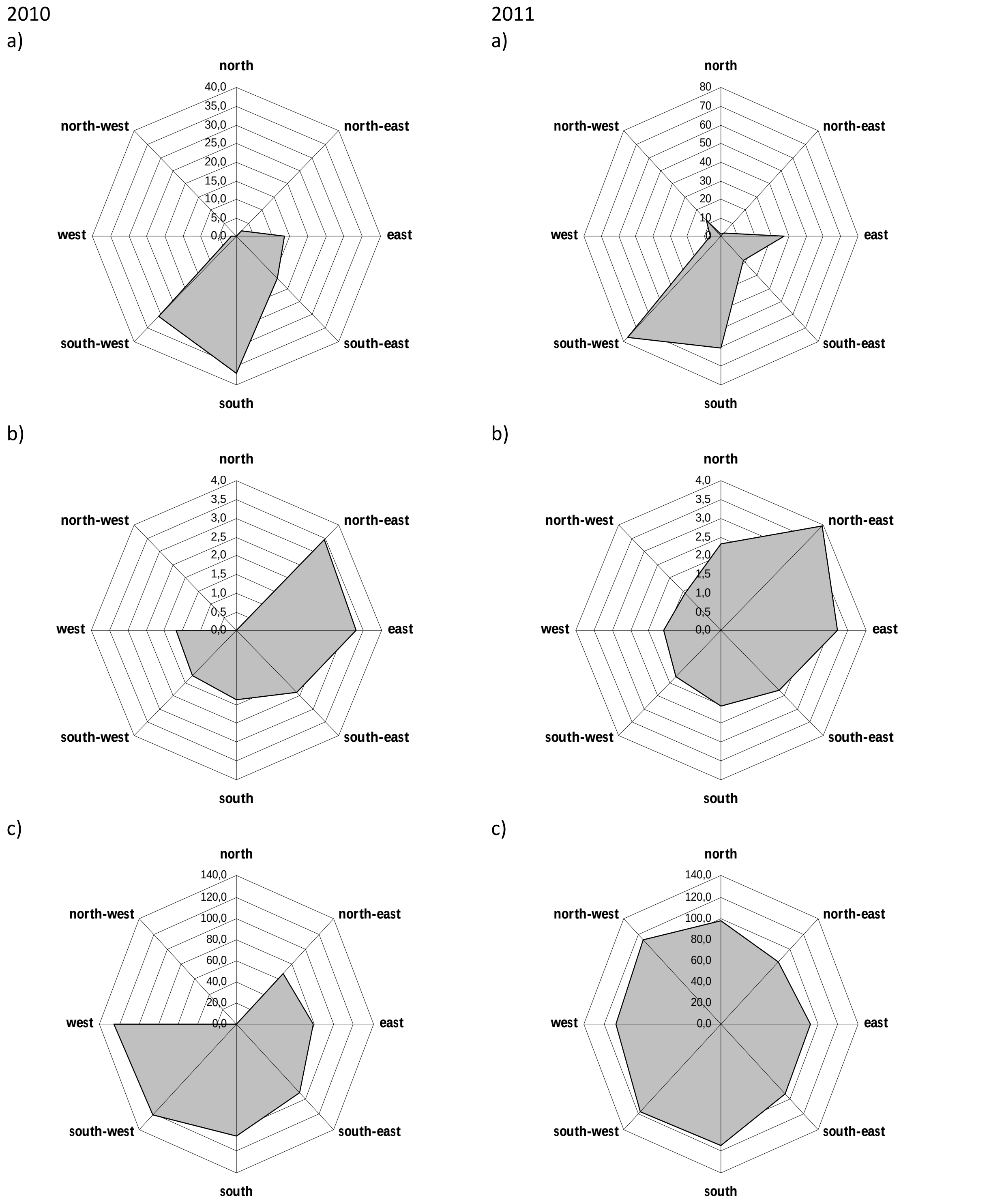

Figure 4.21: The wind direction (a) (percent of days with predominant direction), the wind speed (b) (daily average speed in m/s), and ozone pollution (c) (daily maximum 8-hr average concentration in μg/m^3) roses in the Koper Municipality, Slovenia, for the periods April 1 to October 31, 2010, and April 1 to October 31, 2011.

The distribution of the daily average wind speed is presented in Figure 4.22. Selected statistical typical values of this distribution for the year 2010 are: Mean: 2.11, SD: 0.75, Min: 1.0, Max: 6.3, 25th percentile: 1.6, 50th percentile: 1.9, and 75th percentile: 2.3, and for the year 2011 are: Mean: 2.12, SD: 0.81, Min: 0.5, Max: 5.7, 25th percentile: 1.6, 50th percentile: 1.8, and 75th percentile: 2.4.

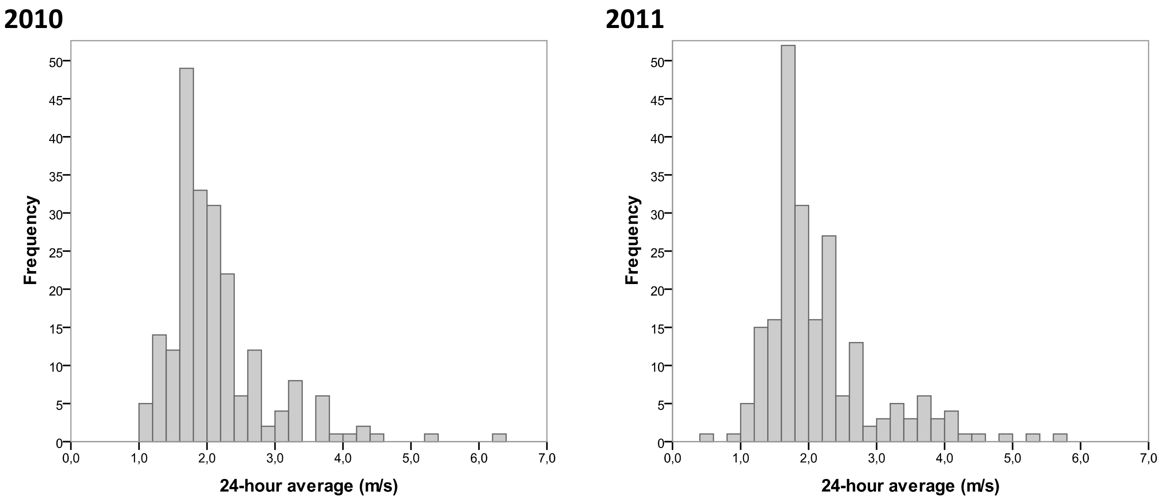

Figure 4.22: The average daily wind speed in the Koper Municipality, Slovenia, from April 1 to October 31, 2010, and April 1 to October 31, 2011.

From Figure 4.21 could be seen that the highest average wind speed was achieved by the north-east winds (2010: 3.4 m/s; 2011: 4,0 m/s), and the lowest by the west (2010: 1.7 m/s) or north-west (2011: 1.4 m/s) winds.

The highest ozone concentrations expressed as daily maximum 8-hr average concentration were observed in west (2010: 125.3 μg/m^3), south-west (2010: 119.9 μg/m^3; 2011: 116.7 μg/m^3) and south (2011: 114.1 μg/m^3) winds (Figure 4.21).

In higher concentrations of ozone south-west direction was predominant. At highest concentrations this was more expressed (Figure 4.23). In 2011 situation was to the certain extent similar (Figure 4.23).

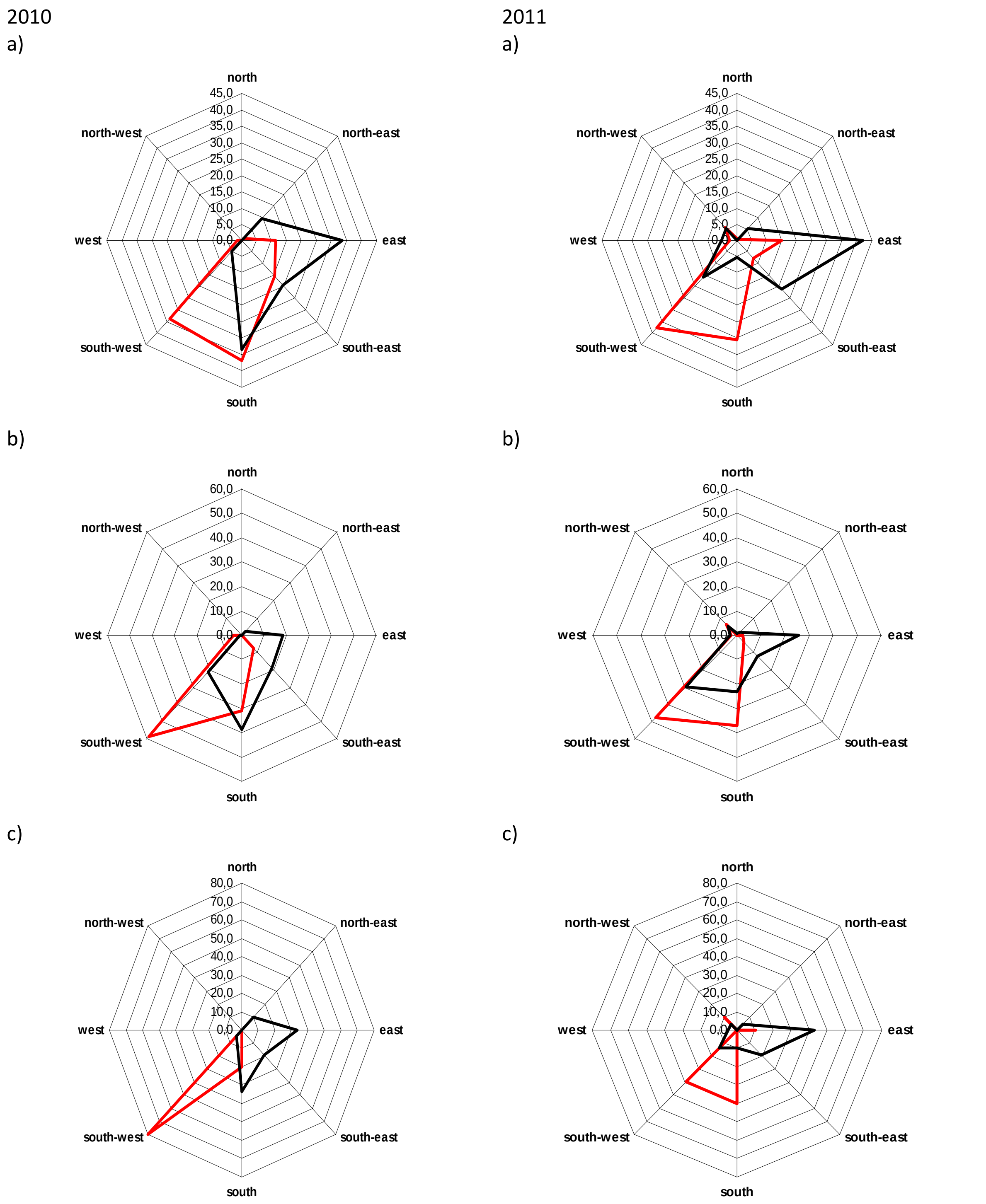

Figure 4.23: Percent of days with predominant direction of wind at different levels of ozone concentrations (daily maximum 8-hr average concentration in μg/m^3): (a) ▬ = 70 μg/m^3 or higher, ▬ = less than 70 μg/m^3, (b) ▬ = 120 μg/m^3 or higher, ▬ = less than 120 μg/m^3, and (c) ▬ = higher than 95th percentile (2010: 145.2 μg/m^3; 2011: 139.5 μg/m^3), ▬ = lower than 10th percentile (2010: 69.2 μg/m^3; 2011: 71.5 μg/m^3), in the Koper Municipality, Slovenia, for the period April 1 to October 31, 2010, and April 1 to October 31, 2011.

4.1.3.7 Seasonal indicators

In each of observed years, 2010 and 2011, there were in total 152/214 (71.0%) workdays and 62/214 (29.0%) week-end days in the observed period.

In each of observed years, 2010 and 2011, there were in total 74/214 (34.6%) holidays days (school holidays and work-free days) and 140/214 (65.4%) non-holidays days in the observed period.

4.2 RELATIONSHIP ANALYSIS

4.2.1 Uni-pollutant models

4.2.1.1 Consultations for all respiratory tract diseases symptoms

4.2.1.1.1 Ozone 24-hr average concentration

Summary results of the Poisson regression analysis of association between the number of consultations for all respiratory tract diseases symptoms and ozone 24-hr average concentration for uni-pollutant models for lags 0-5 are presented in Table 4.11. Full uni-pollutant models are presented in Appendix 1, Tables A1-1 to A1-6.

In any of the lags the association did not make sense in terms of literature - the results indicated that higher ozone 24-hr average concentrations were associated with a lower number of daily consultations. In lag 0 the association was statistically significant (Table 4.11). Nonetheless, no lag was chosen to enter the multi-pollutant model.

Table 4.11: Summary results of the Poisson regression analysis of association between the number of consultations for all respiratory tract diseases symptoms and ozone 24-hr average concentration for uni-pollutant models for lags 0 (N=424), 1 (N=421), 2 (N=418), 3 (N=416), 4 (N=414), and 5 (N=412).

Explanatory factor/covariate	**IRR**	**95 % C.I. limits for IRR**		**p-value**
		lower	upper	
Ozone 24-hr average concentration, lag 0	0.998	0.996	1.000	0.023
Ozone 24-hr average concentration, lag 1	0.999	0.997	1.001	0.246
Ozone 24-hr average concentration, lag 2	0.999	0.997	1.001	0.197
Ozone 24-hr average concentration, lag 3	0.998	0.996	1.000	0.106
Ozone 24-hr average concentration, lag 4	0.999	0.997	1.001	0.150
Ozone 24-hr average concentration, lag 5	0.999	0.997	1.001	0.210

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval

4.2.1.1.2 Ozone daily maximum 8-hr average concentration

Summary results of the Poisson regression analysis of association between the number of consultations for all respiratory tract diseases symptoms and ozone daily maximum 8-hr average concentration for uni-pollutant models for lags 0-5 are presented in Table 4.12. Full uni-pollutant models are presented in Appendix 1, Tables A1-7 to A1-12.

Table 4.12: Summary results of the Poisson regression analysis of association between the number of consultations for all respiratory tract diseases symptoms and ozone daily maximum 8-hr average concentration for uni-pollutant models for lags 0 (N=423), 1 (N=420), 2 (N=417), 3 (N=415), 4 (N=413), and 5 (N=411).

Explanatory factor/covariate	**IRR**	**95 % C.I. limits for IRR**		**p-value**
		lower	upper	
Ozone daily maximum 8-hr average concentration, lag 0	0.997	0.995	0.999	<0.001
Ozone daily maximum 8-hr average concentration, lag 1	0.997	0.995	0.999	0.001
Ozone daily maximum 8-hr average concentration, lag 2	0.997	0.995	0.999	<0.001
Ozone daily maximum 8-hr average concentration, lag 3	0.998	0.997	1.000	0.041
Ozone daily maximum 8-hr average concentration, lag 4	0.998	0.997	1.000	0.041
Ozone daily maximum 8-hr average concentration, lag 5	0.998	0.996	1.000	0.033

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

In any of the lags the association did not make sense in terms of literature - the results indicated that higher ozone daily maximum 8-hr average concentrations were associated with a lower number of daily consultations. In all lags it was statistically significant (Table 4.12). Nonetheless, no lag was chosen to enter the multi-pollutant model.

4.2.1.1.3 Ozone daily maximum 8-hr average concentration 70 μg/m^3 or exceeded

Summary results of the Poisson regression analysis of association between the number of consultations for all respiratory tract diseases symptoms and ozone daily maximum 8-hr average concentration 70 μg/m^3 or exceeded for uni-pollutant models for lags 0-5 are presented in Table 4.13. Full uni-pollutant models are presented in Appendix 1, Tables A1-13 to A1-18.

Table 4.13: Summary results of the Poisson regression analysis of association between the number of consultations for all respiratory tract diseases symptoms and ozone daily maximum 8-hr average concentration 70 μg/m^3 or exceeded for uni-pollutant models for lags 0 (N=423), 1 (N=420), 2 (N=417), 3 (N=415), 4 (N=413), and 5 (N=411).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average	No	1.000			
concentration 70 μg/m^3 or exceeded, lag 0	Yes	0.839	0.753	0.937	0.002
Ozone daily maximum 8-hr average	No	1.000			
concentration 70 μg/m^3 or exceeded, lag 1	Yes	0.844	0.756	0.944	0.003
Ozone daily maximum 8-hr average	No	1.000			
concentration 70 μg/m^3 or exceeded, lag 2	Yes	0.803	0.719	0.899	<0.001
Ozone daily maximum 8-hr average	No	1.000			
concentration 70 μg/m^3 or exceeded, lag 3	Yes	0.915	0.817	1.028	0.131
Ozone daily maximum 8-hr average	No	1.000			
concentration 70 μg/m^3 or exceeded, lag 4	Yes	0.946	0.835	1.075	0.390
Ozone daily maximum 8-hr average	No	1.000			
concentration 70 μg/m^3 or exceeded, lag 5	Yes	0.862	0.759	0.983	0.025

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

In any of the lags the association did not make sense in terms of literature - the results indicated that ozone daily maximum 8-hr average concentration 70 μg/m^3 or exceeded was associated with a lower number of daily consultations. In lags 0-2 and 5 it was statistically significant. Nonetheless, no lag was chosen to enter the multi-pollutant model.

4.2.1.1.4 Ozone daily maximum 8-hr average concentration 120 μg/m^3 or exceeded

Summary results of the Poisson regression analysis of association between the number of consultations for all respiratory tract diseases symptoms and ozone daily maximum 8-hr average concentration 120 μg/m^3 or exceeded for uni-pollutant models for lags 0-5 are presented in Table 4.14. Full uni-pollutant models are presented in Appendix 1, Tables A1-19 to A1-24.

Table 4.14: Summary results of the Poisson regression analysis of association between the number of consultations for all respiratory tract diseases symptoms and ozone daily maximum 8-hr average concentration 120 μg/m^3 or exceeded for uni-pollutant models for lags 0 (N=423), 1 (N=420), 2 (N=417), 3 (N=415), 4 (N=413), and 5 (N=411).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average	No	1.000			
concentration 120 μg/m^3 or exceeded, lag 0	Yes	0.891	0.813	0.976	0.013
Ozone daily maximum 8-hr average	No	1.000			
concentration 120 μg/m^3 or exceeded, lag 1	Yes	0.991	0.906	1.083	0.841
Ozone daily maximum 8-hr average	No	1.000			
concentration 120 μg/m^3 or exceeded, lag 2	Yes	0.967	0.887	1.054	0.445
Ozone daily maximum 8-hr average	No	1.000			
concentration 120 μg/m^3 or exceeded, lag 3	Yes	0.987	0.906	1.074	0.760
Ozone daily maximum 8-hr average	No	1.000			
concentration 120 μg/m^3 or exceeded, lag 4	Yes	0.917	0.842	0.998	0.045
Ozone daily maximum 8-hr average	No	1.000			
concentration 120 μg/m^3 or exceeded, lag 5	Yes	0.932	0.857	1.013	0.100

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

In any of the lags the association did not make sense in terms of literature - the results indicated that ozone daily maximum 8-hr average concentration 120 μg/m^3 or exceeded was associated with a lower number of daily consultations. In lags 0 and 4 it was statistically significant. Nonetheless, no lag was chosen to enter the multi-pollutant model.

4.2.1.1.5 Ozone daily maximum 1-hr average concentration

Summary results of the Poisson regression analysis of association between the number of consultations for all respiratory tract diseases symptoms and ozone daily maximum 1-hr average concentration for uni-pollutant models for lags 0-5 are presented in Table 4.15. Full uni-pollutant models are presented in Appendix 1, Tables A1-25 to A1-30.

Table 4.15: Summary results of the Poisson regression analysis of association between the number of consultations for all respiratory tract diseases symptoms and ozone daily maximum 1-hr average concentration for uni-pollutant models for lags 0 (N=424), 1 (N=421), 2 (N=418), 3 (N=416), 4 (N=414), and 5 (N=412).

Explanatory factor/covariate	IRR	95 % C.I. limits for IRR		p-value
		lower	upper	
Ozone daily maximum 1-hr average concentration, lag 0	0.997	0.995	0.999	<0.001
Ozone daily maximum 1-hr average concentration, lag 1	0.998	0.996	0.999	0.004
Ozone daily maximum 1-hr average concentration, lag 2	0.997	0.996	0.999	0.001
Ozone daily maximum 1-hr average concentration, lag 3	0.999	0.998	1.001	0.228
Ozone daily maximum 1-hr average concentration, lag 4	0.999	0.997	1.000	0.070
Ozone daily maximum 1-hr average concentration, lag 5	0.999	0.997	1.000	0.114

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

In any of the lags the association did not make sense in terms of literature - the results indicated that higher ozone daily maximum 1-hr average concentrations were associated with a lower number of daily consultations. In lags 0-2 it was statistically significant. Nonetheless, no lag was chosen to enter the multi-pollutant model.

4.2.1.1.6 PM_{10} 24-hr average concentration

Summary results of the Poisson regression analysis of association between the number of consultations for all respiratory tract diseases symptoms and PM_{10} 24-hr average concentration for uni-pollutant models for lags 0-5 are presented in Table 4.16. Full uni-pollutant models are presented in Appendix 1, Tables A1-31 to A1-36.

Table 4.16: Summary results of the Poisson regression analysis of association between the number of consultations for all respiratory tract diseases symptoms and PM_{10} 24-hr average concentration for uni-pollutant models for lags 0 (N=424), 1 (N=421), 2 (N=418), 3 (N=416), 4 (N=414), and 5 (N=412).

