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Analysis of the territorial patterns of the life contexts of children up to 6 years of age and their potential influence on the coverage of immunization programs in Chile

Análisis de patrones territoriales de contextos de vida de niños hasta 6 años y su potencial influencia en la cobertura de programas de inmunización en Chile

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ABSTRACT The aim of this paper was to analyze selected variables that could be involved in vaccination coverage of children in different communal territories of Chile, including the vaccines bacillus Calmette-Guérin (BCG) at birth, pentavalent at 6 months and measles-mumps-rubella (MMR) at 12 months and 6 years, in the period 2008-2011. The methodology includes three phases. The first corresponds to the operationalization of twenty socio-territorial variables that account the general life contexts of the target population. The second phase involves the definition of a scale of values through a panel of experts to weigh the importance of each of the variables. The third phase integrates the information into a spatial decision support system for the identification of territorial patterns, through multi-criteria evaluation and multivariate cluster analysis. The results indicate that it is feasible to group territories into four types. In general terms, it is possible to observe that as the life context improves, higher levels of coverage can be found for each vaccine.

KEY WORDS Spatial Analysis; Immunization Programs; Immunization Coverage; Risk Groups; Chile.

RESUMEN El objetivo es analizar determinadas variables que puedan estar implicadas en la cobertura de vacunación de niños en diferentes territorios comunales de Chile, para las vacunas bacillus Calmette-Guérin (BCG) al nacer, pentavalente a los 6 meses, y triple vírica a los 12 meses y 6 años de edad, en el periodo 2008-2011. La metodología contempla tres fases: la primera, corresponde a la operacionalización de veinte variables socioterritoriales, que dan cuenta de los contextos generales de vida de la población objetivo; la segunda, refiere a la definición de una escala de valores a través de un panel de expertos, para ponderar la importancia de cada una de las variables; y, la tercera, integra la información en un sistema de ayuda a la decisión espacial para la identificación de patrones territoriales, por medio de una evaluación multicriterio y el análisis multivariante clúster. Los resultados indican que es factible agrupar cuatro tipos de territorio. De forma general es posible advertir que, mientras mejora el contexto de vida, se pueden encontrar mayores niveles de cobertura para cada vacuna.

PALABRAS CLAVES Análisis Espacial; Programas de Inmunización; Cobertura de Vacunación; Grupos de Riesgo; Chile.

SALUD COLECTIVA. 2018;14(1):93-107. doi: 10.18294/sc.2018.1192

INTRODUCTION

According to scientific evidence, the region of the world which includes Latin America and the Caribbean shows the highest level of social inequality and huge disparities in both health conditions and access to health services, despite the development of programs that have the exact opposite objective.[1,2]

At present, the emphasis on health promotion for individuals, families and communities for disease prevention requires certain measures of protection against communicable diseases, occupational problems and threats to maternal and child health. Among the different types of prevention, primary prevention prevents almost every disease or injury before it occurs. Immunization against infectious diseases is a clear example of this type of prevention.[3]

Immunization programs are an effective method to protect individuals and populations from vaccine-preventable diseases.[4,5] Consequently, improving the vaccination coverage of children is a priority for Latin America's health systems, as it is a cost-effective intervention that helps reduce the burden of disease of the population.[6] In health services, these programs also offer mechanisms which help develop a relationship between children and women to whom many other interventions are offered.[7]

Despite the gradual increase in mass immunization campaigns since the first half of the 1970s until the present, these campaigns have demonstrated the existence of a barrier to equity related to socioeconomic disadvantages, fear of immunization and lack of information.[8] These facts become especially important at the moment of explaining the link between these disadvantages and their immediate territorial contexts. Studies focused on revealing this relationship are scarce or nonexistent.

This matter becomes even more important for public policies related to health matters in Chile, given that they are strongly inspired by four essential principles: right to health, health equity, solidarity in health and resource efficiency. These principles, for example, have led to the consideration, identification and elimination of barriers to both health service access and social safeguards. Among those barriers, the barrier to physical accessibility is the cause of inequity in Chile.[9,10]

In this context, this research study covers fundamental matters for the analysis of spatial relations between the different socio-territorial factors that influence vaccination coverage of children. In order to promote social equity, it is essential to identify and analyze those variables that may be involved in the vaccination coverage of children in different areas of the country. The vaccination coverage includes the following vaccines of the National Immunization Program: bacillus Calmette-Guérin (BCG), pentavalent at 6 months and measles-mumps-rubella (MMR) at 12 months and 6 years. The ultimate aim of this analysis is to identify – at a communal political-administrative unit level (for example, a municipal scale analysis) – a territorial typology that makes it easier to analyse inequality in vaccination coverage.

Theoretical-methodological guidelines of these types of geographical studies are mainly supported by a long-established tradition of investigation referred to as *welfare geography*, a disciplinary approach that deals with the matter of social welfare, answering the questions: *who* (the population being studied), *what is obtained* (what gives welfare to the population), *where* (identifying and evaluating variations in welfare resulting from the place or places where the population inhabits) and *how* (the process or causal mechanism that provides "utility").[11] Although these matters are applicable to various public goods and services, they have been a subject of particular attention, especially regarding *health geography* or *medical geography*.[12,13]

However, there is scarce analysis concerning Latin America, where health circumstances demand more attention from the research community with regard to the provision of resources that are properly contextualized for this subcontinent, and could

SALUD COLECTIVA. 2018;14(1):93-107. doi: 10.18294/sc.2018.1192

consequently be more accurately applied by public administrations. This study aims to contribute to such matter.

