Impact of Flood on Physical Growth of the Children and Adolescents of the District Rudraprayag, Uttarakhand, India

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ABSTRACT: Growth and development of human are determined by intrinsic & extrinsic factors. How natural calamities like flood are impacting it is least explored. Hence this study is an attempt to understand the role of flood on the growth and development of child and adolescents district Rudraprayag of Uttarakhand and to find out the differential growth trend of stature and weight among the children affected by flood as well as who were not affected by the flood. A cross sectional study was conducted to evaluate the relationship between different malnutrition indicators and exposure to floods among children aged 4 to 18 years. A total of 1,757 children were measured, consisting of 737 females and 1,020 males. Out of which 817 were flood affected and 940 were not affected by the flood. It was found that non-flood-affected individuals generally had higher body weight and taller stature compared to flood-affected individuals. The differences were more prominent among females, the flood-affected cohorts consistently showing lower weight and stature across various age groups.

INTRODUCTION

The Himalayan region is prone to various kinds of natural disasters. The area selected for the present investigation was a flood-prone zone. It is well known that households in developing countries often experience weather-related and other shocks that drastically affect incomes (Hoddinott and Kinsey, 2001).During childhood, there is a significant need for proper nutrition due to the rapid growth and ongoing development. A high-quality diet is essential at this stage, the absence of specific essential nutrients may lead to long-term physical and mental impairments(Chaurasia *et al*., 2019). Approximately 70% of the world's malnourished children live in Asia, giving that region the highest concentration of childhood malnutrition worldwide (Khor, 2005), and children in disaster-prone areas in India are twice as likely to be living in chronic poverty, and three times as likely to become impoverished(Diwakar *et al*., 2019).It is estimated that the population from 4-18 years of age contributes to 34.3 %of the total population of India (Census of India, 2011).Despite a large amount of literature on child health, there is relatively little work on how shocks from natural hazards affect the health of children. Many natural hazards, such as floods and droughts, occur frequently in many developing countries and are potentially very destructive. These may impact both children's current health status and their long-term outcomes such as stunting and wasting. Child growth is a good indicator of health status hence one of the crucial aims of this investigation is to improve the understanding of nutritional status among the flood exposed population and its related consequences among the population

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of Himalayan region. In other words, the study is focused on the most nutritionally vulnerable segments of the population (especially children and adolescents) that experience flood. Since nutrition is one of the most important factors which influence the growth of children. The children born to mothers having optimal nutrition have been found to possess greater birth weight as compared to their peers born to mother having inadequate nutrition(Chaurasia *et al*., 2020). Flood victims are vulnerable to long-term physical and psychological health effects, which persist for an undefined time period in the aftermath of a flood event (Stephenson *et al*., 2014a) Furthermore, the primary objective of this study is to understand the differential growth pattern of the children and the adolescents who experience the flood. Hence on the basis of anthropometric data, body weight and stature of flood affected and non-affected individuals were studied. In this paper, the following hypothesis were tested:

H^1: There is an impact of the flood on human growth and development.

H^2: There is a difference of impact on males and females.

H^3 : There is differential stature and body weight of different age cohort of flood affected and non-affected.

MATERIAL AND METHODS

Study Area

Present study was conducted in a Himalayan state of India known as Uttarakhand which lies between 28.44 to 31.28 N latitude to 77.35 to 81.01 E longitude. The total area of this hilly state is 53,483 square km constituting 1.63% of the landmass of India. The state is consisting of 13 districts and 95 development blocks. This state has two divisions; the western part is Garhwal and the Eastern part is known as Kumaun. The state capital is Dehradun, located in the Garhwal division(Census of India, 2011). Uttarakhand shares its boundary with Tibet in the North, Nepal in the East, and Himachal Pradesh in North-West. Rudraprayag district (30.4807° N, 79.0645° E) is a low hill area and has an average elevation of 895 meters (2,936 feet).

Sampling Strategy

This study was carried outon1757 individuals consisting of 737 female 1020 males. The samples were drawn from Anganwadi and School; children and adolescents from the age of 4 to 18 years were chosen randomly. From 6 Government and Private Schools, The socioeconomic status (SES) was evaluated using a modified version of the scale of Kuppuswamy (Mishra & Singh, 2003). Only those males and females were included in this study, who have an accurate date of birth. The subjects were carefully selected and due care was taken to include only those who were physically and mentally normal and did not suffer from any kind of illness, which may affect their normal process of growth. A pre-structured schedule was used to collect the necessary information on sex, age, religion, family income, number of siblings, diet, caste categories, family type, parents' education, and occupation.