Explanatory factor/covariate	IRR	95 % C.I. limits for IRR		p-value
		lower	upper	
PM_{10} 24-hr average concentration, lag 0	1.010	1.006	1.013	<0.001
PM_{10} 24-hr average concentration, lag 1	1.001	0.997	1.005	0.613
PM_{10} 24-hr average concentration, lag 2	0.998	0.993	1.002	0.233
PM_{10} 24-hr average concentration, lag 3	1.004	1.000	1.008	0.040
PM_{10} 24-hr average concentration, lag 4	1.008	1.004	1.012	<0.001
PM_{10} 24-hr average concentration, lag 5	1.002	0.998	1.006	0.254

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

In all lags except in lag 2 the association made sense in terms of literature - the results indicated that higher PM_{10} concentrations were associated with a higher number of daily consultations. In lags 0, 3 and 4 it was statistically significant. Since the strongest association was in lag 0, this lag could be chosen to enter the multi-pollutant model. Nonetheless, because no ozone variable was chosen to enter the multi-pollutant model, this model was not defined.

4.2.1.1.7 NO_2 24-hr average concentration

Summary results of the Poisson regression analysis of association between the number of consultations for all respiratory tract diseases symptoms and NO_2 24-hr average concentration for uni-pollutant model for lags 0-5 are presented in Table 4.17. Full uni-pollutant models are presented in Appendix 1, Tables A1-37 to A1-42.

Table 4.17: Summary results of the Poisson regression analysis of association between the number of consultations for all respiratory tract diseases symptoms and NO_2 24-hr average concentration for uni-pollutant model for lags 0 (N=414), 1 (N=412), 2 (N=410), 3 (N=409), 4 (N=408), and 5 (N=407).

Explanatory factor/covariate	IRR	95 % C.I. limits for IRR		p-value
		lower	upper	
NO_2 24-hr average concentration, lag 0	1.011	1.006	1.017	<0.001
NO_2 24-hr average concentration, lag 1	1.002	0.996	1.007	0.600
NO_2 24-hr average concentration, lag 2	0.998	0.992	1.047	0.500
NO_2 24-hr average concentration, lag 3	1.001	0.996	1.006	0.656
NO_2 24-hr average concentration, lag 4	1.006	1.001	1.012	0.015
NO_2 24-hr average concentration, lag 5	1.008	1.003	1.014	0.001

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

In all lags except in lag 2 the association made sense in terms of literature - the results indicated that higher NO_2 concentrations were associated with a higher number of daily consultations. In lags 0, 4 and 5 it was statistically significant. Since the strongest association was in lag 0, this lag could be chosen to enter the multi-pollutant model. Nonetheless, because no ozone variable was chosen to enter the multi-pollutant model, this model was not defined.

4.2.1.1.8 Daily average pollen concentration

Summary results of the Poisson regression analysis of association between the number of consultations for all respiratory tract diseases symptoms and daily average pollen concentration for uni-pollutant models for lags 0-5 are presented in Table 4.18. Full uni-pollutant models are presented in Appendix 1, Tables A1-43 to A1-48.

Table 4.18: Summary results of the Poisson regression analysis of association between the number of consultations for all respiratory tract diseases symptoms and daily average pollen concentration for uni-pollutant models for lags 0 (N=212), 1 (N=211), 2 (N=210), 3 (N=209), 4 (N=208), and 5 (N=207).

Explanatory factor/covariate	**IRR**	**95 % C.I. limits for IRR**		**p-value**
		lower	upper	
Pollen concentration 24-hr average, lag 0	0.999	0.999	1.000	0.003
Pollen concentration 24-hr average, lag 1	1.000	0.999	1.000	0.270
Pollen concentration 24-hr average, lag 2	1.000	0.999	1.000	0.148
Pollen concentration 24-hr average, lag 3	1.000	0.999	1.000	0.538
Pollen concentration 24-hr average, lag 4	0.999	0.999	1.000	0.020
Pollen concentration 24-hr average, lag 5	0.999	0.999	1.000	0.003

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

In lags 1-3 the association made sense in terms of literature - the results indicated that higher pollen concentrations could be associated with a higher number of daily consultations, since in lag 2 it was borderline statistically significant. This lag could be chosen to enter the multi-pollutant model. Nonetheless, because no ozone variable was chosen to enter the multi-pollutant model, this model was not defined.

4.2.1.2 Consultations for asthma symptoms

4.2.1.1.1 Ozone 24-hr average concentration

Summary results of the logistic regression analysis of association between daily occurrence of any consultation for asthma symptoms and ozone 24-hr average concentration for uni-pollutant models for lags 0-5 are presented in Table 4.19. Full uni-pollutant models are presented in Appendix 2, Tables A2-1 to A2-6.

Table 4.19: Summary results of the logistic regression analysis of association between daily occurrence of any consultation for asthma symptoms and ozone 24-hr average concentration for uni-pollutant models for lags 0 (N=424), 1 (N=421), 2 (N=418), 3 (N=416), 4 (N=414), and 5 (N=412).

Explanatory factor/covariate	OR	95 % C.I. limits for OR		p-value
		lower	upper	
Ozone 24-hr average concentration, lag 0	1.005	0.989	1.021	0.562
Ozone 24-hr average concentration, lag 1	1.002	0.986	1.017	0.846
Ozone 24-hr average concentration, lag 2	0.999	0.984	1.015	0.947
Ozone 24-hr average concentration, lag 3	0.995	0.980	1.011	0.547
Ozone 24-hr average concentration, lag 4	1.000	0.984	1.015	0.976
Ozone 24-hr average concentration, lag 5	0.993	0.977	1.009	0.370

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

In lags 0, 1, and 4 the association made sense in terms of literature - the results indicated that higher ozone 24-hr average concentrations could be associated with a higher probability for daily occurrence of any consultation for asthma symptoms. However, in none of these lags the association was statistically significant (Table 4.19). Consequently, no lag was chosen to enter the multi-pollutant model.

4.2.1.1.2 Ozone daily maximum 8-hr average concentration

Summary results of the logistic regression analysis of association between daily occurrence of any consultation for asthma symptoms and ozone daily maximum 8-hr average concentration for uni-pollutant models for lags 0-5 are presented in Table 4.20. Full uni-pollutant models are presented in Appendix 2, Tables A2-7 to A2-12.

Table 4.20: Summary results of the logistic regression analysis of association between daily occurrence of any consultation for asthma symptoms and ozone daily maximum 8-hr average concentration for uni-pollutant models for lags 0 (N=423), 1 (N=420), 2 (N=417), 3 (N=415), 4 (N=413), and 5 (N=411).

Explanatory factor/covariate	**OR**	**95 % C.I. limits for OR**		**p-value**
		lower	upper	
Ozone daily maximum 8-hr average concentration, lag 0	0.999	0.985	1.013	0.906
Ozone daily maximum 8-hr average concentration, lag 1	1.005	0.991	1.019	0.459
Ozone daily maximum 8-hr average concentration, lag 2	0.998	0.984	1.011	0.741
Ozone daily maximum 8-hr average concentration, lag 3	1.003	0.990	1.016	0.670
Ozone daily maximum 8-hr average concentration, lag 4	1.001	0.988	1.015	0.846
Ozone daily maximum 8-hr average concentration, lag 5	0.988	0.975	1.002	0.095

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

In lags 1, 3 and 4 the association made sense in terms of literature - the results indicated that higher ozone daily maximum 8-hr average concentrations could be associated with a higher probability for daily occurrence of any consultation for asthma symptoms. However, in none of these lags the association was statistically significant (Table 4.20). Consequently, no lag was chosen to enter the multi-pollutant model.

4.2.1.1.3 Ozone daily maximum 8-hr average concentration 70 μg/m^3 or exceeded

Summary results of the logistic regression analysis of association between daily occurrence of any consultation for asthma symptoms and ozone daily maximum 8-hr average concentration 70 μg/m^3 or exceeded for uni-pollutant models for lags 0-5 are presented in Table 4.21. Full uni-pollutant models are presented in Appendix 2, Tables A2-13 to A2-18.

Table 4.21: Summary results of the logistic regression analysis of association between daily occurrence of any consultation for asthma symptoms and ozone daily maximum 8-hr average concentration 70 μg/m^3 or exceeded for uni-pollutant models for lags 0 (N=423), 1 (N=420), 2 (N=417), 3 (N=415), 4 (N=413), and 5 (N=411).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average	No	1.000			
concentration 70 μg/m^3 or exceeded, lag 0	Yes	0.687	0.262	1.797	0.444
Ozone daily maximum 8-hr average	No	1.000			
concentration 70 μg/m^3 or exceeded, lag 1	Yes	1.857	0.581	5.940	0.297
Ozone daily maximum 8-hr average	No	1.000			
concentration 70 μg/m^3 or exceeded, lag 2	Yes	1.211	0.408	3.596	0.730
Ozone daily maximum 8-hr average	No	1.000			
concentration 70 μg/m^3 or exceeded, lag 3	Yes	1.931	0.604	6.177	0.267
Ozone daily maximum 8-hr average	No	1.000			
concentration 70 μg/m^3 or exceeded, lag 4	Yes	3.571	0.775	16.447	0.102
Ozone daily maximum 8-hr average	No	1.000			
concentration 70 μg/m^3 or exceeded, lag 5	Yes	0.625	0.213	1.833	0.392

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

In lags 1-4 the association made sense in terms of literature - the results indicated that ozone daily maximum 8-hr average concentration 70 μg/m^3 or exceeded could be associated with a higher probability for daily occurrence of any consultation for asthma symptoms, since in lag 4 the association was borderline statistically significant (Table 4.21). Consequently, this lag was chosen to enter the multi-pollutant model.

4.2.1.1.4 Ozone daily maximum 8-hr average concentration 120 µg/m^3 or exceeded

Summary results of the logistic regression analysis of association between daily occurrence of any consultation for asthma symptoms and ozone daily maximum 8-hr average concentration 120 µg/m^3 or exceeded for uni-pollutant models for lags 0-5 are presented in Table 4.22. Full uni-pollutant models are presented in Appendix 2, Tables A2-19 to A2-24.

Table 4.22: Summary results of the logistic regression analysis of association between daily occurrence of any consultation for asthma symptoms and ozone daily maximum 8-hr average concentration 120 µg/m^3 or exceeded for uni-pollutant models for lags 0 (N=423), 1 (N=420), 2 (N=417), 3 (N=415), 4 (N=413), and 5 (N=411).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average	No	1.000			
concentration 120 µg/m^3 or exceeded, lag 0	Yes	0.800	0.414	1.547	0.507
Ozone daily maximum 8-hr average	No	1.000			
concentration 120 µg/m^3 or exceeded, lag 1	Yes	0.960	0.501	1.840	0.902
Ozone daily maximum 8-hr average	No	1.000			
concentration 120 µg/m^3 or exceeded, lag 2	Yes	0.922	0.487	1.747	0.803
Ozone daily maximum 8-hr average	No	1.000			
concentration 120 µg/m^3 or exceeded, lag 3	Yes	1.407	0.758	2.609	0.279
Ozone daily maximum 8-hr average	No	1.000			
concentration 120 µg/m^3 or exceeded, lag 4	Yes	0.718	0.382	1.351	0.304
Ozone daily maximum 8-hr average	No	1.000			
concentration 120 µg/m^3 or exceeded, lag 5	Yes	0.387	0.197	0.759	0.006

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Only in lag 3 the association made sense in terms of literature - the results indicated that ozone daily maximum 8-hr average concentration 120 µg/m^3 or exceeded could be associated with a higher probability for daily occurrence of any consultation for asthma symptoms. However, this association was not statistically significant. In lag 5 the association was statistically significant, however it did not make sense in terms of literature (Table 4.22). Consequently, no lag was chosen to enter the multi-pollutant model.

4.2.1.1.5 Ozone daily maximum 1-hr average concentration

Summary results of the logistic regression analysis of association between daily occurrence of any consultation for asthma symptoms and ozone daily maximum 1-hr average concentration for uni-pollutant models for lags 0-5 are presented in Table 4.23. Full uni-pollutant models are presented in Appendix 2, Tables A2-25 to A2-30.

Table 4.23: Summary results of the logistic regression analysis of association between daily occurrence of any consultation for asthma symptoms and ozone daily maximum 1-hr average concentration for uni-pollutant models for lags 0 (N=424), 1 (N=421), 2 (N=418), 3 (N=416), 4 (N=414), and 5 (N=412).

Explanatory factor/covariate	**OR**	**95 % C.I. limits for OR**		**p-value**
		lower	upper	
Ozone daily maximum 1-hr average concentration, lag 0	1.000	0.987	1.013	0.980
Ozone daily maximum 1-hr average concentration, lag 1	1.007	0.994	1.021	0.265
Ozone daily maximum 1-hr average concentration, lag 2	1.004	0.992	1.016	0.538
Ozone daily maximum 1-hr average concentration, lag 3	1.002	0.990	1.014	0.784
Ozone daily maximum 1-hr average concentration, lag 4	1.000	0.988	1.012	0.994
Ozone daily maximum 1-hr average concentration, lag 5	0.990	0.978	1.002	0.117

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

In lags 0-4 the association made sense in terms of literature - the results indicated that higher ozone daily maximum 1-hr average concentrations could be associated with a higher probability for daily occurrence of any consultation for asthma symptoms. However, in none of these lags the association was statistically significant (Table 4.23). Consequently, no lag was chosen to enter the multi-pollutant model.

4.2.1.1.6 PM_{10} 24-hr average concentration

Summary results of the logistic regression analysis of association between daily occurrence of any consultation for asthma symptoms and PM_{10} 24-hr average concentration for uni-pollutant models for lags 0-5 are presented in Table 4.24. Full uni-pollutant models are presented in Appendix 2, Tables A2-31 to A2-36.

Table 4.24: Summary results of the logistic regression analysis of association between daily occurrence of any consultation for asthma symptoms and PM_{10} 24-hr average concentration for uni-pollutant models for lags 0 (N=424), 1 (N=421), 2 (N=418), 3 (N=416), 4 (N=414), and 5 (N=412).

Explanatory factor/covariate	OR	95 % C.I. limits for OR		p-value
		lower	upper	
PM_{10} 24-hr average concentration, lag 0	1.031	1.001	1.063	0.045
PM_{10} 24-hr average concentration, lag 1	1.031	0.999	1.064	0.056
PM_{10} 24-hr average concentration, lag 2	1.033	1.002	1.065	0.038
PM_{10} 24-hr average concentration, lag 3	1.005	0.975	1.036	0.749
PM_{10} 24-hr average concentration, lag 4	0.997	0.966	1.029	0.851
PM_{10} 24-hr average concentration, lag 5	0.997	0.966	1.028	0.830

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

In lags 0-3 the association made sense in terms of literature - the results indicated that higher PM_{10} concentrations were associated with a higher probability for daily occurrence of any consultation for asthma symptoms. In lags 0 and 2 it was statistically significant. The association was slightly stronger in lag 2. However, since this difference was not big, and biologically more plausible is lag 0, this lag was chosen to enter the multi-pollutant model.

4.2.1.1.7 NO_2 24-hr average concentration

Summary results of the logistic regression analysis of association between daily occurrence of any consultation for asthma symptoms and NO_2 24-hr average concentration for the uni-pollutant model for lags 0-5 are presented in Table 4.25. Full uni-pollutant models are presented in Appendix 2, Tables A2-37 to A2-42.

Table 4.25: Summary results of the logistic regression analysis of association between daily occurrence of any consultation for asthma symptoms and NO_2 24-hr average concentration for the uni-pollutant model for lags 0 (N=414), 1 (N=412), 2 (N=410), 3 (N=409), 4 (N=408), and 5 (N=407)

Explanatory factor/covariate	**OR**	**95 % C.I. limits for OR**		**p-value**
		lower	upper	
NO_2 24-hr average concentration, lag 0	1.033	0.990	1.077	0.139
NO_2 24-hr average concentration, lag 1	1.030	0.986	1.075	0.185
NO_2 24-hr average concentration, lag 2	1.022	0.980	1.064	0.309
NO_2 24-hr average concentration, lag 3	1.006	0.964	1.050	0.783
NO_2 24-hr average concentration, lag 4	0.996	0.955	1.038	0.838
NO_2 24-hr average concentration, lag 5	1.023	0.981	1.066	0.288

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

In all lags except in lag 4 the association made sense in terms of literature - the results indicated that higher NO_2 concentrations could be associated with a higher probability for daily occurrence of any consultation for asthma symptoms. However, only in lags 0 and 1 the association was borderline statistically significant. It was slightly stronger in lag 0. Consequently, this lag was chosen to enter the multi-pollutant model.

4.2.1.1.8 Daily average pollen concentration

Summary results of the logistic regression analysis of association between daily occurrence of any consultation for asthma symptoms and daily average pollen concentration for uni-pollutant models for lags 0-5 are presented in Table 4.26. Full uni-pollutant models are presented in Appendix 2, Tables A2-43 to A2-48.

Table 4.26: Summary results of the logistic regression analysis of association between daily occurrence of any consultation for asthma symptoms and daily average pollen concentration for uni-pollutant models for lags 0 (N=212), 1 (N=211), 2 (N=210), 3 (N=209), 4 (N=208), and 5 (N=207).

Explanatory factor/covariate	**OR**	**95 % C.I. limits for OR**		**p-value**
		lower	upper	
Pollen concentration 24-hr average, lag 0	1.002	0.999	1.005	0.234
Pollen concentration 24-hr average, lag 1	1.003	1.000	1.006	0.025
Pollen concentration 24-hr average, lag 2	1.001	0.998	1.004	0.349
Pollen concentration 24-hr average, lag 3	1.002	0.999	1.005	0.169
Pollen concentration 24-hr average, lag 4	0.999	0.995	1.003	0.563
Pollen concentration 24-hr average, lag 5	1.000	0.997	1.003	0.788

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

In lags 1-3, and 5 the association made sense in terms of literature - the results indicated that higher pollen concentrations were associated with a higher probability for daily occurrence of any consultation for asthma symptoms. In lag 1 it was statistically significant. Consequently, this lag was chosen to enter the multi-pollutant model.

4.2.2 Multi-pollutant models

4.2.2.1 Models without pollen concentration included

Results of the logistic regression analysis of association between daily occurrence of any consultation for asthma symptoms and ozone concentration, controlling for selected covariates, without pollen concentration included, are presented in Tables 4.27 and 4.28.

In Table 4.27, Model 1 is presented. In this model, which was defined using direct method, all the best variants and lags of the explanatory factor/covariates chosen in uni-pollutant models as suitable to enter the multi-pollutant model/models were considered.

Table 4.27: Results of the logistic regression analysis of association between daily occurrence of any consultation for asthma symptoms and ozone concentration, controlling for selected covariates (without included pollen concentration) – Model 1 (direct method), (N=388).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average	No	1.000			
concentration 70 μg/m^3 or exceeded, lag 4	Yes	4.060	0.858	19.208	0.077
PM_{10} 24-hr average, lag 0		1.031	0.995	1.068	0.089
NO_2 24-hr average, lag 0		1.006	0.957	1.057	0.824
Year	2010	1.000			
	2011	0.398	0.223	0.708	0.002
Work day	No	1.000			
	Yes	5.010	2.051	12.237	<0.001
Holiday	No	1.000			
	Yes	0.383	0.178	0.820	0.014
Temperature 24-hr average		1.047	0.967	1.133	0.256
Relative humidity 24-hr average		1.008	0.983	1.035	0.522

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

In this model, the association between daily occurrence of any consultation for asthma symptoms and ozone daily maximum 8-hr average concentration 70 μg/m^3 or exceeded, lag 4, was borderline statistically significant (Table 4.27). The situation in PM_{10} 24-hr average, lag 0, was similar, while association between consultations for asthma symptoms and NO_2 24-hr average, lag 0, was not significant (Table 4.27).

In Table 4.28, Model 2 is presented. In this model, which was defined using the stepwise method, the same independent variables were considered as in Model 1, only the method for the definition of the final model was different.

Table 4.28: Results of the logistic regression analysis of association between daily occurrence of any consultation for asthma symptoms and ozone concentration, controlling for selected covariates (without included pollen concentration) – Model 2 (stepwise method), (N=388).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average	No	1.000			
concentration 70 μg/m^3 or exceeded, lag 4	Yes	4.769	1.057	21.520	0.042
PM_{10} 24-hr average, lag 0		1.036	1.005	1.068	0.024
Year	2010	1.000			
	2011	0.412	0.236	0.719	0.002
Work day	No	1.000			
	Yes	5.021	2.075	12.150	<0.001
Holiday	No	1.000			
	Yes	0.485	0.258	0.910	0.024

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

In this model, in which all statistically non-significant variables were omitted by the procedure itself, the association between daily occurrence of any consultation for asthma symptoms and ozone daily maximum 8-hr average concentration 70 μg/m^3 or exceeded, lag 4, was statistically significant (Table 4.28). The results indicated that on days on which ozone daily maximum 8-hr average concentration reached or exceeded the value of 70 μg/m^3 the odds for any consultation for asthma symptoms were 4.77-times higher than on other days (Table 4.28). In PM_{10} 24-hr average, lag 0, the association was also statistically significant (Table 4.28).

4.2.2.2 Models with pollen concentration included

Results of the logistic regression analysis of association between daily occurrence of any consultation for asthma symptoms and ozone concentration, controlling for selected covariates, including pollen concentration, are presented in Tables 4.29 to 4.31.

In Table 4.29, Model 1 is presented. In this model, which was defined using the direct method, all the best variants and lags of the explanatory factor/covariates chosen in uni-pollutant models as suitable to enter the multi-pollutant model/models were considered.

