Geo-Medical Analysis of the Detection of Cervical Pre-Cancer Cases Using Telemedicine System in Kerala State, India

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Abstract
Cancer cases are increasing in our nation at an alarming rate. Cervical cancer is a leading cause of cancer mortality in women. It is estimated that 1.2 lakh women die of cervical cancer in India annually. India lacks systematic cancer screening and awareness programmes, especially in the rural areas. Patients from rural areas often have to travel long distances even for diagnosis and treatment in super speciality hospitals, which remains quite expensive. The Sanjeevani mobile telemedicine system is an initiative of Malabar Cancer Care Society, Kannur and has its operations more focused in the Northern region of the Kerala state. Early detection of cancer is crucial in determining the prognosis and survival rate of the patients. Majority of the rural folks are unaware of the importance of early cancer detection and the facilities available for that. The Mobile Telemedicine Unit would visit pre-scheduled medical camps of rural and tribal areas of Malabar region and offer tele-consultation for early detection of cervical cancer and on the spot treatments were given for the ailment. This article attempts to analyse the spatio-temporal variations in the cervical pre-cancer cases detected through the mobile telemedicine unit in the state. The camp data for five years from the year 2013- 2017 were collected and analysed using the statistical standard score techniques of 'Z' score using SPSS. The Geographic Information System (GIS) was incorporated to produce cartographic outputs for assessing the spatio-temporal variations of the incidence.
Key words: *Cervical pre-cancers, Telemedicine, Early detection, Z score techniques, Spatio-temporal variations, GIS.*

I. Introduction

Cancer is a serious non-communicable disease with high fatality rate after cardiovascular diseases. Around the globe, every year there is a steady increase in the number of people affected by cancer.. Cervical cancer is a leading cause of cancer mortality in women. It is estimated that 1.2 lakh women die of cervical cancer in India annually[1]. It is the cervical cancer which is the commonest gynaecological malignancy encountered in India with a reported age-standardized incidence rate of 30.7 per 100,000. The causes of cancer vary from place to place, person to person and from one cancer site to other. The possible causes of cancer can be classified as environmental factors and hereditary factors. Around five to ten per cent of cancers in the world are hereditary in nature. About 90-95 per cent of cancers occurred due to environmental factors[2]. Kerala which forms just 1.18 per cent of the geographical area and 2.76 per cent of population of India (2011 Census), has the highest number of cancer cases reported in the country. One of the major reason behind this high number of case reports is due to the greater awareness and better health care facilities in Kerala resulting in organized recording of cases. As per WHO, chances for successful treatment of cancer is depended on early detection. Awareness among public that promotes screening and early diagnosis are two major components of early cancer detection. Cancer remains a major public health challenge in the healthcare system of Kerala[3]. Thus, early detection and timely intervention play a crucial role in saving the lives of cancer patients. One of the most effective technologies to overcome the geographical barriers of health care assistance is telemedicine system. It is identified that the telemedicine initiative in the state is focused on delivering healthcare in the areas of oncology effectively. Medical geography is a multidimensional body of knowledge and at the same time a multifaceted approach is geared towards understanding the spatial aspects of health problems [4,5] . The geo-medical studies deals with the influence of geographic factors in disease, health and health care [6,7]

There is no single definite definition of telemedicine available. The WHO has adopted a broad description of telemedicine, which says telemedicine is 'the delivery of health care services , where distance is a critical factor, by all health care professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education for the health care providers, all in the interests of advancing the

health of individuals and their communities'[8] . In simple terms, telemedicine is the delivery of medical services and medical information using information and communication technology to the remote, distant and underserved regions of the country for medical diagnosis and patient care. This innovative technology uses the benefit of satellite communication and medical sciences. The pioneer project in the state of Kerala in this regard was the ***Sanjeevani Mobile Tele-oncology system*** of Malabar Cancer Care Society (MCCS), Kannur. In this new mode, the specially designed mobile telemedicine unit for oncology with diagnostic instruments, experienced doctors and health care professionals go to the doorstep of the needful. This leads to a revolution in the healthcare delivery system in the regions of its influence. Thousands of people got the benefit of this technology through the early detection of diseases, pain relief, patient follow-up, and different community outreach programmes aimed at spreading the health awareness[9]. In the present study the GIS (Geographical Information System) is incorporated for the display of medical data. GIS provides a digital lens for exploring the dynamic connection between people, their health and wellbeing , and changing physical and social environments[10,11,12] .

