Review Article

Distribution of neurologists and neurosurgeons in India and its relevance to the adoption of telemedicine

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ABSTRACT

Majority of Indians have no access to centres of neurological excellence in the country. A detailed analysis of 3666 members of the Neurological Society of India and the Indian Academy of Neurology revealed *that not a single member lived in a geographical area covering 934.8 million people.* 30.09% live in the four major metropolitan cities, 29.54% in the state capitals, 30.58% in Tier 2 cities, 7.12% in tier 3 cities and 2.67% in rural areas covering a population of 84.59 million. Building additional neurological centres cannot be the only answer, given the acute shortage of funds and trained personnel. In 1999, the author among others, foresaw that it could be possible, to extend the reach of urban specialists to suburban and rural India, by virtual means. The neurological community has been slow to use Information and Communication Technology (ICT) as an integral part of their health care delivery system. This article analyses the distribution of neurologists and neurosurgeons in India and suggests that providing additional virtual neurological care can be the only answer to offset the lop sided distribution of clinical care givers in neurosciences. In this article, the authors' considerable experience in introducing and developing telehealth in India over the last 15 years is being shared with specific emphasis on its relevance to neurosciences. A review of the global literature on telemedicine and neurosciences will substantiate the plea that telemedicine must be deployed by neurologists and neurosurgeons in India to extend their reach to patients particularly those residing in rural areas.

Key words: Telemedicine and neurosciences; distribution of neurologists and neurosurgeons in India; telemedicine in India

Introduction

The term "Telemedicine" encompasses the entire spectrum of technology, armamentarium and processes that are required to enable history taking, conduct a clinical examination, perform investigations and manage a patient, with the consultant and the patient physically at different locations. It presupposes the availability of a personal computer (PC)/laptop/tablet/smart phone, a good video conferencing system/digital camera, adequate connectivity, and software to capture, store, transfer, visualise data, and enable the teleconsultant at the remote end to view reports and digitally manipulate images.[1-10] Peripheral medical devices, for example, a blood pressure apparatus or an ophthalmoscope need to be connected to the internet to enable remote monitoring. The role of telemedicine lies in rendering the concept of "distance" and "terrain" meaningless. The role of telemedicine in developing countries is different from that in the developed countries, and this has been adequately highlighted.[11,12] Once the "virtual" presence of a specialist is acknowledged, a patient can access resources existing in a tertiary referral centre without the constraints imposed by distance [Figures 1-5]. It is easier to set up a telecommunication infrastructure in suburban and rural areas than to make specialists available there. In developing countries, most citizens do not have immediate access to an appropriate specialist. Incentives to entice specialists to practice in suburban and rural areas have failed. Making necessary infrastructure available is as important as providing monetary compensation.

Access this article online	
Website: www.neurologyindia.com	Quick Response Code
DOI: 10.4103/0028-3886.156274	

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Traditionally, it was believed that communities most likely to benefit from telemedicine are those least likely to be able to afford it and also those least likely to have the requisite communication infrastructure. With exponential growth of ICT, this no longer holds true.

Introduction to the neurological scenario in India

The WHO initiated "Global Burden of Disease Study" in 2013[13] has confirmed that worldwide, neurological disorders are priority health problems. Neurologic disorders, including stroke, dementia, epilepsy, migraine, Parkinson's disease, central nervous system (CNS) infections and neoplasms, account for 8.7% of premature deaths and disability across the world. This excludes traumatic brain injury which itself is a harbinger of major disability. With increasing life expectancy, the burden of neurological diseases is also increasing. According to Gourie Devi,[14,15] the prevalence of neurological disorders (more in rural areas) in India ranges from 967–4,070 with a mean of 2394 patients per 100,000 population. This figure of 30 million people with neurological disorders does not include neuro-trauma and neuro-infections. The 6–8 million epileptics and 27–42% of stroke fatalities themselves call for urgent strategies to establish outreach neurology services to cater to rural areas. Policymakers and administrators concentrate on allocation of funds, human resources and infrastructure, to provide secondary and tertiary care. Using ICT to provide virtual specialists is unfortunately, seldom considered. Today, the latter is far more cost effective and eminently doable rather than providing "brick and mortar" specialist centres. Clinical neurology can be provided from a distance offering a sophisticated tele-triage.