Therefore, by collecting all proposals of the deep-rooted research tradition related to this matter, and in accordance with the principles of the current Chilean health policies, this research study will be focused on selecting a set of cross-sectional and specific territorial variables of each vaccine that account for the social determinants applied to immediate territorial contexts.

More specifically, the main questions to be answered in this investigation are: What are the socio-territorial variables that could affect the vaccination coverage of children? What are the territories in the worst situation of general life contexts? What are the territories in the best conditions? The answers to these questions could provide instructions regarding the decisions that should be made by planners and responsible persons in order to reduce inequality and achieve greater equity, thus improving the quality of life of the population.

MATERIALS AND METHODS

Research Design

This study follows a descriptive research design, which involved compiling information that helps identify immediate territorial contexts that could influence the vaccination coverage of children up to 6 years of age. Such information was gathered from different secondary sources of public access of more than 5 years old, at a communal scale, due to the fact that the Census of Population and Housing in 2012 reported serious problems in geodemographic aspects regarding the coverage obtained, age and sex structure of the population and migration variables.[14] Table 1 shows the supplied vaccines and the lifestyle context in which the target population lives.

Chart 1. Vaccines supplied by the National Immunization Program and the lifestyle context in which the target population lives. Chile, 2008-2011.

Vaccine	Disease protected against	Target population of the vaccine	Lifestyle context of the target population
BCG	Tuberculosis	Newborns	Living conditions of the mother
Pentavalent (6 months)	Hepatitis B	Infants up to 6 months of age	Socioeconomic conditions of the household
	Diphtheria		
	Tetanus		
	Pertussis		
	Haemophilus influenzae type B		
MMR (12 months)	Measles	Infants up to 1 year of age	Socioeconomic conditions of the household
	Mumps		
	Rubella		
MMR (6 years)	Measles	Children up to 6 years of age	Socioeconomic conditions of the household and educational status of the child
	Mumps		
	Rubella		

Source: Own elaboration based on information supplied by the National Immunization Program of the Ministry of Health.

SALUD COLECTIVA. 2018;14(1):93-107. doi: 10.18294/sc.2018.1192

METHODOLOGY

The study included three methodological phases. The first phase involved the operationalization of a set of socio-territorial variables that explained the general lifestyle contexts of the target population. The second phase involved the definition of a scale of values through a panel of experts to weigh the importance of each of the variables. The third phase integrated the information into a Spatial Decision Support System for the identification of territorial patterns, through a multi-criteria evaluation and a multivariate cluster analysis.

Operationalization of a set of socio-territorial variables

Socio-territorial variables that express lifestyle circumstances of children up to 6 years of age can be grouped into two levels: cross-sectional and specific. Cross-sectional variables are meant to be analyzed along with vaccine coverage in its entirety; whereas specific variables depend on the target population of each vaccine. In short, both categories aim to measure social and economic risks in households, focusing on mothers and minors covered by the National Immunization Program. The following cross-sectional variables can be found:

1. *School Vulnerability Index* (SVI): The agency in charge of creating this index is the National Board of School Aid and Scholarships [*Junta Nacional de Auxilio Escolar y Becas*] within the Ministry of Education. This board evaluates the vulnerability condition of students using different variables that are highly associated with poverty and vulnerability. Year 2012.
2. *Isolation Index* (II). The institution in charge of this index is the Undersecretariat of Regional Development (UNREDE) [*Subsecretaría de Desarrollo Regional (SUBDERE)*], which uses five criteria to create this index: 1) physical, related to climate conditions; 2) demographic, which examines the distribution of the population and their ethnic groups; 3) economic, which expresses the dependency on national funds; 4) access to services, which evaluates the accessibility to services; 5) political-administrative, related to long or short distances to centers of power. These criteria were established to determine whether a territory is either isolated or integrated into the rest of the country. Year 2009.
3. *Municipal Health Expenditure per Capita* (MHEC). It stated the annual health expenditure per inhabitant correctly registered with and validated by a municipality. This expenditure is registered with the National System of Municipal Indicators. Year 2010.
4. *Percentage of Female-Headed Households* (FHH). Percentage of households with a female lead. Information provided by the Department of Epidemiology within the Ministry of Health. Year 2009.
5. *Live births to women aged under 15 years* (LB-15). Number of live births to women aged under 15 years. Information provided by the Department of Statistics and Health Information within the Ministry of Health. Year 2009.
6. *Live Births to Women aged 15 to 19 years* (LB15-19). Number of live births to women aged 15 to 19 years. Information provided by the Department of Statistics and Health Information within the Ministry of Health. Year 2009.
7. *Live Births to Women aged 20 to 34 years* (LB20-34). Number of live births to women aged 20 to 34 years. Information provided by the Department of Statistics and Health Information within the Ministry of Health. Year 2009.
8. *Live Births to Women aged over 34 years* (LB + 34). Number of live births to women aged over 34 years. Information provided by the Department of Statistics and Health Information within the Ministry of Health. Year 2009.
9. *Postpartum depression* (PPD). Number of women affected by postpartum

SALUD COLECTIVA. 2018;14(1):93-107. doi: 10.18294/sc.2018.1192

depression. Information provided by the National Immunization Program within the Ministry of Health. Year 2011.

