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Research Article

Determinants and Spatial Distribution of Obesity among Women of Childbearing Age in the Democratic Republic of Congo : Analysis Based on Data from the 2013-2014 Demographic and Health Survey

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Abstract

Introduction: Good nutritional security is part of the fundamental rights of individuals to food, to health and constitutes the foundation of their good health and well-being. On the other hand, obesity affects all countries with limited resources, the DRC is not spared. Ensuring good health for women of childbearing age would lead to better pregnancy outcomes and healthy newborns. Our work aims to analyze the determinants andthe spatial distribution of obesity in women aged 15-49 years in the DRC.

Methods: We carried out a secondary analysis of data from the Demographic and Health Survey (DHS) of the DRC, carried out in 2013-2014. This was a cross-sectional survey, national in scope, with a level of regional representativeness. Our study concerned non-pregnant women aged 15 to 49. The determinants were identified from a multilevel logistic regression. Spatial disparities were identified by two detection approaches, Moran's local index and Kulldorff's statistic.

Results: The prevalence of obesity was 4%. Regarding the determinants, the effect of age on women's BMI shows that for each unit increase in age, the tendency to be obese is multiplied by 2.4 (95% CI [192%; 317%], p-value < 0.001). Women with husbands with primary education have a 54% (95% CI [21%; 99%], p value < 0.05) reduced risk of being obese compared to those with husbands with no level of education . Women from rich households have a risk of being obese multiplied by 5.7 (95% CI [247%; 1346%], p value < 0.001) compared to those from very poor households.LMoran's statistic was - 0.142 (p = 0.217) showing the absence of spatial correlation for 3 provinces: Lomami, Tshopo, North Kivu. TheKulldorff's statistic shows a non-significant cluster for obesity (p = 0.237, with a radius of 31.82 km).

Conclusion: The spatial distribution of malnutritionconfirms that in women of childbearing age, obesity is a clustered phenomenon with a random spatial pattern in the DRC.We have identified the main determinants of obesity that are demographic and socioeconomic.Therefore, the fight against obesity remains multidisciplinary and it is important to multiply targeted preventive actions in the fight against overnutrition in this important segment of women aged 15-49 years of the Congolese population.

Keywords: Déterminants; Spatial distribution; Women; Obesity; DRC

Abbreviations

VAC/SCN: Administrative Committee on Coordination/ Sub-Committee on Nutrition; CS: Health Center; DALYs: Disability-Adjusted Life Years; DHS: Department of Homeland Security; DHS: Demographic and Health Survey; CAM: Food and Agriculture Organization of the United Nation; IFPR: International Food Policy Research Institute; BMI: Body mass index; CAM: General Additive Model; RGH: Reference General Hospital; SDGs: Sustainable Development Goal; WHO: World Health Organization; MDGs: Millennium Development Goal; Lisa: Local Indicators of Spatial Association; LLIN: Mosquito Net Impregnated with Long-lasting Insecticide; GDP:Gross Internal Product; Ground floor: Democratic Republic of Congo; R-INLA: R-Integrated Needed Laplace Approximation software; AIDS: Acquired Immunodeficiency Syndrome; STAR: Statistical Additive Regression; UNICEF: UNICEF; QGIS-GPS: Quantum Geographic Information System-Global Positioning System; HIV: Human Immunodeficiency Virus; TR: Response Rate

Introduction

Malnutrition is a public health problem worldwide. Indeed, according to the WHO in 2014, 462 million adults were underweight [1-3]. The situation of malnutrition is even more worrying among women of childbearing age and children under 5 years old. The evaluation of the nutritional status of women aged 15 to 49 is one of the determinants of the course of pregnancy, its outcome and maternal mortality [1]. It also influences the morbidity and mortality of infants and young children [1]. Key indicators of nutritional burden are increasing globally and low- and middle-income countries are the most affected; malnutrition in women of childbearing age is a global public health problem [3]. Malnutrition prevalence remains high among girls and women aged 15-49, with significant differences in favor of non-pregnant women [4,5].

