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Toni Buterin,[1] Robert Doričić,[1] Dalibor Broznić,[1] Tanja Ćorić,[2] Amir Muzur[1,3]

[1]Faculty of Medicine, University of Rijeka, Rijeka; [2]Andrija Štampar Teaching Institute of Public Health, Zagreb; [3]Faculty of Health Studies, University of Rijeka, Rijeka, Croatia

Abstract

The history of the Labin region in Croatia includes intensive industrial development with repercussions of pollution on environment and health. Assuming that prolonged exposure to polluted environments causes qualitative changes in mortality, the aim was to analyse the mortality characteristics of the population of the Labin Region for the 1968-2008 period based on data from the Croatian Bureau of Statistics. Public health and social opportunities in this geographical area carry a long-term burden of exposure to an industrial polluted environment with outcomes expressed by mortality or/and morbidity in the population. This study includes data on 11,903 deaths, most of which due to diseases of the circulatory, respiratory and digestive systems as well as neoplasms. In the third and fourth decade of the study period, a group of neoplasms showed significant increases, while the increase in respiratory diseases were more gradual. The female population died mostly from diseases of the circulatory and endocrine system as well as neoplasms, while the male population mainly died from diseases of the digestive system and external causes. This research provides guidelines that could create better public health, raising the quality of life and contribute to a future environmental protection in local communities by targeted policies.

Correspondence: Robert Doričić, Faculty of Medicine, University of Rijeka, B. Brancheta 20, 5100 Rijeka, Croatia. Tel.: +38551554927.
E-mail: robert.doricic@medri.uniri.hr

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Introduction

Istria, a largest peninsula in Croatia and the Adriatic, has played a historic role under the modern-age economic development that started under the Italian rule between World War I and II and continued - through ups and downs - until the present-day as part of the Republic of Croatia. Mining has shaped the economic and social history of the Labin Region. Although the extraction of raw materials was common in this area since the Middle Ages, activities modernized and strengthened in the 1930s (Ratkajec, 2014). Labin experienced its greatest industrial development in the years under Italian rule in the 1920s and 1930s. Export of coal, bauxite and cement marl electrified the area, introduced a water supply network, reclaimed the Raša River and drained the Čepić Lake. Mining in the wider Labin area, significantly improving social contacts and living standards (Stemberger, 1983). However, the gradual closure of mines over later years due to legal provisions on coal led to its substitution (1971) and replacement with cheaper fuel, which marked the end of centuries of mining in the Labin Region (Vorano, 1998). In the forthcoming period, other activities followed, including the development of new industrial plants and factories (Licul, 1989).

The thermal power plant of Plomin has been operating in this geographical area from 1970 until today. An industrial plant was built in the Plomin Bay near the old town of Plomin, which is today the only active coal-based thermal power plant in Croatia. The place was targeted as location due to the proximity of former coal mines from which coal was taken in the beginning. This part of the industry (Block A) was closed in 2018 due to the termination of its environmental permit and replaced by Block B (also a coal-fired power plant), which was put into operation in 2000 (https://www.hep.hr/proizvodnja/termoelektrane-1560/termoelektrane/te-plomin/1563). In recent times, there has been public debate about the possible construction of a Block C powered by gas or renewable energy sources.

Impact of industrial pollution on the environment and health

Many studies from various scientific fields have shown that industrial pollution has a negative impact on the environment and thus on human health. One of the most significant causes of increased morbidity and mortality is exposure to environmental pollution (Briggs *et al.*, 1996). The World Health Organization (WHO) points out that environmental factors cause up to 13 million deaths a year globally, either due to short-term exposure to high levels of pollution or long-term exposure to low levels of pollution (WHO, 2018). In addition to the negative impact on water and soil, air pollution is the leading cause of death. One in eight annual deaths worldwide, which translates into 7 million people, is directly related to air pollution, which is an unacceptable prize for economy growth (Ahmad *et al.*, 2021). Although thinking is now changing, the increased number of factories resulted in increased combustion, transport and poor waste management that endanger human health by burdening the environment with various pollutants. Human health is thus directly related to the health of the environment (Sofilić, 2015). Many studies show that long-term exposure to polluted air significantly increases mortality (Lipfert and Wyzga, 1995; Di *et al.*, 2017; Peters *et al.*, 2000; Ahmad *et al.*, 2021). Negative effects caused by the use of industrially polluted water is a well-known outcome worldwide (Hendryx *et al.*, 2012; Wang and Yang, 2016). However, the relation between morbidity, mortality and soil contamination is the least investigated because the connection is indirect. Thus, soil contamination affects health by aggregation, while gravity or rain pollutes water sources and eventually plants grown for food (Kodrić-Šmit and Pajtlar-Gaćeša, 2007).

