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ORIGINAL ARTICLE

Urban diabetes: analysis of diabetes prevalence in cities of the Lombardy region participating in the cities changing diabetes project

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Abstract

Aim The urban population increases by about 60 million people/year. Urbanization, unhealthy lifestyle and aging of the population are reflected in a constant growth in the prevalence of diabetes. In 2014, Steno Diabetes Centre in Copenhagen, University College London and Novo Nordisk, launched the Cities Changing Diabetes® program with the aim of creating a unified movement that would stimulate policy-makers to prioritize urban diabetes.

Methods The socio-demographic data derive from (1) ISTAT (National Institute of Statistics of Italy), (2) ATS Metropolitan City of Milan, (3) ATS Val Padana-Cremona, (4) ATS Insubria-Varese, (5) The unemployment rates of the various municipalities have been extrapolated from an ISTAT-MEF elaboration published by Sole 24 Ore journal.

Results In the different sanitary districts of the Metropolitan City of Milan, a strong linear correlation was found between the prevalence of diabetes and the prevalence of heart disease ($R = 0.695$, $p < 0.001$), as well as between the prevalence of diabetes and of nephropathies ($R = 0.316$, $p < 0.001$). The analysis concerning the province of Cremona showed a fair correlation between the prevalence of diabetes and cardiovascular disease ($R = 0.658$, $p < 0.001$). Even for the municipalities of Varese, the analysis documented a good correlation between the prevalence of diabetes and heart disease ($R = 0.419$, $p < 0.001$), but not between diabetes and nephropathies.

Conclusions Interesting differences in the relationship of diabetes prevalence with several diseases and socio-demographic factors have been found when comparing the metropolitan City of Milan with two smaller size cities as Varese and Cremona. Our present data confirm the hypothesis that urban diabetes will be the challenge for our society during the next decades.

Keywords Urban diabetes · Diabetes and obesity prevalence · Cities changing diabetes project · Lombardy region

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Abbreviations

ASST	Aziende Socio Sanitarie Territoriali (*Territorial Social Health Companies*)
ATS	Agenzie di Tutela della Salute (*Health Protection Agency*)
BMI	Body Mass Index
ISTAT	National Institute of Statistics of Italy
MEF	Ministero dell'Economia e delle Finanze (*Ministry of Economy and Finance*)
WHO	World Health Organization

Introduction

The urban population is constantly growing: every year it increases by about 60 million people, particularly in middle-income countries. Population projections show that over the next 30 years, global growth will only occur in urban areas. The ongoing demographic changes (urbanization, worsening lifestyles, aging of the population and social isolation) are reflected in a constant progression in the prevalence of diabetes, which is already one of the most widespread chronic diseases in the world and constitutes one of the most significant and expensive social illnesses of our time.

Several studies identified a high Body Mass Index (BMI) as a risk factor for chronic diseases as cardiovascular diseases, diabetes mellitus, chronic kidney disease, many cancers, and an array of musculoskeletal disorders [1, 2].

Most of the world's population live in countries where overweight and obesity kill more people than underweight. The worldwide prevalence of obesity nearly tripled between 1975 and 2016. In 2016, more than 1.9 billion adults were overweight, of these over 650 million were obese [3].

Globally, the prevalence of obesity tends to be higher in richer countries across Europe, North America and Oceania. Age-standardized estimates for 2016, from the WHO Global Health Observatory, indicate that obesity prevalence for adults in the WHO European Region is higher than in any other WHO region except the Region of the Americas [4–6].

Overweight and obesity in adults have reached epidemic proportions in the WHO European Region, WHO estimates that 59% of adults are living with overweight or obesity, with more than half of adults in 50 out of 53 Member States in the European Region living with overweight or obesity [4–6]. Across WHO European Region, overweight and obesity cause more than 1.2 million deaths every year, the fourth highest cause after high blood pressure, dietary risks and tobacco and corresponding to more than 13% of total deaths [4].