Table 4.29: Results of the logistic regression analysis of association between daily occurrence of any consultation for asthma symptoms and ozone concentration, controlling for selected covariates (including pollen concentration) – Model 1 (direct method), (N=187).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average	No	1.000			
concentration 70 μg/m^3 or exceeded, lag 4	Yes	6.677	0.779	57.221	0.083
PM_{10} 24-hr average, lag 0		1.019	0.976	1.064	0.390
NO_2 24-hr average, lag 0		1.005	0.941	1.073	0.886
Pollen 24-hr average, lag 1		1.004	1.000	1.007	0.042
Work day	No	1.000			
	Yes	4.547	1.580	13.088	0.005
Holiday	No	1.000			
	Yes	0.568	0.210	1.536	0.265
Temperature 24-hr average		1.022	0.922	1.132	0.683
Relative humidity 24-hr average		1.027	0.992	1.062	0.132

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

In this model the association between consultations for asthma symptoms and ozone daily maximum 8-hr average concentration 70 μg/m^3 or exceeded, lag 4, was borderline statistically significant, while association between consultations for asthma symptoms and PM_{10} 24-hr average, lag 0, and NO_2 24-hr average, lag 0, was not significant (Table 4.29). Only in pollen 24-hr average, lag 1, the association was statistically significant (Table 4.29).

In Table 4.30, Model 2 is presented. In this model, which was defined using the stepwise method, the same independent variables were considered as in Model 1, only the method for the definition of the final model was different.

Table 4.30: Results of the logistic regression analysis of association between daily occurrence of any consultation for asthma symptoms and ozone concentration, controlling for selected covariates (including pollen concentration) – Model 2 (stepwise method), (N=187).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Pollen 24-hr average, lag 1		1.003	1.000	1.006	0.027
Work day	No	1.000			
	Yes	4.951	1.741	14.079	0.003

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

In this model, in which all statistically non-significant variables were omitted by the procedure itself, the association between daily occurrence of any consultation for asthma symptoms and ozone daily maximum 8-hr average concentration 70 μg/m^3 or exceeded, lag 4, was not statistically significant, therefore this variable was not chosen to enter the final model (Table 4.30). Only in pollen 24-hr average, lag 1, the association was statistically significant (Table 4.30).

In Table 4.31, Model 3 is presented. In this model, which was again defined using the direct method, both variables chosen in Model 2 were considered. The ozone variable was added (forced to enter) in order to assess its contribution to the stepwise model. In this model, the association between daily occurrence of any consultation for asthma symptoms and ozone daily maximum 8-hr average concentration 70 μg/m^3 or exceeded, lag 4, was borderline statistically significant, and its contribution similar as in Model 1 (Table 4.29). Only in pollen 24-hr average, lag 1, the association was statistically significant (Table 4.31).

Table 4.31: Results of the logistic regression analysis of association between daily occurrence of any consultation for asthma symptoms and ozone concentration, controlling for selected covariates (including pollen concentration) – Model 3 (direct method), (N=205).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average	No	1.000			
concentration 70 μg/m^3 or exceeded, lag 4	Yes	6.823	0.781	59.569	0.082
Pollen 24-hr average, lag 1		1.004	1.001	1.007	0.015
Work day	No	1.000			
	Yes	3.410	1.380	8.427	0.008

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

5 DISCUSSION

5.1 METHODOLOGY OF THE STUDY

The methodology of this study has been defined 1) on the basis of the recommendations for similar study design (De Souza Tadano et al., 2012), 2) on the basis of a review of methodology used in previous similar studies, the results of which were published in accessible articles (Spix et al., 1993; Castellsague et al., 1995; Katsouyanni et al., 1995; Vigotti et al., 1996; Stieb et al., 1996, Stedman et al., 1997; Anderson et al., 1997; Wong et al., 1999; Gouveia et al., 2000; Gwynn et al., 2000; Hagen et al., 2000; Braga et al., 2001; Burnett et al., 2001; Conceicao et al., 2001; Fusco et al., 2001; Hajat et al., 2002; Galan et al., 2003; Gryparis et al., 2004; Peel et al., 2005; Lee et al., 2006; Zhang et al., 2006; Babin et al., 2007; Myers et al., 2007; Ostro et al., 2007; Vigotti et al., 2007; Strickland et al., 2010; Fraga et al., 2011), 3) on the basis of available data (Ministrstvo za kmetijstvo in okolje Republike Slovenije in Agencija Republike Slovenije za okolje, 2011), and 4) on the basis of available analytical tools.

Regarding the time period of observation initially was planned that this period would be only the April-October period of the year 2011. However, when it was realized that this would make too short time series, it was decided to extend the period. The observation was firstly extended to the April-October period of the years 2009-2011, and available environmental data were obtained for the whole extended period. Unfortunately, high quality health data were only available for the April-October period of the years 2010 and 2011. Then came the opportunity to include very important information on pollen concentration. Therefore, we obtained these data, too. Unfortunately, these data were only available for the April-October period of the year 2010. The end result is a limited period of observation. This is not in itself unusual, since there are other studies with similar short period of observation (Wong et al., 1999; Gouveia et al., 2000; Fusco et al., 2001; Neuberger et al., 2004; Moshammer et al., 2006; Vigotti et al., 2007; Ostro et al., 2007), however, the problem is the small population of the Koper Municipality. Also the choice to observe only the April-October period of the observed years is not in itself unusual, since also other studies used the similar period (Stieb et al. 1996; Stedman et al., 1997; Myers et al., 2007; Fraga et al., 2011). As already explained in the Introduction section, limiting the period of observation to warm season of the year has the advantage

of some factors being standardized in this way (Fraga et al., 2011). This problem is further discussed in the section on limitations of the study.
On the basis of the recommendations for similar study designs the observed endpoints, consultations of children in primary health care facilities due to all respiratory diseases and consultations of children in primary health care facilities due to asthma symptoms in Koper Municipality, were explored/modelled by Poisson models (De Souza Tadano et al., 2012). Later in the course of the analysis it turned out that it would be sensible to use in specific parts of the analysis also logistic regression. The situation was similar to the situation described by Myers et al. (2007).

In the models ozone was included as explanatory variable. It was included in the models in all three forms used in other similar studies. All of them were observed as lags of up to 5 days, like in most of other similar studies (Castellsague et al., 1995; Stieb et al., 1996; Anderson et al., 1997; Wong et al., 1999; Gwynn et al., 2000; Braga et al., 2001; Fusco et al., 2001; Gryparis et al., 2004; Peel et al., 2005; Lee et al., 2006; Zhang et al., 2006; Myers et al., 2007; Ostro et al., 2007; Strickland et al., 2010).

The relationship between the outcome and explanatory variable of interest was adjusted for several co-factors (other air pollutants, and meteorological and seasonal factors). On the basis of available data and on the basis of relevance of relations between phenomena, PM_{10} and NO_2, as well as pollen concentrations were included as co-pollutants in the model. Adjustment for potential influenza epidemics was not necessary since only the warm season of the year was observed in which respiratory viral infection epidemics are not common (Lipfert, 1993; Fraga et al., 2011). Among meteorological factors, as in other similar studies temperature and relative humidity were modelled (Spix et al., 1993; Stieb et al., 1996; Vigotti et al., 1996; Castellsague et al., 1995; Katsouyanni et al., 1995, Anderson et al., 1997; Stedman et al., 1997; Wong et al., 1999; Gouveia et al., 2000; Gwynn et al., 2000; Hagen et al., 2000; Braga et al., 2001; Burnett et al., 2001; Conceicao et al., 2001; Fusco et al., 2001; Hajat et al., 2002; Galan et al., 2003; Neuberger et al., 2004; Peel et al., 2005; Lee et al., 2006; Zhang et al., 2006; Neuberger et al., 2007; Vigotti et al., 2007; Fraga et al., 2011), while the wind parameters were not. The reasons are discussed later in the section on limitations of the study. Among factors which vary on shorter timescale calendar specific days were included, more precisely, days of the week and holidays. Unfortunately, the information on days of the week due to short time period of observation and consequently limited number of units of observation was only possible to include in the models as a binary variable (whether it was a workday or weekend day). This is also discussed later in the section on limitations of the study in more details. It is estimated that in the given situation the most appropriate co-variates and confounding factors were chosen to assess the relationship between respiratory disease visits/consultations to the primary health care unit in the observed population group, and the level of ozone concentration with the smallest possible bias. With regard to bias which could be introduced in the study due to selection of co-variates and confounding factors included in the multivariate models, it is estimated that this bias is much less important in the given situation than the bias related to the nature of collection of data on the exposure of interest. This problem is further discussed in the section on limitation of the study.

5.2 MAIN RESULTS OF THE STUDY AND COMPARISON TO THE RESULTS OF OTHER SIMILAR STUDIES

The most important results of our study showed that there exists an association between increased ozone levels and daily occurrence of any consultation for asthma symptoms in the Koper Municipality. These results relate to the analysis of association between the ozone levels and at least one consultation for asthma on any given day in the observation period. Statistically significant association was demonstrated in the multi-pollutant model, which did not include pollen as a covariate (Table 4-28).

The model which showed statistically significant association between ozone levels (in the form of daily maximum 8-hr average concentration 70 $\mu g/m^3$ or exceeded, lag 4) and daily occurrence of any consultation for asthma symptoms, included all covariates which demonstrated at least borderline statistical significance in the uni-pollutant models according to Hosmer and Lemeshow criteria (Hosmer and Lemeshow, 2000). In the first multi-pollutant model, which did not include pollen as a covariate and was determined according to the direct method in order to estimate the contribution of all factors included on the basis of inclusion criteria, ozone still had only borderline statistical significance When the same input data were used for the model according to the stepwise method, the daily maximum 8-hr average concentration 70 $\mu g/m^3$ or exceeded, lag 4, was among the significant factors (Table 4-28). The results indicated that on days on which ozone daily maximum 8-hr average concentration reached or exceeded value of 70 $\mu g/m^3$, the odds for any consultation for asthma symptoms were 4.77-times higher than on other days. In the multi-pollutant model, which then included pollen as a covariate, as it is a strong inducer of problems in asthma patients, ozone in the direct models was constantly close to statistical significance (Tables 4-29 and 4-31). However, when the same input data were used for the model according to the stepwise method, the daily maximum 8-hr average concentration 70 μg/m^3 or exceeded, lag 4, was not among the significant factors. Nevertheless, the influence of ozone on consultations for asthma symptoms should not be considered unimportant, not even in the models including pollen. As it appears, pollen is the most important of the pollutants in the input data; however, the fact that this was a very short time-series, which could also provide different results, if extended for another year or two, should not be ignored. This is also indicated by the odds ratio, which was higher than in the model without pollen (the odds for any consultation for asthma symptoms were almost 7-times higher than on other days) (Table 4-31).

On the other hand, the results relating to the analysis of association between ozone levels and the number of consultations for all respiratory diseases on any day in the observation period show that there is no association between the observed phenomena or even that increased ozone levels are associated with reduced frequency of such consultations. These results are not consistent with results of many similar studies (Galan et al., 2003; Wong et al., 2006; Babin et al., 2007; Moura et al., 2008; Strickland et al., 2010; Fraga et al., 2011), which confirmed the positive association between observed outcome and ozone concentrations. This is probably due to the fact that most of these studies had longer time-series than ours, and, more importantly, they observed much larger populations, and consequently the observed number of observed outcomes was much larger than in our study. Other possible reasons that may account for these findings are further discussed below. However, there exist also many studies that got similar results as ours – no association between the observed outcome and ozone concentration (Castellsague et al., 1995; Schouten et al., 1996; Sunyer et al., 1997), or even very small beneficial effect rather than an adverse one (Peacock et al., 2003). The results are comparable also to the results of the study of Myers et al. (2007), which is one of the studies most similar to our study in terms of the methodology employed. Similar to our study, this study also employed logistic regression for modelling of the daily occurrence of any consultation for asthma symptoms, in addition to Poisson regression, due to a small number of consultations for asthma. The results were also similar – ozone (lagged two days) was statistically significantly associated with increased odds of at least one asthma-related medical visit per day, while the association with count of visits was not (Myers et al., 2007). In a part, our results are also similar to results reported by Ji et al. (2011) in their meta-analysis. This meta-analysis reports that by comparing results from different studies, it is evident that number of consultations for any respiratory disease in children in emergency department is not statistically significantly associated with ozone levels if all respiratory diseases are observed, but the association is statistically significant if only asthma is observed. Additionally, a meta-analysis of European studies provided a summary relative risk of 0.999 for respiratory hospital admissions in children aged 0–14 years per 10 μg/m^3 surface ozone increase (Anderson et al., 2004) as well. Such results could be mistakenly interpreted as a protective role of ozone. One should be aware that in interpretation of results of epidemiological studies, especially in assessing causality of effect of observed factor, it is always necessary to consider biological plausibility of a relationship (Dos Santos Silva, 1999). One factor that may account for these findings, is exposure misclassification (i.e. poor correlation between the commonly used surface ozone levels measured at fixed sites and personal exposure) (Dos Santos Silva, 1999), an occurrence that tends to cause an underestimation bias in the health effect estimates, particularly in urban areas (Amann et al., 2008). This applies to both, the ozone and the other pollutants included in the model. By this, even the apparently protective effect of surface ozone that has been found in some European studies could be explained (World Health Organization, Regional Office for Europe, 2005b).

In relation to the aim of the study it could be concluded on the basis of these results that with some improvements (at least a uniform method to collect health-related data, and preferably more sites to measure air pollution in more polluted areas), linkage of existing health and environmental data in Slovenia could be feasible in identifying the grounded need for public health action. In relation to objectives of the study it could be concluded that they were achieved. The temporal variability of the occurrence of respiratory diseases in the study area as well as the temporal variability of the ozone concentrations in the study area were shown, and relationship between respiratory disease visits/consultations to the primary health care unit in the observed population group, and the level of ozone concentration in the study area on the population level was assessed. In relation to the main hypothesis of the study which stated that an increased number of consultations for respiratory diseases in children in the Koper Municipality are associated with increased outdoor air concentrations of ozone it could be concluded on the basis of the results that this hypothesis was at least partly confirmed.

5.3 THE MEANING OF THE RESULTS

The results of our study indicate that problems in children with asthma in the Koper Municipality occur already in daily maximum 8-hr average concentration of 70 $\mu g/m^3$ or exceeded. This is consistent with WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulphur dioxide (World Health Organization, 2006) and indicates that we should pay attention to adverse effects of ozone in much lower concentrations than are at the moment set threshold values such as the 8-hr average target value of 120 $\mu g/m^3$.

Statistically significant or close to significant association was detected in daily maximum 8-hr average concentration of 70 $\mu g/m^3$ or exceeded, lag 4. This could be explained by the fact that patients with respiratory diseases in Slovenia are well-informed as to how to act in relation to their disease. This group also includes mothers of asthmatic children. For them, a special publication was prepared by the non-governmental organisation Pulmonary and Allergic Patients Association of Slovenia such as 'Your Child and Chronic Disease' and other publications such as 'Ambient Air, Pollution and Respiratory Tract' (Pulmonary and Allergic Patients Association of Slovenia – DPABS, 2012). The number of consultations increasing by a 4-day delay after exposure to high ozone levels could be due to the fact that mothers of asthmatic patients, particularly those who have been experiencing the disease of their child for some time, are able to manage their child's disease on their own. Only when the condition fails to improve they decide to consult a doctor. Since preventive notification of the population on the air pollution in Slovenia is also well-managed, as daily air pollution levels, in our case ozone, are daily monitored by SEA, which promptly notifies the public (Agencija Republike Slovenije za okolje, 2012b), the mothers have additional information enabling them to react accordingly. In the Koper Municipality, the Institute of Public Health Koper provides for additional information on the air pollution with ozone. According to the Institute of Public Health Koper, they have been preparing annual traditional press conferences in May since 2006 before the period of the highest air pollution with ozone. All coastal radio and television stations and news publishers attend the conference and from then on regularly inform the population of any increased air pollutions, not only with ozone. These warnings are then regularly issued by the Institute of Public Health Koper from May to September every year. The Institute of Public Health Koper also informs the population by means of a brochure prepared to this end, which is being distributed in kindergartens, schools, healthcare infirmaries and hotels (Šömen Joksić & Krek, 2008). The Institute of Public Health Koper distributes approximately 3000 brochures per year. The brochure contains all main information on ozone, consequences of increased ozone levels, applicable regulation, descriptions of each value and recommendations on how to act when ozone levels are increased. The brochure also includes a card with additional warnings and information on the current pollution in Koper. The population is also informed through the website of the Institute of Public Health Koper, where daily situation may be checked (Institute of Public Health Koper, 2012). In 2006, the Institute of Public Health Nova Gorica also began with similar notification, awareness-raising and education, being one of the most ozone-polluted areas in Slovenia (Šimac, 2008).

The facts listed above, may to a certain extent influence also the picture obtained when associating medical consultations for any respiratory disease and concentration of ozone in various forms. This indicates that increased ozone levels might be associated with lower frequency of such consultations. This result was most probably influenced by the fact that we observed a relatively short time-series on a small population, which meant relatively low frequency of the endpoint. However, this result could also be explained by the fact that people in the Koper Municipality (mostly the locals) stay at home when ozone levels are high because they are well-informed of its current levels and the adverse effects, and do not even consult a doctor, and, on the other hand, the irritation symptoms are not so pronounced they would need a consultation. Another explanation could be that local children already have chronic inflammation of the airways mucous membranes due to chronic ozone irritation and have been already prescribed a therapy.

5.4 LIMITATIONS AND STRENGTHS OF THE STUDY

5.4.1 Limitations of the study

Our study has several limitations. The first one is the data on air pollution in the Koper Municipality. The biggest problem is that the Municipality only has one fixed air pollution measuring device, making detection of any differences between individual areas in the Koper Municipality impossible. Values at particular microlocations may vary considerably from values measured on fixed measuring devices (Šömen Joksić et al., 2008). Moreover, this measuring device is the only one for the wider area of South Primorska, which also includes the Koper Municipality. One of the possibilities would be to install additional measuring devices, at least temporarily (Šömen Joksić et al., 2008), and another possibility would be to evaluate exposure to polluted air by mathematical modelling (Briggs et al., 1996; Brindley et al., 2004). In this case, the study could be upgraded with a geographical analysis taking into account places of residence of children who sought medical attention for asthma or other respiratory diseases in the observation period. At this level of research, the number of hours per day with exceeded limit values was not taken into account. It would be reasonable to do so in further research of ozone problem in the area of the Koper Municipality.

The second limitation is about the data on consultations for respiratory diseases. As it was seen during the study that the previously planned period (7 months in 2011) was too short to observe the association between ozone levels and the number of consultations for respiratory diseases in children, we wanted to extend the study to three years (2009-2011). Unfortunately, we were not able to do so since the data necessary for our study were not available for the time before 2010 because the CHCK had used the old software which did not allow for a display of information needed for the analysis in our study. Only the data for 2010 and 2011 could thus be considered in our study. The general problem in Slovenia with health-related data for the use in ecological research is the lack of uniform software for recording health-related data. The method of recording probably also varies considerably between healthcare institutions, what is indicated by the results of other similar studies in Slovenia (Kukec et al., 2012). In the study by Kukec et al., the experts for respiratory diseases participating in the research established that repeated consultations should also be taken into account in ecological studies of chronic diseases (Kukec et al., 2012). If this had been done in our study, statistical significance of the results would have further increased.

The third limitation is the data on confounding factors. One problem are data on pollen as one of important potential confounding factors in assessment of the relationship between respiratory disease visits/consultations to the primary health care unit in the observed population group, and the level of ozone concentration. The Institute of Public

Health of the Republic of Slovenia has been collecting data on pollen in Koper since 2010. Unfortunately, there were some problems in collecting the data for the year 2011, so the data was not suitable to be included in our study and the information on pollen could only be taken into account for a single season. The model with pollen included was performed on a much shorter time-series and is thus considerably less reliable. Among confounding factors that could be important for our study are also other diseases of children, in addition to asthma or other respiratory diseases. The presence of other diseases could mean that medical consultation was due to the presence of these diseases and not due to the respiratory disease or asthma itself. Eržen et al. (Eržen et al., 2010) also faced similar problems in their study from 2010. Other important confounders include the information as to which air pollution the children were exposed to in their indoor living quarters, e.g. smoking (Fischer et al., 1999), during the time when the respiratory problems arose which made the children consult a doctor. This information could be additionally useful in in-depth analysis of the problem. However, we could only get this information if another study had been conducted before or during this study aimed at evaluating the presence of such confounding factors. Similarly was done by Kukec et al. in their study examining the influence of air pollution on respiratory diseases in children in Zasavje (Kukec et al., 2013). Such study was outside the scope of our study, but it would be reasonable to perform it in the future. With such research, other information would be obtained as to which outdoor activities were performed by children with the abovementioned problems during the study and to what extent. McConnel et al. (2002) found out in their study that the increased number of asthma cases in the area where high ozone levels is also associated with outdoor play/physical activity. With regard to the potential confounders/covariates anyone could dispute that we have not included wind parameters in the models. We thought about it, but we were strongly limited by the number of units of observation. The increased number of covariates would mean reduced reliability of the models (Hosmer and Lemeshow, 2000). Therefore we decided to limit the meteorological covariates at this stage of the analysis of the problem to those, which are usually placed in the models, i.e. temperature and humidity (De Souza Tadano et al., 2012). Wind parameters are rarely included in the set of explanatory/confounding variables, consequently it was found only one paper that describes a study in which these parameters were included (Katsouyanni et al., 1995). In addition, the fact is that the wind speed and direction are predictive factors for ozone concentration, but not directly for the number of primary health care consultations. In contrast, one of predictive factors for the number of primary health care consultations is also the ozone concentration. Wind speed and direction information is therefore already mainly contained in the information on ozone concentrations. It would be sensible to include wind parameters in the model only if the number of the units would be large enough to do so. With regard to the potential confounders/covariates anyone could dispute also that we considered in the study, as already stated in the discussion about methodology of the study, only binary indicator on days of the week, precisely whether it was a workday or weekend day, and not each day separately. On week-ends in Slovenia only a limited primary health care service is provided and one would expect more patients to attend the CHCK on Mondays. However, similar as with inclusion of wind indicators, also for this indicator holds that due to short time period of observation and consequently limited number of units of observation according to criteria for sample size needed in multivariate analyses for definition of valid models (Glantz & Slinker, 1990; Harrell, 1999) inclusion of six dummy variables only for information on days of the week was impossible. Nevertheless, due to its importance the rough information on this factor, which varies on short timescale, was included in the multivariate models as a binary one.

