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Multilevel Analysis of Infant Mortality in Romania

Ana-Maria BURLEA[1,2]

Abstract

Appraise infant mortality evolution at different territorial scales, identify disparities in terms of trend evolution and explore the contribution of some socio-economic factors (educational attainment, unemployment rate and ethnicity) in the existing regional differences of infant mortality levels. As the aim of our study is to identify geographic disparities based on different spatial tendencies in infant mortality evolution, trend analysis was the most suited method. Cluster analysis was used to organize data into meaningful structures and allowed the identification of relatively homogenous groups of counties and municipalities. With the help of GIS techniques we have created cartographic material for a better visualization of the results. Linear regression was used to analyze the contribution of some socioeconomic factors on regional differences in infant mortality level. The results have demonstrated that, although the general downward trend is characteristic for infant mortality evolution in Romania, important variations between different geographic areas and between different social classes remain. Determined by the level of analysis, the results will vary. The model that summarizes the combined influence of all variables on infant mortality at national level explained 25% of the infant mortality variability and only 7% at district level. Of all independent variables, percentage of population with no education was the only indicator identified as having a significant influence on infant mortality. Multilevel analysis of infant mortality can give to scientists a better perspective and a better understanding of its relations with socioeconomic and biological determinants.

Keywords: infant mortality; trends; socioeconomic factors; dissimilarities; Romania.

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Introduction

In the past two decades Romania has experienced important social and economic transformation, and transition was a word used to describe the mutations that have characterized the evolving structures. Urbanization level raised, unemployment rate declined and GDP has increased. Socio-economic transformations were accompanied by important demographic changes. Birth rate and fertility rate decreased, number of newborns dropped, especially in the rural areas, international migration of adult population for work has grown. The improvements in quality of life were reflected by the increased in life expectancy for Romanian population and in the evolution of health indicators (Dumitrache, 2004). The combined effects of all this factors are to be found behind infant mortality decline in Romania (Rotariu, 2009). One of the most important and commonly used indicators for assessing the health status of a population has been, and still is, infant mortality. Known as one of the best indicators of the general development level of a community, it is defined as number of the children deaths before their first anniversary per number of live birth (Reidpath & Allotey, 2003**).**

A barometer of socioeconomic development level, infant mortality reflects changes in living conditions. The interrelatedness of infant mortality (evolution) and socioeconomic is already widely demonstrated. Level of education, unemployment rate, household conditions and ethnicity are known for playing an important part in the existence of geographical disparities in infant mortality rate (Cadwell, 1990; Rosicova et al., 2010; Hollowell et al., 2011). Different geographic areas imply: different socioeconomic status, different access to health services, and, different infant mortality rates (Chen, Matthews & Boyce, 2002; Normanet al., 2008). In this context, spatial analysis of infant mortality variations is becoming an important tool needed to identify spatial patterns and decrypt sources of heterogeneity (Comber, Brunsdon & Radburn, 2011).

Our study follows two directions of analysis. First one is to appraise infant mortality evolution performed at different territorial scales (national and subnational) and identify existing disparities in terms of trend evolution (different territorial evolution typologies), which can be seen as a direct consequence of socioeconomic transition that characterizes Romania. Infant mortality rates vary across districts and across municipalities. For this reason we wanted to compare different geographical levels and underline the existing disparities at different analysis scale. Initially we focused on national districts and afterwards we looked at a smaller level, corresponding to all municipalities included in the area chosen for our analysis. This is a necessary step in any research that wants to point out territories that need special attention and a more profound analysis for understanding the causes that are generating them. Second direction of our research is to assess the contribution of some socio-economic factors (educational attainment,

unemployment rate and ethnicity) in the existing regional differentials of infant mortality levels.

Data and methodology

The study areas

The first level of analysis (national) corresponds to Romania – which is divided in 41 districts plus Bucharest. The second hierarchical level – refers to the sub-national one. Neamt County is the territory of our interest. Its social and geographic characteristics draw our attention. This district it is placed in the northeast of the country, in the region with the lowest socioeconomic development level. 62 % of the population is living in rural communities and 51 % of its surface represented by the mountain areas (western part of the county). The district is divided in 74 municipalities, 69 rural communities and five cities.