In Odisha, 20% of posts of specialists and assistant surgeons in peripheral hospitals are vacant. Specialists are not available in two of the three government medical colleges. In Karnataka, 30% of posts of generalists and 65% of specialists and super specialists in the government hospitals are vacant. Often, one has to travel more than 20 km to reach the nearest Primary Health Centre in Karnataka.[16] Seven thousand patients visit

Figure 1: Teleconsult from Chennai to Andaman & Nicobar islands

Figure 2: Teleneurological evaluation from Chennai of a Tanzanian in Muscat followed by radiosurgery at Chennai

Figure 3: Tele CME programme (originating from Chennai) attendees in 39 countries in Africa under the Pan African eNetwork project

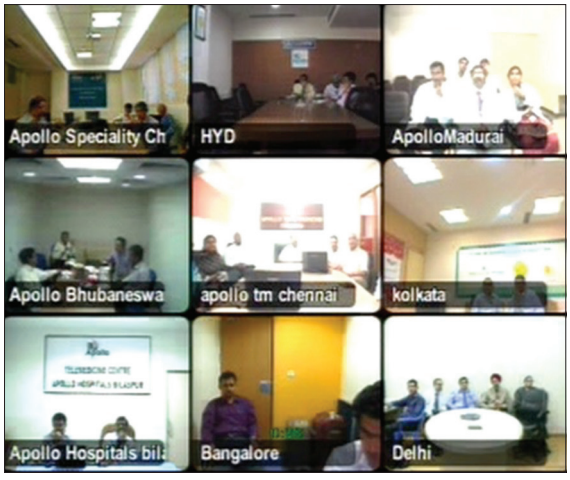

Figure 4: Apollo interhospital Tele Grand rounds in neurosciences

speciality and super speciality OPD's at AIIMS New Delhi every day from various states. The waiting time for elective neurosurgery is at least 7 months.

Eighty percent of India's specialist doctors live in urban India. 700 million people living in rural India have to travel a distance of 75 to 100 km for a tertiary consultation. In January 2015, the Indian Academy of Neurology had approximately 1312 members (including associate members) [Figure 6] and the Neurological Society of India, approximately 2500 members [including associate members] [Figure 6]. An analysis of the confirmed addresses from both societies revealed that 30.9% of the members lived in the four major metropolitan cities (1103 for 38.72 million population), 29.54% in the state capitals (1083 for 48.80 million population), 30.58% in tier 2 cities (1121 for 158 million population), and, 7.12% in tier 3 cities (261 for 69.6 million population) [Figures 7-10]. 2.67% members lived in rural areas covering a population of 84.59 million. *There was not a single member living in a geographical area covering nearly 934.88 million people* [Tables 1-4]. The purist would argue that extrapolating membership of neurological societies to the availability of neurologists and neurosurgeons might not be scientifically valid. However, the small numbers clearly reveal that even if 20% specialists are not society members and even if there is a 10% error in analysis due to wrong information and some inaccuracy in the census data, considering that the denominator is 1250 million, the differences would not be statistically significant.

Postgraduate training

Indian Universities only train 387 new postgraduates annually in neurology and neurosurgery [Figure 10]. While Southern India has 205 seats and Northern India 126, North Eastern India with a population of 260 million has only 4 seats. The National Board of Examination produces an additional 44 specialists per year (some of whom have already cleared their qualifying examination earlier) [Figure 10]. Neurologists located in the districts see about 80 patients daily leaving little time for academics and research.[17] Indian neurologists examine four times the number of patients seen in USA and UK. Greater involvement of primary physicians and internists in the neurological care of patients is, therefore, necessary.[18]