The fourth limitation might be that children without permanent residence in the Koper Municipality were included in our analysis who came to the doctor due to current health aggravation. Particularly during summer months, there are many tourists staying in the Koper Municipality, including many children. However, we established that the majority of children seeking medical assistance in Koper Primary Health Care Centre came from the Municipality Koper (all respiratory diseases: 85%; asthma: 70%). We decided for this inclusion during the study, as the number of consultations for respiratory diseases, and specifically asthma, was small from the aspect of analytical methods. One could argue that, given that the analysis also included consultations of temporary residents of the Municipality, consultations of children staying in Ankaran in the Debeli Rtič Youth Health Resort during the tourist season should have also been included (Slovenian Red Cross, 2012a; Slovenian Red Cross, 2012b). The Health Resort has its own infirmary, and children having problems with asthma or other respiratory diseases seek medical attention in that infirmary and not in the CHCK. More than 10,000 children and adolescents under 15 years of age are treated and accommodated there (Slovenian Red Cross, 2012a; Slovenian Red Cross, 2012b). The data on the consultations of children from this institution were not included in our study simply because these additional data were not obtained in time for inclusion. If the research is to be continued, the study should be extended to include these children.

Finally, limitations in all types of data - environmental and health data, and data on important confounding factors - lead to a decrease in the number of units of observation. Consequently, the time period observed in the study was very short, what resulted in the uncertainty of results of the study. In connection with this limitation, one could dispute that only warmer period of the year was selected for observation. The choice is justifiable - in relation to the seasonal variations, the highest values of ozone are observed in the summer months (June-September) (Agencija Republike Slovenije za okolje, 2012c). Additionally, it was found that surface ozone peaks are also observed in the spring, namely in April (Carvalho et al., 2010). Thus we restricted the period of observation to the April-September months, which has been also proposed by WHO (World Health Organization, EURO, 2005b). Additionally, October was also included in the period of observation since the temperatures as well as ozone concentrations could be relatively high in this month in Koper Municipality as well (Agencija Republike Slovenije za okolje, 2008a). Restricting only to the months April-October could have negative consequences, which have already been discussed. But it could also have positive consequences in the sense of standardization of the data on some confounders, e.g seasonal influenza activity (Lipfert, 1993). Unfortunately, all of these limitations led to uncertainty of study results.

5.4.2 Strengths of the study

The study has also some strengths. The first one is the result of the study, which already in such a short time-series indicates positive association between air pollution with ozone and the number of consultations for asthma in children.

The second strength of the study is that the present study provides important information for further work in the field of health promotion in the region.

The third strength is that all issues arisen during the study represent a new challenge for further work, particularly in the field of studying the association between environmental and health-related data (ecological studies), since the results and particularly the process itself provide information as to what should be improved if such studies are to be carried out in Slovenia in the future.

5.5 CHALLENGES FOR FUTURE RESEARCH

The present study brought several starting points and challenges for future research of the problem. The first challenge is undoubtedly to harmonise the method of collecting health-related data. Across Slovenia, these data are being collected in a similar, but sufficiently different way so to hinder or even disable certain analyses in this moment. This was also demonstrated by the recent project carried out by the Chair of Public Health at the Faculty of Medicine, University of Ljubljana, entitled "The Study of Comprehensive Coupling of Health-Related and Environmental Data in Zasavje as a Study Model for Supporting Design and Implementation of Cross-Sectoral Policies in the Field of Environment and Health" (Kukec et al., 2012). Within this challenge and with regard to the conclusions of the above project, it should be examined how health-related data are being collected, particularly for chronic diseases which are long-term conditions (e.g. how an individual consultation for a chronic disease is coded and recorded in the database). Another challenge is how to increase the number of measuring sites for air pollutant measuring. A single monitoring site is certainly enough for the entire area. Neighbouring Portorož and Piran, which are strong tourist places, for example, may have a significantly higher burden of ozone than Koper and surroundings, but this is not known. If this cannot be achieved (which is a realistic possibility given the economic situation in Slovenia), it should be examined whether the only measuring device in the Koper Municipality is in the right position, and, even better, it should be considered how to evaluate exposure to polluted air by mathematical modelling (Briggs et al., 1996; Brindley et al., 2004). Due to the fact that the values at each microlocation might vary considerably from the values measured at fixed measuring devices (Šömen Joksić et al., 2008), it would be reasonable to consider geographical analysis. The third challenge would be how to additionally obtain information from the data – as previously mentioned under the limitations of the study, it would be reasonable to consider the number of hours per day with exceeded limit values in the further research of the ozone problem in the area of the Koper Municipality. The fourth challenge is how to extend the study to the entire Koper healthcare region to include consultations of children staying in Debeli rtič Health Resort in the analysis. Finally, it would be interesting to expand the observation period in the whole year. Of course in this case it would be necessary to add significant potential confounding variables that have already been discussed. In addition, in such case it may be also possible to include wind parameters in the multivariate models and evaluate their contribution.

Therefore, our study opened quite a number of challenges for future research. If they are resolved, evidence-based approach to public health activities in the field of environmental health in Slovenia would be strongly improved on the basis thereof.

5.6 THE IMPORTANCE OF THE RESULTS OF THE STUDY TO PUBLIC HEALTH

The results of the study could, together with the information provided by the various sectors in Slovenia, help to think about the public health activities in two main directions.

The first direction is the work with the population, especially in the sense of its information and rising of awareness of ozone dangers. In 2007, experts from Institute of Public Health pointed out that with regard to the harmful effects of ozone need to be set in the target group-oriented prevention programs (Krek, 2007). With the help of these programs the knowledge of parents of children in Koper Municipality on the dangers of ozone as a dangerous pollutant in air would be supplemented. In this way, they would have been provided with additional knowledge and skills, and empowered to adequately protect their children (Krek, 2007). Since then much has been done in this direction. The local population is now extensively informed (Šömen Joksić & Krek, 2008; Institute of Public Health Koper, 2012). This was already discussed previously. The question that still remains open is, how well-informed are the tourists coming to spend their holidays in the region, or even more important, what is the health risk to tourists at all. Swedish Environmental Research Institute has already over a decade ago drawn attention to the problem of ozone pollution in the southern Europe where the most serious problems occurred in densely-populated areas, often near the coasts. This was especially the case in Athens and its surroundings, in parts of the coast of eastern Spain, and the Po valley in northern Italy (Pleijel, 2000). The highest concentrations happened to occur in the most attractive tourist areas. Unfortunately our study did not succeed to include in the analysis the most susceptible population of children that are coming to spend their holidays at the coastal area from other regions of Slovenia (and wider) - children staying in Debeli rtič

Health Resort. The risk assessment, what it means for the health of tourists, if staying in the region for about 14 days, should certainly be done. However, there exist considerable methodological problems if we want to include the whole population of tourists in the analyses at the moment. For example, at the moment there is no information on detailed structure of tourists in the region available.

The second direction is to reduce sources of ozone pollution to the greatest possible extent. In accordance with the known facts what the major sources of ozone precursors are, and on the basis of previous reports, we could conclude that in the coastal area of Slovenia itself there are no very large sources of air pollution. Cities are not large, and also there is no larger industry (Agencija Republike Slovenije za okolje, 2008b). We could find road traffic as one of the major sources. In the days of the summer tourist season (mid-June to mid-September) coastal leg of Slovenian motorway network (more than 60,000 vehicles per day) and the coastal highway are very busy (more than 70,000 vehicles per day). Among the busiest main roads in Slovenia is also the main road from Koper to Izola (28,135 vehicles per day). This is partly due to tourists who spend their holidays on the Slovenian coast, and partly due to transit traffic of tourists who travel to the Croatian coast (Rejec Brancelj & Zupan, 2007). However, there exists also more distant source of pollution - the industrial and densely populated northern Italy, which starts in Trieste and continues towards the Po valley (Agencija Republike Slovenije za okolje, 2008b). It is this valley that is one of the most polluted areas in Europe producing the greatest amounts of ozone (Pleijel, 2000; Spirig et al., 2002; Bolte, 2009). It is impossible that this pollution would not impact neighbouring countries, and when western winds are blowing this pollution has certain impact on the air quality at the western border of Slovenia, where lies also a coastal region (Agencija Republike Slovenije za okolje, 2008b). Erlih and Eržen (2010) concluded in their survey that transfer of ozone air pollution from the densely populated and industrial north of Italy seems to be the main cause of pollution with ozone in the Koper Municipality. Results of their study also show that in children from Koper Municipality the respiratory diseases accumulate in the local communities that are oriented towards Italy (St. Anton, Marezige and Vanganel) (Erlih & Eržen, 2010). The fact is that the highest ozone concentrations occur in the coastal region in the summer when this region is on the western outskirts area of higher air pressure. In such situations the prevailing winds are weak west and south-west winds (Bolte, 2009; Agencija Republike Slovenije za okolje, 2012a). This hypothesis is supported by the results of other studies in Slovenia (Agencija Republike Slovenije za okolje, 2008b), and by studies in Italy (Martuzzi et al., 2006). Finally this is supported also by the findings of our study (Figure 4.23). The question is what could be done. Probably, at the local level in the near future the situation will be partly eased with the construction of a new part of the coastal highway to the Croatian border. However, the transboundary pollution with ozone is one of hardest solvable public health problems. Martuzzi et al. (2006) stressed in their study that the magnitude of the health impact estimated for the 13 Italian cities underscored the need for urgent action to reduce the health burden of air pollution. They concluded that compliance with European Union legislation could result in substantial savings in terms of ill health avoided. Also, local authorities, through policies aiming at reducing the emissions from urban transport and energy production, could achieve considerable health gains (Martuzzi et al., 2006). In any case, the (political) will to solve this problem should be on a higher level than the level of one country, or even local level because a whole region of European Union suffers from this problem.

6 CONCLUSIONS

In relation to the aim of the study it could be concluded on the basis of the results that with some improvements (at least a uniform method to collect health-related data, and preferably more sites to measure air pollution in more polluted areas), linkage of existing health and environmental data in Slovenia could be feasible in identifying the grounded need for public health action.

In relation to objectives of the study it could be concluded that they were achieved. The temporal variability of the occurrence of respiratory diseases in the study area as well as the temporal variability of the ozone concentrations in the study area were shown, and relationship between respiratory disease visits/consultations to the primary health care unit in the observed population group, and the level of ozone concentration in the study area on the population level was assessed.

In relation to the main hypothesis of the study which stated that an increased number of consultations for respiratory diseases in children in the Koper Municipality are associated with increased outdoor air concentrations of ozone it could be concluded on the basis of the results that this hypothesis was at least partly confirmed.

Yet these conclusions must be evaluated in the light of the limitations of the study in all types of input data - environmental and health data, and data on important confounding factors – that led to a decrease in the number of units of observation, and resulted in certain bias and uncertainty of results of the study.

However, despite all limitations, we believe that this study contribute some additional new insights on the problem of ozone in the coastal area of Slovenia, which can help the profession of public health in the Koper Municipality in its future activities.

Our study also opened many challenges for future research. If they are resolved, evidence-based approach to public health activities in the field of environmental health in Slovenia would be strongly improved on the basis thereof.

ACKNOWLEDGEMENTS

First of all, I would like to express my gratitude to my mentor Prof. Lijana Zaletel-Kragelj, MD, PhD, from Chair of Public health at the Faculty of Medicine, University of Ljubljana, for her effort to help me, to point my thoughts in the right direction and for her patience, understanding, encouragement and comments in a number of consultations.

I would also like to thank other co-workers at Chair of Public Health at the Faculty of Medicine, University of Ljubljana, especially to Ms. Andreja Kukec, BSc in San Eng, for her help with the gathering of literature and with the collection, preparation and analysis of data, and helping me in preparation of GIS figures on the Koper Municipality.

Furthermore, I would like to thank Milan Krek, MD, from Regional Public Health Institute Koper, who helped me with the data and was kind enough to answer any question.

Many thanks to Prof. Anamarija Jazbec, PhD, from Faculty of Forestry, University of Zagreb, Croatia, for all information and help regarding statistical analysis.

Finally, many thanks to my family and all who sincerely stood beside me and provided me with space and understanding, despite my health problems and perpetual lack of time. This allowed me to complete the study without disturbance, and who now share my happiness and joy of the final success.

REFERENCES

Agencija Republike Slovenije za okolje (2005a). Kakovost zraka v Sloveniji v letu 2002. Ljubljana: Agencija Republike Slovenije za okolje.

Agencija Republike Slovenije za okolje (2005b). Kakovost zraka v Sloveniji v letu 2003. Ljubljana: Agencija Republike Slovenije za okolje.

Agencija Republike Slovenije za okolje (2008a). Kakovost zraka v Sloveniji v letu 2007. Ljubljana: Agencija Republike Slovenije za okolje.

Agencija Republike Slovenije za okolje (2008b). Meritve onesnaženosti zraka v Lovranu nad Ankaranom od maja 2007 do junija 2008. Ljubljana: Agencija Republike Slovenije za okolje.

Agencija Republike Slovenije za okolje (2012a). Ozon – naš zaščitnik in sovražnik [Homepage on the Internet]. Avaliable from URL: www.arso.gov.si/novice/datoteke/028475-Ozon_clanek_2012.pdf. Accessed: August 10, 2012.

Agencija Republike Slovenije za okolje (2012b). Onesnaženost zraka. Povprečne urne koncentracije [Homepage on the Internet]. Avaliable from URL: http://www.arso.gov.si/zrak/kakovost%20zraka/podatki/dnevne_koncentracije.html. Accessed: August 10, 2012.

Agencija Republike Slovenije za okolje (2012c). Kakovost zraka v Sloveniji v letu 2011. Ljubljana: Agencija Republike Slovenije za okolje.

Albreht T, Turk E, Toth M, Ceglar J, Marn S, Pribaković Brinovec R, Schäfer M, Avdeeva O (ed.), Van Ginneken E (ed.) (2009). Health systems in transition: Slovenia: health system review. Health systems in transition, vol. 11, no. 3. Copenhagen: World Health Organization.

Amann M, Derwent D, Forsberg B, Hänninen O, Hurley F, Krzyzanowski M, de Leeuw F, Liu SJ, Mandin C, Schneider J, Schwarze P, D Simpson (2008). Health risks of ozone from long-range transboundary air pollution. Copenhagen: World health Organization, Regional Office for Europe. Available from URL: http://www.euro.who.int/__data/assets/pdf_file/0005/78647/E91843.pdf. Accessed: July 12, 2012.

American Academy of Pediatrics (2004). Ambient air pollution: health hazards to children. Pediatrics. 114:1699-1707.

Anderson HR, Atkinson RW, Peacock JL, Marston L, Konstantinou K (2004). Meta-Analysis of time-series studies and panel studies of particulate matter (PM) and ozone (O_3). Report of a WHO Task Group. Copenhagen: WHO Regional Office for Europe.

Anderson HR, Spix C, Medina S, Schouten JP, Castellsague J, Rossi G, Zmirou D, Touloumi G, Wojtyniak B, Ponka A, Bacharova L, Schwartz J, Katsouyanni K (1997). Air pollution and daily admissions for chronic obstructive pulmonary disease in 6 European cities: results from the APHEA project. Eur Respir J. 10:1064-71.

Babin SM, Burkom HS, Holtry RS, Tabernero NR, Stokes LD, Davies-Cole JO, DeHaan K, Lee DH (2007). Pediatric patient asthma-related emergency department visits and admissions in Washington, DC, from 2001–2004, and associations with air quality, socio-economic status and age group. Environ Health. 6:9.

Bailey D, Solomon G (2004). Pollution prevention at ports: clearing the air. Environ Impact Assess Rev 24:749–774.

Bailey L, Vardulaki K, Langham J, Chandramohan D (2005). Introduction to epidemiology. Maidenhead: Open University Press; 2005.

Balmes J (1993). The Role of Ozone Exposure in the Epidemiology of Asthma. Environ Health Perspect. 101:219-24.

Bobak M., Leon D.A. (1992). Air pollution and infant mortality in the Czech Republic, 1986-88. Lancet, 340 (8826):1010-14.

Bolte T (2009). Vpliv onesnaženega zraka na ljudi, živali in rastline. V: Cegnar T. Vreme, podnebje in zrak, ki ga dihamo. Ljubljana: Ministrstvo za okolje in prostor, Agencija RS za okolje.

Braga ALF, Saldiva PHN, Pereira LAA, Menezes JJC, Conceiceao GMS, Lin CA, Zanobetti A, Schwartz J, Dockery DW (2001). Health effects of air pollution exposure on children and adolescents in Sao Paulo, Brazil. Pediatr Pulmonol. 31:106-113.

Briggs D, Corvalan C, Nurminen M (Eds.) (1996). Linkage methods for environment and health analysis. General guidelines. Geneva: World Health Organization, Office of Global and Integrated Environmental Health.

Brindley P, Maheswaran R, Pearson T, Wise S, Haining R (2004). Using modeled outdoor air pollution data for health surveillance. In: Maheswaran R, Craglia M. GIS in public health practice. Boca Raton, FL: CRC Press.

Burnett RT, Smith-Doiron M, Stieb D, Raizenne ME, Brook JR, Dales RE, Leech JA, Cakmak S, Krewski D (2001). Association between ozone and hospitalization for acute respiratory diseases in children less than 2 years of age. Am J Epidemiol. 153:444-52.

Carvalho A, Monteiro A, Ribeiro I, Tchepel O, Miranda AI, Borrego C, Saavedra S, Souto JA, Casares JJ (2010). High ozone levels in the northeast of Portugal: Analysis and characterization. Atmosph Environ. 44:1020-31.

Castellsague J, Sunyer J, Sáez M, Antó JM (1995). Short-term association between air pollution and emergency room visits for asthma in Barcelona. Thorax. 50:1051-56.

Castro AH, Hacon S, Argento R, Junger WL, Mello CF, Castiglioni Junior N, Costa JG (2007). Air pollution and respiratory diseases in the Municipality of Vitória, Espírito Santo State, Brazil. Cad Saude Pública. 23:5630-5642.

Commitee of the Environmental and Occupational Health Assembly of the American Thoracic Society (1996). State of the art: Health Effects of Outdoor Air Pollution**.** Am J Respir Crit Care Med. 153:3-50.

Conceicao GM S, Miraglia SGEK, Kishi HS, Saldiva PHN, Singer JM. (2001). Air pollution and child mortality: A time-series study in Sao Paulo, Brazil. Environ Health Perspect. 109:347-50.

Corvalan C, Nurminen M, Pastides H (Eds.) (1997). Linkage methods for environment and health analysis. Technical guidelines. Geneva: World Health Organization, Office of Global and Integrated Environmental Health.

Coxe S, West SG, Aiken LS (2009). The analysis of count data: a gentle introduction to poisson regression and its alternatives. J Pers Assess. 91:121-36.

De Souza Tadano Y, Ugaya CML, Franco AT (2012). Methodology to assess air pollution impact on human health using the generalized linear model with Poisson Regression.

In: Khare M., ed. Air Pollution - Monitoring, Modelling and Health. Rijeka: InTech. Available from URL: http://www.intechopen.com/books/air-pollution-monitoring-modelling-and-health. Accessed: July 12, 2012.

Dietert RR, Etzel RA, Chen D, Halonen M, Holladay SD, Jarabek AM, Landreth K, Peden DB, Pinkerton K, Smialowicz RJ, Zoetis T (2000). Workshop to identify critical window of exposure for children´s health immune and respiratory systems work group summary. Environ Health Perspect. 108 (Suppl. 3):483-90.

Diette GB, McCormack MC, Hansel NN, Breysse PN, Matsui EC (2008). Environmental issues in managing asthma. Respir Care. 53:602-615.

Dos Santos Silva I (1999). Cancer Epidemiology: Principles and Methods. Lyon: IARC.

Društvo pljučnih in alergijskih bolnikov Slovenije – DPABS (2012). Društvo pljučnih in alergijskih bolnikov Slovenije [Homepage on the Internet]. Available from URL: http://www.dpbs.si/. Accessed: July 12, 2012.

Environment Protection Authority (EPA) Victoria (2012). Air [Homepage on the Internet]. Available from URL: http://www.epa.vic.gov.au/. Accessed: July 12, 2012.

Erlih S, Eržen I (2010). Geografski vzorci pojavljanja bolezni dihalnih poti otrok v občini Koper. Zdrav Var. 49:19-27.

Eržen I, Cegnar T, Podkrajšek D, Furlan N, Juričič M, Konec Juričič N, Lovrečič M, Uršič A, Zadnik V, Zaletel Kragelj L (2003). Proučevanje vpliva okolja na pojav določenih bolezni in povečano stopnjo umrljivosti prebivalcev na območju dela Mestne občine Koper*:* zaključno poročilo. Celje: Zavod za zdravstveno varstvo Celje.

Eržen I, Kukec A, Zaletel-Kragelj L (2010). Air pollution as a potential risk factor for chronic respiratory diseases in children: A prevalence study in Koper Municipality. Healthmed. 4 (Suppl 1):945-954.

