Geo-Medical Analysis of Telemedicine Based Mobile Tele-Ophthalmology Screening For Cataract Cases in Thiruvananthapuram District, Kerala, India

Sheheersha.S.K.*, Dr.V.Saravanabavan**

* Assistant Professor, Department of Geography, University College, Thiruvananthapuram, Kerala
**Assistant Professor, Department of Geography, School of Earth and Atmospheric Sciences, Madurai Kamaraj University, Madurai, Tamil Nadu.

ABSTRACT
Health care of the people is prime important as conservation of the earth system and natural resource management. The global disease distribution is heterogeneous in nature. Over the past decades we have witnessed so many sophisticated developments in Information and Communication Technologies (ICTs). The modern healthcare delivery system use different applications of ICTs effectively. The use of spatial technologies plays a prime role to manage the health problems and extend healthcare delivery system effectively in the society. Telemedicine system for ophthalmology plays a pivotal role in Kerala state for identifying different eye ailments and preventing vision loss among the population. Early detection of the eye ailments like cataract, glaucoma, retinopathy and diabetic retinopathy are the major diagnostic facilities operated through the existing telemedicine platform. The first mobile tele-ophthalmology unit was introduced in the Kerala state in 2011 by Regional Institute of Ophthalmology (RIO), Thiruvananthapuram. This sophisticated mobile tele-ophthalmology unit is used for diagnosing and early detection of eye ailments of the people in Thiruvananthapuram district at their doorsteps. The cartographic techniques using GIS is used to produce the map output of the incidence.
KEY WORDS: Telemedicine, Tele-ophthalmology, Early Detection, Spatial Technologies, cataract, Disease Diagnosis, GIS.

I. INTRODUCTION

Medical geography is a part of human geography which studies the influence of geographical factors on health. Howe (1989) defined "Medical geography as an interdisciplinary field of study concerned with variations of disease incidence as expressed in mortality or morbidity with the demonstration of possible cause and effect relationship with elements of physical , biological and socio-cultural environments in space [1]. The concept of health evolved as an individual concern to a global concern which determines the quality of life. Telemedicine includes, a growing variety of applications and services using two-way video, e-mails, smart phones, wireless tools and other form of telecommunication technology" [2] . The use of geo-spatial technologies plays a prime role to manage the health problems and extend healthcare delivery system effectively in the society. GIS provides a digital lens for exploring the dynamic connections between people, their health and wellbeing, and changing physical and social environments [3,4,5,6,7] . The biomedical concept of health was popular in ancient time, and in this concept the health has been viewed as an absence of disease[8,9,10,11,12]. The early detection of these eye problems saved thousands of people in these two districts from the serious vision loss complications. The most notable advantage of this system is that the patient gets the consultation facilities with an expert doctor and the availability of sophisticated laboratory equipment at their doorsteps. Kerala is one of the pioneer states in India implemented telemedicine based health care to its population.

II. MATERIALS AND METHODS

Thiruvananthapuram is the southernmost district of Kerala, bounded by Kollam district in the north, Tirunelveli and Kanyakumari districts in the east and south and the Arabian Sea (Lakshadweep Sea) in the west. The district is situated between north latitudes of 8°17'-8°47 and east longitudes 76°41'-77°16'. The total geographical area of the district is 2192 sq. km and falls in Survey of India degree sheets 58 D and H. The Western Ghats, which form the eastern boundary of the district as well as the State, are comparatively closer to the coast in this district, than in other parts of the State. Administratively, the Thiruvananthapuram district can

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be broadly grouped into 6 taluks viz., Thiruvananthapuram, Neyyatinkara, Chirayinkil, Varkkala, Kattakkada and Nedumangad consisting of 11 blocks, 84 panchayats, 4 municipalities and 1 corporation.The effectiveness of modern healthcare delivery system largely depends upon the coverage of population through field based telemedicine camps. It is estimated that the Sunayanam mobile tele-ophthalmology unit operated 237 camps at various parts of the district during this period. To assess the effectiveness and efficiency of telemedicine unit for screening the cataract problems, the secondary data from medical camp records of mobile telemedicine platform for the period of five years (2013-2017) were collected. The per cent data for the beneficiary participation and screened cataract cases were depicted cartographically by using Arc.GIS 10.3.1 software.

