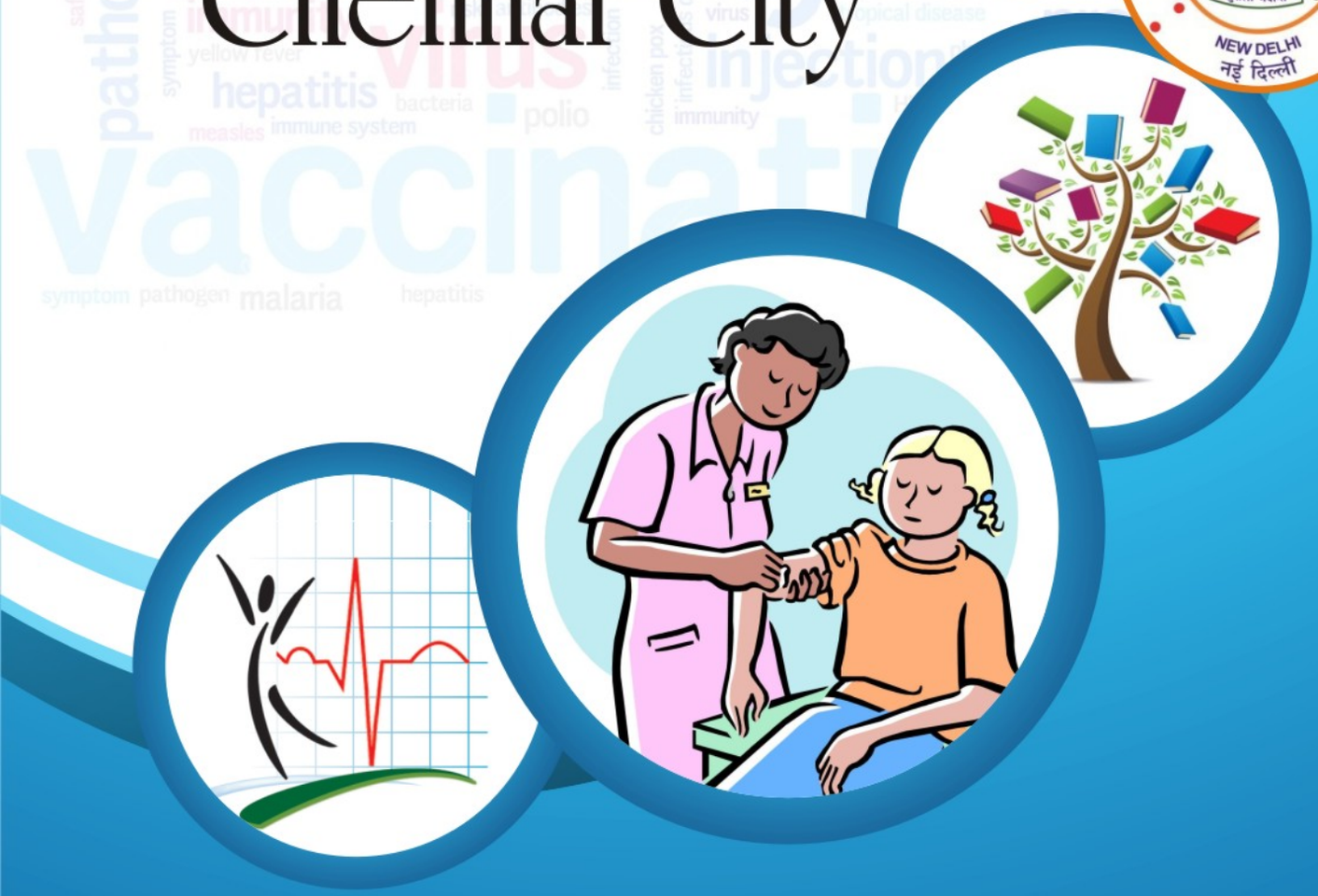
LITERACY IMMUNIZATION HEALTH INDICATORS OF Chennai City



Dr. VASNA JOSHUA, M.Sc., Ph.D.,

Scientist B

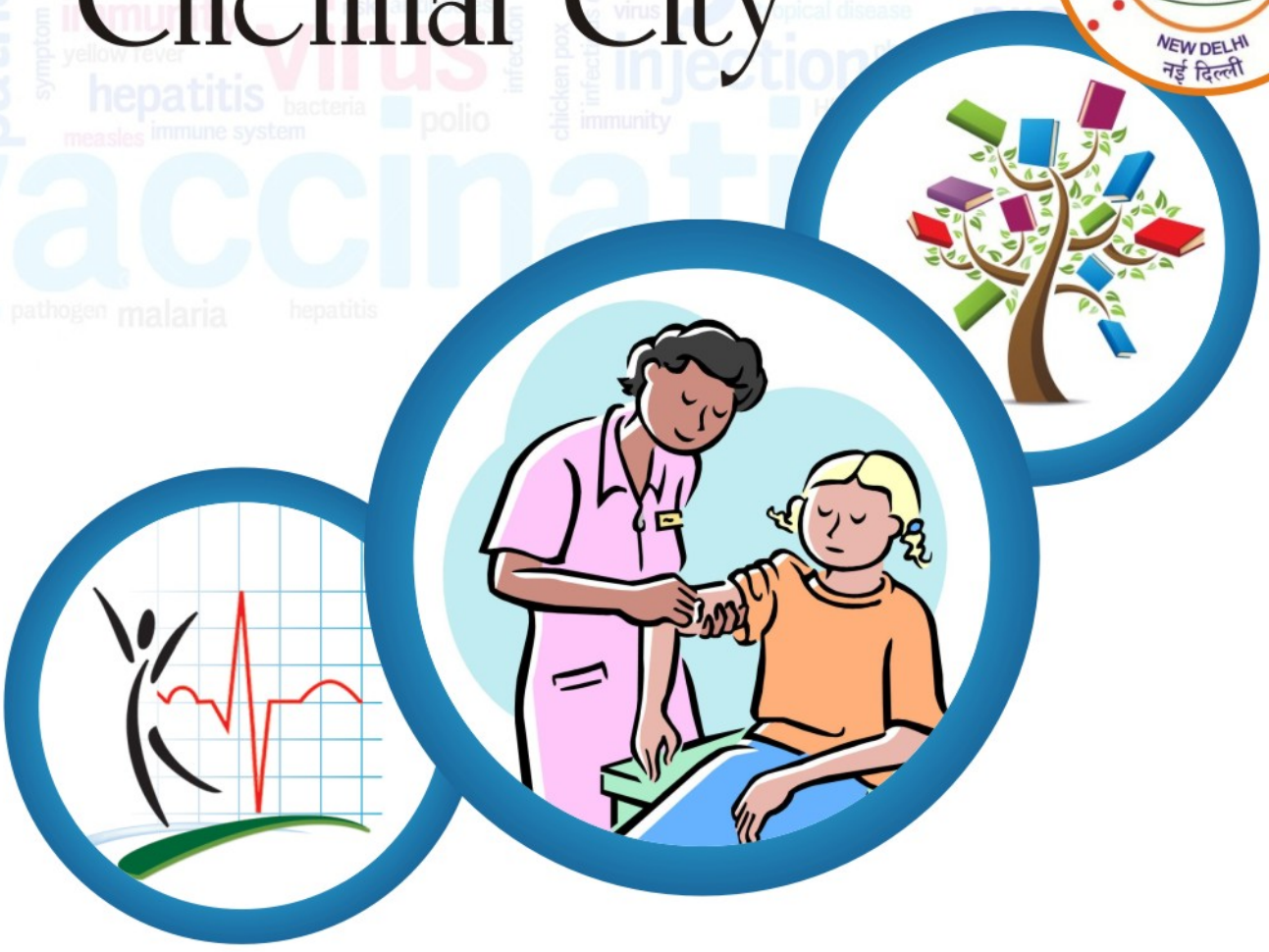
NATIONAL INSTITUTE OF EPIDEMIOLOGY, Chennai

LDCE PROJECT REPORT

STUDY PERIOD

Mar 2015-Feb 2016

LITERACY IMMUNIZATION HEALTH INDICATORS OF Chennai City



Dr. VASNA JOSHUA, M.Sc., Ph.D.,

Scientist B

NATIONAL INSTITUTE OF EPIDEMIOLOGY, Chennai

LDCE PROJECT REPORT

STUDY PERIOD

Mar 2015-Feb 2016

CONTENTS

Acknowledgement

My sincere thanks to

- *Secretary, DHR & Director General, ICMR for funding the project.*
- *Dr Sanjay Mehendale, Director, National Institute of Epidemiology for providing me all support and intellectual inputs.*
- *Dr S. Venkatasubramanian for his timely suggestions as Co-PI.*
- *Chennai Corporation Health Authorities and all zonal medical officers for providing me the data.*
- *Dr K. Kolandaswamy, Director of Public Health & Preventive Medicine, Chennai for permitting me to use the PICME data.*
- *Mr M. Chandrasekar, Project Statistical Assistant, NIE for data collection & data entry.*
- *Mr D. Augustine, Technical Asst., NIE for data entry.*

Overview of the study

A city health profile is a valuable document which provides a scientific account of health; stimulates public interest and commitment and can help to identify targets for future and monitor progress towards them. Chennai City, with its historical past, current administration and commercial nature, has been a major populous urban centre in Tamil Nadu state in India. It has 15 percent of the state's population. The demand for having periodic information on diverse aspects of socio-economic, health and other aspects of population has increased and it is expected to grow with the progress of any city because it provides a strong basis for policy formulation and program implementation. This paper reviews the historical development of the city and describes selected health indicators of Chennai City. The purpose of this study was to collate the available information and to examine literacy, immunization and health indicators in relation to health outcomes.

The Report consists of two sections a) Consolidated Data; and b) Analysis.

Two types of analyses *were done based on the available information;*

i) *an index and a smoothened map for illiteracy using several covariates (population, average family size, proportion of slum population, proportion of illiterates, proportion of female illiteracy, proportion of births, proportion of person unemployed, proportion of tribal population, average no. of children per government school, average no. of persons using per public water facility, average no. of persons using per public convenience) simultaneously for ten zones of Chennai city for the year 2011 were generated.*

ii) *determinants associated with the complete immunization of infants for Chennai City for the year 2012 and 2013 were identified using binary logistic regression model to produce a smoothened surface map of Chennai City with predicted values of Complete immunization coverage of Chennai city for both years respectively.*

Getting reliable information was a great ***challenge****, entire zonal boundary structure had been changed and hence comparison over years was difficult. Some information was available by wards /divisions, some by health posts and some based on revenue division and civic division. Thus collation of data was difficult. Also data available were under different administrative boundaries like Chennai City, Chennai Metropolitan Area and Chennai district which posed difficulties in meaningful comparisons. The present study time period was one year, which got further restricted due to prevalent floods in December 2015.*

1. Records from Chennai Corporation.
2. Annual Reports of Corporation of Madras/Chennai.
3. Census of India. http://censusindia.gov.in/
4. https://en.wikipedia.org/wiki/List_of_Chennai_Corporation_zones
5. https://en.wikipedia.org/wiki/Timeline_of_Chennai_history#19th_century
6. https://en.wikipedia.org/wiki/History_of_Chennai
7. https://en.wikipedia.org/wiki/Chennai
8. http://www.ijhssi.org/papers/v3(8)/Version-2/F0382030042.pdf
9. http://shodhganga.inflibnet.ac.in/bitstream/10603/24086/8/08_chapter3.pdf
10. http://www.censusindia.gov.in/2011census/dchb/3302_PART_B_DCHB_CHENNAI.pdf
11. http://censusindia.gov.in/2011-prov-results/data_files/tamilnadu/3.Tamil%20Nadu_PPT_2011-BOOK%20FINAL.pdf
12. http://www.cmdachennai.gov.in/Volume1_English_PDF/Vol1_Chapter02_Demography.pdf
13. http://www.cmdachennai.gov.in/Volume3_English_PDF/Vol3_Chapter03_Demography.pdf
14. http://www.hrdp-idrm.in/.../**info**boxContent32717/Floodriskandcontextofland-usesChennaicitycase-GuptaandNair.pdf
15. Vijayalakshmi R, Toshiyuki K, 2014. A Simulation of Land Use/Cover Change for Urbanization on Chennai Metropolitan Area, India. http://conference.corp.at/archive/CORP2014_73.pdf
16. http://www.cmdachennai.gov.in/Volume3_English_PDF/Vol3_Chapter08_Social%20Facilities%20.doc.pdf
17. http://www.kicc.jp/auick/database/training/2006-1/CR/WS2006-1CR-Chennai.pdf
18. www.indiaonlinepages.com/population/chennai-current-population.html
19. Madras, Chennai: A 400-year Record of the First City of Modern India, Volume 1. The land, people and their governance, edited by S. Muthiah, Palaniappa Brothers.
20. Annual reports of Institute for Research in Medical Statistics, Chetput, Chennai, 1988.

Chennai city

History of Chennai City

Chennai is an ancient city in South India. Originally known as "Madras patnam" this was located in the province of Tondaimandalam, an area lying between Pennar river of Nellore and the Pennar river of Cuddalore. The capital of the province was Kancheepuram. In the year 1646, the settlement had 19,000 persons with the Portuguese and Dutch populations.

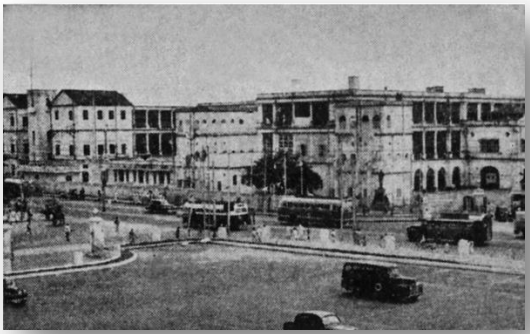
During the course of the late 17th century, both plague and genocidal warfare reduced the population of the colony dramatically. Later the neighbouring villages of Triplicane, Egmore, Purasawalkam and Chetput were annexed with the city to form the city of *Chennapatnam*. The English merchants and the planter families who, allied with their wealthy Indian counterparts, jointly controlled Chennapatnam under the supervision of White Town. Over a period of time and following administrative reforms, the area was fully incorporated into the new metropolitan charter of Madras.

Ripon building

Ancient Chennai dwellers

Chennai central railway station

Govt. general Hospital, Park Town



The development of a harbour in Madras led the city to become an important centre for trade between India and Europe in the 18th century. In 1788, Thomas Parry came to Madras as a merchant and he set up the oldest company in the country (EID Parry). John Binny came to Madras in 1797 and he established the textile company Binny & Co in 1814. Spencer's started a small business in 1864 which later became the biggest department stores in Asia. The original building which housed Spencer & Co. was burnt down in a fire in 1983 and the present structure houses one of the largest shopping malls in India, Spencer Plaza. Other prominent companies in the city included Gordon Woodroffe, Best & Crompton, Higginbotham's, Hoe & Co and P. Orr & Sons.

In 1901 the city, covering an area of about 70 sq km, had a population of 540,000. And in 1905 the Chennai Port Trust was formed. The Government Royapettah Hospital was established in 1911. Water mains and drainage were formed in 1914 and the Street lights were introduced. Kilpauk water works was inaugurated. The First aeroplane flew to Chennai in 1917 arranged by Simpson & Co. The city was expanded to an area of about 80 sq km in 1923. The School of Indian Medicine was founded in 1924 and in 1925 the Loyola College was founded. Tambaram TB Sanatorium was established in 1928. The first broadcasting station was founded at Ripon Buildings complex in 1930. Suburban electric train services started from Chennai Beach to Tambaram in 1931. Raja Sir Muthiah Chettiyar was appointed as the first mayor of the city in 1934. Government Stanley Hospital was established. In 1942 the Second World War resulted in evacuation of Madras. Japanese fighter planes dropped bombs on the city in 1943. Population of the city crossed million persons. The Regional Meteorological Centre was established from the old Madras observatory in 1945.