According to estimates from the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2019, diabetes was the eighth leading cause of death and disability combined in the world, with nearly 460 million people across every country and age group living with the disease in 2019 [7, 8]. The global prevalence of this disease has almost doubled in the last 20 years—from 4.6% in 2000 [9] to 10.5% in 2021 [10] with around 537 million people suffering from diabetes, resulting in health expenditures of US$966 billion globally, forecast to reach more than $1054 billion by 2045 [7, 10, 11]. In the absence of specific interventions, the prevalence of diabetes has expected to rise up to 12.2% in 2045 with 783 million people suffering from this disease. Known the devastating human and economic costs of diabetes and its complications, this growth is simply unsustainable for all countries. Established drivers of the increasing prevalence of type 2 diabetes include an aging growing population and global trends such as urbanization, unhealthy eating and reduced physical activity [10].

Nowadays, in large cities live two-thirds of people with diabetes; hence the need to implement an integrated strategy in urban areas, aimed at building an idea of the city as a "health promoter".

In 2014, three global partners, Steno Diabetes Centre in Copenhagen, University College London and Novo Nordisk, launched the Cities Changing Diabetes® programme with the aim of creating a unified movement that would stimulate policy-makers to prioritize urban diabetes [12]. The Cities Changing Diabetes program is coordinated by a wider Institution named Health City Institute. Its role is to map, share and cat on health related problems with other not sanitary entities operating in metropolitan areas (administration, epidemiological, architectural, social and academic institution). The Cities Changing Diabetes® program highlights the need to act in view of the growing number of people with diabetes and the resulting economic and social burden. To date, the program has established local partnerships in 42 cities; among these, in Lombardy, the Metropolitan City of Milan and the municipalities of Varese and Cremona have joined the Cities Changing Diabetes program.

Purpose

To analyze, using existing data sources, the prevalence of diabetes in Lombardy cities included in the Cities changing diabetes project by identifying social factors and cultural determinants that may increase the vulnerability of type 2 diabetes. The prevalence and relationship will be tested in two smaller Lombardy Cities, Varese and Cremona. In all the 3 cities under analysis we assessed the relationship between diabetes mellitus and heart and renal disease.

Methods

The socio-demographic data of the cities included in the study and the data on university enrolments were obtained by the National Institute of Statistics of Italy (ISTAT) [13].

For the municipalities belonging to the Metropolitan City of Milan, the prevalence of diabetes was extrapolated from the portal on the state of health of the population of the ATS Metropolitan City of Milan [14]. For the municipalities belonging to the province of Cremona and Varese, the prevalence of diabetes has been provided by the epidemiological services of the ATS Val Padana and ATS Insubria [15], respectively.

The unemployment rates of the various municipalities have been extrapolated from an ISTAT-MEF elaboration published by Sole 24 Ore journal [16]. The research was conducted in accordance with the principles embodied in the Declaration of Helsinki and in accordance with local statutory requirements.

The association between diabetes prevalence across health territories and different socioeconomic indicators was assessed by linear regression analysis and Pearson correlation coefficient. The following indicators were considered: Old Age Index (expressed as the percentage ratio between the number of residents aged 65 or over and the population aged 0–14 years); Elderly Dependency Index (expressed as the ratio between the number of people aged 65 or over and the active population aged 15–64); Structural Dependency Index (expressed as the ratio between the number of non-active population, 0–14 years and 65 years and over on the active one, 15–64 years), Unemployment Rate (considered as the percentage of the population residing in the 15–64 age group that is not employed), University Index, assumed as the ratio between the number of adult residents (≥ 15 years) enrolled in Universities and the total of adult residents (≥ 15 years) and the mortality index understood as a ratio between the number of deaths from any cause and the number of residents. The analysis of the data refers to January 1, 2021 (year 2020).