Anthropometric Measurements

Anthropometric measurements (stature and weight) were taken with all possible cautions maintaining uniformity and accuracy, according to the standard technique suggested by Preedy, (2012). The stature was measured to the nearest 0.1 cm by the anthropometer rod (Manufactured by Galaxy Informatics, India), which is a two hundred centimetres long rod made of nickelled steel and consists of four equal segments to form a straight rigid rod. One side of this instrument is a fixed sleeve on the top and the rod is graduated in a descending scale towards the bottom. At the time of measurements, the minimum number of cloths had been ensured to be worn and stand erect on the level of the floor against a wall where his buttock touches the wall and head was rested in the eye ear plane. The Anthropometer rod was placed in a vertical position by the side of the subject. After locating the landmark (vertex) by hand, the movable sleeve is raised with the help of a crossbar; the crossbar will measure at the upper end of the window of the movable sleeve. While taking the weight of the subject they were requested to stand on the portable weighing machine barefoot and keeping them erect at the time of noting the weight to the nearest 0.1 kg.

Inclusion Criteria: The study has defined

specific inclusion criteria for participants. Firstly, the age range includes children between 4 and 18 years old. This ensures that the study focuses on children within a specific developmental stage. Secondly, both males and females are eligible to participate, promoting inclusivity and gender representation in the study population. Lastly, participants should be in good overall health, free from any significant medical conditions that could potentially affect their growth. By establishing these inclusion criteria, the study aims to gather data from a diverse yet healthy group of children to obtain meaningful and relevant results.

Exclusion Criteria: Children with chronic medical conditions such as endocrine disorders or renal disease that may affect growth, as well as those diagnosed with unrelated growth disorders like skeletal dysplasia or congenital growth hormone deficiency, were excluded. Additionally, children with severe cognitive impairments hindering their cooperation or comprehension during the study procedures were not included. Furthermore, children who migrated from outside the study area were excluded to maintain a consistent population.

RESULTS

The Table 1 presents a comprehensive overview of the background characteristics of the sample and their families. It is apparent that 5.9 % of fathers and 8.5 % of mothers of male participants were illiterate, similarly 6.4% of fathers and 10.3% of mothers of female participants were illiterate. A total of 77.5 % of fathers and 85.2% of mothers of males have formal education from the primary to higher secondary. Only 16.6% of fathers and 6.3 % of mothers of male participants were graduate and postgraduate. In the case of females, 80.1 % of fathers and 83.9 % of mothers have formal education from primary to higher secondary, and only 13.4 % of fathers and 5.7 % of mothers were graduate or postgraduate. It reveals that there are significant differences between the two groups in terms of fathers' education (χ^2 =18.72, df=6, p-value=0.00). The proportion of flood-affected males who are illiterate (6.7%) is higher compared to non-affected males (5.2%), Similarly (χ^2= 36.87df=6, p-value=0.00) the proportion of flood-affected females with a primary school education (14.7%) is lower than that of non-affected females (19.4%).

Family Type

A total of 59.4% of male and 57% of the female participant belongs to nuclear family, while 38.1 % male and 38.4 % female were in the joint family and only 2.5 % of male and 4.6 % female were part of extended family type. However, the χ^2 value does not indicate any statistically significant differences between the two groups regarding family type.

Diet

In case of the diet of the participant, majorities 77.1% of males and 62.1% of females are non-vegetarians and the remaining participants are vegetarians (22.9% and 37.9% respectively). Significant differences were observed among the male and female of between flood affected and non-affected (χ^2=9.88, df=1, p-value=0.00) and, χ^2=27.67, df=6, p-value=0.00) respectively). The proportion of flood-affected individuals who follow a vegetarian diet (27.5%) is higher than that of non-affected individuals (19.2%).Lastly, the table includes information on ethnic groups, namely general, backward caste, scheduled caste, and scheduled tribe. It presents the number and percentage of individuals in each ethnic group category for both flood-affected and non-affected samples, the table reveals that 82.9% male and 81% females belong to the general caste while only 17.1% of males and 19% of remaining participants belong to backward, schedule caste and schedule tribe. The chi square (χ^2=0.43,df=3, p-value=0.93) was found insignificant for the males, on the other hand it was found significant for the females (χ^2=10.0,df=4, p-value=0.04).The proportion of flood-affected individuals belonging to the scheduled caste (10.2%) is higher compared to non-affected individuals (9.1%).