Around 1946 Mambalam, Saidapet, Government farm Puliyur, Kodambakkam, Saligramam, Adayar and Alandur villages which were part of Saidapet Municipality; Sembiyam, Siruvallur, Peravallur, Small Sembarambakkam and Ayanavaram which were part of Sembium, Panchayat Board; Aminjikarai, Periyakudal, Maduvankarai villages which were part of Aminjikarai Panchayat Board and Part of Velacheri village, belonging to Velacheri Panchayat Board, were annexed to the city.

After India became independent in 1947, the city became the administrative and legislative capital of Madras State which was renamed as Tamil Nadu in 1968.

With the inclusion of 12 Panchayats around Chennai in 1978, the Chennai district area extended from 128.83 sq. kms to 175 sq. kms as per revenue authorities. From time to time, the Chennai

district was divided into number of Divisions for administrative convenience and for rendering effective civic service. The total numbers of Divisions/ Wards increased from 150 in 1981 to 155 in 1991 with the inclusion of five areas such as Cherian Nagar, Dr. Radhakrishnan Nagar (South), Villivakkam (South), Virugambakkam (South) and Aminjikarai (Central). As per 2011 census, Chennai city has 155 Divisions distributed in 10 Zones. Chennai city with an area of 175 sq. km and a population of 4646732. High degree of urbanization and density resulted from immigration and sporadic development of industries on the outskirts. Although Chennai is the smallest of the entire district in the state, it has the highest population density. Chennai district is a city district which has the capital of the state of Tamil Nadu. Chennai district was divided into 5 taluks, namely: (1) Egmore-Nungambakkam (2) Fort Tondiarpet (3) Mambalam-Guindy (4) Mylapore-Triplicane and (5) Perambur-Purasawalkkam.

Profile of Chennai City

Chennai is located on the northeastern part of Tamil Nadu, on the east coast adjoining the Bay of Bengal. It lies between 12^{o} 09' N and 13^{o} 09' N of the latitudes and 80^{o} 0' 12'' E and 80^{o} 0' 19'' E of the longitudes, on a 'sandy shelving breaker swept beach'. It stretches for 25.6 km along the Bay coast, from Thiruvanmiyur on the south to Thiruvottiyur on the north. It is bounded on the east by the Bay of Bengal and on the remaining three sides by Kanchipuram and Thiruvallur districts. The City is accommodating the ever increasing population and the City has fast developed into a Mega city. Chennai City is by population graded as 4th largest in India and 36th-largest urban area in the world. Chennai is the 38th most visited city in the world. "The quality of living survey" rated Chennai as the safest city in India. Chennai attracts about 45% of health tourists from abroad to India, so the city was termed as "health capital of India".

Chennai city had large population in India after Mumbai and Delhi, with 5.41 lakhs in 1901 and steadily increasing to 46.46 lakhs in 2011. Tourism guide publisher Lonely Planet named Chennai as one of the top ten cities in the world to visit in 2015.

Chennai Corporation

DATA CONSOLIDATED AS TABLES & FIGURES

Table 1: Area and population of Chennai City, 1901-2011

Year	Area in sq km	Total Population (in lakhs)	Population density (per hect.)	Decadal growth in %
1901	68.17	5.41	80	-
1911	68.17	5.56	82	2.77
1921	68.17	5.78	85	3.96
1931	68.17	7.13	105	23.36
1941	77.21	8.65	112	21.32
1951	128.83	14.27	111	64.97
1961	128.83	17.49	136	22.56
1971	128.83	26.42	192	51.06
1981	176.00	32.84	187	24.30
1991	176.00	38.43	218	17.02
2001	176.00	43.44	247	13.04
2011*	176.00	46.47	264	6.98
2012#	426.00	69.00	162	48.48
2013-14	426.00	70.81	167	2.62

* As per 2011 census; #As per new structure of Chennai City with 200 wards

The population of Chennai from 5.41 lakhs in 1901 with an area of 68.17 sq km and 38.43 lakhs in 1991 with an area of 176 sq km, had rapidly increased to 70.81 lakhs in 2014 with an area of 426 sq km. The decal growth rate varied from a minimum of 2.62% to a maximum of 64.97%.

Chennai accounted for 6.8 percent of the total population of 62,110,839 of the state in 2001. Among them, 51.3 per cent were males. It ranked 2nd highest population among all the districts of Tamil Nadu, next to Coimbatore district.

Table 2: Age structure of population of Chennai (%).

Age Group	1961	1971	1981	1991	2001	2011
0-4	13.2	12.51	11.03	8.68	7.31	6.93
5-9	12.39	11.74	10.35	9.56	7.97	7.69
10-14	10.64	10.97	11.37	10.51	8.95	8.92
15-19	8.66	9.97	10.61	10.22	9.55	9.68
20-24	10.73	11.05	10.68	11.14	10.47	10.67
25-29	10.21	9.29	9.61	10.2	10.33	10.59
30-34	7.98	7.15	7.46	8.06	8.46	8.76
35-39	6.69	6.99	6.66	7.48	8.04	8.29
40-44	5.49	5.14	5.36	5.68	6.19	6.42
45-49	4.15	4.33	4.7	4.98	5.5	5.72
50-54	3.65	3.51	3.7	3.92	4.37	4.58
55-59	2.1	2.46	2.73	2.9	3.1	3.22
60-64	2.06	2.3	2.4	2.64	2.83	1.37
65-69	1.1	1.15	1.37	1.51	1.96	2.15
>70	1.2	1.65	1.97	2.33	3.02	3.69
Not Known	0	0	0	0.18	1.93	1.63

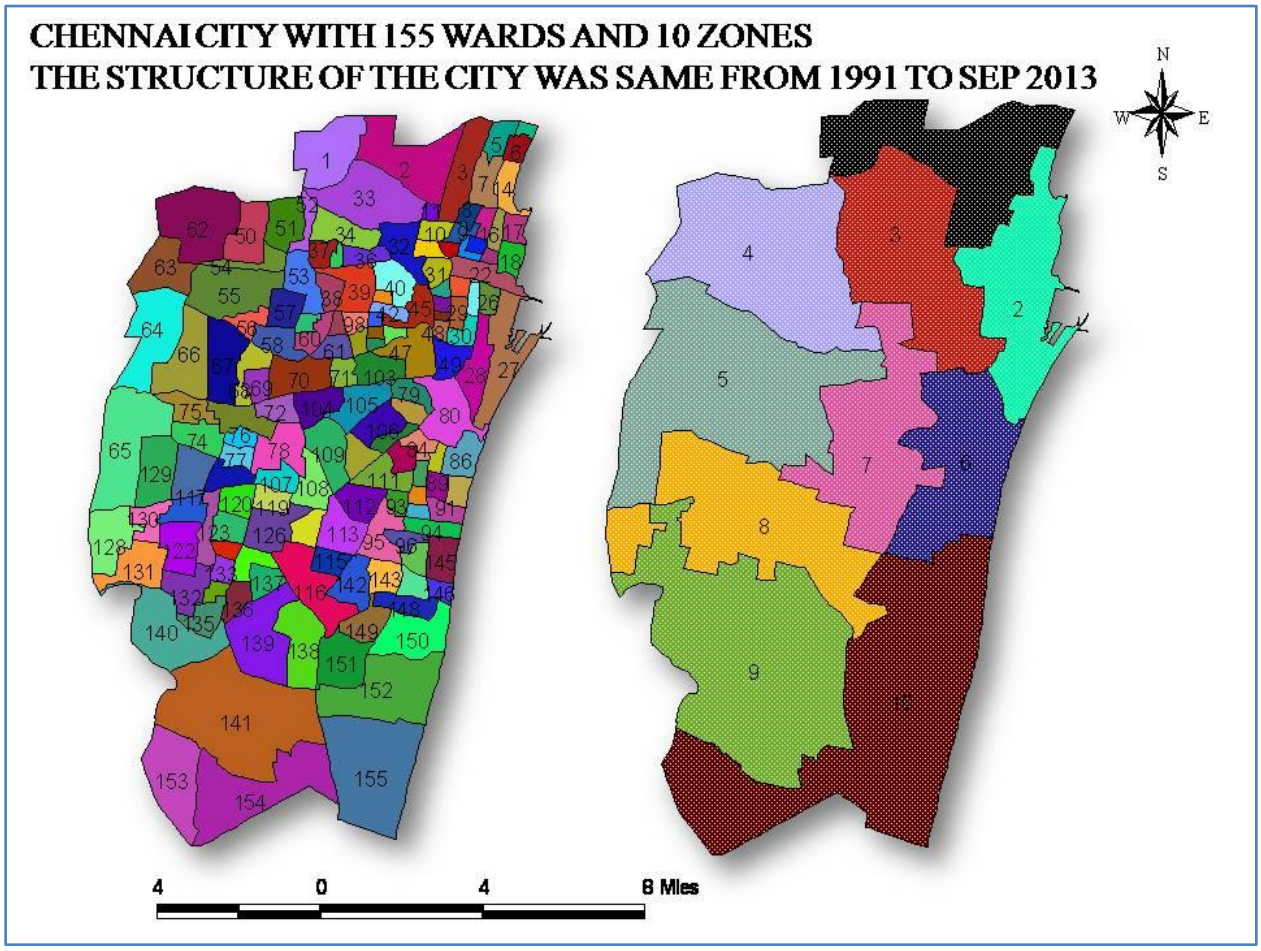
Less than 5 year age group population gradually decreased from 13.2%in 1961 to 6.93% in 2011, Whereas 50-59 age group population gradually increased.

Table 3: Sex ratio per 1000 Males of Chennai

Year	Sex- Ratio	Year	Sex -Ratio
1901	983	1961	901
1911	949	1971	904
1921	913	1981	934
1931	901	1991	934
1941	911	2001	957
1951	922	2011	986

There were 983 females for 1000 males in 1901 but there was an oscillation of decrease and increase and finally reached to 986 females for 1000 males in 2011.

Figure 1:



The Chennai city had 150 wards in 1981, remained the same up to the year 1991. Later in 1991 the city got expanded to 155 wards of 10 zones till September 2011. The above figure shows the ward boundaries of the city.

The following table (4) shows the three decadal population of Chennai city and table5 shows the variation in the annual growth rate of the wards over decades. The annual growth rate varied from -2.93 to a maximum of 13.22 in 1991-01 and varied from -3.37 to 5.20 in 2001-11. The highest growth rate was in 'kodungaiyur' and 'Perambur east' divisions respectively.

Table 6 shows the zonal population and growth rate over three decades. Kilpauk zone with less dense population showed a higher growth rate over years.

Table 4: CHENNAI CITY WARD WISE POPULATION 1991, 2001 & 2011

Division No.	zone no.	Division name	Pop 1991	Pop 2001	Pop2011	Division No.	zone no.	Division name	Pop 1991	Pop 2001	Pop2011
1	1	Kodungaiyur west	24857	57723	76760	79	6	Adikesavapurram	22384	25192	19748
2	1	Kodungaiyur east	27506	50385	66897	80	6	Nehru nagar	18838	30626	20318
3	1	Dr. Radhakrishnan nagar north	30250	43112	52995	81	6	Chinthadrripet	21080	22068	17123
4	1	Cheriyan nagar north	22883	20961	15186	82	6	Komaleeswaranpet	18313	20501	16338
5	1	Jeeva nagar north	39168	38446	45204	83	6	Balasubramaniam nagar	21281	20990	19140
6	1	Cheriyan nagar south	23389	22210	19523	84	6	Thiruvateeswaranpet	16277	15913	17825
7	1	Jeeva nagar south	23520	21720	22161	85	6	Dr. Natesan nagar	12195	13395	11304
8	1	Korrukkupet	30897	31558	33039	86	6	Chepauk	16057	15285	16185
9	1	Mottai garden	22984	19301	20306	87	6	Jam Bazar	17196	15121	14375
10	1	Kumaraswamy nagar south	23931	38511	44747	88	6	Umarpulavar nagar	18043	20921	23618
11	1	Dr. Radhakrishnan nagar south	22736	28146	33287	89	6	Triplicane	18494	16358	16014
12	1	Kumaraswamy nagar north	22233	17071	16254	90	6	Marina	18430	16549	17329
13	1	Dr. vijayaraghavalu nagar	19852	21192	21829	91	6	Krishnampet	22148	21557	22285
14	2	Tondiarpet	27765	32373	35130	92	6	Bharathi nagarr	17613	18410	16511
15	2	Sanjeevirayanpett	20874	21589	19952	93	6	Azad nagar north	17689	17929	17368
16	2	Grace garden	19832	23959	22947	94	6	Bharathidasan nagar	17581	21995	22407
17	2	Ma.po.si.nagar	22445	24152	24670	95	6	Azad nagar south	12144	12387	11664
18	2	Royapuram	15199	15719	16424	96	6	Vivekanadapuram	13504	16608	12954
19	2	Singaragarden	16872	17174	15457	97	7	Anjugamammaiyar nagar	23929	25559	20860
20	2	Narayanappanaicken garden	15451	16921	13276	98	7	Kosapet	16492	17614	17466
21	2	Old washermenpet	17692	19681	16044	99	7	Pattalam	17397	19784	15460
22	2	Meenakshiammanpet	25500	27698	26177	100	7	Anbazhagan nagar	12888	13682	9545
23	2	Kondithope	16770	16510	18434	101	7	Perumalpet	15312	16210	12703
24	2	Sevenwells north	16589	17326	21002	102	7	Kannappannagar	10602	11947	9377
25	2	Ammankoil	18113	17669	19261	103	7	Dr. Ambedkar nagar	14238	17091	16595
26	2	Muthialpet	20291	22797	20239	104	7	Chetpet	23904	24422	20897
27	2	Vallalseetthakadinagar	25475	17999	24426	105	7	Egmore	16650	19473	17965
28	2	Katchaleeswarar nagar	21341	24788	26156	106	7	Pudupet	20704	22316	20023
29	2	Sevenwells south	16832	16769	19415	107	7	Ko.su.maninagar	23198	26213	22902
30	2	Sowcarpet	15905	16718	25286	108	7	Nakkeerar nagarr	28294	30112	20042
31	2	Basinbridge	22047	25845	32152	109	7	Thousand lights	21521	23439	18546
32	3	Vysarpadi south	28400	37155	32269	110	7	Azhagiri nagar	16190	16793	13867
33	3	Vysarpadi north	31570	34667	41617	111	7	Amir mahal	21268	21537	18480
34	3	Perambur north	35986	38650	49559	112	7	Royapettah	16792	17818	14912
35	3	Perambur east	23772	26359	40075	113	7	Teynampet	22623	23888	19701
36	3	Elangonagar	34915	39649	52262	114	8	Sathyamurthy nagar	31528	34722	32913
37	3	Perambur south	22918	22692	26491	115	8	Alwarpet north	23925	25425	24775
38	3	Thiru.vi.ka.nagar	30662	36038	35187	116	8	Alwarpet south	27894	25917	23624
39	3	Wadia nagar	26218	30533	30573	117	8	Vadapalani west	28047	29762	36192
40	3	Dr.sathiavanimuthu nagar	37979	41934	51479	118	8	Vadapalani east	27054	29635	34310
41	3	Pulianthope	21321	18632	21550	119	8	Kalaivanar nagar	25535	23839	23472
42	3	Dr.Besant nagar	23095	24145	27857	120	8	Navalar nedunchezhian nagar east	28236	29896	28874
43	3	Peddunaickenpet	15008	13469	15835	121	8	Navalar nedunchezhian nagar west	27999	26778	25912
44	3	Perumalkoil garden	16323	13642	14291	122	8	Ashok nagar	30884	32736	30204
45	3	Thattankulam	24240	20101	17871	123	8	MGR nagar north	20534	22454	25733
46	3	Choolai	15273	11970	12747	124	8	Kamarajar nagar north	21086	20574	22907
47	3	Parktown	13917	12308	14379	125	8	Kamarajar nagar south	24102	29261	20416
48	3	Elephantgate	19317	22615	18269	126	8	Thyagaraya nagar	19247	21521	17718
49	3	Edapalayam	15910	15004	16889	127	8	Rajaji nagar	21777	24918	24606
50	4	Agaram north	34256	43398	51527	128	8	Virugambakkam south	29123	44712	58003
51	4	Sembiam	34778	44279	46250	129	8	Saligramam	33944	44234	59322
52	4	Siruvalloor	20831	21284	23233	130	9	Kodambakkam north	39238	44525	55784
53	4	Nagammaiammaiyar nagar north	20416	23985	23831	131	9	Kodambakkam south	31832	50264	58468
54	4	Agaram south	32043	35744	39058	132	9	Saidapet west	29011	38334	41733
55	4	Viduthalaigurusami nagar	28278	29434	23220	133	9	Kumaran nagar north	25018	23167	25793
56	4	Ayanavaram	25378	32498	38123	134	9	Kumaran nagar south	25004	25756	23054
57	4	Nagamaniammaiyar nagar south	22328	20535	21805	135	9	Saidapet east	39603	41157	49869
58	4	Panneerselvam nagar	33731	35899	30577	136	9	KK nagar	25789	24672	33270
59	4	Maraimalaiadigal nagar north	24999	21258	23595	137	9	VOC nagar	24573	22923	22019
60	4	Maraimalaiadigal nagar south	27831	29183	29821	138	9	G.D.Naidu nagar east	33357	36751	37720
61	4	Purasaiwakkam	16461	16415	17321	139	9	G.D.Naidu nagar west	28783	31759	35299
62	4	Kolathur	39625	74363	110474	140	9	Guindy west	22386	30240	33089
63	4	Villiwakkam north	56687	68502	81648	141	9	Guindy east	34950	45787	54598
64	5	Villiwakkam south	58304	68185	72144	142	10	Bheemannapet	25851	25642	26525
65	5	Virugambakkam north	47650	68054	95564	143	10	Tiruvalluvar nagar	21499	16855	20124
66	5	Annanagar west	41528	47327	50926	144	10	Madhavaperumalpuram	22359	19001	21231
67	5	Annanagar central	28953	33609	37331	145	10	Karaneeswararpuram	22775	20483	24508
68	5	Annanagar east	36979	34647	32999	146	10	Santhome	23928	24258	17539
69	5	Shenoy nagar	24899	25342	27133	147	10	Mylapore	22285	18234	17881
70	5	Kilpauk north	19750	25583	26313	148	10	Avvai nagar north	23564	21464	17914
71	5	Gangadeeswararkoil	15324	13107	12091	149	10	Rajaannaimalaipuram	30678	31730	32138
72	5	Kilpauk south	24803	28872	32446	150	10	Avvai nagar south	28102	31688	31270
73	5	Aminjikarai east	25067	23976	22662	151	10	Adayar west	30884	38366	34509
74	5	Aminjikarai central	41361	46416	56960	152	10	Adayar east	28421	24555	25707
75	5	Aminjikarai west	38744	55735	60126	153	10	Velachery	43796	95818	143626
76	5	Periyar nagar north	21043	23136	24524	154	10	Thiruvanmiyur west	31936	41627	53855
77	5	Periyar nagar south	19526	22457	23619	155	10	Thiruvanmiyur east	48553	78007	75748
78	5	Nungambakkam	27435	25686	23476	Total Population			2015031	2284495	2542633

