

# An ecological study on health inequalities in the city of Bologna (Emilia-Romagna Region, Northern Italy): bridging knowledge and action

Uno studio ecologico sulle disuguaglianze in salute a Bologna: unire conoscenza e azione

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## ABSTRACT

**BACKGROUND:** since January 2017, a multidisciplinary research group, involving the Local Health Authority, the Municipality, and the University of Bologna, carried out a city-wide action-research project on health inequalities consisting of an ecological study over the years 2011-2015 based on indicators that are routinely available within health and social services.

**OBJECTIVES:** to document existing geographical inequalities in health outcomes and use of healthcare services in the city of Bologna (Emilia-Romagna Region, Northern Italy), with the aim to suggest policy action to tackle them.

**DESIGN:** the results of the first phase of the above-mentioned project were reported: five related to the social determinants of health (exposure) and five related to the social determinants of ill-health (outcomes). For each municipal statistical area, the distribution of the exposures as well as rates and Bayesian Relative Risks of the outcomes were plotted on the city map. To evaluate the association between social determinants and health outcomes, Spearman correlation coefficients were estimated.

**SETTING AND PARTICIPANTS:** residents in the city of Bologna aged  $\geq 18$  years in the period 2011-2015, grouped into 90 statistical areas.

**RESULTS:** a North-South divide was apparent for most of the socioeconomic and ill-health indicators, with a high concentration of adverse outcomes in the North-Western part of the city. Adherence to cancer screening represented an exception, being greater in the areas with higher proportion of unfavourable health outcomes. An inverse association between education level and health outcomes was found. Low family income was weakly to moderately correlated with health outcomes. Proportion of residents in council houses and of the teenage foreign population showed a moderate to strong association with all outcomes, but mortality and screening adherence.

**CONCLUSIONS:** an ecological analysis based on data that are routinely collected by local health and social institutions can be effective in revealing the geographical patterns of health inequalities. When accompanied by strategic choices aimed at bridging knowledge and action, this approach may facilitate the direct engagement of local actors towards health equity.

**Keywords:** health inequities, know-do gap, ecological analysis, multi-stakeholder approach, action-research

## WHAT IS ALREADY KNOWN

- Health inequalities have been found among different population groups and geographical areas.
- Despite the growing body of literature on the topic, inequities have grown in many contexts.

## WHAT THIS STUDY ADDS

- An ecological analysis based on data that are routinely collected by the local health and social institutions can be effective in revealing the geographical patterns of health inequalities.
- If embedded in a framework that aims to bridge knowledge and action, such an approach may facilitate the direct engagement of local actors.
- Strategic choices that support this aim are the use of maps, mixed methodology, action-research, and multi-stakeholder approach.

## RIASSUNTO

**INTRODUZIONE:** da gennaio 2017, un gruppo multidisciplinare, comprendente l'Azienda USL, il Comune e l'Università di Bologna, porta avanti un progetto cittadino di ricerca-azione sulle disuguaglianze di salute che consiste in uno studio ecologico basato su dati correnti disponibili nei servizi sanitari e sociali, che ha valutato, per gli anni 2011-2015, indicatori relativi ai determinanti sociali di salute (esposizione) e alle condizioni di salute (esito).

**OBIETTIVI:** studiare le disuguaglianze di salute a Bologna in termini di esiti e accesso ai servizi, allo scopo di suggerire politiche di contrasto.

**DISEGNO:** si riportano i risultati della prima fase dello studio e, per ogni area statistica, sono rappresentati sulla mappa cittadina la distribuzione delle esposizioni e i tassi e i rischi relativi bayesiani attinenti agli esiti. Per valutare l'associazione tra determinanti sociali ed esiti in salute, sono stati stimati i coefficienti di correlazione di Spearman.

**SETTING E PARTECIPANTI:** popolazione maggiorenne residente a Bologna dal 2011 al 2015, suddivisa in 90 aree statistiche.

**RISULTATI:** si è riscontrato un divario Nord-Sud per la maggior parte degli indicatori socioeconomici e di esito; le aree del Nord e dell'Ovest della città presentavano i peggiori esiti di salute, a eccezione dell'adesione agli screening colorettole e mammografico, che invece era maggiore in tali aree. L'analisi delle correlazioni ha messo in luce un'associazione inversa tra livello di istruzione ed esiti sanitari. Il basso reddito fami-

liare risultava, invece, da debolmente a moderatamente correlato. La proporzione di residenti in case popolari e della popolazione straniera minorenni mostrava una correlazione da moderata a forte con tutti gli esiti, a eccezione della mortalità e degli screening.

**CONCLUSIONI:** uno studio ecologico basato su dati correnti sanitari e sociali può essere efficace nel mettere in luce la di-

stribuzione geografica delle disuguaglianze in salute. Se accompagnato da scelte strategiche volte a unire conoscenza e azione, questo approccio può facilitare il coinvolgimento diretto degli attori locali nella definizione di politiche orientate all'equità.

**Parole chiave:** disuguaglianze in salute, know-do gap, studio ecologico, approccio multi-stakeholder, ricerca-azione

## INTRODUCTION

There is vast evidence on how the social, political, and cultural context shapes the distribution of health and disease within society. Several epidemiological studies have shown how lower socioeconomic classes systematically have higher incidence of mortality and morbidity, and how worse health outcomes linked to barriers in accessing healthcare services particularly concern the populations that are most vulnerable and discriminated against.<sup>1-5</sup> Inequalities have been found among individuals with different levels of education or income, among different population groups, and among different geographical areas,<sup>6,7</sup> including different areas of the same city.<sup>8-10</sup> The existing literature covers mainly inequalities among countries or regions/areas within a country. Studies that map the situation at a smaller level, for example in a city, are much less frequent and, yet, they are more informative in terms of orienting (and possibly monitoring) local policies.<sup>11</sup> Moreover, quite disappointingly, as the body of literature on the topic has grown exponentially in the past twenty years, inequities have also grown in many contexts, thus reinforcing the know-do gap.<sup>8</sup>

Since January 2017, a multidisciplinary, multiprofessional, and interinstitutional research group has carried out an action-research project on health inequities in the city of Bologna, with an approach strongly oriented to making an impact in terms of health policies and outcomes, towards health equity.<sup>12</sup> The group is mixed in terms of disciplines (public health, medical anthropology, epidemiology, and statistics) and involves the Local Health Authority (Departments of Public Health and Primary Care and the City Health District), the Municipality of Bologna, and the Centre for International and Intercultural Health (CSI), a multidisciplinary group composed of medical professionals and anthropologists created in the University of Bologna and linked to a civil society organisation by the same name. From the encounter of these actors, the efforts converged to design a city-wide project in two steps: a first phase of quantitative analysis of health inequalities and a second phase of qualitative research in selected areas of the city, aimed at understanding the local determinants responsible for the reproduction of inequities and informing policy to address them. An action-research approach was embedded throughout the project in order to allow the integration of research findings and evidence into healthcare policy and practice, with periodic evaluations to ensure progress towards the intended results.