In 2014, the WHO estimated that the prevalence of obesity in the South and Southeast Asia region was 8.6% in 2014 among women of reproductive age [6]. In Bangladesh, obesity was 48.6% in 2016 [7]. In 2016, the prevalence of obesity among women was 13% in Brazil and 23% in Mexico, and in Jordan it is 59% among women of childbearing age [8]. In sub-Saharan Africa, the prevalence of overweight and obesity is increasing among women of childbearing age.There area rapid increase in obesity relative to underweight, particularly among women in urban areas with extreme prevalence in South Africa where 44% of women were obese in 2016 [9]. In sub-Saharan Africa the prevalence of overweight combined with obesity among women was 15.9%, lowest in Madagascar (5.6%) and highest in Swaziland (27.7%). Similarly, the prevalence of obesity was also lowest in Madagascar 1.1% and highest in Swaziland 23% [10]. The prevalence of overweight and obesity among women has increased in Africa; In Ghana, overweight nearly doubled while obesity tripled between 1993 and 2014. Egypt has the highest level of overweight and obesity at 44% and 39%, respectively in 2013 and 2014 [11]. Additionally, obesity doubled in Kenya, Benin, Niger, Rwanda, Ivory Coast and Uganda, while it tripled in Zambia, Burkina Faso, Mali, Malawi and Tanzania [9]. Madagascar and Ethiopia had the lowest prevalence of obesity and overweight, with overweight ranging from 12% and 7% and obesity from 4% and 1% [11]. In the DRC, overweight is increasingly becoming a public health problem. The proportion of women with overweight is increasing, from 10% in 2001 to 11% in 2007 and 16% in 2013. As for obesity, it was 2% in 2007 and rose to 7% in 2013 [1]. In 2003, studies on malnutrition and its inequalities were conducted by the «People's Global Nutrition Forum» [12]. According to these studies, the fundamental determinants are: poverty, inequality, injustice, unemployment, underpaid jobs, wild and uncontrolled urbanization, degradation of the agricultural environment. The underlying determinants: the insufficiency of health services, the lack of education and information, the insufficient sanitary situation, water pollution and those immediate: the destruction of the ecosystem, indigenous cultures and traditional, war [8].

In 2013 in Bangladesh, Mobarak Hossain Khan., *et al*. in their study oflevels, trends and disparities in malnutrition indicators among women of reproductive age found inequitable access to food resources and income inequality as determinants of malnutrition [13]. Dickson., *et al*. in 2017, during a study carried out in 24 African countries on the temporal trends of malnutrition among women residing in urban areas cites poverty, education, inequality and inequitable access to food resources, the health situation insufficient, market speculation, insufficient regulation of food quality [14] as determinants of malnutrition. A systematic review by Black., *et al*. in 2013, cite poverty, education, inequality andinequitable access to food resources, insufficient sanitary situation, inequitable access to food resources [4]. Unfair trade, market speculation, insufficient regulation of food quality, aggressive promotion of breast milk substitutes, promotion of cheap food, economic, political, demographic, socio-cultural and biological factors as factors that influence malnutrition in women of childbearing age [14,15]. In Ethiopia Ferede., *et al*. in 2017 found among othersthatched housing conditions, unprotected sources of drinking water, lack of habit of washing hands after using the toilet, consumption of fish, consumption of dairy products and food insecurity [13]. Adebowale., *et al*. in 2015 in Burkina Faso in its study on women's wealth and under-

nourishment cites poverty, insufficient regulation of food quality [16]. In conclusion, at the end of this analysis, we find that the determinants of malnutrition in women of childbearing age are diverse and deserve special attention.

One of the strengths of our study lies in the use of the national DHS 2014 with representativeness at the provincial level based on population and covering both rural and urban areas. This study will fill the knowledge gap on the spatialization of obesity among women in Central Africa, the DRC in particular; an analysis with two models: the classics, the space. The results will contribute to the improvement of the protocol for the prevention and protection of women of childbearing age at risk of overnutrition in the DRC and to establish priorities for areas at risk where malnutrition is necessary and facilitate interventions.

The objectives for this study were to: Determine the prevalence ofIa default and excess malnutritionamong women aged 15-49 in the DRC; identify the demographic and socio-economic determinants influencing malnutritiondefault and excessamong women aged 15-49 in the DRC; to identify the spatial distribution of themalnutrition default and excessamong women aged 15-49 in the DRC.

Patients and Methods

Type and setting of study

This is a cross-sectional descriptive study with an analytical aim carried out in 26 provinces in the Democratic Republic of Congo (DRC).

Study population

For our study, women of childbearing age, i.e. aged 15 to 49, represent the study population..

Data source overview

The EDS concerned the population of individuals residing in households. We extracted the data from the DHS database. The EDS carried out a stratified random sampling at the level of the sampling units proportional to the size (1° neighborhoods/villages at the level of cities/rural areas), systematic drawing with equal probability (2° with 34 households/neighbourhoods or several villages 3° 34 village households drawn from 2), 540 clusters with 18,360 households including 5,474 in urban areas (161 clusters) and 12,886 in rural areas (379 clusters). A total of 540 clusters were selected, of which 536 could be visited due to insecurity (2 in Katanga, Orientale and North Kivu). Of 18,224 selected households, 18,171 were successfully surveyed (99.9% response rate).Three questionnaires were used during the DHS: the household questionnaire, the women's questionnaire and the men's questionnaire. The content of these questionnaires is based on the model questionnaires developed by the MEASURE DHS program and adapted to the realities of the country.Thus, the detailed methodologies and the collection process are available in the DHS reports[1], on the website of theDHS MEASUREMENT(http://www.measuredhs.com/).The study focuses on data of women of childbearing age (aged 15-49) from the selected DHS on household and women's questionnaires to achieve the study objectives.

