Vitamin B12 Deficiency: Case Study of Vadodara, Ahmedabad and Surat City

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Abstract: **Vitamin B_{12} also known as cobalamin which is one of the eight B - vitamins, is a water-soluble (body does not store) vitamin with a vital role in the normal functioning of the brain and nervous system, and also important for the formation of blood. Vitamin B_{12} is found in most animal derived foods, including fish and shellfish, meat (especially liver), poultry, eggs, milk, and milk products. Vitamin B_{12} deficiency can potentially cause severe and irreversible damage, especially to the brain and nervous system. Psychological indices related to dementia and depression may be improved through B12 supplementation.**

In this paper we have tried to depict the overall picture of Vitamin B12 in selected cities. In Gujarat vegan or vegetarian population is more than that of non vegetarian. So we have collected data from different laboratories and doctors from Ahmedabad, Surat and Vadodara. It was found that almost 27% of people are having deficiency of B12 level. The lowest deficiency of B12 level is in Surat (15%) and the highest deficiency of B12 level is in Ahmedabad (35%). We have also tried to produce future limits using parametric and non parametric tests.

Key words**: Vitanit D3, Parametric Limits, Nonparamtri limits, Staistical significance.**

I. INTRODUCTION

All eight B vitamins help the body by converting food (carbohydrates) into fuel (glucose), through which energy is produced. These B vitamins often referred to as B complex vitamins; also help our body to use fats and protein. B complex vitamins are necessary for healthy skin, hair, eyes, and liver.

Vitamin B_{12} also known as **cobalamin** which is one of the eight B - vitamins, is a water-soluble (body does not store) vitamin with a vital role in the normal functioning of the brain and nervous system, and also important for the formation of blood. It is normally involved in the metabolism of every cell of the human body, especially affecting not only DNA synthesis and regulation but also fatty acid metabolism and amino acid metabolism. Fungi, plants, animals or human beings cannot produce Vitamin B_{12}. Though many foods are a natural source of B_{12} because of bacterial symbiosis, only bacteria and archaea have the enzymes required for its synthesis. Vitamin B12 is the largest and most structurally complicated vitamin and can be produced industrially only through bacterial fermentation-synthesis.

II. SOURCE OF VITAMIN B12

Vitamin B_{12} is found in most animal derived foods, including fish and shellfish, meat (especially liver), poultry, eggs, milk, and milk products. (National Institute of Health, 2011) listed a fact sheet which showed variety of animal food sources of B_{12}. Vegans and Vegetarians who do not use animal products should take vitamin B12 product with water preferably after meal. It is proved through research the elderly people may need larger amount of vitamin B12 supplements than younger people because the body's ability to absorb vitamin B12 from the diet declines with age.

III. DEFICIENCY

Vitamin B_{12} deficiency can potentially cause severe and irreversible damage, especially to the brain and nervous system. At levels only slightly lower than normal, a range of symptoms such as fatigue, depression, and poor memory may be experienced. Sometimes low level of B12 can cause shortness of breath, nervousness, numbness and Tingling sensation in the fingers and toes.

IV. SOME LITERATURE ON VITAMIN B12

(Doscherholmen, McMahon and Ripley, 1975) deliberated that though eggs are source of obtaining B12, the binding capacity of egg yolks and egg whites is noticeably diminish due to heat treatment.

(Russell, Baik and Kehayias, 2001) studied adult men and women of age 60 or greater than 60 years from the general population of Boston and screened at the Metabolic Research Unit of the Human Nutrition Research Center on Aging at Tufts University. They excluded the prople who have a body mass index of .30 kg/m2; a history of current use of antibiotics, histamine (H2) receptor antagonists, proton

pump inhibitors or antacids; history of gastric or intestinal surgery, diabetes mellitus, pancreatic disease or excessive alcohol consumption. The people taking multivitamin supplement containing vitamin B-12 within 1 month of starting the study as well as the people who received a vitamin B-12 injection within 1 year before the study were also excluded. Then total sample size came at 16. They divided them in three groups. First group having 6 people were given water, second group having 5 people were given milk and third group having 5 people were given fortified bread. On the basis of data analysis, it seemed that the mean value of absorption of vitamin B12 was respectively 55%, 65% and 55%. There was no any statistically significant difference among three groups.

(Ryan – Hashman and Aldoori, 2008) discussed in his paper that vitamin B12 levels may reasonably influence the development of cancer as a result of genetic polymorphisms. The precious information about nutrient-gene interactions and chronic disease is likely to be generated by new field of nutritional genomics. It was also depicted that psychological indices related to dementia and depression may be improved through B12 supplementation, which should be recommended in conjunction with pharmacotherapy.