In this paper, the results of the first phase of quantitative analysis of existing geographical inequalities are reported and discussed in terms of health outcomes and use of healthcare services in the city of Bologna. In the discussion, key elements of the process and methodological connection between data collection and policy work are commented.

## MATERIALS AND METHODS

### DESIGN AND STUDY POPULATION

An ecological study was conducted over the years 2011-2015. The study population consisted of the residents in the city of Bologna aged  $\geq 18$  years, grouped according to their residential address into 90 municipal statistical areas, which represented the ecological units of analysis. The municipal statistical areas are administrative zones defined by the union of multiple census tracts whose boundaries are generally outlined by physical infrastructures (e.g., railways or main roads); they usually count enough residents to allow meaningful statistical analyses (11 statistical areas with less than 150 inhabitants were excluded from the analysis, because information on sociodemographic characteristics are not routinely released by the municipal Planning and Statistical Control Unit).

### VARIABLES OF INTEREST AND DATA SOURCES

With the aim of describing the distribution of and the relationship between social determinants of health and the disease burden in the city of Bologna, a set of exposure and outcome indicators measured at statistical area level was selected. The choice of the indicators was driven by data accessibility, including issues of privacy that may limit the linkage of information at individual level, and availability. Five indicators of the social determinants of health (i.e., exposure) were chosen in order to cover three main domains:

- educational credentials (education level);
- material resources (income and council housing);
- social support and networks (single-parent families and proportion of immigrants).

For each indicator, definitions and data sources are reported in table 1.

**Educational credentials** reflect the socioeconomic and intellectual resources of the family of origin, contribute to determine the access and the position in the job market, and have an impact on one's ability to look for and understand information, including health messages.<sup>13</sup>

**Income** is considered one of the most direct measures of material resources and affects health through multiple pathways, for example, by enabling people to access healthy food, comfortable housing, services (e.g., health services or education), or through its indirect effect on social participation and opportunity to control life circumstances.<sup>13,14</sup>

It has been argued that the **place where people live**, including the characteristics of the building and the neighbourhood, reflect distinctive material and social aspects, such as the commodities of an area, the level of security, the presence of community life and social support (e.g., contacts with neighbours, presence of meeting spaces, gyms, food markets, etcetera), which have both direct and indirect effects on health.<sup>15</sup> Council housing estates are often areas with high levels of material, social, and economic deprivation and therefore their concentration within a certain neighbourhood may be a marker of poor socioeconomic conditions.

Social support, social networks, and social integration are important determinants of people's wellbeing. Among the indirect indicators of social networks, **single parenthood** has shown to be associated with adverse health outcomes and increased mortality.<sup>16</sup>

Immigrants face different challenges, including sociocultural barriers to access services, low socioeconomic status, lack of family and friendship network, exclusion and discrimination.<sup>17</sup> The **concentration of immigrants within a certain neighbourhood** can therefore be a proxy indicator of the area social support and integration level.

Five indicators of ill health (i.e., outcomes) were chosen in order to assess three main aspects:

- overall health (all-cause mortality);
- disease burden (diabetes prevalence);
- access to health services (Emergency Room access, polypharmacy, and adherence to screening).

For each outcome, definitions and data sources are reported in Table 1.

**All-cause mortality** is a simple yet key indicator of a population's health status. Noncommunicable diseases are the leading cause of morbidity and mortality in Europe and Italy. Among them, **diabetes** represents one of the greatest challenges for the national health system, because it drains a considerable amount of resources and its prevalence has been on the rise in the last decades as a consequence of the population aging.<sup>18</sup> Diabetes is more prevalent among the most disadvantaged population groups who usually experience greater psychosocial stress, economic difficulties that prevent them from adopting healthy lifestyles, and inadequate access to care and health education.<sup>19</sup>

Among the indicators of health care access and utilisation, **Emergency Room (ER) accesses for non-serious conditions** (hereafter, ER access) indirectly represent the missed opportunities for primary care access, **polypharmacy** the burden of multimorbidity in the population mainly re-

sulting from inadequate preventive measures, and the **adherence to organised screening programmes** the system ability to promote effective preventive measures at population level.

## STATISTICAL ANALYSES

### ■ Descriptive analyses

For each statistical area with  $\geq 150$  inhabitants, the selected social determinants of health were plotted on the city map divided into five quantile categories. Similarly, crude age-specific and directly age-standardised rates and prevalences were estimated using the Italian 2011 census population as the standard. To stabilise the estimates, which in some cases were based on small numbers of events and small at-risk populations, the Bayesian Relative Risks (BRR) were calculated using the Besag York and Mollié (BYM) model for the following outcomes: all-cause mortality rate, diabetes, ER access, and polypharmacy prevalence. The BYM model is a lognormal Poisson model which contains a random-effect component for non-spatial heterogeneity and a component that accounts for spatial autocorrelation (i.e., tendency of adjacent areas to have similar characteristics).<sup>21</sup> This model is widely considered an appropriate tool for small area disease mapping and may be better than other models when it comes to the classification of areas into risk groups.<sup>22</sup> BRR values  $>1$  indicate areas with higher rates/prevalences, values  $<1$  those with lower rates/prevalences. BRRs were plotted on the city map to describe the spatial pattern of the health outcomes along with crude rates for the indicator "adherence to screening". For the outcomes, different quantile classifications of the estimates were chosen in order to maximise the difference between classes and minimise those within classes.