European Environment Agency (2007). Air pollution in Europe in 1990-2004: No. 2. Luxemburg.

European Environment Agency (2011). Air quality in Europe - 2011 report. Luxembourg: Publications Office of the European Union. Available from URL: http://www.eea.europa.eu/publications/air-quality-in-europe-2011. Accessed: July 18, 2012.

European Parliament and the Council of the European Union. Directive 2008/50/EC of the European Parliament and of the Council of 21 may 2008 on ambient air quality and cleaner air for Europe. Officl J Europ Union. L 152/1. Available from URL: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:152:0001:0044:EN:PDF. Accessed: July 19, 2012.

Fischer T, Studnicka M, Gartner C, Tauber E, Horak F, Veiter A, Spengler J, Kühr J, Urbanek R (1999). Lung Function Growth and Ambient Ozone A Three-Year Population Study in School Children. Am J Respir Crit Care Med. 160:390-396.

Fortuol TI, Rojas-Lemus M, Rodriguez-Lara V, Cano-Gutierrez G, Gonzalez-Villalva A, Ustarroz-Cano M, Garcia-Pelaez I, Lopez-Valdez N, Falcon-Rodriguez C, Silva-Martinez J, Gonzalez-Rendon ES, Montaño LF, Cano-Gutierrez B, Bizarro-Nevares P, Colin Barenque L (2011). Air pollution and its effects in the respiratory system. In: Khallaf MK, ed. The Impact of air pollution on health, economy, environment and agricultural sources. Rijeka: InTech. p.p. 41-68. Available from URL: http://www.intechopen.com/books/the-impact-of-air-pollution-on-health-economy-environment-and-agricultural-sources. Accessed: October 10, 2012.

Fraga J, Botelho A, Sá A, Costa M, Quaresma M (2011). The lag structure and the general effect of ozone exposure on pediatric respiratory morbidity. Int J Environ Res Public Health,8:4013-24.

Franek W, DeRose L (2003). Principles and Practices of Air Pollution Control. Student Manual. APTI Course 452. Second Edition. Washington, DC: Air Pollution Training Institute (APTI). Available from URL: http://www.4cleanair.org/apti/452combined.pdf. Accessed: October 19, 2012.

Fusco D, Forastiere F, Michelozzi P, Spadea T, Ostro B, Arcà M, Perucci CA (2001). Air pollution and hospital admissions for respiratory conditions in Rome, Italy. Eur Respir J. 17:1143-50.

Galan I, Tobias A, Banegas JR (2003): Short-term effects of air pollution on daily asthma emergency room admissions. Eur Respir J. 22:802-8.

Giovannini M, Sala M, Riva E, Radaelli G (2010). Hospital admissions for respiratory conditions in children and outdoor air pollution in Southwest Milan, Italy. Acta Paediatr. 99:1180-5.

Glantz SA, Slinker BK (1990). Primer of applied regression and analysis of variance. New York: McGraw-Hill, Inc.

Gouveia N, Fletcher T (2000). Respiratory diseases in children and outdoor air pollution in Sao Paulo, Brazil: a time series analysis. Occup Environ Med. 57:477-83.

Gryparis A, Forsberg B, Katsouyanni K, Analitis A, Touloumi G, Schwartz J, Samoli E, Medina S, Ross Anderson H, Niciu EM, Wichmann HE, Kriz B, Kosnik M, Skorkovsky J, Vonk JM, Dörtburak Z (2004). Acute effects of ozone on mortality from the "Air pollution and health: A European Approach" project. Am J Respir Crit Care Med. 170:1080-87.

Gwynn RC, Burnett R T, Thurston GD (2000). A time-series analysis of acidic particulate matter and daily mortality and morbidity in the Buffalo, New York, region. Environ Health Perspect. 108:125-33.

Hagen JA, Nafstad P, Skrondal A, Bjørkly S, Magnus P (2000). Associations between outdoor air pollutants and hospitalization for respiratory diseases. Epidemiology. 11:136-40.

Hajat S, Anderson HR, Atkinson RW, Haines A (2002). Effects of air pollution on general practitioner consultations for upper respiratory diseases in London. Occup Environ Med. 59:294–299.

Hajat S, Haines A, Goubet SA, Atkinson RW, Anderson HR (1999). Association of air pollution with daily GP consultations for asthma and other lower respiratory conditions in London. Thorax. 54:597-605.

Harrell FE Jr (1999). Predicting Outcomes: Applied Survival Analysis and Logistic Regression. Charlottesville: University of Virginia.

Hosmer DW, Lemeshow S (2000). Applied logistic regression, second ed. New York: John Wiley & Sons.

Hwang BF, Lee YL, Lin YC, Jaakkola JJ, Guo YL (2005). Traffic related air pollution as a determinant of asthma among Taiwanese school children. Thorax. 60:467–473.

Inštitut za varovanje zdravja Republike Slovenije (2012). Poročilo o vsebnosti cvetnega prahu v zraku in napoved za prihodnje dni. Pollen level report and forecast [Homepage on the Internet]. Available from URL: http://www.ivz.si/cvetni_prah/vsebnost#napoved. Accessed: July 12, 2012.

Ji M, Cohan DS, Bell ML (2011). Meta-analysis of the association between short-term exposure to ambient ozone and respiratory hospital admissions. Environ Res Lett. 6(2):

Katsouyanni K, Zmirou D, Spix C, Sunyer J, Schouten JP, Pönkä A, Anderson HR, Le Moullec Y, Wojtyniak B, Vigotti MA, Bacharova L (1995). Short-term effects of air pollution on health: a European approach using epidemiological time-series data. Eur Respir J. 8:1030-38.

Krek M (2007). The role of parents in protecting children from the damaging effects of ozone (in Slovene). In: Zaletel-Kragelj L (editor). Zbornik prispevkov. Ljubljana: Medicinska fakulteta, Katedra za javno zdravje. p.116-124.

Kukec A, Farkas J, Erzen I, Zaletel-Kragelj L (2013). A prevalence study on outdoor air pollution and respiratory diseases in children in Zasavje, Slovenia, as a lever to trigger evidence-based environmental health activities. Arh Hig Rada Toksikol (accepted for publication).

Kukec A, Zaletel-Kragelj L, Bizjak M, Fink R, Jereb G, Košnik M, Močnik G, Poljšak B, Zadnik V, Farkaš-Lainščak J (2012). Študija celostnega sklapljanja zdravstvenih in okoljskih podatkov v Zasavju kot model študije za podporo pri oblikovanju in izvajanju medsektorskih politik s področja okolja in zdravja. Zaključno poročilo. Ljubljana: Center za javno zdravje, Medicinska fakulteta Univerze v Ljubljani.

Kupchella CE, Hyland CM (1992). Environmental science: Living within the systems of nature. 3rd edition. London: Prentice-Hall International.

Last JM, editor (2001). A dictionary of epidemiology. Oxford: Oxford University Press.

Lee SL, Wong WHS, Lau YL (2006). Association between air pollution and asthma admission among children in Hong Kong. Clin Experiment Allergy. 36:1138–46.

Lin S, Bell ME, Liu W, Walker RJ, Kim NK, Hwang SA (2008a). Ambient ozone concentration and hospital admissions due to childhood respiratory diseases in New York State, 1991-2001. Environ Res. 108:42-7.

Lin S, Liu X, Le LH, Hwang SA (2008b). Chronic Exposure to Ambient Ozone and Asthma Hospital Admissions among Children. Environ Health Perspect. 116:1725–1730.

Lindgren A, Stroh E, Montnemery P, Nihlen U, Jakobsson K, Axmon A (2009). Traffic-related air pollution associated with prevalence of asthma and COPD/chronic bronchitis. A cross-sectional study in Southern Sweden. Int J Health Geogr. 8:2.

Lipfer, FW (1993). A critical review of studies of the association between demands for hospital services and air pollution. Eviron Health Perspect. 101, Suppl. 2:229-68.

Lippmann M (1989). Health effects of ozone. A critical review. JAPCA. 1989 May;39(5):672-95.

Mar TF, Larson TV, Stier RA, Claiborn C, Koenig JQ (2004). An analysis of the association between respiratory symptoms in subjects with asthma and daily air pollution in Spokane, Washington. Inhal Toxicol. 16:809-15.

Martuzzi M, Mitis F, Lavarone I, Serinelli M (2006). Health impact of PM10 and ozone in 13 Italian cities. Cgagen: WHO, Regional Office for Europe, 2006.

McConnell R, Berhane K, Gilliland FD, London SJ, Islam T, Gauderman WJ, Avol E, Margolis HG, Peters JM (2002). Asthma in exercising children exposed to ozone. Lancet. 359:386-391.

Mestna občina Koper (2012). Basic and statistical data [Homepage on the Internet]. Available from URL: http://www.koper.si/index.php?page=static&item=57&tree_root=345. Accessed: July 12, 2012.

Ministrstvo za kmetijstvo in okolje Republike Slovenije in Agencija Republike Slovenije za okolje (2011). Program ocenjevanja kakovosti zraka za obdobje 2012-2014. Ljubljana: Ministrstvo za kmetijstvo in okolje Republike Slovenije in Agencija Republike Slovenije za okolje Available from URL: http://www.arso.gov.si/zrak/kakovost%20zraka/ocenjevanje%20kakovosti/Program%20ocenjevanja%202012.pdf. Accessed: October 30, 2012.

Ministrstvo za okolje in prostor Republike Slovenije (2011). Pravilnik o ocenjevanju kakovosti zunanjega zraka Ur List RS. 21(55):7771-7773. Available from URL: http://www.uradni-list.si/1/objava.jsp?urlid=201155&stevilka=2525. Accessed: July 12, 2012.

Morgenstern H (1982). Uses of ecologic analysis in epidemiologic research. Am J Public Health. 72:1336-44.

Morgenstern H, Thomas D (1993). Principles of study design in environmental epidemiology. Environ Health Perspect. 101(Suppl 4):23-38.

Morgenstern H (1998). Ecologic studies. In: Rothman KJ, Greenland S, editors. Modern Epidemiology. Philadelphia: Lippincott-Raven; 1998. pp.459-80.

Moshammer H, Hutter HP, Hauck H, Neuberger M (2006). Low levels of air pollution induce changes of lung function in a panel of schoolchildren. Eur Respir J. 27:1138–43.

Moura M, Junger WL, Silva Mendonca GA, De Leon AP (2008). Air quality and acute respiratory disorders in children. Rev Saude Publica. 42:1-8.

Myers O, Flowers H, Kang H, Bedrick E, Whorton B, Cui X, Stidley CA (2007). The association between ambient air quality ozone levels and medical visits for asthma in San Juan County. Albuquerque, NM: Environmental Health Epidemiology Bureau.

NASA Goddard Earth Sciences (GES) Data and Information Services Center (DISC) (2012). Ozone production and destruction [Homepage on the Internet]. Available from URL: http://disc.sci.gsfc.nasa.gov/ozone/additional/science-focus/about-ozone/ozone_cycle.shtml. Accessed: July 12, 2012.

Nastos PT, Paliatsos AG, Anthracopoulos MB, Roma ES, Priftis KN (2010). Outdoor particulate matter and childhood asthma admissions in Athens, Greece: a time-series study. Environmental Health. 9:45.

Neuberger M, Moshammer H, Kundi M (2002). Declining ambient air pollution and lung function improvement in Austrian children. Atmos Environ. 36:1733–6.

Neuberger M, Rabczenko D, Moshammer H (2007). Extended effects of air pollution on cardiopulmonary mortality in Vienna. Atmos Environ. 41:8549–56.

Neuberger M, Schimek MG, Horak Jr. F, Moshammer H, Kundi M, Frischer T, Gomiscek B, Puxbaum H, Hauck H, AUPHEP-Team (2004). Acute effects of particulate matter on respiratory diseases, symptoms and functions: epidemiological results of the Austrian Project on Health Effects of Particulate Matter (AUPHEP). Atmos Environ. 38:3971–81.

Orru H, Teinemaa E, Lai T, Tamm T, Kaasik M, Kimmel V, Kangur K, Merisalu E, Forsberg B (2009). Health impact assessment of particulate pollution in Tallinn using fine spatial resolution and modeling techniques. Environmental Health. 8:7.

Ostro BD, Eskeland GS, Sanchez JM, Feyzioglu T (1999). Air pollution and health effects: a study of medical visits among children in Santiago, Chile. Environ Heal Perspct. 107:69-73.

Parodi S, Bottarelli E (2006). Poisson regression model in epidemiology - an introduction. Ann Fac Medic Vet di Parma. 26:25-44.

Peacock J, Symonds P, Jackson P, Bremner S, Scarlett J, Strachan D, Anderson H (2003). Acute effects of winter air pollution on respiratory function in schoolchildren in southern England. Occup Environ Med. 60:82-9.

Peel JL, Tolbert PE, Klein M, Busico Metzger K, Flander WD, Todd K, Mulholland JA, Ryan PB, Frumkin H (2005). Ambient Air Pollution and Respiratory Emergency Department Visits. Epidemiology. 16:164-74.

Planinšek A. (2010). Ocena onesnaženosti zraka z žveplovim dioksidom, dušikovimi oksidi, delci PM_{10}, ogljikovim monoksidom, benzenom, težkimi kovinami (Pb, As, Cd, Ni) in policikličnimi aromatskimi ogljikovodiki (PAH) v Sloveniji za obdobje 2005-2009. Ljubljana: Agencija Republike Slovenije za okolje.

Pleijel H (2000). Ground-level ozone. A problem largely ignored in southern Europe. Air pollution and climate series. Göteborg: Swedish NGO Secretariat on Acid Rain.

Pope CAIII, Burnett RT, Thurston GD, Thun MJ, Calle EE, Krewski D, Godleski JJ (2004). Cardiovascular mortality and longterm exposure to particulate air pollution: Epidemiological evidence of general pathophysiological pathways of disease. Circulation. 109:71–7.

Port of Koper. Port of Koper [Homepage on the Internet]. Available from URL: http://www.luka-kp.si/eng/. Accessed: July 12, 2012.

Rdeči križ Slovenije (2012a). Letovanje in okrevanje [Homepage on the Internet]. Available from URL: http://www.rks.si/sl/Letovanje_in_okrevanje/. Accessed: August 10, 2012.

Rdeči križ Slovenije (2012b). Mladinsko zdravilišče in letovišče Rdečega Križa Slovenije Debeli rtič [Homepage on the Internet]. Available from URL: http://www.zdravilisce-debelirtic.org/. Accessed: August 10, 2012.

Rejec Brancelj I, Zupan N (2007). Okolje na dlani. Ljubljana: Ministrstvo za okolje in prostor, Agencija Republike Slovenije za okolje. Available from URL: http://eionetsi.arso.gov.si/publikacije/Datoteke/OND07/OND1_celota.pdf. Accessed: October 31, 2012.

Ren C, Tong S (2008). Health effects of ambient air pollution – recent research development and contemporary methodological challenges. Environ Health. 7:56.

Rojas-Martinez R, Perez-Padilla R, Olaiz-Fernandez G, Mendoza-Alvarado L, Moreno-Macias H, Fortoul T, McDonnell W, Loomis D, Romieu I (2007). Lung function growth in children with long-term exposure to air pollutants in Mexico city. Am J Respir Crit Care Med. 176:377–384.

Schouten JP, Vonk JM, de Graaf A (1996). Short term effects of air pollution on emergency hospital admissions for respiratory disease: results of the APHEA project in two major cities in The Netherlands, 1977-89. J Epidemiol Community Health. 50(Suppl 1): s22-s29.

Schwartz J (2004). Air pollution and children's health. Pediatrics. 113:1037-43.

Šimac N (2008). Air pollution by ozone in Nova Gorica region - evaluation of effects on human health: specialization thesis (in Slovene). Nova Gorica: Zavod za zdravstveno varstvo Nova Gorica.

Šömen Joksić A, Bažec B, Cepak F, Šturm M, Turk D (2011). Ocena vplivov na zdravje zaradi onesnaženosti zraka na obalnem območju: PM_{10} in ozon [research report]: Koper: Zavod za zdravstveno varstvo.

Šömen Joksić A, Cepak F, Škvarč S (2008). Ocena onesnaženosti zraka z ozonom v obmorskem delu Slovenije z uporabo pasivnih vzorčevalnikov. Ann Ser Hist Nat. 2008;18:59-70.

Šömen Joksić A, Krek M (2008). Priporočila občutljivim ljudem za ravnanje med povišano koncentracijo ozona. Koper: Zavod za zdravstveno varstvo Koper. Available from URL: http://www.zzv-kp.si/wp-content/uploads/letak_100x210_SLO.indd_.pdf. Accessed: August 10, 2012.

Spirig C, Neftel A, Kleinman LI, Hjorth J (2002). NOx versus VOC limitation of O_3 production in the Po valley: Local and integrated view based on observations. J Geophys Res. 107(D22): 8191. Available from URL: http://www.ecd.bnl.gov/pubs/BNL68582.pdf. Accessed: July 12, 2012.

Spix C, Heinrich J, Dockery D, Schwartz J, Völksch G, Schwinkowski K, Cöllen C, Wichmann HE (1993). Air pollution and daily mortality in Erfurt, East Germany, 1980-1989. Environ Health Perspect. 101: 518-26.

Statistični urad Republike Slovenije, SI-STAT podatkovni portal (2012). Podatki po občinah. Prebivalstvo po starosti in spolu, občine, Slovenija, polletno. Available from URL: http://pxweb.stat.si/pxweb/Dialog/varval.asp?ma=05C4002S&ti=&path=../Database/Dem_soc/05_prebivalstvo/10_stevilo_preb/20_05C40_prebivalstvo_obcine/&lang=2. Accessed: July 12, 2012.

Stedman JR, Anderson HR, Atkinson RW, Maynard RL (1997). Emergency hospital admissions for respiratory disorders attributable to summer time ozone episodes in Great Britain. Thorax. 52:958-63.

Stieb DM, Judek S, Burnett RT (2002). Meta-analysis of time-series of air pollution and mortality: effects of gases and particles and the influence of cause of death, age, and season. J Air Waste Manag Assoc. 52:470-84.

Stieb DM, RT Burnett, RC Beveridge, JR Brook (1996). Association between ozone and asthma emergency department visits in Saint John, New Brunswick, Canada. Eviron Health Perspect. 104:1354-60.

Stieb DM, Szyszkowicz M, Rowe BH, Leech JA (2009). Air pollution and emergency department visits for cardiac and respiratory conditions: a multi-city time-series analysis. Environ Health. 8:25.

Strickland MJ, Darrow LA, Klein M, Flanders WD, Sarnat JA, Waller LA, Sarnat SE, Mulholland JA, Tolbert PE (2010). Short-term associations between ambient air pollutants and pediatric asthma emergency department visits. Am J Respir Crit Care Med 182:307-316.

Sunyer J, Spix C, Quenel P, Ponce-de-Leon A, Ponka A, Barumandzadeh T, Touloumi G, Bacharova L, Wojtyniak B, Vonk J, Bisanti L, Schwartz J, Katsouyanni K (1997). Urban air pollution and emergency admissions for asthma in four European cities: the APHEA Project. Thorax. 52:760-5.

Suwanwaiphatthana W, Ruangdej K, Turner-Henson A (2010). Outdoor air pollution and children's health. Pediatr Nurs. 36:25-32.

Szklo M, Nieto FJ (2007). Epidemiology beyond the basics. Sudbury, MA: Jones and Bartlett Publishers.

Tamburlini G, Ehrenstein O S, Bertolini R (editors) (2002). Children's health and environment: A review of evidence. Luxemburg: WHO, European Environmental Agency.

U.S. Environmental Protection Agency (2010). Ozone [Homepage on the Internet]. Available from URL: http://www.epa.gov/ozone/. Accessed: June 19, 2012.

UCLA Academic Technology Services, Statistical Consulting Group (2012a). SPSS Data Analysis Examples: Logit Regression [Homepage on the Internet]. Available from URL: http://www.ats.ucla.edu/stat/spss/dae/logit.htm. Accessed: July 19, 2012.

UCLA Academic Technology Services, Statistical Consulting Group (2012b). SPSS Data Analysis Examples: Poisson Regression [Homepage on the Internet]. Available from URL: http://www.ats.ucla.edu/stat/spss/dae/poissonreg.htm. Accessed: July 19, 2012.

Ursic A, Krulec A, Zagajsek A, Tominsek L, Samardzic S (2000). Preliminary monitoring of air quality in Koper Municipality (in Slovene). Celje: ZZV Celje.

Verma M, ed. (2009). Cancer epidemiology. Volume I. Host susceptibility factors. New York, NY: Humana Press, c/o Springer Science + Business Media.

Vigotti MA, Chiaverini F, Biagiola P, Rossi G (2007). Urban air pollution and emergency visits for respiratory complaints in Pisa, Italy. J Toxicol Environ Health A. 70(3-4): 266-9.

Vigotti MA, Rossi G, Bisanti L, Zanobetti A, Schwartz J (1996). Short term effects of urban air pollution on respiratory health in Milan, Italy, 1980-89. J Epidemiol Community Health. 50(Suppl 1):S71-S75.

Vittinghoff E, Shiboski SC, Glidden DV, McCulloch CE (2005). Regression methods in biostatistics. Linear, logistic, survival, and repeated measures models. New York, NY: Springer Science+Business Media, Inc.

Vlada Republike Slovenije (2011). Uredba o kakovosti zunanjega zraka. Ur List RS. 21(9):964-983. Available from URL: http://www.uradni-list.si/1/objava.jsp?urlid=20119&stevilka=368. Accessed: July 12, 2012.

Walter SD (1991). The ecologic method in the study of environmental health. I. Overview of the method. Environ Health Perspect. 94:61-65.