Starting from the analysis of the local nutritional situation and the determinants of malnutrition among women of childbearing age in the DRC, we based ourselves on a conceptual framework inspired by the framework of UNICEF, 2000[4].

Sample size and statistical power

We considered all women meeting the inclusion criteria and whose Body Mass Index was measured during the survey. Our total sample size was8164women.We carried out the calculation of the statistical power to identify the subjects necessary for our study and because we use the secondary data. The calculation of the statistical power was carried out respectively, for obesity from the comparison of the theoretical proportion of 7% (EDS) with that calculated of 4%. We obtained a statistical power of 100%.

Study variables

- **Dependent variable:Overnutrition (Obesity):** (0 "Normal weight: BMI ≥18.5 and BMI < 25»; 1 "obesity:BMI ≥ 30»)
- **Contextual variables:** Household wealth index, access to media (newspapers/magazines, listening to the radio or watching television) at least once a week, occupation of husbands, sources of drinking water, sanitary facilities, health insurance.
- **Sociodemographic variables:** Women's age in years, marital status, living children, the occupation of the wife, the education of the husbands, the highest level of schooling of the women.
- **Individual and behavioral variables:** eg tobacco, alcohol, religion, breastfeeding, childbirth, time traveled to water source, use of contraceptive methods, ethnicity.
- **Geographic variables:** The province of residence of the respondents, the place of residence.

Statistical analysis

Descriptive analyzes

For this first part of the analysis, we chose multilevel logistic regression as the statistical method of analysis. The conditions of application of the logistic regression and the conditions of validity of a logistic regression model were checked before any analysis by checking the selection of the explanatory variables. The independence of observations, the distribution of quantitative variables and the linearity of their relationship with the dependent variable. We also took into account the measures of the quality of the estimation of the final model: The discriminating power of the model, the sensitivity and the specificity of the model, the rate of good prediction of the model, the specification of the model and finally the calibration. of the model with the Hosmer-Lemeshow test.

Also, the p-value of the multilevel model, compared to the logistic model was decided on the basis of the appreciation of the intra-class correlation coefficient (ICC). As a hierarchical structure of the data, we considered women and provinces as levels of analysis. The justification for this hierarchy is based on the fact that, in our view, women of the same level may have lifestyles and determinants that are similar. The level of statistical significance was set at 0.05 for all statistical tests.

Spatial statistical analyzes

Local and global cluster trend detection techniques have been applied to search for spatial disparities in the distribution of overnutrition. We used GeoDa software for an interactive environment that combines maps with statistical graphs, using dynamically linked window technology. For the visualization of the global and local spatial autocorrelation, we first loaded the manager weights file in the tool menu which contained four submenus (adjacency matrix type (queen 1), symmetry (unknown), shape(COD-admbnda-adm1-20170407 Proportions), variable id (object ID) this to process the construction and analysis of spatial weights [46, 47] The conversion and creation of point and polygon shapefiles, and data export were performed as a second step to finally calculate the Moran and Gertis statistic [8, 47]. The spatial scanning method detected spatial or spatio-temporal clusters, as well as their significances. The radius of the window varied between 0% and 50% of the population at risk. We also chose the Poisson model, depending on the objective of the study and the type of cluster to be detected (low or high prevalence). For the Monte Carlo study, 999 simulations were carried out. We also chose the Poisson model, depending on the objective of the study and the type of cluster to be detected (low or high prevalence). For the Monte Carlo study, 999 simulations were carried out. We also chose the Poisson model, depending on the objective of the study and the type of cluster to be detected (low or high prevalence). For the Monte Carlo study, 999 simulations were carried out.

Results

Sociodemographic characteristics

As shown in Table 1, 9.6% of women of reproductive age lived in the capital of the DRC (Kinshasa), 36% of women of reproductive age were from urban areas, and 64% lived in rural areas. Women between 25-35 years old accounted for 31%. Women from very poor households represented 23.1% of our sample, 18.2% had no level of education and 27% were unemployed. For the use of contraceptive methods, 1% of them were using modern contraceptive methods, while 74% had not given birth in the year preceding the survey, 96% of women had not subscribed to health insurance and 1% smoked tobacco. These results are shown in the table below.

Prevalence of obesity

The highest prevalence of obesity was found in the city of Kinshasa with 12.9% (95%CI [9%; 16%]), the lowest prevalence was observed in Kwango province with 0. 2% (95% CI [0%; 1%]) (Table 2).