Data – source

The National Institute of Statistics provided us with the statistical information collected for every district in the country and for each municipality regarding population, number of live births, stillbirths and deaths under one year, between 2000 and 2009 (table 2). As the aim of the analysis is to identify spatial disparities of trends evolution at different geographical scale we used aggregated data at district and municipality level. In order to assess the relationship between infant mortality level and socioeconomic status, we used information on the educational level, unemployment rate and the percentage of Roma population. This information is only available in the censuses, so our research is based on the last available set of data – from 2002 Population and Housing Census (*Table 1*).

Table 1. Data on socioeconomic indicators in Romania and Neamț County in the year 2002 (Population and Housing Census)

Administrative unit	Unemployment rate (%)	Proportion of population with no education (%)	Proportion of the Roma population (%)
Romania total	12.45	6.17	2.64
County with minimum value	5.97	2.06	0.76
County with maximum value	21.91	12.3	6.95
Neamț County	15.87	5.09	1.11
Municipality with minimum value	2.57	2.43	0
Municipality with maximum value	29.37	14.13	6.04

Methods

Infant mortality rates were calculated as the number of deaths under one year of age per 1000 live births during the same period. Calculations were made for every district in Romania and for every municipality in Neamt County. As the aim of our study is to identify geographic disparities based on different spatial tendencies in infant mortality evolution and because we used aggregate data at district and municipality level, trend analysis was the most suited method. Through analyzing the trends researchers can get a more accurate picture when they are comparing level of an indicator across different geographic areas. Three year moving average technique was applied to smooth out short term fluctuations. Cluster analysis was used to organize data into meaningful structures and allowed us to identify relatively homogenous groups of counties and municipalities, with specific type of infant mortality evolution. Among the available methods, the Ward method based on the squared Euclidean distance was selected. With the help of GIS techniques we have created cartographic material for a better visualization of the results. The maps (*Figure 1 and 3*) present spatial distribution of the different trend types we identified based on cluster analysis at national and subnational level. To suggest spatial and temporal evolution, every map is accompanied by a chart that is showing the dynamics for every trend type. We maintained the same range of colours, in maps, as well for the charts, to underline the

correspondence between the representations. Every tendency type in the map will have the same colour in the chart. Linear regression was used to analyze the contribution of education, unemployment rate and percentage of Roma population on regional differences in infant mortality level

Results

Geographical structure of infant mortality

National level

Romania has registered between 2000 and 2009 a total number of 32,882 deaths under year**.** The downward trend was the general characteristic for the evolution of (number of) deaths under one year, as well for infant mortality rate, that declined from 18.63 ‰ to 10.11‰ (table 2). Applying the methodology described above to all 42 major administrative units, we identified five types of evolution. Figure 1 shows the territorial distribution of the trends. While all districts experienced a decrease in levels of infant mortality, what made the difference between the counties was the pace of reduction. Different geographic areas imply different dynamics. First type of evolution/ trends – constant descendant, with no fluctuation, corresponds to the counties that have registered the most important improvements. Progress has been made by the northeastern (Iasi, Suceava) and southeastern (Ialomița, Tulcea) districts. Infant mortality rate dropped from 20.60 ‰ to 10.40 ‰. Counties that are characterized by the highest infant mortality rates (Botoșani, Vaslui, Călărași, Mehedinți) are included in type four. It has to be mentioned that although values dropped significantly to 13.55 ‰ in 2009, infant mortality remains above national average. A particular situation is given by the districts defined by type 3 of evolution (Vrancea, Galați, Olt, Teleorman). These areas presented an ascending trend between 2003 and 2005. The best situation is described by type five which corresponds to Bucharest, Cluj and Sibiu districts. This is not a surprising situation, as all three mentioned districts are known for higher economic and social development levels. We can distinguish two periods in the national infant mortality dynamics marked by the year 2006 (figure 2). The first phase corresponds to very clear dissimilarities between the typology of trends. In the second stage differences are becoming less pronounced and values more homogeneous. The best evolution, as shown by the data, is held by type one. Although, at the beginning of the interval, values were one of the highest in the country, infant mortality rate diminished by half at the end of the ten years under analysis. Neamț County, which is included in this profile, is no exception. For the sub-national level we are going to focus our attention on this district.