(Sobczyńska-Malefora A. et al., 2014) studied on the basis of all samples received for the assessment of vitamin B12 status between January 17th and April 16th 2012 from in- and out-hospital patients from both Guy's and St. Thomas' Hospitals, London, UK. They considered the parameters Methylmalonic acid(MMA), Holotranscobalamin (holoTC), Leucocytes (WBC), erythrocytes (RBC) and haemoglobin (Hb) for the study. The variables which were not normally distributed even after the log10 transformation statistical analyses using either nonparametric tests. The Mann–Whitney test was used to compare values between patients with known and unknown estimated glomerular filtration rate (eGFR). Spearman rank correlation coefficients were used to assess simple correlation coefficient. Correlation coefficients were found significant between holoTC with MMA, RBC, creatinine, WBC and folate as well as between MMA with creatinine, age and MCV.

(Hunt, 2014) stated in the paper that deficiency can apparent in different groups such as during growth in children and adolescence or in pregnancy as during this period requirements are increased. Certain groups like people with poor nutrition, older people or people who adhere to a vegan or vegetarian diet may have less intake of B12 which results to its deficiency.

In this paper we have tried to check prevailing level of B12 in selected cities. Gujarat has more vegetarian population than non vegetarian population. Many people of Gujarat are even Vegan. So there may be the reason of deficiency of B12. Even many people do not eat sufficient milk and milk products.

V. DATA COLLECTION AND DATA DESCRIPTION

We have collected data from different laboratories and doctors from Ahmedabad, Surat and Vadodara. But following points should be kept in mind while making any general statement.

- Majority of the data are due to the suggested blood test following some health problems. Very few observations are from free check up camp.
- For many cases observations were given as > some value, in those cases for the sake of analysis we have taken next integer value as the observed value, therefore instead of mean we suggest to observe median as the measure. And hence for inference nonparametric techniques.
- In Ahemdabad data neither sex nor the ages are specified therefore we tried to identify the sex from the names. So there chances of mistake to identify the sex as some names may be common for both male and female. Where as in data from Surat and Vadodara, sex is mentioned as only male and female. So child category is prepared from male and female whose age is up to 15.
- For all the categories (sex wise as well as age wise) common limits are used.

B12 Analysis of collected data from different labs of consideredcity

Table:1: details of No. of data

City	no. of observations	Obs.s with age	Obs.with sex
Surat	4002	4002	3990
Vadodara	6784	6776	6784
Ahmedabad	3752	0	3688
Total	**14538**	**10778**	**14462**

Table: 2: age wise category

Age wise Category	Age
Child (C)	0 - 15
Adult (A)	15 -60
Senior citizens (S.C.)	≥ 60

Table: 3: Sex wise Category
Child (C)
Male (M)
Female (F)

Table 4: B12 Level limits used by Indian labs (pg/ml)	
Deficiency	<187
Normal	187 to 883
Good	>883

VI. STATISTICAL ANALYSIS

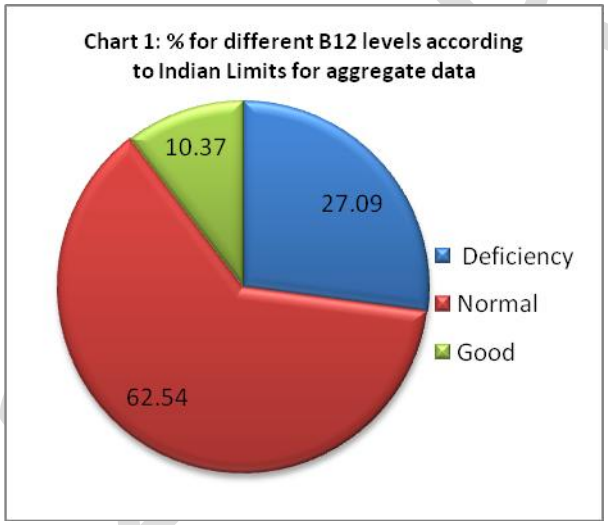
- *Comparisons on the basis of descriptive statistics*:

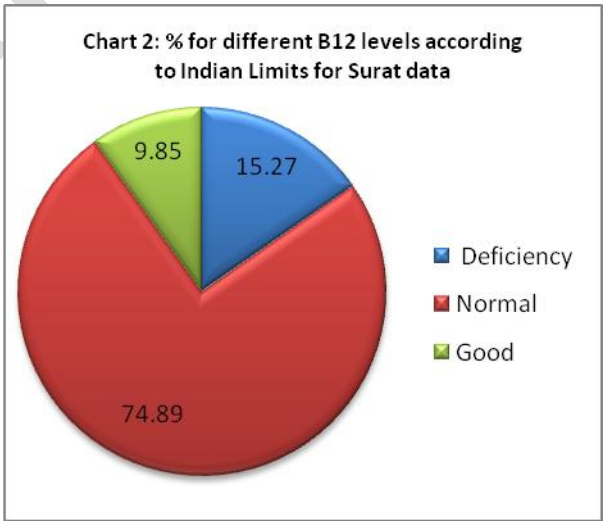
i) Overall comparison:

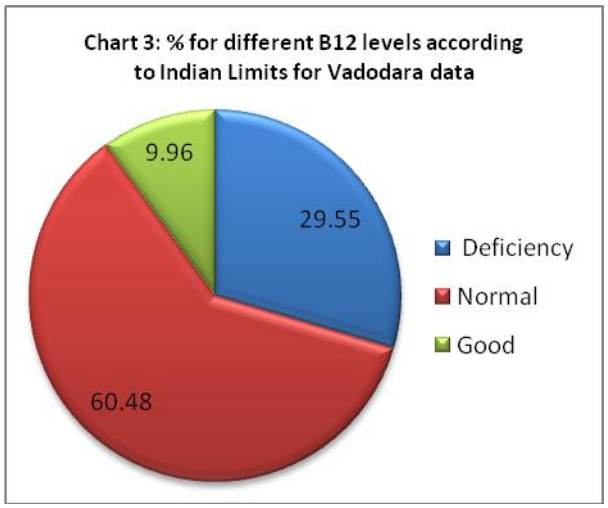
In the given sample of 14538 persons, percentage of people having different levels of B12 according to Indian limits are reported in the following table: 5. From the table it is very clear that almost 27% of people are having deficiency of B12 level. The lowest deficiency of B12 level is in Surat (15%) and the highest deficiency of B12 level is in Ahmedabad (35%).

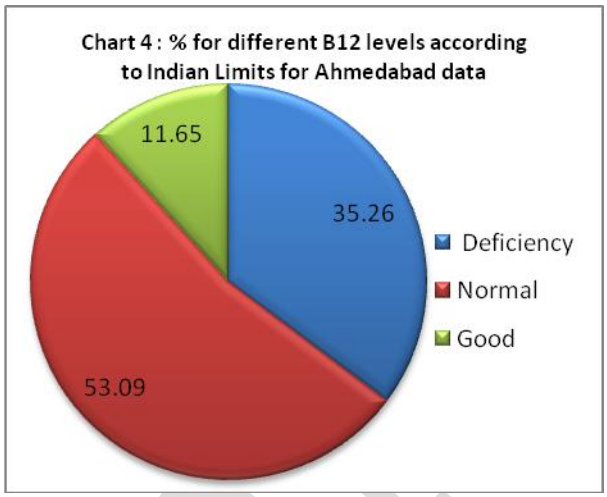
Table: 5: Percentage for different B12 levels according to Indian Limits (combined)

Level of B12	Aggregate	Surat	Vadodara	Ahmedabad
Deficiency	27.09	15.27	29.55	35.26
Normal	62.54	74.89	60.48	53.09
Good	10.37	9.85	9.96	11.65









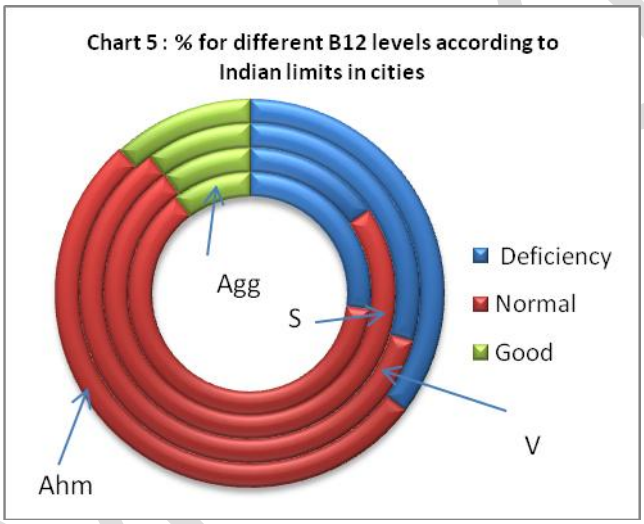


Table: 6(A) : Percentiles number for different cut off points of the limits of B12 level for aggregate data (Including Ahmedabad Data)			
N	14538		
Median	273.0000		
Mode	149.00		
Minimum	1.39		
Maximum	4031.00		
Percentile	10	149.0000	Maximum count for first 10% of ordered data
	20	164.0000	Maximum count for first 20% of ordered data
	25	179.9500	Maximum count for first 25% of ordered data
	27.09	**186.2000**	**Maximum count for first 27.09% of ordered data**
	27.1	**187.0000**	**Maximum count for first 27.10% of ordered data**
	27.47	**187.0000**	**Maximum count for first 27.47% of ordered data**
	27.48	**187.1903**	**Maximum count for first 27.48% of ordered data**
	30	197.0000	Maximum count for first 30% of ordered data
	40	232.0000	Maximum count for first 40% of ordered data
	50	273.0000	Maximum count for first 50% of ordered data
	60	326.0000	Maximum count for first 60% of ordered data
	70	403.0000	Maximum count for first 70% of ordered data
	75	460.0000	Maximum count for first 75% of ordered data
	80	545.0000	Maximum count for first 80% of ordered data
	89.62	**882.0000**	**Maximum count for first 89.62% of ordered data**
	89.63	**883.0306**	**Maximum count for first 89.63% of ordered data**
	90	910.0000	Maximum count for first 90% of ordered data