Determinants of obesity

In bivariate analysis we found the statistically significant association between the variables, age, place of residence, wealth index, access to the media, level of education of women. Demographic and socioeconomic factors, taking into account the effect of age on women's BMI, for each unit of increase in age, the tendency to be obese increases by 75% (95%CI [143%; 215%], p value < 0.001); also women living in rural areas have a reduced risk of 85.5% (95% CI [7%; 27%], p value < 0.001) of being obese compared to those living in cities. Higher level women have a 54% increased risk (95% CI [116%; 204%], p value < 0.05) of being obese compared to those with no level of education, women at secondary level have a risk multiplied by 5 (95% CI [203%; 1253%], p value < 0.05) of being obese compared to those with no level of education and, women with secondary education have a risk multiplied by 2 (95% CI [111%; 508%], p value < 0.05) to be obese compared to those with no level of education. Women from very rich households have the risk of being obese multiplied by 30 (95%CI [1218%, 7863%], p value < 0.001) compared to those from very poor households, Wo-

Variables	Frequencies (n = 8164)	Percentages (%)	Weighted percentages (%)
Age groups			
Under 18	1129	14	14
18-24 years old	2139	26	26
25-35 years old	2497	31	31
Over 35 years old	2399	29	29
provinces			
Kinshasa	785	9.6	11.8
kwango	380	4.6	4.6
Kwilu	404	5	6.9
Mai-ndombe	295	3.6	4.4
Central Kongo	418	5.1	5
Ecuador	209	2.5	2.5
Mongala	231	3	2.2
North Ubangi	221	3	1.4
South Ubangi	256	3.1	4.3
Tshuapa	215	4	2
Kasai	299	3.6	3
Kasai-central	320	3.9	4
Kasai-Oriental	331	4	4.2
Lomami	355	4.3	4.4
sankuru	242	2.9	1.5
Upper Katanga	255	3.1	4
Upper Lomami	248	3	2
Lualaba	198	2.4	1.7
Tanganyika	239	2.9	1.5
Maniema	379	4.6	3.1
North Kivu	523	6.4	9.2
Lower Uele	194	2.3	1.7
Haut Uele	218	2.6	2
Ituri	262	3.2	3.1
Tshopo	251	3	2.5
South Kivu	436	5.3	7
Place of residence			
Urban	2973	36	38
Rural	5191	64	62
Wealth indices	Household		
Very poor	1890	23.1	18.4

Poor	1587	19.4	18.6
Medium	1608	19.9	19.5
Rich	1480	18.1	19.5
Very rich	1599	19.5	24
Highest level of	Female education		
None	1486	18.2	16
Primary	3130	38.3	36.3
Secondary	3300	40.5	44
Superior	248	3	3.7
Occupancy of the	Women		
Unemployed	2222	27	28
With a job	5942	73	72
Use of	Methods	contraceptives	
No method	8089	99	99
modern method	75	1	1
Childbirth			
Nope	6049	74	74
Yes	2115	26	25
Health insurance			
Nope	7814	96	95
Yes	349	4	5
Tobacco			
Nope	8081	99	99
Yes	83	1	1

Table 1: Characteristics of women of childbearing age in the DRC 2013-2014.

Variables	Normal weight (n%)	Obesity (not%)	Prevalences (not%)	95% CI	p-value
Provinces					**<0.001**
Kinshasa	9.7	1.4	12.9	[9%; 16%]	
kwango	4.0	0.0	0.2	[55%; 1%]	
Kwilu	6.6	0.0	0.8	[0%; 3%]	
Mai-ndombe	4.5	0.0	1.1	[0%; 4%]	
Central Kongo	4.3	0.0	2.6	[1%; 5%]	
Ecuador	2.6	0.0	2.3	[0%; 8%]	
mongala	2.3	0.0	1.1	[0%; 4%]	
North Ubangi	1.6	0.0	0.5	[0%; 3%]	
South Ubangi	5.0	0.0	0.4	[0%; 2%]	

Tsupa	1.7	0.0	1.9	[0%; 8%]	
Kasai	2.8	0.0	1.1	[0%; 3%]	
Kasai-central	4.0	0	Nope	Comments	
Kasai-Oriental	4.0	0.3	8.6	[5%; 14%]	
lomami	4.5	0.0	0.7	[0%; 3%]	
sankuru	1.5	0.0	0.9	[0%;3%]	
Upper Katanga	3.6	0.3	8.4	[4%;14%]	
Upper Lomami	1.8	0.0	1.5	[0%; 5%]	
Lualaba	1.6	0.0	1.1	[0%; 5%]	
Tanganyika	1.5	0	Nope	Comments	
Maniema	3.1	0.0	2	[0%; 6%]	
North Kivu	8.5	0.8	8.7	[5%; 13%]	
Lower Uele	1.6	0.0	3	[0%; 13%]	
Haut Uele	1.8	0.0	1.2	[0%; 3%]	
Ituri	3.2	0.1	3.3	[1%; 9%]	
Tshopo	2.2	0.2	1.1	[4%; 24%]	
South Kivu	6.2	0.5	8.5	[4%; 17%]	

Table 2: Prevalence of obesity in women of childbearing age in the DRC 2013-2014.