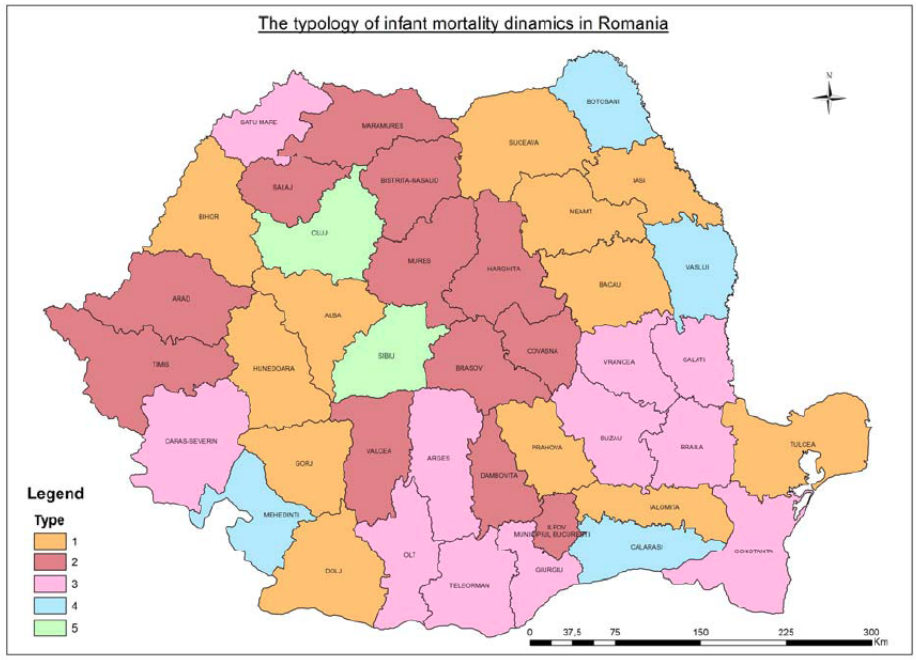

Fig. 1. *The typology of infant mortality dynamics in Romania (2000-2009)*

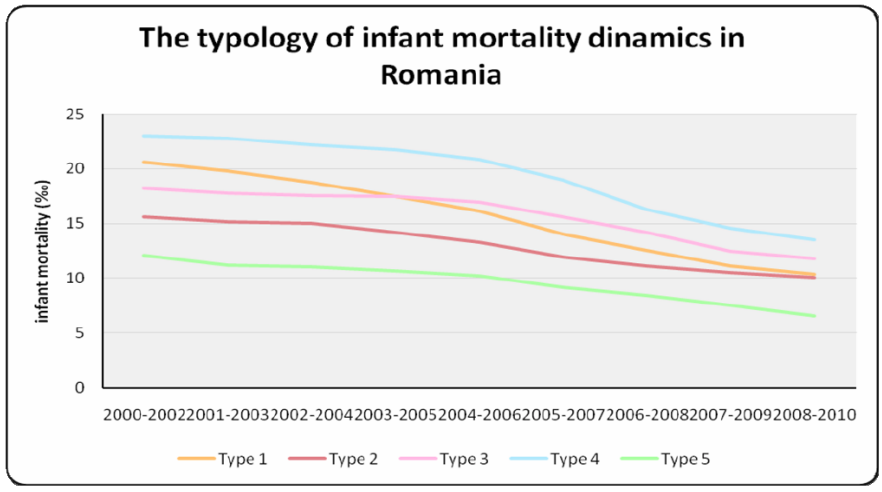

Fig. 2. *Types of infant mortality evolution in Romania (2000 - 2009)*

Table 2. Number of live births, deaths under one year and infant mortality rate in Romania and Neamț County between 2000 and 2009