### ■ Correlations

In order to evaluate the relationship between social determinants of health and health outcomes measured at the statistical area-level, Spearman rank correlation coefficients (RHO) were estimated; they quantify the relationship between two variables X and Y and can take values between  $-1$  and  $+1$ , where  $1$  is a total positive correlation,  $-1$  is a total negative correlation, and  $0$  indicates the absence of correlation. The Spearman rank test was chosen, because the data were not always normally distributed and outliers were present (figures S1-S6, see on-line supplementary materials). 95% confidence intervals were obtained using bootstrap with 1,000 replicas in order to provide information on the uncertainty around the estimates. Although cut-off points are usually deemed to be arbitrary, conventional approaches to interpret correlations consider the association very weak for absolute values of the coefficient between  $0$  and  $0.19$ , weak for values  $0.2-0.39$ , moderate for values  $0.40-0.59$ , strong for values  $0.6-0.79$ , and very strong for values  $0.8-1.0$ .<sup>23</sup>

DOMAIN	DEFINITION	DATA SOURCES	OVERALL CITY ESTIMATE
<b>EXPOSURE</b>			
<b>Educational credentials</b>	% of graduates aged 25-44 years over the total population aged 25-44 years	2011 Census	39.7%
<b>Material resources</b>	% of families with a per-capita equalised income <12,338 euro (corresponding to 60% of median equalised income)	Tax return database 2014	24.9%
	% of residents in council housing	2011 Census	5.6%
<b>Social support and networks</b>	% of underages in single parent families over the total of underage population	Municipal register 2016	19.6%
	% of foreign population aged 0-19 years over the total population aged 0-19 years	Municipal register 2016	21.8%
<b>OUTCOME</b>			
<b>Overall health status</b>	<b>All-cause mortality rate</b>	Mortality register and municipal register 2011-2015	753.3
	For each statistical area, the numerator is the number of overall deaths among subjects aged $\geq 18$ years, and the denominator is the sum of the residents for each year and age-class (18-24, 25-44, 45-64, 65-74, 75-84, 85+).		
<b>Disease burden</b>	<b>Diabetes prevalence</b>	Hospital discharge archive, drug prescription database, exemption database, and municipal register 2015	5.8
	For each statistical area, the numerator is the number of diabetes cases identified through a validated algorithm,* and the denominator is the sum of the residents by age-class (18-24, 25-44, 45-64, 65-74, 75-84, 85+).		
<b>Health service access and utilisation</b>	<b>Emergency Room (ER) access for non-serious conditions prevalence</b>	Emergency Room (ER) database and municipal register 2015	4.9
	For each statistical area, the numerator is the number of subjects with >1 access to A&E for non-serious conditions (white and green triage codes), and the denominator is the sum of the residents by age-class (18-24, 25-44, 45-64, 65-74, 75-84, 85+).		
	<b>Polypharmacy prevalence</b>	Drug prescription database and municipal register 2015	8.1
	For each statistical area, the numerator is the number of subjects with prescription or dispensing of $\geq 3$ drugs from different ATC group codes (excluding group J drugs: anti-infective for systemic use) in the last three months of the index year, and the denominator is the sum of the residents by age-class (18-24, 25-44, 45-64, 65-74, 75-84, 85+).		
<b>Adherence to breast and colorectal cancer screening</b>	Breast and colorectal cancer screening database 2011-2015	64.5 (breast) 52.7 (colorectal)	
	For each statistical area, the numerator is the number of subjects who were tested among those who were invited, and the denominator is the number of women aged 45-74 years or the number of subjects aged 50-69 years who were invited for breast and colorectal cancer screening, respectively, between 2011 and 2015.		

\* Diabetes cases are identified through the hospital discharge archives (code 250.xx of the ICD-9-CM), the drug prescription database (codes A10A, A10B and/or A10X of the ATC system), and the exemption database (exemption from co-payment of diabetes-related health care services due to a diabetes diagnosis).<sup>20</sup> / I casi di diabete identificati tramite schede di dimissione ospedaliera (codice 250.xx dell'ICD-9-CM), il database delle prescrizioni di farmaci (codici A10A, A10B e/o A10C del sistema ATC) e il database delle esenzioni (esenzioni in regime di copagamento di servizi sanitari legati al diabete a seguito di diagnosi di diabete).<sup>20</sup>

**Table 1.** Indicators of the social determinants of health and outcomes: domain, definition, data sources, and overall city estimates.

**Tabella 1.** Indicatori relativi ai determinanti sociali di salute e agli esiti: domini, definizione, fonti dei dati e valore medio cittadino.

## RESULTS

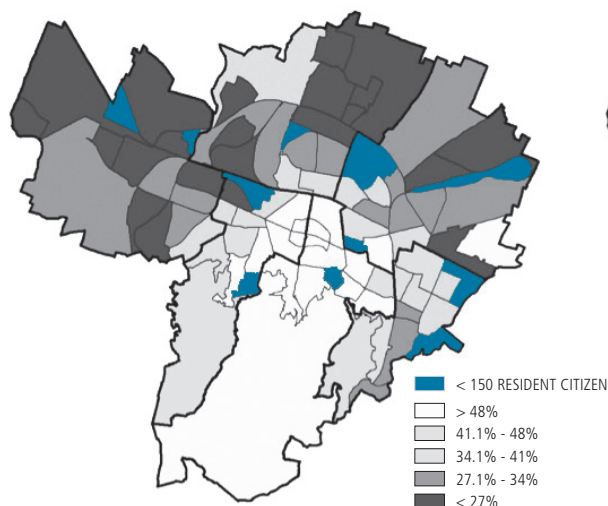
The mapping of the social determinants and of the ill-health indicators revealed their unequal distribution across the city (figures 1 and 2).