The following specific variables of the BCG vaccine can be found:

10. *Percentage of pregnant women aged under 15 years accessing and utilizing prenatal care services* (PCS-15). Health checks on pregnant women aged under 15 years. Information provided by the Department of Epidemiology within the Ministry of Health. Year 2010.
11. *Percentage of pregnant women aged 15 to 19 years accessing and utilizing prenatal care services* (PCS15-19). Health checks on pregnant women aged 15 to 19 years. Information provided by the Department of Epidemiology within the Ministry of Health. Year 2010.
12. *Rate of reports on domestic violence against women* (DVW). Domestic violence against women, rate per 100,000 inhabitants. Information provided by the Ministry of the Interior and Public Security. Year 2011.
13. *Professional assistance during birth* (PAB). Number of births attended by health professionals. Information provided by the Department of Statistics and Health Information within the Ministry of Health. Year 2010.

The following specific variables of the pentavalent (6 months) and the MMR (12 months) can be found:

14. *Concentration of health controls in children* (HCC). Average number of controls (health screening/population undergoing controls). Information provided by the National Immunization Program within the Ministry of Health. Year 2011.
15. *Rate of reports on domestic violence against children* (DVC). Domestic violence against children, rate of 100,000 inhabitants. Information provided by the Ministry of the Interior and Public Security. Year 2011.
16. *Supply of Vaccination Clinics* (SVC). Calculation of the Coefficient of Localization[12] that can have 4 possible values: CL = 0 the *comuna* [smallest administrative subdivision in Chile] does not have vaccination clinics; CL = 1 there is sufficient supply for the current demand for equipment; CL < 1 the supply does not meet the requirements of the demand; and CL > 1 the supply is higher than the current demand. Information provided by the National Immunization Program. Year 2011.
17. *Percentage of the population having Public Health Insurance coverage* (PHI). Population covered by public health insurance. Information provided by the Department of Epidemiology within the Ministry of Health and the National Socioeconomic Characterization Survey. Year 2009.
18. *Percentage of the population having Private Health Insurance coverage, Private Healthcare System* (PHS). Population covered by private health insurance. Information provided by the Department of Epidemiology within the Ministry of Health and the National Socioeconomic Characterization Survey. Year 2009.
19. *Percentage of the population lacking Health Insurance coverage* (NHI). Population that is not covered by any health insurance. Information provided by the Department of Epidemiology within the Ministry of Health and the National Socioeconomic Characterization Survey [*Encuesta de Caracterización Socioeconómica Nacional*]. Year 2009.

The following specific variables of the MMR (6 years) can also be found:

20. *Supply of basic education institutions*. (SBEI) In order to calculate this variable, the same procedure adopted for the variable of the supply of vaccination clinics is followed.

SALUD COLECTIVA. 2018;14(1):93-107. doi: 10.18294/sc.2018.1192

Weighting of socio-territorial variables through a panel of experts

After gathering all the relevant information, a panel of experts in public health fields was formed in order to weigh the relative importance of each socio-territorial variable and contribute to the implementation of vaccination coverage of children up to 6 years of age.

The weighting was carried out with the purpose of quantifying intangible criteria through the decision of different professionals, which helps identify the levels of importance of the socio-territorial variables that define life circumstances in different populations covered by the National Immunization Program.

The aim of the process was to have variables weighed by a panel of experts through an analytic hierarchy process (AHP)[15] and assign such weightings to the variables under review before submitting the information to a spatial decision support system. The participants included personnel within the Ministry of Health who were part of the National Immunization Program, the Women Program [Programa mujer], the National Health Strategy, the Childhood Health Program, the Department of Epidemiology, the Division of Health Planning [División de Planificación Sanitaria] and the Department of Communicable Diseases. The National Board of School Aid and Scholarships and representatives of private vaccination clinics and the academic world were also present.

It should be noted that the analytic hierarchy process is a technique based on mathematics and designed to solve complex multi-criteria problems. It works with pairwise comparisons, that is to say, one-on-one comparisons, and uses verbal scales to interpret the answers of the participants regarding the importance of the variables.[16] These comparisons are imported to a matrix that replaces the semantic expressions with numeric values (from *equal importance* = 1 to *highest importance* = 9), which help establish a ranking using each variable.[17]

By filling the matrix, it is possible to weigh all the variables and their application level (cross-sectional/specific). It is used for each vaccine coverage separately, and the valuation of the variables under review is stated through the opinion of experts.

Data integration in a spatial decision support system

A spatial decision support system is a set of physical and logical elements providing an adequate environment for rational decision making about spatial problems that do not have clearly defined solutions.[18] This system was used to identify territorial patterns through a multi-criteria evaluation in a QGis environment (Easy AHP plugin) and a multivariate cluster analysis in SPSS environment.

As a starting point, to make the variables stated in different magnitudes comparable, a process of standardization following the Omega scoring system[19] was carried out. The extreme values are interpreted as "cost" if the maximum values are undesired. If the maximum values are desired, the extreme values are interpreted as "benefit." The resulting values vary between 0 and 1. The closer the results are to 0, the more favorable the interpretation is; whereas the closer the results are to 1, the more unfavorable the interpretation is.

Once the values were standardized, they were multiplied by the weighting of each variable consistent with the weights established in the process of valuation carried out by experts, according to the following formula:

$$TUV = v1 * w1 + ... + vn * wn$$

Where:

TUV: Territorial unit value (in this case, equivalent to a *comuna*).

v: Standardized variables of the study for each vaccination coverage.

w: Weighting of the variable over the total of variables of the coverage.