Wardle DI, Kerr J, McElroy CT, Francis DR, editors (1997). Ozone science: A Canadian perspective on the changing ozone layer. Gatineau: Environment Canada. Available from URL: http://exp-studies.tor.ec.gc.ca/ozone/Summary97/download.html. Accessed: October 19, 2012.

Wong TW, Lau TS, Yu TS, Neller A, Wong SL, Tam W, Pang SW (1999). Air pollution and hospital admissions for respiratory and cardiovascular diseases in Hong Kong. Occup Environ Med. 56:679-83.

Wong TW, Tam W, Tak Sun Yu I, Wun YT, Wong AHS, Wong CM (2006). Association between air pollution and general practitioner visits for respiratory diseases in Hong Kong. Thorax. 61:585–591.

World Health Organization (2006). WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide. Global update 2005. Summary of risk assessment. Geneva: World Health Organization.

World Health Organization (2011). International Classification of Diseases (ICD) [Homepage on the Internet]. Available from URL: http://www.who.int/classifications/icd/en/. Accessed: July 12, 2012.

World Health Organization, Regional Office for Europe (2001). Quantification of the health effects of exposure to air pollution. Report on a WHO Working Group, Bilthoven, Netherlands, 20–22 November 2000. Copenhagen: WHO Regional Office for Europe.

World Health Organization, Regional Office for Europe (2003). Health aspects of air pollution with particulate matter, ozone and nitrogen dioxide. Report on a WHO Working Group. Copenhagen: World Health Organization, Regional Office for Europe.

World Health Organization, Regional Office for Europe (2005a). Air quality guidelines for Europe, 3rd ed. Copenhagen: European Series No. 91, WHO Regional Office for Europe.

World Health Organization, Regional Office for Europe (2005b). Effects of air pollution on children's health and development: a review of the evidence. Copenhagen: WHO Regional Office for Europe.

World Health Organization, Regional Office for Europe (2006). Air quality guidelines for Europe. Global Update 2005. Particular matter, ozone, nitrogen dioxide and sulfur dioxide. Copenhagen: WHO Regional Office for Europe.

World Port Source (2012). Port of Koper [Homepage on the Internet]. Available from URL: http://worldportsource.com/ports/SVN_Port_of_Koper_607.php Accessed: July 18, 2012.

Yang Q, Wang Y, Zhao C, Liu Z, Gustafson WI Jr., Shao M (2011). NOx emission reduction and its effects on ozone during the 2008 olympic games. Environ. Sci. Technol. 45:6404–10. Available from URL: http://pubs.acs.org/doi/pdf/10.1021/es200675v. Accessed: July 18, 2012.

Zanobetti A, Schwartz J, Samoli E, Gryparis A, Touloumi G, Peacock J, Anderson RH, Le Tertre A, Bobros J, Celko M, Goren A, Forsberg B, Michelozzi P, Rabczenko D, Hoyos SP, Wichmann HE, Katsouyanni K (2003). The temporal pattern of respiratory and heart disease mortality in response to air pollution. Environ Health Perspect. 111:1188-93.

Zavod za zdravstveno vasrtvo Koper (2012). Opozorilo: povišane koncentracije ozona v zraku [Homepage on the Internet]. Available from URL: http://www.zzv-kp.si/obvestila/2012/08/03/opozorilo-povisane-koncentracije-ozona-v-zraku-2/. Accessed: August 10, 2012.

Zdravstveni dom Koper (2012). Predstavitev. [Homepage on the Internet]. http://www.zd-koper.si/index.php?page=predstavitev&id=1. Available from URL: Accessed: October 19, 2012.

Zhang Y, Huang W, London SJ, Song G, Chen G, Jiang L, Zhao N, Chen B, Kan H (2006). Environ Health Perspect. 114:1227-32.

APPENDICES

APPENDIX 1

FULL UNI-POLLUTANT MODELS FOR CONSULTATIONS FOR ALL RESPIRATORY TRACT DISEASES SYMPTOMS

Ozone 24-hr average concentration

Table A1-1: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and ozone 24-hr average concentration for the uni-pollutant model for lag 0 (N=424).

Explanatory factor/covariate		IRR	95 % C.I. limits for IRR		p-value
			lower	upper	
Ozone 24-hr average concentration, lag 0		0.998	0.996	1.000	0.023
Year	2010	1.000			
	2011	0.678	0.632	0.728	<0.001
Work day	No	1.000			
	Yes	11.375	9.477	13.803	<0.001
Holiday	No	1.000			
	Yes	0.591	0.537	0.649	<0.001
Temperature 24-hr average		0.994	0.984	1.003	0.184
Relative humidity 24-hr average		0.998	0.995	1.001	0.243

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-2: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and ozone 24-hr average concentration for the uni-pollutant model for lag 1 (N=421).

Explanatory factor/covariate		IRR	95 % C.I. limits for IRR		p-value
			lower	upper	
Ozone 24-hr average concentration, lag 1		0.999	0.997	1.001	0.246
Year	2010	1.000			
	2011	0.678	0.632	0.728	<0.001
Work day	No	1.000			
	Yes	11.416	9.511	13.853	<0.001
Holiday	No	1.000			
	Yes	0.591	0.537	0.650	<0.001
Temperature 24-hr average		0.991	0.982	1.000	0.051
Relative humidity 24-hr average		0.999	0.996	1.002	0.536

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-3: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and ozone 24-hr average concentration for the uni-pollutant model for lag 2 (N=418).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Ozone 24-hr average concentration, lag 2		0.999	0.997	1.001	0.197
Year	2010	1.000			
	2011	0.679	0.632	0.729	<0.001
Work day	No	1.000			
	Yes	11.189	9.322	13.578	<0.001
Holiday	No	1.000			
	Yes	0.591	0.537	0.650	<0.001
Temperature 24-hr average		0.990	0.981	1.000	0.042
Relative humidity 24-hr average		0.999	0.996	1.002	0.565

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-4: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and ozone 24-hr average concentration for the uni-pollutant model for lag 3 (N=416).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Ozone 24-hr average concentration, lag 3		0.998	0.996	1.000	0.106
Year	2010	1.000			
	2011	0.684	0.637	0.734	<0.001
Work day	No	1.000			
	Yes	11.811	9.761	14.464	<0.001
Holiday	No	1.000			
	Yes	0.593	0.538	0.652	<0.001
Temperature 24-hr average		0.992	0.983	1.001	0.074
Relative humidity 24-hr average		0.999	0.996	1.002	0.430

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-5: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and ozone 24-hr average concentration for the uni-pollutant model for lag 4 (N=414).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Ozone 24-hr average concentration, lag 4		0.999	0.997	1.001	0.150
Year	2010	1.000			
	2011	0.683	0.636	0.733	<0.001
Work day	No	1.000			
	Yes	11.957	9.883	14.643	<0.001
Holiday	No	1.000			
	Yes	0.593	0.538	0.652	<0.001
Temperature 24-hr average		0.991	0.983	1.000	0.057
Relative humidity 24-hr average		0.999	0.996	1.002	0.559

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-6: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and ozone 24-hr average concentration for the uni-pollutant model for lag 5 (N=412).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Ozone 24-hr average concentration, lag 5		0.999	0.997	1.001	0.210
Year	2010	1.000			
	2011	0.681	0.634	0.731	<0.001
Work day	No	1.000			
	Yes	12.277	10.144	15.039	<0.001
Holiday	No	1.000			
	Yes	0.607	0.551	0.668	<0.001
Temperature 24-hr average		0.988	0.979	0.997	0.012
Relative humidity 24-hr average		0.999	0.996	1.002	0.605

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Ozone daily maximum 8-hr average concentration

Table A1-7: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and ozone daily maximum 8-hr average concentration for the uni-pollutant model for lag 0 (N=423).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average concentration, lag 0		0.997	0.995	0.999	<0.001
Year	2010	1.000			
		0.679	0.633	0.728	<0.001
Work day	No	1.000			
	Yes	11.369	9.472	13.795	<0.001
Holiday	No	1.000			
	Yes	0.595	0.540	0.654	<0.001
Temperature 24-hr average		0.998	0.988	1.007	0.634
Relative humidity 24-hr average		0.998	0.995	1.001	0.274

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-8: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and ozone daily maximum 8-hr average concentration for the uni-pollutant model for lag 1 (N=420).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average concentration, lag 1		0.997	0.995	0.999	0.001
Year	2010	1.000			
	2011	0.682	0.635	0.732	<0.001
Work day	No	1.000			
	Yes	11.370	9.472	13.797	<0.001
Holiday	No	1.000			
	Yes	0.597	0.542	0.656	<0.001
Temperature 24-hr average		0.996	0.987	1.006	0.472
Relative humidity 24-hr average		0.999	0.996	1.002	0.452

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-9: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and ozone daily maximum 8-hr average concentration for the uni-pollutant model for lag 2 (N=417).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average concentration, lag 2		0.997	0.995	0.999	<0.001
Year	2010	1.000			
	2011	0.682	0.635	0.732	<0.001
Work day	No	1.000			
	Yes	11.152	9.291	13.533	<0.001
Holiday	No	1.000			
	Yes	0.595	0.540	0.654	<0.001
Temperature 24-hr average		0.997	0.987	1.006	0.481
Relative humidity 24-hr average		0.999	0.996	1.002	0.442

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-10: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and ozone daily maximum 8-hr average concentration for the uni-pollutant model for lag 3 (N=415).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average concentration, lag 3		0.998	0.997	1.000	0.041
Year	2010	1.000			
	2011	0.682	0.635	0.732	<0.001
Work day	No	1.000			
	Yes	11.826	9.774	14.483	<0.001
Holiday	No	1.000			
	Yes	0.593	0.538	0.652	<0.001
Temperature 24-hr average		0.994	0.985	1.003	0.189
Relative humidity 24-hr average		0.999	0.996	1.002	0.471

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-11: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and ozone daily maximum 8-hr average concentration for the uni-pollutant model for lag 4 (N=413).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average concentration, lag 4		0.998	0.997	1.000	0.041
Year	2010	1.000			
	2011	0.683	0.637	0.733	<0.001
Work day	No	1.000			
	Yes	12.052	9.944	14.788	<0.001
Holiday	No	1.000			
	Yes	0.595	0.541	0.655	<0.001
Temperature 24-hr average		0.993	0.984	1.002	0.138
Relative humidity 24-hr average		0.999	0.996	1.002	0.480

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-12: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and ozone daily maximum 8-hr average concentration for the uni-pollutant model for lag 5 (N=411).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average concentration, lag 5		0.998	0.996	1.000	0.033
Year	2010	1.000			
	2011	0.683	0.636	0.733	<0.001
Work day	No	1.000			
	Yes	12.172	10.057	14.909	<0.001
Holiday	No	1.000			
	Yes	0.611	0.554	0.672	<0.001
Temperature 24-hr average		0.990	0.981	1.000	0.044
Relative humidity 24-hr average		0.999	0.996	1.002	0.573

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Ozone daily maximum 8-hr average concentration 70 μg/m^3 or exceeded

Table A1-13: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and ozone daily maximum 8-hr average concentration 70 μg/m^3 or exceeded for the uni-pollutant model for lag 0 (N=423).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average	No	1.000			
concentration 70 μg/m^3 or exceeded, lag 0	Yes	0.839	0.753	0.937	0.002
Year	2010	1.000			
	2011	0.678	0.632	0.727	<0.001
Work day	No	1.000			
	Yes	11.412	9.508	13.847	<0.001
Holiday	No	1.000			
	Yes	0.587	0.533	0.646	<0.001
Temperature 24-hr average		0.994	0.985	1.003	0.180
Relative humidity 24-hr average		0.999	0.996	1.002	0.647

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-14: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and ozone daily maximum 8-hr average concentration 70 μg/m^3 or exceeded for the uni-pollutant model for lag 1 (N=420).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average	No	1.000			
concentration 70 μg/m^3 or exceeded, lag 1	Yes	0.844	0.756	0.944	0.003
Year	2010	1.000			
	2011	0.677	0.631	0.726	<0.001
Work day	No	1.000			
	Yes	11.417	9.512	13.854	<0.001
Holiday	No	1.000			
	Yes	0.587	0.533	0.646	<0.001
Temperature 24-hr average		0.993	0.984	1.003	0.154
Relative humidity 24-hr average		0.999	0.996	1.002	0.626

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-15: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and ozone daily maximum 8-hr average concentration 70 μg/m^3 or exceeded for the uni-pollutant model for lag 2 (N=417).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average	No	1.000			
concentration 70 μg/m^3 or exceeded, lag 2	Yes	0.803	0.719	0.899	<0.001
Year	2010	1.000			
	2011	0.671	0.625	0.719	<0.001
Work day	No	1.000			
	Yes	11.219	9.347	13.614	<0.001
Holiday	No	1.000			
	Yes	0.582	0.529	0.640	<0.001
Temperature 24-hr average		0.995	0.986	1.004	0.295
Relative humidity 24-hr average		0.999	0.996	1.002	0.610

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-16: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and ozone daily maximum 8-hr average concentration 70 μg/m^3 or exceeded for the uni-pollutant model for lag 3 (N=415).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average	No	1.000			
concentration 70 μg/m^3 or exceeded, lag 3	Yes	0.915	0.817	1.028	0.131
Year	2010	1.000			
	2011	0.674	0.628	0.723	<0.001
Work day	No	1.000			
	Yes	11.852	9.796	14.514	<0.001
Holiday	No	1.000			
	Yes	0.584	0.530	0.642	<0.001
Temperature 24-hr average		0.992	0.983	1.001	0.093
Relative humidity 24-hr average		0.999	0.996	1.002	0.499

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-17: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and ozone daily maximum 8-hr average concentration 70 μg/m^3 or exceeded for the uni-pollutant model for lag 4 (N=413).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average	No	1.000			
concentration 70 μg/m^3 or exceeded, lag 4	Yes	0.946	0.835	1.075	0.390
Year	2010	1.000			
	2011	0.677	0.631	0.726	<0.001
Work day	No	1.000			
	Yes	12.038	9.932	14.771	<0.001
Holiday	No	1.000			
	Yes	0.588	0.534	0.646	<0.001
Temperature 24-hr average		0.991	0.982	1.000	0.042
Relative humidity 24-hr average		0.999	0.996	1.002	0.532

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-18: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and ozone daily maximum 8-hr average concentration 70 μg/m^3 or exceeded for the uni-pollutant model for lag 5 (N=411).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average	No	1.000			
concentration 70 μg/m^3 or exceeded, lag 5	Yes	0.862	0.759	0.983	0.025
Year	2010	1.000			
	2011	0.673	0.627	0.722	<0.001
Work day	No	1.000			
	Yes	12.113	10.010	14.835	<0.001
Holiday	No	1.000			
	Yes	0.602	0.547	0.663	<0.001
Temperature 24-hr average		0.990	0.981	0.999	0.027
Relative humidity 24-hr average		0.999	0.996	1.002	0.508

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Ozone daily maximum 8-hr average concentration 120 μg/m^3 or exceeded

Table A1-19: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and ozone daily maximum 8-hr average concentration 120 μg/m^3 or exceeded for the uni-pollutant model for lag 0 (N=423).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average	No	1.000			
concentration 120 μg/m^3 or exceeded, lag 0	Yes	0.891	0.813	0.976	0.013
Year	2010	1.000			
	2011	0.677	0.631	0.726	<0.001
Work day	No	1.000			
	Yes	11.353	9.459	13.777	<0.001
Holiday	No	1.000			
	Yes	0.596	0.542	0.656	<0.001
Temperature 24-hr average		0.993	0.984	1.002	0.116
Relative humidity 24-hr average		0.999	0.996	1.002	0.437

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-20: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and ozone daily maximum 8-hr average concentration 120 μg/m^3 or exceeded for the uni-pollutant model for lag 1 (N=420).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average	No	1.000			
concentration 120 μg/m^3 or exceeded, lag 1	Yes	0.991	0.906	1.083	0.841
Year	2010	1.000			
	2011	0.676	0.630	0.725	<0.001
Work day	No	1.000			
	Yes	11.435	9.526	13.878	<0.001
Holiday	No	1.000			
	Yes	0.590	0.535	0.649	<0.001
Temperature 24-hr average		0.989	0.980	0.998	0.017
Relative humidity 24-hr average		0.999	0.996	1.002	0.652

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-21: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and ozone daily maximum 8-hr average concentration 120 μg/m^3 or exceeded for the uni-pollutant model for lag 2 (N=417).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average	No	1.000			
concentration 120 μg/m^3 or exceeded, lag 2	Yes	0.967	0.887	1.054	0.445
Year	2010	1.000			
	2011	0.674	0.628	0.723	<0.001
Work day	No	1.000			
	Yes	11.238	9.362	13.636	<0.001
Holiday	No	1.000			
	Yes	0.588	0.534	0.647	<0.001
Temperature 24-hr average		0.990	0.981	0.999	0.028
Relative humidity 24-hr average		0.999	0.996	1.002	0.718

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-22: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and ozone daily maximum 8-hr average concentration 120 μg/m^3 or exceeded for the uni-pollutant model for lag 3 (N=415).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average	No	1.000			
concentration 120 μg/m^3 or exceeded, lag 3	Yes	0.987	0.906	1.074	0.760
Year	2010	1.000			
	2011	0.677	0.630	0.726	<0.001
Work day	No	1.000			
	Yes	11.896	9.832	14.568	<0.001
Holiday	No	1.000			
	Yes	0.585	0.531	0.644	<0.001
Temperature 24-hr average		0.991	0.982	1.000	0.040
Relative humidity 24-hr average		0.999	0.996	1.002	0.637

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-23: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and ozone daily maximum 8-hr average concentration 120 μg/m^3 or exceeded for the uni-pollutant model for lag 4 (N=413).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average	No	1.000			
concentration 120 μg/m^3 or exceeded, lag 4	Yes	0.917	0.842	0.998	0.045
Year	2010	1.000			
	2011	0.683	0.636	0.733	<0.001
Work day	No	1.000			
	Yes	12.051	9.942	14.786	<0.001
Holiday	No	1.000			
	Yes	0.595	0.540	0.654	<0.001
Temperature 24-hr average		0.992	0.983	1.001	0.072
Relative humidity 24-hr average		0.999	0.996	1.002	0.554

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-24: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and ozone daily maximum 8-hr average concentration 120 μg/m^3 or exceeded for the uni-pollutant model for lag 5 (N=411).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average	No	1.000			
concentration 120 μg/m^3 or exceeded, lag 5	Yes	0.932	0.857	1.013	0.100
Year	2010	1.000			
	2011	0.681	0.634	0.731	<0.001
Work day	No	1.000			
	Yes	12.108	10.006	14.829	<0.001
Holiday	No	1.000			
	Yes	0.609	0.553	0.671	<0.001
Temperature 24-hr average		0.989	0.980	0.998	0.013
Relative humidity 24-hr average		0.999	0.996	1.002	0.686

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Ozone daily maximum 1-hr average concentration

Table A1-25: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and ozone daily maximum 1-hr average concentration for the uni-pollutant model for lag 0 (N=424).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Ozone daily maximum 1-hr average concentration, lag 0		0.997	0.995	0.999	<0.001
Year	2010	1.000			
	2011	0.681	0.635	0.730	<0.001
Work day	No	1.000			
	Yes	11.372	9.475	13.798	<0.001
Holiday	No	1.000			
	Yes	0.592	0.538	0.651	<0.001
Temperature 24-hr average		0.998	0.989	1.008	0.758
Relative humidity 24-hr average		0.998	0.995	1.001	0.276

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-26: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and ozone daily maximum 1-hr average concentration for the uni-pollutant model for lag 1 (N=421).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Ozone daily maximum 1-hr average concentration, lag 1		0.998	0.996	0.999	0.004
Year	2010	1.000			
	2011	0.682	0.635	0.731	<0.001
Work day	No	1.000			
	Yes	11.387	9.487	13.817	<0.001
Holiday	No	1.000			
	Yes	0.592	0.538	0.651	<0.001
Temperature 24-hr average		0.996	0.986	1.006	0.433
Relative humidity 24-hr average		0.999	0.996	1.002	0.506

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-27: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and ozone daily maximum 1-hr average concentration for the uni-pollutant model for lag 2 (N=418).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Ozone daily maximum 1-hr average concentration, lag 2		0.997	0.996	0.999	0.001
Year	2010	1.000			
	2011	0.685	0.638	0.735	<0.001
Work day	No	1.000			
	Yes	11.164	9.301	13.547	<0.001
Holiday	No	1.000			
	Yes	0.594	0.540	0.653	<0.001
Temperature 24-hr average		0.996	0.986	1.005	0.383
Relative humidity 24-hr average		0.999	0.996	1.002	0.435

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-28: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and ozone daily maximum 1-hr average concentration for the uni-pollutant model for lag 3 (N=416).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Ozone daily maximum 1-hr average concentration, lag 3		0.999	0.998	1.001	0.228
Year	2010	1.000			
	2011	0.683	0.636	0.733	<0.001
Work day	No	1.000			
	Yes	11.822	9.770	14.478	<0.001
Holiday	No	1.000			
	Yes	0.592	0.537	0.651	<0.001
Temperature 24-hr average		0.992	0.983	1.001	0.080
Relative humidity 24-hr average		0.999	0.996	1.002	0.473

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-29: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and ozone daily maximum 1-hr average concentration for the uni-pollutant model for lag 4 (N=414).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Ozone daily maximum 1-hr average concentration, lag 4		0.999	0.997	1.000	0.070
Year	2010	1.000			
	2011	0.684	0.637	0.735	<0.001
Work day	No	1.000			
	Yes	11.925	9.856	14.603	<0.001
Holiday	No	1.000			
	Yes	0.595	0.541	0.655	<0.001
Temperature 24-hr average		0.992	0.983	1.001	0.100
Relative humidity 24-hr average		0.999	0.996	1.002	0.515