A North-South divide was apparent for most of the socioeconomic characteristics evaluated. The areas with the lowest proportion of high-educated individuals were clearly clustered in the North-Western part of the city. Similarly, the majority of those with the highest proportion of families with low income, those with the highest percentage of young foreign residents, and those with the highest concentration of council housing estates were located in the Northern part of the city, although pockets of economic disadvantage were also present in the city Centre. The proportion of underages in single-parent fami-

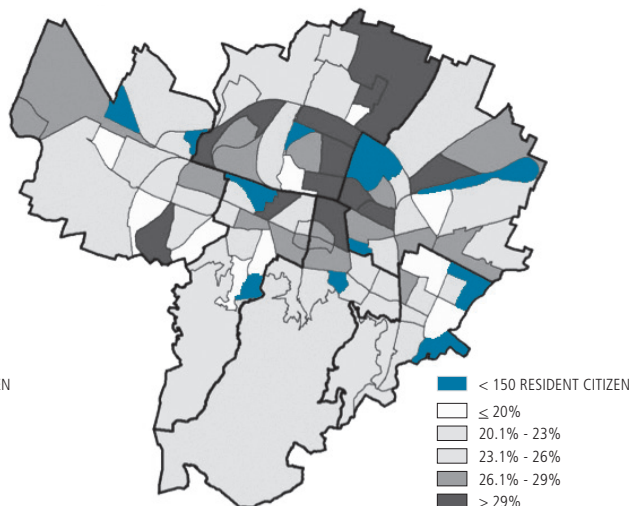
lies was less patterned with the lowest concentration in the western areas and a clusterization in the Central and Eastern areas.

The geographical distribution of the ill-health indicators generally mirrored the distribution of the social determinants, with a high concentration of adverse outcomes in the North-Western part of the city. In those areas, the excess risk (compared to the city average) was often greater than 10% in the case of all-cause mortality and polypharmacy, greater than 20% for diabetes prevalence and ER access prevalence. Adherence to breast and colorectal cancer screening, which is an indicator of the access to preventive measures, represents an exception, being greater in those areas with higher proportion of unfavourable health and access outcomes.

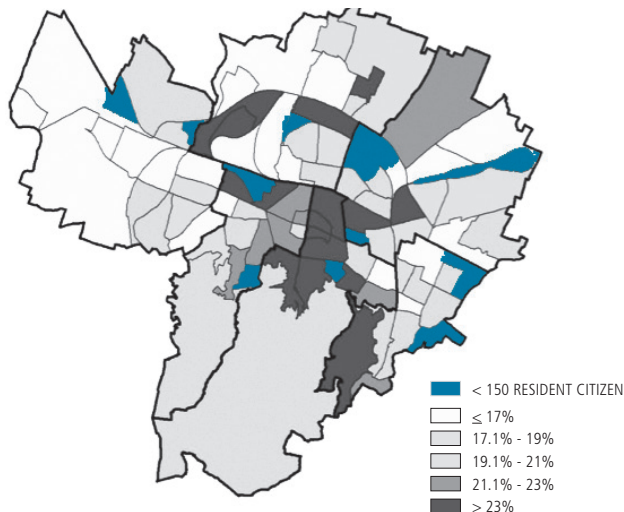
**PROPORTION OF GRADUATES (24-44 YEARS) OVER TOTAL POPULATION (25-44 YEARS)**



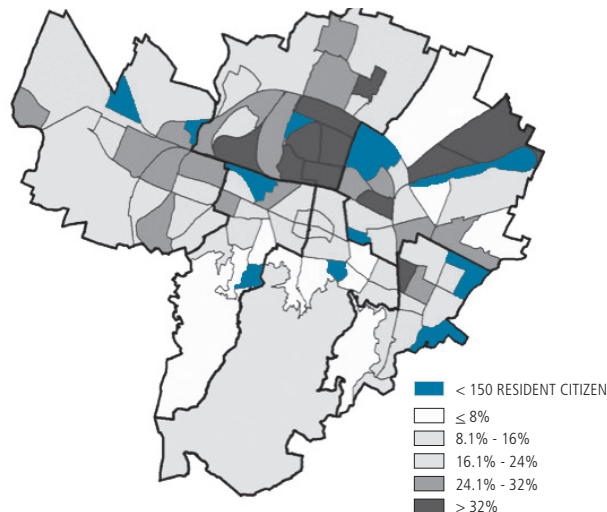
**PROPORTION OF FAMILIES WITH A PER-CAPITA EQUALIZED INCOME <12,337 EUROS**



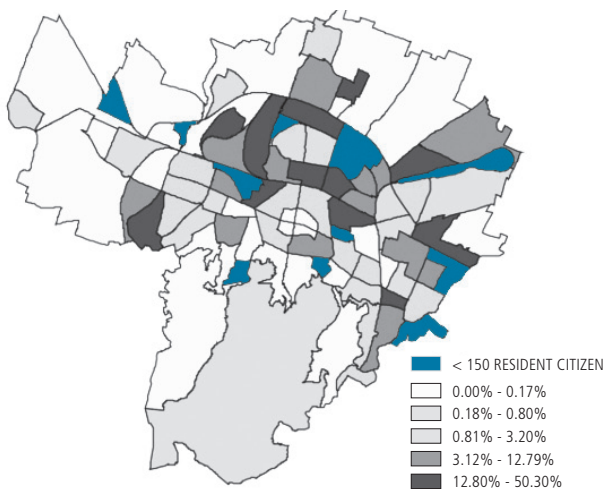
**PROPORTION OF UNDERAGES IN SINGLE-PARENT FAMILIES OVER TOTAL UNDERAGE POPULATION**