Statistical analysis

Linear regression analysis and Pearson coefficient of correlation were used to assess the relationships between diabetes prevalence and single socio-demographic-economic indicators, as previously described [17].

Results

Metropolitan City of Milan

The prevalence of diabetes in the Metropolitan City of Milan is 6.42% with values varying between the male (7.22%) and female (5.54%) population. In absolute terms, it can be estimated that about 80,300 citizens with diabetes live in the city of Milan and 207,500 residents with diabetes live in the Milan Metropolitan area. Within the Metropolitan area of Milan, the prevalence of diabetes varies between the different sanitary districts between 5.84% in downtown Milan center and 7.70% in the peripheral Northern area of Milan (Fig. 1A in main text and Fig. S1 in the Supplementary File).

A fair correlation was found between the prevalence of diabetes in the different municipalities of the Metropolitan City of Milan and the prevalence of heart disease ($R = 0.695$, $p < 0.001$) (Fig. 1B), while a weaker correlation arose with the prevalence of Nephropathies ($R = 0.316$, $p < 0.001$) (Fig. S2, Supplementary File).

Analysing demographic determinants, a fair correlation has been documented between the value of the Aging Index and diabetes prevalence ($R = 0.398$, $p < 0.001$) (Fig. 1C), as well as between the Old Age Dependency Index ($R = 0.405$, $p < 0.001$) and the Structural Dependency Index ($R = 0.323$, $p < 0.001$) and diabetes prevalence (Fig. S3 and Fig. S4, Supplementary File). There was no significant correlation between the Prevalence of Diabetes and the University Index ($R = -0.014$, $p = 0.887$) (Fig. S5, Supplementary File). Finally, there were fair correlations between the prevalence of diabetes and Mortality Index ($R = 0.382$, $p < 0.001$) (Fig. S6, Supplementary Index) and between the prevalence of diabetes and Unemployment Rate ($R = 0.347$, $p < 0.001$) (Fig. S7, Supplementary File).

Province of Varese

The prevalence of diabetes in the province of Varese is 6.02% with over 53.000 citizens with diabetes. There is a significant variability in the prevalence of diabetes between the various sanitary districts, ranging between 5.46% in the district of Sesto Calende and 6.83% in the district of Laveno (Fig. 2A and Fig. S8, Supplementary File). Even for the municipalities of Varese, the analysis documented a good correlation between the prevalence of diabetes and heart disease ($R = 0.419$, $p < 0.001$) (Fig. 2B).

Unlike the Metropolitan City of Milan data, the prevalence of diabetes in the province of Varese does not correlate with the prevalence of some socio-demographic determinants (Old Age Dependency, Structural Dependence Index), and with the prevalence of other chronic diseases (e.g., nephropathies). The results of the statistical analysis are summarized in Figures S9, S10, S11, S12, S13, S14 and S15 of the Supplementary File.

Province of Cremona

The prevalence of diabetes in the province of Cremona is 6.82% with almost 22,000 citizens with diabetes. The territory of the province of Cremona is divided into three sanitary districts in which the prevalence of diabetes varies between 6.32% in the district of Crema and 7.28% in the