Year	Live births		Deaths under one year		Infant mortality rate (‰) [95 % CI]	
	Romania	Neamț County	Romania	Neamț County	Romania	Neamț County
2000	234521	6824	4370	162	18.63 [18.08 19.18]	23.73 [20.08 27.39]
2001	220368	6127	4057	144	18.41 [17.84 18.97]	23.50 [19.66 27.34]
2002	210529	5823	3648	121	17.32 [16.76 17.89]	20.77 [17.07 24.48]
2003	212459	5716	3546	109	16.69 [16.14 17.23]	19.06 [15.48 22.64]
2004	216261	5980	3641	94	16.83 [16.28 17.38]	15.71 [12.54 18.89]
2005	221020	5865	3310	91	14.97 [14.46 15.48]	15.51 [12.32 18.70]
2006	219483	5931	3052	80	13.90 [13.41 14.39]	13.48 [10.53 16.44]
2007	214728	5542	2574	73	11.98 [11.52 12.45]	13.17 [10.15 16.19]
2008	221900	5624	2434	62	10.96 [10.53 11.40]	11.02 [8.28 13.76]
2009	222388	5410	2250	39	10.11 [9.69 10.53]	7.20 [5.10 9.68]

Sub - national level: Neamț County

Table 2 summarizes the data for live births, stillbirths and deaths under one year for the levels of analysis, and is presenting an interesting evolution. It shows that the difference between infant mortality level for Romania and for Neamț County disappears over time, starting 2002 when the rates are still different, but the dissimilarities are no longer statistically significant. At this geographic degree of analysis trends are more difficult to decrypt, due to a bigger variability of values. Moving average allowed us to (partially) overcome this problem. The national descending trend is also to be found in Neamț County. This district recorded during the ten years studied a total number of 976 deaths under one year. Annual fluctuations are important, the number of deaths under one year between 2000 and 2009 declined nearly four times. Infant mortality rate registered important drops, from 23.73‰ in 2000 to 7.20‰ in 2009 (*Table 2*). Spatial distribution of infant mortality dynamics is characterized by heterogeneity, and is highlighting the gaps that exist at local level (*Figure 3*). Analogous to the Romanian case, we identified five types of evolution the major difference is given by higher fluctuations (*Figure 4*). First two categories that dominate the western municipalities (the mountain region) are indicating the downward trend. Localities included in series one (Piatra Neamț, Bicaz – Chei, Pângărați) have the best profile, with constant dropping in infant mortality rate and no fluctuation. The last

two series are pointing contrasting situations and an increasing trend. Type four defines municipalities with the highest variability (Agapia, Ion Creangă, Săvinești). Between 2003 and 2007 infant mortality rate raised from 8.28‰ to 25.23‰, in the last two years general tendency is present again. The last class (type five) includes municipalities that have registered the biggest infant mortality rates in the county (Costișa, Icușești, Moldoveni). Although values decreased significantly, in 2009 they still have the highest rates.