Body Weight

Age, sex, and flood exposure wise growth trend of anthropometric measurements (viz; Body weight and stature) are presented in Table 2, which depict that during the period from 4 to 18 years of age, both flood-affected and non-flood-affected individuals experienced a consistent growth in average weight. Among flood-affected males, the highest increment of body weight was 4.4 Kg among children aged 6 to 7 and 11 to 12 years.

TABLE 1

Background characteristics of the sample and their family

Background Characteristics	Male							Female						
	Flood-affected		Non-affected		Total		χ^2	Flood-affected		Non-affected		Total		χ^2
	N	%	N	%	N	%		N	%	N	%	N	%	
Fathers' Education														
Illiterate	31	6.7	29	5.2	60	5.9	18.72**	31	8.7	16	4.2	47	6.4	36.870**
Primary School	48	10.4	69	12.4	117	11.5		49	13.8	61	16.0	110	14.9	
Middle School	111	24.0	178	31.9	289	28.3		82	23.1	137	35.9	219	29.7	
High School	105	22.7	142	25.4	247	24.2		74	20.8	100	26.2	174	23.6	
Higher Sec. School	74	16.0	64	11.5	138	13.5		57	16.1	31	8.1	88	11.9	
Graduate	20	4.3	14	2.5	34	3.3		11	3.1	7	1.8	18	2.4	
Post Graduate and above	73	15.8	62	11.1	135	13.2		51	14.4	30	7.9	81	11.0	
Total	462	100	558	100	1020	100		355	100	382	100.1	737	100	
Mothers' Education														
Illiterate	30	6.5	57	10.2	87	8.5	31.54**	35	9.9	41	10.7	76	10.3	27.27**
Primary School	68	14.7	108	19.4	176	17.3		52	14.6	94	24.6	146	19.8	
Middle School	178	38.5	145	26.0	323	31.7		112	31.5	110	28.8	222	30.1	
High School	87	18.8	140	25.1	227	22.3		77	21.7	95	24.9	172	23.3	
Higher Sec. School	61	13.2	81	14.5	142	13.9		48	13.5	31	8.1	79	10.7	
Graduate	15	3.2	16	2.9	31	3.0		15	4.2	7	1.8	22	3.0	
Post Graduate and above	23	5.0	11	2.0	34	3.3		16	4.5	4	1.0	20	2.7	
Total	462	100	558	100	1020	100		355	100	382	100	737	100	
Family Type														
Nuclear	257	55.6	349	62.5	606	59.4	5.03	200	56.3	220	57.6	420	57.0	0.16
Joint	193	41.8	196	35.1	389	38.1		139	39.2	144	37.7	283	38.4	
Extended	12	2.6	13	2.3	25	2.5		16	4.5	18	4.7	34	4.6	
Total	462	100	558	100	1020	100		355	100	382	100	737	100	
Dietary habits														
Vegetarian	127	27.5	107	19.2	234	22.9	9.88**	169	47.6	110	28.8	279	37.9	27.67**
Non-Vegetarian	335	72.5	451	80.8	786	77.1		186	52.4	272	71.2	458	62.1	
Total	462	100	558	100	1020	100		355	100	382	100	737	100	
Ethnic Group														
General	382	82.7	464	83.2	846	82.9	0.43	279	78.6	318	83.2	597	81.0	10.00*
Backward Caste	32	6.9	42	7.5	74	7.3		22	6.2	32	8.4	54	7.3	
Schedule Caste	47	10.2	51	9.1	98	9.6		51	14.4	29	7.6	80	10.9	
Scheduled Tribe	1	0.2	1	0.2	2	0.2		3	0.8	3	0.8	6	0.8	
Total	462	100	558	100	1020	100		355	100	382	100	737	100	

All χ^2-value in asterisks is significant at $p<0.05$

All χ^2-value in double asterisks is significant at $p<0.001$

In contrast, non-affected males showed their highest weight increment between the ages of 9 to 10 and 11 to 12 years. The total increment of body weight from the age of 4 to 18 years was 35.3 Kg for flood-affected males and 34.1 Kg for non-affected males. For flood-affected females, the most significant weight increment of 4.8 kg occurred between the ages of 14 to 15 years, followed by 3.8 Kg between 17 to 18 years. Among non-flood-affected females, the highest increments of body weight was 4.7 Kg at ages 7 to 8 and 9 to 10 years. Overall, these findings indicate notable differences in growth patterns between males and females in the context of flood impact.