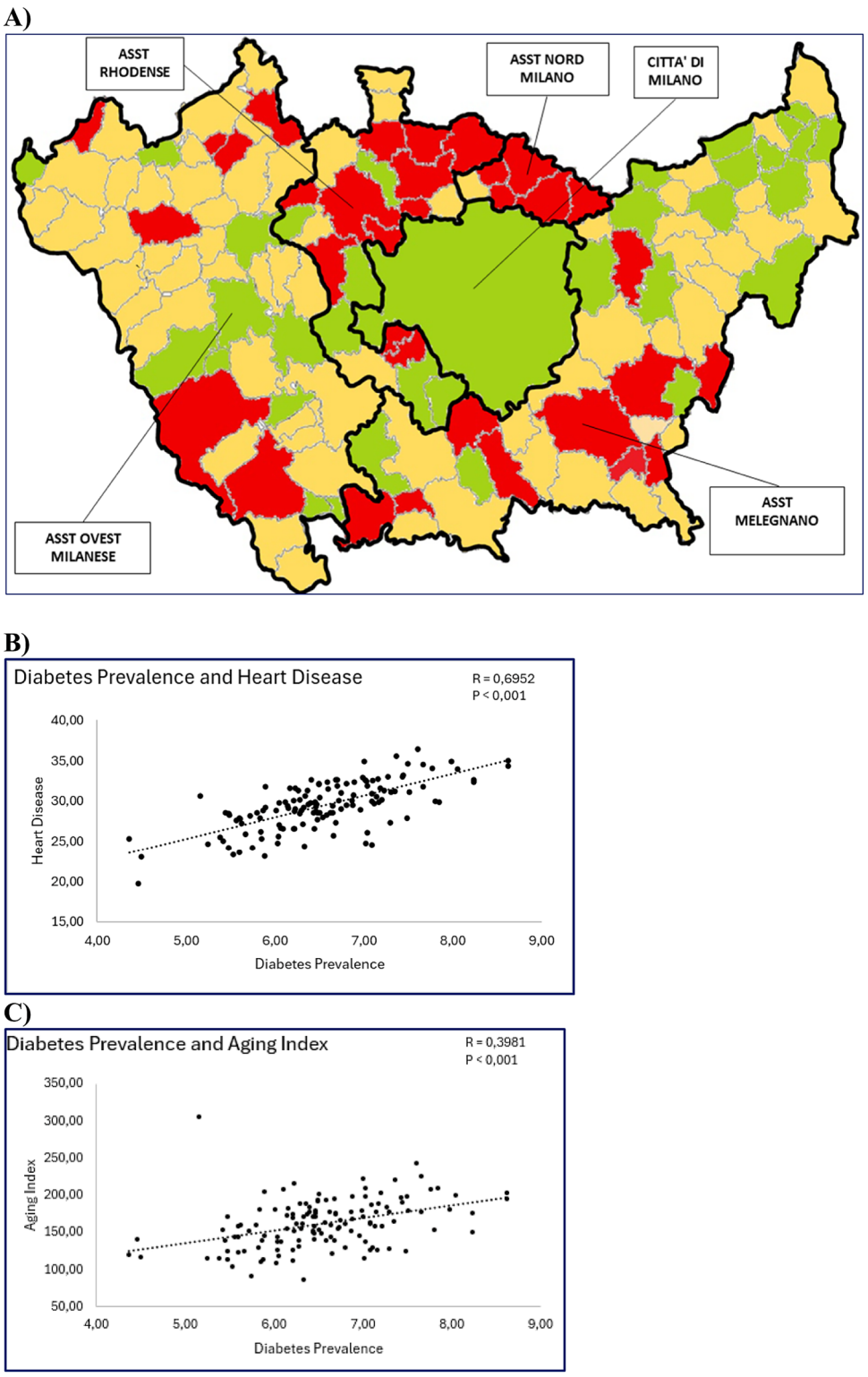

Fig. 1 **A** Within the Metropolitan area of Milan, the prevalence of diabetes ranged between 5.84% in downtown Milan center and 7.7% in the peripheral Northern area. The red color represents a higher prevalence of diabetes mellitus, yellow a medium prevalence of diabetes, green a lower prevalence of diabetes. Fair correlations were found between the prevalence of diabetes and heart disease ($R = 0.695$, $p < 0.001$) (**B**), and between prevalence of diabetes and ageing index ($R = 0.398$, $p < 0.001$) (**C**)

district of Cremona (Fig. 3A and Fig. S16, Supplementary File).

The analysis showed fair correlations between the prevalence of diabetes and the prevalence of cardiovascular disease ($R = 0.658$, $p < 0.001$) (Fig. 3B) and between the prevalence of diabetes and nephropathies ($R = 0.599$, $p < 0.001$) (Fig. S17, Supplementary File).