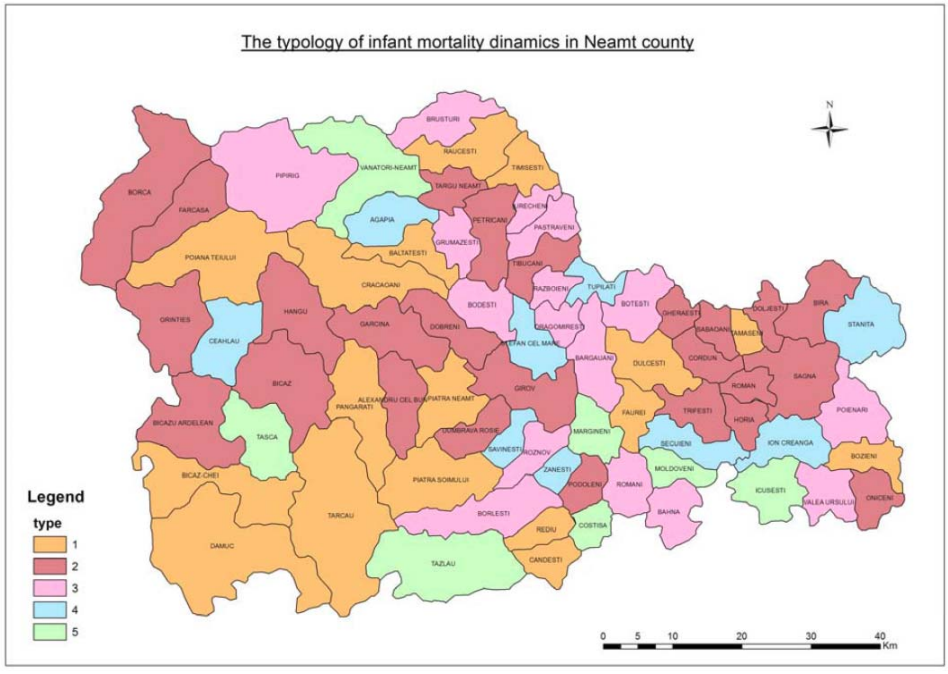

Fig. 3. *The typology of infant mortality dynamics in Neamț County (2000-2009)*

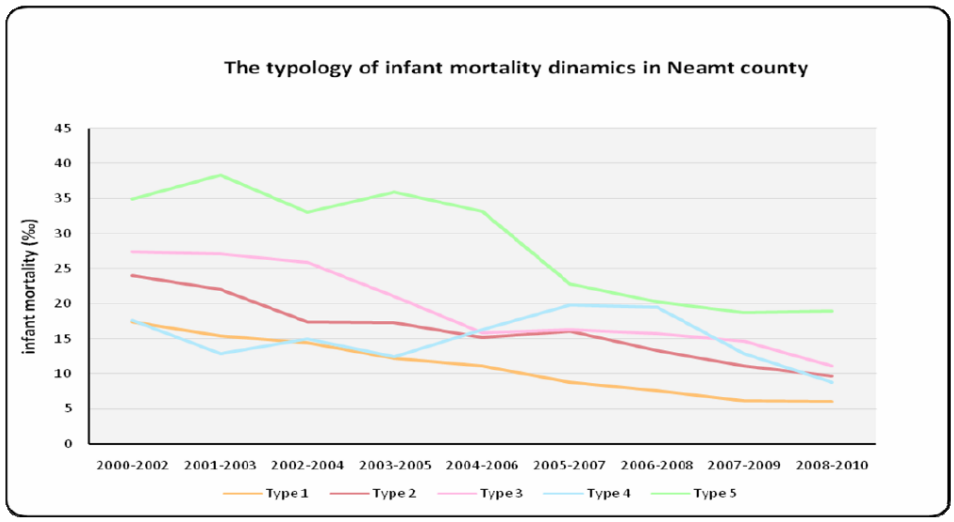

Fig. 4. *Profiles of infant mortality evolution in Neamț County (2000 - 2009)*

Socioeconomic indicators influencing infant mortality

The influence of the chosen socioeconomic indicators (unemployment rate, educational attainment and Roma population) on infant mortality was evaluated in two stages/phases. In the first model we assessed the individual effects of each independent variable. The second one takes into account the combined influence of all the variables. Table 3 presents the relationship between infant mortality and every independent variable evaluated separately, as it resulted from the linear regression analysis. Percentage of population with no education is the only indicator that has a significant effect on infant mortality, its influence being higher at national level. Educational attainment explains 19% of the infant mortality variability in Romania and only 5% in Neamț County case.

Table 3. Bivariate linear regression between infant mortality and socioeconomic indicators for Romania and Neamț County

Administrative unit	Socioeconomic indicators	Infant mortality		
		Standardized coefficients β	Significance	R^2
Romania				
	Unemployment rate	0.289	0.064	0.083
	No education	0.440	0.004*	0.193
	Percentage of Roma population	0.001	0.995	0.000
Neam?County				
	Unemployment rate	0.055	0.639	0.003
	No education	0.231	0.047**	0.053
	Percentage of Roma population	0.172	0.141	0.029

* $p \leq 0.01$ ** $p \leq 0.05$

Results of the second model are shown in table 4 which summarizes the combined influence of all variables on infant mortality. At national level it explains 25% of the infant mortality variability and only 7 % at district level. Of all independent variables, percentage of population with no education was the only indicator identified as having a significant influence on infant mortality. This situation is to be found only on national scale of analysis.

