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Original Article

Infectious Diseases among Malnourished Children: Neurocognitive Performance

Monalisa Debnath[1*], Sharmistha Singh[1], Aruna Agrawal[2], G. P. Dubey[2]

[1]Junior Research Fellow, Genome Foundation (Collaborative project), Department of Kriya Sharir, Faculty of Ayurveda, Institute of Medical Sciences, Banaras Hindu University, India
[2]Professor, Department of Kriya Sharir, Faculty of Ayurveda, Institute of Medical Sciences, Banaras Hindu University, India

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ABSTRACT

Malnutrition plays a pivotal role in the development of various infections viz diarrhoea, pneumonia, hepatitis, tuberculosis, resulting in poor mental performance of the children. A comparative study was conducted to determine the prevalence of infectious diseases among malnourished children and further to evaluate its effect on cognitive status. A comprehensive field study was conducted among 948 malnourished children with an age range of 5-12 years out of which 604 and 344 samples were analysed from the urban and rural localities of Varanasi respectively. Along with anthropometric assessments, the malnourished samples were analyzed to determine the prevalence of infectious diseases and their effect on cognitive function like Intelligent Quotient(IQ), attention span, Long Term Memory(LTM) and Short Term Memory(STM). Our study revealed that rural children were having comparatively lower Body Mass Index and poor skinfold thickness with higher prevalence of infectious diseases than the urban children. Rural malnourished children suffered more from infectious diseases along with poor mental performance resulting in poor scholastic performance of the children. Children belonging to rural areas and poor socio-economic background fail to avail the basic nutritional needs, thus suffer from cognitive impairment. Malnourished children are more prevalent towards various infectious diseases which further affect their brain function.

Keywords: Malnutrition, cognitive function, infection and nutritional deficiencies

BACKGROUND

Malnutrition being one of the most important threat for morbidity and mortality among children, is a major concern to be taken care of worldwide. It includes many aspects of nutritional imbalance i.e. undernutrition, overnutrition and specific deficiency. Malnutrition during the early years of life hinders optimal growth and development required to be fulfilled, thus leading to abnormal changes in the bodily functions. According to the recent estimates, 826 million people in the world are undernourished out of which 792 million and 34 million from developing and developed countries respectively.[1] More than 10 million children of age upto 5 years have been estimated to die each year due to malnutrition globally.[2] The prevalence of infection may be frequent in malnourished children as they usually belong to low socio-economic status, poor sanitary condition, inadequate water supply etc. It is reported that 10% children from rural areas have poor growth as a consequence of suboptimal nutritional uptake.[3] Invading infectious diseases significantly affects the nutritional status by hampering the dietary intake, altering the intestinal absorption, increased catabolic processes and sequestration of nutrients required for tissue synthesis and growth.[4] Malnutrition delays wound healing, impairs oxidative metabolism, depresses immunological aspects and hence, increases the probability for the disease prevalence.[5] The cyclic and synergistic role played by malnutrition and infection inhibits immune response that can exacerbate the health status.[6] Poor nutrition renders distorted epithelial integrity and inflammation thereby making a strong bridge between malnutrition, infection and infant mortality.[7] The increased incidence and severity of infection among underprivileged children is solely due to detoriation of immune system and its function.[8] Nutritional- Acquired Immune Deficiency Syndrome (NAIDS) affects cell mediated immune response, phagocytic/ microbicidal function, humoral response.

