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Nutrition Atlas of ICMR-National Institute of Nutrition: An Informatics Platform on Nutrition in India

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Abstract

Nutrition epidemiology has shifted over the years in India and other low and middle-income countries (LMICs). Due to rapid changes in social dynamics, many such societies now witness a rise in obesity despite pockets of persistent malnutrition. Policy makers and public health researchers are interested in evidence gleaned from longitudinal and spatial monitoring of nutritional characteristics of populations. The present article describes 'Nutrition Atlas', an online informatics resource developed by Indian Council of Medical Research – National Institute of Nutrition (ICMR-NIN). Nutrition Atlas provides easy access to nutrition related datasets in India from various sources through an integrated knowledge platform, equipped with visualization and mapping capabilities that can provide insights for designing further studies, strategizing interventions and translating data to policy.

Key words: Nutrition; Nutrition atlas; India; Database; Public health policy.

1 Introduction

Nutrition epidemiology in many Low and Middle Income Countries (LMIC) has shifted over the years from predominantly under-nutrition to challenges of overweight and obesity. Increasing obesogenic environments and changing lifestyles among populations are key contributors to this shift, leading to overall poorer outcomes for society, and placing significant burdens on already strained healthcare systems. Vir (2011 and 2012).

Policy makers and public health researchers are interested in evidence gleaned from longitudinal and spatial monitoring of nutritional characteristics of populations. Often such

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characteristics may involve complex interplays between individuals and their specific environments, taking place in different socio-economic and cultural contexts. Thus, integrating datasets of diverse types and from different sources and visually representing them can provide key insights, such as mapping risks or identifying associations between nutrition and diseases in different populations.

Undernutrition leads to poor child growth and development, increased susceptibility to infections, and deficiencies in important nutrients. WHO (2013). Undernutrition may occur due to a complex interplay of factors such as poor-quality diets, environments and behaviours that could be attributed to a variety of phenomena ranging from political and socio-economic conditions to even certain aspects of globalization. Black (2013), Nigam (2005). An estimated 45% of deaths in children (age <5 years) are linked to Undernutrition. Black (2013). In 2014, 50 million children worldwide were affected by wasting (low weight-for-height) and 156 million affected by stunting (low height-for-age). WHO (2013), Black (2013), Nigam (2017).

The costs of under-nutrition are staggering, e.g., 38.7% of Indian children (<5 years) are stunted across all socio-economic groups. WHO (2013), Nigam (2017), Vir et. al. (2015). In Africa and Asia, under-nutrition leads to losses of 11% GDP each year. WHO (2013), UNICEF (2016), WHO (2013). India, Bangladesh, and Pakistan contribute to almost half of the total burden of underweight children in the world. UNICEF (2016). Studies in India revealed that prevalence of undernutrition in children varied considerably by age. About 29% children were underweight at 3-5 months of age whereas 60% were underweight by the age of 12-23 months. Similarly, proportions of stunted children are 38.3% between the ages 3-5 months and 67.2% between the ages 12-23 months. Hurt et.al. (2011). Indeed, nutrition supplementation and monitoring are considered to be important interventions in early childhood (age <24 months) to prevent stunting in children. Vir (2011 and 2012), WHO(2013), UNICEF(2016), WHO (2014), Vir et al. (2015), FAO (2017).

Conversely, obesity is often due to advent of calorie-rich processed foods, cultural and social changes including dietary behaviours, and increasingly sedentary lifestyles. (Fig. 1) Most high-income countries saw a rise in obesity in the 1970s and ‘80s. WHO (2014), Finucane et. al. (2011). In 2014, over 1.9 billion adults >18 years' age worldwide (26% of human population) were overweight while 600 million were obese. 42 million children (<5 years) were overweight/obese. WHO (2014 a, b), Finucane et. al. (2011), Mokdad et. al. (2001). The health risks of obesity are well documented. Increased Body-Mass-Index (BMI) is an established risk factor for many non-communicable diseases such as type 2 diabetes, cardiovascular conditions, and many cancers. WCRFI, Mathur et al. (2002), Silva-Sanigorski et al. (2018). In 2004, obesity itself contributed to the cost of >36 million 'Disability Adjusted Life Years' and accounted for 2-6% of total healthcare costs in many countries. Mathur (2002).

Today, obesity rates in LMICs are increasing 30% faster than high-income nations. WHO (2004 a), Popkin et al. (2012), Hurt et al. (2011), Mendez et al. (2005), Monteiro (2004). Obesity is projected to surpass tobacco use as the most economically important and modifiable risk factor in public health Mendez et. al. (2005). Over 50% of Brazilian and Argentinian populations are overweight. Arbex et al. (2014). African countries experiencing rapid urbanization are projected to have 50% obese adults by 2030, and 60% by 2050. Abrha et. al.