The abovementioned formula shows the territorial pattern of the lifestyle circumstances

SALUD COLECTIVA. 2018;14(1):93-107. doi: 10.18294/sc.2018.1192

of children up to 6 years of age for each vaccine coverage.

The purpose of the creation of a multivariate cluster analysis was to diagnose a territorial typology which would make it easier to enquire about disparities in vaccine coverage. This analysis helps to classify a set of spatial units in homogeneous groups and it is mainly used in health-oriented investigations as it considers the territory as a base element to develop and process the acquired data.[20,21,22] It is applicable to the geographical unit known as a *comuna* (n = 315) along with data regarding all the variables, which are either stratified or grouped, and are based on the mentioned cross-sectional and specific variables. The aforementioned variables are analyzed so as to detect any possible correlation between them. Certain correlation matrices from the Bivariate Correlations procedure are used, in which certain aspects of distance are identified, which are either internally similar or externally distant, to make groups or clusters of multivariate similitudes.

Each original variable is analyzed through standardization (Omega scoring system), and then multiplied by the weighting performed by a panel of experts. A cluster analysis is applied to the last result obtained, following a "K-means" cluster analysis (using Euclidean distances) through the statistics software called SPSS.

The application is done by classifying the information in two, three, four, five and six groups of clusters, and then the groups which show the greatest difference among the means in each cluster are selected. Taking these criteria into consideration, four clusters per vaccine coverage are formed, according to the variation of the means in each cluster.

To acquire these four groups, the first step is to observe the mean variation between each cluster in relation to each of the variables and, in the second place, to observe in each cluster the three or four main variables determined by the panel of experts which explain at least 50% of the importance of the cluster. Afterward, using those results, a territorial typology is assigned to each cluster.

RESULTS

Weightings of the panel of experts regarding cross-sectional and specific variables

Through pairwise comparisons made by the group of experts, values of relative importance were assigned to each variable, both cross-sectional and specific (Chart 1). The relevant macro-levels are those for:

- BCG: 46% for cross-sectional and 54% for specific variables of the vaccine.
- Pentavalent (6 months): 85% for cross-sectional and 15% for specific variables of the vaccine.
- MMR (12 months): 66% for cross-sectional and 34% for specific variables of the vaccine.
- MMR (6 years): 51% for cross-sectional and 49% for specific variables of the vaccine.

Regarding the total amount of variables submitted to the experts' analysis, there are weightings of greater importance than other variables. This is the same as individualizing those which better explain living circumstances of the target population for the pertaining vaccine.

Therefore, for cross-sectional variables, regarding BCG coverage, an *isolation index* (15%) can be found. In the case of pentavalent coverage (6 months) in comparison with other variables, both the *index of school vulnerability* (22%) and the *isolation index* (20%) stand out. Similarly, in the coverage of the MMR (6 years), regarding the total variables for the vaccine, *live births to women aged under 15 years* (14%) stands out.

Regarding specific variables for BCG coverage that which most stands out is *Professional assistance during birth* (30%). For the MMR (1 year), the most prominent is *Concentration of health controls in children* (18%). Lastly, regarding MMR (6 years) coverage, the most prominent are the *Supply of basic education institutions* (16%) and *Percentage of the population lacking Health*

SALUD COLECTIVA. 2018;14(1):93-107. doi: 10.18294/sc.2018.1192

Table 1. Results of weightings of the panel of experts regarding cross-sectional and specific variables. Chile, 2009-2012.

Type	N°	Variable	BCG		Pentavalent (6 months)		MMR (12 months)		MMR (6 years)	
			Weighting	%	Weighting	%	Weighting	%	Weighting	%
Cross-sectional	1	School Vulnerability Index	0.0566	6	0.221	22	0.114	11	0.069	7
	2	Isolation Index	0.1458	15	0.198	20	0.115	12	0.060	6
	3	Municipal Health Expenditure per Capita	0.0105	1	0.054	5	0.030	3	0.070	7
	4	Percentage of Female-Headed Households	0.0455	4	0.066	7	0.063	6	0.020	2
	5	Live births to women aged under 15 years	0.0671	7	0.125	13	0.081	8	0.136	14
	6	Live Births to Women aged 15 to 19 years	0.0560	6	0.106	11	0.107	11	0.113	11
	7	Live Births to Women aged 20 to 34 years	0.0347	3	0.015	1	0.045	5	0.013	1
	8	Live Births to Women aged over 34 years	0.0305	3	0.014	1	0.044	4	0.013	1
	9	Postpartum depression	0.0138	1	0.049	5	0.064	6	0.015	2
Specific	10	Percentage of pregnant women aged under 15 years accessing and utilizing prenatal care services	0.0973	10	-	-	-	-	-	-
	11	Percentage of pregnant women aged 15 to 19 years accessing and utilizing prenatal care services	0.0902	9	-	-	-	-	-	-
	12	Rate of reports on domestic violence against women	0.0501	5	-	-	-	-	-	-
	13	Professional assistance during birth	0.3018	30	-	-	-	-	-	-
	14	Concentration of health controls in children	-	-	0.024	2	0.175	18	0.011	1
	15	Rate of reports on domestic violence against children	-	-	0.026	3	0.017	2	0.127	13
	16	Supply of vaccination clinics	-	-	0.053	5	0.049	5	-	-
	17	Percentage of the population having public health insurance coverage	-	-	0.013	1	0.046	5	0.027	3
	18	Percentage of the population having Private Health Insurance coverage, Private Healthcare System	-	-	0.015	2	0.022	2	0.024	2
	19	Percentage of the population lacking Health Insurance coverage	-	-	0.020	2	0.026	3	0.140	14
	20	Supply of basic education institutions	-	-	-	-	-	-	0.164	16

Source: Own elaboration based on the results presented by the panel of experts.