Table 4. Multivariate linear regression between infant mortality and socioeconomic indicators for Romania and Neamț County

Administrative unit	Socioeconomic indicators	Infant mortality	
		Standardised coefficients β	Significance
Romania			
	Unemployment rate	0.211	0.146
	No education	0.447	0.005*
	Percentage of Roma population	-0.140	0.349
	R^2	0.257	
Neam?County			
	Unemployment rate	0.130	0.301
	No education	0.235	0.064
	Percentage of Roma population	0.123	0.295
	R^2	0.074	

* $p \leq 0.01$

A peculiar situation is given by the percentage of Roma population. The analysis pointed out that, at national scale, looking at Roma population alone shows no effect, while together with education and unemployment it does show a negative effect. The two models highlighted that educational attainment, undoubtedly, is influencing infant mortality at district and at municipality level. We decided to scrutinize if there is a parallelism between the geographic distribution of infant mortality rate/ trend and level of education. To achieve our objective two maps for each level of analysis were made (*Figure 5*).

Geographic similarities can be found for national as well for sub-national scale. Romanian districts with best infant mortality profiles have the lowest percentage of population with no education (Sibiu, Cluj). The same situation is encountered at county level, Neamț district is divided east – west. Municipalities that present a higher educational attainment are those in the mountain area (western part), which are characterized by smaller infant mortality rates.