**PROPORTION OF FOREIGN POPULATION (0-19 YEARS) OVER TOTAL POPULATION (0-19 YEARS)**



**PROPORTION OF RESIDENTS IN COUNCIL HOUSING**

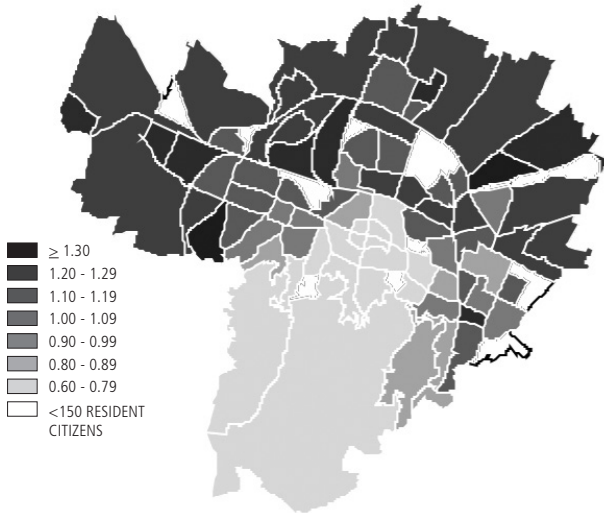


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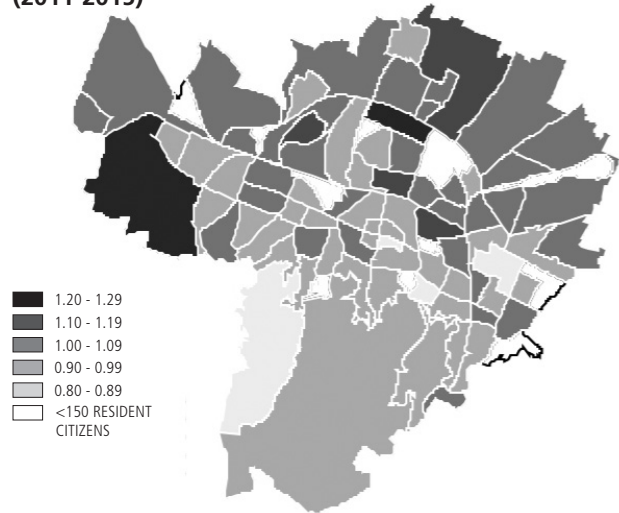
**Figure 1.** Geographical distribution of the exposure indicators by statistical area. Bologna, 2011-2015.  
**Figura 1.** Distribuzione geografica degli indicatori di esposizione per area statistica. Bologna, 2011-2015.

**(A) BAYESIAN RELATIVE RISK**

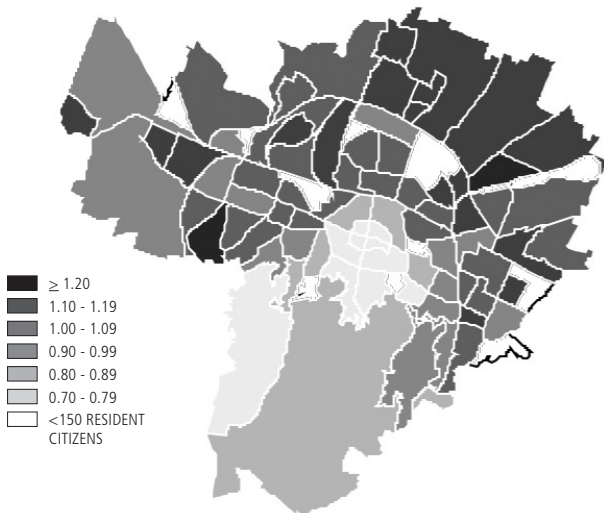
**DIABETES PREVALENCE (2015)**



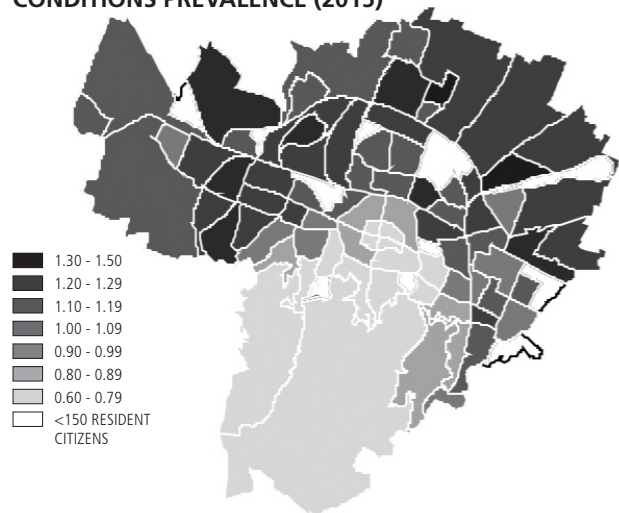
**STANDARDISED ALL-CAUSES MORTALITY RATE (2011-2015)**



**POLYPHARMACY PREVALENCE (2015)**

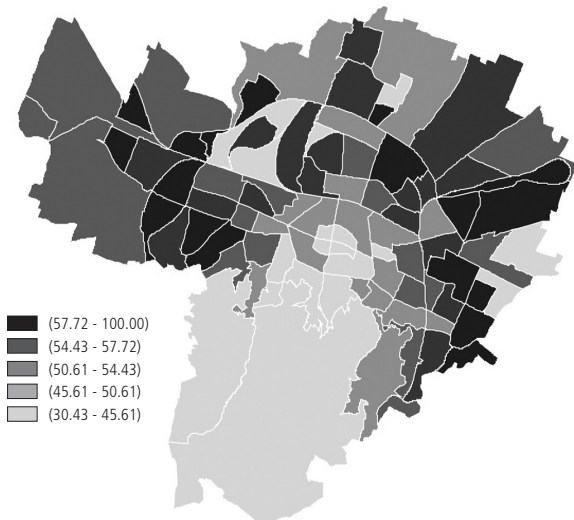


**EMERGENCY ROOM ACCESS FOR NON-SERIOUS CONDITIONS PREVALENCE (2015)**

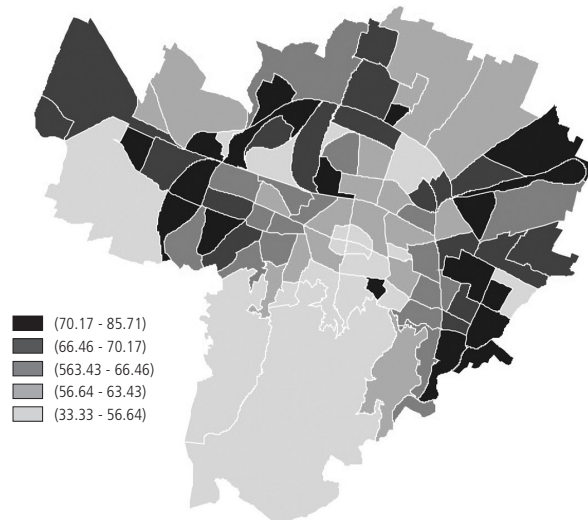


**(B) ADHERENCE TO BREAST COLORECTAL CANCER SCREENING CRUDE RATE (2011-2015)**

**COLORECTAL CANCER SCREENING**



**BREAST CANCER SCREENING**



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**Figure 2.** Geographical distribution of the outcomes by statistical area: (A) bayesian relative risks for diabetes prevalence, overall mortality, polypharmacy prevalence, and emergency room access for non-serious conditions prevalence; (B) crude rates of adherence to colorectal and breast cancer screening. Bologna, 2011-2015.

