The geographical distribution of underweight children in Africa

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Objective To study geographical patterns of underweight children in Africa by combining information on prevalence with headcounts at a subnational level.
Methods We used large-scale, nationally representative nutrition surveys, in particular the Demographic and Health Surveys and the Multiple Indicator Cluster Surveys, which have been designed, analysed and presented according to largely similar protocols, and which report at the national and subnational levels.
Findings We found distinct geographical patterns in the occurrence of underweight children, which could be linked to factors such as agronomic and climatic conditions, population density and economic integration.
Conclusion Patterns of underweight children cross national borders suggesting that regional characteristics and interactions need to be considered when addressing malnutrition.

Keywords Body weight; Thinness/epidemiology/etiology; Child; Child, Preschool; Malnutrition; Geography; Population density; Economics; Nutrition surveys; Africa (*source: MeSH, NLM*).

Mots clés Poids corporel; Maigreur/épidémiologie/étiologie; Enfant; Enfant âge pré-scolaire; Malnutrition; Géographie; Densité population; Economie; Enquête nutritionnelle; Afrique (*source: MeSH, INSERM*).

Palabras clave Peso corporal; Delgadez/epidemiología/etiología; Niño; Preescolar; Desnutrición; Geografía; Densidad de población; Economía; Encuestas nutricionales; África (*fuente: DeCS, BIREME*).

Arabic

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Voir page 768 le résumé en français. En la página 769 figura un resumen en español.

Introduction

With the advent of geographical information systems, the preparation of maps to visualize specific aspects of poverty and development has recently gained in popularity (1–2). An increasing number of studies on health report on geographical aspects of major diseases and health problems, such as malaria, tuberculosis, human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS) and child mortality, while internet sites also provide access to health-related geographical information (3–10). Undernutrition remains one of the most pressing manifestations of poverty in developing countries, and the distribution of undernutrition can be usefully depicted in maps such as those presented in the Fifth Report on the World Nutrition Situation and the Interim Report of the United Nations Millennium Task Force on Hunger (11–12).

One of the choices which often has to be made when preparing geographical representations of undernutrition, is whether to base the information presented on prevalence or on headcounts. Thus, the most recent worldwide undernutrition map developed by the Food and Agriculture Organization of the United Nations (FAO), in which undernutrition is expressed on the basis of stunting in children, consists of two parts (13). One part gives a detailed representation of the prevalence of undernutrition as derived from national nutrition surveys. As a refinement in comparison with earlier maps, information is presented at the level of districts, provinces, or other subnational geographical units. The other part of the FAO map provides quantitative information on numbers of malnourished children, again at the level of subnational geographical units. However, as the areas covered by these geographical units are not of a standard size, the information given by the map on differences between regions with respect to absolute numbers of undernourished children is difficult to interpret. Simply choosing other area sizes (e.g. by combining or splitting geographical units) may change the appearance of the map considerably.

In this paper, we present a geographical representation of underweight children in Africa which differs from the currently available undernutrition maps because prevalence and headcounts have been combined in one chart. The occurrence of low weight-for-age in children has been selected as an indicator of undernutrition, as it combines information on both chronic (height-for-age) and acute undernutrition (weight-for-height). It is one of the most widely used nutritional indicators (14–16), and also the selected anthropometric indicator for the Millennium Development Goals (17). Presenting geographical

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information on underweight children is considered relevant from a policy point of view for two main reasons. Firstly because the subnational-level data on the map presented will give a comprehensive and detailed picture indicating at which locations the nutrition problems are most severe. Secondly, and most importantly, it will be argued that the geographical representation presented here reveals patterns in the occurrence of underweight children which are otherwise difficult to recognize. In particular, the map shows patterns of distribution that cross national borders. In situations where these patterns are clearly crossing national boundaries, regional cooperation is necessary to address undernutrition.

Data and methods

Underweight children are those with a weight that is below 2 standard deviations (SD) of the weight-for-age median value of the United States National Center for Health Statistics/ World Health Organization (WHO) international reference data (*11*, *18*). For an individual child, the *z*-score indicates by how many standard deviations the child's weight is below the sex- and age-specific reference. Although other methods are used to express undernutrition, the use of *z*-scores is strongly advocated by WHO (*18*, *19*). For classifying populations according to various levels of underweight, WHO recommends the following classes: less than 10% (low), 10–19% (medium), 20–29% (high), and 30% or more (very high) (*18*, *20*). For the present study, the category 30% or more was subdivided into 30–39% and 40% or more, to increase the possibility of revealing differences in prevalence of underweight children at the higher end of the range.