TABLE 2

Comparison of Body Weight in Flood-Affected and Non-Affected Children by Age and Gender in Rudraprayag District, Uttarakhand

Age (Years)	Body Weight (kg)																			
	Male										Female									
	Flood- affected				Non-affected						Flood-affected				Non-affected					
	N	Mean	SD	Increment (%)	N	Mean	SD	Increment (%)	Total	t-value	N	Mean	SD	Increment (%)	N	Mean	SD	Increment (%)	Total	t-value
4	6	14.3	2.5	-	17	15.6	1.5	-	23	-1.08	7	13.0	1.0	-	22	13.8	1.8	-	29	-1.1
5	5	15.6	1.5	9.1	13	15.5	1.1	-0.6	18	-0.86	6	13.0	0.9	0.0	9	13.7	1.2	-0.7	15	-0.9
6	19	16.4	1.8	5.1	19	18.1	1.6	16.8	38	-4.25	15	14.9	1.3	1.9	24	17.4	1.2	27.0	39	-4.2
7	11	20.8	1.3	26.8	48	20.8	1.0	14.9	59	-0.40	8	18.5	0.8	3.6	39	18.7	1.3	7.5	47	-0.4
8	26	20.8	1.5	0.0	18	22.7	0.9	9.1	44	0.29*	16	20.7	1.7	2.2	21	20.5	1.4	9.6	37	0.3*
9	30	24.2	3.1	16.3	29	24.2	2.7	6.6	59	-0.20	25	22.6	1.6	1.9	26	22.8	2.6	11.2	51	-0.2
10	53	27.5	3.1	13.6	44	27.8	2.9	14.9	97	-3.54	55	24.6	1.6	2.0	32	27.5	3.4	20.6	87	-3.5
11	61	28.2	2.5	2.5	40	28.4	1.7	2.2	101	-2.24	40	26.4	1.6	1.8	30	27.9	2.3	1.5	70	-2.2
12	49	32.6	2.0	15.6	30	32.0	2.3	12.7	79	-5.03	41	30.0	1.0	3.6	32	32.6	2.0	16.8	73	-5.0
13	61	34.9	2.0	7.1	49	35.0	2.5	9.4	110	-8.12	43	30.6	1.2	0.6	19	35.3	1.7	8.3	62	-8.1
14	51	38.2	3.5	9.5	50	37.9	3.1	8.3	101	-2.31	23	35.4	1.0	4.8	17	38.1	3.8	7.9	40	-2.3
15	27	41.0	3.7	7.3	107	40.5	4.7	6.9	134	-0.35	27	39.1	3.6	3.7	88	39.5	5.0	3.7	115	-0.3
16	21	45.1	3.0	10.0	44	43.4	3.2	7.2	65	-1.65	27	41.6	1.3	2.5	13	43.2	2.7	9.4	40	-1.7
17	20	47.2	3.0	4.7	36	46.7	2.5	7.6	56	-1.12	8	44.7	1.2	3.1	7	46.5	3.0	7.6	15	-1.1
18	22	49.6	2.4	5.1	14	49.7	2.4	6.4	36	0.25*	14	48.5	1.8	3.8	3	47.7	4.7	2.6	17	0.3*
Total (N)	462				558				1020		355				382				737	

All t-value *in asterisks is significant at* $p<0.05$

All t-value *in double asterisks is significant at* $p<0.001$

Difference in body weight between flood affected and non-affected populations among the children and adolescents indicate that the bodyweight of the flood-affected population was lower as compared to the non-flood-affected population, but the difference of body weight between the flood-affected and non-affected for the male population were negligible; moreover, the difference for the adolescent's female can be seen. It can be inferred from Table 2 that there is no impact of the flood on body weight among the children and adolescents of the Rudraprayag district of Uttarakhand.