III. RESULT AND DISCUSSION

TELE-OPHTHALMOLOGY BENEFICIARY PARTICIPATION AND THEIR GENDER

The micro-level village data from the camp records of this system gives a clear outlook of the effectiveness of the telemedicine initiative among the inhabitants of the Thiruvananthapuram district. It is understood from the present study that there are 19,225people who obtained the benefit of this modern healthcare delivery system in the district within the time period of 2013-2017. The number of beneficiaries in each camp site exhibits a wide variation in people's participation. It is identified from the present study that most of the users of telemedicine system in ophthalmology are female. The micro-level beneficiary participation and their gender characteristics in percentage are explained below. In the present study, the spatial evaluation of the percentage of beneficiary participation in each village division in different taluks of Thiruvananthapuram district was analysed. The percentage data was grouped and spatially depicted using the Arc.GIS 10.3.1 software. As per the grouping of data, beneficiary participation percentages were divided into Very High (3.32-5.39%), High (2.04-3.31%), Moderate (1.40-2.03%), Low (0.87-1.39%), Very Low (0.005-0.86%) (Fig 1.1).

A very high rate of beneficiary participation in this system during the timespan of 2013-2017 was observed in seven villages of the Thiruvananthapuram district. In Thiruvananthapuram taluk division, five villages are under this category. Veli coastal region of Kadagampally taluk had 5.39 per cent beneficiaries (M-14%, F-86%). Most of the beneficiaries diagnosed here were the fisher folks of the district. The medical college region of Cheruvaikkal division falls next with 5.36 per cent beneficiaries (M- 41%, F-59%). The health practitioners and medical students also participated in the telemedicine camps for the early detection of various eye ailments. The Poojappura region of Sasthamangalam village division had recorded 4.78 per cent users (M-55%, F- 45%). The largest share of male participants in this region is due to the participation of prisoners from the central prison and correction home, Poojappura. The Palayam region of Vanchiyoor village division had marked 3.90 per cent beneficiaries (M- 56%, F- 44%). The proximity of educational institutions, government offices and market increased the chance for male participation in this division. The Pangappara village division of Thiruvananthapuram taluk had 3.82 per cent beneficiaries (M-45%, F-55%).Two villages of the Neyyatinkara taluk of Thiruvananthapuram district also recorded high beneficiary participation in Sunayanam mobile tele-ophthalmology system. The Poovar coastal region of Karumkulam division had recorded 4.31 per cent beneficiaries (M-39%, F- 61%). The Balaramapuram of Athiyannur division had recorded 3.97 per cent beneficiaries (M-33%, F- 67%).
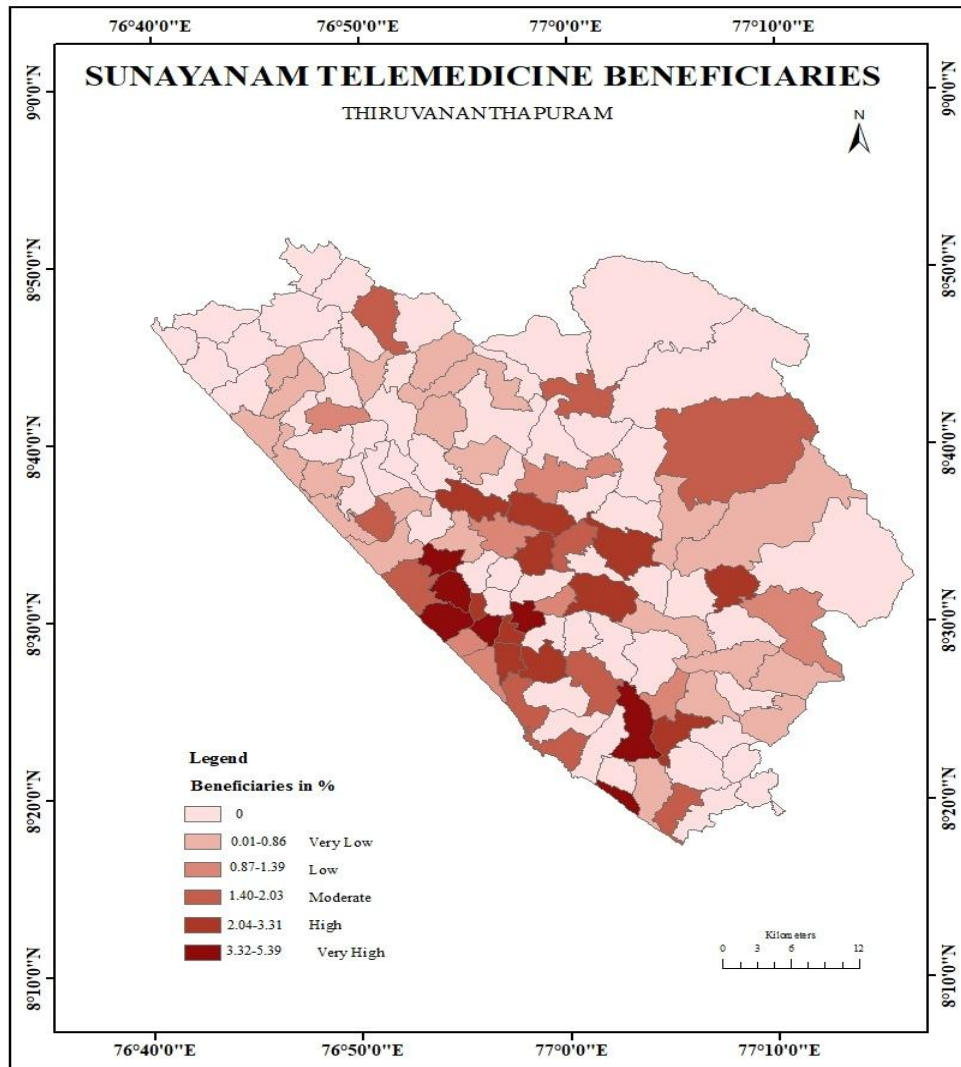
Fig.1.1