***Corresponding Author Address:** Dr. Aruna Agrawal - Department of Kriya Sharir, Faculty of Ayurveda, Institute of Medical Science, Banaras Hindu University, India and the active E-mail: monalisadebnath1108@gmail.com

It has been documented in the previous studies that malnourished children suffer in greater proportion from bacterial, gastrointestinal and respiratory infections.[9] Malnutrition remarkably alters the gastrointestinal system by destroying the epithelial barriers which forms the first line of defense in GI infection maintained by innate immunity.[10] Infectious diseases hamper the cognitive status thus altering the brain physiology and functioning during the early years of life. Undernutrition results in tissue damage, growth retardation, impaired differentiation, synaptic and neurotransmitter reduction, delayed myelination and reduced development of dendritic arborisation of the developing brain. There occur alterations in accordance to the deviations in the temporal sequences of brain maturation, which further hampers the formation of neuronal circuits.[11] Long term alterations in brain function is reported by till date research works done on this aspect, which could be related to long lasting cognitive impairments associated with malnutrition.[12]

The study was conducted to determine the prevalence of infectious diseases among malnourished children and further to evaluate the effect of infections on their cognitive function.

MATERIALS AND METHODS

The study was conducted so as to assess the malnourished children of selected parts of Eastern Uttar Pradesh. It included a total 948 children of age 3-12 years, out of which 344 were selected from the urban localities nearby Varanasi i.e, Avadhgasbi, Nagwa, Durgakund, Khojwa and rest 604 children were selected from rural areas including Bhagwanpur, Daripur, Palhaiya, Daptipur, Roghopur and Kantapur. The study was carried out from 1st July, 2010 to 1st December, 2013. After formulation of the two groups- one group of children belonging to rural areas and the other belonging to the urban areas, the samples were then assessed using a pre-formed questionnaire containing various parameters like socio-demographic, anthropometric, clinical and cognitive status. Socio-demographic assessment included age, gender parental education, working status and income etc. Anthropometric assessment included BMI, skin fold and sub-scapular thickness. Weighing machine, anthropometer, skinfold calliper were used for measurements. Clinical assessment included determining the presence of evidential infectious diseases like diarrhoea, pneumonia, dysentery, hepatitis and tuberculosis. Accordingly, various cognitive tests were done to examine their cognitive status and brain function which included memory and attention span, intelligent quotient, auditory and visual reaction time tests. Various electronic devices were used for it.

RESULT AND DISCUSSION

The study included a total of 948 children out of which 344 and 604 were selected from urban and rural localities respectively. Based on the field study done on urban and rural children population, distinct patterns of socio-economic and socio-cultural variables were observed. Table 1 Depicts that Children belonging to rural areas showed more prevalence of malnutrition than those living in the urban localities. Svedberg P (2007) documented in his study that the gender of children is an important influential factor in determining nutritional status. Unhygienic condition among rural children was more as observed in their surrounding areas than those living in urban areas.

Data shown in Figure 2 reveals that a large percentage of fathers of the children belonging to the urban area completed their secondary education whereas 30% of father of the samples belonging to rural area were found illiterate. Mother's illiteracy was prevalent to about 57% in rural area whereas about 17% in urban area. Literature revealed that mother's education is one of the important factors relating to childhood nutrition (Rahman M et.al. 2010). Many studies have demonstrated that improvements in secondary school enrolment rates among females are estimated to be 43%. Parental education is strongly accounted for variance in the neurocognitive systems. Father's education also emerged as an important factor that has significantly associations with underweight status among under-five children (Bornstein, et al 2003). Socioeconomic status (SES) is strongly associated with achievements during childhood and it also predicts many outcome measures, including IQ achievement test scores, grade retentions and functional literacy. Indeed, SES has stronger associations with cognitive performance than with other seemingly more concrete outcomes, such as health and behaviour (Brooks et al., 1993; Liaw & Brooks-Gunn, 1994; Smith et al., 1997; Baydar et al., 1993; Duncan et al., 1998). Data shown in the Table 3 inferred that majority of the individuals belonging to the rural areas had family income of Rs 2000-5000. In urban group of individuals, the family income was Rs 2000 to >Rs8000 per month. The children belonging from poor socio-economic groups were found more susceptible to metabolic deformities due to nutrient deprivation and underprivileged conditions.