men from rich households have the risk of being obese multiplied by 8 (95% CI [270%; 2561%], p value < 0.001) compared to those from very poor households. Women with access to the media once a week have a risk multiplied by 2 (95% CI [150%; 410%], p value < 0.001) of being obese compared to those who do not have access to the media, taking into account the effect of marital status on women's BMI,110%; 159%], p-value < 0.05); women with husbands with primary education have a reduced risk of 80.6% (95% CI [7%; 50%], p value < 0.05) compared to those with husbands with no level of education. Women from households with a number greater than 4 have a reduced risk of 33.7% (95% CI [45%; 96%], p value < 0.05) compared to those from households less than 4; taking into account the effect of contraceptive methods on women's BMI, for each unit increase in contraceptive methods, the tendency to be obese decreased by 92.5% (95% CI [0%; 57%], p-value < 0.05). These results are shown in Table III. For multivariate analysis, two models were subjected to multilevel analysis. The first (Model 0), unconditional does not include any variable except the dependent variable and the second level. This model presents the total variance of undernutrition among the groups. The second (Model 1) includes only the individual level variables in model 0. In addition, for the choice of the best model, the significance of the lrtest and the ICC were interpreted.

Holding the other variables constant, and taking into account the two levels (individual and province), taking into account the effect of age on women's BMI, for each unit of increase in age, the trend being obese is multiplied by 2.4 (95% CI [192%; 317%], p value < 0.001). The wives of primary school husbands have a 54% (95% CI [21%; 99%], p value < 0.05) reduced risk of being obese compared to those with no level of education. Women from very rich households have a risk of being obese multiplied by 33.5 (95% CI [1337%; 8424%], p value < 0.001) compared to those from very

poor households, women from rich have a risk of being obese multiplied by 5.7 (95% CI [247%; 1346%], p value < 0.001) compared to those from very poor households; and women from average households have a risk of being obese multiplied by 2.7 (95% CI [116%; 666%], p value < 0.05) compared to those from very poor households. These results are shown in the following table

Variables	Not adjusted		Adjusted	
	OR[IC]	p-value	OR[IC]	p-value
Age	1.75[143%; 215%]	0.000**	2.47 [192%; 317%]	0.000**
Middle of	Residence			
Urban	1			
Rural	0.14[7%; 27%]	0.000**		
provinces	1.03[93%; 96%]	0.004*		
Education	husbands			
None	1		1	
Primary	0.19[7%; 50%]	0.001*	0.46[21%; 97%]	0.049*
Superior	1.13[56%; 230%]	0.719*	0.73[39%; 136%]	0.335
Education	women			
None	1			
Primary	0.94[39%; 225%]	0.894		
Secondary	2.37[111%; 508%]	0.026*		
Superior	5.04[203%; 1253%]	0.001*		
Index of	household wealth			
Very poor	1		1	
Poor	0.64[19%; 212%]	0.470	1.32[48%; 359%]	0.580
Medium	2.71[91%; 811%]	0.073	2.78[116%; 666%]	0.021*
Rich	8.32[270%; 2561%]	0.000**	5.77[247%; 1346%]	0.000**
Very rich	30.95[1218%; 7863%]	0.000**	33.57[1337%; 8424%]	0.000**
marital status	1.33[110%; 159%]	0.002*		
Methods	Contraceptives			
	0.07[0%; 57%]	0.013*		
Number of	living people	in the	Households	
< 4	1			
> 4	0.66[45%; 96%]	0.034*		
Access to	Media			
Nope	1			
Yes	2.48[150%; 410%]	0.000**		
**p < 0.001, *p < 0.05			Prob > chi2 = 0.0000	

Table 3: Determinants of obesity in bivariate analysis and in multivariate multilevel analysis.

Spatial distribution

Moran's index

The local Moran's index was used as the local indicator of spatial association (LISA).Thereby,to further explore spatial dependence in obesity data. We calculated Moran's I index using GeoDa 1.12.1.161. From the result, it was observed that at a Moran's I of -0.142 and at a non-significant level of 0.05 (p = 0.217), the spatial pattern of obesity is random (Figure 1).

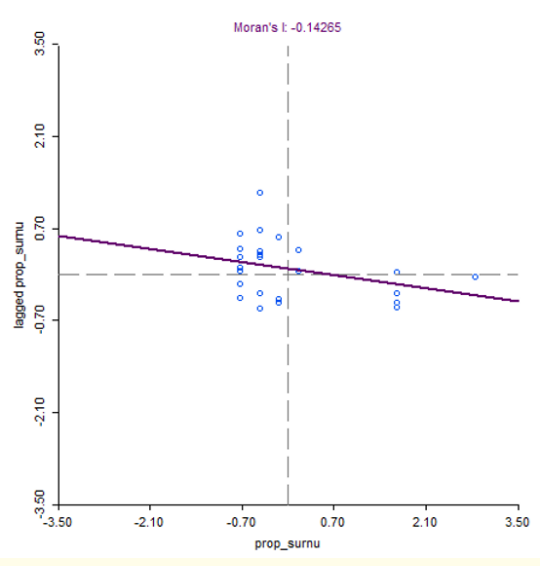

Figure 1: I Moran on obesity in 2014.