Table5: CHENNAI WARD WISE ANNUAL GROWTH RATE 1991-01 & 2001-11

Division No.	zone no.	Division name	Growth rate 1991-01	Growth rate 2001-11	Division No.	zone no.	Division name	Growth rate 1991-01	Growth rate 2001-11
1	1	Kodungaiyur west	13.22	3.30	79	6	Adikesavapurram	1.25	-2.16
2	1	Kodungaiyur east	8.32	3.28	80	6	Nehru nagar	6.26	-3.37
3	1	Dr. Radhakrishnan nagar north	4.25	2.29	81	6	Chinthadrripet	0.47	-2.24
4	1	Cheriyan nagar north	-0.84	-2.76	82	6	Komaleeswaranpet	1.19	-2.03
5	1	Jeeva nagar north	-0.18	1.76	83	6	Balasubramaniam nagar	-0.14	-0.88
6	1	Cheriyan nagar south	-0.50	-1.21	84	6	Thiruvateeswaranpet	-0.22	1.20
7	1	Jeeva nagar south	-0.77	0.20	85	6	Dr. Natesan nagar	0.98	-1.56
8	1	Korrukkupet	0.21	0.47	86	6	Chepauk	-0.48	0.59
9	1	Mottai garden	-1.60	0.52	87	6	Jam Bazar	-1.21	-0.49
10	1	Kumaraswamy nagar south	6.09	1.62	88	6	Umarpulavar nagar	1.60	1.29
11	1	Dr. Radhakrishnan nagar south	2.38	1.83	89	6	Triplicane	-1.15	-0.21
12	1	Kumaraswamy nagar north	-2.32	-0.48	90	6	Marina	-1.02	0.47
13	1	Dr. vijayaraghavalu nagar	0.67	0.30	91	6	Krishnampet	-0.27	0.34
14	2	Tondiarpet	1.66	0.85	92	6	Bharathi nagarr	0.45	-1.03
15	2	Sanjeevirayanpett	0.34	-0.76	93	6	Azad nagar north	0.14	-0.31
16	2	Grace garden	2.08	-0.42	94	6	Bharathidasan nagar	2.51	0.19
17	2	Ma.po.si.nagar	0.76	0.21	95	6	Azad nagar south	0.20	-0.58
18	2	Royapuram	0.34	0.45	96	6	Vivekanadapuram	2.30	-2.20
19	2	Singaragarden	0.18	-1.00	97	7	Anjugamammaiyar nagar	0.68	-1.84
20	2	Narayanappanaicken garden	0.95	-2.15	98	7	Kosapet	0.68	-0.08
21	2	Old washermenpet	1.12	-1.85	99	7	Pattalam	1.37	-2.19
22	2	Meenakshiammanpet	0.86	-0.55	100	7	Anbazhagan nagar	0.62	-3.02
23	2	Kondithope	-0.16	1.17	101	7	Perumalpet	0.59	-2.16
24	2	Sevenwells north	0.44	2.12	102	7	Kannappannagar	1.27	-2.15
25	2	Ammankoil	-0.25	0.90	103	7	Dr. Ambedkar nagar	2.00	-0.29
26	2	Muthialpet	1.24	-1.12	104	7	Chetpet	0.22	-1.44
27	2	Vallalseetthakadinagar	-2.93	3.57	105	7	Egmore	1.70	-0.77
28	2	Katchaleeswarar nagar	1.62	0.55	106	7	Pudupet	0.78	-1.03
29	2	Sevenwells south	-0.04	1.58	107	7	Ko.su.maninagar	1.30	-1.26
30	2	Sowcarpet	0.51	5.13	108	7	Nakkeerar nagarr	0.64	-3.34
31	2	Basinbridge	1.72	2.44	109	7	Thousand lights	0.89	-2.09
32	3	Vysarpadi south	3.08	-1.32	110	7	Azhagiri nagar	0.37	-1.74
33	3	Vysarpadi north	0.98	2.00	111	7	Amir mahal	0.13	-1.42
34	3	Perambur north	0.74	2.82	112	7	Royapettah	0.61	-1.63
35	3	Perambur east	1.09	5.20	113	7	Teynampet	0.56	-1.75
36	3	Elangonagar	1.36	3.18	114	8	Sathyamurthy nagar	1.01	-0.52
37	3	Perambur south	-0.10	1.67	115	8	Alwarpet north	0.63	-0.26
38	3	Thiru.vi.ka.nagar	1.75	-0.24	116	8	Alwarpet south	-0.71	-0.88
39	3	Wadia nagar	1.65	0.01	117	8	Vadapalani west	0.61	2.16
40	3	Dr.sathiavanimuthu nagar	1.04	2.28	118	8	Vadapalani east	0.95	1.58
41	3	Pulianthope	-1.26	1.57	119	8	Kalaivanar nagar	-0.66	-0.15
42	3	Dr.Besant nagar	0.45	1.54	120	8	Navalar nedunchezhian nagar east	0.59	-0.34
43	3	Peddunaickenpet	-1.03	1.76	121	8	Navalar nedunchezhian nagar west	-0.44	-0.32
44	3	Perumalkoil garden	-1.64	0.48	122	8	Ashok nagar	0.60	-0.77
45	3	Thattankulam	-1.71	-1.11	123	8	MGR nagar north	0.94	1.46
46	3	Choolai	-2.16	0.65	124	8	Kamarajar nagar north	-0.24	1.13
47	3	Parktown	-1.16	1.68	125	8	Kamarajar nagar south	2.14	-3.02
48	3	Elephantgate	1.71	-1.92	126	8	Thyagaraya nagar	1.18	-1.77
49	3	Edapalayam	-0.57	1.26	127	8	Rajaji nagar	1.44	-0.13
50	4	Agaram north	2.67	1.87	128	8	Virugambakkam south	5.35	2.97
51	4	Sembiam	2.73	0.45	129	8	Saligramam	3.03	3.41
52	4	Siruvalloor	0.22	0.92	130	9	Kodambakkam north	1.35	2.53
53	4	Nagammaiammaiyar nagar north	1.75	-0.06	131	9	Kodambakkam south	5.79	1.63
54	4	Agaram south	1.16	0.93	132	9	Saidapet west	3.21	0.89
55	4	Viduthalaigurusami nagar	0.41	-2.11	133	9	Kumaran nagar north	-0.74	1.13
56	4	Ayanavaram	2.81	1.73	134	9	Kumaran nagar south	0.30	-1.05
57	4	Nagamaniammaiyar nagar south	-0.80	0.62	135	9	Saidapet east	0.39	2.12
58	4	Panneerselvam nagar	0.64	-1.48	136	9	KK nagar	-0.43	3.48
59	4	Maraimalaiadigal nagar north	-1.50	1.10	137	9	VOC nagar	-0.67	-0.39
60	4	Maraimalaiadigal nagar south	0.49	0.22	138	9	G.D.Naidu nagar east	1.02	0.26
61	4	Purasaiwakkam	-0.03	0.55	139	9	G.D.Naidu nagar west	1.03	1.11
62	4	Kolathur	8.77	4.86	140	9	Guindy west	3.51	0.94
63	4	Villiwakkam north	2.08	1.92	141	9	Guindy east	3.10	1.92
64	5	Villiwakkam south	1.69	0.58	142	10	Bheemannapet	-0.08	0.34
65	5	Virugambakkam north	4.28	4.04	143	10	Tiruvalluvar nagar	-2.16	1.94
66	5	Annanagar west	1.40	0.76	144	10	Madhavaperumalpuram	-1.50	1.17
67	5	Annanagar central	1.61	1.11	145	10	Karaneeswararpuram	-1.01	1.97
68	5	Annanagar east	-0.63	-0.48	146	10	Santhome	0.14	-2.77
69	5	Shenoy nagar	0.18	0.71	147	10	Mylapore	-1.82	-0.19
70	5	Kilpauk north	2.95	0.29	148	10	Avvai nagar north	-0.89	-1.65
71	5	Gangadeeswararkoil	-1.45	-0.78	149	10	Rajaannaimalaipuram	0.34	0.13
72	5	Kilpauk south	1.64	1.24	150	10	Avvai nagar south	1.28	-0.13
73	5	Aminjikarai east	-0.44	-0.55	151	10	Adayar west	2.42	-1.01
74	5	Aminjikarai central	1.22	2.27	152	10	Adayar east	-1.36	0.47
75	5	Aminjikarai west	4.39	0.79	153	10	Velachery	11.88	4.99
76	5	Periyar nagar north	0.99	0.60	154	10	Thiruvanmiyur west	3.03	2.94
77	5	Periyar nagar south	1.50	0.52	155	10	Thiruvanmiyur east	6.07	-0.29
78	5	Nungambakkam	-0.64	-0.86	Total Population			1.34	1.13

Pink Colour shows the highest decadal growth rate and green colour shows the lowest decadal growth rate in the respective yrs.

Table 6:

CHENNAI CITY ZONE WISE POPULATION & ANNUAL GROWTH RATE 1971-2011

Zone no	Name of the Zone	Area in sq Km(2001)	Density per sq hect. (2001)	Population in Lakhs					Annual rate of growth in percent			
				1971	1981	1991	2001	2011	1971-81	1981-91	1991-01	2001-11
1	Tondiarpet	17.30	243	2.01	2.69	3.72	4.10	4.68	2.95	3.28	1.00	1.41
2	Basin Bridge	11.52	335	3.59	3.52	3.27	3.76	3.96	-0.21	-0.74	1.40	0.55
3	Pulianthope	13.51	349	3.34	4.13	4.31	4.59	5.19	2.13	0.44	0.64	1.30
4	Ayanavaram	19.76	258	2.22	3.58	4.12	4.97	5.60	4.89	1.42	1.89	1.28
5	Kilpauk	26.38	211	2.18	3.45	4.94	5.42	5.98	4.68	3.66	0.93	1.04
6	Ice-House	10.15	346	3.27	3.49	3.20	3.42	3.13	0.63	-0.84	0.65	-0.86
7	Nungambakkam	12.90	277	2.91	3.09	3.20	3.48	2.89	0.61	0.35	0.83	-1.68
8	Kodambakkam	13.00	368	2.48	3.33	4.39	4.66	4.89	2.96	2.81	0.61	0.48
9	saidapet	23.56	180	1.89	2.61	3.33	4.15	4.71	3.25	2.48	2.23	1.33
10	Mylapore	27.92	180	2.50	2.97	3.95	4.88	5.43	1.70	2.89	2.13	1.12
	Chennai City	176	247	26.39	32.85	38.43	43.44	46.47	2.20	1.58	1.23	0.70

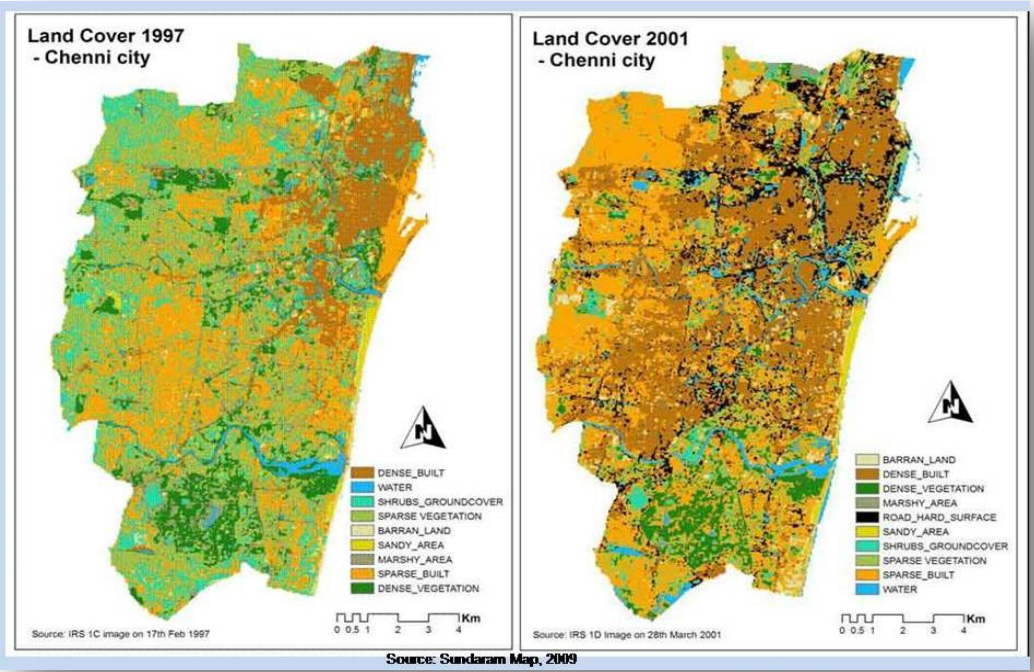
Table 7: Chennai City Zone wise Literacy Level in 2001 & 2011

Zone no	2001			2011		
	Total Literates	Male Literates	Female Literates	Total Literate	Male Literates	Female Literates
Zone 1	79.40	85.43	73.22	85.31	89.79	80.87
Zone 2	80.30	85.00	75.29	88.58	92.31	84.74
Zone 3	81.27	86.68	75.59	87.08	91.50	82.62
Zone 4	86.62	91.28	81.89	91.45	94.75	88.22
Zone 5	88.44	92.80	83.87	92.55	95.70	89.42
Zone 6	86.15	90.18	81.77	89.56	93.00	85.99
Zone 7	88.11	92.18	83.93	92.05	95.00	89.15
Zone 8	88.67	92.71	84.48	92.38	95.46	89.31
Zone 9	86.65	91.57	81.33	90.42	94.02	86.67
Zone 10	86.76	91.25	82.22	91.84	94.91	88.84
Chennai City	85.24	89.91	80.36	90.12	93.64	86.58

In general male literacy rate was high compared to female literacy rate in both the years 2001 and 2011. It was also observed the female literacy rate was on the higher side over all zones when compared 2001 to 2011. It shows a positive sign to the city.

