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Modeling Food Energy in Bioenergetics

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

The measurement of net food energy is in great coup on the helm of designing an apt dieting. The prevailing procedures in this ground are relatively time consuming, laboratory tests induced and often the confusing data contributors while planning a balanced dieting in nutrition counseling. The dietician is often in confusion in planning a perfect dieting to hold up nutritional soundness of the sample at a population in a community. The aim of this current study is to make a dot over these enduring perils exploring a mathematical modeling to be used in an apt dieting in nutrition counseling. The study saga can directs a biophysical modeling to be used in energy balancing in bioenergetics to shirk the frequently of ongoing health horrors in worldwide nutritional epidemiology. The study verdict is the π modeling in biological mathematics in name of determinant of net food energy (DNFE) in nutritional physics on the envelop of a linear equation (16) which can be a superb mathematical modeling as a dieting tool in bioenergetics in worldwide nutritional physics and health statistics.

Keywords: Bioenergetics; energy yielding determinant of the power house; nutritional physics; mathematical modeling; net food energy.

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1. INTRODUCTION

About 2 billion people in the world are suffering from different forms of malnutrition [1]. Malnutrition is the leading causes of stunted growth and increasing mortality and morbidity rates in the world [2-8]. About 4 of each 5 malnourished children in South-East-Asian (SEA) regions contributing about 83% of their deaths due to mild to moderate malnutrition [9-11]. Malnutrition in developing countries is due to poverty, household food insecurity, gender bias, population pressure, food taboos, health, hygiene, nutritional negligence, famine and man-made disasters [12-18]. Malnutrition also occur from intra-family feud, lower class livelihood, child abuse, deprivation of schooling opportunity and consequence of faulty family planning practices in their families [19-22]. These nutritional giants are engulfing the population and therefore initiatives are in need of galore need to avoid these malnutrition facing factors [23-25].

Therefore, this study was conducted to develop an effective dieting tool to help the dietician to plan the proper dieting for both the therapeutic and normal diet aiming to turn tail the ongoing malnutrition headache across the globe and the government and different international and national non government organizations are urged to organize health and nutritional campaigning to aid the population to practice a healthy diet using this study proposed π modeling of food energy in bioenergetics in nutrition counseling.

2. METHODOLOGY AND DATA SOURCES

The study was a cross-sectional study using secondary data analysis method. The data were collected from the biophysical equation of dietary energy, fuel factor of foods, the TEF content and the mass of consuming nutrients in nutrition. The π modeling of equations from mathematics was in application to undergo in analyzing all the data using mathematical modeling to hit upon a chic and time saving biophysical modeling to calculate net food energy needed for individuals in the communities due to consumption of foods aiming at curbing malnourishment maintaining an apt dieting in nutrition counseling.

3. RESULTS

Food energy is the amount of energy released in human body through the digestion and absorption of foods associated in a diet [26-29]. Biophysically, it is the product of fuel factor and mass of consuming nutrients in food science [30-33].

So,

$$E_f = fm; \quad (1)$$

Where,

f = fuel factor of food,
m = mass of food in g and
E_f = food energy in kcal

The human diet comprises three main sources of dietary energy namely carbohydrates, proteins and fats among the six components in the diet and alcohol in lesser degree [34-36].

Let,

The fuel factors of carbohydrates, proteins, fats and alcohol be f_c, f_p, f_f and f_a kcal g^{-1} to be responsible to yield $(E_d)_c$, $(E_d)_p$, $(E_d)_f$ and $(E_d)_a$ kcal of dietary energy for corresponding consumption of m_c, m_p, m_f and m_a g of carbohydrates, proteins, fats and alcohol respectively.

So, considering the equation (1) in the form of carbohydrates, proteins, fats and alcohol consumption,

$$(E_d)_c = f_c\, m_c \quad (2)$$

$$(E_d)_p = f_p\, m_p \quad (3)$$

$$(E_d)_f = f_f\, m_f \quad (4)$$

$$(E_d)_a = f_a\, m_a \quad (5)$$

Adding the equations (2), (3), (4) and (5),

$$(E_d)_c + (E_d)_p + (E_d)_f + (E_d)_a = f_c\, m_c + f_p\, m_p + f_f\, m_f + f_a\, m_a \quad (6)$$

None but carbohydrates, proteins, fats and alcohol are the dietary energy yielders in nutrition [37].