Kulldorff statistical index

The aggregation of local clusters showed the absence of significant clusters, however only one cluster is found in the capital Kinshasa with 36 cluster locations and 492 total locations. The aggregate is not significant (p = 0.237, with a radius of 31.82 Km) represented in a red circle corresponds to the province of Kinshasa for the year 2014. The overall relative risk within this aggregate is 1 .13 with the ratio of observed cases to expected cases of 1.12. Thus Obesity is not a clustered phenomenon (Figure 2).

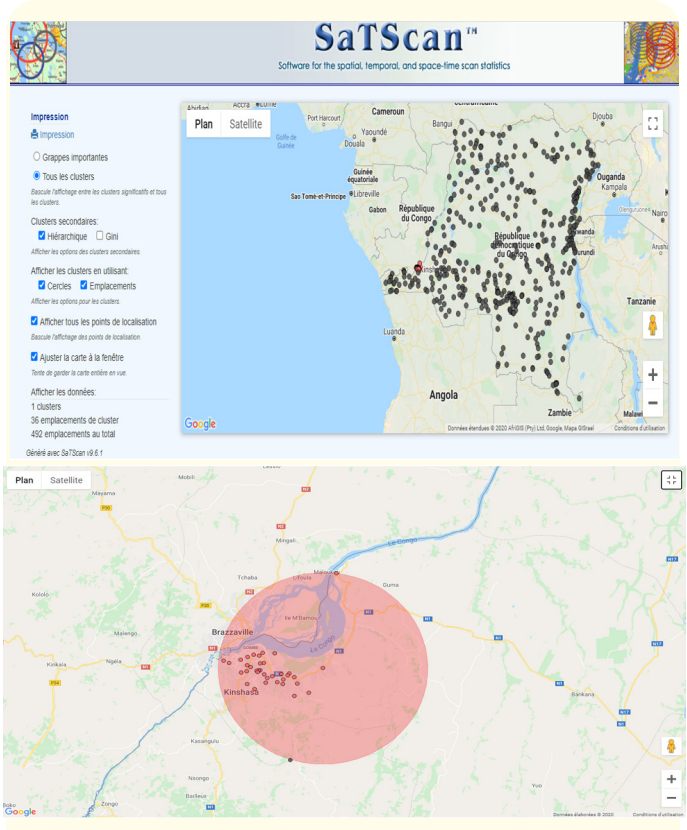

Figure 2: Location of clusters on obesity in the DRC 2013-2014.

Discussion

Prevalence of obesity

The prevalence of obesity is steadily increasing in almost all countries, whether resource-limited nations or developed ones [3-5,17]. We found for our study 4% (95% CI [3%; 4%]).As part of measures to design appropriate interventions to reduce the prevalence of malnutrition among women, it is very necessary to know how many women are obese and to identify the socio-demographic factors responsible. The high prevalence of obesity was observedin the city-province of Kinshasa with 12.9% (95% CI [9%; 16%]).The STEPS survey in 2006 found 5.7%. Our results could be explained by the nutritional transition that the large cities of the DRC are undergoing, che populations use more imported food, on the other handno observations found in two provinces (Kasaï-Central and Tanganyika), hereit is the local foods that have always helped the populations of these provinces to maintain a good nutritional state. In contrast, the prevalence of obesity in Asian regions was 8.6% in 2014 [6]. In Bangladesh, obesity was 48.6% in 2016, the increase is observed in both urban and rural areas [7,18]. In 2016, the prevalence of obesity among women was 13% in Brazil [8]. In South Africa where 44% of women were obese in 2016, between 1 to 4% in Ethiopia and Madagascar [9]. The prevalence of overweight and obesity among women has increased in Africa; in Ghana, obesity tripled between 1993 and 2014. Egypt was at 39% in 2014 [11]; Akseer., *et al*. [15,19], in 2018 in Afghanistan found a prevalence of 20%.This differential distribution of obesity confirms its multifactorial nature.