**Figura 2.** Distribuzione geografica degli esiti per area statistica: (A) rischi relativi bayesiani di prevalenza di diabete, mortalità per tutte le cause, prevalenza di poliprescrizione e di accessi al pronto soccorso per codici bianchi e verdi; (B) tassi grezzi di adesione agli screening colorettae e mammografico. Bologna, 2011-2015.

Table 2 reports the correlation coefficients for the association between social determinants of health and health outcomes.

As expected, there was an inverse association between the proportion of highly educated people and health outcomes (i.e., as the education level increases the probability of the adverse outcome decreases). The correlation was strong for diabetes prevalence, ER access and polypharmacy, and weak for all-cause mortality. Screening adherence showed a tendency to decrease with the area education level increase. Low family income appeared to be weakly to moderately correlated with mortality, diabetes, ER access, polypharmacy (positive correlation), and with screening adherence (negative correlation). Proportion of residents in council houses and of the teenage foreign population showed a moderate to strong association with all outcomes, except for mortality and screening adherence. The association between the proportion of underages in single-parent families and the outcomes presented a somewhat unexpected direction, being the increase in that proportion correlated with a decrease in the probability of adverse health outcomes.

## DISCUSSION

### SUMMARY OF THE QUANTITATIVE RESULTS

The present study represents the first attempt to map health inequalities using aggregate administrative health data in the city of Bologna. Despite the limitations of this approach, the Northern and Western areas of the city are shown to be generally the most socioeconomically deprived and to bear the greatest burden of adverse health outcomes. To an extent that varied according to the indicator of socioeconomic position and the health outcome

considered, there was an association between the social determinants of health and the probability of ill-health (mortality and diabetes) and hampered access to primary and preventive health services (polypharmacy and ER access). These were inversely correlated with the area-level proportion of graduates and directly correlated with the area-level proportions of families with low income, immigrants, and council houses. Proportion of single-parent families and adherence to colorectal and breast cancer screening were exceptions to this pattern, the former being mainly clustered in the Central and Eastern areas of the city, the latter showing highest rates in the most deprived areas.

The findings presented in this study are in line with the vast evidence on social inequalities in health. Education is one of the most widely used indicators of socioeconomic position, consistently showing an inverse association with health outcomes, at international,<sup>6</sup> national,<sup>24</sup> and local level.<sup>25</sup> Similarly, studies that looked at the impact of income and immigrant status in the local context have shown that economically disadvantaged groups and immigrants experience the highest risk of hospitalisation for conditions amenable to ambulatory care, highlighting the issue of fairness in healthcare access.<sup>26,27</sup>

The somehow counterintuitive finding of a lower screening adherence in less deprived areas may be partially explained by a greater propensity of well-off individuals to seek private specialist care. Higher adherence rates in areas with worse socioeconomic conditions may also be interpreted as the effectiveness of free population-based organised preventive programmes, such as cancer screening, in reducing socioeconomic inequalities in access and, possibly, outcomes.<sup>28</sup>

HEALTH OUTCOMES	SOCIAL DETERMINANTS (%)				
	GRADUATES (25-44 YEARS) OVER THE TOTAL POPULATION (25-44 YEARS)	FAMILIES WITH A PER-CAPITA EQUALISED INCOME <12.338 €	RESIDENTS IN COUNCIL HOUSING	UNDERAGES IN SINGLE PARENT FAMILIES OVER THE TOTAL OF UNDERAGE POPULATION	FOREIGN POPULATION (0-19 YEARS) OVER THE TOTAL POPULATION (0-19 YEARS)
All-cause mortality rate (2011-2015)	-0.47 (-0.65;-0.29)	0.46 (0.27;0.64)	0.34 (0.11;0.58)	-0.45 (-0.30;-0.21)	0.37 (0.16;0.59)
Diabetes prevalence (2015)	-0.79 (0.90;-0.67)	0.35 (0.15;0.55)	0.46 (0.25;0.67)	-0.41 (-0.63;-0.21)	0.67 (0.53;0.81)
ER access for nonserious conditions prevalence (2015)	-0.73 (-0.85;-0.60)	0.36 (0.15;0.56)	0.53 (0.34;0.73)	-0.37 (-0.61;-0.14)	0.63 (0.46;0.80)
Polypharmacy prevalence (2015)	-0.64 (-0.80;-0.47)	0.11 (-0.10;0.33)	0.44 (0.24;0.65)	-0.32 (-0.56;-0.09)	0.48 (0.29;0.68)
Adherence to breast cancer screening (2015)	-0.55 (-0.74;-0.37)	-0.29 (-0.52;-0.05)	0.26 (0.04;0.48)	-0.52 (-0.72;-0.32)	0.33 (0.10;0.59)
Adherence to colorectal cancer screening (2015)	-0.51 (-0.71;-0.32)	-0.43 (-0.64;-0.21)	0.23 (0.00;0.46)	-0.54 (-0.71;-0.36)	0.26 (0.03;0.49)

**NOTE:** the green scale represents the magnitude of the correlation, from very weak to very strong, as detailed in the statistical analysis section. / **NOTA:** la scala di verdi rappresenta l'intensità della correlazione, da molto debole a molto forte, come dettagliato nella sezione delle analisi statistiche.

**Table 2.** Spearman correlation coefficients and relative 95% confidence intervals for the association between selected social determinants and health outcomes. Bologna, 2011-2015.

**Tabella 2.** Coefficienti di correlazione di Spearman e relativi intervalli di confidenza al 95% per la stima dell'associazione tra determinanti sociali ed esiti di salute. Bologna, 2011-2015.