Insurance coverage (14%) over the total values of the vaccines.

Territorial patterns of the life contexts of children up to 6 years

For the purpose of establishing a territorial typology that takes into consideration groups that are internally homogeneous and different to each other, four types of territories were identified (Figure 1) based on observations of the variation on the average between each cluster and the three or four principal variables determined by the panel of experts, explaining at least 50% of the importance of the cluster (Chart 2).

- Type I - *Unfavorable context*: There are values that are too high for the variables of "cost," and values that are too low for the variables of "benefit." In BCG, it pertains to cluster number 3. In pentavalent (6 months), to cluster number 2. In MMR (12

SALUD COLECTIVA. 2018;14(1):93-107. doi: 10.18294/sc.2018.1192

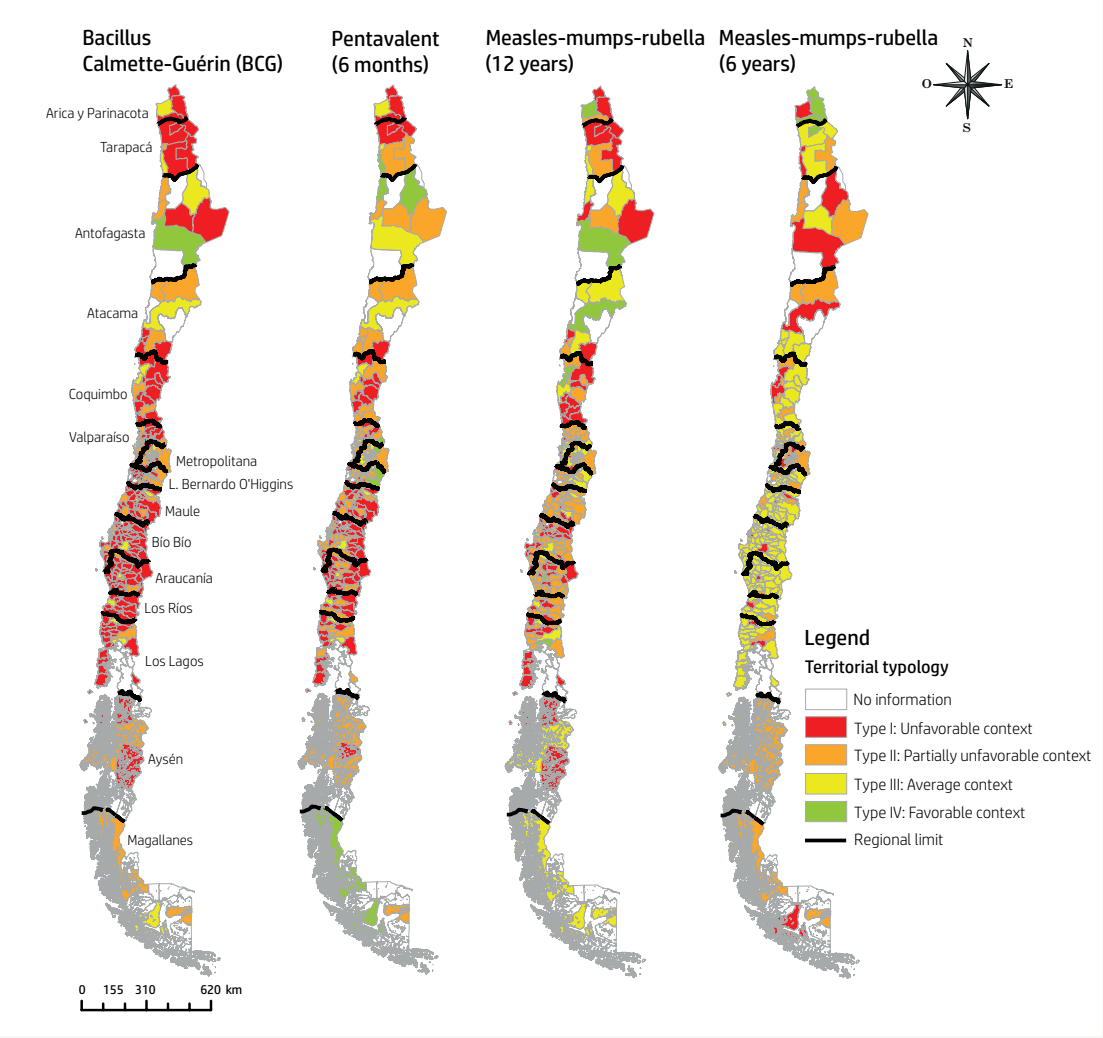

Figure 1. Categorization of the communal territories in Chile through an analysis of k-means for the calculation of the lifestyle context of children up to 6 years, in relation to the four vaccines under analysis. Chile, 2009-2012.

Source: Own elaboration based on secondary sources of public access at a communal political-administrative scale.

months), to cluster number 3. In MMR (6 years), to cluster number 4.