Sociodemographic determinants also showed a good correlation with the prevalence of diabetes. The Aging index, the Old Age Dependency Index, the Structural Dependence

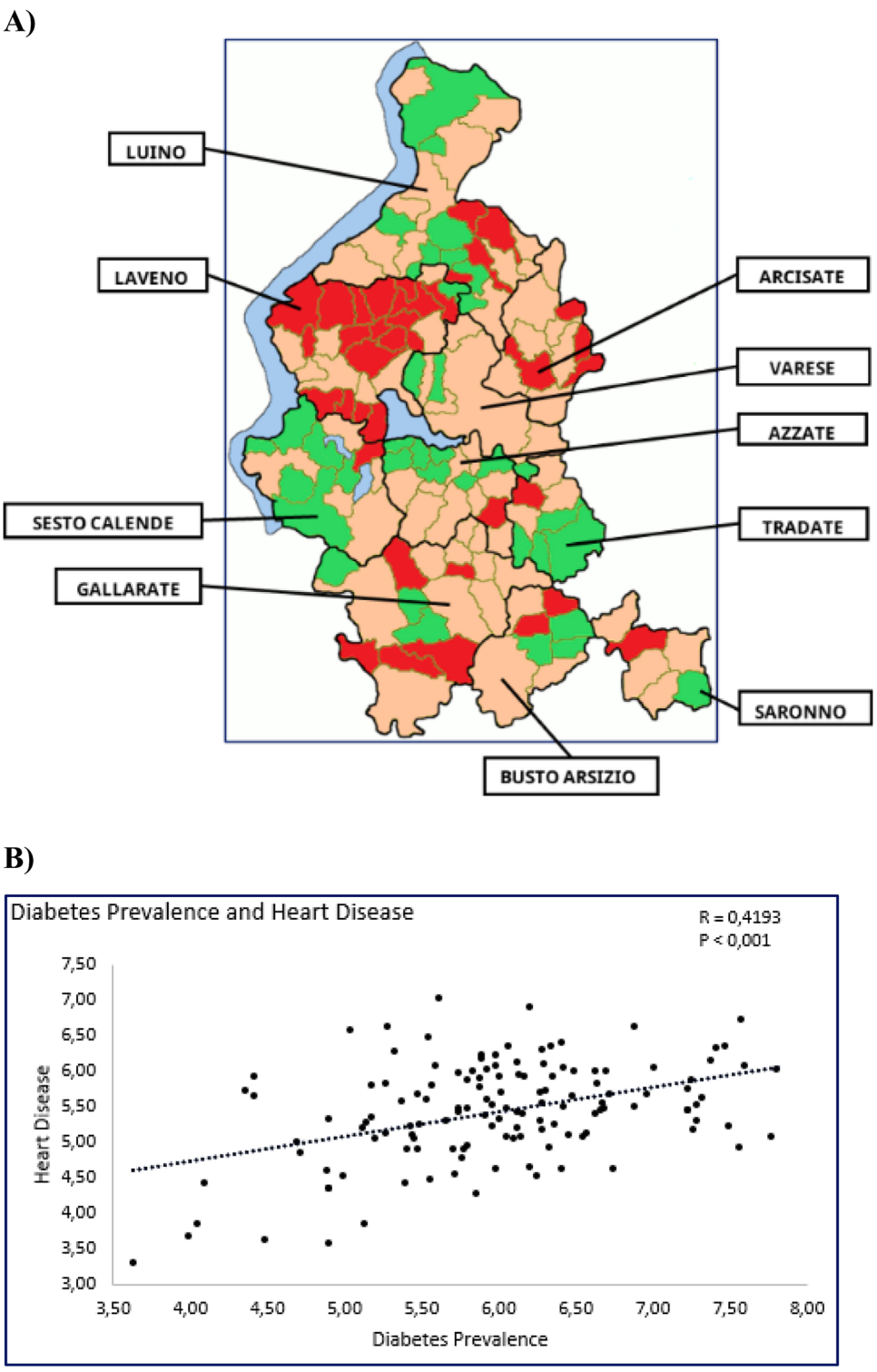

Fig. 2 **A** Within the province of Varese, the prevalence of diabetes ranged between 5.46% and 6.83%. The red color represents a higher prevalence of diabetes mellitus, yellow a medium prevalence of diabetes, green a lower prevalence of diabetes. A good correlation was found between prevalence of diabetes and heart disease (R = 0.419, $p < 0.001$) (**B**)

Index and the Mortality Index gave a Pearson correlation coefficient of 0.494, 0.593, 0.532 and 0.598, respectively (Fig. S18, S19, S20 and S22, Supplementary File).

Instead, weak correlations were highlighted with the Unemployment Rate and the University index (Fig. S21 and Fig. S23, Supplementary File).

Discussion

Since 2010, more than half of the world population lives in large cities and metropolis. Cities offer citizens unique opportunities to increase their income and benefit from education, as well as health and social services. Despite these