The direction of the correlations between health outcomes and the proportion of underages in single-parent families was also unexpected, given the positive association between single parenthood and worst health outcome reported in other countries, which, however, may present family structures different from the Italian one.<sup>29</sup> On the one side, the ecological nature of the study may partially contribute to explain this finding; on the other side, it may be argued that the proportion of underages in single-parent families is not a valid indicator of socioeconomic circumstances in the local context, as the uneven distribution at city level seems to suggest.

### METHODOLOGICAL CHOICES

■ **Routinely available datasets.** An added value of this work is the choice to rely on data that are routinely collected by the local health and social institutions, and build indicators based on those data. This choice significantly reduced problems related to data collection and accessibility, including issues of privacy. It also allowed a greater and more direct involvement of the relevant public institutions and services into the action-research process. Finally, it is a promising step towards the systematic analysis of inequalities and the replication of the approach in other contexts. However, such choice also implied some limitations, first and foremost the fact that indicators based on administrative data tend to underestimate the prevalence of morbidity and access to services. This is mainly because mild-disease cases may not be detected and because access to private health services remains untraced.

■ **The use of maps.** Maps are powerful and evoking tools;<sup>30</sup> in this study, they were used to illustrate the geographic distribution of social determinants and health outcomes within the city. At the end of phase 1 of the project, the maps were presented and discussed at several interinstitutional tables, both at the municipal level and in the neighbourhoods, and used in public presentations, in order to raise awareness on the existing geographical inequalities and collect the input of local actors on the potential links with other determinants.<sup>12</sup> For instance, the maps showed that some areas of the city share similar socioeconomic and health problems; many of those area have a higher concentration of council housing estates (something confirmed also by the results of the correlation analysis used in the present study).

At the same time, maps are also useful to engage the communities who are affected and the civil society organisations that represent or work with them, in order to:

- expose health inequalities to public scrutiny;
- develop participatory and empowerment-oriented processes leading not only to analyse the problems, but also their root causes and the possible solutions;<sup>31</sup>
- advocate for action from institutions and services.

The presentation and discussion of the maps with the

communities has been piloted in a neighbourhood at the end of phase 1 and will be an action of the second phase of the project.

Since maps are apparently easy to understand, it is important to carefully plan a comprehensive knowledge transfer towards local institutions, public services, and the population to prevent misinterpretations.

■ **Addressing the know-do gap.** Other choices that need to be accounted for are related to the effort to link knowledge on health inequalities and action to address them, a process affected by the so-called “know-do gap”, considered one of the most important challenges for public health by the World Health Organisation.<sup>32</sup> Based on the experience of the Authors, the action-research approach was promising in this sense.<sup>33</sup>

It was chosen a quantitative analysis and mapping in the first phase, both to have a broad epidemiological picture and to increase the chances to engage the relevant stakeholders. In fact, when dealing with complex issues and social phenomena, decision-makers tend to rely more on abstract standardised knowledge.<sup>34</sup>

From its inception, the project has been co-constructed with the stakeholders involved in addressing local inequalities. Multi-stakeholder approaches have become very common in public health policy-making, less in public health research. However, the early engagement of decision-makers in research is a good practice towards addressing and reducing the know-do gap.<sup>35</sup>

A tangible result of this approach has been the signing, at the end of phase 1, of an inter-institutional agreement involving the Municipality, the Local Health Authority, the University of Bologna, and the S. Orsola teaching hospital in order to finance the second phase of the project, based on qualitative methods and aimed at orienting policy making.

■ **Limitations and strengths.** Beyond those already mentioned, a few more limitations need to be highlighted. First of all, what is called ‘ecological fallacy’,<sup>36</sup> that is the impossibility to assume that the relationships observed at area-level necessarily hold at individual level. In fact, they mainly show how some indicators are distributed across areas and which areas are more disadvantaged, thus pointing on policy-relevant, societal level determinants of health outcomes.

The choice to use statistical areas as unit of analysis, though relevant because tightly linked to the administrative data collection system, also posed some limitations, as areas are not always homogeneous in terms of social, historical, and urbanistic factors. Moreover, some areas are particularly small, which is a limit when trying to quantitatively study phenomena with a low frequency.

Exposures and outcomes were measured at the same time. This prevented from accounting for any latency between exposure to socioeconomic determinants and their health



consequences, although the results here presented are in line with previous research that looked directly at the mechanisms and associations between material and/or psycho-social deprivation and health.

Finally, compared to self-standing epidemiological researches, this project is more complex and labour-intensive, requiring many actions at different levels, that are made possible only through the engagement of multiple actors. This, however, appears as a productive investment when the expected outcome is generating change in policy and practice.

## CONCLUSIONS

This experience shows that an ecological analysis based on data routinely collected by the local health and social institutions can be effective in describing health inequalities and may facilitate the direct engagement of local actors if they are embedded in an approach that aims to bridge knowledge and action. A set of strategic and methodolog-

ical choices are relevant to this end, including the use of maps, adopting a mixed methodology, framing the project as an action-research, and adopting a multi-stakeholder approach.

Given the tailored adaptation to the context, there is a limit to the replicability of this project. However, the core epidemiological and public health practice involved – the use of routinely available data to map inequalities – can be easily exported, knowing that it is the less challenging part of a much larger task which involves engaging the local stakeholders towards greater health equity.