- Type II - *Partially favorable context*: There are values that are high for the variables of "cost" and values that are low for the variables of "benefit." In BCG, it pertains to cluster number 1. In pentavalent (6 months), to cluster number 3. In MMR (12 months), to cluster number 1. In MMR (6 years), to cluster number 1.
- Type III - *Average context*: There are average values for the variables of "cost" and "benefit." In BCG, it pertains to cluster number 2. In pentavalent (6 months), to cluster number 1. In MMR (12 months), to cluster number 2. In MMR (6 years), to cluster number 2.
- Type IV - *Favorable context*: There are low values for the variables of "cost" and high values for the variables of "benefit." In BCG, it pertains to cluster number 4. In pentavalent (6 months), to cluster number 4. In MMR (12 months), to cluster number 4. In MMR (6 years), to cluster number 3.

SALUD COLECTIVA. 2018;14(1):93-107. doi: 10.18294/sc.2018.1192

Table 2. Average results obtained through a cluster analysis carried out for each type of vaccine. Chile, 2009-2012.

Vaccine	Weight (%)	Cluster			
		1	2	3	4
BCG					
School Vulnerability Index	6	0.0326	0.0290	0.0441	0.0214
Isolation Index	15	0.0378	0.0111	0.0883	0.0046
Municipal Health Expenditure per Capita	1	0,0077	0.0082	0.0079	0.0091
Percentage of Female-Headed Households	4	0.0197	0.0210	0.0176	0.0136
Live births to women aged under 15 years	7	0.0044	0.0158	0.0013	0.0476
Live Births to Women aged 15 to 19 years	6	0.0052	0.0171	0.0015	0.0454
Live Births to Women aged 20 to 34 years	3	0.0313	0.0225	0.0339	0.0043
Live Births to Women aged over 34 years	3	0.0274	0.0190	0.0298	0.0049
Postpartum depression	1	0.0051	0.0050	0.0036	0.0058
Percentage of pregnant women aged under 15 years accessing and utilizing prenatal care services	10	0.0900	0.0912	0.0920	0.0900
Percentage of pregnant women aged 15 to 19 years accessing and utilizing prenatal care services	9	0.0723	0.0721	0.0715	0.0697
Rate of reports on domestic violence against women	5	0.0162	0.0157	0.0158	0.0114
Professional assistance during birth	30	0.2736	0.1968	0.2945	0.0428
Pentavalent (6 months)					
School Vulnerability Index	22	0.1344	0.1870	0.1405	0.0925
Isolation Index	20	0,0179	0,1303	0,0889	0,0102
Municipal Health Expenditure per Capita	5	0.0445	0.0407	0.0394	0.0380
Percentage of Female-Headed Households	7	0.0291	0.0260	0.0257	0.0312
Live births to women aged under 15 years	13	0.0350	0.0021	0.0046	0.0149
Live Births to Women aged 15 to 19 years	11	0.0356	0.0025	0.0054	0.0185
Live Births to Women aged 20 to 34 years	1	0.0102	0.0150	0.0145	0.0114
Live Births to Women aged over 34 years	1	0.0093	0.0136	0.0132	0.0097
Postpartum depression	5	0.0192	0.0116	0.0159	0.0186
Concentration of health controls in children	2	0.0168	0.0159	0.0160	0.0167
Rate of reports on domestic violence against children	3	0.0043	0.0034	0.0045	0.0039
Supply of vaccination clinics	5	0.0524	0.0451	0.0499	0.0521
Percentage of the population having public health insurance coverage	1	0.0023	0.0009	0.0016	0.0043
Percentage of the population having Private Health Insurance coverage, Private Healthcare System	2	0.0128	0.0143	0.0137	0.0103
Percentage of the population lacking any health insurance coverage	2	0.0051	0.0033	0.0045	0.0057
MMR (12 months)					
School vulnerability index	11	0.0854	0.0592	0.0880	0.0588
Isolation index	12	0.0619	0.0167	0.0722	0.0089
Municipal health expenditure per capita	3	0.0235	0.0223	0.0216	0.0255
Percentage of Female-Headed Households	6	0.0235	0.0290	0.0259	0.0268
Live births to women aged under 15 years	8	0.0022	0.0091	0.0011	0.0333
Live Births to Women aged 15 to 19 years	11	0.0040	0.0164	0.0025	0.0534
Live Births to Women aged 20 to 34 years	5	0.0439	0.0372	0.0446	0.0218
Live Births to Women aged over 34 years	4	0.0434	0.0360	0.0440	0.0215
Postpartum depression	6	0.0223	0.0220	0.0112	0.0260
Concentration of health controls in children	18	0.1249	0.1191	0.0962	0.1192
Rate of reports on domestic violence against children	2	0.0026	0.0028	0.0023	0.0025
Supply of vaccination clinics	5	0.0446	0.0474	0.0405	0.0480
Percentage of the population having public health insurance coverage	5	0.0042	0.0113	0.0035	0.0108
Percentage of the population having Private Health Insurance coverage, Private Health/Healthcare System	2	0.0211	0.0180	0.0213	0.0180
Percentage of the population lacking any health insurance coverage	3	0.0050	0.0069	0.0044	0.0083
MMR (6 years)					
School vulnerability index	7	0.0389	0.0523	0.0617	0.0374
Isolation index	6	0.0197	0.0331	0.0497	0.0055
Municipal health expenditure per capita	7	0.0425	0.0540	0.0696	0.0579
Percentage of female-headed households	2	0.0086	0.0076	0.0134	0.0085
Live births to women aged under 15 years	14	0.0063	0.0035	0.0000	0.0376
Live births to women aged 15 to 19 years	11	0.0073	0.0042	0.0001	0.0395
Live births to women aged 20 to 34 years	1	0.0114	0.0121	0.0125	0.0080
Live births to Women aged over 34 years	1	0.0116	0.0126	0.0130	0.0083
Postpartum depression	2	0.0064	0.0040	0.0003	0.0054
Concentration of health controls in children	1	0.0070	0.0070	0.0047	0.0073
Rate of reports on domestic violence against children	13	0.0214	0.0187	0.0000	0.0198
Percentage of the population having public health insurance coverage	3	0.0063	0.0022	0.0014	0.0054
Percentage of the population having Private Health Insurance coverage, Private Healthcare System	2	0.0201	0.0231	0.0240	0.0205
Percentage of the population lacking Health Insurance coverage	14	0.0511	0.0202	0.0324	0.0351
Percentage of the population lacking Health Insurance coverage	16	0.1582	0.1511	0.0512	0.1625

