5: PHASE III

5.1 Introduction

Oral diseases such as dental caries, periodontal diseases, tooth loss and oral cancer have emerged as a major public health problem in the member countries of the South-East Asia (SEA) region of WHO (WHO, 2008). In view of the prevalence of risk factors and inadequate access to and affordability of preventive and curative oral health services oral diseases have a growing impact on the health and well being of people in the region and in particular on vulnerable and marginalized groups of population. The 60th World Health Assembly through its resolution WHA 60.17 on oral health an action plan for promotion and integrated disease prevention - acknowledged the intrinsic link between oral health, general health and quality of life and emphasized the need to incorporate programmes for promotion of oral health and prevention of oral diseases into integrated prevention and control of chronic diseases. The resolutions of the WHO Regional Committee for South-East Asia (SEA/RC6/R6, SEA/RC8/R9 and SEA/RC9/R18) paved the way for stronger national and inter-country action and WHO technical support in the area of prevention and control of chronic diseases including oral health.

The current oral health system in India is clinically oriented. A large rural population still needs to be attended to with respect to essential oral health services. The Ministry of Health and Family Welfare, Government of
India is taking steps to reduce oral disease burden and integrate oral health with NCDs that share common risk factors. Considering that oral health is an integral component of general health and that oral diseases are largely preventable, the Government of India has proposed the National Oral Health Care Programme under the centrally sponsored XIth Five-Year Plan. There is a structured referral system involving primary health centres, district hospitals and tertiary health care institutions. India has a reasonable health infrastructure and manpower. Large numbers of dental institutions provide education to both undergraduate and postgraduate students. Despite a considerable number of dental surgeons in India there is a huge gap in oral health services between urban and rural settings. Accumulation of dental surgeons in the urban areas leaves the rural population largely unattended for even basic oral health care services. The country needs an oral health policy that can be integrated with the National Health Policy. Judicious planning for the development of an oral health workforce (dental surgeons, dental hygienist etc.) and its involvement in the implementation of proper preventive, promotive and curative strategies is needed (WHO 2008).

During the past decades the common consensus from many reports worldwide was that dental caries had declined significantly and was continuing to decline in populations (Bagramian et al 2009). The dental community has prided itself on efforts that have reduced dental caries including use of systemic and topical fluorides, toothpastes, sealants, improvements in diet, oral health education and dental care (First International Conference on Declining Caries 1982, Second International
There are however, recent studies that report alarming increases in caries (Bagramian et al. 2009). These increases are in children and adults, primary and permanent teeth, and include coronal and root surfaces. The emerging public health issues are related to disparities in prevalence and treatment of dental caries. An important facet is the social impact of differences in dental caries for specific groups of individuals throughout the world. The increases in caries appear to occur in lower socioeconomic groups, new immigrants and children (Bagramian et al. 2009).

While causes for these increases in caries are unclear, it is possible that the benefits of prevention are not reaching these groups (Bagramian et al., 2009). A very extensive and comprehensive National Health Survey was conducted in 2004 throughout the entire country of India in order to ascertain the oral health status and prevalence of dental disease in representative age groups (NHS 2004). The following percent prevalence of dental caries was reported for the various age groups examined, for both coronal and rootsurfaces: 51.9% in 5 year-old children, 53.8% in 12 year-old children, 63.1% in 15 year-old teenagers, 80.2% in adults aged 35-44 years-old and 85.0% in adults aged 65-74 years-old. The report concluded that a preventive dentistry program, such as water fluoridation, should be initiated to address this national crisis in dental caries.

Chennai is the fourth most populous metropolitan city of India, after Mumbai, Delhi and Kolkata. But it is the largest city in the southern region of India followed by Bangalore and Hyderabad. It is the capital of Tamil Nadu State, which ranks first in the degree of urbanization in India with
almost 44 per cent of its population being urban (TN Govt report 2011). The pre-eminence of Chennai in the urban seen of Tamil Nadu is discernible from the fact that the next biggest agglomeration of Coimbatore and Madurai each hardly account for more than one fifth of the total population of Chennai. The population of Chennai city was half a million during the initial period of 20th century (1901). The city had doubled its population in 60 years from 3.23 lakh in 1871 to 6.47 lakh in 1931. The period between 1947 to 2001 has seen unprecedented spatial growth of the city required largely by post independence industrialization, liberalization, privatization and globalization. It has been observed that the highest level of exponential growth rate during 1991-2001 was observed in Chennai among the seven-megapolitan cities in India. The highest exponential growth rate of population in other megopolitan cities in India may be due to large level of migration by the enormous increase in the level of employment opportunities in all sectors, mainly in service and small and tiny industrial sectors. It is a well known fact that Tamil Nadu is the most urbanized states in the country, with over 44 percent of its population living in urban areas. It is expected that by the end of the eleventh plan period, more than half of the state’s population would be living in urban areas (TN Govt report 2011).

The level of urbanization in Tamil Nadu was very much higher than the national level during the four decades and last decade showed a higher percentage of 16.3 per cent. The highest difference during the last decade in Tamil Nadu showed a positive sign of urbanization, mainly due to the development in small and medium towns, especially majority of the people
involving in informal and service sector activities. Tamil Nadu has a fairly large interstate migrant population, estimated to be over ten lakhs, with large concentrations around Chennai, Coimbatore, Trichy, Madurai, Hosur, Tirupur, Kanyakumari and Tirunelvelli. Hailing from Assam, Bihar, Orissa, Bengal, Uttar Pradesh and even Nepal (TN Government report 2011).

Dental caries continues to be a major health concern for populations worldwide with disparities related to well-known issues of socioeconomics, immigration, lack of preventive efforts and dietary changes (Bagramian et al 2009). Thus taking all these facts into consideration the third phase of our epidemiologic survey was planned and implemented to scientifically gather important caries information that can help direct resources to stop and reverse the serious deterioration that has been identified with dental caries.