Distribution of neurological specialists worldwide

Neurological expertise is not available in several areas of the world.[19–26] 20% of the US population has no direct access to

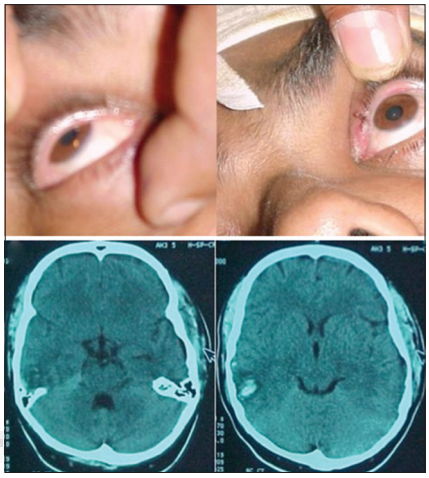

Figure 5: An unconscious head injury patient at Port Blair, Andaman and Nicobar Islands, being managed from Chennai

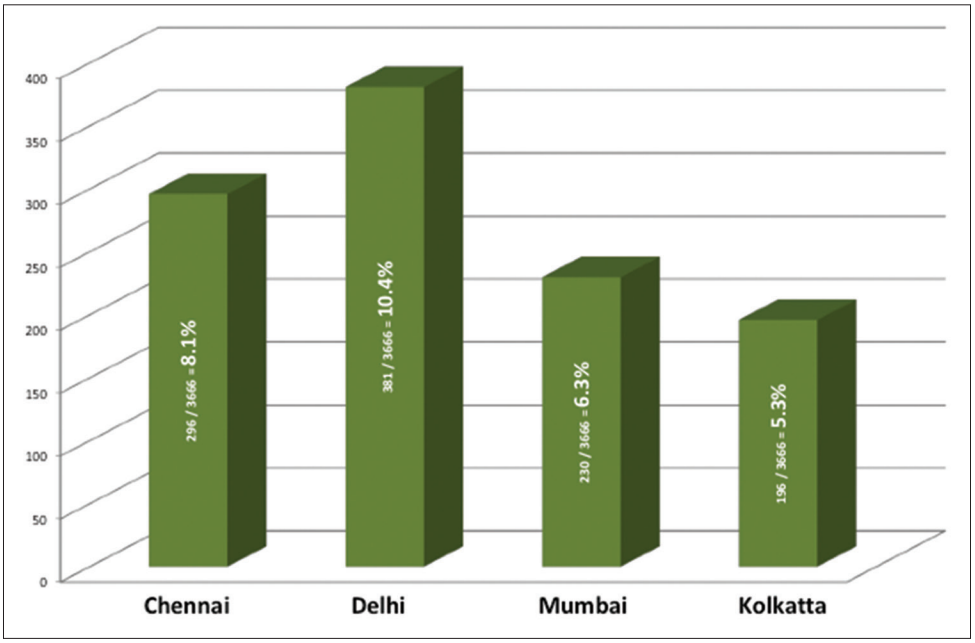

Figure 6: Distribution of NSI and IAN members in the major metropolitan cities