Research on the negative impact of industrial pollution on health and mortality of population is mainly conducted in micro-regional areas, depending on the type of industry in the area. Some reports show increased mortality near industrial plants (Mataloni *et al.*, 2012) and ecological studies emphasize the inability to relate cause and effect since many other factors that can affect mortality - confounding variables (Peršić *et al.*, 1984). Other studies show that environmental pollution caused by industrial process can also affect the reproductive system and cause congenital malformations (Genowska *et al.*, 2015; Baldacci *et al.*, 2018). Overall, assumptions about the negative impact and risk of industrial pollution on health and mortality are justified (García-Pérez *et al.*, 2012).

The studies published so far on the impact of industry on the environment in Croatia, especially in the Labin Region, are mainly based on analyses of water, air and soil, some of which based on predictive models (Tomić *et al.*, 2013; Skoko, 2014; Medunić *et al.*, 2016a, 2016b, 2018, 2020). Some reports include a sociological perspective (Mišetić *et al.*, 2008; Matošević and Baćac, 2015). Recent research in the Labin Region shows that the soil is still contaminated with sulphur, polycyclic aromatic hydrocarbons, selenium and cadmium, all resulting from combustion of coal mostly coming from Raša Region, which is extremely rich in sulphur. The same coal was used during the first thirty years in the Thermal Power Plant of Plomin (Medunić *et al.*, 2016a). Much research covers pregnant women by analysing the negative impact of pollution on their reproductive system (Mohorović, 2014a). The reason for this research was the proximity of the power plant and the high percentage of sulphur of the fuel used at that time (Mohorović, 2014a; Medunić *et al.*, 2016a).

The results of morbidity and mortality analyses for the general population are considered to be the most relevant health statistics. Studies focusing on upper respiratory tract diseases, lower respiratory tract diseases, eye mucus and stillbirths have shown that it is not possible to determine the existence of a direct negative effect of environmental pollution, but a certain increase in morbidity and mortality from groups of diseases, mainly of the respiratory tract, were observed (Peršić *et al.*, 1984, 1985). Also, the areas around the City of Bakar in the northern area of Kvarner Bay (northeast of Labin Region) were in the past exposed to industrial pollution and an analysis of the causes of death was conducted (Doričić *et al.*, 2018). An increase in the average standardised mortality rate from respiratory diseases in the areas exposed to industrial pollution was confirmed and the conclusion was that this fact needs to be further investigated (Doričić *et al.*, 2018). Although many studies have shown that air pollution adversely affects the respiratory system, recent epidemiological studies have found that prolonged exposure to air pollution also have an effect on mortality by cardiovascular morbidity, neurological effects and occurrence of neoplasms (Boogaard *et al.*, 2019). Other research has shown an association of coal exploitation with a wide range of diseases of populations living in areas of mining activities or in their vicinity (Cortes-Ramirez *et al.*, 2018). We considered the Labin Region as the primary target area for research on links between human health and vulnerable ecosystem since the impact of industrial pollution there was stable and dominant during the research period.

Materials and methods

Study site

Shaped by Istria's geological features, the historic political and economic interests resulted in various forms of socio-economic development (Kopal *et al.*, 1993). The peninsula (Figure 1) can be divided into Red Istria, the south-western area characterized by its terracotta-coloured soil; Gray Istria, the central area dominated by grey sand (this is the best preserved environment with large biodiversity); and White Istria, the Učka and Ćićarija hills, which mainly consists of rocky soils (Vinšćak, 1999). Each of these three geographical areas can be further divided according to the economic branches that shaped the past: agriculture, trade, industry and tourism. This paper focused on the industrial area in the south-eastern part of the Istrian peninsula; more precisely the Labin Region, which can be characterized as an ecologically vulnerable geographical area negatively affected by industry.