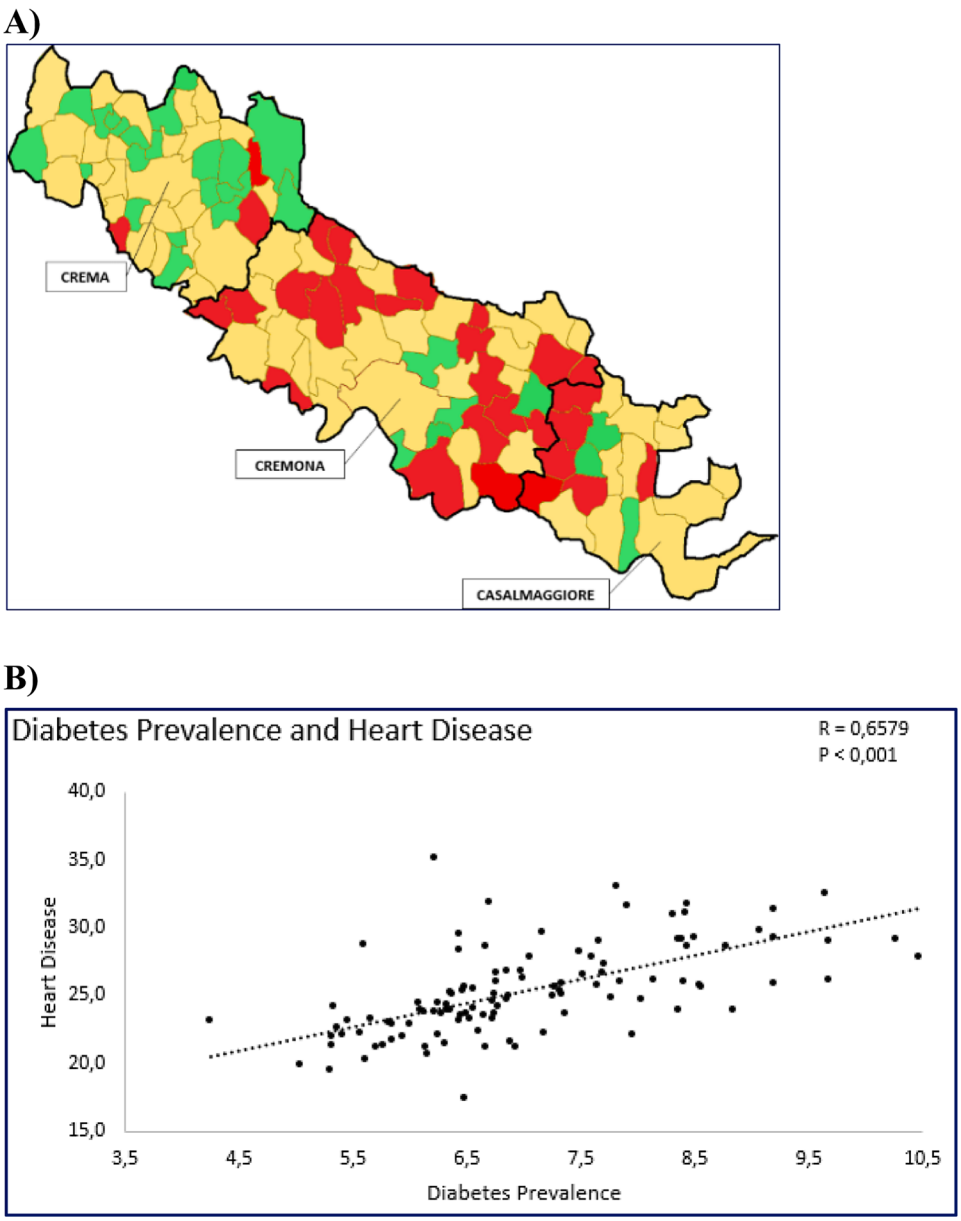

Fig. 3 **A** Within the province of Cremona, the prevalence of diabetes ranged between 6.32% and 7.28%. The red color represents a higher prevalence of diabetes mellitus, yellow a medium prevalence of diabetes, green a lower prevalence of diabetes. A fair correlation was found between prevalence of diabetes and cardiovascular disease ($R = 0.658$, $p < 0.001$) (**B**)

opportunities and benefits, the urban environment can also have a negative impact on citizen's health by exacerbating the relevant factors that lead to chronic non-communicable diseases such as diabetes mellitus and related diseases. Cities therefore offer enormous opportunities to study and understand the factors underlying urban diabetes.

In the present work, we compare diabetes prevalence and related demographic variables assessed in the area of Metropolitan City of Milan with respect to two smaller cities of Lombardy region, namely Varese and Cremona. Our data indicate a similar direct relationship between diabetes and cardiovascular disease in Milan, Cremona and Varese. In the city of Varese, there was no correlation between diabetes prevalence and kidney disease. This finding is intriguing and difficult to explain based on our analysis. Firstly, we may speculate that in a more limited area it is possible to achieve a generalized better diabetes management when compared with Cremona and Milan. It is also possible that a wealthier average socioeconomic status in the Varese area may contribute to leverage the differences in diabetes complications. Analysis of data from the cities involved in this study indicates that the prevalence of diabetes in the Milan Metropolitan area, although below the national value, varies greatly between the different