II. Material and Methods

Kerala is a narrow coastal strip of land along the Malabar Coast, located in the south western tip of Indian peninsula. The state of Kerala is located very close to the equator between 8^0 17'30" and 12^0 47'40" North latitudes and $74^0$51'57"and 77^0 24'47" East longitudes in the extreme south west of Indian Peninsula[13]. The state is divided into 14 revenue districts and the total geographic area of the state is 38,863sq.km, and has a base length of 580 km along the coast, which accounts 1.18 per cent of the total area of the nation. In terms of size, Kerala accounts 22nd position in India. As per the 2011 census, the state contains a population of 3, 33, 87677, which carries the 2.76 per cent of the country's population. On the basis of altitude and other physiographic features, the state of Kerala can be divided into three broad natural divisions, namely Highland, Midland and Lowland, each of them running parallel from north to south [14] . The highland (75m + MSL) extends over an area of 18650 sq km, which accounts 48 per cent of total land area of Kerala. The central midland (7.5m-75m MSL) situated in between the highland and low land. This region extends over an area of 16200 sq km and accounts 40 per cent of the total land area of the state. The low land (< 7.5m MSL) region is also known as coastal area. Which have an average width of 7 km and it covers an area of 4000 sq.km. The coastal belt is comparatively plain. It is the highly populated region of the state.
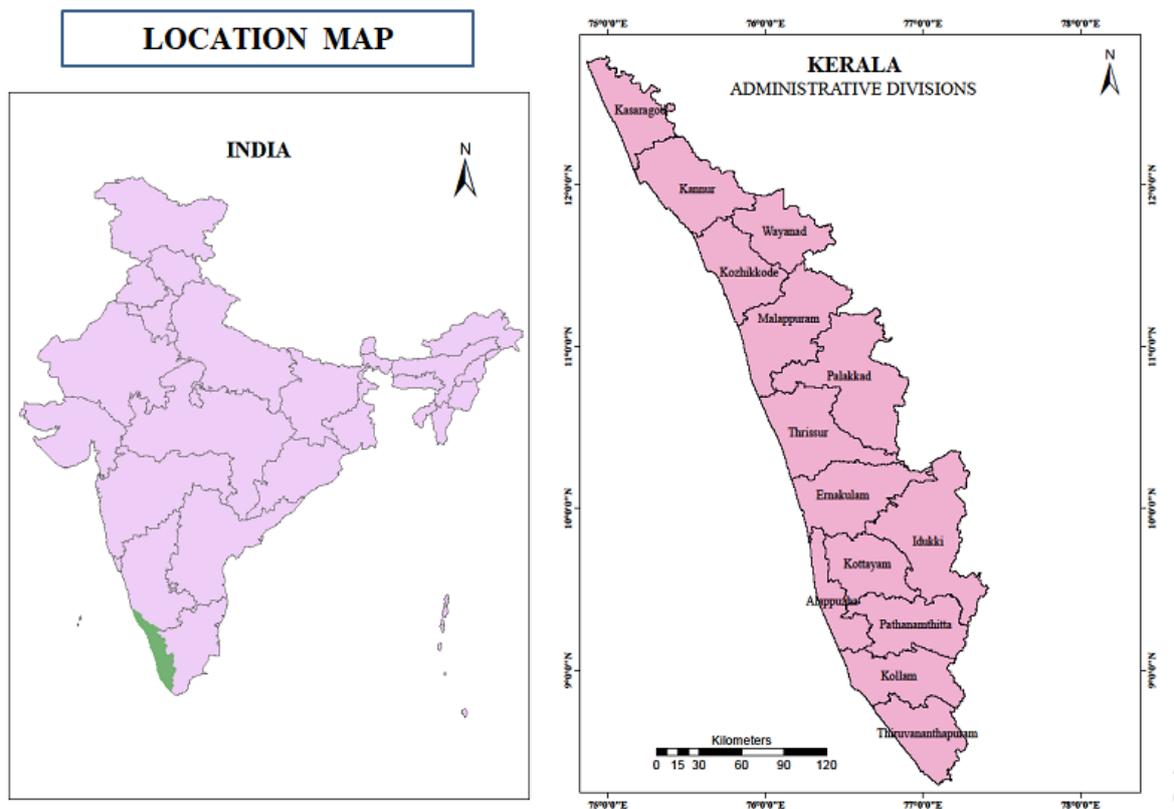