Population and timeframe

The Labin Region consists of the City of Labin and the neighbouring municipalities of Kršan, Pićan, Sveta Nedelja and Raša. According to the censuses during the period included in this study (1968-2008), there was an average of 25,000 inhabitants in the Labin area (Zupanc, 2004) in the period covered by the study (Table 1).

The timeframe was set from 1968 to 2008 and divided into four decades: 1968-1978; 1979-1988; 1989-1998; and 1999-2008 comparing the values of variables in the first decade with those in

Table 1. Population levels in the Labin Region at the end of the 20th century.

Area \ Census	1971	1981	1991	2001
Labin	10,778	12,014	13,144	12,426
Kršan	3905	3372	3495	3264
Pićan	2611	2346	2133	1997
Raša	4821	4460	4124	3535
Sv. Nedelja	3562	3308	3087	2909
Total	25,677	25,500	25,983	24,131

the three later decades. This timeframe was chosen since the 1960s represented a decade of significant beginnings of industrial development in the research area, while 2008 marked the start of more intensive environmental care emphasizing the reduction of pollutant emissions as decided at the European Union level with the adoption of Directive 2008/50/EC aiming at the protection of human health and the environment.

Variables

The socio-demographic characteristics of the Labin Region population for the period 1968-2008 including mortality data were obtained from the Croatian Bureau of Statistics. The investigation used aggregated mortality data with respect to gender, age and cause of death.

Statistical analysis

The study focused on the cause of death for the Labin Region for the period from 1968 to 2008 by the group of diseases as given in the International Classification of Diseases (ICD-10) as follows: neoplasms (II); the endocrine, metabolic system (IV); the circulatory system (IX); the respiratory system (X); the digestive system (XI); Ill-defined conditions (XVIII); and external causes (XIX). These variables were presented as cumulative for each decade and the median of ten values for each decade with the corresponding minimum and maximum values were calculated for each variable.

Commercially available Statistica software® version 14.0 (StatSoft Inc., Tulsa, OK, USA) was used for all statistical analyses performed at the significance level of $P<0.05$. The differences between the variables in the population of the first decade compared to the remaining decades were tested by the nonparametric Kruskal-Wallis (multiple comparisons) test. To analyse the potential effect on the leading causes of death according to the ICD-10, nonparametric Kendal-Tau, and principal component analysis (PCA) (Naik, 2018) were used.

Results

The mortality rate for the Labin Region was monitored for forty years, starting from 1968 until 2008 with a sample of 11,903 deceased (5707 females and 6196 males). In Figure 2, the total number of deaths by decade is presented together with the gender distribution showing the median plus minimum and maximum values. Comparing the total number of deaths between the first and the other decades, a significant increased trend was observed, with values ranging from 12.7% to 18.1%. The largest statistically significant increase in the number of deaths occurred in the second (1979-1988) and third decades (1989-1998) with 16.4% ($P=0.001$) and 18.1% ($P=0.001$), respectively. A slightly lower, though statistically significant increase (12.7%; $P=0.026$), occurred between the first and the last decade. In all decades, male mortality was more pronounced compared to female mortality, especially in the first two decades. The contribution of different age groups to the total mortality between the first and the remaining decades was