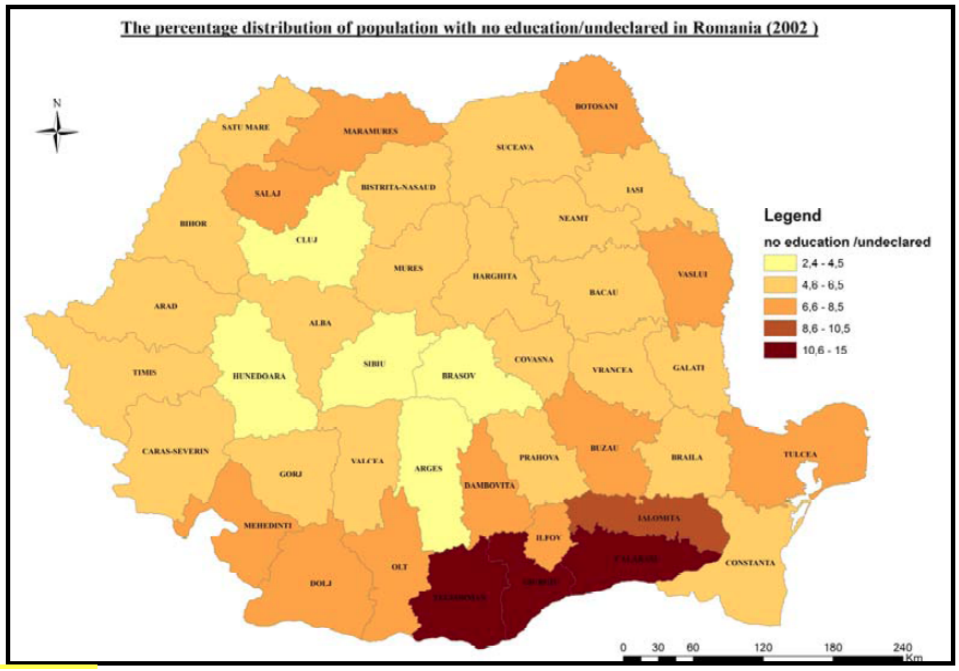

Fig. 5 (a) *National level*

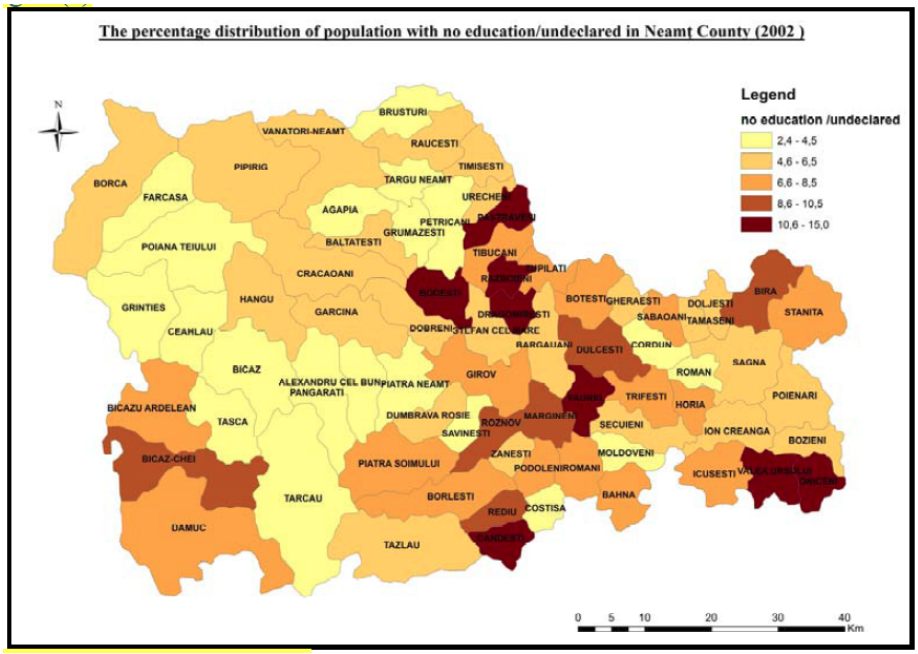

Fig. 5 (b) *Sub-national level*

Fig. 5 Spatial distribution of population with no education/undeclaired

Discussion

In the past decades researchers attention was focused mainly on international comparisons of infant mortality (Hobcraft, McDonald & Rutstein, 1984; Wagstaff, 2000; Aleshina & Redmond, 2005; Fantini et al., 2006; Storeygard et al., 2008), but, it is a fact that dissimilarities can be found not only between the countries, but within the same country (Sparks, McLaughlin & Stokes, 2009; Sartorius et al., 2011). One territory (country, region or district) can integrate different examples of evolution and even contrasting situations. The results have demonstrated that, although the general downward trend is characteristic for infant mortality evolution in Romania, important variations between different geographic areas and between different social classes remain. Our study showed that geographic variations and typologies at national and sub-national level exist and can be identified. The analysis has demonstrated that higher variability of values is a distinctive element at municipality scale.

Studies that are focused on a smaller scale can easier highlight territorial "hotspots" and become a useful guide for researchers and policy makers, by giving them the possibility to look more closely at the local environment (Waldhoer, Wald & Heinzl, 2008).

In our research we combined descriptive trend analysis with a statistical approach, with the first intent to scrutinize infant mortality tendencies in Romania and in Neamț County and second, to evaluate the relationship between some socioeconomic factors and our indicator of interest. The sequence of methods it is useful especially when studies are conducted in small geographic areas or the analysis is centered on a limited period of time (ten years in our case) (Rosenberg, 1997). The combination of descriptive and analytic approach helped us to group the Romanian districts and the municipalities from Neamt County in five classes, each being characterized by a specific type of evolution. At national level differences are not as high as the ones that are describing the realities in Neamț County. Trend analysis was the most appropriate method for this study and provided the possibility to monitor infant mortality pattern of evolution in Romanian counties and in all rural and urban communities that are included in Neamț district. Also, gave us the possibility to make comparisons between different geographic areas and to underline territories with constant values. In this situation further studies are required to understand causality chain. When geographic disparities are to be discussed, social characteristics of the study zone have to be included into analysis. Socioeconomic characteristics of an area are seen as the main causes of geographical variations of infant mortality rates. Determined by the level of analysis, the results will vary.

One of the findings of our study was that socioeconomic indicators at different geographic scale have different influence on infant mortality rate. The percentage

at Roma population analyzed at district level, showed no effect, but at municipality scale, its effect can be detected. Communities where Roma population is present in a higher percentage are characterized by higher unemployment rates, lower level of education and poor living conditions (UNDP, 2006; EU MISID, 2010; Masseria, Mladovsky & Hernandez-Quevedo, 2010). Although associations between infant mortality and ethnicity exist, their interpretation requires special attention and researchers need to remember that this type of connection may be partially due to the influence of other factors. Ethnic association can give useful hints for evaluating geographic variations of infant mortality at different analysis scales. To reflect an appropriate image of the field realities, when it is possible and when the data are available, ethnicity has to be combined with other socio-economic and demographic indicators.