Hence,

$$(E_d)_c + (E_d)_p + (E_d)_f + (E_d)_a = (E_f)_T \quad (7)$$

Where,

$(E_f)_T$ = Total food energy

Putting the value of equation (7) in equation (6),

$$(E_f)_T = f_c\, m_c + f_p\, m_p + f_f\, m_f + f_a\, m_a \quad (8)$$

The fuel factors of carbohydrates, proteins, fats and alcohol representing f_c, f_p, f_f and f_a are 4, 4, 9 and 7 kcal g^{-1} [38-44].

So,

$$f_c = 4 \quad (9)$$

$$f_p = 4 \quad (10)$$

$$f_f = 9 \quad (11)$$

$$f_a = 7 \quad (12)$$

Inserting the value of equations (9), (10), (11) and (12) into equation (8),

$$\begin{aligned}(E_f)_T &= 4m_c + 4\, m_p + 9m_f + 7m_a \\ &= 4m_c + 4\, m_p + 4\, m_f + 5\, m_f + 4\, m_a + 3m_a \\ &= 4m_c + 4\, m_p + 4\, m_f + 4\, m_a + 5\, m_f + 3m_a \\ &= 4\,(m_c + m_p + m_f + m_a) + 5\, m_f + 3m_a \\ &= 4 \sum m_{c,\,p,\,f,\,a} + 5\, m_f + 3m_a \end{aligned} \quad (13)$$

The equation (13) is a meaningful mathematical statement to express the total energy gained through various sources of foods consumption and therefore this biophysical myth is termed as the energy yielding determinant of the power house (EYDPH) in cell biology [81-84].

The net food energy yields in the body can be found considering the TEF content in bioenergetics [45,46] as per the following equation in nutritional mathematics,

$$\begin{aligned}(E_f)_n &= (E_f)_T - \text{TEF} \\ &= (E_f)_T - 10\%\ \text{of}\ (E_f)_T \\ &= (E_f)_T - 0.1(E_f)_T \\ &= 0.9\,(E_f)_T \end{aligned} \quad (14)$$

Where,

$(E_f)_n$ = Net food energy

Inserting the numeric value of π in mathematics in equation (14),

$$\begin{aligned}(E_f)_n &= 0.9 \times 7/22 \times 22/7\ (E_f)_T \\ &= 0.3\,\pi\,(E_f)_T \end{aligned} \quad (15)$$

Putting the value of equation (13) into the equation (15),

$$(E_f)_n = 0.3\,\pi\,(4 \sum m_{c,\,p,\,f,\,a} + 5\, m_f + 3m_a) \quad (16)$$

The equation (16) is applicable in determining the net food energy in nutritional physics and health statistics and so this linear equation could be a bold determinant of net food energy (DNFE) in health science and nutritional physics [47-53].

4. DISCUSSION

Maintenance of complete physical, mental, social and spiritual well-being is the desire for proper health planning in different countries [54-57]. The people are often deprived of their country's constitution named basic health, hygiene, nutritional care and shelter [58-60]. The population is want of balanced diet for frequent occurring dieting malpractices and the dieticians are in search of a time saving and easy method in measuring total dietary energy needed for the observance of healthy population [57] in the community. There are different degree of health and nutritional problems such as concept of mass, dietary energy, fuel factor, TEF content and the information gap between the dietary energy and net dietary energy in nutritional physics. The study proposed determinant of net food energy (DNFE) in bioenergetics can be a solvable bid in overcoming different problems during designing an apt dieting in nutrition counseling [61-64]. The present study result is cut and dried by adding the fuel factor of alcohol along with other energy yielders naming carbohydrates, proteins and fats. The $(E_f)_n$ evaluating method is cut short using the upshot of the study [equation (16)] in name of the determinant of net food energy (DNFE) in nutritional biochemistry. This study proposed determinant of net food energy (DNFE) can be an effective spatial microsimulation modeling [65-68,88-93] to be constructive in designing policies for the governments and NGOs for environmental and spatial effects across different countries [69-72] in the world to aid healthy dieting practices [73-75] for sustaining sound health. This health microsimulation modeling [equation (16)] found from the carried out study can be an effective tool at health pedagogy [76-80,85-87] in nutritional epidemiology for maintaining health status learning the logarithmic biophysical modulator of health status in statistical modeling [81,82].