5.2 Objective

To determine the prevalence of dental caries and different dermatoglyphic patterns (fingers) in the population and subsequently assess the reliability of specific dermatoglyphic patterns (fingers) in predicting the susceptibility to dental caries. Along with the phase II objectives,

- To do qualitative analysis.
- To assess the association of specific finger dermatoglyphic patterns with gender and dental caries.
- To analyze for any difference in the number of specific finger dermatoglyphic pattern between the individual fingers and dental caries.
5.3 Study Design

Variables:

- Pattern difference in males and females
- Pattern difference in individual fingers


Sample Selection:

The states were divided into a few homogeneous regions, comprising of a number of districts, on the basis of agro-climatic factors used by the Planning Commission and the physio-geographic factors used by the Office of the census Commissioner and the Registrar General of India. The total sample of households from a state thus depended upon the number of such homogeneous regions.

A three-stage sampling design was adopted to select 210 rural households from each homogeneous region. The first stage was the random selection of a district from a region. The second was selection of 15 villages with probability proportional to size of the village and, finally selection of 14 households randomly from each selected village.

In the case of the urban sample of 105 households from a homogeneous region, eight blocks/wards were randomly selected from the selected district. From these eight blocks, 15 wards or census enumeration blocks (CEBs) were randomly selected (each CEB has almost equal population). In the next stage, 7 households were selected from each CEB. Again, 105 subjects from each group (5-7y, 12-14y, 15-17y, 25-28y, and 35-45y) were to be examined, with males making up half the number and females the other half.
Cluster sampling method:

Chennai District – Urban and Rural Districts around Chennai

**Age Group:** 5-7y, 12-14y, 15-17y, 25-28y, 35-45y

**Sample Size:** 315 per Age Group

**Total:** 1,575 Subjects.

**Gender:** Equal Distribution between Males and Females

**Rural Areas:** 210 – 105 Males and 105 Females. (42 per Age Group-21 Males and 21 Females)

**Urban Areas:** 105 – 55 Males and 50 Females (21 Per Age Group – 11 Males and 10 Females)

**Rural Districts**

**First Stage:** Rural Districts around Chennai – 4

**Second Stage:** 4 Taluks per District = 16 Taluks

**Third Stage:** 14 Household.

**Urban**

**First Stage:** Chennai Corporation

**Second Stage:** 8 Zones (A) 15 Wards

**Third Stage:** 7 Household

5.4 Analysis of Data:

- The overall prevalence of dental caries was 45.1%.
- The overall prevalence of whorls was 63.2%, loops 98.3% and others was 8.4% respectively.
- The distribution of whorls among males is 62% and 64.4 % in females.
The distribution of whorls in left hand was 51.3% and right hand 52.2% respectively.

The frequency of occurrence of whorls in individual fingers are 13% in left thumb, 25.5% in left index, 23.6% in left middle finger, 35.4% in left ring finger, 14.2% in left little finger respectively. (Table 1) In the right hand, whorls were distributed as follows, 8% in right thumb, 27.3% in right index finger, 18.3% in right middle finger, 34% in right ring finger and 12.7% in right little finger respectively. (Table 2)

Among males, 13.4% have only one whorl, 12.1% have 2 whorls, 10.7% have 3 whorls, 7.4%, 6.2% and 4.7% have 4, 5, 6 whorls, 2.7%, 2.3%, 0.5% and 2.1% have 7, 8, 9 and 10 whorls respectively.

Among females, 16.9% have only one whorl, 11.9%, 8.6% and 9% had 2, 3 and 4 whorls, 6%, 5.2%, 2.3% had 5, 6 and 7 whorls, 1.7% had 8 and 9 whorls and 1.1% had 10 whorls respectively.

The distribution of whorls in the males was 54.93% in left hand and 54.84% in right hand respectively. Females had 45.06% whorls in left hand and 45.15% whorls in right hand respectively. The association of dental caries and whorls was 60.4% (Graph I) and 55.69% of loops was associated with no caries. (Graph II)

The association between whorls, dental caries and males was 62.98%. The association of whorls, dental caries and females was 57.7%. There is statistically significant difference between the association of whorls in males and dental caries and whorls and females respectively (p < 0.001).
The association between whorls, dental caries in males in left hand is 68.76% and 64.38% in females. (Table 3) The association between whorls, dental caries in males in right hand is 66.66% and 62.73% in females. (Table 4) There is statistically significant difference between the association of whorls, males and females, dental caries, right hand and left hand respectively (p < 0.001).

The overall association of dental caries and the number of whorls were as follows: one whorl had 26.05% association with dental caries, 2whorls is 40.74%, 3 whorls is 55.48%, 4 whorls is 77.34%, 5 whorls is 87.5%, 6 whorls is 93.5% ,7 whorls is 97.5%, 8 whorls is 100%,9 whorls is 93.7% and 10 whorls is 92%.There was statistically significant association between the number of whorls and dental caries with a p<0.001 respectively.

The association of dental caries and the number of whorls in males were as follows: one whorl had 30.76% association with dental caries, 2 whorls is 42.45%, 3 whorls is 62.76%, 4 whorls is 81.53%,5 whorls is 83.33%, 6 whorls is 95.12%, 7 whorls is 100%, 8 whorls is 100%,9 whorls is 100% and 10 whorls is 94.44%.There was statistically significant association between the number of whorls and dental caries with a p < 0.001 respectively.

The association of dental caries and the number of whorls in females were as follows: one whorl had 23.72% association with dental caries, 2whorls is 38.55%, 3 whorls is 61.66%, 4 whorls is 73.1%, 5 whorls is 92.85%, 6 whorls is 91.66%, 7 whorls is 93.75%,8 whorls is 100%,9 whorls is 91.66% and 10 whorls is 87.5%.There was statistically significant
association between the number of whorls and dental caries with a p < 0.001 respectively.