We restricted this analysis to Africa because in many African countries the Demographic and Health Surveys (DHS) and the Multiple Indicator Cluster Surveys (MICS) have been implemented with similar protocols since the late 1980s (*21–22*). These surveys follow standardized methods of nationally representative sampling (generally using a probabilistic two-stage sampling frame), data collection, analysis and presentation. The sample sizes of DHS and MICS surveys are generally of the order of 3000–5000 children. Results from DHS and MICS studies are generally presented both at the national and subnational levels (districts, provinces or other subnational geographical units). Table 1 provides detailed information on the datasets used for the present analysis. For 42 of the 53 countries listed, data were available from at least one DHS or MICS survey. For 15 countries (additional) data are taken from the World Health Organization (WHO) statistics (*23*). Finally, for one country, Sudan, additional data were obtained from UNICEF (*24*). The subnational geographical units for which underweight prevalence is reported generally included samples of a few hundred children. Table 1 gives the mean sample size at the subnational level for each country. Provinces or districts with sample sizes of fewer than 100 children have been combined with adjacent provinces or districts to arrive at sample sizes of at least one hundred. Where feasible, the reported prevalence of underweight children in the national capital was merged with the prevalence of the district or area in which the capital is located. In all cases where data from provinces or districts were combined, we calculated weighted averages of prevalence.

For a few countries, the available datasets did not cover the entire country. For example, the MICS survey of Sudan covered only the northern part of the country. For the southern regions only data on prevalence of low weight-for-height were available (*24*). In estimating prevalence of underweight children, we used the fact that nutrition surveys reveal that the prevalence of low weight-for-age is always considerably higher than that of low weight-for-height, generally at least twice as high. For example, in the 2003 MICS survey of northern Sudan this ratio varied for the 10 regions included in the survey from 1.9 to 4.3, with an average of 2.7. Thus, on the basis of information on the prevalence of low weight-for-height at several locations in southern Sudan, we estimated that the prevalence of underweight children is at least in the range of 30–40%. With respect to Kenya, only in the most recent survey (2003), was the north-eastern province included in the sample.

The age group for which underweight prevalence was considered in this study was 0–35 months (under 3 years old). The reason is that in a number of DHS surveys, samples only included children up to the age of 3 years. For those countries where underweight prevalence was reported for under 5-year-olds (the majority), a conversion factor was calculated. DHS reports provide, at the national level, an age breakdown with respect to prevalence of underweight children. We converted the prevalence in children aged under 5 years at the subnational level to prevalence in children aged less than 3 years by multiplying with this calculated conversion factor. It should be noted that these conversions had little effect on the prevalence of underweight children, as the ratio between underweight children aged under 5 years and under 3 years is generally close to one (mean 1.01, range 0.87–1.13). Finally, for those countries where nutritional data were available at more than one point in time, we calculated averages.

We then mapped the weight-for-age information at the level of subnational units according to a standardized scheme for the administrative units database for Africa, being developed by the Second Administrative Level Boundaries project, and currently used by FAO (*25*, *26*). For most countries this mapping was unambiguous, which implies that the districts, provinces or other regions on which the DHS, MICS and other surveys report, could be directly matched with the administrative database. However, for a few countries this matching was less straightforward and available data were allocated to the administrative units database, by aiming for the best overlap between the geographical units of the surveys and the geographical units of the administrative database.

Next, we combined the dataset with a population density map for Africa for the year 1995, with a grid resolution of 2.5 kilometres (*27*, *28*). Population density data were scaled up to the year 1998, by making the nationally aggregated grid data consistent with national population statistics for 1998 as derived from the statistical database of FAO (*29*), followed by proportional adjustment of population density at grid level. The year 1998 was selected because it was closest to the time period in which most of the data on underweight children were collected.

As the data on underweight children concern those under 3 years of age, we converted the gridded population density data to "child" density data by using the African country information on the proportion of children aged under 5 years of the total population. (The United Nations' Population Division database (*30*) provides data on population numbers of under 5-year-olds, not on numbers of under 3-year-olds.) For most African countries these proportions vary at the national level from 15–20% (*30*).