It can be inferred from the data shown in Table4/Figure 4 that the percentage of male children attending schools regularly was found to

be 93% and 76% whereas for girl children, it was 88% and 58% in urban and rural areas respectively. Being deprived of the basic needs to be fulfilled during the early years, large masses of children from poor socio-economic background fails to get proper education which becomes secondary for their sustenance. Early brain development research uplifts the efficacy of intervention and support programmes designed to influence family function and child development during child's first five years of life. Literature shows that children who grow up in poverty and/or stressful environments are at risk for reduced intellectual and educational attainment. These children also are at risk for a variety of poor life course outcomes.

Body mass index (BMI) is one of the most important anthropometric parameter with respect to age. Malnutrition is responsible for poor intelligence and increased susceptibility to various types of infection and it also increases the incidences of stunting and low birth weight.[13, 14] Generally, it is reported that malnutrition is associated with poor productivity, disability and premature death .[15, 16] Malnutrition affects both the pre-adolescent and adolescent age groups.[17, 18, 19, 20] Inadequate diet including insufficient intake of energy stores, protein and micronutrients lead to weight loss, retarded growth rate, diminished immunity and mucosal damage that further increases the incidence, severity and duration of infectious diseases.

Data given in Table 5 showed the distribution of infectious diseases among the malnourished children living in urban and rural areas. Children belonging to rural areas were found more affected with infectious diseases as compared to the ones living in urban areas. Children suffering from various infectious diseases were mostly of 3-5 years of age. The median height/weight and BMI of malnourished children were comparably less as compared to the normal children of same age group. BMI was found lowest among the 3-5 aged children with 13.7 Kg/m^2 and 13.9 Kg/m^2 recorded in rural and urban areas respectively. Skin fold thickness at the triceps as observed was very poor among the malnourished samples in rural areas. The skin fold thickness at the sub scapular region as recorded was 4.12 mm, 5.30 mm and 5.82 mm among children of rural areas whereas 4.21mm, 5.26mm, and 5.93 mm among children of rural areas belonging to 3-5, 6-8 and 9-12 years of age respectively.

Table 6 shows that the percentage of involvement of various types of infections like diarrhoea, tuberculosis, hepatitis, dysentery and pneumonia has shown a distinct pattern. The study provided evidence that burden of infectious diseases along with malnutrition plays a big role globally on the cognitive ability among malnourished children. A high percentage of children showed incidence of diarrheal infection than the others. All the cognitive parameters i.e, IQ, Attention span, STM, LTM and reaction time are reduced during diseased conditions. IQ is severely decreased in dysentery whereas, attention span, STM and LTM are observed the lowest among pneumonia patients (Table 6). Our study showed involvement of malnourished children with different types of infection like diarrhoea, pneumonia, dysentery, tuberculosis, hepatitis etc (Table 7). The prevalence of diarrhoea and dysentery were found highest aggravating the degree of malnutrition among children. A distinct pattern is noticed in the development of these infections in different age group. On regard to the cognitive function of malnourished children is concerned, an overall poor mental performance was noticed in rural malnourished children suffering from different degree of infections in comparison to the children of urban locality. Table 7 showed a poor Intelligence Quotient (IQ) with poor memory and attention span which was recorded in almost all the malnourished children of both the localities. A poor scholastic performance of the children was observed showing evidence of malnutrition. Poor learning and memory performance was the major presenting cognitive feature of these children as reported by their parents and teachers. Our Study revealed that the nutritional deficiency is the major causative factor for poor learning and overall mental performance. It is reported that malnutrition may produce behavioural inadequacy like aggressive behaviour, virulence and poor attention span.