sanitary districts: the same pattern of variation is also confirmed in the city of Cremona, but not in the city of Varese. City and provinces sectors with a higher prevalence of diabetes are the most socioeconomically disadvantaged. In fact, there was a strong association

between a higher prevalence of diabetes, and a higher concentration of elderly subjects in the Milan Metropolitan Area and in the city of Cremona. In contrast, there was an inverse correlation between the educational attainment of the population and the prevalence of diabetes only in the Milan Metropolitan Area, not in Cremona. This is potentially explained by the higher density of Universities and High Educational Institutes in the Milan metropolitan Area with respect to the Cremona area. Similarly, a direct correlation between unemployment rate and diabetes prevalence was found in Milan, but not in Cremona. This finding may be related to the much higher richness variation in a metropolitan city as Milan with respect to a smaller size city like Cremona. Last but not least, air pollution in Milan is definitely higher than in Varese and Cremona and this difference may contribute to a different prevalence of diabetes, since air pollution acts as an endocrine disruptor modulating diabetes prevalence [18].

The implementation of the Cities changing diabetes project in the Metropolitan City of Milan led to the identification of a series of actions to perform in the territory. Those actions aim to counteract the evolution of diabetes disease and have been collected in an Action Plan [19]. Increase citizens awareness on the importance of correct lifestyles (nutrition and physical activity) as tool for the prevention of chronic diseases is the main action implemented in the City of Milan.