Source: Own elaboration based on the results presented by the panel of experts.

SALUD COLECTIVA. 2018;14(1):93-107. doi: 10.18294/sc.2018.1192

The most prominent findings in the evaluation of spatial distribution of the territorial typology of children's contexts show the following territorial patterns: for BCG (Figure 1), the unfavorable context is present all throughout the country, with *comuna* in different political-administrative regions far away from the main metropolitan areas of the country, and it presents undesirable values in professional assistance during birth, percentage of pregnant adolescent women accessing and utilizing prenatal care services and a territorial isolation that leads to people moving to other *comunas* or go to Higher-Complexity Health centers. Therefore, it may be concluded that, generally speaking, if there is a larger rural population in a *comuna*, the level of distribution of the population and its communities will be higher. Consequently, accessibility will be harder to accomplish and those *comunas* with high rates of indigenous peoples will have higher levels of cultural isolation, regarding difficulties integrating a population at a sociocultural level.[23] Regarding the latter item, it is important to emphasize the different locations in which different ethnicities can be found in the continental territory. As an example, in the north of the country, the *aymará* (Arica, Parinacota, Tarapacá), *quechuas* and *atacameños* (Antofagasta), *collas* (Atacama) and *diaguitas* (Coquimbo) live in plateaus and valleys on the mountain ranges. In the Southern area, there are a considerable number of *mapuche* people (Bío Bío, Araucanía, Los Ríos and Los Lagos) who mostly live in the rural area which goes from the coast to the Andean Mountains.

The pentavalent (6 months) (Figure 1) shows a bigger unfavorable context in South-Central Chile, outside of the influence area of important metropolitan cities, where high unfavorable levels of territorial isolation as well as high rates of school vulnerability are predominant. The MMR vaccine (12 months) (Figure 1) is shown at random, and the territorial context shows low levels of health controls for children and high levels of school vulnerability related to a relative territorial isolation. Regarding the MMR Vaccine (6 years) (Figure 1), there are average living conditions. The main problems are related to unfavorable social conditions for mothers and the reduced supply of compulsory education institutions.

Analysis of the territorial types based on the level of vaccination coverage

The vaccination coverage was provided by the National Immunization Program for the period 2008-2011. They are calculated based on the division of the number of administered doses by the population that should have received these vaccine doses by the population projection of the National Statistics Institute.

The official communal vaccination coverage went through a long process of validation. Different anomalous situations were identified in the temporal variations of the information, and, as a result, not all the *comunas* could achieve the purpose of study. Some *comunas* are excluded: those *comunas* in which the lack of immunization could be attributed to an error in the registration of applied vaccines or to problems in the population projections of the National Statistics Institute for the year of application of the vaccine. The *comunas* having a high variability in their information each year are also excluded. Examples of these *comunas* are those having "0" (zero) record values or with no information at all, and those which have only a few number of cases, causing coverage percentages to be highly changeable.

It is important to mention that the detected problem regarding variability in vaccine coverage can be caused by the lack of vaccination or a generalized error because the occurrence record was filled out by *comuna* and not by residence. Moreover, there is not an updated population census to know the real demand of the population for each vaccine coverage. There is only a population projection produced by the 2002 Census at a communal scale. Because of this situation, it is impossible to create a socio-territorial diagnosis for all the *comunas* of the country. However, it is possible to analyze a proportion of *comuna* in each type of vaccine (Chart

SALUD COLECTIVA. 2018;14(1):93-107. doi: 10.18294/sc.2018.1192

Table 3. Absolute and relative frequency of comunas by type of territory as per studied vaccine coverage. Chile, 2008 - 2011.