Figure 2

Land cover information of Chennai city



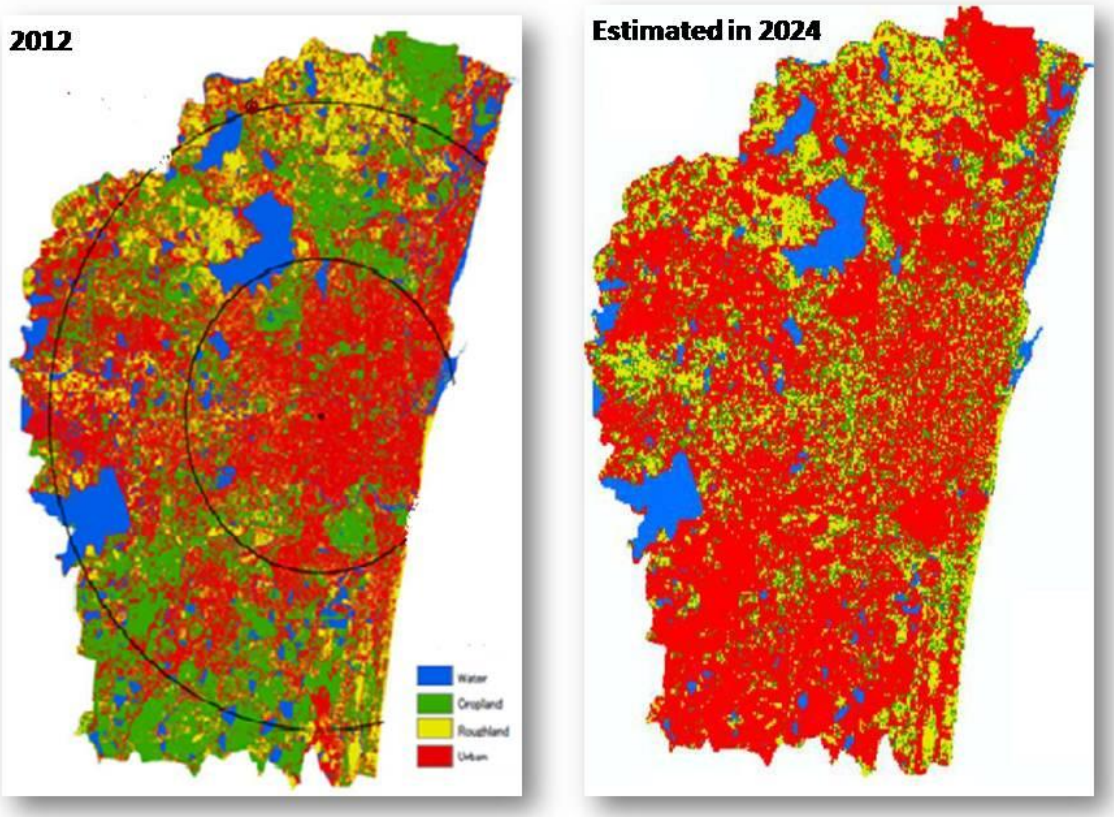
The land cover information tremendously changed over years. Dense vegetation areas in 1997 changed to dense built up areas in 2001.

In 2012 the urban built up areas increased replacing the crop land / vegetation area and the estimated urban areas in the year 2026 with almost invisible crop lands or vegetation.

Though the Chennai City shows an improvement over industrialization, population density etc. it also shows an alarming sign of scarcity of good environment.

Figure 3:

Land cover information in 2012 and in 2024 estimated

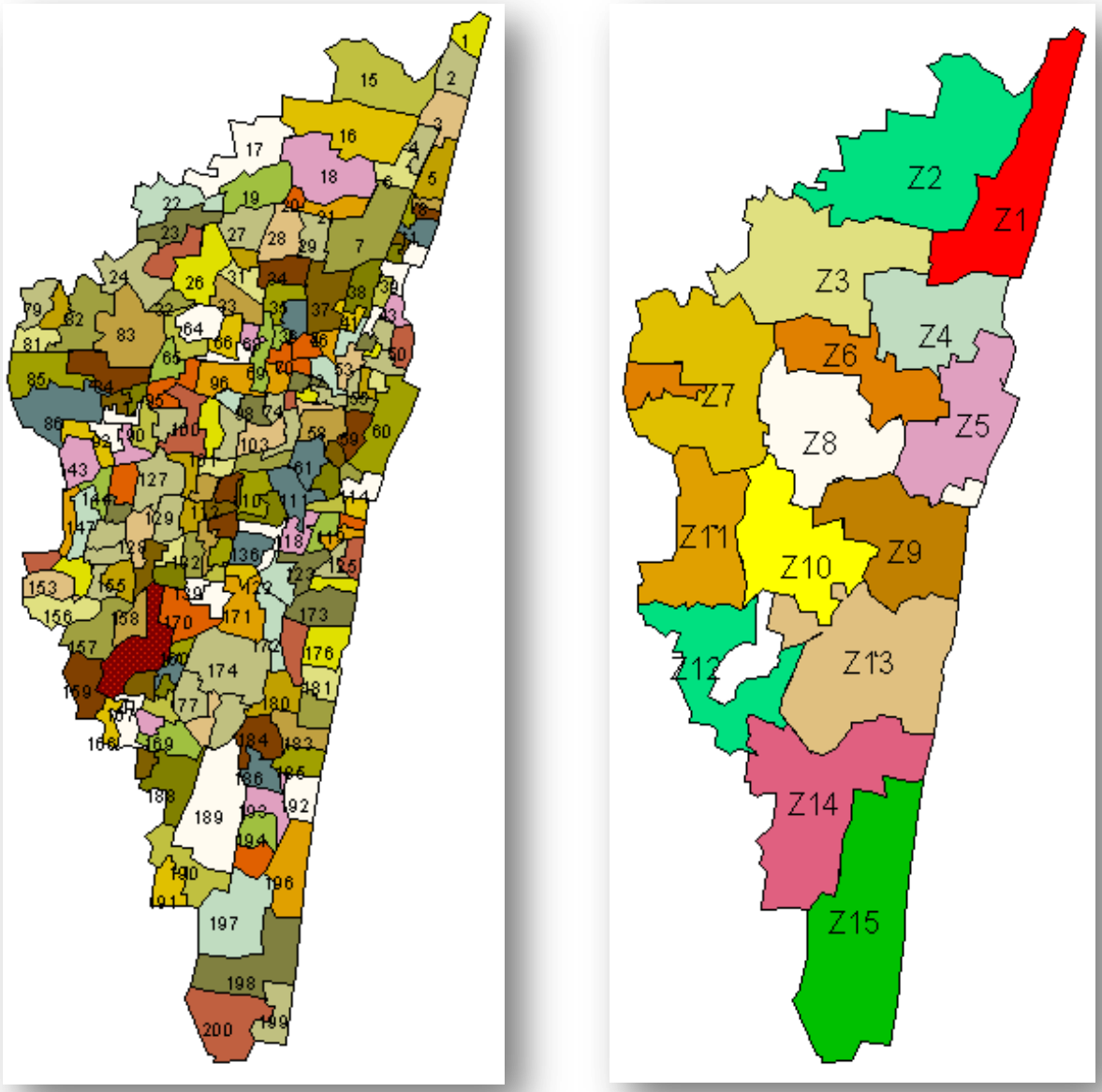


Source:Vijayalakshmi Rajendran, Toshiyuki Kaneda

Legend colour	Land use /cover classes	General Description
	Water	An areas covered by open water such as ocean, river, ponds & artificial aquaculture
	Cropland	An area that is used for any kind of cultivation such as agriculture, tree crops or food crops.
	Rough land	An area covered by shrubs and bare lands
	Urban	An area has all residential, commercial and industrial areas, villages settlements and transportation infrastructure

Figure 4:

Chennai City (Sep 2011) with 200 wards and 15 zones



Formation of new wards of Chennai City in the year 2011.

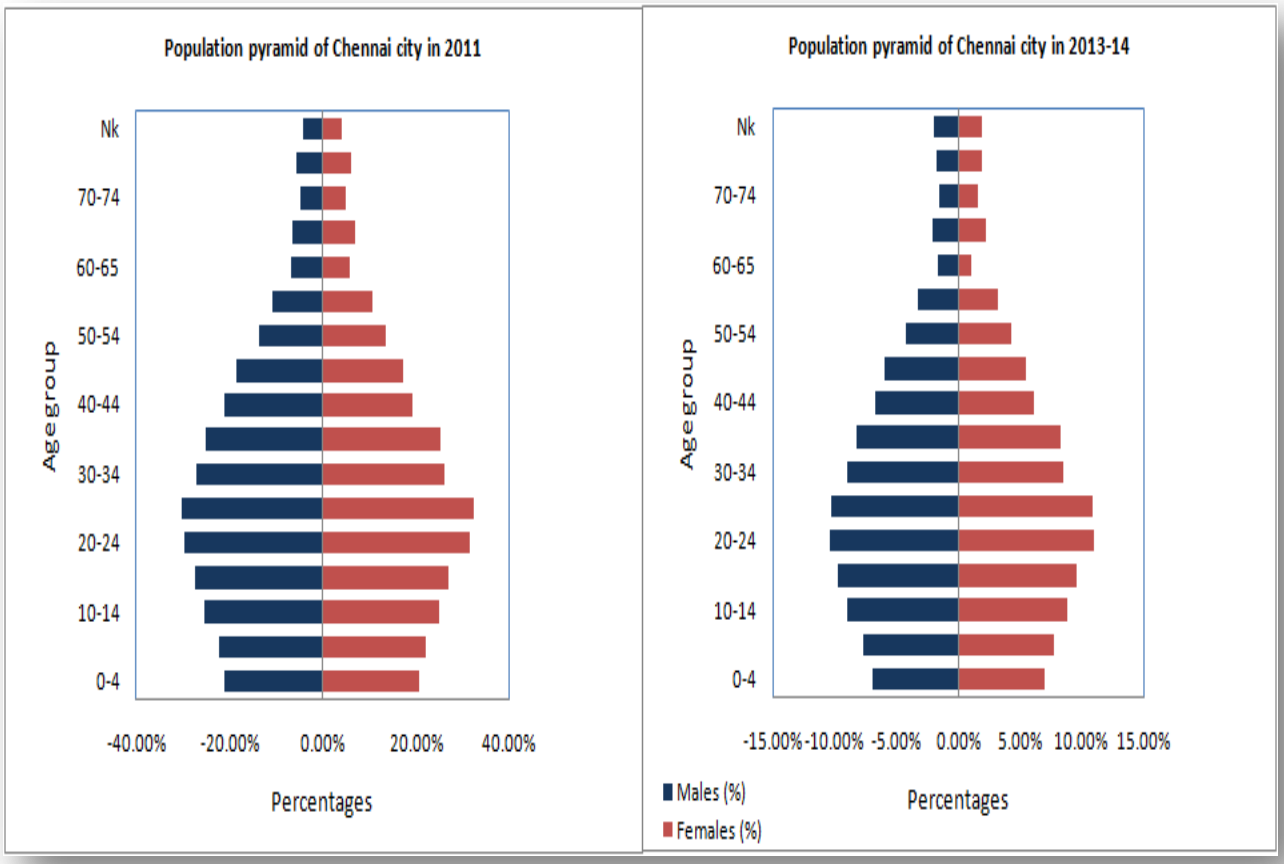
- Chennai Corporation absorbed 7 municipalities, three town panchayats and 13 panchayat unions in Tiruvallur district and 2 municipalities, five town panchayats and 12 panchayat unions in Kanchipuram district.
- A total of 9 municipalities merged into the city Alandur, Ambattur, Kattivakkam,: Madhavaram, Maduravoyal, Manali, Tiruvottiyur, Ullagaram Puzhuthivakkam and Valasaravakkam.
- A total of eight town panchayats merged into the city: Chinnasekkadu, Puzhal,Porur, Nandambakkam, Meenambakkam, Perungudi, Pallikaranai, Sholinganallur.
- A total of twenty five village panchayats merged into the city: Edayanchavadi, Sadayankuppam, Kadapakkam, Theeyampakkam, Mathur,Vadaperumbakkam, Surapet, Kathirvedu, Puthagaram, Nolambur, Karambakkam, Nerkundram, Ramapuram,Mugalivakkam, Manapakkam, Kottivakkam, Palavakkam, Neelankarai, Injambakkam, Karapakkam , Okkiyam,Thuraipakkam, Madipakkam, Jaladampet, Semmencherry, Uthandi.
- The expanded city was re-organized into 15 zones consisting of 200 wards. The newly annexed areas were divided into 93 wards, and the remaining 107 wards were created out of the original 155 within the old city limits. As of September 2011, the new wards of the Chennai City were 200 wards, 26 were reserved for scheduled castes and scheduled tribes and 58 were reserved for women.

Table 8: Zone wise population of Chennai City, 2013-14.

Zone no.	Zone name	Wards in the zone	Total Pop
1	Thiruvotriyur	1–14	307485
2	Manali	15–21	99359
3	Madhavaram	22–33	177148
4	Tondiarpet	34–48	715394
5	Royapuram	49–63	665318
6	Thiru. Vi. Ka. Nagar	64–78	611680
7	Ambattur	79–93	715079
8	Anna Nagar	94–108	757273
9	Teynampet	109–126	767283
10	Kodambakkam	127–142	704697
11	Valasaravakkam	143–155	433077
12	Alandur	156–167	239382
13	Adyar	170–182	490767
14	Perungudi	168, 169,183-191	322728
15	Sholinganallur	192–200	74583
Chennai City- Total population			7081253

The table 8, shows the zone wise population of Chennai city in 2014 with the highest population in zone 9, Teynampet; and the smallest zone as shollinganallur, zone 15.

Figure: 5 Population pyramid of Chennai City



EDUCATION IN CHENNAI CITY

Currently Chennai is in second place for literacy among the metropolitan city centers in India with 90.33 per cent literacy rate. Chennai has a mix of public and private schools. The public school system is managed by the Chennai Corporation with an enrollment of 142,387 students in over 330 schools. Tamil and English are the primary media of instruction, though several schools also use Telugu or Urdu. Public schools run by the Chennai Corporation are all affiliated with the Tamil Nadu State Board, while private schools may be affiliated with either of the Tamil Nadu Board of Secondary Education or the Central Board of Secondary Education (CBSE). There is also the Matriculation School education. The Arts and Science Colleges in Chennai are affiliated to University of Madras, which has five campuses in the city. The Indian Institute of Technology Madras (IITM) and the Anna University are the two well-known centres for engineering education in the city.

Table 9:

Madras /Chennai -Literates by Sex and Sex Ratio of Literates 1901-2011							
	No. of Literates			Percent to total Population			Sex Ratio
Year	P	M	F	P	M	F	Per 1000 males
1901	115481	92394	23087	22.7	36.0	9.1	250
1911	144758	112258	32500	27.9	42.0	12.9	290
1921	168690	125136	43554	32.0	45.3	17.4	348
1931	199870	147872	51998	30.8	43.3	16.9	352
1951	490912	297853	193059	34.7	40.4	28.4	648
1961	1028326	633203	395123	59.5	69.6	48.2	624
1971	1531406	915488	615918	62.0	70.6	52.5	673
1981	2241149	1280772	960337	68.4	75.6	60.7	750
1991	2752341	1535351	1216990	71.6	77.3	65.6	793
2001	3336695	1799981	1536714	76.8	81.1	72.3	854
2011	3776276	1968079	1808197	90.12	93.64	86.58	949

A gradual increase in the literacy level over the years has been observed. In the year 1901 there were 250 females for 1000 males where as it increased to 949 females per 1000 males in 2011.