5. CONCLUSION

Malnutrition is the most common health crisis in the world. The present study results can take a serious turn in evading the malnutrition across the globe. This study rendering determinant of net food energy (DNFE) should be taking into action in designing healthy diet at different

demographic sites in a country. So the health and nutritional think tank should bear the testimony in making awareness on the determinant of net food energy (DNFE) as a part of effective dieting tools in nutrition counseling and health science. Future research should adopt this cozy $(E_f)_n$ measuring modeling to explore a new trend in health pedagogy for taking intervention in policy designing, analysis and checking spatial effects for health and nutritional condition upgrading bid across the globe.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. IFAD/FAO/WFP. The state of food insecurity in the world, In Rome, Italy: FAO; 2011.
2. Megabiaw B, Rahman A. Prevalence and determinants of chronic malnutrition among under-5 children in Ethiopia. Int J Child Health Nut. 2013;2(3):230-236.
3. UN inter-agency group for child mortality estimation. Levels and trends in child mortality: Report, New York: UNICEF; 2011.
4. Hakim MA, Kamruzzaman M. Nutritional status of preschoolers in four selected fisher communities. Am J Life Sci. 2015;3 (4):332-336.
5. Rahman A, Hakim MA. Malnutrition prevalence and health practices of homeless children: A cross-sectional study in Bangladesh. Sci J Public Health. 2016;4 (1-1):10-15.
6. Rahman A, Chowdhury S. Determinants of chronic malnutrition among preschool children in Bangladesh. J Biosoc Sci. 2007;39(2):161-173.
7. Genton B, Al-Yaman F, Ginny M, Taraika J, Alpers MP. Relation of anthropometry to malaria morbidity and immunity in Papua New Guinean. Am J Clin Nutr. 1998;68: 734-41.
8. Beyene F. Pattern and outcome of diseases in medical patients admitted to Asella hospital, South-Eaast Ethiopia. J Public Health Dev Ctries. 2016;2(1):102-108.
9. Rahman A, Hakim MA. An epidemiological study on hygiene practice and malnutrition prevalence of beggars children in Bangladesh. Int J Nutr Diet. 2016;4(1):29-46.
10. UNICEF. Malnutrition in South Asia; A Regional Profile, UNICEF report. 1997;8.
11. Rahman A, Chowdhury S, Hossain D. Acute malnutrition in Bangladeshi children: Levels and determinants. Asia Pac J Public Health. 2009;21(1):294-302.
12. Hakim MA, Talukder MJ, Islam MS. Nutritional status and hygiene behavior of government primary school kids in central Bangladesh. Sci J Public Health. 2015;3 (5):638-642.
13. Fakir AMS, Rahman MW. Determinants of malnutrition among urban slun children in Bangladesh. Health Educ Rev. 2015;5:22.
14. Kamruzzaman M, Hakim MA. Child criminalization at slum areas in Dhaka city. Am J Psycho Cog Sci. 2015;1(4):107-111.
15. Ghosh S, Shah D. Nutritional problems in urban slum children. Ind Pediatr. 2004; 41(7):682-696.
16. Hakim MA, Kamruzzaman M. The dance of poverty and education for childhood nutritional victimization in Bangladesh. J Biolog Env Engg. 2016;1(1):6-9.
17. Rahman A, Karim R. Prevalence of food insecurity among women in rural area of North West Bangladesh. Pak J Nutr. 2013;12(4):329-333.
18. Hakim MA, Kamruzzaman M. Nutritional status of central Bangladesh street children. Am J Food Sci Nutr Res. 2015;2 (5):133-137.
19. Weitzmawqn M. Excessive school absence. Adv Develop Behav Pediatr. 1987;8:151-78.
20. Kamruzzaman M, Hakim MA. Family planning practices among married women attending primary health care centers in Bangladesh. Int J Bioinfo Biomed Engg. 2015;1(3):251-255.
21. Kamruzzaman M, Hakim MA. Socio-economic status of child beggars in Dhaka city. J Soc Sci Human. 2015;1(5):516-520.
22. Kamruzzaman M, Hakim MA. Basic rights on the wane, human rights on brown study: a case study on thrown away children in Bangladesh. J Env Plan Manage. 2016;2(4):29-35.