Fig.No.1

The study has been done with the help of secondary data of cervical pre-cancer cases collected from the camp records of Sanjeevani mobile telemedicine unit. The camp data of five years were compiled (2013-2017) for analysing spatio-temporal variation of cervical pre-cancer incidence. For the geo-medical analysis of the data, the standard score (Z-score) technique in SPSS is used as a statistical tool for cartographic interpretation[15]. A Z-score is a numerical measurement to denote the relationship of a value to the mean or average of a group of values calculated in terms of standard deviations from the mean. It is very useful to describe the relationship between the sets of variables. The relationship and the interdependency of different variables can be easily understood through these standard scores. The value may be positive or negative. If a Z-score value is indicated as 0, it means that the point score of the data is identical to the mean score. Likewise, a Z-score value of 1 shows that the value in the dataset is one standard deviation above the mean. The negative score indicating it is below the mean. The Z-score forms an important tool to identify certain areas and people who exhibit certain trends and disease characteristics. Here the data have been transferred into a single standard indicator for analysis. The cartographic outputs were prepared by using Arc.Gis 10.3.1 software. The Survey of India (SOI) Toposheets at 1: 50,000 scales were used for base map preparation.

III. Result and Discussion

As an increasing and serious public health threat, spatial assessment of the occurrence of cancer cases is significant in evaluating the risk of the population and helps in determining local risk factors resulting in the disease. In the present study, the telemedicine camp data was analysed through Z-score analysis where within an year comparison of variables of the data between the districts of Kerala was done. According to Z- score analysis , the state may be classified into 5 categories, such as 'Very high'- representing Z-value of greater than 1, 'High' : 0.5- 1, 'Moderate' : 0- 0.5 , 'Low' : -0.5- 0 , 'Very low' : -1 - -0.5[16,17]. Thus the data pertaining to different variables were ranked and mapped into these scores to evaluate the degree of level of variation between districts. The Z-score values for the districts not having any camp data were not considered in the study. To assess the spatio-temporal variations of Sanjeevani mobile telemedicine camps, the data spanning 5 years (2013-2017) were analysed. This study gives a comprehensive picture of implementation and effectiveness of the mobile telemedicine facility - Sanjeevani by MCC, Kannur.

Z-Score Analysis of the cervical pre-cancer cases detected through telemedicine platform 2013-2017

The geo-medical evaluation of the cervical pre-cancer cases was performed using the Z-score analysis. In 2013, cases of cervical pre-cancers were detected from four districts of the state. Early diagnosis is crucial in medical management of cervical cancer.

Table. No. 1: Z score values of cervical pre-cancer cases in Kerala state 2013-17

Sl.No	Name of the District	Cervical pre-cancer (2013)	Cervical pre-cancer (2014)	Cervical pre-cancer (2015)	Cervical pre-cancer (2016)	Cervical pre-cancer (2017)
1	Thiruvananthapuram					
2	Kollam					
3	Pathanamthitta					
4	Alappuzha				-0.07	-0.34
5	Kottayam					
6	Idukki					
7	Eranakulam	-0.34	0.13	0.4	0.28	-0.31
8	Thrissur					
9	Palakkad	-0.31			0.12	-0.53
10	Malappuram		-0.13	0.19		1.02
11	Kozhikode	3.25	3.44	3.02	3.33	2.76
12	Wayanad			0.94	-0.26	1.26
13	Kannur	0.98		0.19	0.28	0.07
14	Kasaragod		-0.03	-0.04		

Source: Compiled by the researcher from Camp records of Sanjeevani mobile telemedicine unit

