



# Journal of Nursing

Revista de Enfermagem

UFPE On Line

ISSN: 1981-8963

## ORIGINAL ARTICLE

### ARTIFICIAL NEURAL NETWORK AND THE DECISION SUPPORT IN NUTRITIONAL FOOD SAFETY MODEL

#### REDE NEURAL ARTIFICIAL E O MODELO DE APOIO À DECISÃO EM SEGURANÇA ALIMENTAR NUTRICIONAL

#### REDE NEURONAL ARTIFICIAL Y EL MODEL DE APOYO DE DECISIONES EN SEGURIDAD ALIMENTARIA NUTRICIONAL

Cleyton César Souto Silva<sup>1</sup>, Rodrigo Pinheiro de Toledo Vianna<sup>2</sup>, Ronei Marcos de Moraes<sup>3</sup>, Sérgio Ribeiro dos Santos<sup>4</sup>, Gracielle Malheiro dos Santos<sup>5</sup>

#### ABSTRACT

**Objective:** to create an artificial neural network for decision support in nutritional food security. **Method:** observational and cross-sectional study, population-based, whose sample unit was 287 families who live in São José dos Ramos, in the state of Paraíba, taken from the research database published in 2008 and defined by stratified random sampling; the city was divided into two sections: urban and rural areas. The research project was approved by the Ethics and Research Committee of the CCS / UFPB in its 53<sup>rd</sup> regular meeting. **Results:** the generated artificial neural network has achieved 81% of hits in deciding on food security and food insecurity x 80.2% in the decision to mild-moderate food insecurity x severe insecurity for São José dos Ramos; Nova Floresta have obtained 80.7% of hits in deciding on food security and food insecurity x 80.4% in the decision to mild-moderate food insecurity x severe insecurity. **Conclusion:** this model demonstrated to assist in making decisions on nutritional food security. **Descriptors:** Food Security and Nutrition; Artificial Neural Networks; Techniques of Decision Support.

#### RESUMO

**Objetivo:** criar uma rede neural artificial para o apoio à decisão em segurança alimentar nutricional. **Método:** estudo observacional, transversal, de base populacional, cuja unidade amostral foi de 287 famílias residentes em São José dos Ramos, no interior do estado da Paraíba, retirados do banco de dados da pesquisa publicada em 2008 e definidas por amostragem aleatória estratificada, em que o município foi dividido em dois estratos: área urbana e área rural. O projeto de pesquisa teve a aprovação do Comitê de Ética e Pesquisa do CCS/UFPB na sua 53<sup>ª</sup> reunião ordinária. **Resultados:** a rede neural artificial gerada obteve 81% de acertos na decisão sobre segurança alimentar x insegurança alimentar e 80,2% na decisão de insegurança alimentar leve-moderada x insegurança grave para São José dos Ramos; Nova Floresta obteve 80,7% de acertos na decisão sobre segurança alimentar x insegurança alimentar e 80,4% na decisão de insegurança alimentar leve-moderada x insegurança grave. **Conclusão:** este modelo demonstrou auxiliar na tomada de decisões em segurança alimentar nutricional. **Descritores:** Segurança Alimentar e Nutricional; Redes Neurais Artificiais; Técnicas de Apoio para a Decisão.

#### RESUMEN

**Objetivo:** Crear una red neuronal artificial para apoyar las decisiones en la seguridad alimentaria nutricional. **Método:** estudio observacional y transversal, de base poblacional, la unidad muestra de 287 familias que viven en São José dos Ramos, en el estado de Paraíba, tomada de la base de datos de investigación publicado en 2008 y se define mediante un muestreo aleatorio estratificado en que la ciudad se dividió en dos estratos: zonas urbanas y rurales. El proyecto de investigación fue aprobado por el Comité de Ética e Investigación de la CCS/UFPB en su 53<sup>ª</sup> reunión ordinaria. **Resultados:** la red neuronal artificial generada alcanzó 81% de aciertos en la decisión sobre la seguridad alimentaria y la inseguridad alimentaria x 80,2% en la decisión de la inseguridad alimentaria leve-moderada x incertidumbre grave para São José dos Ramos; Nova Floresta obtuvo el 80,7% de respuestas correctas en la decisión sobre la seguridad alimentaria y la inseguridad alimentaria x 80,4% en la decisión de la inseguridad alimentaria leve-moderada x grave inseguridad. **Conclusión:** Este modelo demostró ayudar en la toma de decisiones sobre la seguridad alimentaria nutricional. **Descritores:** Seguridad Alimentaria Y Nutrición; Redes Neuronales Artificiales; Técnicas De Soporte de Decisiones.