23. Rahman A. Significant risk factors for childhood malnutrition: Evidence from an Asian developing country. Sci J Public Health. 2016;4(1-1):16-27.
24. Hoddinott J, Rosegrant M, Torero M. Challenge paper: Hunger and malnutrition; 2012.
25. Shomoye FB, Kabir R. Health effects of solid waste disposal at a dumpsite on the surronding human settlements. J Public Health Dev Ctries. 2016;2(3):268-275.
26. Sampey BP, Vanhoose AM, Winfild HM, Freemerman AJ, Muehlbauer MJ, Fueger PT, Newgard CB, Makowski L. Cafeteria diet is a robust model of human metabolic syndrome with liver and adipose inflammation: Comparison to high-fat diet. Obesity 2011;19(6):1109-1117.
27. Ledikwe JH, Blank HM, Kettel KL, Serdula MK, Seymour JD, Tohill BC, Rolls BJ. Dietary energy density is associated with energy intake and weight status in US asdults. Am J Clin Nutr. 2006;83(6):1362-8.
28. Linkon MR, Prodhan UK, Elahi T, Talukder J, Alim MA, Hakim MA. Comperative analysis of the physicochemical and antioxidant properties of honey available in Tangail, Bangladesh. Int J Res Engg Tech. 2015;4(3):89-92.
29. Makowski L, Hotamisligil GS. Fatty acid binding proteins-the evolutionary crossroads of inflammatory and metabolic response. J Nutr. 2004;134:2464S-2468S.
30. Linkon KMMR, Prodhan UK, Hakim MA and Alim MA. Study on the physicochemical and antioxidant properties of Nigella honey. Int J Nutr Food Sci. 2015; 4(2):137-140.
31. Kane G. The mysteries of mass. scientific American (Nature America, Inc.). 2008;32-39.
32. Hakim MA. Physicochemical properties of Dhania honey. Am J Food Sci Nutr Res. 2015;2(5):145-148.
33. Jammer M. Concept of mass in classical and modern physics, New York: Dover; 1997.
34. Buffy G. Kupffer cells in non-alcoholic fatty liver disease: The emerging view. J Hepatol. 2009;51:212-223.
35. Despres JP. Is visceral obesity the cause of metabolic syndrome. Ann Med. 2006;38:52-63.
36. Rolls BJ. The relationship between dietary energy density and energy intake. Physiol Behav. 2009;97:609-615.
37. Zou ML, Moughan PJ, Awati A, Livesey G. Accuracy of the atwater factors and related food energy conversion factors with low-fat, high fiber diets when energy intake is reduced spontaneously. Am J Clin Nutr. 2007;86(6):1649-56.
38. Hakim MA. Food and nutrition counseling in Bangladesh: A NC4HD approach in health statistics. Am J Prev Med Res; 2017.
39. Mitchell MC, Herlong HF. Alcohol and nutrition: Calorie value, bioenergies and relationship to liver damage. Annu Rev Nutr. 1986;6:457-74.
40. Gruner J, Ohri-Vachaspati P. Food and beverage selection patterns among menu label users and nonusers: Results from a cross-sectional study. J Academy Nutr Diet. 2017;117(6):929–936.
41. Wilson GB, Kaner EFS, Croslard A, Ling J, Haighton CA. Quantitative study of alcohol, health and identities among UK adults in later life. PLoS ONE. 2013;8(8):e71792.
42. Shirali S. A premier in logarithm, Hyderabad: Universities Press; 2002.
43. Gulberg J. Mathematics: From the birth of numbers, New York: WW. Norton & Co; 1997.
44. Kate SK, Bhapkar HR. Basics of mathematics, Pune: Technical publications; 2009.
45. Crovetti R, Porrini M, Santangelo A, Testolin G. The influence of thermic effect of food on satiety. Eur J Clin Nutr. 1998;52 (7):482-8.
46. Binns A, Gray M, Brezzo RD. Thermic effect of food, exercise and total energy expenditure in active females. J Sci Medicine Sport. 2015;18(2):204-208.
47. Bernard JE, Bright GW. Students performance in solving linear equations. Int J Math Educ Sci Tech. 2006;15:399-421.
48. Denzer CM, Young CG. The effect of résistance exercise on the thermal effect of food. Int J Sports Nutr Exercise Metab. 2003;13(3):396-402.
49. Rahman A, Hakim MA. Measuring modified mass energy equivalence in nutritional epidemiology: A proposal to adapt the biophysical modelling approach. Int J Stat Med Res. 2016;5(3):219-223.
50. Einstein A. Ist dies tragheit eines korpers von seinem energieinhalt abhangig? Annalen der Physik. 1905;18:639-643.
51. Kittel C, Kroemer H. Thermal physics. Macmillan; 1980.