Obesity was higher among the rich 4.3% (95%CI [2%; 8%]) than among the poor 0.3%, as previously found in a study in Burkina Faso and Nigeria [2,15,16,20]. The good socio-economic status of a minority of the inhabitants of the DRC could be a possible explanation for our finding [21]. This trend was also observed in a systematic review by Black and in many other studies [2,4,13,19]. Our study also found 1.5% (95%CI [0%; 2%]) of obese women in rural areas versus 9.8% (95%CI [8%; 11%]) in urban areas. This result is different from that found in Nigeria in 2018 by Akeresola., *et al*. [2]. 25.9% (95%CI [11%; 39%]) in urban areas. In Pakistan Uzma in 2019, found 10.6% of women of reproductive age in rural areas [22]. The difference in prevalence could be attributed to the nutritional transition, thesocio-cultural values that value weight. Also, a better understanding of socio-cultural factors is essential for the implementation of effective prevention policies; based on public information about the real dangers of obesity [23-25]. Obesity is recognized as a consequence of high wealth index, affluent life people[26]. It is well known that increasing rates of obese women are found in much more civilized areas although the trend is beginning to reverse [9,25].

Determinants of obesity

Taking household size as a demographic factor, household size > 4, underweight was not significant at 1.5% (95%CI [81%; 119%], p-value = 0.884). The argument would be the lack of adequate nutrition in terms of quantity and quality for these households. This result is similar to that found by Ferede., *et al*. [13] in 2017, in Ethiopia 1.1% (95%CI [68%; 180%], p-value > 0.05), and by Muteba in 2014 (DRC) in Kinshasa who found that the size of households did not show a significant difference in both the well-to-do and poor neighborhoods, they refer either to the apparent size (restricted family) or to the actual size of the household (extended family). Socio-economic factors associated with being underweight are numerous [27,28]. Underweight decreased significantly when moving from very wealthy households 71.1% (95% CI [19%; 43%], p value < 0.001) to wealthy households 27.7% (95% CI [52% ;98%], p-value = 0.016). Indeed, due to the lack of financial means, it is probably difficult for women from the lowest socio-economic levels to have a rich and diversified diet, covering their need for essential micronutrients, which exposes them to greater risk. Underweight [8,13,22,29]. In the context of the DRC, the diet of these women is for the most part made up of cereals, therefore not diversified [30]. The study by Ferede., *et al*. [13]. in Ethiopia in 2017 found the same observation. Akeresola., *et al*. [2] in Nigeria in 2018 also came to the same conclusion. The higher level of education of husbands was not significant 23.3% (95%CI [57%; 102%], p value = 0.072), this result is contrary to that of Adebowale., *et al*. [16,20]. in Burkina Faso and DRC in 2015 which showed that the level of education of husbands was significant. We found 15.4% of uneducated women. Emphasizing the education of women, with a view to improving their knowledge of a rich and diversified diet would help to prevent underweight; this can be done through awareness and information campaigns. Lower levels of education have also been identified as predisposing factors for underweight in Bangladesh [7,13,27]. Access to the media (television, radio or newspapers and religious teachings) was not significant 5.2% (95%CI [78%; 114%], p value = 0.582). This could be explained by the weak nationwide awareness campaigns on malnutrition and the different eating habits to adopt. Akeresola in 2018 in Nigeria, Ferede in 2017 in Ethiopia, Moshe in 2015 in Bangladesh, also reported a low risk of being underweight for women exposed to the media [2,13,20,27,31]. Regarding health characteristics; exposure to disease risk is associated with the occurrence of malnutrition [5,8]. The presence of a source of drinking water was statistically non-significant 5.5% (95% CI [97%; 114%], p value = 0.177); on the other hand, Ferede., *et al*. [13] in Ethiopia in 2017 found a statistically significant association between the source of drinking water and underweight, i.e. 2% (95% CI [135%; 310%], p value < 0.05). Thus, the development of drinking water sources is one of the solutions to reduce parasitic infections and diarrheal diseases which are an integral part of the determinants of malnutrition [5,8,21].

The age variable is cited as factors that may explain obesity. Our study found a significant association with a risk of beingobese multiplied by 2.4%(95% CI [192%; 317%], p value = 0.000). In contrast, Ramesh in 2009 in India found 26% for the 35-49 age group of women of childbearing age [20]. The results of the EDS/DRC 2014 showed that the proportion of women with obesity increased with age to 5% [1,12,32]. This would be explained by the social position of women in the DRC remains worrying because of socio-cultural constraints [1]. Our results showed a non-significant association of smoking with a reduced risk of 40.7% (95% CI [7%; 479%], p value = 0.624). Unlike Clair C. in 2011 in Switzerland,who found that tobaccois the most important associated behavioral cardiometabolic risk factor andto avoid smoking-related weight fluctuations is probably to never start smoking, they concluded.. Our results could be explained by the failure to take into account the influence of other risk factors related to lifestyle such as alcohol consumption and physical inactivity in our study.