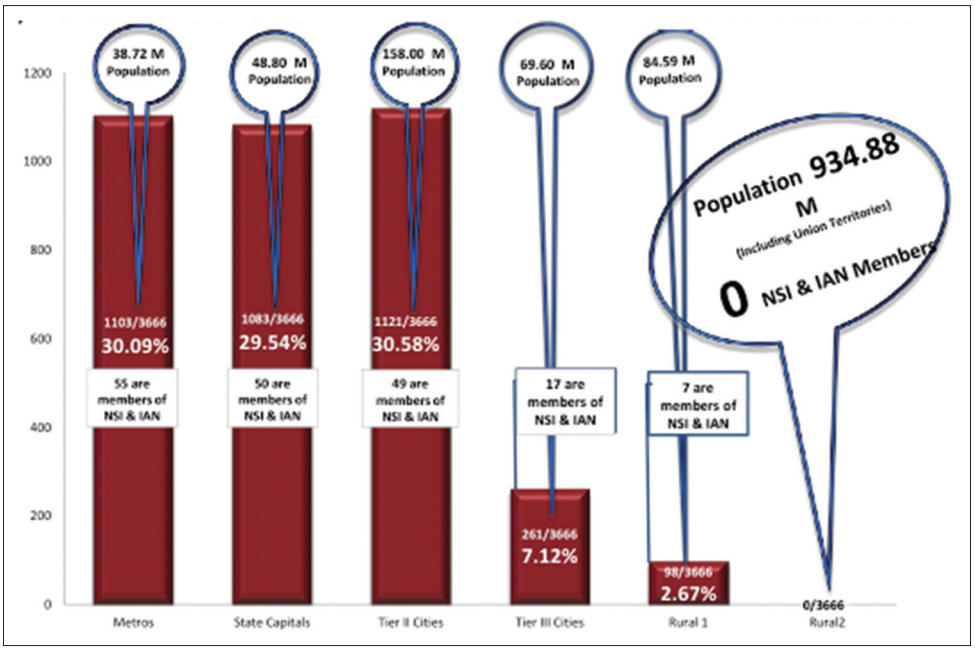

Figure 7: NSI and IAN member distribution

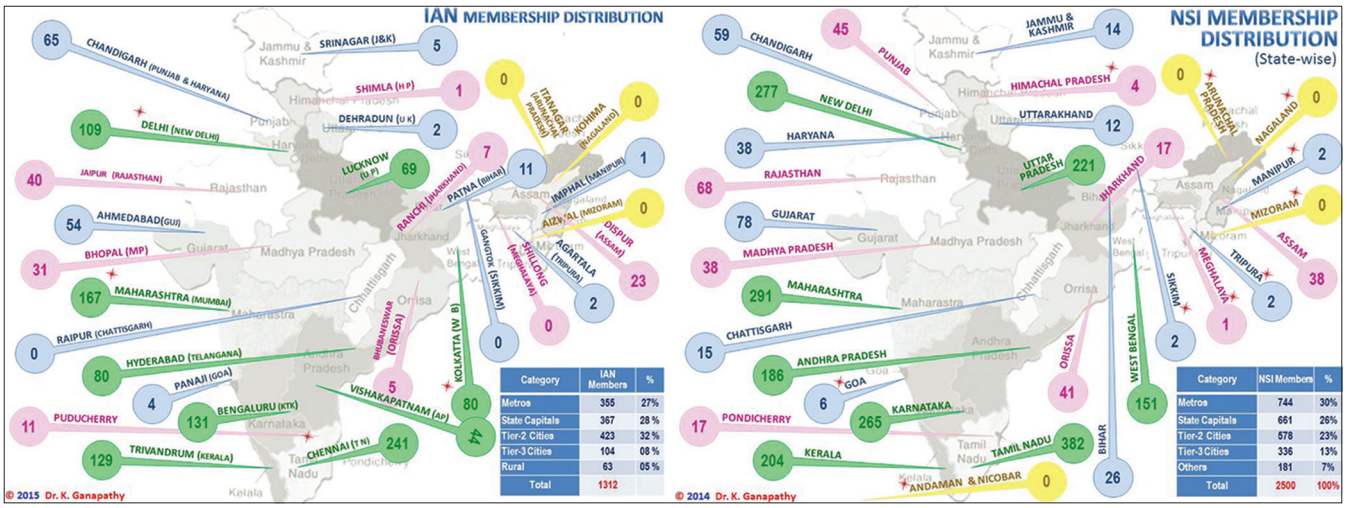

Figure 8: NSI IAN member distribution in the states of India

Table 1a: Distribution of IAN and NSI members in the major metropolitan cities

Metros	IAN	NSI	IAN and NSI	Pop. City
Chennai	119	177	296	47,92,949
Delhi	104	277	381	16,787,941
Mumbai	65	165	230	1,26,55,220
Kolkatta	67	129	196	4,486,679
Total	355	748	1103	3,87,22,789