<sup>1</sup>Nurse, Master in Decision Models in Health, Universidade Federal da Paraíba/UFPB. João Pessoa (PB), Brazil. E-mail: [csoutosilva@outlook.com](mailto:csoutosilva@outlook.com); <sup>2</sup>Food Engineer, Post-PhD, Health Sciences Center. Department of Nutrition, Universidade Federal da Paraíba/UFPB. João Pessoa (PB), Brazil. E-mail: [vianna\\_rodrigo@yahoo.com.br](mailto:vianna_rodrigo@yahoo.com.br); <sup>3</sup>Electrical Engineer, Post-PhD in Engineering, Center of Exact Sciences and Nature, Department of Statistics, Universidade Federal da Paraíba/UFPB. João Pessoa (PB), Brazil. E-mail: [ronei@de.ufpb.br](mailto:ronei@de.ufpb.br); <sup>4</sup>Nurse, PhD Professor in Sociology, Health Sciences Center / Graduate Program in Decision Model in Health, Universidade Federal da Paraíba/UFPB. João Pessoa (PB), Brazil. E-mail: [srsantos207@gmail.com](mailto:srsantos207@gmail.com); <sup>5</sup>Nutritionist, Master in Public Health, Universidade Estadual da Paraíba/UEPB. Campina Grande (PB), Brazil. E-mail: [granut@gmail.com](mailto:granut@gmail.com)

## INTRODUCTION

The concept of nutritional food security (NFS) involves interdisciplinary issues of access to quality food; decision support models; sustainable production practices; citizenship; good eating habits; cultural, social and economic diversity; and human rights. Food insecurity (FI) exists when the availability of nutritionally adequate and safe foods or the ability to acquire them in a socially acceptable way is limited or uncertain.<sup>1-5</sup>

The lack of food and hunger are generally found to be more prevalent in poor countries than in rich countries. Studies in developed countries have shown that in the last 12 years the prevalence of FI varies between 4 and 14% in representative samples of the population and up to 82% among disadvantaged groups such as ethnic minorities and mono-parental families.<sup>6-8</sup>

Data on the prevalence of FI in Brazil were limited; most estimates based only on indirect indicators of the process, such as income, nutritional status of the population and household food availability. With the design of the Brazilian Food Insecurity Scale (BFIS), a way to evaluate the situation of family FI including both people's perception of other issues on access and availability of household food, filling the gaps left by other methods.<sup>9-10</sup>

The hunger relief organizations and governments need to create a viable and effective system for political decision-making, establishing which interventions are needed to improve the condition of their populations. To do this, finding the prevalence of FI is a great importance for the assessment of living conditions and hence to the planning of public policies to fight hunger. It is timely and relevant to create indicators that can verify from the right of access to food to the concrete conditions of access and its ultimate consequences in the health and nutrition of individuals and collectivities.<sup>11-3</sup>

Artificial neural networks (ANN) are designed to perform complex tasks with a mathematical modeling strategy of problems with ability to learn through real examples, recognizing situations similar to those used in training.<sup>14</sup> A decision model of this type is characterized by the standard its connections between neurons (called architecture), the method of determining the weights of the connections (called training or learning, algorithm) and its function of activation.<sup>15-6</sup>