Analysis of the ***occurrence of cervical pre-cancer cases in 2013*** revealed that the cervical cancer cases were very high among women in Kozhikode district (Z-score **3.25**). It is estimated that 164 users were under risk of cervical cancer. Kannur is the district which recorded the next position with a high case occurrence (Z-score value of **0.98)**, where 61 cancer risk cases were identified during this year. Only 2 cases were found as at risk cervical cancers in Palakkad district with a low score (Z score **-0.31**). One among the only two cases screened in Ernakulam was a cervical pre-cancer case (Z-score **-0.34)**.
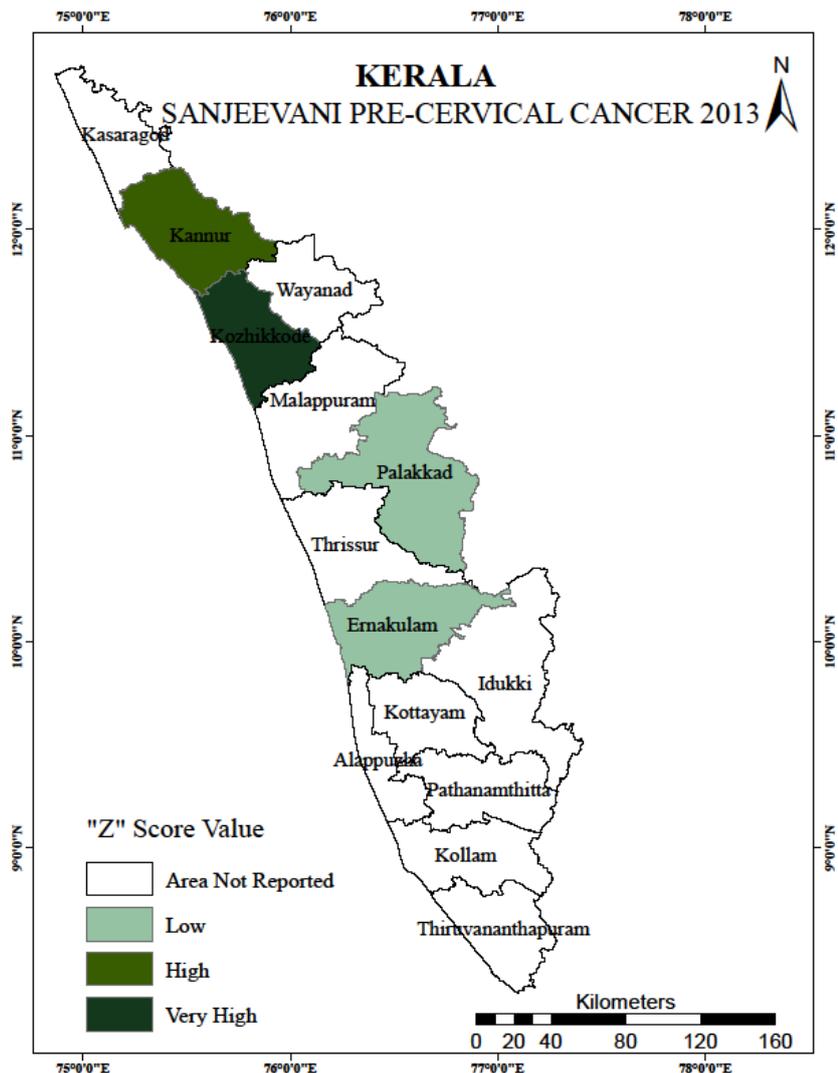
Fig.No.2