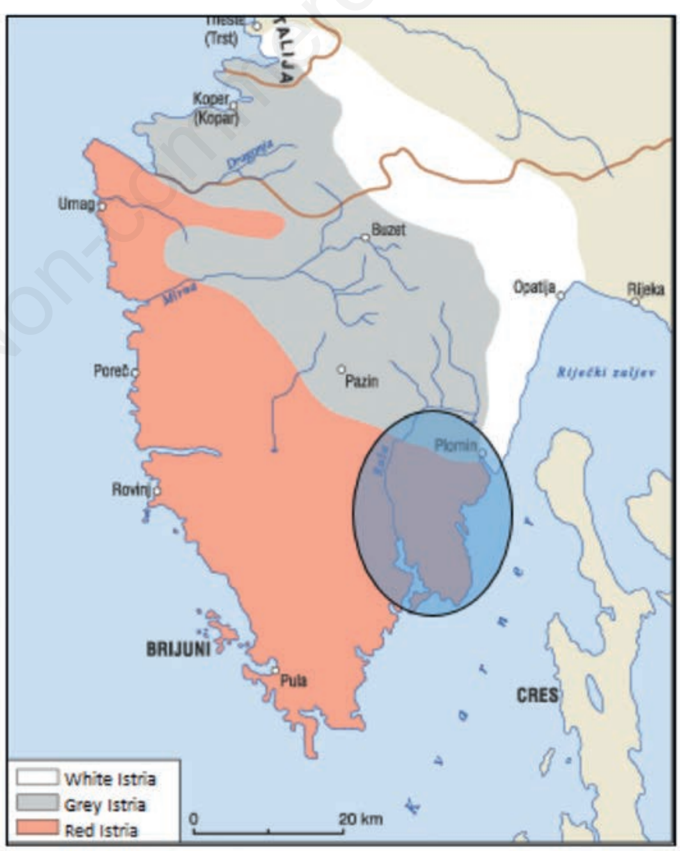

Figure 1. Geomorphological view of the Istrian peninsula. The Labin Region encircled.

monitored for a more detailed insight (Table 2). The contribution to the total mortality of young people, *i.e.* age groups from 1 to 19 years, was negligible and amounted to less than 1%. Children >1 year of age contributed slightly more but only for the first decade (2.3%) and the second (1.8%). As expected, the contribution to the total mortality increased with age, with those aged from 20 to 29 years participating with 1.5%, while the >80 age group contributed with an average of 34.2%. Analysing the differences between the first and the other decades further, a statistically significant decrease in the mortality of children >1 year of age in the third decade (66.7%; P=0.023) and the fourth (83.3%; P=0.002) was observed. In contrast, a statistically significant increase in the 70-79 years age group occurred in the second decade (35.9%; P=0.002) as well as in the fourth (28.2%; P=0.033) and for the >80 years group between the first and all the following three decades.

When the previous health status of the people who had died was studied with respect to treatment received during life and whether or not they had died in a health institution, it was observed that a high percentage of the total number of deaths consisted of people who had been under treatment during their life. Indeed, an increased trend over the four decades was observed, with the lowest percentage seen in the first decade (86.9%). Comparing the first decade with the others, a statistically significant increase of 24.4% (P<0.011) in average was achieved There was also an increase in number of deaths in health care institutions in the more recent decades, with an average value of 84.2% (P=0.001).

The distribution of the seven leading causes of death according to ICD-10 diseases for the four decades under study is presented in Figure 3. The largest number of deaths was associated with diseases of the circulatory system (49.7%), followed by neoplasms (21.6%), while diseases of the respiratory and digestive systems together with diseases caused by external factors only accounted for approximately 5% of the total number of deaths. Comparing the causes of death in the first decade with the other decades, there was an extreme, statistically significant increase of neoplasms in the third decade (78.6%, P=0.001) and in the fourth (81.0%; P=0.001, while the increase of respiratory diseases was more gradual [from 14.8%; (P=0.007) for the second decade to 30.3%; (P=0.001)] for the fourth. The proportion of respiratory diseases in the total mortality decreased over the fourth decade by 56.5% (P=0.003) compared to the first, while the cause of death from the digestive systems showed a sharp increase between the first and the second decade (65.4%; P=0.001) followed by a non-statistically significant sharp decline (11.5%; P=0.072).

A strong positive correlation was observed between the number of total deaths due to diseases of circulatory system (τ=0.58), the digestive system (τ=0.31) and neoplasms (τ=0.44). The female population was more susceptible to causes of death due to diseases of the circulatory system diseases (τ=0.60) compared to the male population (τ=0.33), while males were more susceptible to dis-

Table 2. Deaths by age group and other variables for the 1968-2008 period in the Labin Region.