Stansfield et al. have demonstrated that early childhood infections are common in low income group and affect the child's development both at mental and physical level. He found gastroenteritis, respiratory tract infections and malaria as the most prevalent and serious conditions that may affect the developmental pattern in the first three years of life.[21] His study has confirmed that acute bacterial infections are the major cause of death in severe malnourished condition. Further, diarrhoea has said to be the most important causative factor responsible for death among children with Protein Energy Malnutrition (PEM). Similarly, prolonged episodes of diarrhoea have shown more deleterious effects resulting in growth failure of the children. According to Nesheim (1993), around 10% of children suffer from meningitis due to malnutrition. Thus, infection occurring in undernourished children is the major risk factor for their poor development. [22, 23] In our study, it was evidential

through our results that the children with nutrient deficient diets and underprivileged conditions were found more susceptible towards cognitive alterations and suboptimal brain functions. Therefore, such type of results need necessity for composite program involving supplementation of food, implementation so as to curb off micronutrient deficiencies, improvement in mother's feeding, provision of purified water, proper sanitation and food, programming regular physical activity, regular monitoring and surveillance of under taken management strategies.[24, 25, 26]

Present study revealed that children belonging to rural areas are more prone to malnutrition as they lack in availing the chief needs for sustenance so as to achieve better growth and development. Children belonging to poor socio-economic background mostly remain deprived of the optimum nutritional requirement and hence are more prone to the infections aggravated by malnutrition and that may finally alter the cognitive development as well. It also concludes that children who grow in poverty and/or stressful environments are at risk for reduced intellectual and educational attainment. Parental education is also a very remarkable factor which determines the child's upbringing. It was observed that malnourished samples showed involvement of various types of infections aggravated particularly by poor nutritional status. A poor memory, attention and Intelligence Quotient were observed among the children who showed involvement with different types of infection. A large percentage of children were found to suffer from diarrheal infection as compared to other infectious diseases. Existence of malnourished group of children suggests requirement of pharmacological as well as dietary interventions to recover their health and curb nutritional deficiencies. It is also a matter of discussion that whether the malnourished children are able to improve their cognitive functions or not after the management strategies. The cognitive deficits noticed in the function of poor IQ, memory, attention and psychomotor performance should also be given due attention for a proper management. Various investigations have demonstrated that either pre or post natal malnutrition causes an increase in brain concentration of monoamines, serotonin and nor-epinephrine.[27, 28, 29, 30] On contrary a decrease in monoamines was also reported by some of workers.[31, 32, 33, 34] However these levels are unrecognized after nutritional rehabilitation.

It is important to mention here that malnourished children who fail to respond to treatment should be investigated for various infections showing evidence of malnutrition. Those malnourished children who don't respond to specific treatment and supplements should be investigated further. The specific infections that are most prevalent among malnourished children includes live persistent diarrhoea, dysentery, otitis media, pneumonia, urinary tract infection, skin infection, tuberculosis, helminthiasis, malaria, HIV infection, AIDS and also some serious underlying diseases that are required to be investigated further. Subsequently, it is also important to note that the concerned emotional and social factors and the necessary management programmes should be run to fight against malnutrition.

CONCLUSION

Within the past few decades, studies have focused towards those infections which lead to deficits in cognitive function during early childhood as it is well established that the first three years of life is very critical with regard to the development of brain is concerned. Present study reveals the need for composite program involving supplementation of food, sustainable correlation of micronutrient deficiencies, improvement in mother's feeding and child caring behaviour, provision of purified water and proper sanitation, strengthening health care system and programme of regular physical activity and regular monitoring and surveillance of under taken management strategies.

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Table 1: Age wise prevalence of malnourished children in urban and rural localities of Eastern Uttar Pradesh

Age	Urban area		Rural area	
	Male (%) (Total n=203)	Female (%) (Total n=141)	Male (%) (Total n=382)	Female (%) (Total n=222)
3-5	53.20 (n=108)	53.20 (n=84)	65.96 (n=252)	62.16 (n=138)
6-9	25.62 (n=52)	25.62 (n=36)	18.58 (n=71)	16.66 (n=37)
10-12	21.18 (n=43)	21.18 (n=21)	15.44 (n=59)	21.17 (n=47)