The association of whorls, dental caries in individual fingers in males are as follows: 88% in left little finger, 87.09% in right little finger, 83.44% in right middle finger, 82.17% in left middle finger, 77.67% in left thumb, 76.71% in left index finger, 76.10% in right index finger, 75.95% in left ring finger, 73.05% in right thumb, 72.36% in right ring finger. There was statistically significant association between the number of whorls, dental caries and individual finger in males with a p < 0.001 respectively. (Graph III to XXII)

The association of whorls, dental caries in individual fingers in females are as follows: 84.05% in right middle finger, 81.28% in left middle finger, 80.26% in right little finger, 77.24% in left index finger, 75% in left little finger, 72.33% in right index finger, 72.10% in left ring finger, 69.95% in left ring finger, 69.89% in left thumb, 66.66% in right thumb. There was statistically significant association between the number of whorls, dental caries and individual finger in females with a p < 0.001 respectively. (Graph III to XXII)

The overall association of the various groups, dental caries and whorls are as follows: group I in the age group of 5-7 years is 59.9%, group II in the age group of 12-14 years is 62.60%, group III in the age group of 15-17 years is 56.50%, group IV in the age group of 25-28 years is 60.50% and group V in the age group of 35-45 years is 63.60%. There was statistically significant association between various groups, dental caries and whorls with a p < 0.001 respectively. (Graph XXIII to XXXII)
The overall frequency of loops is 98.3%. The overall occurrence of loops in left hand is 97% and 97.3% in right hand. The overall occurrence of loops in males is 97.9% and 98.9% in females. The distribution of loops in individual fingers are 87% in left thumb, 74.2% in left index finger, 23.6% in left middle finger, 35.4% in left ring finger and 80.5% in left little finger. 88% in right thumb, right index finger in 72.7%, 81.7% in right middle finger, 66% in right ring finger and 87.3% in right little finger.

The frequency of loops in males in increasing order 0.5%, 2.3% and 3.1% had 1, 2 and 3 loops, 4.5%, 6.2%, 8.1% had 4, 5, 6 loops, 10.7%, 12.8%, 16.6% and 33.3% had 7, 8, 9 and 10 loops respectively. The frequency in females are as follows 1.6%, 1.7%, 2.4% had 1, 2 and 3 loops, 5.2%, 6.4%, 8.9%, 9.4% had 4, 5, 6 and 7 loops, 12.6%, 19.5% and 31% had 8, 9 and 10 loops respectively.

53.96% of males had loops in left hand and 53.77% in right hand.43.36% of females in left hand and 43.87% in right hand. The association of loops, males and no caries is 54.94% and in females is 56.52%. The association of loops, males, left hand and no dental caries is 55.41% and 55.6% in right hand. The association of females, left hand and no dental caries is 57.54% and right hand is 56.8%.

The overall association of no dental caries and the number of loops were as follows: one loop had 3%, 2 loops is 0%, 3 loops is 7%, 4 loops is 17%, 5 loops is 15.4%, 6 loops is 16.1%, 7 loops is 21.8%, 8 loops is 39.9%, 9 loops is 66.8% and 10 loops is 132% (sometimes percentages are used in varied ways eg. No of questions received was up 15.7% from 5450 in feb to 6305 in march. In other words, the increase from feb to march was
855 and 855 is 15.7% of 5450. Now, if the no of questions went up in april to 14000 there will an increase of 122%. So percentage larger than 100 can exist.). There was statistically significant association between the number of loops and no dental caries with a $p < 0.001$ respectively.

The association of no dental caries and the number of loops in males were as follows: one loop had 0% association with dental caries, 2 loops is 0%, 3 loops is 3.7%, 4 loops is 5.12%, 5 loops is 14.81%, 6 loops is 21.1%, 7 loops is 39.96%, 8 loops is 60.71%, 9 loops is 68.96% and 10 loops is 82.47%. There was statistically significant association between the males, number of loops and no dental caries with a $p < 0.001$ respectively.

The association of no dental caries and the number of loops in females were as follows: one loop had 9.09% association with dental caries, 2 loops is 0%, 3 loops is 5.8%, 4 loops is 8.3%, 5 loops is 6.6%, 6 loops is 29.3%, 7 loops is 45.4%, 8 loops is 63.6%, 9 loops is 77.2% and 10 loops is 79.7%. There was statistically significant association between the females, number of loops and no dental caries with a $p < 0.001$ respectively.

The association of loops, no dental caries in individual fingers in females are as follows: 69.91% in right ring finger, 69.39% in left ring finger, 68.21% in left index finger, 67.97% in left middle finger, 67.73% in right index finger, 65.78% in right middle finger, 60.49% in left little finger, 60.41% in right little finger, 59.96% in left thumb, 58.68% in right thumb. There was statistically significant association between the number of loops, no dental caries and individual finger in females with a $p < 0.001$ respectively. (Graph II to XXII)
The association of loops, no dental caries in individual fingers in males are as follows: 70.78% in left ring finger, 67.95% in right ring finger, 64.78% in left middle finger, 64.40% in right index finger, 64.17% in left index finger, 60.08% in left little finger, 59.25% in right thumb, 58.58% in left thumb, 53.94% in right little finger, 58.68%. There was statistically significant association between the number of loops, no dental caries and individual finger in males with a p < 0.001 respectively. (Graph III to XXII)

The overall association of the various groups, no dental caries and loops are as follows group I in the age group of 5-7 years is 56.5%, group II in the age group of 12-14 years is 56.80%, group III in the age group of 15-17 years is 57.50%, group IV in the age group of 25-28 years is 55.40% and group V in the age group of 35-45 years is 51.20%. There was statistically significant association between various groups, no dental caries and loops with a p < 0.001 respectively. (Graph XXIII to XXXII).

As far as the association of loop with dental caries is concerned, loop is the most commonly observed pattern, since the number of whorl pattern is less, its significance with dental caries was observed. Also previous studies have also studied that whorl is associated with dental caries. As summarized in the review of literature the whorl pattern is most commonly associated with disease (for example Lu 1968, Preus et al 1982, Chinthamani et al 2007), hence more impetus has given to whorls. Also, as observed in the bar chart II there was no predictable association between loops and dental caries.

The association for other patterns was non-significant as the numbers were minimum.
With the observations of phase II we wanted to further validate the association by also considering gender and individual finger in varied age groups as clusters apart from the primary objective in the phase III of our study. The overall prevalence of whorls was 63.2%, loops 98.3% and others was 8.4% respectively.