Variable		1968-1978	1979-1988	1989-1998	1998-2008
		Median with minima and maxima (number of deaths)			
Total		259 (231-285)	301.5 (269-346)	306 (273-335)	292 (268-322)
Deaths by age	0	6 (2-8)	5.5 (0-10)	2[a] (P=0.023) (0-4)	1[a] (P=0.002) (0-3)
	1-4	1 (0-3)	1 (0-2)	0 (0-1)	0[a] (P=0.046) (0-1)
	5-9	0 (0-2)	1 (0-2)	0 (0-1)	0 (0-1)
	10-19	1 (0-4)	1 (0-3)	1 (0-4)	1 (0-2)
	20-29	5 (1-7)	4 (2-8)	3 (1-4)	2 (0-6)
	30-39	4 (1-9)	6 (2-9)	4.5 (0-8)	3 (1-8)
	40-49	16 (6-21)	14 (10-22)	11 (5-14)	10 (6-14)
	50-59	25 (15-30)	31.5 (23-44)	29 (14-35)	20.5 (15-30)
	60-69	49 (38-60)	45 (38-62)	60 (48-74)	46 (32-68)
	70-79	71 (56-91)	96.5[a] (P=0.002) (80-123)	75.5 (61-105)	91[a] (P=0.033) (84-111)
	>80	81 (65-99)	94 (77-113)	112[a] (P=0.001) (94-147)	110.5[a] (P=0.001) (91-140)
Treated		225 (193-235)	280.5[a] (P=0.001) (246-320)	290[a] (P=0.001) (251-315)	269[a] (P=0.011) (251-297)
Untreated/Unknown		48 (31-54)	22[a] (P=0.006) (14-32)	17[a] (P=0.001) (10-26)	22[a] (P=0.002) (15-28)
Death at a care facility		65 (0-73)	107[a] (P=0.001) (82-158)	132.5[a] (P=0.001) (77-153)	N/A

N/A, not available. The results are presented as median with minimum, and maximum values (N=10-11); median values marked with the lower case letter *a* represent significant differences between 1968-1978 decade and other decades for different variables (total number of deaths, deaths by ages, treated, untreated and death at a health institution; P<0.05 when not given); non-parametric Kruskal-Wallis (multiple comparisons) test.

eases of the digestive system. There was a strong correlation between neonatal/premature death and diseases of the respiratory system (τ=0.34) as well as with ill-defined conditions (τ=0.40). Similarly, ill-defined conditions significantly affected mortality of the 1-4 olds (τ=0.31), while the same age group correlated moderately (τ=0.23) with diseases of the respiratory system. These results indicate a dominance of the cause of death due to these diseases in this age group, while digestive system as cause of death dominated in the 5-9 olds. The Kendall-Tau correlation revealed a strong influence of ill-defined conditions in the 20-29 years age group (τ=0.26) and the 40-59 years one (τ=0.31), while in the 60-69 years group, diseases of the endocrine metabolic system prevailed (τ=0.26). In the 70-79 years old, diseases of the digestive (τ=0.31) and circulatory systems (τ=0.30) as well as neoplasms (τ=0.25) dominated. In the oldest population (>80 years), neoplasms (τ=0.50) and diseases of the circulatory system (τ=0.57) were the most common.

PCA was used to determine the potential correlation between the variables analysed (total number of deaths, deaths by gender, deaths by age group, treated/untreated patients and death at a health institution) and the leading causes of death as supplementary variables at different decades (as cases). PCA reduces the dimensionality of the large set of variables included in the model while maintaining maximum variability in terms of variance-covariance structure. In other words, the variance-covariance structure of the data set can be explained as using a new set of coordinate system with dimensions less than the number of original variables and yet covering most of the variability in the source dataset. By transforming the data into a new coordinate system, the largest variance of any projection of the dataset come to lay on the first axis making up the first main component (p1), and the remaining main components on the second (p2). To reduce the number of variables in PCA analysis Cattell scree test (1966) was used, according to which, the two main components are retained in the analysis. Their values, together with their contributions to the total variance, are presented in Figure 4. The total cumulative value of variance was 86.8%, with 56.0% explained by the first main component (p1) and the remaining 30.8% by the second main component (p2). All together we deal with 17 variables (Table 3, first column) and 7 supplementary variables (the ICD-10 diseases), which give a total annual dataset for the 41 study years of 24x41=984 that covers the four decades. Eigenvectors of the correlation matrix (Cattel, 1966; Naik, 2018) were used for the interpretation of the main components. The calculations provide various levels of support for explaining (by positive correlation) the cause of death by the following p1 components: female population (0.26), ages 60-69 years (0.09), >80 years olds (0.26), treated populations (0.25), death in a health institution (0.25), with neoplasms (0.27), diseases of the endocrine system (0.21) and the circulatory system (0.27). Negative p1correlations were achieved with age groups <1 (–0.23), 1-4 (–0.22), 10-19 (–0.26), 20-29 (–0.24), 40-49 (–0.25), untreated populations (–0.26), and with disease of the respiratory system (–0.26) and ill-defined conditions (–0.25), while the remaining variables, such as the male population, age group 5-9, 30-39, 50-59, 70-79 and external causes were grouped around the p2 component. Figure 4 presents the distribution of all analysed variables over the four decades in four quadrants. Most observed variables with positive values are found on the right side of p1 leading to the assumption that the second, third and fourth decade define this area. The female population most often died because of problems related to the circulatory or endocrine systems or otherwise neoplasms. The male population most often succumbed to problems related to the digestive system or external causes. The left side of the p1 is defined by first-decade variables, such as a higher mortality of the entire population not been treated in health facilities. Death due to diseases of the respiratory system and ill-defined conditions dominated in that period.