Sectional study evaluated the NFS situation of households in the state of Paraíba, more specifically in 14 municipalities identified as

the poorest of semi-arid of Paraíba. The result was a serious insecurity level that ranged between 5.4% and 22.8%, identifying São José dos Ramos as the municipality that has the lowest FS (30.2%) and the most serious food insecurity index (22, 8%).<sup>9,11</sup>

By using the same database of this research with information on the characterization of these families and factors on food access limitation, another study created a neural network model to support decision-making using such data as information, obtaining 99.4 % accuracy in differentiating between food security and insecurity and 83.3% accuracy for unsafe levels of families.<sup>17</sup>

The Health has been increasingly using tools and computer technologies to provide the precision and success in decision making, therefore, the present study aims to:

- Create an artificial neural network for decision support in nutritional food security.

## METHODOLOGY

This article was elaborated from the thesis "Artificial Neural Network: A model of decision support in food security for interior municipalities of Paraíba", presented to the Graduate Program in Decision Models and Health, of the Center for Exact and Nature Sciences, Universidade Federal da Paraíba/UFPB, João Pessoa/PB, Brazil, 2012.

This is an observational, cross-sectional and population-based study, whose sample unit was 287 families who live in São José dos Ramos, in the state of Paraíba, taken from the research database published in 2008<sup>11</sup> and defined by stratified random sampling; the city was divided into two sections: urban and rural areas.

Families were classified with EBIA<sup>18</sup>:

- Nutritional food security situation;
- Mild food insecurity (MFI): fear of hunger in the future, reflecting the psychological component and the problem of family food quality;
- Moderate food insecurity (MFI): restriction on the amount of food in the family;
- Severe food insecurity (SFI): hunger among adults and/or children in the family.

For creation of decision support model, data were grouped as mild-moderate food insecurity (MMFI) and severe food insecurity (SFI), also being able to distinguish the NFS. We selected 10 variables of socioeconomic importance as input data for ANN through the Matrix Laboratory software (MATLAB):

- Number of rooms in the house;
- Number of rooms in the house used to sleep;

- Total of household members;
- Education in years of the family head;
- Number of children and adolescents attending at school;
- Number of children;
- Number of adolescents;
- Number of Adults;
- Senior Quantity;
- The relationship between workers and the unemployed.

The MATLAB, software developed by The MathWorks, Inc., is an interactive system and technical and scientific programming language based on a matrix, where problems and solutions are expressed in mathematical language.<sup>19</sup>

To create ANN, the following steps were performed: definition of standards, network initialization, and setting of training parameters, network training and testing of the network. The choice of optimal neural network model is an exhaustive procedure of trial and error. To this end, it was defined the multilayer network architecture “feedforward” (1 input layer, one hidden layer and one output layer) with backpropagation algorithm, ideal for standards of recognition of problems.

This algorithm is a supervised learning method that works covering the error function at the network output, looking for a minimum point, and acting as the predictive variables are processed by ANN presenting the answer in the output layer predicted by the network and, then, comparing it to the genuine value. If the difference between the predicted value and the actual one is greater than given error, the network recalculates the process by changing the weighting for each neuron, adjusting it to minimize the forecast errors within the range test. Based on that error between observed and estimated, weights are adjusted to obtain a minimal error, which can only be applied to the output layer, for it is assumed that the output desired value is known.<sup>14,20-3</sup>

This type of architecture used in MATLAB automatically sets the weights and biases and assigns processing functions for the inputs and outputs of the network, the *removeconstantrowse* function, which removes the constant input and output data, and the *mapminmax* function that normalizes the data in a range [1 -1]. This function is

especially useful when the values of the input and output variables are very uneven, i.e., has a high variance, which makes the learning on network difficult.<sup>19</sup>

The number of neurons in the hidden layer were defined, which were determined through simulations ranging between 10 and 30 neurons, followed by transfer and training functions, and the propagation gradient Scaled Conjugate Gradient (trainscg). Hidden layers of a multilayer network act in order to find the best architecture or group of networks that acquire the best learning capabilities. The hidden neurons play a crucial role because they act as information when characterizing the detectors training data, performing a nonlinear transformation of the input data.<sup>19,20,24-5</sup>