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-30: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and ozone daily maximum 1-hr average concentration for the uni-pollutant model for lag 5 (N=412).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Ozone daily maximum 1-hr average concentration, lag 5		0.999	0.997	1.000	0.114
Year	2010	1.000			
	2011	0.683	0.636	0.733	<0.001
Work day	No	1.000			
	Yes	12.285	10.151	15.047	<0.001
Holiday	No	1.000			
	Yes	0.610	0.554	0.672	<0.001
Temperature 24-hr average		0.989	0.980	0.998	0.021
Relative humidity 24-hr average		0.999	0.996	1.002	0.588

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

PM_{10} 24-hr average concentration

Table A1-31: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and PM_{10} 24-hr average concentration for the uni-pollutant model for lag 0 (N=424).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
PM_{10} 24-hr average concentration, lag 0		1.010	1.006	1.013	<0.001
Year	2010	1.000			
	2011	0.707	0.658	0.760	<0.001
Work day	No	1.000			
	Yes	11.910	9.842	14.586	<0.001
Holiday	No	1.000			
	Yes	0.599	0.542	0.663	<0.001
Temperature 24-hr average		0.981	0.972	0.989	<0.001
Relative humidity 24-hr average		1.002	0.999	1.005	0.205

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-32: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and PM_{10} 24-hr average concentration for the uni-pollutant model for lag 1 (N=421).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
PM_{10} 24-hr average concentration, lag 1		1.001	0.997	1.005	0.613
Year	2010	1.000			
	2011	0.690	0.642	0.741	<0.001
Work day	No	1.000			
	Yes	12.311	10.171	15.080	<0.001
Holiday	No	1.000			
	Yes	0.591	0.535	0.653	<0.001
Temperature 24-hr average		0.985	0.976	0.993	0.001
Relative humidity 24-hr average		1.001	0.998	1.004	0.708

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-33: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and PM_{10} 24-hr average concentration for the uni-pollutant model for lag 2 (N=418).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
PM_{10} 24-hr average concentration, lag 2		0.998	0.993	1.002	0.233
Year	2010	1.000			
	2011	0.692	0.645	0.743	<0.001
Work day	No	1.000			
	Yes	12.247	10.110	15.016	<0.001
Holiday	No	1.000			
	Yes	0.587	0.531	0.647	<0.001
Temperature 24-hr average		0.986	0.977	0.995	0.002
Relative humidity 24-hr average		1.000	0.997	1.003	0.843

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-34: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and PM_{10} 24-hr average concentration for the uni-pollutant model for lag 3 (N=416).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
PM_{10} 24-hr average concentration, lag 3		1.004	1.000	1.008	0.040
Year	2010	1.000			
	2011	0.696	0.649	0.748	<0.001
Work day	No	1.000			
	Yes	13.187	10.785	16.343	<0.001
Holiday	No	1.000			
	Yes	0.571	0.517	0.630	<0.001
Temperature 24-hr average		0.989	0.980	0.997	0.011
Relative humidity 24-hr average		1.000	0.997	1.003	0.854

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-35: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and PM_{10} 24-hr average concentration for the uni-pollutant model for lag 4 (N=414).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
PM_{10} 24-hr average concentration, lag 4		1.008	1.004	1.012	<0.001
Year	2010	1.000			
	2011	0.696	0.648	0.747	<0.001
Work day	No	1.000			
	Yes	13.223	10.816	16.387	<0.001
Holiday	No	1.000			
	Yes	0.563	0.511	0.621	<0.001
Temperature 24-hr average		0.990	0.982	0.998	0.020
Relative humidity 24-hr average		1.000	0.997	1.003	0.902

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-36: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and PM_{10} 24-hr average concentration for the uni-pollutant model for lag 5 (N=412).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
PM_{10} 24-hr average concentration, lag 5		1.002	0.998	1.006	0.254
Year	2010	1.000			
	2011	0.690	0.642	0.740	<0.001
Work day	No	1.000			
	Yes	13.233	10.823	16.399	<0.001
Holiday	No	1.000			
	Yes	0.588	0.532	0.648	<0.001
Temperature 24-hr average		0.986	0.977	0.995	0.002
Relative humidity 24-hr average		1.000	0.997	1.003	0.945

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

NO_2 24-hr average concentration

Table A1-37: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and NO_2 24-hr average concentration for the uni-pollutant model for lag 0 (N=414).

Explanatory factor/covariate		IRR	95 % C.I. limits for IRR		p-value
			lower	upper	
NO_2 24-hr average concentration, lag 0		1.011	1.006	1.017	<0.001
Year	2010	1.000			
	2011	0.682	0.635	0.731	<0.001
Work day	No	1.000			
	Yes	11.688	9.680	14.278	<0.001
Holiday	No	1.000			
	Yes	0.611	0.555	0.673	<0.001
Temperature 24-hr average		0.991	0.982	0.999	0.030
Relative humidity 24-hr average		1.000	0.997	1.003	0.774

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-38: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and NO_2 24-hr average concentration for the uni-pollutant model for lag 1 (N=412).

Explanatory factor/covariate		IRR	95 % C.I. limits for IRR		p-value
			lower	upper	
NO_2 24-hr average concentration, lag 1		1.011	1.002	0.996	0.600
Year	2010	1.000			
	2011	0.680	0.633	0.730	<0.001
Work day	No	1.000			
	Yes	12.450	10.269	15.280	<0.001
Holiday	No	1.000			
	Yes	0.596	0.540	0.656	<0.001
Temperature 24-hr average		0.989	0.980	0.997	0.010
Relative humidity 24-hr average		0.999	0.996	1.002	0.695

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-39: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and NO_2 24-hr average concentration for the uni-pollutant model for lag 2 (N=410).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
NO_2 24-hr average concentration, lag 2		0.998	0.992	10.004	0.500
Year	2010	1.000			
	2011	0.675	0.629	0.725	<0.001
Work day	No	1.000			
	Yes	11.718	9.706	14.313	<0.001
Holiday	No	1.000			
	Yes	0.591	0.536	0.651	<0.001
Temperature 24-hr average		0.989	0.981	0.997	0.011
Relative humidity 24-hr average		0.999	0.996	1.002	0.675

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-40: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and NO_2 24-hr average concentration for the uni-pollutant model for lag 3 (N=409).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
NO_2 24-hr average concentration, lag 3		1.001	0.996	1.006	0.656
Year	2010	1.000			
	2011	0.683	0.636	0.734	<0.001
Work day	No	1.000			
	Yes	12.823	10.530	15.819	<0.001
Holiday	No	1.000			
	Yes	0.583	0.528	0.642	<0.001
Temperature 24-hr average		0.991	0.982	0.999	0.035
Relative humidity 24-hr average		0.999	0.996	1.002	0.642

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-41: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and NO_2 24-hr average concentration for the uni-pollutant model for lag 4 (N=408).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
NO_2 24-hr average concentration, lag 4		1.006	1.001	1.012	0.015
Year	2010	1.000			
	2011	0.687	0.639	0.737	<0.001
Work day	No	1.000			
	Yes	13.020	10.691	16.063	<0.001
Holiday	No	1.000			
	Yes	0.581	0.526	0.640	<0.001
Temperature 24-hr average		0.992	0.983	1.001	0.066
Relative humidity 24-hr average		0.999	0.997	1.002	0.739

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-42: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and NO_2 24-hr average concentration for the uni-pollutant model for lag 5 (N=407).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
NO_2 24-hr average concentration, lag 0		1.008	1.003	1.014	0.001
Year	2010	1.000			
	2011	0.683	0.636	0.733	<0.001
Work day	No	1.000			
	Yes	12.394	10.242	15.179	<0.001
Holiday	No	1.000			
	Yes	0.596	0.539	0.657	<0.001
Temperature 24-hr average		0.991	0.982	0.999	0.036
Relative humidity 24-hr average		1.000	0.997	1.003	0.929

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Daily average pollen concentration

Table A1-43: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and daily average pollen concentration for the uni-pollutant model for lag 0 (N=212).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Pollen concentration 24-hr average, lag 0		0.999	0.999	1.000	0.003
Work day	No	1.000			
	Yes	6.433	5.345	7.825	<0.001
Holiday	No	1.000			
	Yes	0.579	0.506	0.661	<0.001
Temperature 24-hr average		0.990	0.979	1.002	0.100
Relative humidity 24-hr average		0.995	0.991	0.999	0.011

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-44: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and daily average pollen concentration for the uni-pollutant model for lag 1 (N=211).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Pollen concentration 24-hr average. lag 1		1.000	0.999	1.000	0.270
Work day	No	1.000			
	Yes	6.388	5.306	7.772	<0.001
Holiday	No	1.000			
	Yes	0.592	0.518	0.677	<0.001
Temperature 24-hr average		0.990	0.979	1.002	0.100
Relative humidity 24-hr average		0.996	0.992	1.000	0.029

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-45: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and daily average pollen concentration for the uni-pollutant model for lag 2 (N=210).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Pollen concentration 24-hr average, lag 2		1.000	0.999	1.000	0.148
Work day	No	1.000			
	Yes	6.415	5.329	7.804	<0.001
Holiday	No	1.000			
	Yes	0.591	0.517	0.675	<0.001
Temperature 24-hr average		0.989	0.978	1.001	0.078
Relative humidity 24-hr average		0.996	0.992	1.000	0.045

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-46: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and daily average pollen concentration for the uni-pollutant model for lag 3 (N=209).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Pollen concentration 24-hr average, lag 3		1.000	0.999	1.000	0.538
Work day	No	1.000			
	Yes	6.903	5.690	8.474	<0.001
Holiday	No	1.000			
	Yes	0.597	0.522	0.681	<0.001
Temperature 24-hr average		0.990	0.979	1.002	0.098
Relative humidity 24-hr average		0.996	0.992	1.000	0.030

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-47: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and daily average pollen concentration for the uni-pollutant model for lag 4 (N=208).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Pollen concentration 24-hr average, lag 4		0.999	0.999	1.000	0.020
Work day	No	1.000			
	Yes	6.802	5.607	8.349	<0.001
Holiday	No	1.000			
	Yes	0.586	0.512	0.669	<0.001
Temperature 24-hr average		0.991	0.979	1.002	0.120
Relative humidity 24-hr average		0.995	0.991	0.999	0.020

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

Table A1-48: Results of the Poisson regression analysis of association between consultations for all respiratory tract diseases symptoms and daily average pollen concentration for the uni-pollutant model for lag 5 (N=207).

Explanatory factor/covariate		**IRR**	**95 % C.I. limits for IRR**		**p-value**
			lower	upper	
Pollen concentration 24-hr average, lag 5		0.999	0.999	1.000	0.003
Work day	No	1.000			
	Yes	6.949	5.728	8.530	<0.001
Holiday	No	1.000			
	Yes	0.612	0.533	0.701	<0.001
Temperature 24-hr average		0.987	0.975	0.999	0.034
Relative humidity 24-hr average		0.996	0.992	1.000	0.032

Abbreviations: IRR – incident rate ratio; C.I. – confidence interval; N – number of days

APPENDIX 2

FULL UNI-POLLUTANT MODELS FOR CONSULTATIONS FOR ASTHMA SYMPTOMS

Ozone 24-hr average concentration

Table A2-1: Results of the logistic regression analysis of association between consultations for asthma symptoms and ozone 24-hr average concentration for the uni-pollutant model for lag 0 (N=424).

Explanatory factor/covariate		OR	95 % C.I. limits for OR		p-value
			lower	upper	
Ozone 24-hr average concentration, lag 0		1.005	0.989	1.021	0.562
Year	2010	1.000			
	2011	0.384	0.221	0.667	0.001
Work day	No	1.000			
	Yes	4.873	2.144	11.075	<0.001
Holiday	No	1.000			
	Yes	0.327	0.160	0.668	0.002
Temperature 24-hr average		1.082	1.002	1.170	0.045
Relative humidity 24-hr average		0.998	0.974	1.023	0.865

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-2: Results of the logistic regression analysis of association between consultations for asthma symptoms and ozone 24-hr average concentration for the uni-pollutant model for lag 1 (N=421).

Explanatory factor/covariate		OR	95 % C.I. limits for OR		p-value
			lower	upper	
Ozone 24-hr average concentration, lag 1		1.002	0.986	1.017	0.846
Year	2010	1.000			
	2011	0.377	0.215	0.659	0.001
Work day	No	1.000			
	Yes	4.766	2.093	10.856	<0.001
Holiday	No	1.000			
	Yes	0.317	0.154	0.652	0.002
Temperature 24-hr average		1.104	1.021	1.194	0.013
Relative humidity 24-hr average		1.002	0.978	1.027	0.868

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-3: Results of the logistic regression analysis of association between consultations for asthma symptoms and ozone 24-hr average concentration for the uni-pollutant model for lag 2 (N=418).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Ozone 24-hr average concentration, lag 2		0.999	0.984	1.015	0.947
Year	2010	1.000			
	2011	0.379	0.217	0.664	0.001
Work day	No	1.000			
	Yes	4.698	2.062	10.705	<0.001
Holiday	No	1.000			
	Yes	0.322	0.157	0.660	0.002
Temperature 24-hr average		1.106	1.024	1.195	0.011
Relative humidity 24-hr average		1.002	0.978	1.027	0.865

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-4: Results of the logistic regression analysis of association between consultations for asthma symptoms and ozone 24-hr average concentration for the uni-pollutant model for lag 3 (N=416).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Ozone 24-hr average concentration, lag 3		0.995	0.980	1.011	0.547
Year	2010	1.000			
	2011	0.382	0.219	0.666	0.001
Work day	No	1.000			
	Yes	4.590	2.014	10.460	<0.001
Holiday	No	1.000			
	Yes	0.340	0.166	0.697	0.003
Temperature 24-hr average		1.101	1.022	1.186	0.011
Relative humidity 24-hr average		1.000	0.977	1.025	0.970

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-5: Results of the logistic regression analysis of association between consultations for asthma symptoms and ozone 24-hr average concentration for the uni-pollutant model for lag 4 (N=414).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Ozone 24-hr average concentration, lag 4		1.000	0.984	1.015	0.976
Year	2010	1.000			
	2011	0.376	0.215	0.656	0.001
Work day	No	1.000			
	Yes	4.738	2.081	10.787	<0.001
Holiday	No	1.000			
	Yes	0.333	0.162	0.683	0.003
Temperature 24-hr average		1.092	1.014	1.176	0.020
Relative humidity 24-hr average		1.002	0.978	1.026	0.884

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-6: Results of the logistic regression analysis of association between consultations for asthma symptoms and ozone 24-hr average concentration for the uni-pollutant model for lag 5 (N=412).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Ozone 24-hr average concentration, lag 5		0.993	0.977	1.009	0.370
Year	2010	1.000			
	2011	0.388	0.223	0.678	0.001
Work day	No	1.000			
	Yes	5.027	2.196	11.512	<0.001
Holiday	No	1.000			
	Yes	0.346	0.169	0.712	0.004
Temperature 24-hr average		1.099	1.019	1.185	0.015
Relative humidity 24-hr average		1.000	0.977	1.024	0.988

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Ozone daily maximum 8-hr average concentration

Table A2-7: Results of the logistic regression analysis of association between consultations for asthma symptoms and ozone daily maximum 8-hr average concentration for the uni-pollutant model for lag 0 (N=423).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average concentration, lag 0		0.999	0.985	1.013	0.906
Year	2010	1.000			
	2011	0.380	0.219	0.661	0.001
Work day	No	1.000			
	Yes	4.878	2.146	11.087	<0.001
Holiday	No	1.000			
	Yes	0.319	0.155	0.653	0.002
Temperature 24-hr average		1.100	1.014	1.193	0.021
Relative humidity 24-hr average		0.996	0.973	1.020	0.732

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-8: Results of the logistic regression analysis of association between consultations for asthma symptoms and ozone daily maximum 8-hr average concentration for the uni-pollutant model for lag 1 (N=420).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average concentration, lag 1		1.005	0.991	1.019	0.459
Year	2010	1.000			
	2011	0.367	0.209	0.643	<0.001
Work day	No	1.000			
	Yes	4.890	2.142	11.162	<0.001
Holiday	No	1.000			
	Yes	0.303	0.147	0.627	0.001
Temperature 24-hr average		1.095	1.010	1.188	0.028
Relative humidity 24-hr average		1.003	0.979	1.028	0.782

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-9: Results of the logistic regression analysis of association between consultations for asthma symptoms and ozone daily maximum 8-hr average concentration for the uni-pollutant model for lag 2 (N=417).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average concentration, lag 2		0.998	0.984	1.011	0.741
Year	2010	1.000			
	2011	0.390	0.223	0.682	0.001
Work day	No	1.000			
	Yes	4.613	2.025	10.510	<0.001
Holiday	No	1.000			
	Yes	0.336	0.163	0.692	0.003
Temperature 24-hr average		1.107	1.022	1.199	0.013
Relative humidity 24-hr average		1.001	0.977	1.026	0.924

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-10: Results of the logistic regression analysis of association between consultations for asthma symptoms and ozone daily maximum 8-hr average concentration for the uni-pollutant model for lag 3 (N=415).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average concentration, lag 3		1.003	0.990	1.016	0.670
Year	2010	1.000			
	2011	0.364	0.208	0.636	<0.001
Work day	No	1.000			
	Yes	4.751	2.083	10.839	<0.001
Holiday	No	1.000			
	Yes	0.317	0.153	0.655	0.002
Temperature 24-hr average		1.089	1.009	1.176	0.028
Relative humidity 24-hr average		1.002	0.979	1.027	0,845

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-11: Results of the logistic regression analysis of association between consultations for asthma symptoms and ozone daily maximum 8-hr average concentration for the uni-pollutant model for lag 4 (N=413).

Explanatory factor/covariate		OR	95 % C.I. limits for OR		p-value
			lower	upper	
Ozone daily maximum 8-hr average concentration, lag 4		1.001	0.988	1.015	0.846
Year	2010	1.000			
	2011	0.372	0.213	0.649	<0.001
Work day	No	1.000			
	Yes	4.654	2.044	10.597	<0.001
Holiday	No	1.000			
	Yes	0.329	0.160	0.676	0.002
Temperature 24-hr average		1.089	1.009	1.175	0.028
Relative humidity 24-hr average		1.002	0.979	1.027	0.854

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-12: Results of the logistic regression analysis of association between consultations for asthma symptoms and ozone daily maximum 8-hr average concentration for the uni-pollutant model for lag 5 (N=411).

Explanatory factor/covariate		OR	95 % C.I. limits for OR		p-value
			lower	upper	
Ozone daily maximum 8-hr average concentration, lag 5		0.988	0.975	1.002	0.095
Year	2010	1.000			
	2011	0.392	0.225	0.683	0.001
Work day	No	1.000			
	Yes	5.115	2.230	11.731	<0.001
Holiday	No	1.000			
	Yes	0.358	0.174	0.738	0.005
Temperature 24-hr average		1.115	1.031	1.206	0.007
Relative humidity 24-hr average		1.000	0.976	1.024	0.968

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Ozone daily maximum 8-hr average concentration 70 µg/m³ or exceeded

Table A2-13: Results of the logistic regression analysis of association between consultations for asthma symptoms and ozone daily maximum 8-hr average concentration 70 µg/m³ or exceeded for the uni-pollutant model for lag 0 (N=423).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average	No	1.000			
concentration 70 µg/m³ or exceeded, lag 0	Yes	0.687	0.262	1.797	0.444
Year	2010	1.000			
	2011	0.381	0.219	0.661	0.001
Work day	No	1.000			
	Yes	4.840	2.129	11.001	<0.001
Holiday	No	1.000			
	Yes	0.314	0.153	0.645	0.002
Temperature 24-hr average		1.108	1.028	1.195	0.007
Relative humidity 24-hr average		0.996	0.973	1.020	0.746

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-14: Results of the logistic regression analysis of association between consultations for asthma symptoms and ozone daily maximum 8-hr average concentration 70 µg/m³ or exceeded for the uni-pollutant model for lag 1 (N=420).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average	No	1.000			
concentration 70 µg/m³ or exceeded, lag 1	Yes	1.857	0.581	5.940	0.297
Year	2010	1.000			
	2011	0.371	0.212	0.648	0.001
Work day	No	1.000			
	Yes	4.885	2.142	11.142	<0.001
Holiday	No	1.000			
	Yes	0.314	0.153	0.645	0.002
Temperature 24-hr average		1.097	1.017	1.184	0.017
Relative humidity 24-hr average		1.003	0.979	1.027	0.819

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-15: Results of the logistic regression analysis of association between consultations for asthma symptoms and ozone daily maximum 8-hr average concentration 70 µg/m³ or exceeded for the uni-pollutant model for lag 2 (N=417).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average	No	1.000			
concentration 70 µg/m³ or exceeded, lag 2	Yes	1.211	0.408	3.596	0.730
Year	2010	1.000			
	2011	0.387	0.222	0.676	0.001
Work day	No	1.000			
	Yes	4.651	2.042	10.594	<0.001
Holiday	No	1.000			
	Yes	0.334	0.163	0.685	0.003
Temperature 24-hr average		1.096	1.016	1.183	0.018
Relative humidity 24-hr average		1.002	0.978	1.026	0.892

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-16: Results of the logistic regression analysis of association between consultations for asthma symptoms and ozone daily maximum 8-hr average concentration 70 µg/m³ or exceeded for the uni-pollutant model for lag 3 (N=415).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average	No	1.000			
concentration 70 µg/m³ or exceeded, lag 3	Yes	1.931	0.604	6.177	0.267
Year	2010	1.000			
	2011	0.370	0.212	0.646	<0.001
Work day	No	1.000			
	Yes	4.809	2.107	10.975	<0.001
Holiday	No	1.000			
	Yes	0.326	0.160	0.667	0.002
Temperature 24-hr average		1.083	1.006	1.167	0.034
Relative humidity 24-hr average		1.004	0.980	1.028	0.772