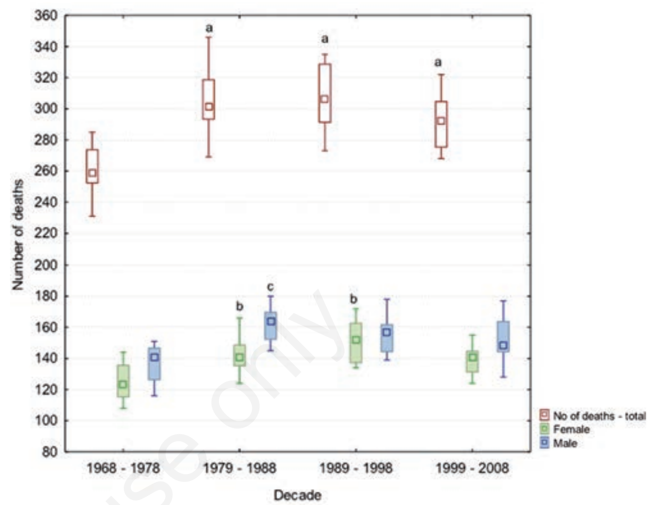

Figure 2. The number of total deaths and gender distribution of deaths over four decades (from 1968 to 2008) for the Labin Region. The results are presented as a median with minimum and maximum values (N=10-11). Median values marked with lower case letters (a, b and c) represent significant differences between the decade from 1968 to 1978 and other decades for total deaths, and female and male deaths (P<0.05); non-parametric Kruskal-Wallis (multiple comparisons) test.

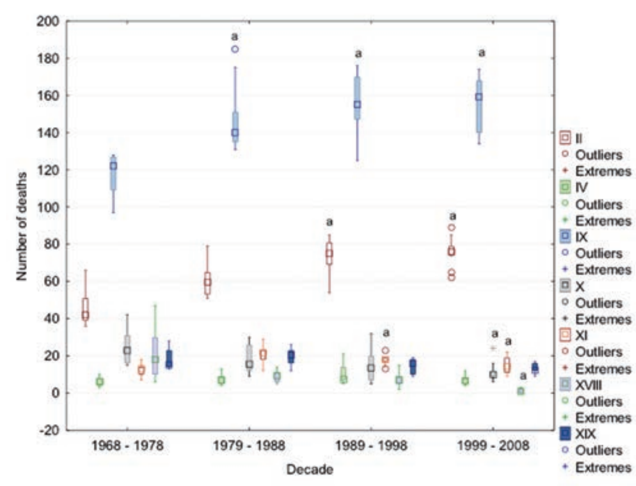

Figure 3. Distribution of leading causes of death according to the International Classification of Diseases Groups (ICD-10) for four decades in the Labin Region. The first decade has a range of 11 years and the other three 10 years. II, neoplasms; IV, endocrine, metabolic system; IX, circulatory system; X, respiratory system; XI, digestive system; XVIII, ill-defined conditions; XIX, external causes. The results are presented as median values with minima and maxima. Values marked with a, b or c represent significant differences compared to the first decade (1968-1978) according to the Kruskal-Wallis test (P<0.05).

Discussion

The significant trend of the increased numbers of deaths between the first decade and the later ones seen when the total number of deaths are compared can be interpreted as a transition between the two mortality regimes, one of reducing mortality rates that dominated from the mid-1960s, and another earlier period represented by increasing mortality not only evident in Croatia but also in Europe (Mrđen, 2000).