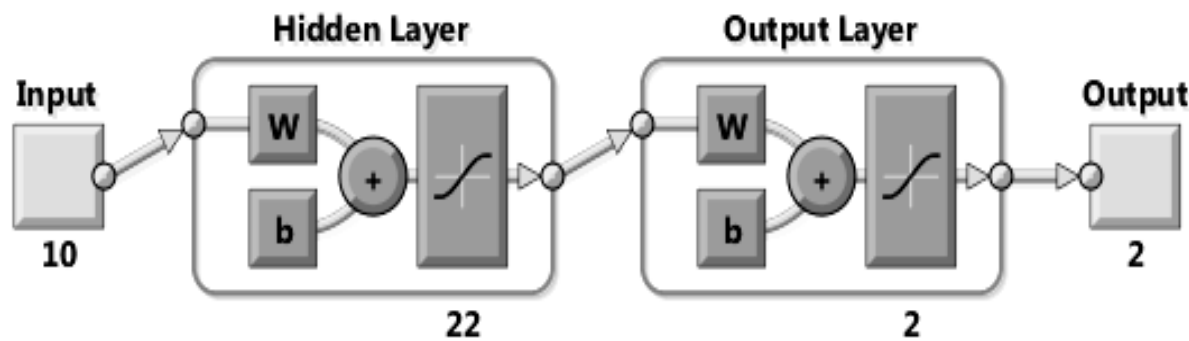
There are several functions transfers and training, however, those which showed the highest coefficient of correlation and lower root mean square error, and is consequently more appropriate and faster, are the sigmoid tangent (tansig) and the Levenberg-Marquardt (trainlm) used in this model. The network was trained by batch mode where all inputs are applied to network before the weights are updated, defined by dividerand function, which divides the data randomly into three subsets with 70%, 15% and 15%, respectively, training, validation and test.<sup>19</sup>

The survey conducted in 2005, which belongs to the database of this research, was approved by the Research Ethics Committee of the Health Sciences Center and obeyed all ethical and legal aspects of a study involving human subjects. Respondents received and signed a free and informed consent in accordance with Resolution No. 196/96, demonstrating to understand the research objectives and agreeing to the participation in it.

RESULTS

The data were transferred from the database on Microsoft Access 2007 to MATLAB, where the socioeconomic and demographic variables were used as input and data on household food security as targets (target), the actual information obtained from the EBIA. It was created an RNA model with one input layer with 10 inputs, one hidden layer of 22 neurons, and one output layer with 2 neurons and 2 outputs (outputs) (Figure 1).

FIGURE 1: Representation of new Neural Network created in MATLAB. João Pessoa, 2012.



In search of the best results, the model was divided into two decisions: the first decision classifies families in nutritional food security or food insecurity; and the second one classifies families in mild-moderate insecurity (MMFI) or severe insecurity (SFI).

Turning the ANN model with data from the city of São José dos Ramos, the results were

presented in confusion matrix with the percentage of trial and error: the decision between the situations of NFS x FI model hit 81% (Figure 2 ), while in the decision between MMFI x SFI were 80.2% correct (FIGURE 3).

| Cross-Validation Matrix |       |       |
|-------------------------|-------|-------|
| 44                      | 16    | 73,3% |
| 35                      | 173   | 83,2% |
| 55,7%                   | 91,5% | 81%   |

Figure 2. Cross-Validation Matrix NFS x FI in São José dos Ramos. João Pessoa, 2012.

| Cross-Validation Matrix |       |       |
|-------------------------|-------|-------|
| 204                     | 49    | 80,6% |
| 4                       | 1     | 73,3% |
| 98,1%                   | 18,3% | 80,2% |

Figure 3. Cross-Validation Matrix MMFI x SFI in São José dos Ramos. João Pessoa, 2012.