Table 1. **Sources of anthropometric data**

Country	Source[a]	No.[b] of units	Mean unit sample size[c]	Country	Source	No. of units	Mean unit sample size
Algeria	MICS 2000	4	1026	Libyan Arab Jamahiriya	WHO 1995	6	726
Angola	WHO 1996; MICS 2001	13	311	Madagascar	DHS 1992, 1997	5	730
Benin	DHS 1996, 2001	6	528	Malawi	DHS 1992, 2000; WHO 1995	3	1800
Botswana	MICS 2000	9	302	Mali	DHS 1995/96, 2001	6	1232
Burkina Faso	DHS 1993, 1998/99	5	796	Mauritania	DHS 2000/01	5	711
Burundi	MICS 2000	5	451	Mauritius	WHO 1995	1	2430
Cameroon	DHS 1991, 1998	4	535	Morocco	DHS 1992	7	643
Cape Verde	WHO 1994	1	1610	Mozambique	DHS 1997	10	284
Central African Republic	DHS 1994/95	5	445	Namibia	DHS 1992, 2000	13	252
Chad	DHS 1996/97; WHO 2000	14	382	Niger	DHS 1992, 1998 ; MICS 2000	5	863
Comoros	DHS 1996	1	921	Nigeria	DHS 1999, 2003	5	626
Congo, Democratic Republic of the	MICS 2001	9	960	Rwanda	DHS 2000	10	239
Congo, Republic of	WHO 1987	8	304	Sao Tome and Principe	WHO 2000	1	1646
Côte d'Ivoire	WHO 1994	10	334	Senegal	MICS 2000	10	0.12 m[d]
Djibouti	WHO 1996	1	–	Seychelles	WHO 1988	1	836
Egypt	DHS 1995, 2000, 2003	4	2144	Sierra Leone	WHO 1990; MICS 2000	4	850
Equatorial Guinea	WHO 1992	1	1252	Somalia	MICS 2000	3	1422
Eritrea	DHS 1995, 2002	6	645	South Africa	WHO 1993/94	9	1090
Ethiopia	DHS 2002	10	1045	Sudan	MICS 2000; UNICEF 2003	16	1128
Gabon	DHS 2000	5	622	Swaziland	MICS 2000	4	806
Gambia	WHO 1997; MICS 2000	5	495	Tanzania, United Republic of	DHS 1991/92, 1996	23	249
Ghana	DHS 1998, 2003	9	320	Togo	DHS, 1998	5	652
Guinea	DHS 1999; WHO 2000	4	624	Tunisia	WHO 1996/97; MICS 2000	7	1508
Guinea-Bissau	MICS 2000	9	598	Uganda	DHS 1995, 2000	4	1298
Kenya	DHS 1998, 2003; MICS 2000	7	745	Zambia	DHS 1992, 1996, 2001/02 MICS 1999	9	850[e]
Lesotho	WHO 1992 ; MICS 2000	10	382	Zimbabwe	DHS 1994, 1999	10	277
Liberia	WHO 1999/2000	9	503				

[a] Demographic Health Surveys (DHS); Multiple Indicator Cluster Surveys (MICS); World Health Organization (WHO) (21–23).
[b] Number of subnational geographical units for which the nutrition surveys report rates of prevalence of underweight children.
[c] Mean sample size at the level of subnational geographical units.
[d] Sample size of MICS-survey in Senegal 1.2 million children.
[e] MICS-survey of Zambia not included for calculation of mean sample size (sample size MICS-1999 Zambia 1 095 000 children).

Our final geographical representation was based on data for 356 geographical units divided over 53 countries. We used colour codes to visualize both the information on the prevalence of underweight children and on absolute numbers of underweight children: the colour indicates the prevalence of underweight children and the colour intensity indicates the population density of under 5-year-olds (0–1, 2–5, 6–10, 11–20 and > 20 children per square kilometre).