The results from Phase III clearly validate the association of dental caries and dermatoglyphics as verified with various parameters.
TABLES AND GRAPHS

PHASE III:

BAR CHART I: Association between whorls and dental caries.

BAR CHART II: Association between loop and dental caries.
BAR CHART III TO XXII: Association of Whorls, loops and others in Individual Fingers, Gender and DC

Bar Chart III: Association of whorls, loops and others in the right thumb and dental caries in males

Bar Chart IV: Association of whorls, loops and others in the right thumb and dental caries in females

Bar Chart V: Association of whorls, loops and others in the right index finger and dental caries in males

Bar Chart VI: Association of whorls, loops and others in the right index finger and dental caries in females

Bar Chart VII: Association of whorls, loops and others in the right middle finger and dental caries in males

Bar Chart VIII: Association of whorls, loops and others in the right middle finger and dental caries in females
Bar Chart IX: Association of whorls, loops and others in the right ring finger and dental caries in males

Bar Chart X: Association of whorls, loops and others in the right ring finger and dental caries in females

Bar Chart XI: Association of whorls, loops and others in the right last finger and dental caries in males

Bar Chart XII: Association of whorls, loops and others in the right ring finger and dental caries in females

Bar Chart XIII: Association of whorls, loops and others in the left thumb and dental caries in males

Bar Chart XIV: Association of whorls, loops and others in the left thumb and dental caries in females
Bar Chart XV: Association of whorls, loops and others in the left index finger and dental caries in males

Bar Chart XVI: Association of whorls, loops and others in the left index finger and dental caries in females

Bar Chart XVII: Association of whorls, loops and others in the left middle finger and dental caries in males

Bar Chart XVIII: Association of whorls, loops and others in the left middle finger and dental caries in females

Bar Chart XIX: Association of whorls, loops and others in the left ring finger and dental caries in males

Bar Chart XX: Association of whorls, loops and others in the left ring finger and dental caries in females
Bar Chart XXI: Association of whorls, loops and others in the left last finger and dental caries in males.

Bar Chart XXII: Association of whorls, loops and others in the left last finger and dental caries in females.

BAR CHART XXIII TO XXXII: Association of age groups, DC and whorls and loops. GRAPHS XXIII TO XXVII: WHORLS

Bar Chart XXIII: Association of whorls and dental caries in 5-7 years age group.

Bar Chart XXIV: Association of whorls and dental caries in 12-14 years age group.

Bar Chart XXV: Association of whorls and dental caries in 15-17 years age group.

Bar Chart XXVI: Association of whorls and dental caries in 25-29 years age group.
Bar Chart XXVII: Association of whorls and dental caries in 35-45 years age group.

**BAR CHART XXVIII TO XXXII: LOOPS**

Bar Chart XXVIII: Association of loops and dental caries in 5-7 years age group.

Bar Chart XXIX: Association of loops and dental caries in 12-14 years age group.

Bar Chart XXX: Association of loops and dental caries in 15-17 years age group.

Bar Chart XXXI: Association of loops and dental caries in 25-29 years age group.
Table 1: Frequency distribution of dermatoglyphic pattern in different fingers (Left)

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<th>Fingers - left hand</th>
<th>Dermatoglyphic pattern</th>
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<td>Whorl</td>
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<td>Thumb</td>
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<td>Index</td>
<td>408</td>
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<tr>
<td>Middle</td>
<td>373</td>
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<td>Ring</td>
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<tr>
<td>Last</td>
<td>225</td>
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Bar Chart XXXII: Association of loops and dental caries in 35-45 years age group.
Table 2: Frequency distribution of dermatoglypic pattern in different fingers (Right)

<table>
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<th>Fingers - Right hand</th>
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<th></th>
<th>Total</th>
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</thead>
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<td>Loop</td>
<td>Others</td>
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<td>1580</td>
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<td>Ring</td>
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<td>1043</td>
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<td>1380</td>
<td>0</td>
<td>1580</td>
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Table 3: p Value - Chisquare test – Right hand – Dermatoglypic pattern vs Dental caries

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<th>P value (&lt;0.001)</th>
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<td>Index</td>
<td>0.001</td>
</tr>
<tr>
<td>3</td>
<td>Middle</td>
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</tr>
<tr>
<td>4</td>
<td>Ring</td>
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</tr>
<tr>
<td>5</td>
<td>Last</td>
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</table>

Table 4: p Value - Chisquare test – Left hand – Dermatoglypic pattern vs Dental caries

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<th>P value (&lt;0.001)</th>
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<td>0.001</td>
</tr>
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<td>Index</td>
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<tr>
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5.6 Discussion

To the best of our knowledge, apart from Bhasin who had published in 2007 a comprehensive analysis from various studies, this is the first study to analyze fingerprints from a large population as sample size and have screened 1,575 in phase III and 10,250 in phase II fingers for the patterns especially in Indian population.

The present study reaffirms the fact that loop is the most commonly encountered pattern (98.3% & 81.8%) among Indian population as in accordance with literature from most geographical locations across the world and studies conducted in populations different pockets of India.

The distribution of the frequencies of different finger patterns (in percentage) may be generalized among major population groups as follows: Whorls: Mongoloids > American Indians > Europeans > Africans, Loops: Africans > Europeans > American Indians > Mongoloids Arches: Africans > American Indians > Europeans > Mongoloids (Bhasin, 2007).

In general, among Indian populations, the frequency of whorls is low (43.62 per cent, varies from 22.50 to 66.70) as compared to loops (53.30 per cent, ranges from 33.00 to 75.30), whereas the frequency of arches is 3.08 per cent (from complete absence to 8.10 per cent) (Bhasin 2007).

Gangadhar and Rajashekara Reddy (1993) in their study on 360 unrelated Adikarnataka population of Mysore city of Karnataka State, found that the frequency of loop patterns (57.11%) were common followed by whorls (27.89%) and arches (15%). Nithin et al 2007 in a study of 500
subjects of south Indian population concluded that the most frequent pattern among South Indian population is loop (ulnar).