Table: 6(B) : Percentiles number for different cut off points of the limits of B12 level for Surat data			
N	4002		
Median	298.0000		
Mode	2001.00		
Minimum	68.00		
Maximum	2001.00		
Percentile	10	169.0000	Maximum count for first 10% of ordered data
	15.28	**186.6584**	**Maximum count for first 15.28% of ordered data**
	15.29	**187.0000**	**Maximum count for first 15.29% of ordered data**
	20	201.0000	Maximum count for first 20% of ordered data
	25	217.0000	Maximum count for first 25% of ordered data
	30	231.0000	Maximum count for first 30% of ordered data
	40	261.0000	Maximum count for first 40% of ordered data
	50	298.0000	Maximum count for first 50% of ordered data
	60	347.0000	Maximum count for first 60% of ordered data
	70	413.0000	Maximum count for first 70% of ordered data
	75	468.2500	Maximum count for first 75% of ordered data
	80	537.0000	Maximum count for first 80% of ordered data
	90	876.0000	Maximum count for first 90% of ordered data
	90.14	**882.9126**	**Maximum count for first 90.14% of ordered data**
	90.15	**884.1135**	**Maximum count for first 90.15% of ordered data**

Table: 6(C) : Percentiles number for different cut off points of the limits of B12 level for Vadodara data			
N	6784		
Median	262.0000		
Mode	149.00		
Minimum	1.39		
Maximum	2001.00		
Percentile	10	149.0000	Maximum count for first 10% of ordered data
	20	159.0000	Maximum count for first 20% of ordered data
	25	174.0000	Maximum count for first 25% of ordered data
	29.56	**186.7168**	**Maximum count for first 29.56% of ordered data**
	29.57	**187.0000**	**Maximum count for first 29.57% of ordered data**
	29.97	**187.0000**	**Maximum count for first 29.97% of ordered data**
	29.98	**187.0858**	**Maximum count for first 29.98% of ordered data**
	30	187.6500	Maximum count for first 30% of ordered data
	40	222.2000	Maximum count for first 40% of ordered data
	50	262.0000	Maximum count for first 50% of ordered data
	60	315.0000	Maximum count for first 60% of ordered data
	70	392.0000	Maximum count for first 70% of ordered data
	75	449.2250	Maximum count for first 75% of ordered data
	80	535.0000	Maximum count for first 80% of ordered data
	90	879.5000	Maximum count for first 90% of ordered data
	90.02	**882.5710**	**Maximum count for first 90.02% of ordered data**
	90.03	**883.0536**	**Maximum count for first 90.03% of ordered data**

Table: 6(D) : Percentiles number for different cut off points of the limits of B12 level for Ahmedabad data			
N	3752		
Median	255.5000		
Mode	82.00		
Minimum	82.00		
Maximum	4031.00		
Percentile	10	95.0000	Maximum count for first 10% of ordered data
	20	132.0000	Maximum count for first 20% of ordered data
	25	149.2500	Maximum count for first 25% of ordered data
	30	167.0000	Maximum count for first 30% of ordered data
	35.27	**186.6831**	**Maximum count for first 35.27% of ordered data**
	35.28	**187.0000**	**Maximum count for first 35.28% of ordered data**
	35.54	**187.0000**	**Maximum count for first 35.54% of ordered data**
	35.55	**187.1915**	**Maximum count for first 35.55% of ordered data**
	40	206.0000	Maximum count for first 40% of ordered data

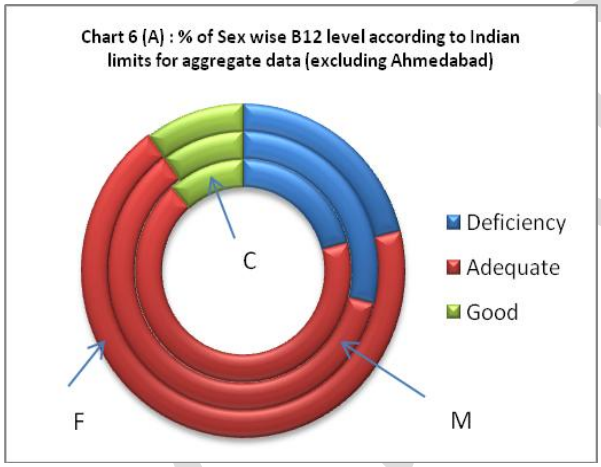
	50	255.5000	Maximum count for first 50% of ordered data
	60	316.0000	Maximum count for first 60% of ordered data
	70	407.0000	Maximum count for first 70% of ordered data
	75	476.0000	Maximum count for first 75% of ordered data
	80	567.0000	Maximum count for first 80% of ordered data
	88.34	**882.6008**	**Maximum count for first 88.34% of ordered data**
	88.35	**884.1020**	**Maximum count for first 88.35% of ordered data**
	90	1032.1000	Maximum count for first 90% of ordered data

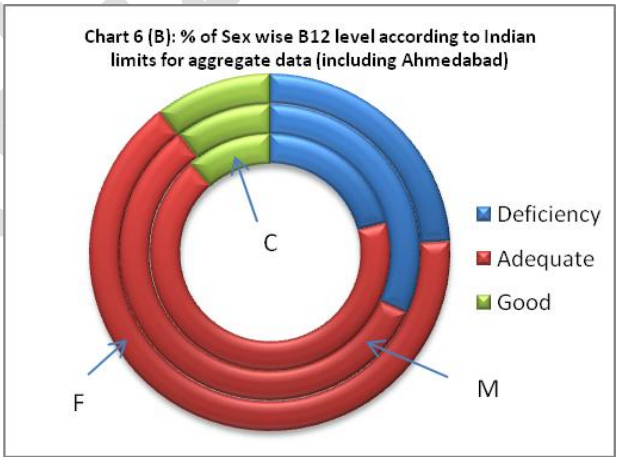
From the table of percentile it becomes easier to observe that how many % of people are having the B12 level below that particular value.