It is identified that 11 villages in the Thiruvananthapuram district come under the high beneficiary participation category. In Thiruvananthapuram taluk, four villages had high rate of user participation. Manacaud division had 2.83 per cent users (M-30%, F- 70%). It was followed by Nemom division with 2.52 per cent beneficiaries (M- 32%, F- 68%).The Kesavadasapuram region of Pattom village had 2.49 per cent users (M- 23%, F- 77%). The Vazhuthacaud region of Thaicaud division had marked 2.41 per cent user participation (M- 33%, F- 67%). In Neyyatinkarataluk, only one village exhibits high number of beneficiary participation. Neyyatinkara village division had 3.32 per cent users (M- 34%, F- 66%). The user participation profile of Nedumangad taluk reveals that, four villages of the taluk come under this category. The Nedumangad village division recorded 3.04 per cent beneficiary participation (M- 30%, F- 70%). It was followed by Vembayam village division with 2.90 per cent users (M- 32%, F- 68%). The Vellanad division had 2.68 per cent beneficiaries (M- 32%, F- 78%). The Karakulam village division of the Nedumangad taluk recorded 2.42 per cent beneficiaries (M- 31%, F-69%) during the period of study. In Kattakkada taluk, two villages come under the category of high participation rate in Sunayanam mobile tele-ophthalmology camps. The Vilappil village had 3.29 per cent user participation (M- 27%, F- 73%). It was followed by Amachal region of Kallikkad division, the village had recorded 2.83 per cent beneficiaries (M- 26%, F- 74%). None of the villages in the northern most taluks of Thiruvananthapuram, ie. Varkkala and Chirayinkeezhu fall under this category.