Table 10: Education Facilities in Chennai City (2005)				
Sl.No.	Category of Institutions	Govt / Govt aided	Private	Total
1	Schools			
	(a) Primary	164	315	479
	(b) Middle	125	127	252
	(c) High School	55	171	226
	(d) Higher Secondary	60	366	426
2	Colleges			
	(a) Arts and Science colleges	22	11	33
	(b) Training Colleges	5	1	6
	(c) Physical Education	1		1
	(d) Others including Research Institutions	25	13	38
3	Technical Education			
	(a) I.I.T.s	3	87	90
	(b) Polytechnics	11	2	13
	(c) Engineering colleges	4	2	6
4	Medical Colleges			
	(a) Medical Education	3		3
	(b) Dental Colleges	1	0	1
	(c) Siddha	1	0	1
	(d) Homeo			
	(e) Unani	1		1
	(f) Ayurveda		1	1
	(g) Pharmacy	1	2	3
	(h) Nursing	1		1
5	Veterinary Colleges	1		1
	Law Colleges	1		1

Figure 6: Chart showing the trend of Birth & death rates of Chennai City 1971-2011

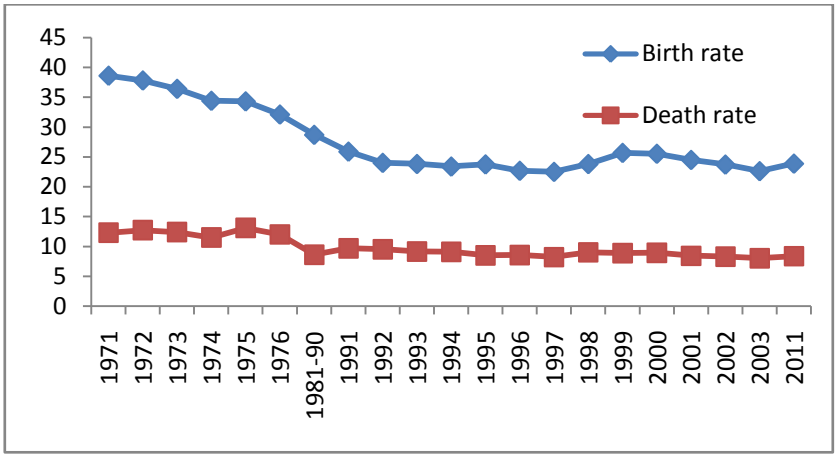


Table 11:

Birth rates and Death rates of Chennai City 1971-2011 (per 1000 population).		
Year	**Birth rate**	**Death rate**
1971	**38.60**	**12.30**
1972	**37.80**	**12.70**
1973	**36.40**	**12.40**
1974	**34.40**	**11.50**
1975	**34.30**	**13.10**
1976	**32.10**	**12.00**
1981-90	**28.70**	**8.60**
1991	**25.89**	**9.67**
1992	**24.01**	**9.50**
1993	**23.82**	**9.14**
1994	**23.39**	**9.07**
1995	**23.75**	**8.49**
1996	**22.68**	**8.54**
1997	**22.50**	**8.20**
1998	**23.81**	**9.00**
1999	**25.68**	**8.87**
2000	**25.53**	**8.92**
2001	**24.50**	**8.42**
2002	**23.72**	**8.27**
2003	**22.62**	**8.01**
2011	**23.88**	**8.36**

The data shown in the table are illustrated through the chart. The chart shows the trend over yrs from 1971 to 2011. Birth rates show a decline, whereas the death rate does not decrease sharply but shows slight variation over years from 1995 to 2011.

Table: 12
Registered deaths of Chennai city 1975-76 & 1983-84 per 1000 population

Division No	Name of the Division	Death Rates 1975-76	Death Rates 1983-84	Division No	Name of the Division	Rates 1975-76	Rates 1983-84
2	Dr Radhakrishna Nagar(North)	16.36	5.96	77	Aminjikarai (West)	13.50	3.60
3	Jeeva Nagar (North)	11.85	5.09	78	Aminjikarai (East)	13.50	3.41
4	Cherian Nagar (North)	10.06	3.92	79	Periyar Nagar (north)	9.41	6.35
5	Cherian Nagar (south)	10.06	3.21	80	Periyar Nagar (South)	9.41	5.51
6	Tondiyarpet	13.27	5.44	81	Nungambakkam	9.80	4.46
7	Jeeva Nagar (South)	11.85	2.67	82	Kilpauk (South)	9.80	3.22
8	Korukupet	11.60	5.91	83	Chetpet	9.80	4.13
9	Sanjeevarayanpet	11.60	3.04	84	Egmore	10.98	5.87
10	Grace Garden	11.20	3.07	85	Pudupet	10.24	5.17
11	Ma Po SI Nagar	11.20	3.62	86	Adikesawapuram	12.28	6.10
12	Royapuram	9.36	3.98	87	Chindadripet	10.04	5.27
13	Singara Garden	11.48	4.79	88	Nehru Nagar	14.35	5.49
14	Meenakshiammanpet	13.81	5.38	89	Chepauk	6.64	4.98
15	Old washermenpet	13.81	6.31	90	Dr Natesan Nagar	9.18	4.25
16	Nayanappa Naickan Garden	7.99	2.71	91	Thiruvatteswaran Nagar	9.70	4.43
17	Mottai Garden	10.86	3.00	92	Komaleeswaranpet	10.53	4.31
18	Kumaraswamy Nagar (North)	16.55	6.48	93	Balasubramaniya Nagar	9.70	6.76
19	Kumarasamy Nagar (South)	9.66	4.93	94	Zambazzar	9.18	3.95
20	Dr Vijayaraghavalu Nagar (North)	16.55	8.00	95	Umarpulavar Nagar	8.17	5.75
21	Dr Vijayaraghavalu Nagar (South)	16.36	8.12	96	Tiruvallikeni	8.17	4.59
23	Vyasarpadi (South)	10.53	6.59	97	Marina	14.25	5.88
24	Elango Nagar	10.53	5.35	98	Krishnampet	17.17	7.35
25	Perambur (East)	10.53	5.77	99	Bharathidasan Nagar	10.02	7.88
26	Perambur (South)	15.70	4.46	100	Vivekanandapuram	10.02	5.11
27	Perambur (North)	10.53	3.62	101	Azad Nagar (South)	10.02	4.51
28	Siruvallur	9.76	4.45	102	Bharathi Nagar	9.00	4.76
29	Sembiam	10.27	5.11	103	Azad Nagar (North)	8.04	4.88
30	Agaram (North)	10.27	4.22	104	Ameer Mahal	10.65	6.50
31	Agaram (South)	10.27	4.91	105	Alagiri Nagar	10.51	5.04
34	Vidudhalai Gurusamy Nagar	8.21	3.23	106	Thousand Lights	9.94	3.34
35	Nagamma Amaiyar Nagar (North)	9.76	4.50	107	Nakkeeyar Nagar	9.94	2.24
36	Nagamma Amaiyar Nagar (South)	9.76	4.54	108	Ko Su. Mani Nagar	10.67	4.90
37	Ayanavaram	11.62	4.60	109	Vadapalani (East)	12.30	3.47
38	Panner sevam Nagar	13.50	3.85	110	Vadapalani (West)	12.30	2.75
39	Purasawalkam	12.64	6.24	111	Navaar Nnedunchezhian Nagar	11.05	4.36
40	Marai Malai Adigal Nagar (South)	13.50	7.74	114	Ashok Nagar	8.28	3.73
41	Marai Malai Adigal Nagar (North)	13.50	3.96	115	M G R Nagar	8.28	2.50
42	Thiru Vi Ka Nagar	15.70	3.59	116	Navaar Nedunchezhian Nagar (East)	11.05	5.05
43	Wadia Nagar	15.70	6.32	117	Kamaraj Nagar (North)	6.86	2.46
44	Dr Sathyavanimuthu Nagar	28.87	6.68	118	Kamaraj Nagar (South)	6.86	4.5
45	Basin Bridge	18.85	6.67	119	Rajaji Nagar	10.66	3.79
46	Kondithope	10.32	3.84	120	Thiyagaraya Nagar	9.92	4.33
47	Seven wells (North)	11.18	3.27	121	Kalaivanar Nagar	10.67	3.48
48	Amman Koil	12.48	5.41	122	Sathyamurty Nagar	13.99	5.30
49	Muthialpet	9.07	3.43	123	Royapettah	10.28	3.69
51	Katchaleswarar Nagar	10.34	3.48	124	Tenampet	10.09	3.92
52	Seven wells (South)	10.97	3.90	125	Alwarpet (North)	10.16	3.33
53	Sowcarpet	10.74	5.54	126	Alwarpet (South)	10.16	4.23
54	Edapalayam	12.21	4.46	127	Bheemannapet	11.85	4.71
55	Elephant Gate	9.88	4.39	128	Thiruvalluvar Nagar	11.85	6.00
56	Perumal Koil Garden	10.97	3.83	129	Madhavaperumalpuram	13.08	7.64
57	Pedhu Naicken Pet	10.32	3.32	130	Karneeswaran Nagar	11.57	6.58
58	Puliyanthope	15.52	5.28	131	Santhome	10.22	5.17
59	Dr Besant Nagar	15.52	6.81	132	Mylapore	9.11	5.58
60	Thattan Kulam	12.05	7.08	133	Avvai Nagar North)	9.04	5.93
61	Choolai	11.08	4.25	134	Raja Annamaai Nagar	9.04	6.31
62	Park Town	12.67	6.31	135	Avvai Nagar (South)	9.04	5.37
63	Dr Ambedkar Nagar	12.28	6.09	136	Adyar (East)	9.22	5.06
64	Kannappar Nagar	10.33	4.18	137	Adyar (west)	9.22	4.90
65	Anbazhagan Nagar	10.66	4.95	138	G D Naidu Nagar (East)	13.06	4.31
66	Pattalam	12.17	6.33	139	G D Naidu Nagar (west)	13.06	3.51
67	Kosapet	12.17	4.40	140	V.O.C. Nagar	8.07	3.74
68	Anjugam Ammaiyar Nagar	12.64	6.56	141	Kalaiynar Karunanidhi Nagar	10.66	5.56
69	Perumalpet	9.54	6.40	142	Kumaran Nagar (North)	7.64	4.61
70	Gangadheeswaran Koil	9.84	3.83	143	Kumaran Nagar (South)	7.64	3.37
71	Kilpauk (North)	9.84	4.41	144	Saidapet	7.64	3.62
72	Shenoy Nagar	11.34	5.69	145	Saidapet ((West)	10.10	5.50
73	Anna Nagar (East)	13.16	3.68	146	Guindy (West)	10.10	4.77
74	Anna Nagae (Central)	13.16	6.12	147	Guindy (East)	10.24	2.63
75	Anna Nagar (West)	13.16	3.60				

Source: Data from Chennai Corporation, A study done by Institute for Research in Medical Statistics (ICMR) in 1988.

Table 13:

Health Infrastructure in Chennai Medical College hospitals -2005

Health Infrastructure in Chennai	
Type of Hospital	**No.**
Medical College Hospitals	4
Maternity Hospitals	3
Emergency Obstetric Care Centre	10
Communicable Diseases Hospital	1
Urban Primary Health Centres	80
Peripheral Hospitals	3
ESI Hospitals	3
Institute of Child Health	1
Institute of Mental Health	1
Private Hospitals	451
Private Medical Practitioners	> 10,000
ICDS Centres	1600

Table 14: Health Infrastructure in Chennai City 2011

LIST OF HOSPITALS IN CHRONOLOGICAL ORDER OF YEARS						
Institute	Hospital type	Locality	Established	Main Specialty	Number of beds	Remarks
Government General Hospital	Government	Park Town	1664	General medicine	2029	The first medical institution in India
Government Institute of Mental Health	Government	Kilpauk	1794	Neurology	1800	Second largest mental health institute in India
Government Stanley Hospital	Government	Vallalar Nagar	1799	General medicine	1271	
Regional Institute of Ophthalmology and Government Ophthalmic Hospital	Government	Egmore	1819	Ophthalmology	478	
Institute of Obstertrics & Gynaecology Hospital for Women & Children	Government	Egmore	1844	Obstetrics & Gynaecology and Paediatrics	752	
Raja Sir Ramasamy Mudaliar Lying-In Hospital	Government	Royapuram	1880		510	
Government Kasthuribai Gandhi Hospital	Government	Chepauk	1885	Gynaecology and Paediatrics	695	
Government Royapettah Hospital	Government	Royapettah	1911	General medicine	712	
Institute of Thoracic Medicine, Chetput	Government	Chetput	1916			
Government Hospital of Thoracic Medicine	Government	Tambaram Sanatorium	1920	Thoracic medicine	776	
Perambur railway hospital	Government	Ayanavaram	1928	medicine	505	
LIMA (Lifeline Institute of Minimal Access) Keyhole Surgery	Corporate	Kilpauk	1932	Keyhole Surgery (since 1997)	100	individual-owned clinic
Institute of Child Health & Hospital for Children	Government	Egmore	1948	Paediatrics	537	
Tamil Nadu Government Dental College and Hospital	Government	George Town	1953			
Adyar Cancer Institute	NGO	Adyar	1954	Oncology	423	Top ranking centre in the the country by WHO
Kilpauk Medical College Hospital	Government	Kilpauk	1960	General medicine	515	
Thiruvetreeswarar Hospital for Thoracic Medicine, Otteri	Government	Otteri	1963	Thoracic medicine		
Sir Ivan Stedeford Hospital	NGO	Ambattur	1966		212	
Government Peripheral Hospital, K. K. Nagar	Government	K. K. Nagar	1977	General medicine	100	
Sankara Nethralaya			1978			
Government Peripheral Hospital, Tondiarpet	Government	Tondiarpet	1979	General medicine	100	
Government Peripheral Hospital, Anna Nagar	Government	Anna Nagar	1979	General medicine	100	
Government Institute of Rehabilitation Medicine	Government	K. K. Nagar	1979		60	
Hindu Mission Hospital	NGO	Tambaram	1982		220	
Apollo Hospitals	Private	Greams Road	1983			First corporate hospital in the country
Sri Ramachandra Medical College	Private	Porur	1985		>1500	
Madras Medical Mission	Mission	Mugappair	1987		207	
Sundaram Medical Foundation	Private	Anna Nagar	1990			
Billroth Hospitals	Private	Shenoy Nagar, RA Puram &Tiruvallur	1990		600	
Dr. Mohan's Diabetes Specialities Centre	Private	Gopalapuram	1991	Diabetes		
Fortis Malar Hospital	Corporate	Adyar	1992		161	
Balaji Dental and Craniofacial Hospital	Private	Teynampet	1994		25	
MIOT Hospital	Corporate	Manapakkam	1999		500	
National Institute of Siddha	Government	Tambaram	2005		120	
Chettinad Health City	Corporate	Kelambakkam	2007		600	
Government multi-super specialty hospital	Government	Government Estate	2014	General medicine	400	

Table 15:

Number of Beds in Private Hospitals in Chennai City (year 2005)		
S. No.	Name of the Hospital	No of Beds
1	A.G. Hospital	55
2	Apollo First Med Hospital	80
3	Apollo Hospital	201
4	Apollo Hospital (Creams Road)	600
5	Apollo Hospital (Tondiarpet)	60
6	Apoiio Specialty Hospital	200
7	Aysha Hospital	60
8	Balaji Hospital	75
9	Billroth Hospital	600
10	C.S.I. Rainy Multi Specialty Hospital	250
11	Cancer Institute	156
12	Chennai Kalliappa Hospital	65
13	Child Trust Hospital	200
14	City Tower Hospital	70
15	Deepam Hospital (p) Ltd.	100
16	Devaki Hospital	100
17	Dr. Agarwal Eye Hospital	112
18	Durgabai Deshmuk Hospital	175
19	Esware Prasad Tottathrya Orthopedic Clinic	111
20	Frontier Lifeline Pvt.Ltd.	120
21	Hande Hospital	50
22	Hindu Mission Hospital	160
23	Kalyani General Hospital	200
24	Kumaran Hospital	100
25	M.V.Diabetics Research Centre	50
26	Madras Medical Mission	218
27	Malar Hospital	160
28	Medical Research Foundation	101
29	MIOT Hospital	296
30	Philips Hospital	75
31	Santhosh Hospital	60
32	Saveetha University	100
33	Soorya Hospital	110
34	Sri Ramachandra Medical Centre	1650
35	St. Isabel Hospital	250
36	St. Joseph Hospital	50
37	Sundaram Medical Foundation	100
38	Sundaram Medical Foundation	161
39	The Guest Hospital	50
40	Vijaya Hospital	610
41	Vijaya Medical Educational Trust	250
42	voluntry Health Services	220
	Total	8411