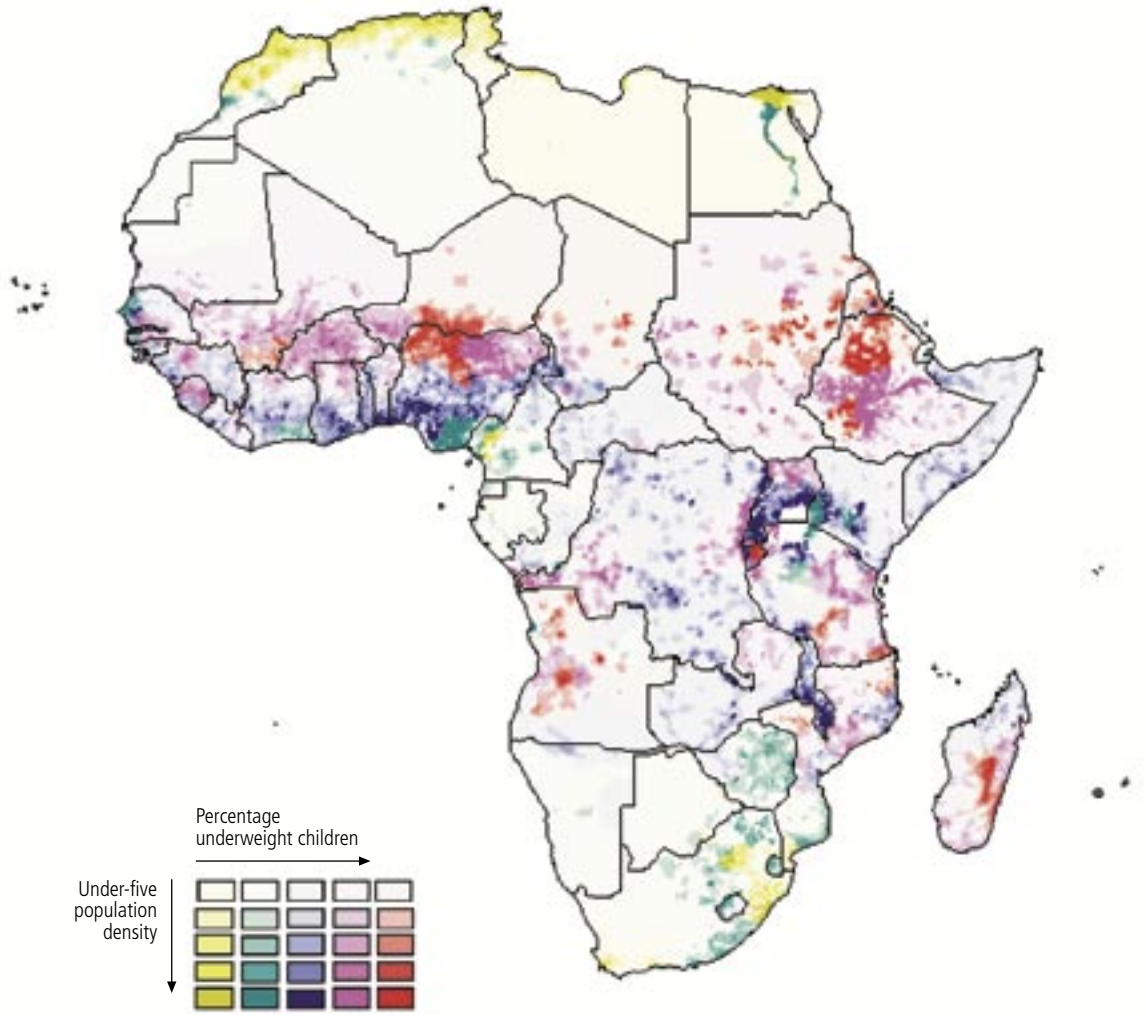
Finally, to gain some insight into the robustness of differences in prevalence of underweight children between subnational units within countries, for one country for which four survey results were available (Zambia), we made a graphical comparison between the patterns of underweight prevalence as reported in these four surveys for the nine provinces of the country.

Results

Geographical patterns in the occurrence of underweight

Fig. 1 depicts the occurrence of underweight children in Africa and shows clearly where the nutritional problems are most severe. At locations marked in red and with the highest colour intensity, more than 40% of children are underweight and the population density of under 5-year-olds was higher than 20 chil-

Fig. 1. **Geographical representation of underweight in children (0–3 years) in Africa**



Underweight prevalence (weight-for-age below median -2sd) in 5 percentage classes (0–10%, 11–20%, 21–30%, 31–40%, > 40 %). Under-five population density in five classes, 0–1, 2–5, 6–10, 11–20, >20 persons/sq km.
Sources: Deichmann, 1994 (*27*); DHS/MICS-UNICEF/WHO (*21,22,23*) ; FAO, 2003 (*26*); SALB, 2004 (*25*).