Education is one key determinant of health and its positive effects on health outcomes are well known (Kickbusch, 2001; Cammu et al., 2010). Of all indicators we used to assess their contribution to infant mortality, education has been found to have the most powerful impact in Romania, as well in Neamț County. Although the relationship between educational attainment and infant mortality variations in specific geographical areas can be difficult to map, as showed in the results section, similarities high percentage of population with no education - high infant mortality rates, exist at district and municipality level. Education, occupational status and income combined with local factors affect the distribution of infant mortality rate at different geographic scale. Regions characterized by lower income levels, high unemployment rates and lower educational attainment, have lower development levels, tend to invest fewer resources in the health care system and infant mortality levels reflects socioeconomic conditions that are describing areas of interest.

Geographic dimension of infant mortality rate implies various distribution, territorial disparities and different types of evolution (Kleinman, Feldman & Mugge, 1976). Our research pointed out that distinctive spatial tendencies with specific pace of evolution are realities, at national, as well at sub – national level. Identification and understanding of geographic inequalities of infant mortality rate becomes an important mechanism needed in any study that aims a thorough analysis of causalities. Spatial analysis is an important tool for every study that aims to detect possible sources of heterogeneity or spatial patterns. Cartographic representation opens up the possibility to assess infant mortality with respect to local factors (Rytkönen, 2004). Analysis of infant mortality evolution and interpretation of its variations at different geographical levels it is an objective that requires much attention and implies the decryption the sensitive connections that exist with local environment. Analysis conducted at national and district levels have suggested that infant mortality variation is a result of socio-demographic, economic and environmental factors; each and every one is playing a different part in the spatial disparities (Kunst et al, 2005; Sousa, Hill & Dal Poz, 2010).

Socioeconomic status and access to medical services vary widely across different geographic area. And all this differences are reflected in infant mortality evolution. Identification, interpretation and spatial analysis of infant mortality distribution represent a great challenge and all that are not possible without geographic tools and methods. GIS techniques enable visual perception of the existing spatial patterns (Tanser & Le Sueur, 2002). Maps allow the spatial visualization of variables of interest and can give important hints regarding the relationships established between the indicator of interest and its geographic localization (Koua & Kraak, 2004).

Conclusions

Infant mortality is one of the most widely used indicators to assess population health status, and has received great attention from scientist trough its demographic and social implications. Infant mortality rate at national and sub-national scale, registered important progress, and had a clear descendant trend; as shown by results the national average declined from 18.63‰ to 10.11‰; despite all the improvements national values is one of the highest in the European Union. At district level the progresses are even more substantial, infant mortality rate in Neamț County for year 2009 – goes below 10‰ – at a value of 7.20‰. It has to be mentioned that the differences between the two territorial scale starting 2002 are becoming less pronounced, and the pace of reduction at district level is amplified**.**

A multilevel analysis of infant mortality, as the one in our study, and a combined methodology that brings together geographic tools and sociological techniques can give to scientists a better perspective and a better understanding of its relations with socioeconomic and biological determinants. Cluster analysis helped us to identify and to group districts in Romania and municipalities from Neamț County in five classes characterized by different values and by a specific type of infant mortality evolution. Territorial dissimilarities exist and maps proved to be a useful instrument that points out spatial distribution of a very well-known reality: different geographic areas present different infant mortality rates. At national scale a spatial pattern of the indicator dynamics was more difficult to identify as the values are more homogenous. At sub – national level an east - west division was established. The municipalities with the best profile (type one and two) and the best dynamics are placed in the mountain (western) half of the district.

Identification and evaluation of determinants contributing to national and sub-national differentials in infant mortality levels are to be considered when policy makers are designing and tailoring public health interventions. In this paper authors have scrutinized the influence of some of the most important and

widely discussed socio-economic determinants: educational attainment, unemployment rate and percentage of Roma population. Their impact on infant mortality varies across the analytic scale and it is more perceivable on major territorial administrative units. The analysis has underlined that the highest effect is assigned to education. Although the impact of the other two elements is not statistically significant, is worth to mention that at a smaller administrative scale ethnicity's imprint is more obvious. To obtain coherent conclusions regarding narrow territories, researches attention has to be focused on local factors.

Identification and valuation of different types of infant mortality dynamics at different territorial scale can help policy makers and stakeholders in finding the most suitable measures needed to reduce geographical heterogeneity, measures adjusted for every administrative level in which differential occur.

Acknowledgments

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