To understand the growth trend of the present studied population in reference to flood affected, non-affected and international standards a comparative line graph of three i.e., flood affected, non-affected and NCHS 2005 (National Centre for Health Statistics) was drawn. In the initial stage of life, up to 8 years of the age, the gap between mean body weight (Fig.1) of NCHS and present studied population is less, but with the increment of age the gap is widen significantly. Although the line graph of flood affected & non affected is overlapping. Hence it is apparent that there is no difference in mean body weight of flood affected & non affected individual of 4 to 18 years of Males although they are not up to NCHS standard.

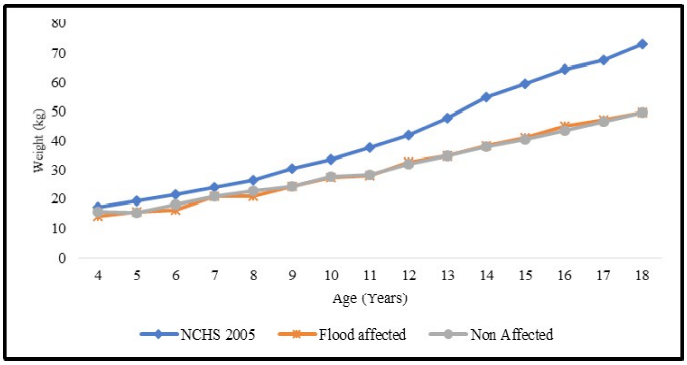

Fig. 1: Comparison of body weight between flood affected, non-affected males of Rudraprayag district and NCHS data

In case of females (Fig. 2), at the age of 4, NCHS standard is 16.79 kg. However, females who were affected by flooding weighed slightly less at 13 kg, while those not affected had an average weight of 13.8 kg. As the females progress in age, the weights generally increase. However, it can be seen that the impact of flooding appears to vary. In all the age group, flood-affected females have lower body weights compared to their non-affected counterparts. As age progress, the discrepancies in weight between females (of both group flood-affected and non-affected) and NCHS standard become more prominent and pronounced.

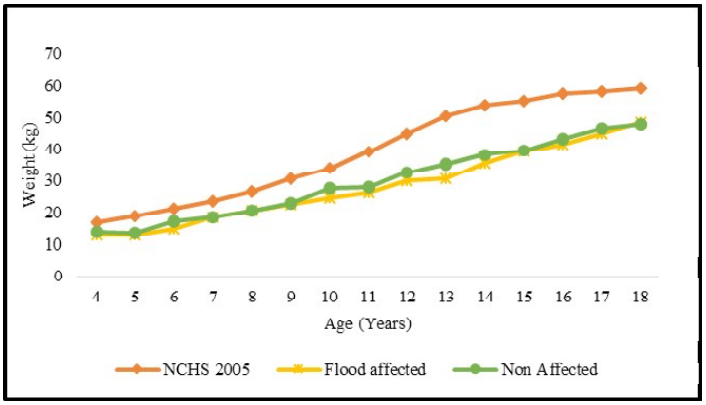

Fig. 2: Comparison of body weight between flood affected, non-affected females of Rudraprayag district and NCHS data

Stature

In the case of stature (Table 3); non-flood-affected children and adolescents of both the sexes are taller as compared to the flood-affected, further onward 10 years of age for the female counterpart the difference is broader between the flood-affected and non-affected population. The highest increment in stature of flood-affected males was from the age of 6 to 7 years (16.3 cm) followed by 14 to 15 years (10.7 cm). The highest increment of stature among the male who hadn't been affected by the flood was found in the age of 6 to 7 years (9.6 cm) followed by 14 to 15 (8.7 cm). In case of flood-affected females, the increment was found in the age of 6 to 7 years (12.1 cm) followed by 7 to 8 years (10.9cm), while among the female who hadn't been affected by the flood, the highest increment was found in the age of 6 to 7 years of age (10.3 cm) followed by the age 4 to 5 years (8.7 cm). The total increment for flood-affected and non-affected males was 75.1 cm and 69.6 cm respectively in the case of females this total increment was found 61.1 cm and 66.8 cm respectively.

To understand the impact of the flood on the stature of males and females paired t-test was executed in SPSS, which was found significant for males of 15 years of age. On the other hand, females are highly affected by the flood during the age of 5 to 18 (except females of age 8,9 and 10 years). There is significant difference in stature between flood-affected and non-affected females.