The same model with 10 variables and with the same parameters of architecture and processing were used to run the ANN with information on the city Nova Floresta. The

results obtained in the model for it show hits in decisions between situations NFS x FI (80.7% accuracy) (Figure 4) and 80.4% correct in deciding MMFI x SFI (Figure 5).

| Cross-Validation Matrix |       |       |
|-------------------------|-------|-------|
| 207                     | 46    | 81,8% |
| 13                      | 40    | 75,5% |
| 94,1%                   | 46,5% | 80,7% |

Figure 4. Cross-Validation Matrix NFS x FI in Nova Floresta. João Pessoa, 2012.

| Cross-Validation Matrix |       |       |
|-------------------------|-------|-------|
| 207                     | 46    | 81,8% |
| 13                      | 40    | 75,5% |
| 94,1%                   | 46,5% | 80,7% |

Figure 5. New Cross-Validation Matrix MMFI x SFI in Nova Floresta. João Pessoa, 2012.

DISCUSSION

Studies which involve neural networks have been conducted with prediction and classification purposes as an alternative to traditional statistical models. Its use has helped the medicine, for example, at the intersection of patient’s data with similar clinical problems, doctors’ requirements are more appropriate; in the financial system it is used to contain fraud in the credit card system. It is also used for climate applications.<sup>22,26</sup>

It’s been emerging in the area of nutrition the use of ANN to predict the number of meals in university restaurants, through learning by backpropagation, achieving a 90.5% hit rate in the decisions, replacing a subjective way, a little appropriate, or the simple arithmetic mean method.<sup>14</sup> During another study there was the monitoring of food intake behavior, by chewing and swallowing sounds of patient, using for this a feedforward neural network with detection algorithm. The results of the network were 72% of hits for the detection of food intake activity.<sup>27</sup>

After preprocessing described in the methods and numerous simulations, we had the decision support model of this work, with the best parameters that allowed to minimize the mean square error through an exhaustive trial of error procedure, reaching the goal of creation of an artificial neural network of decision support to food security through socioeconomic and demographic variables such as numbers of rooms in the house; number of rooms in the house used to sleep; Total of family members; schooling in years of the family head; number of children and adolescents attending at school; number of children; amount of adolescents; amount of adults; number of elderly and relationship between workers and the unemployed. When comparing with these studies submitted and to the literature, we found that the percentage of correct answers was the average of successful experiences.

It is important to note the information on the number of children and adolescents at school to build a model to predict the FI because the school is a potential agent of change in the family and in the community where they are inserted. The school environment is considered a strategic space for food education actions because children learn the food characteristics not only from their experiences, but also by observation and imitating their parents, teachers and classmates, for the great time spent by these students at school, which offers one or two meals for five days a week. The Ministry of

Health also considers that nutrition education must be taught in early age with little aged children.<sup>29,30</sup>

The relationship workers and unemployed is also a strong variable to predict the FI of families. According to the survey, mothers with food insecurity problems report that the situation worsens when there is not a job for, consequently, the income is limited. In addition, when schools are on vacation these mothers feel themselves helpless for not having certain types of foods at home. On the other hand, even with the presence of women at home and their activities are more focused on the house management, the family group without income are more concerned about the lack of food items.<sup>29</sup>

The importance of knowing the family constitution is due to the association to food insecurity, beyond economic issues to ensure proper and acceptable access to food, there are also environmental factors related to housing and access to care services; social and inherent educational training, social support, sociability etc.; politicians on the availability of care and attention differentiated, are guarantees of state, etc., and individual related to biological characteristics for each stage of life and emotional in the construction of beings.<sup>30</sup>

CONCLUSION

This study achieved its goal of creating a model of artificial neural network to support decision-making on food and nutrition security for the city of São José dos Ramos, in Paraíba. However, NFS should be understood beyond the biological dimensions of simple adaptation of the daily nutrient requirements for maintenance of survival. Admittedly, the definition is the guarantee of quality basic food, obtained permanently, but it is necessary to promote critical and scientific thinking for individuals able to observe their own life in perspective and then to make decisions.