It is identified that, 10 villages from the four taluk divisions of the districts come under moderate category of beneficiary participation. In Thiruvananthapuram taluk, the Thiruvallom village division had recorded 1.78 per cent beneficiaries (M- 36%, F- 64%) in the telemedicine camps. It was followed by Karikkakom region of Attipra division with 1.68 per cent users (M- 36%, F- 64%). The Pallippuram village had 1.48 per cent users (M- 52%, F- 48%). The beneficiary participation profile of Neyyatinkara taluk reveals that

the coastal village of Vizhinjam had marked 1.84 per cent users (M- 38%, F- 62%). The Kulathoor village had recorded 1.69 per cent beneficiaries (M- 34%, F- 66%) in this telemedicine system. It was followed by the Pallichal village with 1.47 per cent beneficiaries (M- 40%, F- 60%). Three villages in the Nedumangad taluk also fall under the moderate category of telemedicine users in the district. The tribal dominant village of the taluk, Palode had recorded 2.03 per cent (M- 40%, F- 60%) beneficiaries in this system. The eastern highland village of Vithura, which also shares a major group of tribal population in the district had marked 1.66 per cent users (M- 10%, F- 90%). The Aruvikkara village division of Nedumangad taluk had 1.46 per cent (M- 30%, F- 70%) beneficiaries during this period. In Chirayinkeezhu taluk only the village of Kilimanoor comes under the moderate level of beneficiary participation, it is identified that 2.57 per cent beneficiaries (M- 30%, F- 70%) got the benefit of this telemedicine system. The involvements of local healthcare workers are essential for male participation in telemedicine camps. It is understood that the awareness among male population regarding this modern healthcare delivery system is essential for their participation in these medical camps. None of the villages in Varkkala and Kattakkada taluk fall under this category.

There are eight villages in the five taluks of Thiruvananthapuram district that come under the low category of beneficiary participation. In Thiruvananthapuram taluk division, Vattiyurkkavu village had recorded 1.35 per cent users (M- 50%, F- 50%), Muttathara village had recorded 1.28 per cent users (M- 19%, F-81%) and Pettah village division had recorded 1.25 per cent users (M- 46%, F- 54%) during the period of study. The Perumpazhuthoor village of Neyyatinkara taluk had 0.96 per cent beneficiaries (M- 27%, F-73%). In Kattakkada taluk, only one village named Amboori comes under this category with 1.04 per cent users (M- 12%, F- 88%). It is identified from the present study that, two villages of Nedumangad taluk fall under low rate of user participation. The Vattappara village had recorded 1.39 per cent users (M- 23%, F- 77%). It was followed by Chullimanoor region of Anad division with 1.04 per cent beneficiaries (M- 40%, F- 60%). In Chirayinkeezhu taluk, only the village of Attingal had recorded 0.95 per cent beneficiaries (M- 56%, F- 44%). The highest rate of male participation in this division may be due to the proximity of government offices and educational institutions in the region. There is no village from the Varkkala taluk that falls under this category.