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## REFERENCES

- Marmot MG, McDowall ME. Mortality decline and widening social inequalities. *Lancet* 1986;2(8501):274-76.
- Wilkinson RG. *Unhealthy Societies: The Afflictions of Inequality*. Routledge; 2002.
- Acheson D. *Independent Inquiry into Inequalities in Health Report*. HM Stationery Office; 1998.
- Marmot M, Wilkinson R. *Social Determinants of Health*. OUP Oxford; 2005.
- Clavenna A. Osservatorio italiano sulla Salute Globale. *Ric Prat* 2006;22(6).
- Mackenbach JP, Valverde JR, Artnik B, et al. Trends in health inequalities in 27 European countries. *Proc Natl Acad Sci U S A* 2018;115(25):6440-45.
- Di Girolamo C, Nusselder WJ, Bopp M, et al. Progress in reducing inequalities in cardiovascular disease mortality in Europe. *Heart* 2020;106(1):40-49.
- World Health Organization. *Closing the Gap in a Generation: Social Equity Through Action on the Social Determinants of Health*. Commission on Social Determinants of Health Final Report. Geneva: World Health Organization; 2008.
- Costa G, Strocchia M, Zengarini N, Demaria M. *40 Anni Di Salute a Torino, Spunti per leggere i bisogni e i risultati delle politiche*. Milano: Inferenze; 2016.
- Petrelli A, Di Napoli A, Sebastiani G, et al. Italian Atlas of mortality inequalities by education level. *Epidemiol Prev* 2019;43(1) Suppl 1:1-120.
- Barr B, Higginson J, Whitehead M. Investigating the impact of the English health inequalities strategy: time trend analysis. *BMJ* 2017;358:j3310.
- Bodini C, Gentilini V. Addressing Health Inequities in the City of Bologna: A Mixed-Method, Multi Stakeholder and Action-Research Approach Towards Health Equity. In: Battisti A, Marceca M, Iorio S (eds). *Urban Health. Participatory Action-research Models Contrasting Socioeconomic Inequalities in the Urban Context*. Springer International Publishing. 2020 (in press).
- Galobardes B, Shaw M, Lawlor DA, Lynch JW, Smith GD. Indicators of socioeconomic position (part 1). *J Epidemiol Community Health* 2006;60(1):7-12.
- Marmot M. The influence of income on health: views of an epidemiologist. *Health Aff (Millwood)* 2002;21(2):31-46.
- Galobardes B, Morabia A. Measuring the habitat as an indicator of socioeconomic position: methodology and its association with hypertension. *J Epidemiol Community Health* 2003;57(4):248-53.
- Chiu M, Rahman F, Vigod S, Lau C, Cairney J, Kurdyak P. Mortality in single fathers compared with single mothers and partnered parents: a population-based cohort study. *Lancet Public Health* 2018;3(3):e115-23.
- Castañeda H, Holmes SM, Madrigal DS, DeTrinidad Young ME, Beyeler N, Quesada J. Immigration as a social determinant of health. *Annu Rev Public Health* 2015;36:375-92.
- Gnavi R, Migliardi A, Maggini M, Costa G. Prevalence of and secular trends in diagnosed diabetes in Italy: 1980-2013. *Nutr Metab Cardiovasc Dis* 2018;28(3):219-25.
- Bartolini L, Caranci N, Gnavi R, Di Girolamo C. Educational inequalities in the prevalence and outcomes of diabetes in the Emilian Longitudinal Study. *Nutr Metab Cardiovasc Dis* 2020;30(9):1525-35.
- Dalla Zuanna T, Pitter G, Canova C, Simonato L, Gnavi R. A systematic review of case-identification algorithms based on Italian health care administrative databases for two relevant diseases of the endocrine system: diabetes mellitus and thyroid disorders. *Epidemiol Prev* 2019;43(4) Suppl 2:17-36.
- Besag J, York J, Mollié A. Bayesian image restoration, with two applications in spatial statistics. *Ann Inst Stat Math* 1991;43(1):1-20.
- Best N, Richardson S, Thomson A. A comparison of Bayesian spatial models for disease mapping. *Stat Methods Med Res* 2005;14(1):35-59.
- The British Medical Journal. *The BMJ Statistics at Square One, Ninth Edition*. Chapter 11. Correlation and regression. Available from: <https://www.bmj.com/about-bmj/resources-readers/publications/statistics-square-one/11-correlation-and-regression>
- Petrelli A, Zengarini N, Demuru E, et al. Differences in mortality by educational level in Italy (2012-2014). *Epidemiol Prev* 2018;42(5-6):288-300.
- Di Girolamo C, Caranci N, Giorgi Rossi P, et al. Andamento delle disuguaglianze per livello di istruzione nella mortalità prematura tra il 2001 e il 2016 nello Studio Longitudinale Emiliano. *Epidemiol Prev* 2020 - Accepted.
- Pirani M, Schifano P, Agabiti N, Davoli M, Caranci N, Perucci CA. Potentially avoidable hospitalisation in Bologna, 1997-2000: temporal trend and differences by income level. *Epidemiol Prev* 2006;30(3):169-77.
- Agabiti N, Barbieri G, Bardin A, et al. Salute degli immigrati e disuguaglianze socioeconomiche nella popolazione residente in Italia valutate attraverso la rete degli Studi Longitudinali Metropolitani. *Epidemiol Prev* 2019;43(5-6) Suppl 1:1-80.
- Pacelli B, Carretta E, Spadea T, et al. Does breast cancer screening level health inequalities out? A population-based study in an Italian region. *Eur J Public Health* 2014;24(2):280-85.
- Chiu M, Rahman F, Kurdyak P, Cairney J, Jembere N, Vigod S. Self-rated health and mental health of lone fathers compared with lone mothers and partnered fathers: a population-based cross-sectional study. *J Epidemiol Community Health* 2017;71(5):417-23.
- Krieger N. Putting health inequities on the map: social epidemiology meets medical/health geography – an ecosocial perspective. *GeoJournal* 2009;74(2):87-97.
- De Vos P, De Ceukelaire W, Malaise G, Pérez D, Lefèvre P, Van der Stuyf P. Health through people's empowerment: a rights-based approach to participation. *Health Hum Rights* 2009;11(1):23-35.
- World Health Organization. *Bridging the "know-dDo" gap: Meeting on knowledge translation in global health 10-12 October 2005*. Geneva: WHO; 2005.
- Loewenson R, Laurell AC, Hogstedt C, D'Ambruoso L, Shroff Z. *Participatory Action Research in Health Systems: A Methods Reader*. TARSC, AHPSP, WHO, IDRC Canada, Equinet; 2014.
- Borghi V, Giullari B. Trasformazioni delle basi informative e immaginazione sociologica. *Rassegna Ital Sociol* 2015;56(3-4):379-404.
- Grimshaw JM, Eccles MP, Lavis JN, Hill SJ, Squires JE. Knowledge translation of research findings. *Implement Sci* 2012;7:50.
- Pearce N. The ecological fallacy strikes back. *J Epidemiol Community Health* 2000;54(5):326-27.