Sanjeevani comprehensive mobile telemedicine unit exhibited a different profile in 2014. During this time period, the cancer screening camps were comparatively lesser than the previous year. The northern districts of Kasaragod, Kozhikode, Malappuram and the central district of Ernakulam received the benefits of oncology camps during this year. The Z-score analysis of the disease profile of the district gives the trends of pre-cancer cases in the study area in 2014. The ***occurrence of cervical pre-cancer cases*** during this year indicated a very high incidence in Kozhikode district with 73 cases (Z-score **3.44**). It was followed by Ernakulam district with a moderate value of nine cases (Z-score **0.13**). Kasaragod and Malappuram districts had a lower occurrence. A total of six cervical pre-cancer cases were reported in Kasaragod district (Z score **-0.03**) and Malappuram district had four cases (Z-score **-0.13**).
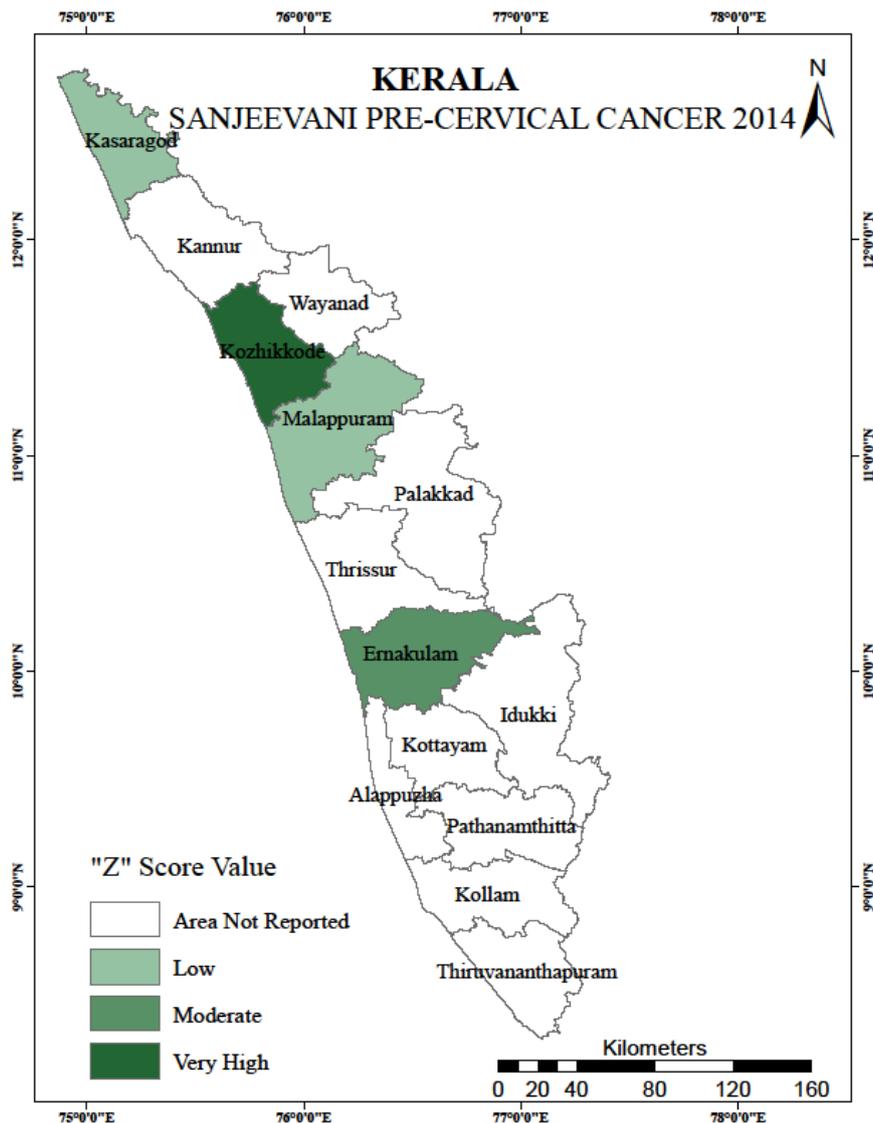
Fig.No.3