There are 22 villages in Thiruvananthapuram district that come under low beneficiary participation. Villages from all the six taluks of Thiruvananthapuram district are included in this category. In Thiruvananthapuram taluk, Kaniyapuram region of Kadinamkulam village had recorded 0.79 per cent beneficiaries (M- 21%, F- 79%), Pothencode region of Andoorkkonam village had recorded 0.54 per cent beneficiaries (M- 28%, F- 72%), Chempazhanthi region of Uliyazhathura village had recorded 0.52 per cent beneficiaries (M- 48%, F- 52%) and Kariavattom region of Kazhakkoottom-Meenomkulam division had recorded 0.42 per cent beneficiaries (M- 47%, F- 53%). The beneficiary profile of the Neyyatinkara taluk reveals that the Anappara region of Vellarada division had recorded 0.64 per cent users (M- 30%, F- 70%), Karakkonam region of Kunnathukal division had 0.62 per cent users (M-20%, F- 80%), Pallithara region of Perumkadavila division recorded 0.61 per cent users (M- 35%, F- 65%) and the Pozhiyoor region of Thirupuram division had 0.52 per cent users (M- 36%, F- 64%). The very low rate of user profile in the Kattakkada taluk recorded in three villages. The Keezharoor village recorded 0.78 per cent beneficiary participation (M- 42%, F- 58%), Kattakkada region of Kulathummal division had 0.64 p[er cent beneficiary participation (M- 27%, F- 73%) and Kottoor region of Mannurkkara division had 0.46 per cent beneficiary participation (M- 43%, F-57%) in the taluk. There are four villages in the Nedumangad taluk that fall under this very low rate of beneficiary participation in Sunayanam tele-ophthalmology system. The Venjaramoodu region of Nallanad division marked 0.78 per cent users (M- 17%, F- 83%), Aryanad village marked 0.71 per cent users (M- 26%, F- 74%), Manikkal village marked 0.48 per cent users (M- 30%, F- 70%) and Vamanapuram village marked 0.20 per cent users (M- 28%, F- 72%) during the period of study. The beneficiary profile of the Chirayinkeezhu taluk reveals that the Pulimath village had 0.86 per cent users (M- 28%, F- 72%), Chirayinkeezhu village had 0.77 per cent users (M- 25%, F- 75%), Anjuthengu region of Kadakkavoor division recorded 0.29 per cent users (M- 52%, F- 48%), Nagaroor village recorded 0.22 per cent users (M- 17%, F-83%) and Azhoor village had 0.18 per cent users (M- 40%, F- 60%). The northern most taluk of Thiruvananthapuram district, Varkkala had two villages under this category. The Njekkad region of Ottoor division recorded 0.26 per cent beneficiaries (M- 26%, F- 74%) and the Manampoor village had recorded 0.54 per cent beneficiaries (M- 20%, F- 80%) in the tele-ophthalmology camps of Sunayanam system.

SPATIAL DISTRIBUTION OF CATARACT CASES SCREENED BY TELEMEDICINE SYSTEM

The mobile tele-ophthalmology system effectively diagnosed undetected cataract cases among the population of Thiruvananthapuram district. There were 237 mobile tele-ophthalmology camps in the 58 villages of Thiruvananthapuram district during the period of study. The details of cataract case occurrence (in percentage) with reference to its spatial information are explained below. The percentage data was grouped and spatially depicted. As per the grouping of data, cataract occurrence percentages of sunayanam telemedicine system were divided into Very High (3.15-7.59%), High (1.80-3.14%), Moderate (0.92-1.79%), Low (0.01-0.91%) (Fig 1.2).
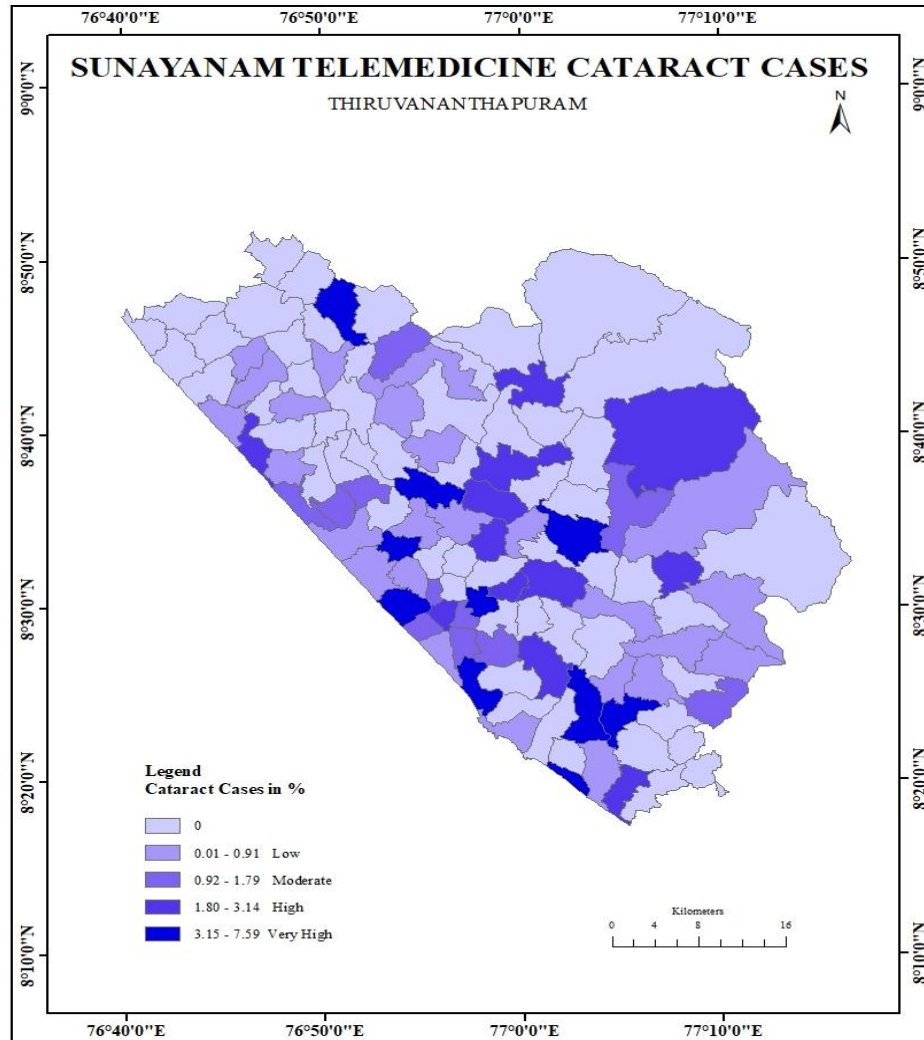
Fig.1.2