TABLE 3

Comparison of stature in Flood-Affected and Non-Affected Children by Age and Gender in Rudraprayag District, Uttarakhand

Age (Years)	Stature (cm)													
	Male							Female						
	Flood- affected			Non-affected			t-value	Flood-affected			Non-affected			t-value
	Mean	SD	Increment (%)	Mean	SD	Increment (%)		Mean	SD	Increment (%)	Mean	SD	Increment (%)	
4	91.3	1.9	-	93.6	3.4	-	1.59	90.6	0.8	-	91.7	3.4	-	0.89
5	97.0	1.4	6.2	100.5	5.9	7.4	1.30	89.2	1.0	-1.5	100.4	6.0	9.5	4.52**
6	102.8	4.4	6.0	105.4	4.3	4.9	1.82	96.3	2.8	8.0	103.5	4.5	3.1	5.56**
7	119.1	4.2	15.9	115.0	5.6	9.1	2.29	108.4	2.1	12.6	113.8	4.5	10.0	3.37**
8	119.6	1.7	0.4	119.9	2.8	4.3	0.49	119.3	2.7	10.1	118.3	2.1	4.0	1.22
9	123.8	5.0	3.5	122.5	4.3	2.2	1.03	119.8	2.0	0.4	120.8	3.5	2.1	1.15
10	129.9	5.0	4.9	129.0	4.6	5.3	0.91	126.7	3.2	5.8	128.0	4.8	6.0	1.51
11	133.8	5.9	3.0	133.6	5.5	3.6	0.21	129.1	2.2	1.9	133.8	6.6	4.5	4.17**
12	139.1	6.6	4.0	136.5	5.8	2.2	1.76	132.7	2.3	2.8	138.3	7.2	3.4	4.73**
13	140.8	6.2	1.2	141.8	5.1	3.9	0.92	134.4	2.5	1.3	144.7	8.3	4.6	7.41**
14	148.4	5.1	5.4	147.4	5.5	3.9	0.95	142.5	2.1	6.0	149.1	5.0	3.0	5.74**
15	159.1	6.4	7.2	156.1	5.8	5.9	2.37*	144.3	3.0	1.3	152.5	4.0	2.3	9.71**
16	163.7	5.9	2.9	161.3	6.5	3.3	1.43	146.7	2.8	1.7	156.5	3.1	2.6	10.02**
17	162.3	5.5	-0.9	163.7	5.3	1.5	0.94	154.3	0.9	5.2	159.1	1.4	1.7	8.00**
18	166.4	4.9	2.5	163.2	4.1	-0.3	0.59	151.7	1.2	-1.7	158.5	2.5	-0.4	7.41**

All t-value *in asterisks is significant at p<0.05*
All t-value *in double asterisks is significant at p < 0.001*

It can be observed from the figure 3 that both the flood-affected and non-affected males generally have lower stature as compared to the NCHS standard. However, the non-affected Males tend to have slightly higher stature than the flood-affected Males across most age groups. By the age of 10 years, the non-affected Males are very slightly closer to the NCHS standard, while the flood-affected Males were lagging behind.

In case of females (Fig. 4), both groups (flood affected & non affected) are smaller in stature as compared to the NCHS standard, with flood-affected having a slightly lower stature than non-affected females.

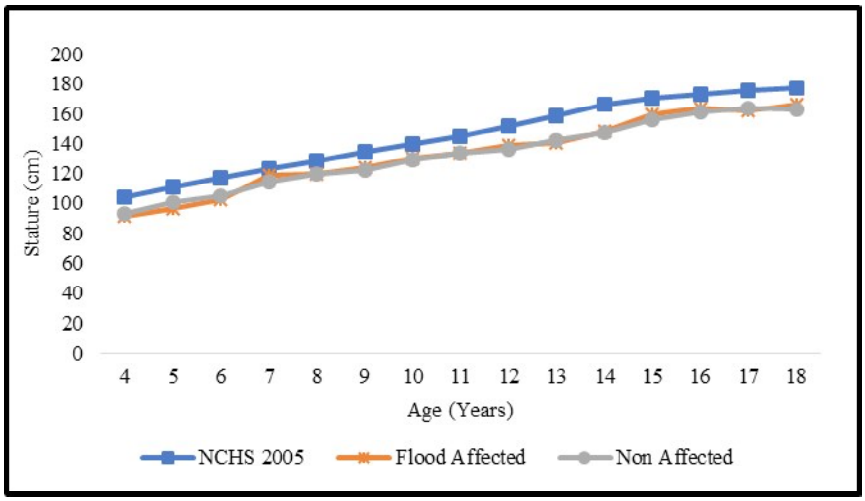

Fig. 3: Comparison of Stature between flood affected, non-affected Males of Rudraprayag district and NCHS data

This trend continues as they progress through the ages of 6 and 7 year. By the age of 8 to 10 years, both flood-affected and non-affected females have similar stature. Between ages 11 to 14 years, the present studied group consistently has broader gap with NCHS standard, this trend suggests that growth becomes more noticeable during this period while moving to the 15 to 18 years, the gap becomes narrow for the same.