52. Hakim MA, Rahman A. Health and nutritional condition of street children of Dhaka city: An empirical study in Bangladesh. Sci J Public Health. 2016; 4(1-1):6-9.
53. Sadava D, Orians G. Life: The science of biology. New York: WH. Freeman and Co. 2000;887.
54. Rahman A, Hakim MA, Hanif MA, Islam MR, Kamruzzaman M. Dietary practices, health status and hygiene obserbance of slum kids: A pilot study in an Asian developing country. JP J Biostat. 2016;13 (2):195-208.
55. Huber M, Knottnerus JA, Green L, van der Horst AR, Kromhout D, Smid H. BMJ. 2011;343:(d4163).
56. Kamruzzaman M, Hakim MA. Socioeconomic status of slum dwellers on the capital city of Bangladesh. Am J Bisiness Society. 2016;1(2):13-18.
57. Kamruzzaman M, Hakim MA, Hanif MA, Rahman MH, Islam MA, Talukder MR, Islam MR. Patterns of behavioral changes among adolescent smokers: An empirical study. Front Biomed Sci. 2016;1(1):1-6.
58. WHO. Constitution of the World Health; 2006.
59. Hakim MA. Nutrition on malnutrition helm, nutrition policy in fool's paradise. The Daily Observer; 2015.
Available:http://www.observerbd.com/2015/09/20/111732.php
(Accessed on September 20, 2015)
60. Hakim MA. Nutritional status and hygiene practices of primary school goers in gateway to the north Bengal. Int J Public Health Res. 2016;3(5):271-275.
61. Islam MS, Hakim MA, Kamruzzaman M, Safeuzzaman, Haque MS, Alam MK. Socioeconomic profile and health status of rickshaw pullers in rural Bangladesh. Am J Food Sci Health. 2016;2(4):32-38.
62. Hakim MA. Malnutrition prevalence and nutrition counseling in developing countries: A case study. Int J Nurs Health Sci. 2016;3(3):19-22.
63. Hakim MA. Nutrition counseling in homelessness: A NC4HD nexus. Int J Health Econ Pol. 2017;2(1):12-15.
64. Hakim MA, Talukder MJ. An assessment of health status of street children in Tangail, Bangladesh. Sci J Public Health. 2016;4(1-1):1-5.
65. Hakim A. Vitamin A deficiency as a global public health threat: A concern in nutritional victimization. J Nutr Health Food Engg. 2016;4(5):00147.
66. Rahman A, Harding A, Tanton R and Liu S. Methodological issues in spatial microsimulation modelling for small area estimations. Int J Microsimul. 2010;3(2):3-22.
67. Rahman A, Harding A. Spatial analysis of housing stress estimation in Australia with statistical validation. Aust J Reg Stud. 2014;20(3):452-486.
68. Rahman A, Harding A, Tanton R, Liu S. Simulating the characteristics of populations at the small area level: New validation techniques for a spatial microsimulation model in Australia. Comput Stat Data Analysis. 2013; 57(1):149-165.
69. Islam D, Ashraf M, Rahman A, Hasan R. Quantitative analysis of amartya sen's theory: An ICT4D perspective. Int J Info Communication Tech Human Dev. 2015; 7(3):13-26.
70. Phill M. Small area housing stress estimation in Australia: Microsimulation modeling and statistical reliability, University of Canberra, Australia; 2011.
71. Rahman A. Small area estimation through spatial microsimulation models: Some methodological issues, paper presented at the 2nd general conference of the international microsimulation association, The National Conference Centre Ottawa, Canada 2009;1-45.
72. Rahman A, Upadhyay S. A Bayesian reweighting technique for small area estimation. Current Trends in Bayesian Methodology with Applications, CRC Press, London; 2015;503-519.
73. Rahman MM, Rahman A, Sajoni TT, Kabir SB, Nahar J, Mehrin F. Knowledge and health problems related to health behavior among the secondary school children in rural community of Dhamrai upazila, Bangladesh. Anwer Khan Modern Med Coll J. 2014;5(2):18-22.
74. Connolly J, Romano T, Patruno M. Effects of dieting and exercise on resting metabolic rate and implications for weight management. Fam Pract. 1999;16(2):196-201.
75. Malinauskas BM, Raedeke TD, Aeby VG, Smith JL, Dallas MB. Dieting practices, weight perceptions and body composition: a comparison of normal weight, overweight and obese college females. Nutr J. 2006; 5:11.