neurological services. In a World Federation of Neurology survey[27] of 63/84 WHO member countries (excluding China), in 31/63 countries, most neurologists worked in large cities. One neurologist served 6,240 to 4,750,000 members of the population. Similar ratios were reported for psychiatrists and neurosurgeons. Ironically, developing countries with the highest burden of neurological disease are those with fewer neurologists, or none at all. In 45/63 (71%) countries, only a small proportion (0–25%) of neurologists worked full time in academic centers. 75–100% of neurologists worked in private practice in 17/63 countries. In 31/63 countries, most neurologists practiced in larger cities.[28] 88.6% of U.S. physicians practiced in urban areas catering to 80.8% of the 2004 U.S. population compared to 11.4% catering to 19.2% people living in rural America.[29] In 2008, there was one active neurosurgeon for 70,000 people[30] and 200 pediatric neurosurgeons in USA.[31] It is estimated that in 2025, there could be a gap of 64,800 speciality physicians and an equal number of primary physicians. In USA, the waiting time for the first appointment with a neurologist is at least 4 weeks.

Table 1b: Distribution of IAN and NSI members in the state capitals

State	IAN	NSI	IAN and NSI	Pop. City
Vishakapatnam (Andhra Pradesh)	19	25	44	1,730,320
Agartala (Tripura)	1	2	3	4,38,408
Aizawl (Mizoram)	0	0	0	6,00,467
Ahmedabad (Gujarat)	26	38	64	55,70,585
Bengaluru (Karnataka)	94	196	290	84,25,970
Bhopal (Madhya Pradesh)	4	13	17	23,68,145
Bhubaneshwar (Odisha)	2	17	19	8,37,737
Chandigarh (Haryana and Punjab)	32	59	91	10,54,686
Dehradun (Uttarakhand)	2	6	8	16,96,694
Dispur (Assam)	1	1	2	9,829
Gangtok (Sikkim)	0	2	2	98,658
Hyderabad (Telangana)	58	89	147	8,746,490
Imphal (Manipur)	1	2	3	2,64,986
Jaipur (Rajasthan)	20	34	54	33,55,070
Itanagar (Arunachal Pradesh)	0	0	0	35,022
Kohima (Nagaland)	0	0	0	2,67,988
Lucknow (Uttar Pradesh)	22	79	101	45,89,838
Panaji (Goa)	0	0	0	40,017
Patna (Bihar)	7	21	28	57,72,804
Puducherry (Puducherry)	11	17	28	675,000
Raipur (Chhattisgarh)	2	11	13	10,10,087
Shillong (Meghalaya)	0	1	1	1,43,007
Ranchi (Jharkhand)	3	13	16	1073440
Shimla (Himachal Pradesh)	1	3	4	169758
Srinagar (Jammu and Kashmir)	1	7	8	1192792
Trivandrum (Kerala)	60	80	140	752490
	367	716	1083	4,88,05,248

Table 1c: Distribution of IAN and NSI members in union territories, the overseas members, and the members whose addresses were insufficient for analysis

Others	IAN	NSI	IAN & NSI	Population
Union Territories:			0	
Port Blair (Andaman and Nicobar Islands)	0	0	0	379,944
Silvassa (Dadar and Nagar Havelli)	0	0	0	10,54,686
Daman (Daman and Diu)	0	0	0	242,911
Kavaratti (Lakshadweep)	0	0	0	64,429
			0	
Overseas Members	18	9	27	
			0	
Addresses of members insufficient for analysis	105	163	268	
Total	123	172	295	1,741,970

Interstate availability of neurologists varies from 2.6 per 100,000 in Nevada and Wyoming to 12.1 in Massachusetts. Many patients have to travel to academic centres, the travelling time to which may be hours away.[32] Only 15 of 72 medical colleges in Pakistan have a faculty in neurology. A neurologist does not teach most of the medical students. There are only 15 programs in 7 cities offering postgraduate training with 1 neurologist per 1 million people.[33] A report