Polluted environment can impact health within a certain time lag or they can occur as long-term consequences of chronic exposure (Sofilić, 2015). The negative impact of the polluted environment has been proven by direct exposure to harmful agents, but also to indirect damage to ecosystems (Prüss-Üstün *et al.*, 2016). The latter can be caused by industrial pollution leaving a mark on humans and the environment alike, such as climate change manifested by an increase in the concentrations of carbon dioxide, methane, nitrogen oxides and tropospheric ozone and resulting in the global warming we are currently experiencing. Industry and human activity are considered the biggest factors in these changes that also preconditions for diseases neither primarily associated with a particular geographical area nor directly related with the negative impact of industrial pollutants on humans (Buterin *et al.*, 2021).

The basic subject of research worldwide is air pollution due to the effect on various systems of the human body (Juginović *et al.*, 2021). In addition to impact on the respiratory and cardiovascular systems, exposure to environmental pollution is also associated with neurodegenerative disorders, neoplasms, skin diseases and endocrine disorders (European Commission, 2018). Our study shows similar causes of death in ecologically vulnerable environments where diseases of the circulatory, respiratory, endocrine/metabolic, digestive systems and neoplasms dominate. Numerous environmental studies on water and soil contamination show a significant impact on public health (Lillini *et al.*, 2021). An increased number causes of death in our study classified as diseases of the digestive system can be repercussion of polluted water and food. The causes of death classified as due to external causes are not negligible either, *e.g.*, this risk for male population in mining regions is increased by accidents that commonly occur there (Cortes-Ramirez *et al*., 2018). Our study has shown a higher frequency of male deaths in the first two decades, *i.e.* at a time when the mines in the Labin Region were still active. The increased infant mortality during the first decade only confirms the need for further research on the reproductive system and pregnant women in this geographic area. Furthermore, this study justified previous similar research in the area (Mohorović, 2003, 2004, 2010, 2014a, 2014b).

Improved diagnostics and other modern technologies can be the reason for the extreme, statistically significant increase in the group of neoplasms in the third and fourth decade studied, but we can also not exclude the fact that in the same period the thermal power plant had been in operation for 20 years. In addition, the exponential growth of people undertreatment or deceased in a health institution may be related to the development of hospital care in the area and the health awareness of the population. The specific relation between environmental pollution and mortality cannot be fully demonstrated and accurately determined due to many other correlating factors (Remoundou and Koundouri, 2009).

We are aware of the limitations of the research due to the change of the classification of diseases (ICD-8, ICD-9 and ICD-10) during the research period, but this was considered in the interpretation of the results. Furthermore, the limitations that could not be fully taken into account in the interpretation of the results were the dearth of availability of more specific data that could have identified confounding variables, *i.e.* other reasons that those investigated could have affected the mortality and mortality values. Thus, we could neither obtain information from the aggregat-

Table 3. Coefficients of the correlation between leading causes of death and variables for the 1968-2008 period in the Labin Region.

Variable \ Cause of death		Neoplasms (II)	Endocrine, metabolic system (IV)	Circulatory system (IX)	Respiratory system (X)	Digestive system (XI)	Ill-defined conditions (XVIII)	External causes (XIX)
No of deaths - total		*0.44*	0.19	*0.58*	–0.10	*0.31*	–0.14	–0.06
Female		*0.36*	0.21	*0.60*	–0.18	*0.26*	–0.15	–0.14
Male		*0.34*	0.11	*0.33*	0.01	*0.30*	–0.03	0.03
Deaths by age	0	*–0.50*	–0.13	*–0.36*	*0.34*	0.07	*0.40*	*0.29*
	1-4	*–0.39*	–0.17	*–0.32*	*0.23*	–0.03	*0.31*	0.16
	5-9	*–0.22*	–0.08	–0.21	0.11	*0.24*	0.12	*0.25*
	10-19	–0.05	0.21	–0.17	0.12	0.09	0.09	0.17
	20-29	*–0.25*	–0.10	–0.17	0.18	–0.05	*0.26*	*0.44*
	30-39	–0.11	0.08	0.04	–0.04	–0.02	0.19	0.13
	40-49	–0.15	*0.23*	–0.18	*0.26*	0.08	*0.31*	0.20
	50-59	–0.03	0.04	0.06	–0.02	*0.21*	*0.23*	*0.30*
	60-69	0.20	*0.26*	0.14	–0.05	0.12	0.12	*-0.24*
	70-79	*0.25*	–0.08	*0.30*	–0.08	*0.31*	*–0.22*	-0.09
	>80	*0.50*	0.10	*0.57*	*–0.26*	0.07	*–0.36*	-0.17
Treated		*0.51*	0.21	*0.65*	–0.18	*0.32*	–0.19	–0.12
Untreated		*–0.42*	–0.12	*–0.50*	*0.40*	*–0.24*	*0.35*	*0.25*
Recorded deaths at a health care facility		*0.41*	*0.23*	*0.57*	*–0.25*	*0.32*	*–0.27*	–0.10