In the Himalayan mountain complex region from where most of the populations are having Mongoloid affinities the frequency of whorls is high (46.5%) and it starts decreasing gradually towards south. The frequency of arches is low in the Himalayan mountain complex and starts increasing towards south. The frequency of various patterns in the Himalayan region is similar to that observed among populations with Mongoloid affinities from East Asia, Southeast Asia, whereas from the non-Himalayan region it is similar to that of European populations (Bhasin, 2007).

In general, the frequency of whorl patterns gradually starts decreasing from north (Himalayan mountain complex region) to south (Indus-Ganga-Brahmaputra plains and Peninsular region) and that of loops and arches from south to north region. (Bhasin, 2007)

This is very well reflected in our study as we have done the survey across subjects representing varied regions in India. Though the loop pattern was encountered as the most commonly observed pattern, the frequency of occurrence of whorls (54.7% and 63.2%) is also comparatively high although we had excluded subjects with known history of genetic, congenital and hereditary disorders. Alternatively, this may also reflect the proneness to certain genetic associated disease and the correlation may be highlighted when analyzing with the specific disease entity in which the individuals may be carrier, partially express or may indicate to proneness to disease process.
The distribution of whorls among males is 62% and 64.4% in females in our study. The distribution of whorls in the males was 54.93% in left hand and 54.84% in right hand respectively. Females had 45.06% whorls in left hand and 45.15% whorls in right hand respectively.

The overall frequency of loops is 98.3%. The overall occurrence of loops in left hand is 97% and 97.3% in right hand. The overall occurrence of loops in males is 97.9% and 98.9% in females. 53.96% of males had loops in left hand and 53.77% in right hand. 43.36% of females had loops in left hand and 43.87% in right hand.

International studies in the past have shown that fingerprint types in females almost universally differ from males. Dermatoglyphics have been used extensively to characterize human populations and most studies have focused on dermatoglyphic variables within and between various populations across the world (Crawford and Duggirala 1992, Demarchi et al 1997, Reddy et al 2001, Weisensee and Siváková 2003 or between sexes (Esteban and Moral 1993, Kusuma et al 2002). In the latter and in more recent studies, the dermatoglyphic traits are used for estimating the genetic distances between populations (Temaj et al 2009, Cheng et al 2009, Avdeychik& Lagerstrom1999) in their study have concluded that Whorl patterns prevail on right hands of men and on the left hands of women. The fingerprints world map has shown that studies in the past have shown that the occurrence of fingerprint types varies significantly in the populations around the world: e.g. Asians are known for a higher occurrence of whorls, and Africans for a higher occurrence of
arches. However there are contradictory reports on the occurrence of patterns from India itself as described previously.

Apart with the facts discussed in phase II, the reasons for sexual dimorphism observed in the dermatoglyphic patterns, can be supported by the fact that differences in heritability and developmental variation among sexes might account for these patterns (Meier 1980). On the other hand, bimanual differences have been attributed to developmental instability, measured by fluctuating asymmetry of bilateral traits which in the particular case of dermatoglyphics, must result from environmental assaults during early embryonary (Cummins and Midlo 1961). But the most important fact is that the human dermatoglyphic traits present variations within and between populations and geographical regions within the same country.

Premalatha (1995) in her study on palmar dermatoglyphics and palmar freckles in south Indians observed ulnar loop, whorl, radial loop and arch. Ulnar loop was the dominating pattern in both sexes. The incidence of ulnar loop pattern (68%) was equal in both hands in males, whereas the incidence was higher in the right hand than that of the left hand in females. The incidence of whorl pattern in the right hand (28%) was higher than that of the left hand (16%) in males. But females showed a slightly higher incidence of whorl pattern in the left hand (32%) than that of the right hand (30.7%).

Rastogi and Pillai (2010) had observed 60.95% of loop and 32.55% of whorls patterns. Zalak Patelin 2011 has observed in males, loop was predominated pattern amount to 51.06% of total males followed by whorls (44.68%) and arch (4.26%). In females, whorl pattern was commonest
pattern amount to 50% of total females followed by loop (38.24%) and arch (11.76%). Contrary to this finding Rastogi & Pillai (2010) found whorls as most common pattern in males (55.78%) and loops predominating in females (52.42%). Ching Cho (2004) observed that whorls were abundant over loops in males (55.6%) as well as in females (65.6). Considering the fact that our study encompassed all subjects barring region and ethnicity as living in the locality of our study area, the results correlate and differ in context to relevant areas.

Most of the authors conclude that whorls occur most commonly on digit VI (Ring finger) on both hands and in both sexes. Many authors have concluded that whorls are more numerous on the ring finger, followed by the thumb, and the index finger. The middle and the little fingers presented a sharp reduction in the frequency of the whorls. Bharadwaja (2004) reported on blood groups and dermatoglyphics have concluded that the tile distribution pattern in individual fingers had high frequency of loops in thumb and little finger whereas ring fingers had more whorls. Our findings are also consistent with literature with 35.4% of whorls in left ring finger and 34% whorls in right ring finger, 87% in left thumb and 88% in right thumb respectively.

The association of dental caries and whorls was 60.4% and 55.69% of loops was associated with no caries has only reiterated the facts and conclusions from phase I and phase II. In fact the association has been further validated by the increased association with the number of whorls and dental caries and loops and with no dental caries with a statistical significance of p< 0.001. The findings from all the three phases therefore
validates that increased number of whorls are associated with dental caries and loops with no dental caries.