The NNA multilayer with supervised training of backpropagation type have been applied satisfactorily in health when compared with other methods, it should be perhaps the only consensus among jobs using neural networks as models for prediction of nonlinear series or recognition standards.

Limitations of this study were based on the drawbacks of the application of ANN practice: first, creating a network is not easy and this requires a good understanding of theory and application. Secondly, there is the need to use sophisticated computer software that are not always available for free and are not easy to handle. Third, without any etiological

interpretation of the weights calculated on the network, we cannot determine a mathematical relationship between the actual values (targets) and the input variables (inputs); many literatures define the processing that occurs in hidden layers as a "black box".

Even with these limitations, this study has, however, exploited the problem in the novelty search. The relevance of this research is the use of an ANN model for decision support on FI at the local level, i.e. in municipalities in the state, using for its construction the socioeconomic and demographic data that are easy to obtain for the primary sources or secondary sources of existing banks and made available by various organs and systems in the country. This kind of work leads managers to use the results to support decisions to be made.

The study also allowed to give more visibility to the issue of FI at the municipal level, it is important for the planning and implementation of local public policies. Nowadays, the representative studies are conducted at the state level, not considering the social and economic discrepancies that there are from city to city. It is intended, therefore, to apply this model of decision support to other cities in the state of Paraíba, generating parameters for evaluation among the different municipalities.

## REFERENCES

1. Kepple AW, Segall-Correa AM. Conceituando e medindo segurança alimentar e nutricional. Ciênc saúde coletiva [Internet]. 2011 [cited 2014 Feb 14];16(1):187-99. Available from: <http://www.scielo.br/pdf/csc/v16n1/v16n1a22.pdf>
2. Silva CCS, Oliveira KBB, Alves AS, Neves JÁ, Modesto CAC, Vianna RPT. Associação entre consumo alimentar e (in)segurança alimentar e nutricional em São José dos Ramos - PB. Braz j food technol. 2012 [cited 2014 Feb 14];15(suppl.1):23-30. Available from: [http://www.scielo.br/pdf/bjft/v15nspe/aop\\_15e0105.pdf](http://www.scielo.br/pdf/bjft/v15nspe/aop_15e0105.pdf)
3. Miller CL et al. Food Insecurity and Sexual Risk in an HIV Endemic Community in Uganda. AIDS Behav [Internet]. 2011 [cited 2014 Feb 14];15(7):1512-19. Available from: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3110536/>
4. Willows N, Veugelers P, Raine K, Kuhle S. Associations between household food insecurity and health outcomes in the Aboriginal population (excluding reserves). Statistics Canada. 2011 [cited 2014 Feb 14];22(2):1-6. Available from: <http://www.statcan.gc.ca/pub/82-003-x/2011002/article/11435-eng.htm>
5. Perez-Escamilla R, Vianna RPT. Food Insecurity and the Behavioral and Intellectual Development of Children: A Review of the Evidence. Journal of Applied Research on Children: Informing Policy for Children at Risk. [Internet] 2012 [cited 2012 Dec 18];3(1). Available from: <http://digitalcommons.library.tmc.edu/childrenatrisk/vol3/iss1/9>
6. Ransey R, Giskes K, Turrell G, Gallegos D. Food insecurity among adults residing in disadvantaged urban areas: potential health and dietary consequences. Public health nutr [Internet]. 2011 [cited 2014 Feb 14];15(2):237-37. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/21899791>
7. El-Sayed AM, Hadley C, Tessema F, Tegegn A, Cowan JA, Galea S. Household food insecurity and symptoms of neurologic disorder in Ethiopia: An observational analysis. BMC public health (Online). 2010 [cited 2014 Feb 14];10:80-2. Available from: <http://www.biomedcentral.com/1471-2458/10/802>
8. Strike C, Rudzinski K, Patterson J, Millson M. Frequent food insecurity among injection drug users: correlates and concerns. BMC public health [Internet]. 2012 [cited 2014 Feb 14];12:155-8. Available from: <http://www.biomedcentral.com/1471-2458/12/1058>
9. Gubert MB, Benício MHA, Santos LMP. Estimativas da insegurança alimentar grave nos municípios brasileiros. Cad saúde pública [Internet]. 2010 [cited 2014 Feb 14];26(8):1595-605. Available from: <http://www.scielo.br/pdf/csp/v26n8/13.pdf>
10. Black MM. Protect Children From Household Food Insecurity: Promote Access To Food and Stress-Alleviating Resources. Journal of Applied Research on Children: Informing Policy for Children at Risk. [Internet]. 2012 [cited 2013 Dez 18];3(1):[about 5 p.]. Available from: <http://digitalcommons.library.tmc.edu/childrenatrisk/vol3/iss1/18>
11. Vianna RPT, Segall-Corrêa AM. Insegurança alimentar das famílias residentes em municípios do interior do Estado da Paraíba, Brasil. Rev nutr [Internet]. 2008 [cited 2014 Feb 14];21(Suppl):111-22. Available from: <http://www.scielo.br/pdf/rn/v21s0/10.pdf>
12. Oliveira JS et al. Anemia, hipovitaminose A e insegurança alimentar em crianças de municípios de Baixo Índice de Desenvolvimento Humano do Nordeste do