Kendall-Tau correlation test (N=41); statistically significant correlations at $P<0.05$ in italics. Effect of leading causes of death according to the ICD-10 groups (supplementary variables) on the analysed variables (total number of deaths, deaths by gender, deaths by ages, treated, untreated and death at a health institution) represented by non-parametric Kendall-Tau correlation test (N=984, 17 variables and 7 supplementary variables, total data set: 24x41 years=984).

ed data on the socio-economic status and lifestyle of individuals nor on the potential consumption of alcohol or data on smoking, which could have affected the characteristics of mortality. Thus, we could only theoretically conclude the quality of life and nutrition based on published literature. Accordingly, in order to broaden the research of the relation between pollution and population mortality, the results of air, water, soil and food quality research should be considered.

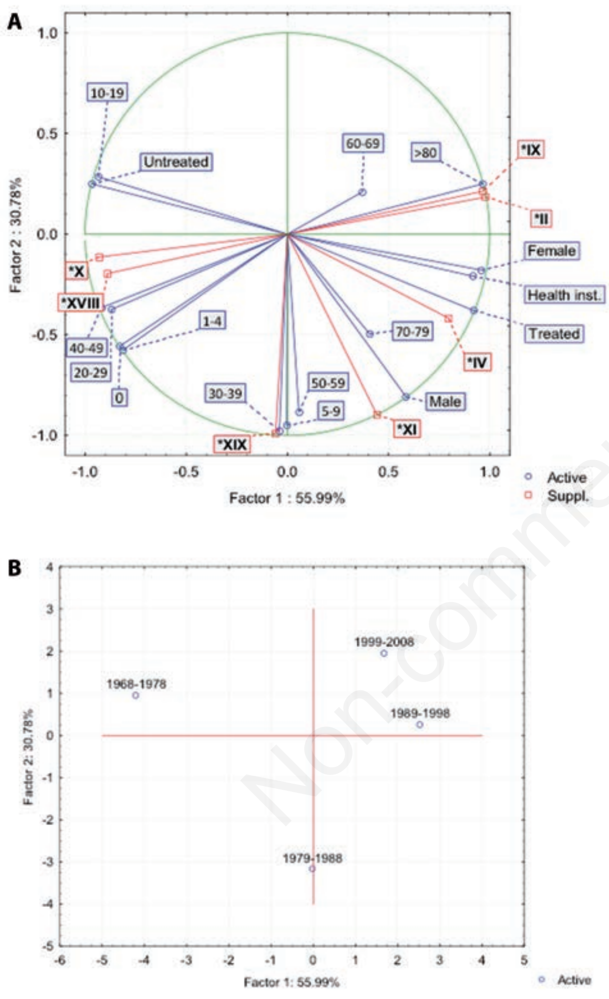

Figure 4. Distribution of the seven leading causes of death 1968-2008 in the Labin Region. II, neoplasms; IV, endocrine, metabolic system; IX, circulatory system; X, respiratory system; XI, digestive system; XVIII, ill-defined conditions; XIX, external causes. Effect of leading causes of death according to the ICD-10 groups (supplementary variables) on the analysed variables (total number of deaths, deaths by gender, deaths by ages, treated, untreated and death at a health institution) represented by principal component analysis (N=984, 17 variables and 7 supplementary variables, total data set: 24x41 years=984) represented by two main components (p1, p2). Projections of: A) the variables and supplementary variables; and B) the cases (decades) on the factor-plane.

Conclusions

Between the first and the three later decades, a significant increased trend in the total number of deaths was observed. The most common causes of death for research period in the Labin Region, were diseases of the circulatory, respiratory, digestive systems, neoplasms and external causes. In the third and fourth decade the most significant increase was various forms of neoplasms, while the increase in the group of respiratory diseases increased more gradually. The female population mainly died from diseases of the circulatory and endocrine system in addition to neoplasms while the male population mainly died from diseases of the digestive system and external causes. For a more concrete relation between industrial pollution and mortality, it is necessary to conduct additional research.

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