(2016). The trend based on the ICMR-INDIAB study shows that the prevalence of obesity is now higher in India as compared to the findings of previous studies. Pradeepa et. al. (2015), Vaz et. al. (2005), Larson et. al. (2017). In fact, it is estimated that 12% of India's population is overweight or obese Pradeepa et. al. (2015), Siddiqui and Donato (2016), Shankar et. al. (2017), Khandelwal and Reddy (2013).

Interventions to address problems of nutrition are generally aimed at behavioural changes (health promotion, education), diet supplementation, policy-making (changing laws and regulations) to counter environmental drivers (such as reducing costs of healthy foods and taxing unhealthy foods.). For instance, obesity related interventions may be used for counteracting the effects of an obesogenic culture. Silva-Sanigorski et. al. (2018), Popkin et. al. (2012), Sanigorski et. al. (2008), Swinburn et. al. (2011). Developing multi-level interventions require significant funding and inputs from various stakeholders, which calls for generation of thorough and reliable datasets through establishment of systematic spatial and longitudinal nutritional monitoring mechanisms. Nigam (2015 and 2016).

The underlying dynamic and multi-level environments consist of diverse locations, communities, households and even individuals. This results in a rich source of so-called high volume and high velocity "big data". A big data perspective to nutrition interventions would involve combining and analyzing massive volumes of data accrued from various sources – environmental, agricultural, food supply chains, dietary habits, consumption, commerce, etc., in order to propose feasible, affordable, and sustainable solutions for a population of interest. WHO (2004 a), Finucane et. al. (2013), Swinburn et. al. (2011).

2 The Resource

Data-driven approaches to address nutritional problems are emerging across the globe ranging from community interventions to nationwide policy making. WHO (2014 a), Mathur (2002), Silva-Sanigorski et. al. (2010), Sanigorski et. al. (2008). Such approaches typically involve systematic data collection, annotation, verification, integration, quality control, basic analytics and visualization (e.g., dashboards) to allow interpretation of rich, multi-source information. An excellent reference on related statistical issues is the text by Nigam (2016). In fact, Nigam (2017) suggested the idea of exploiting big data analysis, simulation and inter sector multi-modeling for measuring hunger and undernutrition. Simulation and the resulting re-sampling inference is a useful tool for validation of integrated data sets from different sources.

Recently, ICMR-NIN has developed an integrated knowledge platform called 'Nutrition Atlas'. It integrates datasets in India collected from various governmental sources along with data collected by the National Nutrition Monitoring Board (NNMB). As a collaborative activity between the state governments of India and ICMR, NNMB has, since 1975, conducted repeated household surveys in the same villages and families to evaluate trends in diet and nutrition over time. Data sources on dietary intake in India are often used to study the major food groups consumed over time, absolute micronutrient intake, and health outcomes related to nutrition intake NNMB. Nutrition Atlas contains data ranging from nutrient values of foods (raw and processed) to specific effects of nutrition in populations (anemia, stunting, etc.).

As a platform, Nutrition Atlas (see URL below) also provides visualization capabilities, including mapping and plotting of relevant public health nutrition statistics in India. Data for such visualizations are collected from several databases (for sources, see table 1). Illustrative examples of some state-wise Indian data visualizations from Nutrition Atlas, shown in figures 2-4, include stunting and wasting (fig. 2a&b), anaemia (fig. 3a&b), underweight and overweight/obesity (fig. 4a-c). The Nutrition Atlas URL is http://218.248.6.39/nutritionatlas/.

3 Discussion

Given its complex and dynamic nature, nutrition is an ideal field for big data research that can allow researchers to combine a variety of sources of information ranging from longitudinal comprehensive surveys of populations to detailed studies focused on micronutrients and genetic determinants in individuals. However, integration of data sets from different surveys is not straightforward as they differ in terms of sampling design, sample size criterion and non-sampling errors. Therefore, there is both ample scope as well as urgent need to integrate available data and metadata to evaluate and mitigate the dual burdens of under- and over-nutrition.

Statistical analysts and modelers can benefit from a baseline resource such as the Nutrition Atlas to provide insights to public health workers and policy makers. Monteiro et al. (2004). Disease mapping techniques can use hierarchical models to determine region-specific risks and test for associations between nutritional status and health outcomes in different populations. As an example of a spatial microsimulation model, SimObesity was used to evaluate obesogenic environments for children in Leeds, UK, which showed that social capital and poverty were strongly associated with childhood obesity in the UK. Edwards and Clarke (2009). India may have different associations between obesity and socioeconomic status, and policy debates and decisions should reflect such region-specific realities. Aleksandrowicz et al. (2017), Aloia et al. (2013), Deaton and Drèze (2009), Kumar et al. (2007), Muthayya et al. (2012), Vir and Nigam (2001), Swinburn et al. (1999).