Table 2: Prevalence of malnourished children in the rural and urban areas on the basis of parental education

Group	Educational status	Urban area % (Total n=344)	Rural area % (Total n= 604)
Father	Illiterate	4.35 (n=14)	29.93 (n=173)
	Primary	14.90 (n=48)	25.08 (n=145)
	Secondary	65.53 (n=211)	39.96 (n=231)
	Graduation	15.22 (n=49)	5.01 (n=29)
Mother	Illiterate	16.94 (n=50)	56.97 (n=339)
	Primary	31.18 (n=92)	32.26 (n=192)
	Secondary	38.98 (n=115)	8.90 (n=53)
	Graduation	12.88 (n=38)	1.84 (n=11)

Table 3: Categorization of malnourished children belonging to different localities on the basis of their family income

Family income (per annum)	Urban area % (Total n=344)	Rural area % (Total n= 604)
2000-5000	34.01 (n=117)	64.90 (n=392)
5000-8000	28.77 (n=99)	20.86 (n=126)
>8000	37.20 (n=128)	14.23 (n=86)

Table 4: Percentage of frequency of school going children in different localities

Group of malnourished samples	Urban area % (Total n=344)	Rural area % (Total n= 604)
Boys	92.61 (n=188)	75.91 (n=290)
Girls	87.94 (n=124)	57.65 (n=128)

Table 5: Anthropometric study of children with malnutrition and showing evidence of various infections

Age (in years)	Number of cases with infectious diseases		Average BMI(Kg/m		Skin fold thickness			
	Rural	Urban	Rural	Urban	Triceps(mm)		Sub scapular (mm)	
					Rural	Urban	Rural	Urban
3-5	203	104	13.7±1.03	13.9±0.91	5.42±0.73	5.73±0.87	4.12±0.45	4.21±0.33
6-8	64	47	14.1±2.01	14.4±1.97	6.22±1.05	6.15±1.03	5.30±0.38	5.26±0.12
9-12	49	32	14.5±1.73	14.5±1.56	6.83±1.14	6.88±1.09	5.82±0.41	5.93±0.37

Table 6: Categorisation of malnourished children belonging to urban population in accordance to the different types of infections prevalent in them and showing status of cognitive function

Type of infection	Patient	IQ	Attention span	STM (Score)	LTM (Score)	Reaction time (min)	
						Auditory	Visual
Diarrheal episodes	53	68.73±5.94	6.90±1.35	7.82±1.06	5.87±0.99	2.51±0.32	2.73±0.42
Tuberculosis	22	61.90±6.25	7.02±.94	7.91±1.33	4.73±1.13	1.98±0.42	2.11±0.45
Hepatitis B	18	63.88±7.39	6.95±1.43	6.85±1.32	4.91±1.30	2.28±0.53	2.13±0.33
Dysentery	75	59.32±6.13	6.28±1.13	5.93±1.28	4.38±0.97	2.18±0.71	2.31±0.42
Pneumonia	15	60.33±5.79	5.90±1.08	5.78±1.13	4.29±0.79	1.98±0.71	1.89±0.45

Table 7: Categorisation of malnourished children belonging to rural population in accordance to the different types of infections prevalent in them and showing status of cognitive function

Type of infection	Cognitive function			Memory span		Reaction time	
	Patients	IQ	Attention span (score)	STM (score)	LTM (score)	Auditory	Visual
Diarrheal disease episode	112	61.22±5.84	6.20±1.34	6.45±1.28	4.97±0.34	2.98±0.51	2.88±0.71
Tuberculosis	47	62.45±6.01	6.82±1.34	6.13±1.08	4.38±0.78	2.79±0.42	2.66±0.31
Hepatitis -B	25	59.85±8.20	5.87±0.82	5.90±0.73	5.02±1.12	1.90±0.35	1.87±0.42
Dysentery episode	109	60.34±8.20	6.13±1.21	5.79±1.22	5.01±0.97	2.04±0.82	2.19±0.32
Pneumonic attack	23	64.10±5.82	5.43±1.35	6.445±1.22	5.39±0.86	1.99±0.22	2.01±1.31