It is estimated that 10 villages in the Thiruvanathapuram district recorded very high number of cataract cases. In Thiruvananthapuram taluk, it is identified that in the Veli region of Kadagampalli division 5.09 per cent cataract cases were identified, it was followed by the Poojappura region of Sasthamangalam village with 4.90 per cent cases of cataract. The Pangappara and Thiruvallom villages of the Thiruvananthapuram taluk had recorded 3.73 and 3.46 per cent cases respectively. The cataract profile of Neyyatinkara taluk shows that the Poovar coastal region of Karumkulam division recorded7.59 per cent cases. The Neyyatinkara village division and the Balaramapuram region of Athiyannur division had 4.09 and 4.05 per cent cases respectively. In Nedumangad taluk, the Vellanad and Vembayam villages had 3.93 and 3.62 per cent cases respectively. The Kilimanoor village division of Chirayinkeezhu taluk recorded 3.62 per cent cataract cases during the period of study. No villages in the Kattakkada and Varkkala taluks come under the very high division of cataract cases in the district.

It is observed that 12 villages in the different taluks of Thiruvananthapuram district come under high occurrence of cateract category. In Thiruvananthapuram taluk, Vattiyoorkkavu village and Palayam region of Vanchiyoor village had recorded 2.34 and 2.30 per cent cataract cases by this telemedicine system. In Neyyatinkara taluk, the Pallichal and the Kulathoor village recorded 2.26 and 2.22 per cent cataract cases respectively under this category. In Kattakkada taluk, the Amachal region of Kallikkad village and Vilappil village recorded 3.14 and 2.58 per cent cataract cases respectively. The cataract profile of Nedumangad taluk under this category reveals that the village of Karakulam had 2.42 per cent cases, Nedumangad had 2.38 per cent cases, Vithura had recorded 2.19 per cent cases, Palode had recorded 2.07 per cent cases and Chullimanoor region of Anad division recorded 1.99 per cent cases of cataracts. In Chirayinkeezhu taluk, only the Chirayinkeezhu village had confirmed 2.03 per cent cataract confirmed cases under this category. There is no village from the northern most taluk of Varkkala that comes under this category during the study period.