Direct and indirect consequences of nutritional challenges in a society can lead to significant healthcare expenditures, strain its systems, and therefore, require well-planned interventions to address the same. A timely, user-friendly and data-rich knowledge platform can be a useful tool to design and test different intervention strategies in terms of their costs and effectiveness. In parallel, it can also serve as a resource for disseminating practical dietary and nutritional information and raising public awareness. For both research and journalistic purposes, the creation of Nutrition Atlas at ICMR-NIN seems to be a key step in the right direction.

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Table 1: **Nutrition Atlas datasets.**

Hypertension	NFHS-4 DLHS-4 AHS	National State District	Women/Men aged 15-49Y and >18Y	Slightly above normal (Systolic 140-159 mm Hg and/or Diastolic 90-99 mm Hg) (%) Moderately high (Systolic 160-179 mm Hg and/or Diastolic 100-109 mm Hg) (%) Very high (Systolic >=180 mm Hg and/or Diastolic>=110 mm Hg) (%)	2016. Completed
HIV-AIDS	NACO (Estimates)	State	Male Female	Prevalence of HIV/AIDS	2016. Continuously updated on different time intervals
TB	RNTCP	State		Tuberculosis(TB) in 1,00,000 population	2016. Continuously updated on different time intervals
Leprosy	NLEP	State		Prevalence (/10,000 Population)	2016. Continuously updated on different time intervals
Malaria	NHP	State		Malaria in 1,00,000 Population	2016. Continuously updated on different time intervals
Total Fertility Rate (TFR)	SRS.www.data.gov.in	State		Total Fertility Rate per 1000 women (births for women)	2015-17. Updated continuously
Crude Birth Rate (CBR)	SRS.www.data.gov.in	State		Crude Birth Rate live births per 1000 population	2015-17. Updated continuously
Maternal Mortality	SRS.www.data.gov.in	State		Maternal Mortality rate per 1,00,000 live births	2015-17. Updated continuously
Neonatal Mortality	SRS.www.data.gov.in	State		Neonatal Mortality rate per 1000 live births	2015-17. Updated continuously
Infant mortality	SRS.www.data.gov.in	State		Infant Mortality rate per 1000 live births	2015-17. Updated continuously
Under 5-Mortality	SRS. Niti Aayog	State		Under 5 Mortality rate per 1000 live births	2015-17. Updated continuously
Demographics	Census – 2011	National State		Population, Child Population, Sex Ratio, Literacy Rate, Type of House, Households Having; Electricity, Drinking Water, Sanitation.	2015-17. Completed

Abbreviations:

EMW = Ever Married Women AW = All Women AM = All Men
EMM = Ever Married Men M = Month Y = Year
NHFS = National Family Health Survey DLHS = District Level Household Survey
AHS = Annual Health Survey NNMB = National Nutrition Monitoring Bureau
NCRP = National Cancer Registry Programme NACO = National AIDS Control Organisation
RNTCP = Revised National Tuberculosis Control Program NLEP = National Leprosy Eradication Programme
NHP = National Health Profile SRS = Sample Registration system.

National Annual Surveys/ Public Domains (Government Organizations):

National Family Health Survey (NFHS)-4 - - 2015-16
National Family Health Survey (NFHS)-3 - - 1998-99
Annual Health Survey (AHS) - - 2011-13
National Family Health Survey (NFHS)-3 - - 2005-06
District Level Household Survey (DLHS)-4. - - 2012-13

National Nutrition Monitoring Bureau (NNMB); 2003
National Cancer Registry Programme (Population based); 2012-14
NACO: National AIDS Control Organization (Estimates); 2009, 11.
RNTCP: Revised National Tuberculosis Control Program; 2015
NLEP: National Leprosy Eradication Programme; 2014-15
NHP: National Health Profile; 2016
SRS: Sample Registration system; 2011.
www.Data.Gov.in, 2011.
Niti Aayog; 2011
Census; 2011

Figure 1: Obesogenic environment and different types of risk factors. WHO (2014 a), FAO (2017), Popkin et al. (2012), Swinburn et al. (2011), Nigam (2016), Swinburn et al. (1999), Shetty PS. (2002), USDA, Pingali and Khwaja (2004).