Table 16:

Zone wise number of Beds in hospitals, in Chennai City 2005

	No of beds in Govt.Hospital					No of beds in Approved Private Hospitals				
Zone	0-50	51-100	101-200	201-500	> 500	0-50	51-100	101-200	201-500	> 500
I	5	1	-	-	-	35	-	-	-	-
II	1	-	-	1	-	23	1	1	-	1
III	6	-	-	-	-	26	-	-	-	-
IV	4	1	-	-	2	12	13	-	-	-
V	2	2	-	1	2	41	12	4	-	-
VI	2	1	-	-	-	15	-	-	1	-
VII	7	1	-	-	2	31	-	1	2	-
VIII	2	-	-	-	-	25	1	3	1	1
IX	1	-	-	-	-	10	-	-	1	-
X		-	1	-	-	29	2	-	-	1
Total	30	6	1	2	6	247	29	9	5	3

Table 17:

No of Hospitals and Dispensaries run by Chennai Corporation- 2005			
S.No.	Corporation Zones	No of Hospitals	No of Dispensary
1	Zone-I	10	6
2	Zone-II	9	10
3	Zone-II	13	12
4	Zone-IV	11	6
5	Zone-V	9	4
6	Zone-VI	8	13
7	Zone-VII	8	8
8	Zone-VIII	11	6
9	Zone-IX	8	4
10	Zone-X	6	7
Total	Chennai City	93	76

Table 18: Public Health facility available in Chennai City- 2013

Number of beds by health facility	40 per facility
Average OPD patients per month by facility	100-120-facility
Average IP patients per month by facility	1527 in 15 Zones
Average number of deliveiries per month by facility	1039 in 15 Zones
Average number of NCDs	150 per facility
Avialable Health service facility	ANC, New born care family planning,OPD,Obstetrics, child care etc
Available diagnostic and other para clinical services by facility	Lab, X-ray. Ultrasound,ECG,etc.
Number of slums covered by outreach camps and its frequencies	600 per month

Table 19: Health post wise Population, ANC mothers, live births and Immunization details for Chennai City 2011-14.

					2010-11						
Name of the zone	Population	Male	Female	Slum Pop	Antenatal care	Institutional deliveries	Live Births	BCG	DPT	POLIO	MEASLES
Dr.R.K. Nagar	490226	249730	240496	286916	8229	1438	7468	7633	6919	6919	6798
Sanjeevarayanpet	446213	226981	219232	147517	7304	1178	6464	2863	4660	4660	4642
Pulianthope	565993	289078	276915	290410	9608	2410	8907	8850	9013	9013	8792
Ayanavaram	556201	281786	274415	155859	9369	1674	8363	8806	8137	8137	10665
Shenoy Nagar	555968	282849	273119	247098	8415	1962	8865	10570	8947	8947	7824
Mirsahibpet	422837	217194	205643	106770	7384	1569	6468	6645	6658	6658	6562
Perumalpet	427894	215288	212606	87443	7438	1916	6556	6557	6653	6653	6610
Vadapalani	528100	266898	261202	156796	8239	1812	7300	7220	7505	7505	7503
Saidapet	476101	240707	235394	170690	7688	2914	6716	9299	7533	7533	6880
Santhome	571611	290598	281013	228951	8472	1154	7564	5737	9487	9487	7204
Total	5041144	2561109	2480035	1878450	82146	18027	74671	74180	75512	75512	73480

					2011-12						
Name of the zone	Population	Male	Female	Slum Pop	Antenatal care	Institutional deliveries	Live Births	BCG	DPT	POLIO	MEASLES
Dr.R.K. Nagar	489955	250684	239271	274222	8159	1265	7614	8361	7071	7071	7414
Sanjeevarayanpet	444540	226318	218222	137783	7318	1390	6405	6873	6666	6666	6728
Pulianthope	561964	284100	277864	292429	9116	2256	8372	8597	8495	8495	8785
Ayanavaram	548526	282423	266103	142557	8819	1808	8060	7923	7701	7701	8143
Shenoy Nagar	557722	283399	274323	247573	9520	1623	8706	8741	8639	8639	8675
Mirsahibpet	426187	219411	206776	109396	7095	1506	6493	6288	6287	6287	6267
Perumalpet	429543	216564	212979	87322	7013	1909	6285	6280	6332	6332	6496
Vadapalani	522030	264788	257242	148712	7613	1853	7027	7978	7228	7228	7063
Saidapet	472178	238827	233351	162401	7434	2697	6676	6582	6520	6520	6367
Santhome	564962	287188	277774	224977	7944	1195	7194	7249	6853	6853	6500
Total	5017607	2553702	2463905	1827372	80031	17502	72832	74872	71792	71792	72438

					2012-13						
Name of the zone	Population	Male	Female	Slum Pop	Antenatal care	Institutional deliveries	Live Births	BCG	DPT	POLIO	MEASLES
Thiruvottiyur	263596	133614	129982	146805	5392	381	4783	4947	4776	4776	4754
Madhavaram	118431	59537	58894	37552	1529	97	1514	1509	1814	1814	1430
Tondiarpet	737953	374689	363264	482698	11568	980	10315	10285	10866	10866	11661
Royapuram	718421	364759	353662	174879	11633	2791	10816	10787	11084	11084	11328
Thiru-vi-ka-nagar	708012	357329	350683	226894	10342	2045	9150	8867	9444	9444	9904
Ambathur	475589	238554	237035	149250	6182	402	5697	5646	5633	5633	5641
Anna Nagar	756319	386462	369857	274893	11583	3214	10453	10348	10404	10404	10484
Teynampet	828548	429207	399341	225901	12229	1169	10870	10715	10638	10638	11266
Kodambakkam	753706	380997	372709	194093	10979	4121	9853	9894	9607	9607	10181
Alandhur	182941	94156	88785	71479	2972	109	2813	2754	2741	2741	3933
Adyar	584965	297026	287939	246812	7596	1148	6712	6976	6839	6839	6914
Total	6128481	3116330	3012151	2231256	92005	16457	82976	82728	83846	83846	87496

					2013-14						
Name of the zone	Population	Male	Female	Slum Pop	Antenatal care	Institutional deliveries	Live Births	BCG	Penta	POLIO	MEASLES
Thiruvottiyur	326352	166039	160313	39751	5162	259	4628	4674	4629	4629	4455
Madhavaram	124105	62389	61716	474514	1623	75	1555	1534	1567	1567	1542
Tondiarpet	740891	375992	364899	177850	11024	1047	9970	10615	10345	10345	8393
Royapuram	723115	368915	354200	234460	10781	1926	10054	10083	10337	10337	5295
Thiru-vi-ka-nagar	709277	360446	348831	157702	9678	1750	8826	8843	9216	9216	9017
Ambathur	479203	239605	239598	281451	6505	422	5705	5647	5880	5880	4723
Anna Nagar	756618	385138	371480	225051	10560	2691	10055	10696	10552	10552	7788
Teynampet	800071	407685	392386	188102	10914	1229	9776	9780	9859	9859	9671
Kodambakkam	750894	380879	370015	71059	9499	3874	8860	8839	8898	8898	8417
Alandhur	182374	94082	88292	233992	2697	149	2590	2566	2636	2636	2131
Adyar	570820	291130	279690	2254302	7613	1221	6963	7924	6800	6800	5249
Total	6163720	3132300	3031420	4338234	86056	14643	78982	81201	80719	80719	66681

Data related to the Zonal Health Post
Note: No vaccinated may include children from other zones
Source: Health & Family Welfare dept., Chennai Corporatior

Table 20:

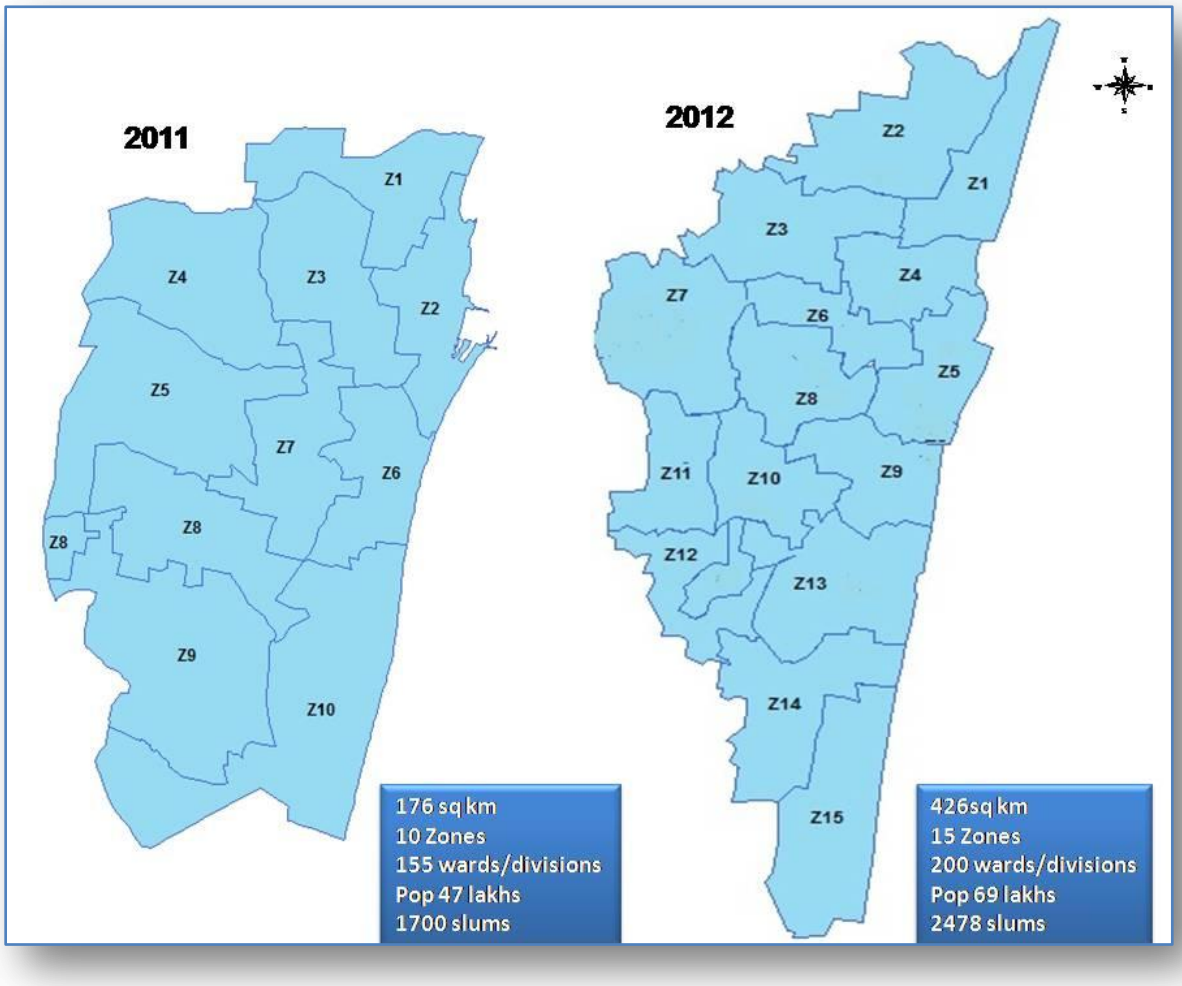
Health Budget of Chennai City 2009-2015

Corporation of Chennai-Public Health Department			Rate of Increase
1	Annual total budget for health Sector 2015-2016	Rs.893 Lakhs	**79**
2	Annual total budget for health Sector 2014-2015	Rs.500 Lakhs	**19**
3	Annual total budget for health Sector 2013-2014	Rs.420 Lakhs	**20**
4	Annual total budget for health Sector 2012-2013	Rs.350 Lakhs	**78**
6	Annual total budget for health Sector 2010-2011	Rs.197 Lakhs	**97**
7	Annual total budget for health Sector 2009-2010	Rs.100 Lakhs	

The annual budget for health sector was 100 lakhs in 2009-10 which increased to 893 lakhs in 2015-16.The budget's annual increase was at a higher level in the year 2010-11 and lower in the year 2014-15.

Limitations of data in Chennai City

Figure 7: Comparison map of Chennai City in 2011 & 2012



When both the zonal maps are compared we can observe that there is a complete change in the zonal boundaries. The entire zonal structure has been changed hence comparison over the years was difficult. The boundaries of the revenue divisions and the health posts are different. Currently no. of wards and no. of health post are different. The above facts pose challenges for trend analysis and GIS mapping. There was also a frequent change in the data personnel. Approachability of personnel was also found to be difficult because of several other commitments of the staff in various programme like Indradhanush, flood relief work etc. Natural disaster like Tsunami & floods of Chennai city made the population unstable. Evacuation of population, migration etc., led to the unaccountability of the population to the respective wards.

ANALYSIS I

The analysis using illiteracy rate (census 2011) and its related covariates (published reports) showed the northern part of Chennai City as a high illiteracy concentrated region. The population significantly consisted of slum dwellers, migrants and under privileged. They remain as an illiterate as they seek mainly for their survival. Future focus should be on sufficient municipal civic amenities, like special schools outside their working time. This would ultimately reduce the illiteracy level in Chennai city to a greater extent.

ANALYSIS II

An analysis on Infant immunization of Chennai City using PICME data for the year 2012 & 2013 showed that the complete immunization coverage (BCG, DPT/Pentavalent, Polio & Measles with proper interval) as 77% and 75% respectively. Mothers attempted for all dosages but with incorrect timings were 22% and 24% in 2012 & 2013. If attempted correctly, Chennai City's complete immunization coverage would be 98 to 99%. Educating the mothers & health workers the importance of proper timings of dosages would be of prime importance. Birth weight of the baby and literacy level more than high school level turned out to be significant predictors for complete immunization of the infants.

Paper I

Submitted for Seventh International Conference on Health GIS 7-9 Dec 2017 held at Mysore.

An index and a smoothed map of illiteracy and its covariates of Chennai City

As per Census of India, a person aged seven and above who can both read and write with understanding in any language, is treated as literate. The word illiteracy refers to the inability of a person above seven years to read or write a simple message in any language. An illiterate is equal to a handicapped person who is unfamiliar with his surroundings and is unable to perform efficiently day to day activities. The factors causing illiteracy vary from region to region. One important factor that causes illiteracy in countries is the social issue of women education. More literacy means more knowledgeable and skilled people in a country which is normally termed as human capital. Literacy enables a person to understand better, so they enjoy a better socio economic life and assist in the family's overall development. Illiteracy is considered to be a vicious cycle; all interlinked may vary with population growth, economic growth and cultural growth. Once we attain the power of literacy, we will become a superpower as we will have the indestructible weapon of "knowledge"[1].

According to a report by United Nations Educational, Scientific and Cultural Organization, India has the highest population of illiterate adults at 287 million. The report further says that the richest young women in India have already achieved universal literacy but the poorest are projected to only do so around 2080, noting that huge disparities within India, point to a failure to target support adequately towards those who need it the most. Post-2015 goals need to include a commitment to make sure the most disadvantaged groups achieve benchmarks set for goals [2]. As per 2011 census India has shown considerable improvement in literacy levels compared to 2010 an increase of 14% but one in 10 households still doesn't have even a single literate member [3].