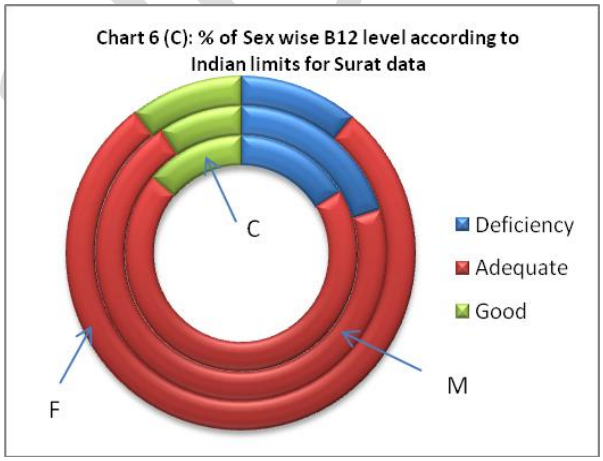
ii) Sex wise comparison:

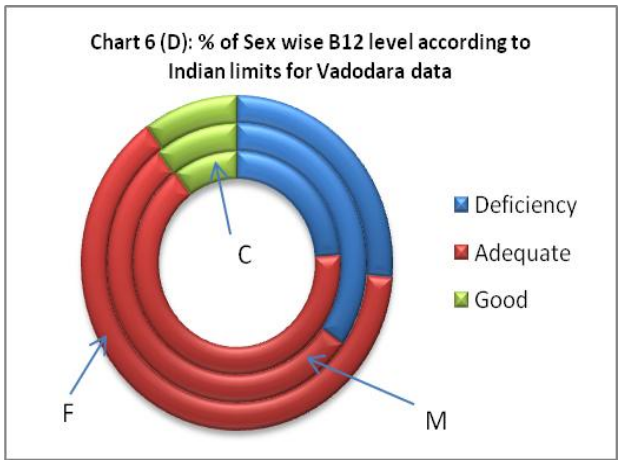
Table 7: Sex wise % of different B12 level for aggregate, surat, vadodara and Ahmedabad Data

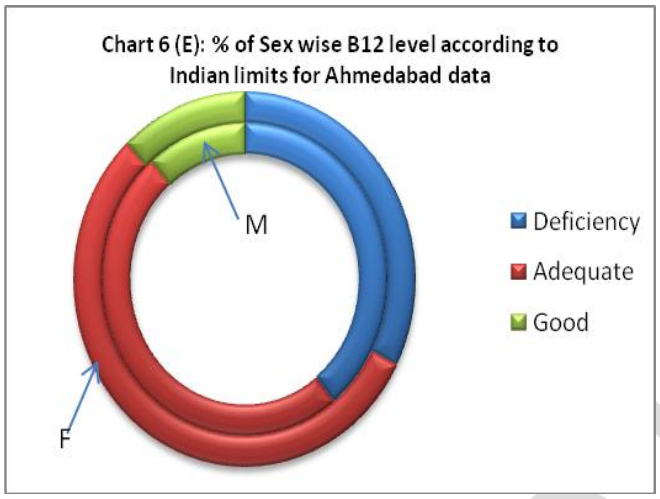
Level of B12	Aggregate (Excluding Ahmedabad)			Aggregate (Including Ahmedabad)			Surat			Vadodara			Ahmedabad		
	C	M	F	C	M	F	C	M	F	C	M	F	C	M	F
Deficiency	20.95	28.76	21.19	20.95	31.66	23.98	16.25	20.15	11.01	23.85	34.86	26.40	-	39.25	32.55
Adequate	67.62	61.35	68.90	67.62	58.07	65.58	70.00	70.62	78.70	66.15	54.79	63.88	-	49.49	55.40
Good	11.43	9.88	9.91	11.43	10.26	10.44	13.75	9.23	10.29	10.00	10.35	9.72	-	11.26	12.05
Total	100	100	100	100	100	100	100	100	100	100	100	100	-	100	100