Vaccine	Registration error Subregistration		≤ 90%		≥91% ≤ 100%		> 100%		Total	
	n	%	n	%	n	%	n	%	n	%
BCG										
Total	190	60.3	3	1.0	51	16.2	71	22.5	315	100.0
Type I	140	73.7	3	1.6	30	15.8	17	8.9	190	60.3
Type II	41	50.6	0	0.0	12	14.8	28	34.6	81	25.7
Type III	7	17.1	0	0.0	9	22.0	25	61.0	41	13.0
Type IV	2	66.7	0	0.0	0	0.0	1	33.3	3	1.0
Pentavalent (6 months)										
Total	150	47.6	2	0.6	68	21.6	95	30.2	315	100.0
Type I	69	56.6	0	0.0	27	22.1	26	21.3	122	38.7
Type II	60	49.6	2	1.7	24	19.8	35	28.9	121	38.4
Type III	11	29.7	0	0.0	9	24.3	17	45.9	37	11.7
Type IV	10	28.6	0	0.0	8	22.9	17	48.6	35	11.1
MMR (12 months)										
Total	185	58.7	7	2.2	53	16.8	70	22.2	315	100.0
Type I	56	66.7	0	0.0	14	16.7	14	16.7	84	26.7
Type II	89	65.0	3	2.2	26	19.0	19	13.9	137	43.5
Type III	30	39.5	4	5.3	9	11.8	33	43.4	76	24.1
Type IV	10	55.6	0	0.0	4	22.2	4	22.2	18	5.7
MMR (6 years)										
Total	142	45.1	61	19.4	43	13.7	69	21.9	315	100.0
Type I	22	48.9	11	24.4	2	4.4	10	22.2	45	14.3
Type II	30	42.3	11	15.5	12	16.9	18	25.4	71	22.5
Type III	88	45.1	39	20.0	29	14.9	39	20.0	195	61.9
Type IV	2	50.0	0	0.0	0	0.0	2	50.0	4	1.3

Source: Own elaboration based on the coverage information provided by the National Program of Immunization within the Ministry of Health.

3). In broader terms, it could be said that as a lifestyle context improves (territorial typology), better coverage for each vaccine can be found. It is not feasible to implement an homogenous intervention strategy for the whole country. Different strategies should be designed for each territory in particular.

DISCUSSION

According to De Maio,[24] contemporary discourse on health revolves mostly around individual "choices" of lifestyle and, more recently, around genetics. However, this perspective seems ahistorical and apolitical, as it does not take into account matters of power and inequity.[24] It is established, then, that the determinants of health conditions are "outside and beyond" the individual. The new public health, within the paradigm of eco-epidemiology, evaluates the interactions among the individuals, the environment and the collective conditions arising from these relations.[25]

From such perspective, important contributions to the debate on social determinants

SALUD COLECTIVA. 2018;14(1):93-107. doi: 10.18294/sc.2018.1192

of health inequality in access to health have been identified, such as the contributions in the study about the West of Australia by Mak et al.,[4] who highlight that living in a geographically remote context or in socio-economically disadvantaged areas are factors associated with lower vaccine acceptance. In fact, the study reveals that a link between vaccine hesitancy and low socio-economic levels has been reported in different countries with programs focused on diverse vaccines. Even more alarmingly, the study reports that vaccine acceptance in programs linked to schools was lower in those institutions with more socio-economic disadvantages than in those located in moderately disadvantaged areas.[4]

The minorities detected by Linn, Guralnik and Patel[26] in their study developed in the US in 2008 are also those demographic groups which, along with socio-economic position, race and ethnic origin, have greater disparities in immunization processes against influenza. These results show that there is a clear social gradient in the vaccination coverage, in which the racial and ethnic minorities are considerably less likely to be vaccinated. It should be mentioned that, according to this study, people having lower levels of education and lower household income were also less likely to be vaccinated than those people with more socio-economic advantages. The aforementioned social class gradient could show that there is a strong relation between the lack of vaccination coverage in minorities and the concentration of poverty.[26]

Furthermore, for Vandermeulen et al.,[27] in a research study carried out in Belgium, one of the most important determinants in a low immunization coverage was the father's unemployment or part-time jobs. As stated by the authors, there is a close relationship between employment and other socio-economic status indicators, such as the level of education of parents and children, the household income and the ethnic origin. Similarly, Thysen et al.[28] state that in South Africa, and other 31 countries of low and average income, the low socio-economic levels of the population have a direct relation on the delay in the administration of the BCG vaccine in infants. In India, the main risk factors for children who were not inoculated with BCG are also their socioeconomic status, in addition to malnutrition and a poor immunization coverage.[29] Moreover, malnourished children are less prone to have a scar caused by the BCG vaccine than children who are well nourished, so it is suggested that either the group of the population with better nourishment may be affected more strongly by the BCG, or that poor children may have had less chances to be vaccinated and/or immunized.[30]

Following this line of thought, Szwarcwald et al.[22] found in their local study on the relationship of health conditions and the spatial distribution of the population that the place with the worst health situation is located within the area which has the biggest concentration of poor neighborhoods in the study area.

In methodological terms, the proposal is a tool to help make decisions. It expresses the construction of clusters from a territorial perspective, and its results will contribute to the development of a solution for a problem related to Public Health.[31] This is the first approach from a statistical analysis using secondary sources. It is recommended to improve registration of vaccination coverage at a communal level for the whole country, so as to use this technique more efficiently.

Lastly, geographical studies applied to the planning and territorial administration of immunization programs offer interesting possibilities for the evaluation of, in general terms, spatial conditions existing at the time of the distribution of the vaccine coverage. Such positive aspects help recognize the areas which are reasonably covered and those which are marginalized, and identify socio-spatial groups which are benefited from or excluded from the accessibility to these programs. The abovementioned possibilities help in the direct evaluation of the achievement of efficiency targets and the equity in non-residential policies implemented for each territory of interest.

SALUD COLECTIVA. 2018;14(1):93-107. doi: 10.18294/sc.2018.1192

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