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-17: Results of the logistic regression analysis of association between consultations for asthma symptoms and ozone daily maximum 8-hr average concentration 70 μg/m^3 or exceeded for the uni-pollutant model for lag 4 (N=413).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average	No	1.000			
concentration 70 μg/m^3 or exceeded, lag 4	Yes	3.571	0.775	16.447	0.102
Year	2010	1.000			
	2011	0.381	0.218	0.665	0.001
Work day	No	1.000			
	Yes	4.654	2.041	10.615	<0.001
Holiday	No	1.000			
	Yes	0.345	0.170	0.703	0.003
Temperature 24-hr average		1.071	0.995	1.153	0.068
Relative humidity 24-hr average		1.005	0.981	1.030	0.693

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-18: Results of the logistic regression analysis of association between consultations for asthma symptoms and ozone daily maximum 8-hr average concentration 70 μg/m^3 or exceeded for the uni-pollutant model for lag 5 (N=411).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average	No	1.000			
concentration 70 μg/m^3 or exceeded, lag 5	Yes	0.625	0.213	1.833	0.392
Year	2010	1.000			
	2011	0.371	0.213	0.645	<0.001
Work day	No	1.000			
	Yes	4.866	2.131	11.115	<0.001
Holiday	No	1.000			
	Yes	0.332	0.161	0.685	0.003
Temperature 24-hr average		1.098	1.018	1.186	0.016
Relative humidity 24-hr average		1.000	0.977	1.024	0.998

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Ozone daily maximum 8-hr average concentration 120 µg/m³ or exceeded

Table A2-19: Results of the logistic regression analysis of association between consultations for asthma symptoms and ozone daily maximum 8-hr average concentration 120 µg/m³ or exceeded for the uni-pollutant model for lag 0 (N=423).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average	No	1.000			
concentration 120 µg/m³ or exceeded, lag 0	Yes	0.800	0.414	1.547	0.507
Year	2010	1.000			
	2011	0.380	0.219	0.661	0.001
Work day	No	1.000			
	Yes	4.834	2.125	10.993	<0.001
Holiday	No	1.000			
	Yes	0.325	0.158	0.666	0.002
Temperature 24-hr average		1.107	1.027	1.194	0.008
Relative humidity 24-hr average		0.995	0.972	1.019	0.698

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-20: Results of the logistic regression analysis of association between consultations for asthma symptoms and ozone daily maximum 8-hr average concentration 120 µg/m³ or exceeded for the uni-pollutant model for lag 1 (N=420).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average	No	1.000			
concentration 120 µg/m³ or exceeded, lag 1	Yes	0.960	0.501	1.840	0.902
Year	2010	1.000			
	2011	0.373	0.213	0.653	0.001
Work day	No	1.000			
	Yes	4.794	2.101	10.937	<0.001
Holiday	No	1.000			
	Yes	0.312	0.151	0.645	0.002
Temperature 24-hr average		1.112	1.030	1.201	0.007
Relative humidity 24-hr average		1.003	0.979	1.027	0.814

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-21: Results of the logistic regression analysis of association between consultations for asthma symptoms and ozone daily maximum 8-hr average concentration 120 μg/m^3 or exceeded for the uni-pollutant model for lag 2 (N=417).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average	No	1.000			
concentration 120 μg/m^3 or exceeded, lag 2	Yes	0.922	0.487	1.747	0.803
Year	2010	1.000			
	2011	0.388	0.222	0.679	0.001
Work day	No	1.000			
	Yes	4.634	2.035	10.551	<0.001
Holiday	No	1.000			
	Yes	0.335	0.163	0.689	0.003
Temperature 24-hr average		1.104	1.023	1.192	0.011
Relative humidity 24-hr average		1.001	0.978	1.026	0.912

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-22: Results of the logistic regression analysis of association between consultations for asthma symptoms and ozone daily maximum 8-hr average concentration 120 μg/m^3 or exceeded for the uni-pollutant model for lag 3 (N=415).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average	No	1.000			
concentration 120 μg/m^3 or exceeded, lag 3	Yes	1.407	0.758	2.609	0.279
Year	2010	1.000			
	2011	0.358	0.204	0.626	<0.001
Work day	No	1.000			
	Yes	4.661	2.044	10.628	<0.001
Holiday	No	1.000			
	Yes	0.311	0.151	0.641	0.002
Temperature 24-hr average		1.083	1.006	1.167	0.035
Relative humidity 24-hr average		1.003	0.979	1.027	0.819

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-23: Results of the logistic regression analysis of association between consultations for asthma symptoms and ozone daily maximum 8-hr average concentration 120 μg/m^3 or exceeded for the uni-pollutant model for lag 4 (N=413).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average	No	1.000			
concentration 120 μg/m^3 or exceeded, lag 4	Yes	0.718	0.382	1.351	0.304
Year	2010	1.000			
	2011	0.382	0.220	0.666	0.001
Work day	No	1.000			
	Yes	4.706	2.065	10.724	<0.001
Holiday	No	1.000			
	Yes	0.343	0.168	0.703	0.003
Temperature 24-hr average		1.103	1.024	1.187	0.009
Relative humidity 24-hr average		1.001	0.978	1.026	0.911

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-24: Results of the logistic regression analysis of association between consultations for asthma symptoms and ozone daily maximum 8-hr average concentration 120 μg/m^3 or exceeded for the uni-pollutant model for lag 5 (N=411).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Ozone daily maximum 8-hr average	No	1.000			
concentration 120 μg/m^3 or exceeded, lag 5	Yes	0.387	0.197	0.759	0.006
Year	2010	1.000			
	2011	0.397	0.227	0.694	0.001
Work day	No	1.000			
	Yes	5.175	2.260	11.848	<0.001
Holiday	No	1.000			
	Yes	0.365	0.176	0.754	0.007
Temperature 24-hr average		1.119	1.038	1.206	0.004
Relative humidity 24-hr average		1.001	0.978	1.025	0.923

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Ozone daily maximum 1-hr average concentration

Table A2-25: Results of the logistic regression analysis of association between consultations for asthma symptoms and ozone daily maximum 1-hr average concentration for the uni-pollutant model for lag 0 (N=424).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Ozone daily maximum 1-hr average concentration, lag 0		1.000	0.987	1.013	0.980
Year	2010	1.000			
	2011	0.388	0.223	0.672	0.001
Work day	No	1.000			
	Yes	4.832	2.128	10.976	<0.001
Holiday	No	1.000			
	Yes	0.328	0.161	0.670	0.002
Temperature 24-hr average		1.093	1.007	1.186	0.033
Relative humidity 24-hr average		0.996	0.973	1.020	0.735

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-26: Results of the logistic regression analysis of association between consultations for asthma symptoms and ozone daily maximum 1-hr average concentration for the uni-pollutant model for lag 1 (N=421).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Ozone daily maximum 1-hr average concentration, lag 1		1.007	0.994	1.021	0.265
Year	2010	1.000			
	2011	0.367	0.209	0.644	<0.001
Work day	No	1.000			
	Yes	4.858	2.129	11.085	<0.001
Holiday	No	1.000			
	Yes	0.312	0.151	0.643	0.002
Temperature 24-hr average		1.082	0.997	1.175	0.060
Relative humidity 24-hr average		1.002	0.978	1.027	0.851

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-27: Results of the logistic regression analysis of association between consultations for asthma symptoms and ozone daily maximum 1-hr average concentration for the uni-pollutant model for lag 2 (N=418).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Ozone daily maximum 1-hr average concentration, lag 2		1.004	0.992	1.016	0.538
Year	2010	1.000			
	2011	0.371	0.211	0.650	0.001
Work day	No	1.000			
	Yes	4.739	2.079	10.801	<0.001
Holiday	No	1.000			
	Yes	0.316	0.153	0.650	0.002
Temperature 24-hr average		1.093	1.008	1.184	0.031
Relative humidity 24-hr average		1.003	0.979	1.027	0.827

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-28: Results of the logistic regression analysis of association between consultations for asthma symptoms and ozone daily maximum 1-hr average concentration for the uni-pollutant model for lag 3 (N=416).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Ozone daily maximum 1-hr average concentration, lag 3		1.002	0.990	1.014	0.784
Year	2010	1.000			
	2011	0.370	0.212	0.648	<0.001
Work day	No	1.000			
	Yes	4.690	2.057	10.693	<0.001
Holiday	No	1.000			
	Yes	0.327	0.159	0.673	0.002
Temperature 24-hr average		1.089	1.009	1.176	0.028
Relative humidity 24-hr average		1.002	0.978	1.026	0.891

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-29: Results of the logistic regression analysis of association between consultations for asthma symptoms and ozone daily maximum 1-hr average concentration for the uni-pollutant model for lag 4 (N=414).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Ozone daily maximum 1-hr average concentration, lag 4		1.000	0.988	1.012	0.994
Year	2010	1.000			
	2011	0.375	0.215	0.655	0.001
Work day	No	1.000			
	Yes	4.738	2.081	10.788	<0.001
Holiday	No	1.000			
	Yes	0.333	0.162	0.684	0.003
Temperature 24-hr average		1.092	1.012	1.177	0.023
Relative humidity 24-hr average		1.002	0.978	1.026	0.882

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-30: Results of the logistic regression analysis of association between consultations for asthma symptoms and ozone daily maximum 1-hr average concentration for the uni-pollutant model for lag 5 (N=412).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Ozone daily maximum 1-hr average concentration, lag 5		0.990	0.978	1.002	0.117
Year	2010	1.000			
	2011	0.397	0.227	0.692	0.001
Work day	No	1.000			
	Yes	5.132	2.242	11.748	<0.001
Holiday	No	1.000			
	Yes	0.359	0.174	0.738	0.005
Temperature 24-hr average		1.112	1.029	1.202	0.008
Relative humidity 24-hr average		1.000	0.976	1.024	0.971

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

PM_{10} 24-hr average concentration

Table A2-31: Results of the logistic regression analysis of association between consultations for asthma symptoms and PM_{10} 24-hr average concentration for the uni-pollutant model for lag 0 (N=424).

Explanatory factor/covariate		OR	95 % C.I. limits for OR		p-value
			lower	upper	
PM_{10} 24-hr average concentration, lag 0		1.031	1.001	1.063	0.045
Year	2010	1.000			
	2011	0.409	0.233	0.718	0.002
Work day	No	1.000			
	Yes	4.440	1.943	10.146	<0.001
Holiday	No	1.000			
	Yes	0.360	0.170	0.762	0.008
Temperature 24-hr average		1.072	0.997	1.152	0.060
Relative humidity 24-hr average		0.999	0.976	1.024	0.964

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-32: Results of the logistic regression analysis of association between consultations for asthma symptoms and PM_{10} 24-hr average concentration for the uni-pollutant model for lag 1 (N=421).

Explanatory factor/covariate		OR	95 % C.I. limits for OR		p-value
			lower	upper	
PM_{10} 24-hr average concentration, lag 1		1.031	0.999	1.064	0.056
Year	2010	1.000			
	2011	0.392	0.222	0.694	0.001
Work day	No	1.000			
	Yes	4.864	2.112	11.202	<0.001
Holiday	No	1.000			
	Yes	0.334	0.157	0.710	0.004
Temperature 24-hr average		1.090	1.011	1.174	0.024
Relative humidity 24-hr average		1.002	0.978	1.027	0.845

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-33: Results of the logistic regression analysis of association between consultations for asthma symptoms and PM_{10} 24-hr average concentration for the uni-pollutant model for lag 2 (N=418).

Explanatory factor/covariate		OR	95 % C.I. limits for OR		p-value
			lower	upper	
PM_{10} 24-hr average concentration, lag 2		1.033	1.002	1.065	0.038
Year	2010	1.000			
	2011	0.401	0.227	0.706	0.002
Work day	No	1.000			
	Yes	4.908	2.136	11.278	<0.001
Holiday	No	1.000			
	Yes	0.305	0.143	0.647	0.002
Temperature 24-hr average		1.100	1.022	1.185	0.011
Relative humidity 24-hr average		1.002	0.978	1.027	0.881

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-34: Results of the logistic regression analysis of association between consultations for asthma symptoms and PM_{10} 24-hr average concentration for the uni-pollutant model for lag 3 (N=416).

Explanatory factor/covariate		OR	95 % C.I. limits for OR		p-value
			lower	upper	
PM_{10} 24-hr average concentration, lag 3		1.005	0.975	1.036	0.749
Year	2010	1.000			
	2011	0.389	0.223	0.681	0.001
Work day	No	1.000			
	Yes	4.543	1.990	10.372	<0.001
Holiday	No	1.000			
	Yes	0.308	0.148	0.643	0.002
Temperature 24-hr average		1.097	1.021	1.178	0.012
Relative humidity 24-hr average		1.000	0.976	1.024	0.984

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-35: Results of the logistic regression analysis of association between consultations for asthma symptoms and PM_{10} 24-hr average concentration for the uni-pollutant model for lag 4 (N=414).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
PM_{10} 24-hr average concentration, lag 4		0.997	0.966	1.029	0.851
Year	2010	1.000			
	2011	0.387	0.222	0.677	0.001
Work day	No	1.000			
	Yes	4.556	1.996	10.397	<0.001
Holiday	No	1.000			
	Yes	0.310	0.149	0.644	0.002
Temperature 24-hr average		1.095	1.019	1.177	0.013
Relative humidity 24-hr average		1.000	0.977	1.025	0.984

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-36: Results of the logistic regression analysis of association between consultations for asthma symptoms and PM_{10} 24-hr average concentration for the uni-pollutant model for lag 5 (N=412).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
PM_{10} 24-hr average concentration, lag 5		0.997	0.966	1.028	0.830
Year	2010	1.000			
	2011	0.388	0.222	0.677	0.001
Work day	No	1.000			
	Yes	4.629	2.029	10.562	<0.001
Holiday	No	1.000			
	Yes	0.328	0.158	0.682	0.003
Temperature 24-hr average		1.085	1.009	1.166	0.027
Relative humidity 24-hr average		1.000	0.976	1.024	0.979

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

NO_2 24-hr average concentration

Table A2-37: Results of the logistic regression analysis of association between consultations for asthma symptoms and NO_2 24-hr average concentration for the uni-pollutant model for lag 0 (N=414).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
NO_2 24-hr average concentration, lag 0		1.033	0.990	1.077	0.139
Year	2010	1.000			
	2011	0.393	0.225	0.686	0.001
Work day	No	1.000			
	Yes	5.398	2.238	13.020	<0.001
Holiday	No	1.000			
	Yes	0.334	0.160	0.697	0.003
Temperature 24-hr average		1.103	1.027	1.185	0.007
Relative humidity 24-hr average		0.998	0.974	1.022	0.868

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-38: Results of the logistic regression analysis of association between consultations for asthma symptoms and NO_2 24-hr average concentration for the uni-pollutant model for lag 1 (N=412).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
NO_2 24-hr average concentration, lag 1		1.030	0.986	1.075	0.185
Year	2010	1.000			
	2011	0.365	0.211	0.631	<0.001
Work day	No	1.000			
	Yes	6.551	2.709	15.844	<0.001
Holiday	No	1.000			
	Yes	0.328	0.159	0.677	0.003
Temperature 24-hr average		1.093	1.020	1.173	0.012
Relative humidity 24-hr average		0.997	0.974	1.021	0.786

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-39: Results of the logistic regression analysis of association between consultations for asthma symptoms and NO_2 24-hr average concentration for the uni-pollutant model for lag 2 (N=410).

Explanatory factor/covariate		OR	95 % C.I. limits for OR		p-value
			lower	upper	
NO_2 24-hr average concentration, lag 2		1.022	0.980	1.064	0.309
Year	2010	1.000			
	2011	0.339	0.194	0.593	<0.001
Work day	No	1.000			
	Yes	6.161	2.563	14.812	<0.001
Holiday	No	1.000			
	Yes	0.309	0.148	0.648	0.002
Temperature 24-hr average		1.073	1.001	1.150	0.047
Relative humidity 24-hr average		0.994	0.971	1.017	0.619

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-40: Results of the logistic regression analysis of association between consultations for asthma symptoms and NO_2 24-hr average concentration for the uni-pollutant model for lag 3 (N=409).

Explanatory factor/covariate		OR	95 % C.I. limits for OR		p-value
			lower	upper	
NO_2 24-hr average concentration, lag 3		1.006	0.964	1.050	0.783
Year	2010	1.000			
	2011	0.345	0.198	0.601	<0.001
Work day	No	1.000			
	Yes	7.641	2.957	19.744	<0.001
Holiday	No	1.000			
	Yes	0.309	0.147	0.650	0.002
Temperature 24-hr average		1.074	0.999	1.154	0.052
Relative humidity 24-hr average		0.996	0.973	1.020	0.745

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-41: Results of the logistic regression analysis of association between consultations for asthma symptoms and NO_2 24-hr average concentration for the uni-pollutant model for lag 4 (N=408).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
NO_2 24-hr average concentration, lag 4		0.996	0.955	1.038	0.838
Year	2010	1.000			
	2011	0.310	0.176	0.545	<0.001
Work day	No	1.000			
	Yes	6.055	2.510	14.607	<0.001
Holiday	No	1.000			
	Yes	0.291	0.138	0.615	0.001
Temperature 24-hr average		1.067	0.995	1.144	0.067
Relative humidity 24-hr average		0.994	0.972	1.018	0.640

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-42: Results of the logistic regression analysis of association between consultations for asthma symptoms and NO_2 24-hr average concentration for the uni-pollutant model for lag 5 (N=407).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
NO_2 24-hr average concentration, lag 5		1.023	0.981	1.066	0.288
Year	2010	1.000			
	2011	0.321	0.184	0.560	<0.001
Work day	No	1.000			
	Yes	5.547	2.427	12.674	<0.001
Holiday	No	1.000			
	Yes	0.292	0.138	0.618	0.001
Temperature 24-hr average		1.079	1.005	1.158	0.035
Relative humidity 24-hr average		0.996	0.974	1.020	0.764

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Daily average pollen concentration

Table A2-43: Results of the logistic regression analysis of association between consultations for asthma symptoms and daily average pollen concentration for the uni-pollutant model for lag 0 (N=212).

Explanatory factor/covariate		OR	95 % C.I. limits for OR		p-value
			lower	upper	
Pollen concentration 24-hr average, lag 0		1.002	0.999	1.005	0.234
Work day	No	1.000			
	Yes	3.714	1.470	9.387	0.006
Holiday	No	1.000			
	Yes	0.484	0.188	1.248	0.133
Temperature 24-hr average		1.083	0.987	1.189	0.092
Relative humidity 24-hr average		1.022	0.990	1.055	0.185

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-44: Results of the logistic regression analysis of association between consultations for asthma symptoms and daily average pollen concentration for the uni-pollutant model for lag 1 (N=211).

Explanatory factor/covariate		OR	95 % C.I. limits for OR		p-value
			lower	upper	
Pollen concentration 24-hr average, lag 1		1.003	1.000	1.006	0.025
Work day	No				
	Yes	4.316	1.640	11.359	0.003
Holiday	No	1.000			
	Yes	0.539	0.211	1.378	0.197
Temperature 24-hr average		1.075	0.979	1.180	0.130
Relative humidity 24-hr average		1.023	0.991	1.056	0.161

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-45: Results of the logistic regression analysis of association between consultations for asthma symptoms and daily average pollen concentration for the uni-pollutant model for lag 2 (N=210).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Pollen concentration 24-hr average, lag 2		1.001	0.998	1.004	0.349
Work day	No	1.000			
	Yes	3.878	1.524	9.868	0.004
Holiday	No	1.000			
	Yes	0.488	0.188	1.264	0.140
Temperature 24-hr average		1.074	0.978	1.179	0.133
Relative humidity 24-hr average		1.018	0.987	1.049	0.264

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-46: Results of the logistic regression analysis of association between consultations for asthma symptoms and daily average pollen concentration for the uni-pollutant model for lag 3 (N=209).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Pollen concentration 24-hr average, lag 3		1.002	0.999	1.005	0.169
Work day	No	1.000			
	Yes	3.839	1.509	9.770	0.005
Holiday	No	1.000			
	Yes	0.516	0.199	1.335	0.172
Temperature 24-hr average		1.072	0.977	1.178	0.143
Relative humidity 24-hr average		1.017	0.987	1.049	0.266

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-47: Results of the logistic regression analysis of association between consultations for asthma symptoms and daily average pollen concentration for the uni-pollutant model for lag 4 (N=208).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Pollen concentration 24-hr average, lag 4		0.999	0.995	1.003	0.563
Work day	No	1.000			
	Yes	3.678	1.453	9.309	0.006
Holiday	No	1.000			
	Yes	0.417	0.158	1.105	0.078
Temperature 24-hr average		1.079	0.981	1.186	0.118
Relative humidity 24-hr average		1.018	0.987	1.049	0.266

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days

Table A2-48: Results of the logistic regression analysis of association between consultations for asthma symptoms and daily average pollen concentration for the uni-pollutant model for lag 5 (N=207).

Explanatory factor/covariate		**OR**	**95 % C.I. limits for OR**		**p-value**
			lower	upper	
Pollen concentration 24-hr average, lag 5		1.000	0.997	1.003	0.788
Work day	No	1.000			
	Yes	3.694	1.459	9.354	0.006
Holiday	No	1.000			
	Yes	0.481	0.182	1.271	0.140
Temperature 24-hr average		1.070	0.972	1.178	0.167
Relative humidity 24-hr average		1.019	0.988	1.050	0.238

Abbreviations: OR – odds ratio; C.I. – confidence interval; N – number of days