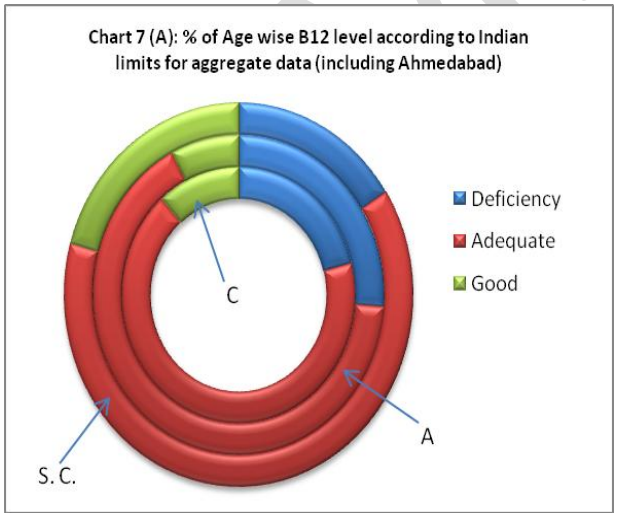


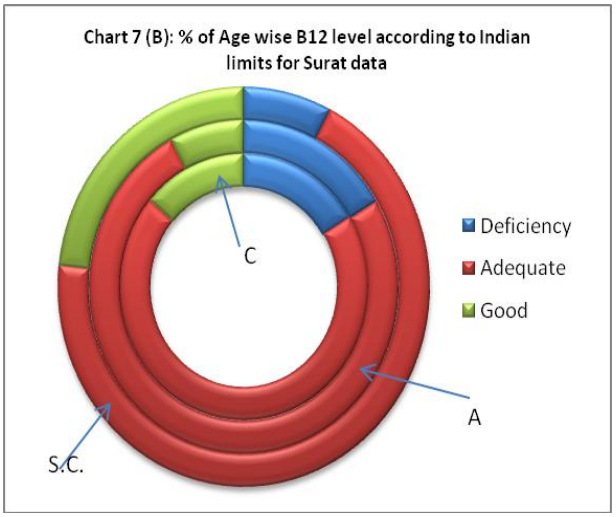


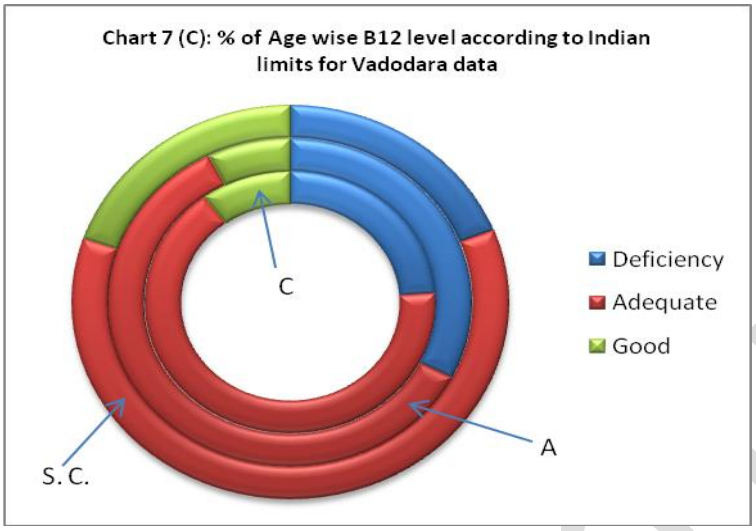
iii) Age wise comparison:

Table 8: Age wise % of different B12 level for aggregate, surat, vadodara and Ahmedabad Data

	Aggregate (Including Ahmedabad)			Surat			Vadodara			Ahmedabad		
	C	A	S. C.	C	A	S. C.	C	A	S. C.	C	A	S. C.
Deficiency	20.95	26.16	16.02	16.25	16.37	7.68	23.85	32.53	19.03			
Adequate	67.62	66.33	63.31	70	75.86	69.09	66.15	60.12	61.22			
Good	11.43	7.51	20.67	13.75	7.76	23.23	10.00	7.35	19.74			
Total	100	100	100	100	100	100	100	100	100	Not Applicable		







- *Comparisons on the basis of inferencial statistics:*
  - For aggregate data, there is statistically significant difference between age wise as well as sex wise B12 level.
  - For Surat data, there is statistically significant difference between age wise as well as sex wise B12 level.
  - For Vadodara data, there is statistically significant difference between age wise as well as sex wise B12 level.
  - For Ahmedabad data, there is statistically significant difference between sex wise B12 level. (Age is not given in the data so age wise comparison is not possible)

- *Future Limits:*

Table: 9: Age wise confidence limits for B12 for Aggregate Data (Including Ahmedabad)(parametric)

Level of B12	limits used by Indian labs							
	Child		Adults		Senior Citizens		Aggregate	
	L.L.	U. L.	L.L.	U. L.	L.L.	U. L.	L.L.	U. L.
Deficiency	15.45	26.46	25.23	27.08	14.38	17.67	26.37	27.82
Adequate	61.29	73.95	65.34	67.33	61.15	65.47	61.75	63.33
Good	7.13	15.73	6.96	8.07	18.85	22.48	9.87	10.86

Table: 10: Age wise confidence limits for B12 for Aggregate Data (Including Ahmedabad) (non parametric)