Among the strategies to counteract the rise of diabetes, intervention on lifestyle plays a pivotal role. To achieve this outcome, therapeutic patient education (TPE), both individual and in group, is currently considered a crucial element; it could be effective in improving diabetes control without intensifying therapy, in reducing adverse effects and costs, and in ameliorating quality of life [20, 21].

Pharmacotherapy approach to treat obesity represents an important option to associate in the event of unmet objectives through only lifestyle changes. To date, U.S. FDA approved the following anti-obesity medications: phentermine, orlistat, phentermine/topiramate extended release, naltrexone sustained release (SR)/bupropion SR, liraglutide, semaglutide and tirzepatide. Among these drugs, orlistat, naltrexone SR/bupropion SR, liraglutide and semaglutide have also been approved by the European Medicines Agency (EMA) [22]. According to the current guidelines, pharmacological treatment should be considered as part of a comprehensive strategy of the disease management for patients with obesity. Furthermore, in the last years several non-drug therapies have been recently tested in obesity, such as non-invasive neurostimulation: repetitive Transcranial Magnetic Stimulation (rTMS) or Transcranial Direct Current Stimulation. Repetitive TMS revealed effective in controlling food craving and in promoting body weight loss, through an enhanced inhibitory control of Prefrontal Cortex on eating behavior, and is almost devoid of side effects, constituting a potential resource for the prevention of metabolic diseases [23, 24]. Currently, bariatric surgery is considered the most effective and durable treatment for obesity and can induce remission or improvement of type 2 diabetes [25].

The analysis of data from other cities confirms this perspective and places it as a priority activity to be actuated in all territories in collaboration with local health administrations and institutions.

The world is rapidly urbanizing, changing not only the place where we live, but the way we live. Today, the way cities are designed, built and operated, poses major health problems for their citizens. This implies new approaches to map the challenge, understand the areas of greatest risk and vulnerability, and design interventions that can have a real impact. Through the Changing Diabetes program, Milan and other participating cities will help develop new tools to rethink diabetes in an urban setting. The comparison of prevalence data with socio-demographic variables in a large city like Milan with smaller cities and, eventually, with the countryside, will furnish important information on possible strategies to bend the growth curve of diabetes expected in the following decades. Since the Cities Changing Diabetes program is operative in all Italian regions, we also expect important information when comparing a highly industrialized region as Lombardy with Italian regions with the economy based mainly on agriculture.

In conclusion, mapping the Lombardy region about diabetes prevalence, we found intriguing differences in the relationship of diabetes prevalence and several socio-demographic factors when comparing the metropolitan City of Milan with two smaller size, human scale cities as Varese and Cremona. Our present data confirm the hypothesis that urban diabetes will be the challenge for our society during the next decades. Future studies may be useful for studying more specifically the incidence/prevalence of diabetes in relation to differences in the use of diabetes medications or other variables, among the three areas of Lombardy.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00592-024-02324-y.

Author contributions L.L., M.C., C.R., S.d.L., M.B., P.B., M.V., F.S., A.L. were involved in the conception and design of the study; L.L., M.C., C.R., S.d.L., M.B., P.B., M.V., F.S., A.L. conducted the study; L.L., M.C., C.R., S.d.L., M.B., P.B., M.V., F.S., A.L., A.F., S.M., P.S. conducted the analysis and interpretation of the results; all authors edited, reviewed, and approved the final version of the manuscript. L.L. is the guarantor of this work and, as such, had full access to all data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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Data availability The datasets analyzed in the current study are available from the corresponding author upon reasonable request.

Declarations

Conflict of interest The authors have declared that no conflict of interest exists.

Artificial intelligence The authors declare that Artificial Intelligence (AI) has not been used in this scientific writing.

Informed consent For this type of article, a formal consent is not required.

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