The literacy rate for Tamil Nadu in 2011 has increased to 80.33 % from73.45% returned in the 2001 Census, while the increase in the decadal literacy rate in Chennai city was 4.85%. Often the literacy level has been viewed as a single entity to measure the economic growth of the country/region. Fortunately Census of India has the data on various parameters at district and ward level. Hence an attempt was made to develop an index and a smoothened map for illiteracy using several covariates simultaneously for zones of Chennai city.

Materials and methods:

Data on illiteracy and its covariates for the year 2011 from Census of India, Corporation of Chennai and published reports [4,5] were used.

Ten zones of Chennai city and eleven covariates of illiteracy for which the information is available were considered for the study. Covariates are based on demographic variables and additional available free amenities. The covariates being population, average family size, proportion of slum population, proportion of illiterates, proportion of female illiteracy, proportion of births, proportion of person unemployed, proportion of tribal population, average no. of children per government school, average no. of persons using per public water facility, average no. of persons using per public convenience. The data matrix is of size 10x11 (table A) and the data set was standardized to eliminate different scales of measurement. We have considered covariates in such a way that they are highly correlated with illiteracy.

Using the data matrix, Correlation matrix between the covariates was computed and examined (87% of the cases correlation > 0.3 in absolute value). Bartlett's sphericity test is found to be highly significant ($P<0.0001$). Thus the indicators selected for the analysis were well correlated as required for factor analysis to be valid. This is readily computed by the SPSS [6] package. The original data set was made into relatively a smaller number of independent factors and to find the estimates of factor scores, which is a linear combination of standardized indicators. The method of principal components [7] was used and factors extracted. And these factors were improved using varimax rotation and factor scores obtained. Then the initial index for a zone is obtained using percent variation as weights on the factor scores and further the index was standardized for comparison purpose.

Kriging technique is an earth science technique based on regionalized variable theory [8,9]. Using the method of least squares, it provides a means of interpolating values for points not physically sampled using the available information and the spatial arrangement of the data set. The standardized score (as proportion) for each zone was expressed as Zobs (xi, yi) where (xi, yi) are the geographic co-ordinates (latitude and longitude). Zobs(xi, yi) was modeled by means of a variogram using geo-statistical (kriging) technique and the kriged estimates were obtained using the ArcGIS software package [10] The map (Fig. A) would identify regions with higher concentration of illiteracy level.

Results:

The factor analysis revealed four factor scores. The first factor explained 26.78% of the total variation, second factor 26.17% third factor 14.7% and fourth factor 14.2%. These four factors together explained 81.8% of the total variation. This is considered as a satisfying result for factor analysis. Initial index for various zones is listed (table B) and the last column represents the corresponding standardized index. If value 50 is taken as an average value, it can be seen that four zones (z1, z3, z4 & z5) have an index of above 50 which shows greater care should be emphasized on these zones to bring down illiteracy.

The map obtained (Figure) gives an optimal unbiased representation of multiple covariates of illiteracy with Kriged estimates. It depicts the regional variation and the high illiteracy concentrated regions. The Kriged estimate shows the high illiteracy concentrated regions as northern part of Chennai city. This map shows the regional variation by simultaneously considering several covariates.

Discussion:

The illiteracy rate varied from 7.45% to 14.69% among the zones of Chennai city. The standardized index and the Kriged map using 2011 data reveals that northern part of the Chennai city needs priority care compared to other parts. Further comparing the four northern zones (i.e Index value more than 50) with the rest of the other zones, the covariates, proportion of slum dwellers and proportion of tribal population turned out to be significant using chi-square statistics ($p<0.05$). As per the report on slum dwellers of Chennai city [11] growth of slums are due to large scale of migration, poverty and unemployment. Chennai being a major metropolitan city with growing industries, people from other parts of districts/state tend to migrate in search of occupation mainly to metros like Chennai. Poor migrants are forced to be an illiterate as they seek for their survival. As a refuge stay squat on the unused land located near their work places and Coovam basin areas which are comfortable and easily adaptable to them. Chennai is ranked as beta level city [12] when compared with other districts of Tamil Nadu ranks top in literacy level but still pockets of illiteracy exists, significantly by slum dwellers and under privileged. Chennai slums are comprised of migrants. Hence policy makers while framing policy should make some provision in filling the gap of illiteracy among slum dwellers mainly migrants and build sufficient municipal civic amenities like special schools / programme outside their working time to wipe out illiteracy from Chennai city.

Limitations

The zone as a unit is too big, if finer grid points like information about wards or division wise for all covariates readily available, it would have been more precise to pin point the pockets in the Chennai city for focused intervention.

Acknowledgement: Our sincere thanks to Corporation of Chennai, Census of India 2011 and to Mr. M Chandrasekar for data collection.

REFERENCES

1. http://www.voicesofyouth.org/en/posts/illiteracy--a-curse-on-development accessed on 1th October 2015.
2. http://www.thehindu.com/features/education/issues/india-tops-in-adult-illiteracy-un-report/article5629981.ece accessed on 1th October 2015.
3. http://timesofindia.indiatimes.com/india/Literacy-rate-jumps-10-in-a-decade-in-India/articleshow/45244626.cms accessed on 1th October 2015.
4. http://www.transparentchennai.com/wp-content/uploads/2011/05/Public-Toilets-Transparent-Chennai-Issue-Brief.pdf accessed on 1th October 2015.
5. http://www.seu.ac.lk/researchandpublications/symposium/4thinternational/socilascienceshumanities/Water%20Supply%20and%20Demand.pdf accessed on 1th October 2015.
6. Statistical package for the social sciences (SPSS) for Windows (version 14), Chicago, Illinois, USA: SPSS Inc, 2006.
7. Bryan F J Manly Multivariate Statistical Methods A Primer 1986; 76-89.
8. Carrat F, Valleron AJ. Epidemiologic mapping using the kriging method: application to an influenza-like illness epidemic in France. Am J Epidemiol 1992; 135 : 1293-300.
9. Vasna J , Gupte MD, Adhikary R , Paranjape RS , Manikar MK , Brahmam GNV, Mahanta J & Ramesh BM. Index based mapping of high risk behaviours for HIV among female sex workers in India. Indian J Med Res 136 (Supplement), October 2012, pp 14-22. http://icmr.nic.in/ijmr/2012/october%20supp/3.pdf
10. Environmental Systems Research Institute (ESRI), ArcGIS Desktop: Release 9.2. Redlands, CA, USA.
11. http://ccs.in/internship_papers/2006/Statistical%20Analysis%20Health%20&%20Education%20in%20Chennai%20Slums%20%20-%20Vydyanathan.pdf accessed on 1th October 2015.
12. https://en.wikipedia.org/wiki/Chennai accessed on 1th October 2015.

Table A: Percent distribution of illiteracy covariates of Chennai City, 2011.

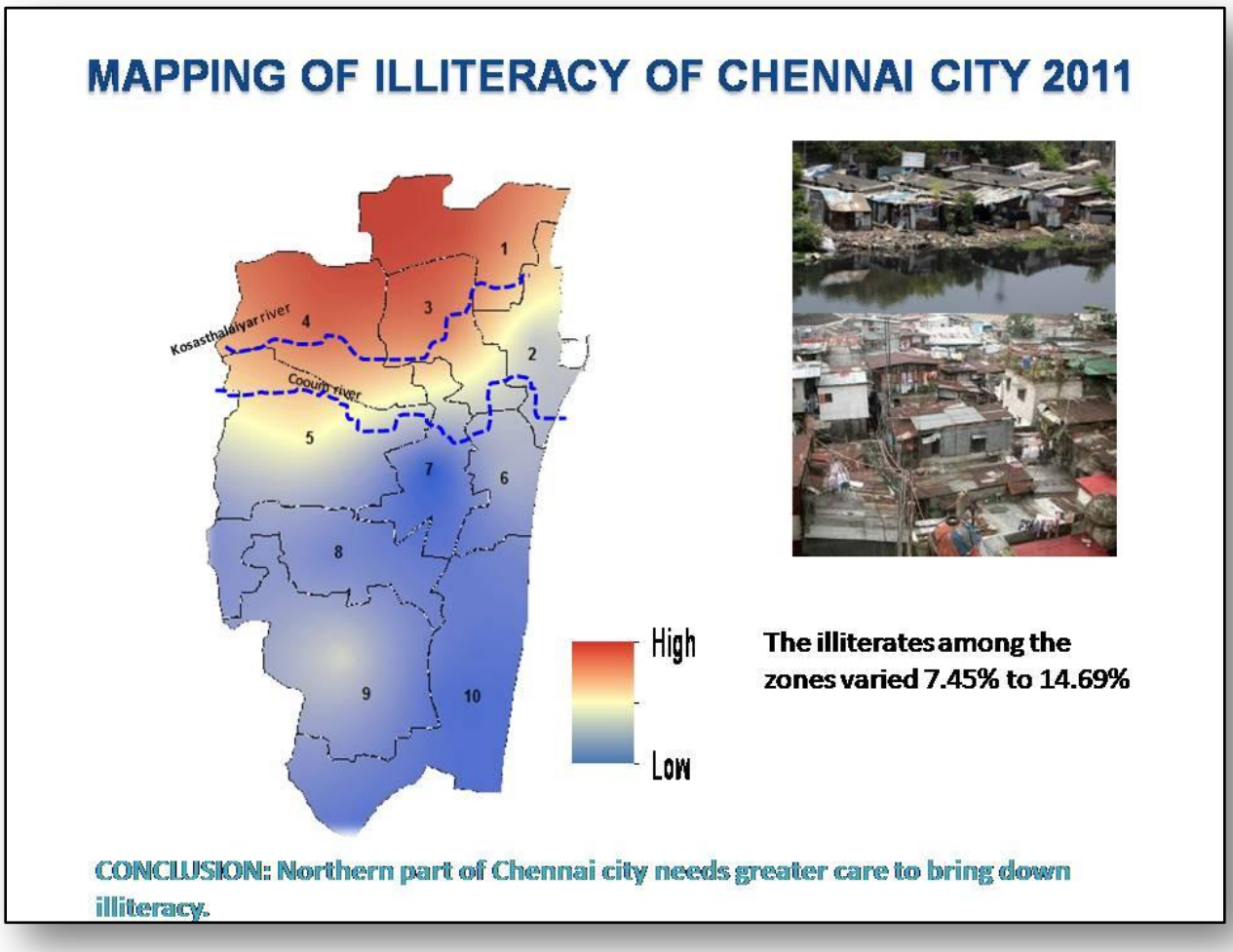
Zone No.	Population	Average fly size	Percent slum pop	Percent Birth rate	No. of persons per public water tank/tap	Average toilet facility	Non_work pop	Percent illiterates	Percent Female_illit	Percent ST	Average persons per school
1	468188	4.051	5.470	1.554	297	1396	62.211	14.690	19.128	0.123	1487
2	396448	4.427	2.750	1.441	438	729	63.046	11.420	15.263	0.123	417
3	519200	4.202	5.830	1.490	689	549	62.819	12.920	17.384	0.174	564
4	560483	3.924	2.840	1.469	540	1425	61.956	8.550	11.783	0.557	583
5	598314	3.957	4.930	1.561	774	1070	60.422	7.450	10.585	0.219	777
6	312506	4.257	2.180	1.524	868	544	60.650	10.440	14.012	0.286	492
7	289341	4.204	1.740	1.463	813	518	59.017	7.950	10.846	0.149	496
8	488981	3.858	2.960	1.346	631	1356	58.774	7.620	10.689	0.149	693
9	470696	3.891	3.240	1.414	587	1059	60.901	9.580	13.328	0.160	807
10	542575	3.811	4.480	1.273	561	742	58.788	8.160	11.161	0.158	782

Table B: Index of illiteracy covariates of Chennai City, 2011.

ZONE	IN_INDEX	STD_INDEX
1	76.52	100.00
2	3.69	36.94
3	60.78	86.37
4	70.20	94.53
5	21.85	52.66
6	-5.10	29.33
7	-38.98	0.00
8	-19.84	16.57
9	7.56	40.29
10	-30.45	7.38

$$\text{STD-INDEX} = \frac{(\text{IN-INDEX} - \text{MIN OF IN-INDEX})}{(\text{MAX IN-INDEX} - \text{MIN IN-INDEX})} * 100$$

Figure A


MAPPING OF ILLITERACY OF CHENNAI CITY 2011
Kosasthalaiyar river
Cooum river
1
2
3
4
5
6
7
8
9
10
High
Low
The illiterates among the zones varied 7.45% to 14.69%
CONCLUSION: Northern part of Chennai city needs greater care to bring down illiteracy.

Paper II

(Under publication process)

Determinants associated with infant immunization in Chennai City 2012, 2013.

Background

Immunization is the best way a child's life can be protected from illness and disability. The vaccination of children against six preventable diseases namely Diphtheria, Pertussis, Tetanus, Measles, Poliomyelitis and Tuberculosis has been the cornerstone of the child health care system. According to United Nations Children's Fund (UNICEF)[1] vaccine preventable diseases (VPDs) cause an estimated 2 million deaths or more every year, of which approximately 1.5 million deaths occur among children below five year age. The Universal Child Immunization programme was implemented during 1985-86. According to India 2009 evaluation survey[2] the immunization coverage for BCG, DPT1, DPT3 and measles are 87%, 83% 72% and 85% respectively. As per the District Level Household Survey (DLHS4)[3] during 2012–13, 58.6% of children aged 12-23 months in the state of Tamil Nadu (urban) were fully vaccinated. A WHO 30-cluster survey[4] in Chennai city (1993) showed Polio and DPT vaccine coverage of 93%, a BCG vaccine coverage of 94% and a Measles vaccine coverage of 75%. A recent study[5] in Tamil Nadu for children aged 12-23 months, has shown that the full vaccination coverage for non slum municipal corporations as 84.3%

Complete and correct dosage of vaccination is a key factor for children preventable diseases. PICME (Pregnancy Infant Cohort Monitoring & Evaluation) is one of the e-health initiatives in Tamil Nadu. This software was initiated on 1 April 2008 for both rural and urban areas of Tamil Nadu. The system has accumulated a large volume of data. The study objective was i) to identify the determinants associated with the complete immunization of infants for Chennai City for the year 2012 and 2013 using binary logistic regression model. ii) to produce a smoothened surface map of Chennai City with predicted values of Complete immunization coverage of Chennai city for both years respectively.

Methods

PICME is user specific software introduced by Directorate of Public Health, Tamil Nadu and it was developed by National Informatics Centre (NIC). It allows the user only for their portfolio of operation. User specific IDs and password have been generated and distributed for each Primary Health Centre (PHC) and the Sector Health Nurse (SHN) is the only authorized person for application of data entry and verification. It gives information of about pregnant mothers. Each mother has been given a unique ID called "PICME Number". The details of pregnant mothers are entered right from the date of early registration of pregnancy up to the completion of first birth day of the child by Village Health Nurses (VHN). The Data's being mainly focused

for high risk cases referral and monitoring mothers. The data consists of mother's details, pre and post natal Care, pregnancy complications and outcome, and the child's immunization details.

Definitions

Completely immunized child[6]: A child who has received 8 vaccines (BCG, 3 doses of DPT, 3 doses of OPV and 1 dose of measles) by the age of 12 months

A child was considered Completely immunized with valid doses, if he/she meets the following condition (a) BCG vaccine – given before attainment of one year of age (b) DPT/Pentavalent vaccine–First dose given after 6 weeks of birth and two subsequent doses with an interval of at least 4 weeks and receipt of all the three doses before the first year of life (c) Measles vaccine – administered after completion of 9 months (270 days) but before the first year of life.

The study was based on Chennai City with 200 wards and 15 zones. Children born in the year 2012 and 2013 and who has completed his/her first birthday was considered for the analysis.

The data set was cleaned and validated for correctness. There were n = 26835 and n = 36125 infants for the year 2012 and 2013 comprised of 122 Public Health Centres (PHC).

Fourteen covariates considered for the study were sex of the baby, birth weight of the baby, whether breast fed at birth, birth complication, height of the mother, community of the mother, education of the mother, education of the father, gravida of the mother, parity of the mother, pregnancy outcome, number of births at delivery, place of delivery, immunization status of the mother (whether completely immunized or not).