The first developmental event which distinguishes left from right would take place on a subcellular scale. However, a mechanism must then exist to transduce subcellular signals to cell fields (Levin and Nascone 1997, Levin and Mercola 1998a). Asymmetric gene expression in embryos requires that fairly large fields of cells already know on which side of the midline they are located (such as the expression of the left-sided gene Nodal). In contrast, proposed mechanisms of step 1 of asymmetry (such as the F-molecule model) rely on subcellular mechanisms for determining which direction is Left and which is Right. Thus, one of the key question concerns how orientation information can be turned into information on a cell’s location, relative to the midline, within the context of the whole embryo. This information flow must take place between cells; ciliary motion driving extracellular flow of signaling molecules and cell–cell communication via gap junctions are both natural candidates for such a signal exchange. Roles for epigenetic factors such as membrane voltage, and CaCC signaling are also likely. One of the key remaining questions is the molecular meaning of ‘randomization’. Upon the initial discovery of the LR pathway, it was observed that embryos with doublesided Nodal expression or lack of Nodal expression (produced by Shh or activin implants, respectively), show a randomization of visceral situs (Levin et al., 1995, 1997b) not a loss of asymmetry in the heart and gut, but heterotaxia. This was interpreted as suggesting that this pathway of genes imparts LR information to the organs but does not control their morphogenesis per se,
leading the organs to independently and randomly choose their situs when presented with identical molecular signals from the L and R sides. However, it is now known that global equalization of signaling in a number of LR pathways including GJC, H,K-ATPase, and apoptosis, also induce randomization of asymmetric genes such as Shh. A mechanistic model for this process would have to explain not simply consistent induction (or repression) of genes such as Shh by gap junctional communication or cell depolarization, but a mechanism by which cells in both sides of the node can be driven to randomly express Shh or not. Even more puzzling for simple gene cascade models is the observation that in several vertebrate and invertebrate systems, symmetrization of an upstream asymmetric gene does not lead to uniformly bilateral or missing expression of downstream genes (in the case of positive and negative regulation, respectively) but rather results in a randomization of downstream gene expression (Morokuma et al 2002), or does not affect downstream LR pathway targets at all (Kelly et al 2002). One candidate for such a bistable mechanism would be a short-range activation/long-range inhibition system such as that which establishes cell polarity via the Notch-Delta pathway. Interestingly, a role for this pathway has recently been implicated downstream of the H,K-ATPase in the chick (Raya et al 2004). Thus, it is possible that such a mechanism works in the node to integrate a number of epigenetic biasing factors into stable domains of downstream gene expression. Future work is necessary to understand how this works in the node and streak; recent mathematical models are beginning to tackle this issue (Meinhardt and Gierer, 2000, Rasskin-Gutman and Izpisua-Belmonte 2004); potential
candidate molecules may include motor proteins from the kinesin family gene which could underlie intracellular transport in node signaling events (Dathe et al 2004).

The association between whorls, dental caries in males and females in left hand was higher compared to the right hand (68% and 64%). Considering the almost equal distribution in general population, there is a statistically significant increase in the number of whorls in the left hand in both the gender. This reflects the significant association of dental caries and the whorl pattern. Phase II had only reflected the overall occurrence of whorls in the hands and there was no distribution of subjects according to the gender. The prevalence of the different patterns in the hands by several authors has already been discussed previously. It has been reported that right hand had higher frequency of whorls than loops in right hand of early childhood caries subjects and only loops predominated in left hands in both their control and study groups. However, Atasu et al (1998) have reported increase in the occurrence of whorls in left hand of caries affected subjects similar to our phase III observation.

It has been observed from our study that there is statistical significance with a $p < 0.001$ for the occurrence of whorls in the individual fingers in association with caries apart from the ring finger. In males the association of individual fingers and dental caries are 88% in left little finger, 87.09% in right little finger, 83.44% in right middle finger, 82.17% in left middle finger, 77.67% in left thumb, 76.71% in left index finger, 76.10% in right index finger. In females 84.05% in right middle finger, 81.28% in left middle finger, 80.26% in right little finger, 77.24% in left index finger, 75% in
left little finger, 72.33% in right index finger respectively. It is interesting to note that right and left ring finger though are increased occur in the least frequency of occurrence. Considering that the frequency of occurrence of loops is very high, the association of the individual fingers with loops and no caries is significant as the order of occurrence of loops is frequent in the right and left ring followed by right thumb which is the reverse order of occurrence as with whorls. This association reaffirms the fact of whorls association with caries and loops with no caries.

It has been reported that ridges are influenced by blood vessel-nerve pairs at the border between the dermis and epidermis during prenatal development (Kahn et al 2008). Factors such as inadequate oxygen supply, unusual distribution of sweat glands and alterations of epithelial growths could influence ridge patterns (Schaumann and Alter 1976). The distribution of interdigital patterns has been proven to follow a multi-allelic major gene mode of inheritance (Meenakshi et al 2006, Bhasin 2007, Cheng et al 2009). Though most authors conclude that the genes play the vital role in determining the fingerprint pattern, Wertheim and Maceo, Hale, Ashbaugh consider ridge alignment, shape, and minutiae location all evolve randomly through various stresses and cellular distributions. But it ultimately most of the above factors are also finally under genetic control and also inheritable feature. Literature suggest that a fetus has an early timing of the onset of ridge proliferation before the volar pad has regressed much, then the volar pad will most likely be symmetrical at the time of proliferation, resulting in a whorl fingerprint pattern. On the other hand, if a fetus has a late timing of the onset of ridge proliferation after the regression of the volar pad, then
the volar pad would have already merged with the contours of the finger, resulting in an arch fingerprint pattern. If a fetus has the onset of ridge proliferation during the middle stages of volar pad regression while the volar pad is most likely asymmetrical, then a loop fingerprint pattern will occur. Already in 1883, Kollmann speculated that the ridge pattern is established as the result of a folding process, which is induced by differential growth (Kollmann 1883). With a lot of histological evidence this idea was promoted by Bonnevie in the 1920s. She argued that there is intense cell proliferation in the basal layer of the epidermis resulting in cylindrical cells, which finally evade the stress by folding toward the dermis, thus resulting in the primary ridges (Bonnevie 1927a,b, 1932). Related to the folding hypothesis is the idea that the ridges form parallel to the largest growth stress as formulated by Cummins (1926). Unfortunately, until now it has never been attempted to identify sources of stress that produce the observed patterns. Due to similar topological properties of fingerprint patterns and cultivated fibroblast cell patterns it has been suggested that fingerprints are induced by a pre-pattern in the dermis. On the basis of mechanical interactions between extracellular matrix, haptotaxis and other processes a model was developed (Bentil 1990, Bentil and Murray 1993). It has been known for some time that loops and triradii and composites thereof such as whorls and dislocations are the canonical singularities of two-dimensional stripe patterns in translationally and rotationally invariant systems (Passot and Newell 1994). These singularities are characterized by a quantity called twist. Penrose also attempted to explain the observation that there is a relation between pattern type and pad geometry.
(Penrose and O’Hara 1973). He thought that the ridges always follow the lines of largest curvature. However, there are a number of exceptions to the rule and no reason is apparent why the ridges should follow the lines of largest curvature. However, his conclusion that ridge direction is determined by a tensor field is consistent with the observation that a pattern containing disclinations (loops and triradii) can only be described by an order parameter which is a director field (equivalent to a tensor field or to a vector field on the double cover of the plane). An expanding cell sheet in which compressive stress is generated due to resistance of the surrounding structures (Kucken and Newell 2005). Primary ridge formation starts at a time when the volar pads digress and become less prominent. Therefore, the assumption that normal displacements create tangential stress is very reasonable. Different forces, growth rates and geometries produce a certain stress field. The shape of the prebuckled surface is chosen so as to have enough flexibility to mimic the spectrum of finger shapes. Roughly, it has the form of a half hemisphere sitting on top of a half cylinder but we endow the analytical formula for the surface with enough parameters in order to capture as many features as possible and in particular those associated with strongly and weakly swollen volar pads.