In the year 2015, Kasaragod, Kannur, Wayanad ,Kozhikkode , Malappuram and Ernakulam districts received the cancer screening service of Sanjeevani mobile telemedicine unit. Compared to the services of previous years, the mobile telemedicine network efficiently increased its service area in the state by covering more districts including districts which had no facilities for cancer screening. The Z-score analysis of the types of cancers was done and the ***occurrence of cervical pre-cancers in 2015*** revealed a very high incidence in Kozhikode district (Z-score **3.02**) with 106 suspected cases. Through the telemedicine facility, a high number of 45 cervical pre-cancer cases were detected in Wayanad district (Z-score **0.94**). Ernakulam, Kannur and Malappuram districts recorded a moderate level of cervical pre-cancer occurrence. In Ernakulam district, 29 cases were identified (Z-score **0.40**). The districts of Kannur and Malappuram recorded 23 at risk cervical cancer cases (Z-score **0.19**). In Kasaragode district, 16 cervical pre-cancer cases were identified (Z-score **-0.04**).
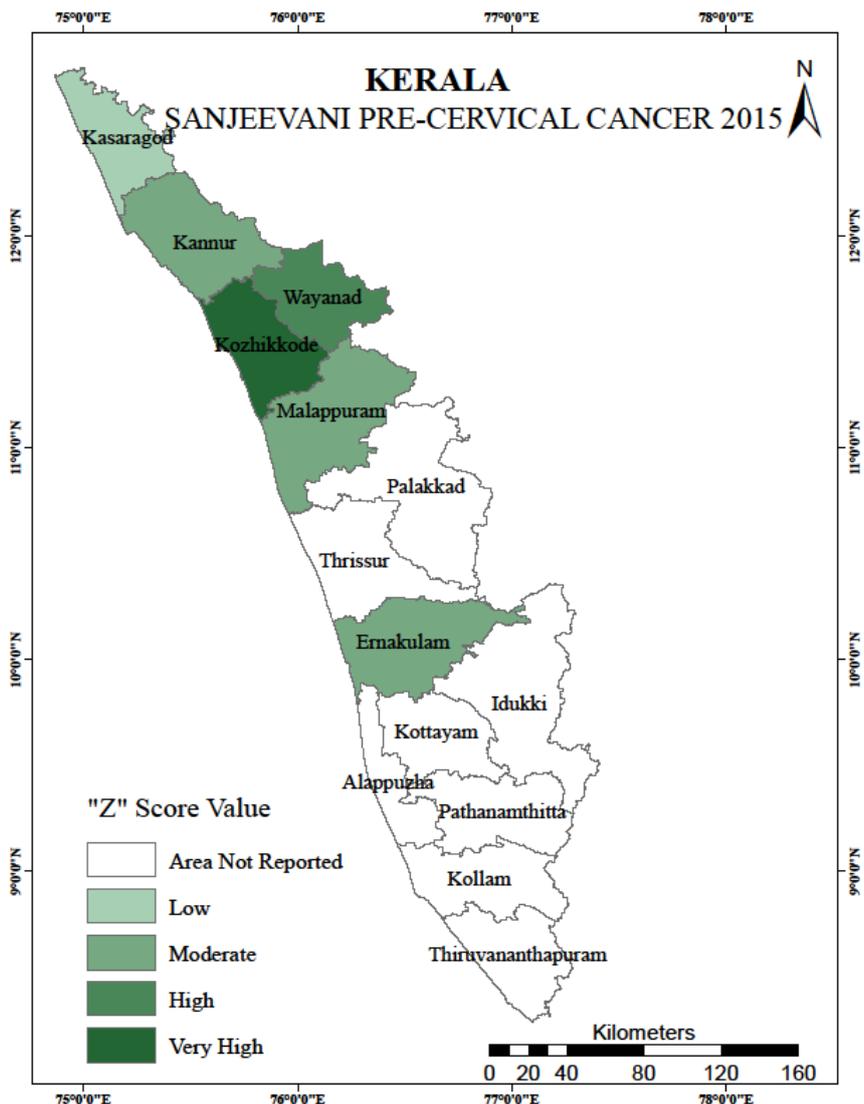
Fig.No.4