Table 2: Details of distribution of IAN and NSI members in tier 2 cities

Tier II Cities	IAN	NSI	Pop. City
Agra (New Delhi)	2	16	4,418,797
Ajmer (Rajsathan)	1	2	2,584,913
Alappuzha (Kerala)	2	4	2,121,943
Allahabad (UP)	2	8	5,954,391
Amravati (Maharashtra)	1	0	646,801
Amreli	0	1	1,514,190
Amritsar (Punjab)	5	7	1,132,761
Ankleshwar (Gujarat)	0	1	140,839
Asansol (WB)	0	0	564,491
Aurangabad (Maharashtra)	4	9	3,701,282
Bagalkot (Karnataka)	0	2	112,068
Bakrol (Gujarat)	0	1	1017
Baroda (Gujarat)	3	5	1,666,703
Bellary (Karnataka)	2	1	2,532,383
Bhavnagar (Gujarat)	2	4	593,768
Bhiwandi (Maharashtra)	0	0	711,329
Bidar (Karnataka)	0	1	1,700,018
Bikaner (Rajasthan)	3	3	2,363,937
Calicut (Kerala)	10	9	3,086,293
Cochin (Kerala)	6	10	601,574
Coimbatore (TN)	18	32	3,458,045
Dhanbad (Jharkhand)	0	2	N/A
Dindigul (TN)	1	0	2,159,775
Ernakulam (Kerala)	2	6	3,282,388
Erode (TN)	5	5	2,251,744
Faridabad (Haryana)	1	5	1,809,733
Goa (Goa)	1	2	14,57,723
Gurgaon (Haryana)	2	9	1,514,432
Guwahati (Assam)	20	30	963,429
Gwalior (MP)	4	9	2,032,036
Hosur (Karnataka)	1	0	116,821
Howrah (WB)	2	5	4,850,029
Indore (MP)	11	26	3,276,697
Jabalpur (MP)	4	9	2,463,289
Jalgaon (Maharashtra)	2	4	4,229,917
Jammu (J and K)	3	6	12 ,55,000
Jamnagar (Gujarat)	1	2	529,308
Jamshedpur (Jharkhand)	1	2	629,659
Jhansi (UP)	1	3	1,998,603
Jodhpur (Rajasthan)	7	12	3687165
Kakinada (AP)	2	8	312255
Kannur (Kerala)	2	2	2523003
Kanpur (UP)	3	12	4581268
Kanyakumari (TN)	0	1	1870374
Kochi (Kerala)	10	22	601574
Kolhapur (Maharashtra)	4	6	3876001
Kollam (Kerala)	4	7	2635375
Kota (Rajasthan)	4	7	1,001,365
Kotayyam (Kerala)	8	0	1974551
Kurnool (Telangana)	4	2	4053463
Ludhiana (Punjab)	9	17	3498739
Madurai (TN)	25	46	3038252

Contd...

Table 2: Contd...