The socio-economic factors associated with obesity are numerous. Regarding the wealth index, obesity dropped significantly when moving from poor households (1.3%) to rich households (5.7%). Gewa., *et al*. [33], in Mali in 2013 found the same observation.In the United States in 2000,there was a significant socio-economic gradient: 14% obese in the general population versus 24% in the low-income population[8]. Our findings can be attributed to the nutritional transition that has resulted in a dietary transition from traditional diets to processed foods high in energy, fat, sugar and sugary drinks in the DRC [1]. Arzel., *et al*. [8], in 2005 in Geneva, found among women with secondary education 3.5% obese against 19% among those with limited education at primary level. Emphasizing the education of women, in order to improve their knowledge of a balanced diet in the fight against obesity, is necessary. Lower levels of education were also identified as factors predisposing to obesity in a review by Marie Ng., *et al*. [2,17,19], in 2014. Additional studies are possible to investigate the association between obesity and education in the DRC, it would be interesting to promote income-generating activities, recreation time in the workplace to move around, in order to to improve the level of production for these women.

Spatial distribution

The spatial distribution of obesity shows thatMoran's statistic is -0.142 (p = 0.217), the spatial pattern of obesity is random. This indicates that the spatial pattern of obesity in the study area is neither scattered nor clustered its occurrence might not be due to the underlying causesin 3 provinces: Tshopo, Lomami, North Kivu. We have an absence of spatial autocorrelation, which reflects a disparity in obesity. Provinces tend to behave differently. This result is similar to that found by Akeresola., *et al*. [2] in Nigeria in 2018, Marie Ng., *et al*. [19], Lancet 2014. Our results could be explained by the fact that staple foods in most territories of these three provinces are generally made up of tubers including potatoes, yams, sweet potatoes accompanied by meat, fish, vegetables, legumes such as beans, peas, peanuts [34]. The presence of armed groups operating in these places and the limited access to agro-pastoral areas would contribute to this situation. These conflicts cause pendular displacements of the population because they are forced to abandon their livelihood zones and strongly affect access to basic social goods and services to resort to industrial agriculture and humanitarian donations [5,34]. Our results are contrary to Tobler's law (2004) [32]. This refers to multisectorality to combat this problem in the long term. The global Gertis index shows an absence of spatial dependence in two hotspot provinces: Tshopo and North Kivu.Indeed, these provinces record good rainfall, which facilitates good agricultural yields and therefore good availability of food products.TheKulldorff's statistic shows the absence of important clusters, but only oneaggregate with p-value, not significant (p = 0.237) calculated from Monte Carlo simulationsproving that Obesity is not a clustered phenomenon. This observation is the same as that found byAkeresola., *et al*. [2] in 2018 in Nigeria. Our observation could find its explanation in the failure to take into account other elements such asfamily history of obesity and other genetic factors over time, second, the low number of cases observed (n = 242) after the data is aggregated.

Study limit

Our study was carried out using secondary data from a cross-sectional survey which is the DHS. Therefore, we can only establish an association between the geographical variation in the occurrence of malnutrition among women of childbearing age in the DRC and the different explanatory variables, but not make a causal attribution to the different factors used. The cross-sectional nature of the study makes it impossible to establish temporal associations between the observed relationships. The data from this survey are essentially based on declarative answers which strongly depend on the sincerity of the respondents. Then, the variables related to food security (consumption, behavior and eating habits), family history of obesity and other genetic factors were not collected during the survey; therefore we were unable to assess the feeding practices that could be linked to the occurrence of overnutrition. The spatial analysis was done with a raw dependent variable, therefore an unadjusted spatial distribution, which means that the dependent variable can be influenced by the spatial variability of the determinants. Notwithstanding these limitations, our results are nationally representative. We believe that selection bias probably did not affect our results due to the high response rates during collection which was 99%. However, the methodology and the quality of the data allowed us to obtain fairly reliable information on the suggestion of etiological hypotheses on malnutrition. These results will contribute to a better understanding of the determinants of the occurrence of malnutrition and to the implementation of promising strategies to strengthen nutrition programs in the DRC.

Conclusion

The present study allowed us to find a prevalence ofobesity of 4% with 9.8% in urban areas against 1.5% in rural areas.Obesity is influenced by several socio-economic and demographic factors, and this, independently of other factors, is:age, wealth index, access to

drinking water supply and level of education of husbands. Finally, the study confirms the non-existence of spatial correlation. Overnutrition among women of childbearing age is a clustered phenomenon with a random spatial pattern in the DRC. Through these results, the fight against overnutrition is multisectoral and cannot be the sole concern of the health sector. This is why we recommend that the Congolese government increase, in the implementation of programs targeting provinces at risk, coordinated prevention strategies aimed at developing educational programs to change cultural perceptions associated with overnutrition among women of to procreate.

Author Contributions

Study design and tools: ANK, PM, analysis and interpretation: ANK, NM, MA,Hand written EMS, AMT: all. All authors have read.

Ethical Approval and Consent to Participate

Ethical approval was obtained from the DHS website (https://dhsprogram.com) who was the lead partner who conducted the survey and after approval was given at our request by Bridgette Wellington Data Archivist. All participants provided written informed consent before participating.

Competing Interests

The authors declare that they have no competing interests.

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