Brasil. Rev bras epidemiol. 2010 [cited 2014 fev 14];13(4):651-64. Available from: <http://www.scielo.org/pdf/rbepid/v13n4/10.pdf>

13. Correia MJFS, Rocha AMCN. A importância dos fatores estruturais na garantia da segurança alimentar na produção de refeições para escolares. DEMETRA: Alimentação, Nutrição & Saúde [Internet]. 2012 [cited 2014 Feb 14];7(1):39-46. Available from: <http://www.e-publicacoes.uerj.br/index.php/demetra/article/view/3277/2274#.UxtZjD2wKSg>

14. Rocha JC, Matos FD, Frei F. Utilização de redes neurais artificiais para a determinação do número de refeições diárias de um restaurante universitário. Rev nutr [Internet]. 2011 [cited 2014 Feb 14];24(5):735-42. Available from: <http://www.scielo.br/pdf/rn/v24n5/a07v24n5.pdf>

15. Cunha GB, Luitgards-Moura JF, Naves ELM, Andrade AO, Pereira AA, Milagre ST. A utilização de uma rede neural artificial para previsão da incidência da malária no Município de Cantá, Estado de Roraima. Rev Soc Bras Med Trop [Internet]. 2010 [cited 2014 Feb 14];43(5): 567-70. Available from: <http://www.scielo.br/pdf/rsbmt/v43n5/v43n5a19.pdf>

16. Borges J, Affonso C, Sassi RJ, Cristi Junior JL. Desenvolvimento de um modelo *neurofuzzy* de rede Neural artificial para aplicação em processamento de materiais poliméricos. Rev Iberoameric Eng Ind [Internet]. 2011 [cited 2014 Feb 14];1(1):62-79. Available from: <http://periodicos.incubadora.ufsc.br/index.php/IJIE/article/view/672/pdf>

17. Silva CCS, Vianna RPT, Moraes RM. Sistema de apoio a decisão: a segurança alimentar e o modelo em rede neural. Rev bras ciênc saúde. 2012 [cited 2014 Feb 12];16(1):79-84.