WHO 05.49

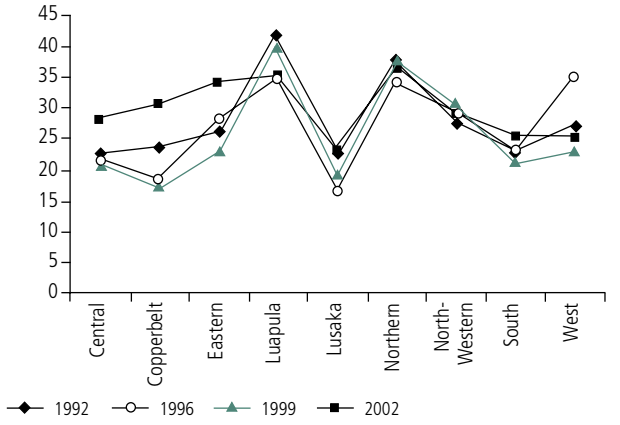
dren per square kilometre. Thus, the occurrence of underweight children was particularly high in northern Nigeria and adjacent Niger, and in large areas of Ethiopia, Sudan and Eritrea. In parts of Angola, Madagascar and the United Republic of Tanzania, a high population density of under 5-year-olds was also combined with a high prevalence of underweight children.

The map reveals distinct regional patterns. There is a clear gradient in the prevalence of underweight children in West Africa. Along the coast of West Africa, there is an intermediate prevalence of underweight children (with the exception of war-torn Sierra Leone), that increases rapidly when moving to the north, with the highest prevalence in the Sahel. In other regions, nutritional conditions clearly cross national borders. In the Great Lakes area, prevalence at several locations was above 30%, and the population density of under 5-year-olds was high. This implies that there are large numbers of undernourished children on both sides of the borders between Burundi, the Democratic Republic of the Congo, Rwanda, Uganda and the United Republic of Tanzania. Regional patterns of low or medium levels of underweight children were also shown. Prevalence below 20% as observed in South Africa continued into neighbouring countries such as Botswana, Namibia and Zimbabwe, and also into the southern part of Mozambique. In coastal central West Africa, there appeared to be a range of low and medium levels of underweight children stretching from south-eastern Nigeria up to Gabon and parts of the Republic of the Congo.

Robustness of results

The prevalence of undernutrition may change over time, and the results for a particular location may depend on the year and the season in which the surveys were done. Four successive surveys (1992, 1996, 1999 and 2001/02) in Zambia show a stable distribution of the prevalence of undernutrition, except for the 2002 survey in the central, copperbelt and eastern regions and for the 1996 survey in the western region (see Fig. 2). The national prevalence of underweight children in these four surveys were 25.1% (1992), 23.5% (1996), 25.0% (1999) and 28.1% (2001/02). These results show that the overall patterns

Fig. 2. **Distribution of underweight prevalence (% children, 0–3 years, with weight-for-age below median – 2sd) over 9 geographical units in Zambia, in 1992, 1996, 1999 and 2001–02**



Source: DHS (*21*). WHO 05.99

in the prevalence of underweight children have not changed significantly during the past 10–15 years.

Discussion

The map (Fig. 1) clearly indicates where in Africa the nutritional problems are most severe, both in terms of prevalence and in terms of headcounts. The identified areas largely coincide with the areas identified as "hunger hotspots" in the Interim Report of the United Nations Millennium Task Force on Hunger (12). In terms of policy relevance, it can be argued that when a large proportion of the child population is affected by malnutrition, economy-wide efforts are needed to improve nutrition. Where prevalence is intermediate or even low, targeted approaches towards alleviating undernutrition may be needed.

The Horn of Africa is a region where a high prevalence of underweight children coincides with high population density. As a result, at many locations, there are more than 20 underweight children per square kilometre. Although high population density is not necessarily associated with undernutrition, high pressure on the land in this part of Africa, and a deterioration in its quality, may contribute to poor nutritional conditions (31–32). Another region of high proportions and absolute numbers is the Great Lakes. The conflicts which ravaged the region in the past decades have undoubtedly contributed to its poor nutritional conditions.