Level of B12	limits used by Indian labs							
	Child		Adults		Senior Citizens		Aggregate	
	L.L.	U. L.	L.L.	U. L.	L.L.	U. L.	L.L.	U. L.
Deficiency	15.66	27.09	25.23	27.10	14.41	17.74	26.37	27.82
Adequate	60.84	73.90	65.32	67.33	61.11	65.47	61.75	63.33
Good	7.46	16.53	6.97	8.09	18.87	22.55	9.87	10.87

Table: 11: Sex wise confidence limits for B12 for Aggregate Data (Including Ahmedabad) (parametric)								
Level of B12	**limits used by Indian labs**							
	Child		**Male**		**Female**		**Aggregate**	
	L.L.	**U. L.**	**L.L.**	**U. L.**	**L.L.**	**U. L.**	**L.L.**	**U. L.**
Deficiency	15.45	26.46	30.49	32.83	23.05	24.90	26.37	27.82
Adequate	61.29	73.95	56.83	59.31	64.55	66.61	61.75	63.33
Good	7.13	15.73	9.50	11.03	9.78	11.10	9.87	10.86

Table: 12: Sex wise confidence limits for B12 for Aggregate Data (Including Ahmedabad) (non parametric)								
Level of B12	**limits used by Indian labs**							
	Child		**Male**		**Female**		**Aggregate**	
	L.L.	**U. L.**	**L.L.**	**U. L.**	**L.L.**	**U. L.**	**L.L.**	**U. L.**
Deficiency	15.66	27.09	30.49	32.85	23.06	24.92	26.37	27.82
Adequate	60.84	73.90	56.82	59.32	64.54	66.61	61.75	63.33
Good	7.46	16.53	9.51	11.05	9.78	11.12	9.87	10.87

Table: 13: Sex wise confidence limits for B12 for Aggregate Data (Excluding Ahmedabad) (parametric)								
Level of B12	**limits used by Indian labs**							
	Child		**Male**		**Female**		**Aggregate**	
	L.L.	**U. L.**	**L.L.**	**U. L.**	**L.L.**	**U. L.**	**L.L.**	**U. L.**
Deficiency	15.45	26.46	27.42	30.10	20.17	22.21	23.44	25.06
Adequate	61.29	73.95	59.91	62.79	67.74	70.05	64.93	66.72
Good	7.13	15.73	9.00	10.77	9.17	10.66	9.36	10.48

Table: 14: Sex wise confidence limits for B12 for Aggregate Data (Excluding Ahmedabad) (non parametric)								
Level of B12	**limits used by Indian labs**							
	Child		**Male**		**Female**		**Aggregate**	
	L.L.	**U. L.**	**L.L.**	**U. L.**	**L.L.**	**U. L.**	**L.L.**	**U. L.**
Deficiency	15.66	27.09	27.43	30.13	20.18	22.23	23.45	25.07
Adequate	60.84	73.90	59.89	62.80	67.73	70.05	64.92	66.72
Good	7.46	16.53	9.02	10.80	9.18	10.69	9.36	10.50

Table: 15: Sex wise confidence limits for B12 for Ahmedabad Data (parametric)								
Level of B12	**limits used by Indian labs**							
	Child		**Male**		**Female**		**Aggregate**	
	L.L.	**U. L.**	**L.L.**	**U. L.**	**L.L.**	**U. L.**	**L.L.**	**U. L.**
Deficiency	N.A.	N.A.	36.91	41.59	30.50	34.60	33.73	36.79
Adequate	N.A.	N.A.	47.10	51.89	53.23	57.57	51.49	54.69
Good	N.A.	N.A.	9.74	12.77	10.62	13.47	10.62	12.67

Table: 16: Sex wise confidence limits for B12 for Ahmedabad Data (non parametric)								
Level of B12	limits used by Indian labs							
	Child		Male		Female		Aggregate	
	L.L.	U. L.	L.L.	U. L.	L.L.	U. L.	L.L.	U. L.
Deficiency	N.A.	N.A.	36.90	41.63	30.51	34.65	33.73	36.81
Adequate	N.A.	N.A.	47.08	51.91	53.20	57.59	51.48	54.70
Good	N.A.	N.A.	9.78	12.87	10.65	13.55	10.64	12.72

Table: 17: Age wise confidence limits for B12 for Surat Data (parametric)								
Level of B12	limits used by Indian labs							
	Child		Adults		Senior Citizens		Aggregate	
	L.L.	U. L.	L.L.	U. L.	L.L.	U. L.	L.L.	U. L.
Deficiency	8.17	24.33	15.13	17.62	5.36	9.99	14.15	16.38
Adequate	59.96	80.04	74.43	77.30	65.08	73.11	73.54	76.23
Good	6.20	21.30	6.86	8.66	19.56	26.90	8.92	10.77

Table: 18: Age wise confidence limits for B12 for Surat Data (non parametric)								
Level of B12	limits used by Indian labs							
	Child		Adults		Senior Citizens		Aggregate	
	L.L.	U. L.	L.L.	U. L.	L.L.	U. L.	L.L.	U. L.
Deficiency	8.95	26.18	15.15	17.66	5.52	10.35	14.17	16.42
Adequate	58.72	79.74	74.39	77.29	64.87	73.09	73.51	76.23
Good	7.07	23.27	6.89	8.71	19.62	27.15	8.94	10.81