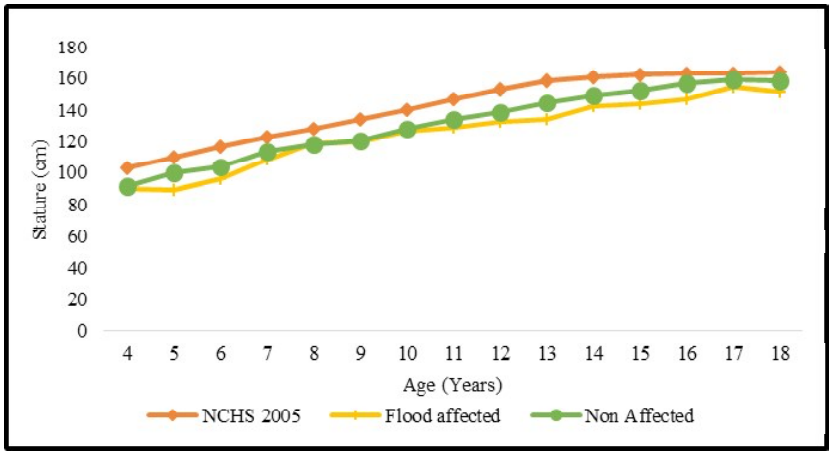

Fig. 4: Comparison of Stature between flood affected, non-affected Females of Rudraprayag district and NCHS data

Scatter plot diagram is used to visualize the relationship between Bodyweight and Stature of flood-affected and non-affected males and females (Fig. 5).

DISCUSSION

The growth and development of humans are complex processes influenced by multiple factors. While extensive research has been conducted on various determinants of human growth and development, the specific effects of natural calamities, such as floods, have received limited attention. Consequently, there is a notable research gap regarding the role of floods in shaping the growth and development of children and adolescents. Floods have both short-term and long-term impacts on growth spurts in children and adolescents.

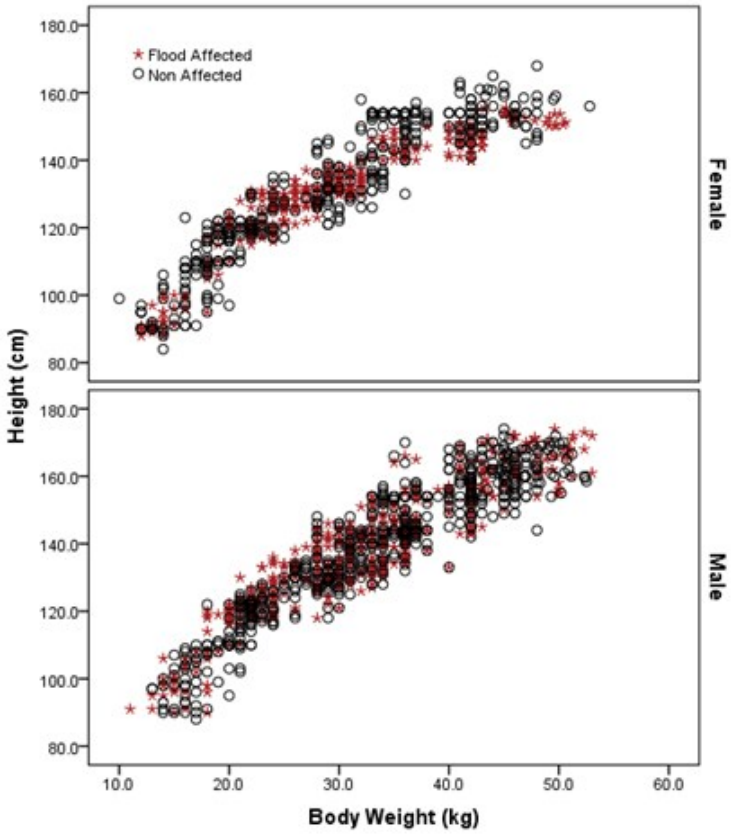

Fig. 5: Scattered plot diagram showing differential correlation of body weight and stature among the flood affected and non-affected individual from age 4 to 18 Years