Moderate number of cataract cases by Sunayanam mobile tele-ophthalmology system shows, there are 11 villages which come under this category. In Thiruvananathapuram taluk, the villages of Manacaud and Nemom confirmed 1.79 and 1.63 per cent cataract cases by Sunayanam telemedicine system. The Vazhuthacaud region of Thaicaud division and the Kesavadasapuram region of Pattom division had recorded 1.51 and 1.43 per cent cases of cataract respectively. The Kadinamkulam village division had 1.23 per cent cases of cataract during this period. The Pettah and Pallippuram village divisions of the taluk had recorded 1.15 and 1.11 per cent cases of cataract respectively. The Pothencode region of Andoorkkonam division in the Thiruvananthapuram taluk also recorded 1.11 per cent confirmed cases of cataract. In Neyyatinkara taluk division, the Karakkonam region of Kunnathukal division had recorded 1.03 per cent cases. In Nedumangad taluk the Aryanad village had 1.31 per cent confirmed cases of cataract. The Pulimath village of Chirayinkeezhu thaluk had confirmed 1.19 per cent cases of cataract during the study period. There are no villages in the Varkkala taluk that come under this category.

Low occurrence of cataract cases in this telemedicine system reveals that most of the villages in Thiruvananthapuram district belong to this category. It is identified that 25 villages in different taluks of Thiruvananthapuram are categorized here. In Thiruvananthapuram taluk, Karikkakom region of Attipra village, and Muttathara village had recorded 0.83 and 0.52 per cent confirmed cataract cases respectively. The Chempazhanthi region of Uliyazhathura and Medical College region of Cheruvaikkal division had marked 0.48 per cent cases each. In Kariavattom region of Kazhakkoottom division only 0.08 per cent cataract cases were detected by this mobile tele-ophthalmology system. The cataract profile of Neyyatinkara reveals that, the Vizhinjam coastal village had recorded 0.91 per cent confirmed cases of cataract. It was followed by the Pozhiyoor region of Thirupuram division with 0.48 per centcases of cataract. The Pallithara region of Perumkadavila and Perumpazhuthoor village had recorded 0.40 per cent cases each under this category. The Anappara region of Vellarada division had recorded only 0.20 per cent cases of cataract during the period of study. In Kattakkada taluk , the telemedicine camps of the Kattakkada region of Kulathummal division and Amboori village division had marked 0.87 and 0.79 per cent cataract cases respectively. The Kottoor region of Mannoorkkara division and Kezhaaroor village recorded 0.64 and 0.44 per cent cases of cataract under this telemedicine system. The Nedumangad taluk of Thiruvananthapuram district had its five villages under this category of cataract cases. The Aruvikkara and Vattappara villages had recorded 0.91 and 0.83 per cent cases respectively. The Manikkal village of this taluk had 0.79 per cent cases of cataract. The Vamanapuram division and Venjaramoodreagion of Nallanad division had marked 0.28 and 0.12 per cent cases respectively. The low rate of cataract detection in Chirayinkeezhu taluk reveals that , the Attingal and Azhoor villages had recorded 0.56 and 0.52 per cent cases of cataracts respectively. The Nagaroor village and the Anchuthengu region of Kadakkavoor division had recorded 0.36 per cent and 0.28 per cent cases through Sunayanam mobile tele-opthalmology system. The northern most taluk of Varkkala indicated that the Manampoor and Njekkad reagion of Ottoor division had recorded 0.72 and 0.64 per cent cases respectively.

IV. CONCLUSION

Telemedicine system for ophthalmology plays a pivotal role in Kerala state for identifying different eye ailments and preventing vision loss among the population. Early detection of the eye ailments like cataract, glaucoma, retinopathy and diabetic retinopathy are the major diagnostic facilities operated through the existing telemedicine platform. The telemedicine based screening for ophthalmologic diseases are essential for the early detection of serious eye ailments. The healthcare services of tele-ophthalmologic units helps to identify the intensity of some eye ailments spatially. The awareness about the telemedicine based ophthalmologic service is crucial for its further expansion to the other regions of the state. The disease density and spatial distribution of telemedicine services are useful for further healthcare planning and disease management.

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