Figure 1: Age wise prevalence of malnourished children in urban and rural localities of Eastern Uttar Pradesh

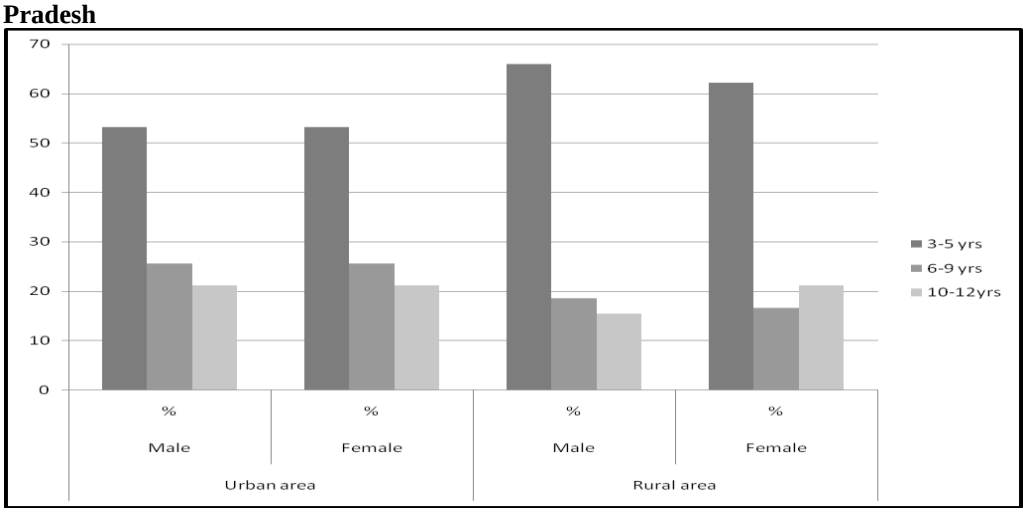


Figure 2: Prevalence of malnourished children in the rural and urban areas on the basis of parental education

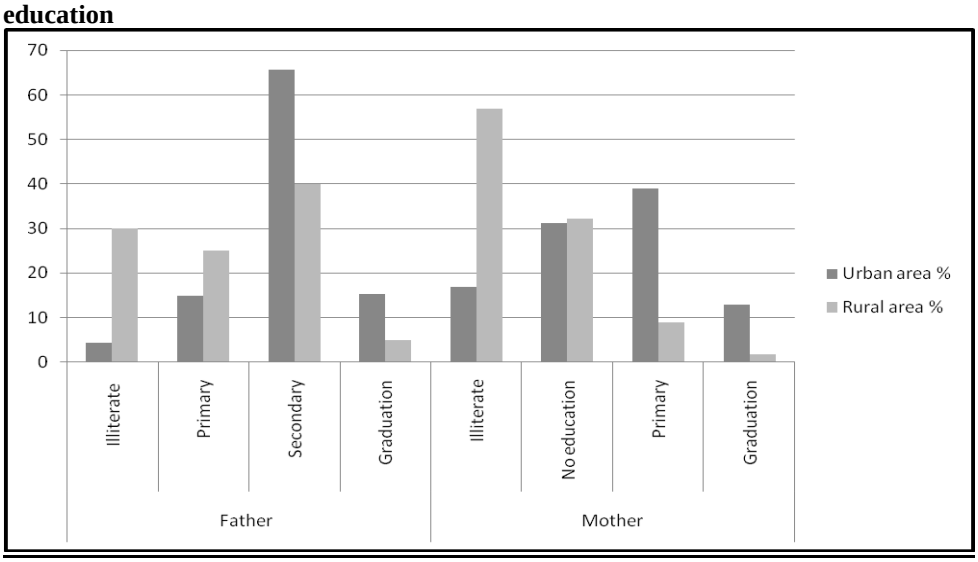


Figure 3: Categorization of malnourished children belonging to different localities on the basis of their family income