Floods often disrupt the availability and access to food, leading to inadequate nutrition. Children experience a lack of essential nutrients, vitamins, and minerals necessary for proper growth. Prolonged malnutrition result in stunted growth and delayed physical development (Antipova and Curtis, 2015). Floodwaters become contaminated with various pathogens, including bacteria, viruses, and parasites. Children are particularly vulnerable to waterborne diseases such as cholera, typhoid, and diarrhoea, which cause malabsorption of nutrients, weight loss, and overall physical weakness (Agabiirwe *et al*., 2022; Mallett *et al*., 2018; Rodriguez-Llanes *et al*., 2016). Floods damage sanitation infrastructure, leading to a lack of proper hygiene facilities. The absence of clean water, functional toilets, and proper waste disposal systems increases the risk of infections and diseases. Poor sanitation further affects children's health, impeding their physical growth and development (Mohamed *et al*., 2012). Floods can be traumatic events for children and adolescents. They may experience fear, anxiety, and emotional distress due to displacement, loss of belongings, and witnessing the destruction. Prolonged exposure to stress can negatively affect physical growth, as stress hormones can disrupt normal hormonal balance and impair overall development (Brock *et al.*, 2015; Hilmert *et al*., 2016; Stephenson *et al*., 2014b).Several studies have documented that flood-affected populations, particularly females, tend to exhibit diminished weights and reduced statures when compared to their non-affected counterparts. Findings of this study corroborate with the study conducted by Xue *et al.* (2018) who examined the effects of floods on the nutritional status of flood-affected individuals in rural China and found that both male and female flood survivors had significantly lower body weights and reduced statures compared to individuals from unaffected communities. However, the decrease in

body weight and stature was more pronounced among females. Similarly, a study by Khan *et al*. (2017) investigated the impact of floods on the nutritional status of women and children in Bangladesh which indicated that flood-affected females had lower body weights and reduced statures compared to non-affected females in the same age group. The present study conducted in Rudraprayag revealed that males exhibited slightly better growth patterns compared to females across various age groups. This finding aligns with previous research conducted by Xue *et al*. (2018) and Khan *et al. (*2017). Additionally, the study found no significant difference in body weight between individuals affected by floods and those who were not affected, except for the age groups of 8 and 18 years in both males and females. However, it was observed that females who were exposed to floods had significantly smaller stature compared to their counterparts who were not exposed. These findings corroborate the existing literature and further contribute to our understanding of the impact of floods on growth parameters (Xue *et al*., 2018; Khan *et al.,* 2017). These findings are consistent with the broader literature on the impact of natural disasters on anthropometric indicators. During flood events, the destruction of infrastructure, loss of crops, and contamination of water sources can lead to limited access to food and clean water. This scarcity of resources can result in malnutrition, weight loss, and growth stunting, particularly among vulnerable populations such as females. It can be stated that the mean values of anthropometric measurements (Bodyweight, Stature) increase with the age, but at a different rate at the different age levels. A difference in the pattern of growth among males and females was found.

CONCLUSION

The findings of the study indicate distinct growth patterns in terms of body weight and stature between males and females. The body weight of flood-affected individuals was found comparatively lower than the non-affected cohort although the difference was found insignificant. However, significant differences in body weight were observed only in the cohort of age of 8 and 18 years, furthermore, when comparing the body weight of both flood-affected and non-affected individuals to the NCHS standard, it was found that present studied population are lagging behind in their body weight from the international weight standard.

Further, flood-affected children and adolescents had shorter stature as compared to their non-affected counterparts. The difference in stature was more pronounced among females, especially beyond the age of 10 years. The largest stature increments for flood-affected males occurred at the ages of 6-7 and 14-15, while for flood-affected females, it was at the ages of 4-5 and 6-7 years. Statistical analysis revealed a significant difference in stature between flood-affected and non-affected females, particularly in the age range of 5-18 years, except for ages 8, 9, and 10 years. These findings highlight the need for further research and targeted interventions to address the impact of floods on growth and development. It is again established that the natural calamities like flood have inverse effect of the growth and development of the children and adolescents.

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