18. Segall-Corrêa AM, Marin-Leon L, Helito H, Pérez-Escamilla R, Santos LMP, Paes-Sousa R. Transferência de renda e segurança alimentar no Brasil: análise dos dados nacionais. Rev nutr [Internet]. 2008 [cited 2014 Jan 14];21(Suppl):39-51. Available from: <http://www.scielo.br/pdf/rn/v21s0/05.pdf>

19. Beale MH, Hagan MT, Demuth HB. Neural Network Toolbox: User's Guide R2012. MathWorks, Inc. 2012.

20. Haykin S. Redes neurais: princípios e prática. 2nd ed. Porto Alegre: Bookman; 2001.

21. Bressan AA. Tomada de decisão em futuros agropecuários com modelos de previsão de séries temporais. RAE-eletrônica [Internet]. 2004 [cited 2013 Dec 18];3(1):1-20. Available from:

<http://www.scielo.br/pdf/raeel/v3n1/v3n1a04>

22. Moraes LG. Uma abordagem alternativa de behavioral scoring usando modelagem híbrida de dois estágios com regressão logística e redes neurais [Dissertação]. Porto Alegre: Universidade Federal do Rio Grande do Sul; 2012.

23. Pasquotto JLD. Previsão de séries temporais no varejo brasileiro: uma investigação comparativa da aplicação de redes neurais recorrentes de Elman [Dissertação]. São Paulo: Universidade de São Paulo; 2010.

24. Russel S, Norving P. Inteligência Artificial: tradução da segunda edição. Rio de Janeiro: Elsevier, 2004.

25. Torres JR, Rubião G, Machado MAS, Souza RC. Previsão de séries temporais de falhas em Manutenção industrial usando redes neurais. Engevista [Internet]. 2007 [cited 2014 Feb 14];7(2):4-18. Available from: [http://www.uff.br/engevista/2\\_7Engevista03.pdf](http://www.uff.br/engevista/2_7Engevista03.pdf)

26. Marangoni PH. Redes Neurais Artificiais para Previsão de Séries Temporais no Mercado Acionário [Dissertação]. Florianópolis: Universidade Federal de Santa Catarina, 2010. Available from: <http://tcc.bu.ufsc.br/Economia292751>

27. Pabler S, Fischer WJ. Food Intake Activity Detection Using an Artificial Neural Network. Biomed Tech (Berl) [Internet]. 2012 [cited 2014 Jan 14];57(Suppl.1):665-8. Available from: <http://www.degruyter.com/view/j/bmte.2012.57.issue-s1-F/bmt-2012-4092/bmt-2012-4092.xml>

28. Paula DV, Botelho LP, Zanirati VF, Lopes ACS, Santos LC. Avaliação nutricional e padrão de consumo alimentar entre crianças beneficiárias e não beneficiárias de programas de transferência de renda, em escola municipal do Município de Belo Horizonte, Estado de Minas Gerais, Brasil, em 2009. Epidemiol serv saúde [Internet]. 2012 [cited 2013 Jan 14];21(3):385-94. Available from: <http://scielo.iec.pa.gov.br/pdf/ess/v21n3/v21n3a04.pdf>

29. Lindsay AC, Ferarro M, Franchello A, Barrera R, Machado MMT, Pfeiffer ME, Peterson KE. Child feeding practices and household food insecurity among low-income mothers in Buenos Aires, Argentina. Ciênc saúde coletiva [Internet]. 2012 [cited 2014 Jan 14];17(3):661-9. Available from: <http://www.scielo.br/pdf/csc/v17n3/v17n3a12.pdf>

30. Azeredo EA, Sá SPC. Educação nutricional com pré-escolares em creche baseado no Pensamento sociointeracionista: relato de experiência. J Nurs UFPE on line [Internet].

Silva CCS, Vianna RPT, Moraes RM de et al.

Artificial neural network and the decision...

2013 [cited 2014 Jan 14];7(esp):7247-53.  
available from:  
[http://www.revista.ufpe.br/revistaenfermagem/index.php/revista/article/view/4581/pdf\\_4355](http://www.revista.ufpe.br/revistaenfermagem/index.php/revista/article/view/4581/pdf_4355)

Submission: 2014/03/14

Accepted: 2014/12/27

Publishing: 2015/03/01

### **Corresponding Address**

Cleyton César Souto Silva  
Rua Coronel Souza Lemos, 307  
Bairro Miramar  
CEP 58043-190 – João Pessoa (PB), Brazil