In 2016, Sanjeevani comprehensive mobile telemedicine unit covered more number of districts than the previous years. The northern districs of Kannur, Kozhikode, Wayanad, the central districts of Ernakulam and Palakkad and the southern district of Alappuzha received the benefits of cancer detection facility of Sanjeevani during this period. The tele-oncological screening was conducted in areas where no facilities for cancer detection was available. Analysis of the ***occurrence of cervical pre-cancer cases in 2016*** revealed that the at-risk cervical cancer cases were very high among women in Kozhikode district (Z-score **3.33**). It is identified that 98 beneficiaries were under risk of cervical cancer. It was followed by a moderate occurrence of cases in Kannur and Ernakulam districts (Z-score **0.28**). In both the districts Sanjeevani telemedicine unit detected 19 cases each during the study period. The district of Palakkad also registered a moderate number of cases (Z-score **0.12**), and there were 15 at-risk cases identified from there. During this time period, Alappuzha district registered a low number of cases in the cancer detection camps (Z-score -**0.07**). There was 10 pre-cancer cases that were traced from the district. The district of Wayanad also indicated a low rate of cervical cancer risk cases (Z-score -**0.26**).During this year, five at-risk cases were identified from Wayanad.
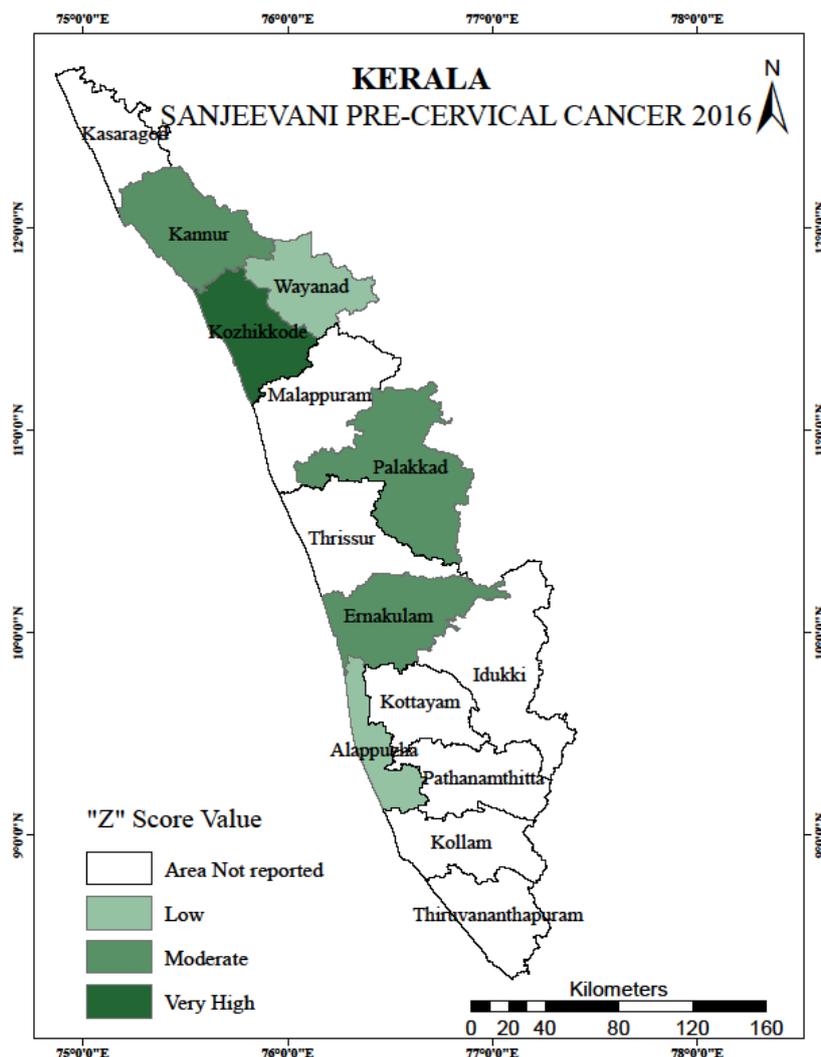
Fig.No.5