Binary logistic regression analysis was used to find the significant predictors of the completely immunized infants (CII). The variables included in the logistic model were based on the Chi-square tests which examines associations of different covariates with the complete immunization status. Finally the covariates namely sex of the baby, birth weight of the baby, gravida of the mother, age of the mother and education of the mother were included in the binary logistic regression model. The model adequacy was examined using Hosmer-Lemeshow test. The model was also assessed for confounding, interaction, and multicollinearity. Receiver operating characteristic (ROC) curves were used both to define the optimal cut-off points and to evaluate the ability of the logistic model to distinguish between CII and not completely immunized infants[7,8].

The predicted values of completely immunized infants of Chennai City were aggregated to simple averages at PHC level. The cleaned information was completely available for 122 PHCs. The latitude and longitude values of the centroids of PHC were identified using the Google earth. The inverse distance weighting (IDW) method was used to interpolate the CII status across Chennai City using ArcGIS11 spatial analyst software, to predict values for unmeasured

locations. For each predicted value, a minimum of 2 and a maximum of 12 surrounding points (default value) were used. The result was the smoothened surface of Chennai City with predicted values of complete immunization status, which took into account all the determinants included in the model.

Results

In the year 2012, 77.4% of the children were completely immunized with correct time intervals where as it was 74.7% in the year 2013. Nearly 1% of the infants were never given any vaccination in both the years and the rest were given incorrect and incomplete doses (table C).

The binary logistic regression model assessed birth weight [(≤2kg) of the baby (OR 0.72; CI : 0.56, 0.93) and (2+ to 3kg) (OR 1.12 ; CI: 1.02,1.23)], education of the mother [(high school or above) (OR 0.87; CI : 0.82, 0.93)] and gravida [3 or more (OR 0.69; CI : 0.59,0.80)] as significant predictors of complete immunization status in the year 2012 (table D) where as in 2013 sex of the baby (OR 0.95; CI : 0.91, 0.99) birth weight of the baby (≤2kg) (OR 0.55; CI : 0.43, 0.69) and education of the mother (high school or above) (OR 0.86; CI : 0.83, 0.94) turns out to be significant predictors of the CII status (table E).

Figure B depicts the smoothened map of completely immunized infants with predicted values of Chennai City. The map shows the regional variation of Chennai City with completely immunized infants monitored in the PICME programme. The northern part of Chennai City Zones 1, 2, 3 and 4 shows higher level of incomplete vaccination coverage in both the years. The spread of lower level of CII has increased in the year 2013 than 2012.The lower south western part of the Chennai city infants were more with CII than the rest of the area.

Discussion

In the present study, the incomplete immunization (less doses) and not vaccinated infants were less (1.1% in 2012 and 1.6% in 2013) but more than one fifth (22% in 2012 and 24% in 2013) attempted for Complete vaccination doses but with incorrect timings. If attempted correctly then the complete vaccination coverage for Chennai City would be 98% to 99%.

In both the years' birth weight of the baby and education of the mother turned out to be significant predictors for complete immunization of the infant.

In the present study out of low birth weights infants (333 in 2012; 334 in 2013), 31% and 38% respectively were not completely immunized. Preterm (PT) and low birth weight (LBW) infants are at greater risk of increased morbidity from vaccine-preventable diseases. Generally they are less likely to receive immunizations in a timely fashion because of their higher rates of medical complications related to preterm birth[9]. The *Red Book* addressed the specific immunization needs of PT and LBW infants and recommended that all PT infants receive, with the qualified exception of hepatitis B vaccine given at birth, full doses of all routinely recommended

childhood vaccines at a chronologic age consistent with the schedule used for full-term (FT) infants[10,11].

There is a enormous demographic literature indicating that female literacy exerts greater influence on fertility and child mortality than male literacy[12,13]. The present study also emphasizes that a mother with high school or higher level of education has a correct understanding and importance of the vaccination schedule.

The negligence of higher order of gravida (3 or more) among mothers in both years was observed and among them nearly one fourth of the children were not completely immunized in Chennai City. In the study there was no significant difference between gravida and live births. An earlier study[12], showed that the likelihood of vaccination decreases with increase in birth-order and the negligence effect was more in urban than in rural mothers in India.

It has also been observed that still slight gender discrimination for vaccinating their children exists in Chennai City. Some researchers have already notified the behaviour of families to neglect and discriminate female children in India[14,15,16].

Future focus should be to i) educate the mother and the health workers with the importance of not only with complete dosages of vaccination but also with the correct time intervals/schedule of vaccination dosages ii) importance of complete vaccination even for low birth weight babies who are at higher risk of morbidity and iii) strategies to eliminate gender discrimination for complete vaccination and negligence of higher order of birth for the healthy survival of the infants from vaccine preventable diseases iv) northern part of Chennai city needs priority care to move one step closer to cent percent complete immunization status of infants.

References

1. Committing to Child Survival: A Promise Renewed. Progress Report 2014. UNICEF, 2014. Retrieved from http://files.unicef.org/publications/files/APR_2014_web_15Sept14.pdf
2. India: WHO and UNICEF estimates of immunization coverage: 2014 revision. http://data.unicef.org/fckimages/uploads/immunization/india.pdf
3. International institute for population sciences (IIPS). District Level Household and Facility Survey-4. State Fact Sheet Tamil Nadu (2012-13).
4. B.N. Murthy, S. Radhakrishna, S. Venkatasubramanian et al. Lot Quality Assurance Sampling for Monitoring Immunization Coverage in Madras City. Indian Pediatrics 1999; 36:555-9.
5. Manoj V. Murhekar, P. Kamaraj, K. Kanagasabai et al. Vaccination coverage among children aged 12-23 months, Tamil Nadu, India. IJMR under press.

6. World development report: investing in health. New York: Oxford University Press; 1993.
7. Hanley J, Mc Neil B. The meaning and use of the area under a ROC curve. Radiology 1982; 143 : 29-36. 9.
8. Haedo, Silvia A, Natal, Liliana M. Logistic regression and ROC curves: a non conventional methodology. Available from: http://isi.cbs.nl/iamamember/CD2/pdf/772.PDF, accessed on March 30, 2009.
9. Long SS, Pickering LK, Prober CG, eds. Principles and Practice of Pediatric Infectious Diseases. New York, NY: Churchill Livingstone Inc; 1997:596–603, 607–608, 619–625, 981.
10. Saari TN. Immunization of Preterm and Low Birth Weight Infants. Pediatrics,. July 2003, VOL 112 (1).
11. American Academy of Pediatrics, Committee on Infectious Diseases. Immunization in special circumstances. Preterm and low birth weight infants. In: Pickering LK, ed. 26th ed. *Red Book: 2003 Report of the Committee on Infectious Diseases.* Elk Grove Village, IL: American Academy of Pediatrics; 2003:66–68
12. Nilanjan Patra, Universal immunization programme in India: the determinants of childhood immunization, http://www.isical.ac.in/~wemp/Papers/PaperNilanjanPatra.pdf
13. Bhat, P.N. Mari and Rajan, S. Irudaya (1992): 'Demographic Transition in Kerala: A Reply', Economic and Political Weekly, June 6, pp-1213-5.
14. Das Gupta, M. (1987): 'Selective Discrimination against Female Children in Rural Punjab, India', Population Development Review, Vol-13, No.-1, pp-77-100.
15. Rajeshwari (1996): 'Gender Bias in Utilization of Health Care Facilities in Rural Haryana', Economic and Political Weekly, Feb 24, pp-489-94.
16. Islam, S.M.S. and Islam, M.M. (1996): 'Influences of Selected Socio-economic and Demographic Factors on Child Immunization in a Rural Area of Bangladesh', Demography India, Vol-25, No.-2, pp-275-83.

Table C:

Infant immunization coverage of Chennai City 2012, 2013.

Immunization status	**2012 No (%)**	**2013 No (%)**
Not Vaccinated	244 (0.9)	231(0.6)
Partially Vaccinated	60 (0.2)	345(1.0)
Fully Vaccinated but in incorrect timings	5760(21.5)	8558(23.7)
Fully vaccinated with correct timings	20771(77.4)	26991(74.7)
Total	26835	36125

Table D:

Determinants associated with the Immunization status in infants, Chennai City, 2012.

Characteristics	**N**	**Adjusted OR (95% CI)**	**P-value**
Sex of the baby			
Male	14286	1	
Female	12487	0.98 (0.92, 1.03)	0.42
Birth weight of the baby			
≤ 2 kg	333	0.72(0.56, 0.93)	**0.01**
2.1kg - ≤3kg	19801	1.12 (1.02,1.23)	**0.02**
3.1kg+	6639	1	0.18
Age of the mother			
≤ 22	5467	1	
23 - 29	18786	1.02 (0.91,1.15)	0.68
30+	2520	1.05 (0.95,1.16)	0.33
Mother's education			
IX std or less	17924	1	
High school or more	8849	0.87 (0.82, 0.93)	**<0.001**
Gravida			
≤2	25519	1	
3 or more	1254	0.69 (0.59,0.80)	**<0.001**

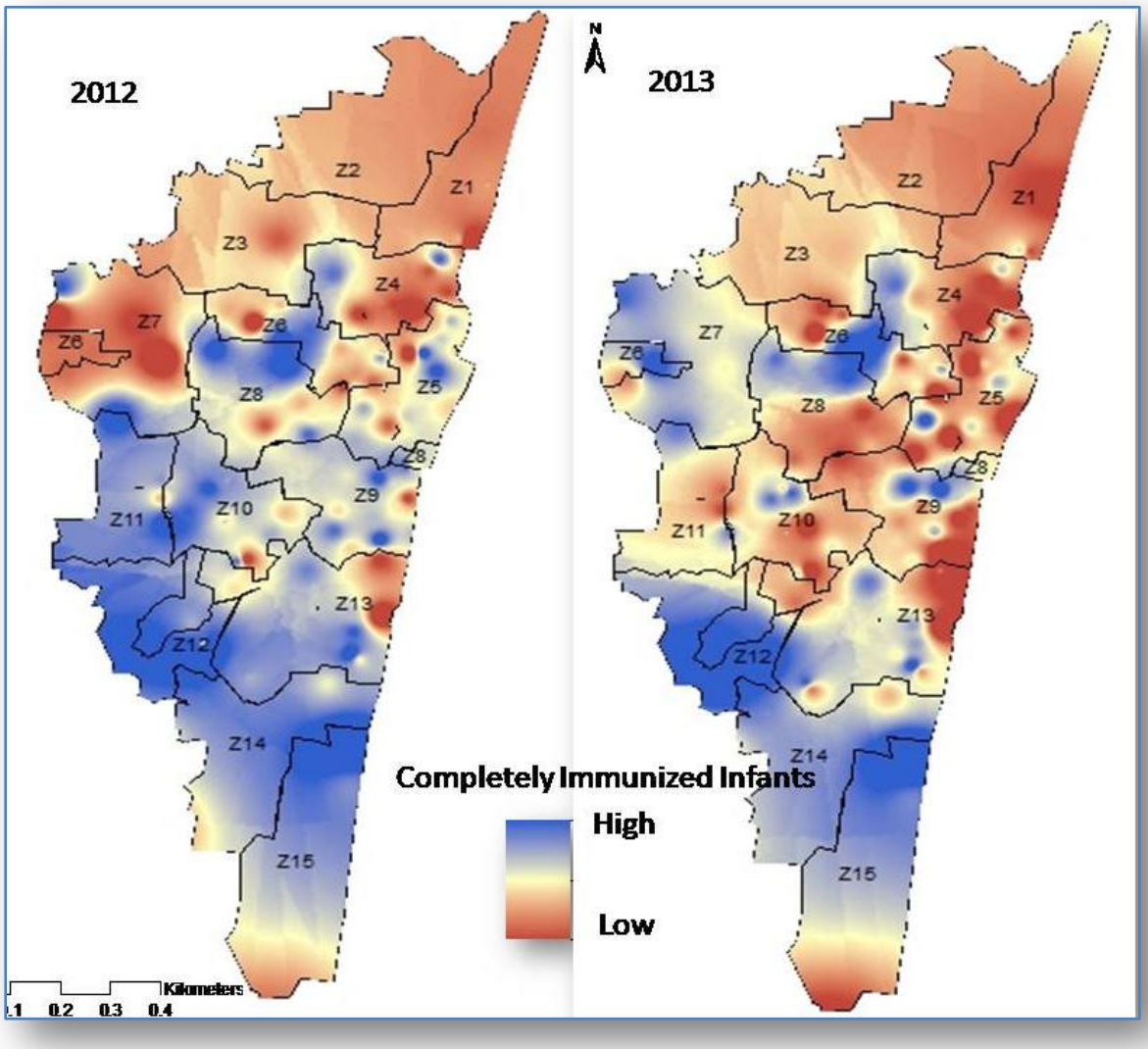
Table E

Determinants associated with the Immunization status in infants, Chennai City, 2013.

Characteristics	N	Adjusted OR (95% CI)	P-value
Sex of the baby			
Male	19471	1	
Female	16678	0.95(0.91, 0.99)	**0.02**
Birth weight of the baby			
≤ 2 kg	334	0.55(0.43, 0.69)	**<0.001**
2.1 - 3kg	26641	0.99(0.90, 1.08)	0.77
3.1kg +	9174		
Age of the mother			
≤ 21	11255	1	
22 - 29	21957	0.99 (0.90, 1.10)	0.93
30+	3003	0.92 (0.84, 1.01)	0.09
Mother's education			
IX std or less	9338	1	
High school or more	13807	0.88 (0.83, 0.94)	**<0.001**
Gravida			
≤2	18785	1	
3 or more	15520	0.93 (0.83, 1.04)	0.18

Figure B:

Spatial mapping of predicted values of Completely Immunized Infants of Chennai City.



References

1. Annual Reports of the Corporation of Madras/Chennai
2. Census of India. http://censusindia.gov.in/
3. https://en.wikipedia.org/wiki/List_of_Chennai_Corporation_zones
4. https://en.wikipedia.org/wiki/Timeline_of_Chennai_history#19th_century
5. https://en.wikipedia.org/wiki/History_of_Chennai
6. https://en.wikipedia.org/wiki/Chennai
7. http://shodhganga.inflibnet.ac.in/bitstream/10603/24086/8/08_chapter3.pdf
8. http://www.censusindia.gov.in/2011census/dchb/3302_PART_B_DCHB_CHENNAI.pdf
9. http://www.cmdachennai.gov.in/Volume1_English_PDF/Vol1_Chapter02_Demography.pdf
10. http://www.cmdachennai.gov.in/Volume3_English_PDF/Vol3_Chapter03_Demography.pdf
11. Vijayalakshmi R, Toshiyuki K, A Simulation of Land Use/Cover Change for Urbanization on Chennai Metropolitan Area, India. http://conference.corp.at/archive/CORP2014_73.pdf
12. http://www.cmdachennai.gov.in/Volume3_English_PDF/Vol3_Chapter08_Social%20Facilities%20.doc.pdf
13. http://www.kicc.jp/auick/database/training/2006-1/CR/WS2006-1CR-Chennai.pdf
14. www.indiaonlinepages.com/population/chennai-current-population.html


infection
healthcare
immunity
pathogen
prevent
physician
infection
malaria
public health
risk
health
bacteria
hepatitis
risk
pandemic
protection
prevent
flu shot
injection
measles
pharmaceuticals
health
bacteria
vaccination
measles
quarantine
tropical disease
yellow fever
injection
flu
infectious disease
infectious disease
protection
immune system
malaria
antibodies
pharmaceuticals
quarantine
travelling
yellow fever
symptom
public health
HPV
quarantine
flu
health
tropical disease
chicken pox
virus
pandemic
safety flu shot
pathogen
immune system
healthcare
pandemic
flu shot
pharmaceuticals
symptom
immunity
risk
antibodies
infectious disease
virus
tropical disease
protection
flu
chicken pox
virus
infection
chicken pox
injection
physician
yellow fever
hepatitis
bacteria
polio
immunity
HPV
physician
public health
travelling
prevent
safety
travelling
HPV
vaccination
healthcare
measles
immune system
safety
polio
antibodies
polio
vaccination
symptom
pathogen
malaria
hepatitis