Because of the non-trivial geometry, the prebuckling stress field is calculated by a finite element algorithm. The epidermal ridge pattern is established as the result of a buckling instability acting on the basal layer of the epidermis and resulting in the primary ridges (Kucken and Newell, 2005).
The buckling process underlying fingerprint development is controlled by the stresses formed in the basal layer, not by the curvatures of the skin surface. The stresses that determine ridge direction are themselves determined by boundary forces acting at creases and the nail furrow and normal displacements, which are most pronounced close to the ridge anlage. The geometry of the volar pads influences this process (Kucken and Newell, 2005).

The embryonic brain is subdivided into the forebrain, midbrain and hindbrain (rhombencephalon), which is further subdivided into eight rhombomeres. The archenteron continues to develop in a posterior to anterior direction and participates in pharyngeal arch formation (Koussoulakou 2009). The pharyngeal arches contain a central blood vessel, the aortic arch, surrounded by paraxial mesoderm. This core is enveloped by a sheet of cnc cells; this cell, in their turn, is covered by continuous sheets of epidermal ectoderm and internal endoderm. The first pharyngeal arch forms the upper and the lower jaws. Massive layers of the oropharyngeal epithelium (stomodeum) migrate over and overlap the pharyngeal arches; odontogenic cells from the neural crest have already migrated and populated the region by this time (Koussoulakou, 2009). Although oral teeth are thought to arise exclusively from the ectoderm, pharyngeal teeth may also be derived from the endoderm epithelium. Cranial neural crest (CNC) cells, although of ectodermal origin, undergo “mesenchymalization” a process justifying their designation as ectomesenchymal cells. Interestingly, before the onset of their migration, the CNC cells express Hox genes; after arrival at their destination places
(first pharyngeal arch), they do not express Hox genes. This fact suggests that the acquired identity is maintained. Some of the CNC cells from the forebrain region migrate ventrally between the surface ectoderm and local mesoderm and establish the frontonasal prominence, where upper incisors form. Cranial neural crest cells from the midbrain and the three first rhombomeres populate the first pharyngeal arch, where all other teeth develop on the rest of the maxilla and the whole mandible. The homeobox genes LHX6 and LHX7 appear to have critical roles in directing the CNC cells to their correct destinations (Koussoulakou 2009).

Tissue recombination experiments performed between ED 8.0-11.5 have shown that the earliest odontogenic potential resides in the dental epithelium rather than the CNC cells and that the patterning information for tooth initiation and type is present in the oral ectoderm prior to epithelial thickening. Later (ED 12), this potential is lost from the epithelium and acquired by the ectomesenchymal cells, which in turn regulate differentiation of the epithelial cells. This acquisition by ectomesenchymal cells was demonstrated when mouse embryonic molar mesenchyme was combined with chick embryonic epithelium and found to result in the formation of tooth germs (Koussoulakou 2009).

The complicated, sequential, reciprocal interactions between the dental epithelium and dental ectomesenchyme that are required for tooth formation are mediated by the spatiotemporal expression of tooth-related genes (approx. 300) and the secretion of growth and transcription factors (approx. 100) that are reiteratively used in regulatory loops.
The simulation of tooth formation and the various ridge formation and the factors influencing the caries formation correlate with the findings in individual fingers, patterns, gender and caries association.

5.7 Conclusion

- The results of the phase III further reinforced the findings from phase I and II where again there was statistically significant association between the number of whorls and dental caries with a p < 0.001 respectively.

- The association of **whorls, dental caries and little finger** was significant in males with the following percentage of occurrence. 88% in left little finger, 87.09% in right little finger. There was statistically significant association between the number of whorls, dental caries and individual finger in males with a p < 0.001 respectively.

- The association of **whorls, dental caries and middle fingers** was significant in females with the following percentage of occurrence. 84.05% in right middle finger, 81.28% in left middle finger. There was statistically significant association between the number of whorls, dental caries and individual finger in females with a p < 0.001 respectively.

- The overall association of the various groups, dental caries and whorls are as follows group I in the age group of 5-7 years is 59.9%, group II in the age group of 12-14 years is 62.60%, group III in the age group of 15-17 years is 56.50%, group IV in the age group of 25-28 years is 60.50% and group V in the age group of 35-45 years
is 63.60%. There was **statistically significant** association between various groups, dental caries and whorls with a $p < 0.001$ respectively.

- The overall association of **no dental caries and the number of loops** were as follows: one loop had 3% association with dental caries, 2 loops is 0%, 3 loops is 7%, 4 loops is 17%, 5 loops is 15.4%, 6 loops is 16.1%, 7 loops is 21.8%, 8 loops is 39.9%, 9 loops is 66.8% and 10 loops is 1.32%. There was statistically significant association between the number of loops and no dental caries with a $p < 0.001$ respectively.