In the year 2017, more number of people in the state received the benefits of telemedicine based early cancer detection programme of Sanjeevani. The telemedicine camp records indicated that 7 districts of the state were covered by this innovative project. The northern districts of Kannur, Kozhikode, Wayanad and Malappuram, the central districts of Ernakulam and Palakkad, and the southern district of Alappuzha got the cancer detection camps either in direct (contact) or in video conferencing mode. Disease profile of all the camp records of Sanjeevani in the state indicated that the cervical cancer risks existed at a major scale. The ***occurrence of cervical pre-cancer cases in 2017*** revealed a very high incidence in Kozhikode district (Z-score **2.76**) with 195 suspected cases. Through the telemedicine facility, a very high number of 107 cervical pre-cancer cases were detected in Wayanad district (Z-score **1.26**). The district of Malappuram also indicated a very high number in its cervical pre-cancer risk cases (**Z- score 1.02**). During the study period 93 cases were reported from the district. A moderate number of cases were identified from Kannur district (**Z- score 0.07**). There were 37 symptomatic cases screened from the district. Ernakulam (**Z- score -0.31**) and Alappuzha (**Z- score -0.34**) districts recorded a low number of cervical pre-cancer cases in 2017. Both the districts recorded 15 and 13 cases respectively. A very low number of cervical cancer risk cases was reported from Palakkad district (**Z- score - 0.53**). Only two cases were diagnosed from here during the period of 2017.
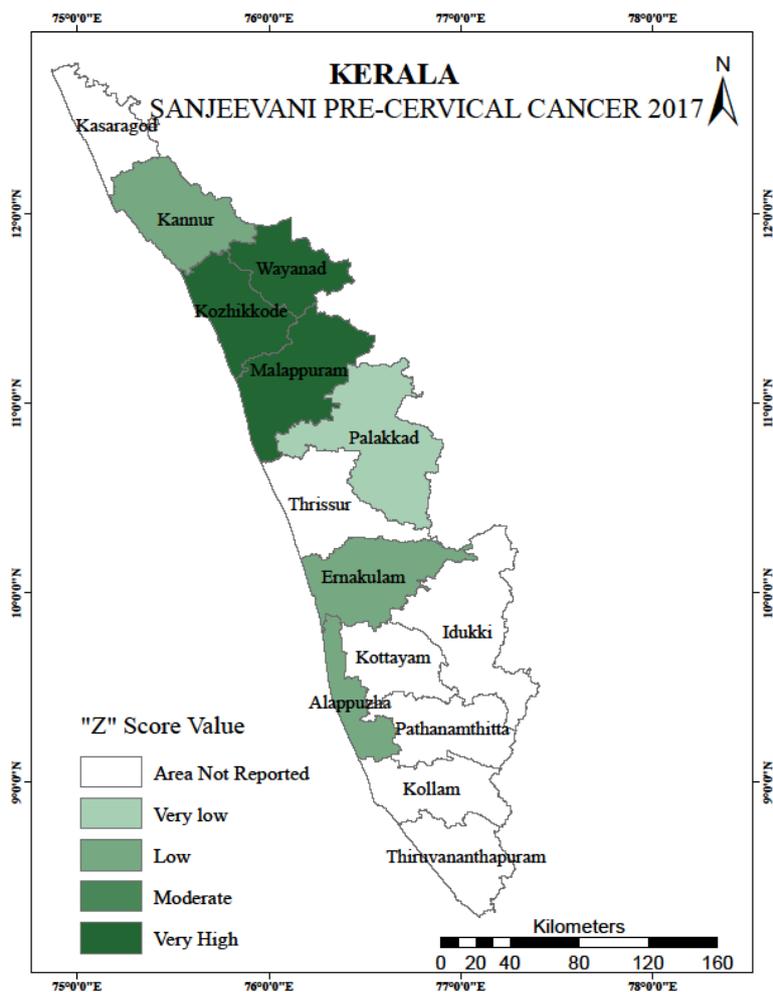
Fig.No.6

IV. Conclusion

For effective planning and administration in the future, the in-depth analysis of the present system, especially the system design, technical feasibility and usability is inevitable. This project effectively analyses the spatio-temporal variation of cervical pre-cancers and the efficiency of mobile telemedicine system for its mass screening by reaching out to the public at their doorsteps. In the state of Kerala, telemedicine has come originally to serve rural populations or any people who are geographically dispersed, where time and the cost of travel to the best medical service is inaccessible.To a greater extend, this system can reduce present rural urban disparities in healthcare delivery system. The underserved communities in the society like tribal people, fisher folks and other people in the rural remote regions who are far away from multi-speciality hospitals can avail this service easily. The users can save the travel expense to the hospital and avoid the wastage of time for waiting for face to face consultation in the specialty hospitals.

As per sanjeevani camp records, Cervical cancer is one of the commonest cancers in the State, but one which can be easily detected in the early stages itself and fully cured. However, there is poor awareness among women about this and generally, women do not get an access to gynaecological screening till the problem becomes critical for them. Most of the rural and tribal people generally hesitate to go to RCC for clinical check-up and follow-up activities. The most important thing in this case to remember is that delayed treatment reduces recovery rate. Through Sanjeevani Telemedicine unit, the team provides cancer awareness and early detection messages prompting people to change their habits and life style. Sanjeevani remains a successful programme in reducing congestion at Regional Cancer Centre. This prestigious project of MCCS-Kannur conducted house to house and person to person campaign which was taken to two million people in Malabar region.

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