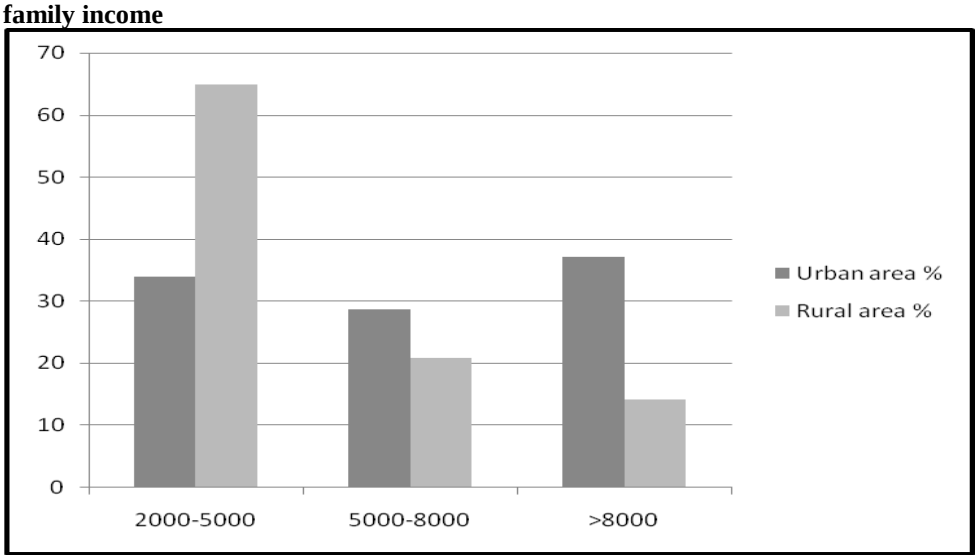
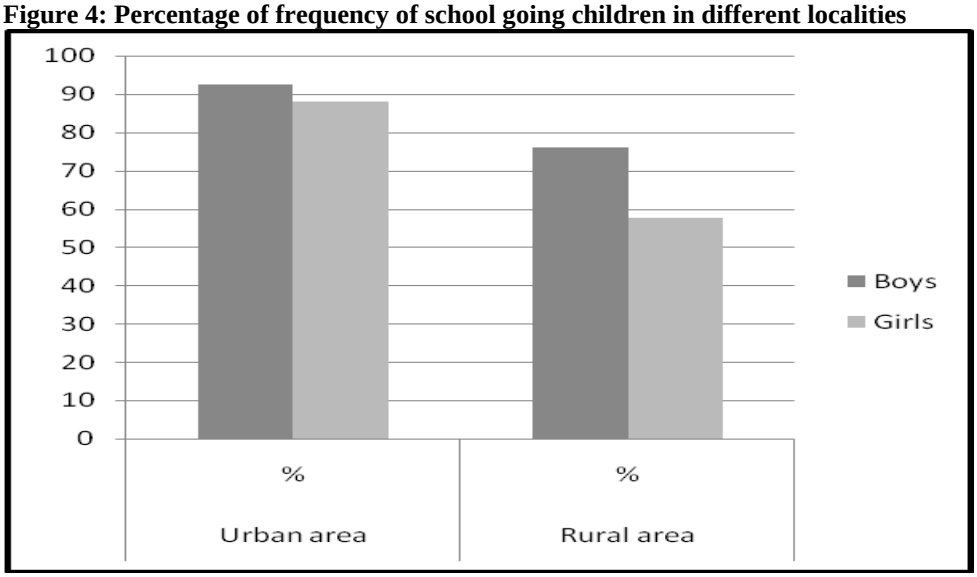


Figure 4: Percentage of frequency of school going children in different localities



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