- These results further validate the association by also considering gender and individual finger in varied age groups as clusters apart from the primary objective in the phase III of our study.

- Finally the cluster sampling results well establishes the fact that whorls association with caries with the age group of 35 - 45 years showing 63.60% which is the highest among all groups and a statistically significant $p < 0.01$.

- Similar association with loops and no dental caries was also observed. As prospective study is not within the scope of this study the cluster groups has definitely ascertained the caries and whorl association. The groups also validate the results of Phase I and II respectively.

- To sum up in a nutshell, the findings of our 3 phased study concludes that an increase in the number of whorls is significantly associated with dental caries and correlation of loops with no caries.
which is in accordance with the findings of Atasu (1998) and Sharma (2009) who had studied this relation to dental caries in children in a very small size of 24 patients and 90 patients respectively.

- We have comprehensively verified the above findings with numerous variables namely different age groups, gender, urban and rural population, hands, individual fingers respectively.
6. CONCLUSION

- The Phase I of our study investigated this as a case control study in children with a calculated sample size of 400 cases and 400 controls with relevance to Indian scenario where caries is a pressing dental health problem. From this phase of the study we have observed that whorls had a positive correlation with dental caries. Also, loops had a negative correlation with dental caries.

- Based on the results of the phase 1, in which the sample size was estimated from pre-existing data in the literature, the second phase of the study was designed wherein we conducted a descriptive study across 4 South Indian cities in 10,250 subjects so as to represent the south Indian population. In this phase, we had therefore ascertained the true prevalence of caries and fingerprint patterns. In addition to the parameters considered in the Phase I, deciduous and permanent teeth, left and right hand were considered in Phase II.

- In the Phase II study, further there was statistically highly significant difference in the number of subjects having whorl pattern with carious teeth when compared to subjects who have whorl pattern with no carious teeth (p<0.001)

- Also, there was statistical significance at p<0.001 among the population who have loop pattern in association with no caries.

- The association of whorls and permanent teeth with carious teeth was highly significant when compared to loops and permanent teeth with carious teeth. (p<0.001) There was statistically significant difference in association of whorls and caries in right hand when compared to both
the hands and left hand (p value < 0.001) with more prevalence of carious teeth.

- The results have shown significant association between finger dermatoglyphic pattern and dental caries in the population studied in phase II including the hands that were studied in this phase.
- The association of whorls with dental caries studied across varied age groups, further validates the findings of our phase I.
- Though a prospective study would be ideal to study the development of dental caries and dermatoglyphics, it remains beyond the scope of the study owing to the time factor. Hence in order to overcome the time barrier and yet study the correlation between dermatoglyphics and dental caries third phase of the study was based on cluster sampling, where in individuals from 5 different age groups were chosen adding specific variables, along with significant variables from the previous phase.
- The results of the phase III further reinforced the findings from phase I and II where again there was statistically significant association between the number of whorls and dental caries with a p <0.001 respectively.
- The association of **whorls, dental caries and little finger** was significant in **males** with the following percentage of occurrence. 88% in left little finger, 87.09% in right little finger. There was statistically significant association between the number of whorls,
dental caries and individual finger in males with a p < 0.001 respectively.

- The association of **whorls, dental caries and middle fingers** was significant in **females** with the following percentage of occurrence. There was statistically significant association between the number of whorls, dental caries and individual finger in females with a p < 0.001 respectively.

- There was **statistically significant** association between various groups, dental caries and whorls with a p < 0.001 respectively.

- There was statistically significant association between the number of loops and no dental caries with a p < 0.001 respectively.

- These results further validate the association by also considering gender and individual finger in varied age groups as clusters apart from the primary objective in the phase III of our study.

- Though previous studies, have studied dermatoglyphics and dental caries, the current study is the first of its kind being exhaustive, comparing a large number of population, across various age groups and other quantitative parameters.

- As described in the various sections the findings of the study would be an useful adjunct in preventive care in dentistry in order to identify high risk individuals at an early stage and reduce the treatment burden.

- It is now universally recognised that the development of new technologies for early detection and quantitative monitoring of dental caries at an early stage of formation could provide health and
economic benefits ranging from timely preventive interventions to reduction in the time required for clinical trials of anticaries agents.

- The use of technologies as adjunct to caries diagnosis will facilitate preventive care in dentistry to lower treatment cost as well as reduce the cost and time for testing potential anti caries agents.

**Educational /Social Implication/Suggestions and Recommendations**

- The findings of the study and software that has been developed is a milestone in the field of dentistry and society as this will be a valuable tool to predict the susceptibility to dental caries in every day practice as this software can be incorporated into any dental chair like the RVG but will be more cost effective and affordable.

- It is recommended that these be expanded and extended in all rural and urban areas in such a way as these are affordable, accessible and acceptable for the all communities.

- This will pave way for us to achieve the overall goal for service provision as oral health care must be to increase the proportion of children and adults with caries-free teeth; to reduce the DMFT (DMFT- decayed, missing, filled teeth in permanent teeth) with special emphasis on the DT ( DT- decayed permanent teeth) component; and to reduce the number of missing or extracted teeth due to caries through preventive measures.

- All this is valid especially in developing countries like India having enormous population and relatively less health budgets.

- This recommendation can be further investigated with varied demographic samples, different races and specific DNA analysis.
Future studies have to be advocated in this rewarding field to establish dermatoglyphic markers for susceptibility to dental caries with prospective studies.

- To conclude, as fingerprints are formed during vital stages of fetal development, dermatoglyphic studies are in unique position to evaluate the effect of environment on early growth.

- Lesser time and cost requirements make dermatoglyphics an easy alternative for much preferred but expensive DNA testings. Dermatoglyphics studies are reliable, non-invasive investigations which have good patient compliance. Thus dermatoglyphic analysis as seen in this study would prove to be an extremely useful tool in dentistry.