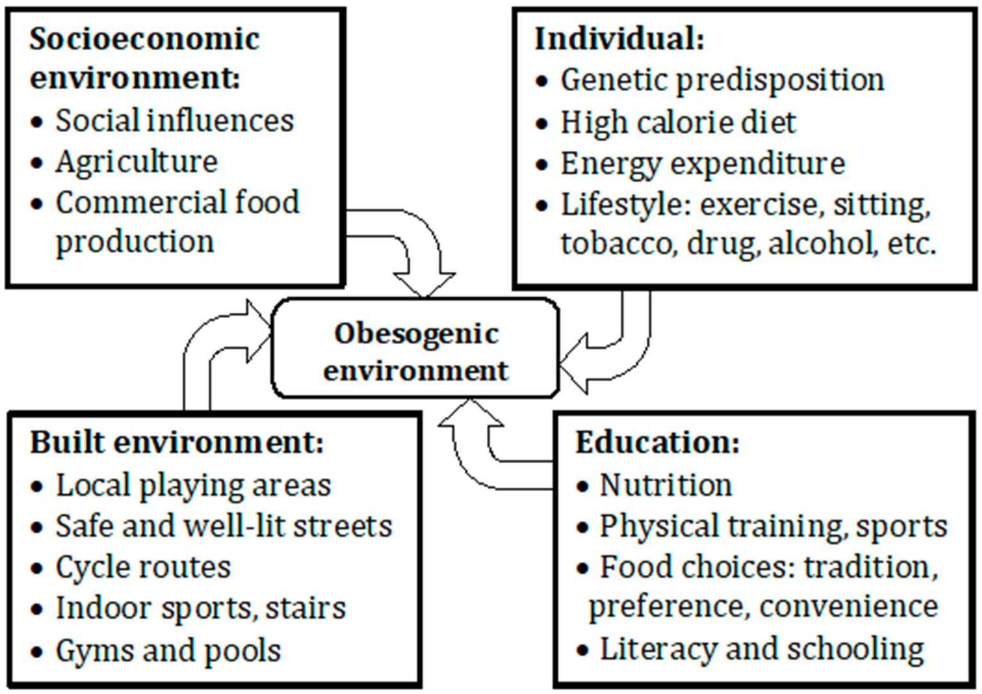

Figure 2a. State-wise prevalence of stunting in children aged 6-59 months

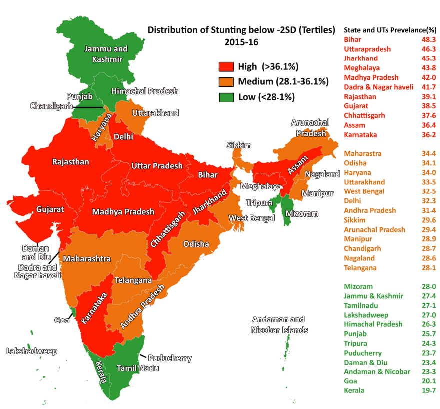

Figure 2b: State-wise prevalence of wasting in children aged 6-59 months

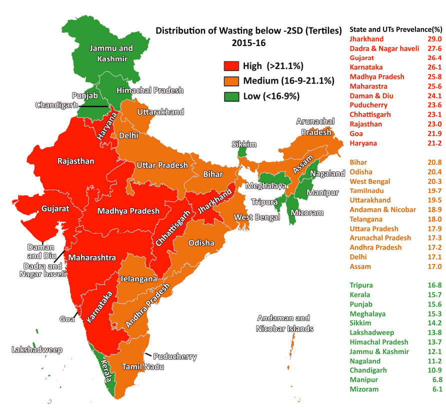

Figure 3a: Comparison of anaemia prevalence among different groups between 2005-06 and 2015-16