76. Kim JS. Experiences in healthy dieting of male college students with obesity in Korea. Osong Public Health Res Perspect. 2015;6(1):59-63.
77. Poole SA, Hart CN, Jelalian E, Raynor HA. Relationship between dietary energy and dietary quality in overweight young children: A cross-sectional analysis. Pediatr Obesity. 2016;11(2):128-135.
78. Hakim MA. Mathematical modeling of energy balancing for diet planning in nutritional physics. Int J Nutr Diet. 2017.
79. Rahman A, Harding A. Prevalence of overweight and obesity epidemic in Australia: Some causes and consequences. JP J Biostat. 2013;10(1): 31-48.
80. Kuddus A, Rahman A, Talukder MR, Hoque A. A modified SIR model to study on physical behaviour among smallpox infective population in Bangladesh. Am J Math Stat. 2014;4(5):231-239.
81. Rahman A. Hakim MA. Modeling health status using the logarithmic biophysical modulator. J Public Health Epidemiol. 2017;9(5):145-150.
82. Islam J, Rahman A, Boland G. Nexus of learning style with satisfaction and success of accounting students: A cross-cultural study at an Australian university. Int J Learn Change 2011;5(3-4):288-304.
83. McBride HM, Neuspiel M, Wasiak S. Mitochondria: More than just a powerhouse. Curr Biol 2006;16(14):R511-60.
84. Gardner A, Boles RG. Is a mitochondrial psychiatry in the future? A review. Curr Psychiatry Review.2005;1(3):255-71.
85. Rahman A. A new method for estimating geographical health related characteristics of populations, paper accepted for presentation at the 23rd Australian statistical conference which is to be held in conjunction with the 14th Australasian data mining conference (Aus DM) and the 9th Australian Conference on Teaching Statistics (OZCOTS), Canberra; 2016.
86. Rahman A. Estimating small area health related characteristics of populations: A methodological review. Geospat Health. 2017;12(1):3-14.
87. Prihandinisari C, Rahman A, Hicks J. What motivate individuals to join public service? Examining public service motivation in a non-western cultural context, paper presented at the 5th global business and finance research conference, Sydney; 2016.
88. Rahman A. Housing projections, statistical reliability and spatial microsimulation, ARC research network in spatially integrated social science (ARCRNSISS) summer school workshops, 3rd – 13th February, The University of Queensland, Brisbane; 2008.
89. Rahman A. New ways for testing small area estimates produced by a spatial microsimulation model in Australia. The Australian housing and urban research institute postgraduate scholar's symposium, 03-04 August. The City-Gate Hotel, Sydney; 2009.
90. Rahman A. Small area housing stress estimation in Australia: Spatial microsimulation modelling and statistical reliability. The Australian housing and urban research institute postgraduate scholar's symposium, 14-17 November, University of Auckland, New Zealand; 2010.
91. Rahman A. Recent developments in small area estimation: A microsimulation technology, Paper presented at the 7th Asian business research conference in Dhaka, Bangladesh; 2012.
92. Rahman A, Harding A, Liu S, Tanton R. Alternative validation tools for small area estimates generated by spatial microsimulation models, Paper presented at the 3rd General Conference of the International Microsimulation Association, The City Conference Center, Stockholm; 2011.
93. Rahman A, Harding A. Tenure specific small area estimation of housing stress in Australia, Paper presented at the 2013 International Indian Statistical Association (IISA) Conference in Chennai, India; 2013.

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