Table: 19: Sex wise confidence limits for B12 for Surat Data (parametric)								
Level of B12	limits used by Indian labs							
	Child		Male		Female		Aggregate	
	L.L.	U. L.	L.L.	U. L.	L.L.	U. L.	L.L.	U. L.
Deficiency	8.17	24.33	18.31	22.00	9.67	12.35	14.15	16.38
Adequate	59.96	80.04	68.53	72.71	76.94	80.45	73.54	76.23
Good	6.20	21.30	7.90	10.55	8.99	11.60	8.92	10.77

Table: 20: Sex wise confidence limits for B12 for Surat Data (non parametric)								
Level of B12	limits used by Indian labs							
	Child		Male		Female		Aggregate	
	L.L.	U. L.	L.L.	U. L.	L.L.	U. L.	L.L.	U. L.
Deficiency	8.95	26.18	18.33	22.07	9.70	12.43	14.17	16.42
Adequate	58.72	79.74	68.47	72.71	76.88	80.44	73.51	76.23
Good	7.07	23.27	7.94	10.65	9.02	11.68	8.94	10.81

Table: 21: Age wise confidence limits for B12 for Vadodara Data (parametric)								
Level of B12	limits used by Indian labs							
	Child		Adults		Senior Citizens		Aggregate	
	L.L.	U. L.	L.L.	U. L.	L.L.	U. L.	L.L.	U. L.
Deficiency	16.52	31.17	31.26	33.80	16.98	21.08	28.47	30.64
Adequate	58.02	74.29	58.79	61.44	58.68	63.77	59.32	61.64
Good	4.84	15.16	6.64	8.06	17.67	21.82	9.25	10.68

Table: 22: Age wise confidence limits for B12 for Vadodara Data (non parametric)								
Level of B12	limits used by Indian labs							
	Child		Adults		Senior Citizens		Aggregate	
	L.L.	U. L.	L.L.	U. L.	L.L.	U. L.	L.L.	U. L.
Deficiency	16.81	32.11	31.26	33.82	17.01	21.18	28.47	30.66
Adequate	57.34	74.22	58.78	61.45	58.62	63.78	59.31	61.65
Good	5.43	16.49	6.66	8.09	17.69	21.92	9.26	10.70

Table: 23: Sex wise confidence limits for B12 for Vadodara Data (parametric)								
Level of B12	limits used by Indian labs							
	Child		Male		Female		Aggregate	
	L.L.	U. L.	L.L.	U. L.	L.L.	U. L.	L.L.	U. L.
Deficiency	16.52	31.17	33.02	36.71	25.04	27.75	28.47	30.64
Adequate	58.02	74.29	52.86	56.71	62.41	65.36	59.32	61.64
Good	4.84	15.16	9.17	11.53	8.81	10.63	9.25	10.68

Table: 24: Sex wise confidence limits for B12 for Vadodara Data (non parametric)								
Level of B12	limits used by Indian labs							
	Child		Male		Female		Aggregate	
	L.L.	U. L.	L.L.	U. L.	L.L.	U. L.	L.L.	U. L.
Deficiency	16.81	32.11	33.02	36.74	25.05	27.78	28.47	30.66
Adequate	57.34	74.22	52.84	56.72	62.39	65.36	59.31	61.65
Good	5.43	16.49	9.20	11.59	8.83	10.67	9.26	10.70

VII. FINDINGS

- For population with aggregate data of all three cities using 95% confidence interval (non parametric) it is estimated that 26.37% to 27.82% person, in the entire population, will be having deficiency, 23.06% to 24.92% females will be having deficiency, 30.49% to 32.85% males will be having deficiency and 15.66 % to 27.09% children will be having deficiency of B12. As per the age group analysis 25.23% to 27.10% Adults will be having deficiency and 14.41 % to 17.74% senior citizens will be having deficiency of B12
- For population of Surat data, using 95% confidence interval (non parametric) it is estimated that 14.15% to 16.42% persons in the entire population will be having deficiency, 9.70% to 12.43% females will be having deficiency, 18.33% to 22.07% males will be having deficiency, 8.95 % to 26.18% children will be having deficiency As per the age group analysis 15.15% to 17.66% Adults will be having deficiency,

5.52 % to 10.35% senior citizens will be having deficiency of B12.

- For population of Vadodara data, using 95% confidence interval (non parametric) it is estimated that 28.47% to 30.66% person, in the entire population, will be having deficiency, 25.05% to 27.78% females will be having deficiency, 33.02% to 36.74% males will be having deficiency 16.81% to 32.11% children will be having deficiency, As per the age group analysis 31.26% to 33.82% Adults will be having deficiency, 17.01 % to 21.18% senior citizens will be having deficiency of B12.

- For population of Vadodara data, using 95% confidence interval (non parametric) it is estimated that 33.73% to 36.81% person, in the entire population, will be having deficiency, 30.51% to 34.65% females will be having deficiency and 36.90% to 41.63% males will be having deficiency of B12.

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