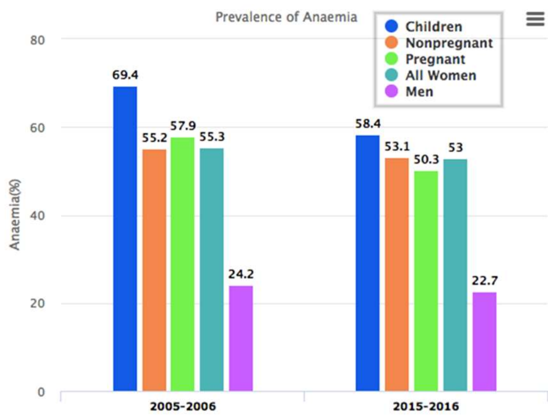

Figure 3b: State-wise prevalence of anaemia in children

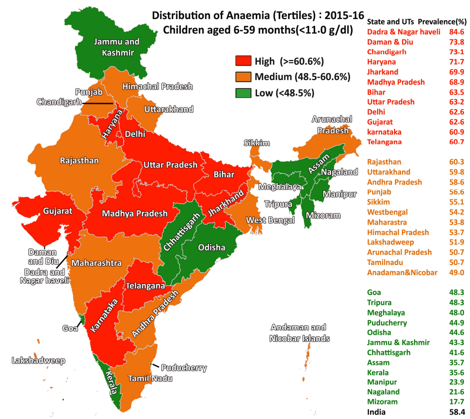

Figure 4a: State-wise prevalence of underweight in children

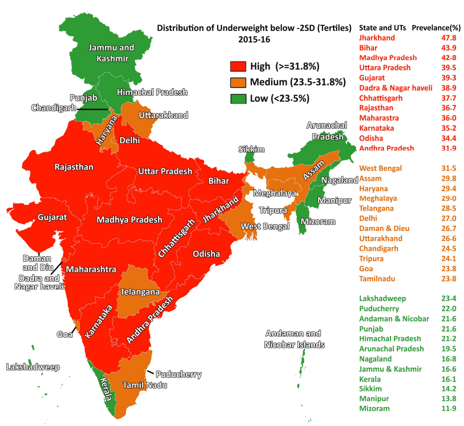

Figure 4b: State-wise prevalence of overweight/obesity in adult males

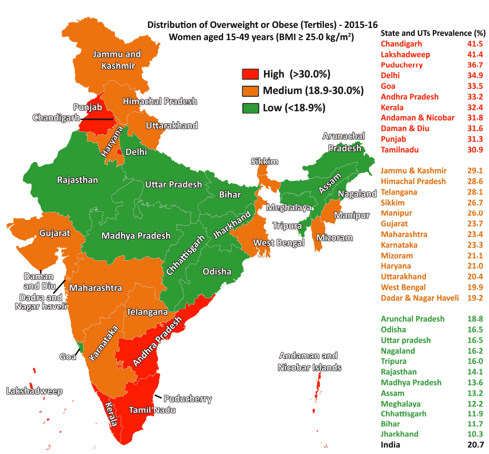

Figure 4c: State-wise prevalence of overweight/obesity in adult females

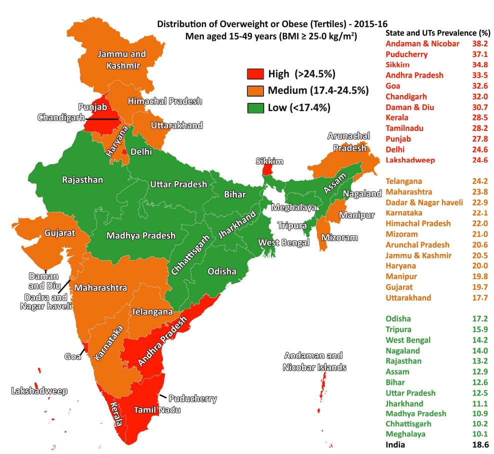

Figure captions

Figure 1: Obesogenic environment and different types of risk factors. WHO (2014a), Arbex AK et.al (2014), NNMB, Nigam AK (2007), Nigam AK (2015), Swinburn B. et.al. (1999), Shetty PS (2002), USDA, Pingali P.

Figure 2: Figs. 2a and 2b provide state-wise heat maps for 2015-16 prevalence among Indian children below 5 years of age for stunting and wasting respectively. Stunting prevalence is depicted as green for low prevalence (<28.1%), orange for medium prevalence (28.1%-36.1%), and red for high prevalence (>36.1%). Similarly, for wasting, green indicates low prevalence (<16.9%); orange indicates medium prevalence (16.9%-21.1%) while red indicates high prevalence (>21.1%).

Figure 3: Fig. 3a depicts changes in anemia prevalence among children (blue), non-pregnant women (orange), pregnant-women (green), all women (light blue) and men (purple) between 2005-06 and 2015-16. Figure 3b provides a state-wise heat map for anaemia prevalence (Hg <11.0 g/dl) among children aged 6-59 months in 2015-2016. Areas in green indicate low prevalence (<48.5%), areas in orange indicate medium prevalence (48.5%-60.6%) and areas in red indicate high prevalence (>60.6%).

Figure 4: Fig. 4a is a state-wise heat map for underweight distribution in children below 5 years of age in 2015-2016. Figures 4b and 4c provide state-wise heat maps for 2015-16 prevalence of overweight/obesity in males (BMI≥25.0) and females aged 15-49 years (BMI≥25.0) respectively.