With respect to the regional patterns revealed in the occurrence of underweight children, the pattern observed in West Africa suggests a relationship with agronomic and climatic conditions in the region, characterized by decreasing rainfall from the coastal to the Sahelian region. A strong correlation between aridity and the occurrence of undernutrition expressed on the basis of weight-for-height (wasting) has been reported in West Africa (33).

A low prevalence of underweight children in neighbouring countries in southern Africa may be partially the result of regional economic integration. For example, hundreds of thousands of migrant workers from Botswana, Mozambique, Namibia and other countries have found employment in South Africa. Remittances to their home countries are likely to have a positive effect on the living conditions of their relatives, including a positive effect on nutrition.

Our map has some limitations. Data availability varies from country to country, in terms of timing, coverage and representativeness of surveys, and in methods of reporting. Clearly, nutritional conditions may change over time, and data which date back several years are less likely to reflect current conditions than more recent data. These changes over time can be related to overall changes in economic conditions, but also to more specific processes such as urbanization which is occurring rapidly in many African countries. Despite these limitations, this map may be a useful tool for the rapid identification of areas or population groups where nutritional intervention appears to be most needed.

Conclusions

Our geographical representation of underweight children in Africa combines information on prevalence and headcounts in one map. Patterns of distribution that continue across borders suggest that regional characteristics as well as national policies and circumstances play a role in the causation or prevention of undernutrition. These regional factors may be related to agronomic or climatic conditions, patterns in the spread of major diseases, and the existence of regional economic cooperation, or, on the contrary, of regional conflicts. The findings of this study imply that a regional perspective is essential in addressing problems of undernutrition and poverty. Undernutrition is one of the most important factors contributing to child morbidity and child mortality in developing countries, and geographical data provide a way to explore the patterns of undernutrition. This exploration can direct research into causative factors; and be used to design regional programmes aimed at reducing undernutrition (34, 35). ■

Competing interests: none declared.

Résumé

Schémas de répartition géographique de l'insuffisance pondérale infantile en Afrique

Objectif Mettre en évidence les schémas de répartition géographique de l'insuffisance pondérale en Afrique, en combinant les taux de prévalence avec les données de recensement au niveau sub-national.
Méthodes On a fait appel à des enquêtes de nutrition de grande ampleur, représentatives à l'échelle nationale, et notamment à des enquêtes de démographie et de santé et à des enquêtes à indicateurs multiples, conçues, analysées et présentées selon des protocoles fortement similaires et fournissant des informations aux niveaux national et sub-national.
Résultats Les résultats font apparaître différents schémas de répartition géographique dans la fréquence de l'insuffisance pondérale infantile, qui pourraient être mis en relation avec des facteurs, tels que les conditions agroclimatiques, la densité de population et l'intégration économique.
Conclusion Les schémas de répartition de l'insuffisance pondérale chez l'enfant ne respectent pas les frontières, ce qui laisse à penser que les caractéristiques et les interactions régionales sont à prendre en compte pour aborder le problème de la malnutrition.

Resumen

Distribución geográfica de la insuficiencia ponderal en la población infantil de África

Objetivo Determinar la distribución geográfica de la insuficiencia ponderal entre los niños de África combinando información sobre las tasas de prevalencia porcentuales y los recuentos de personas a nivel subnacional.

Métodos Se han utilizado encuestas nutricionales en gran escala y nacionalmente representativas, en particular las Encuestas de Demografía y Salud y las Encuestas de Indicadores Múltiples por Conglomerados, que han sido diseñadas, analizadas y presentadas con arreglo a protocolos en gran medida semejantes, y que ofrecen datos de ámbito tanto nacional como subnacional.

Resultados Los resultados ponen de relieve claras diferencias geográficas de la insuficiencia ponderal infantil, que podrían estar asociadas a factores como las condiciones agroclimáticas, la densidad demográfica y el nivel de integración económica.

Conclusión La distribución de la insuficiencia ponderal infantil muestra que ésta no respeta las fronteras, lo que indica que hay características e interacciones regionales, que deben tenerse en cuenta a la hora de hacer frente a la malnutrición.

Arabic

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