Tier II Cities	IAN	NSI	Pop. City
Malappuram (Kerala)	4	6	4112920
Mangalore (Karnataka)	5	14	484785
Manipal (Karnataka)	3	10	34,369
Meerut (UP)	2	10	3443689
Mohali (Punjab)	3	2	146104
Moradabad (P)	1	2	4772006
Mysore (Karnataka)	5	13	3001127
Nagpur (Maharashtra)	42	18	4653570
Nashik (Maharashtra)	6	5	6107187
Navi Mumbai (Maharashtra)	1	4	1119477
New Panvel (Maharashtra)	0	1	194999
Noida (UP)	7	18	642381
Palanpur (Gujarat)	0	1	127125
Panipat (Haryana)	0	1	1205437
Pathanamthitta (Kerala)	1	1	1,197,412
Pathankot (Punjab)	0	1	148,357
Patiala (Punjab)	4	2	1895686
Pune (Maharashtra)	29	45	3,115,431
Raichur (Karnataka)	1	2	1928812
Rajahmundry (AP)	1	5	343903
Rajkot (Gujarat)	5	8	3804558
Ranchi (Bihar)	2	0	N/A
Ratnagiri (Maharashtra)	0	1	76,239
Rohtak (Punjab)	2	5	1,061,204
Secunderabad (Telangana)	15	8	213,698
Shimoga (Karnataka)	2	2	1,752,753
Shirdi (Maharashtra)	0	1	36,004
Solapur (Maharashtra)	3	11	4,317,756
Surat (Gujarat)	4	10	4,462,002
Thane (Maharashtra)	0	9	1818872
Thanjavur (TN)	11	5	222619
Thrissur (Kerala)	8	15	3,121,200
Tirunelveli (TN)	7	3	3,077,233
Tirupathi (AP)	3	0	287035
Tiruvalla (Kerala)	2	1	52,883
Trichy (TN)	11	0	846915
Tripunithura (Kerala)	0	1	69,390
Tuticorin (Kerala)	2	2	410,760
Udaipur (Rajasthan)	4	8	451735
Udupi (Karnataka)	0	1	125350
Vadodara (Gujarat)	7	5	1666703
Vellore (TN)	13	54	185895
Villupuram (TN)	0	2	95,459
Warangal (Telangana)	2	2	620116
	423	698	154,495,099

Table 3: Distribution of IAN and NSI members in TIER III cities

Tier III Cities	IAN	NSI	Pop. City
Aligarh (UP)	1	3	3,673,849
Anand (Gujarat)	1	0	130,685
Bareilly (UP)	2	6	4,448,359
Belgaum (Karnataka)	9	3	488,292
Bilaspur (Maharashtra)	1	2	2,663,629
Bokaro (Bihar)	1	2	2,062,330
Bokaro Steel City (Jharkhand)	1	0	413,934
Cannanore (Kannur)(Kerala)	1	1	2,523,003
Cuddalore (TN)	1	1	2,605,914
Cuttack (Orissa)	2	16	606,007
Dibrugarh (Assam)	1	5	1326335
Durg-Bhilai Nagar (MP)	1	1	10,64,077
Ghaziabad (UP)	6	9	4681645
Gorakhpur (UP)	4	8	4440895
Gulbarga (Karnataka)	3	5	532031
Guntur (AP)	5	8	4,887,813
Hooghly (WB)	1	2	5519145
Hubli-Dharwad (Karnataka)	3	7	943857
Jalandhar (Punjab)	3	7	2193590
Kanchipuram (TN)	1	0	3998252
Karimnagar (Telangana)	1	2	3776269
Kumbhakonam (TN)	1	0	140113
Midnapor (WB)	1	0	169,127
Miraj (Maharashtra)	2	3	278,500
Nagarcoil (TN)	3	0	224329
Namakkal Dist.(TN)	5	4	1726601
Nellore (AP)	6	11	505258
Palakkad (Kerala)	1	2	2809934
Puddukottai (TN)	1	0	1618345
Ramanathapuram (TN)	1	1	1353445
Saharanpur (UP)	3	4	3466382
Salem (TN)	9	16	3482056
Sambalapur (Orissa)	1	0	1041099
Siliguri (WB)	2	6	509709
Tellicherry (Kerala)	2	0	92,558
Tezpur (Assam)	1	0	100477
Tiruchandur (TN)	1	0	308,892
Tripura (Agartala)	1	0	3,671,032
Varanasi (UP)	14	22	1201815
	104	157	69,603,226

in 2005, analyzing data from 50 of 53 African nations, revealed that 11 nations averaged 711,856 population per neurologist, five nations averaged 1,612,039, 23 nations averaged 5,099,908, and 12 nations with a total population of 25,939,273 *had no neurologists*.[34] A survey of 23 African countries revealed that only 5 had pediatric neurology groups with Malawi, Uganda, and Mozambique having only one specialist each. Neurologic diseases affect 7% of children worldwide, and in some areas every fifth child admitted had a neurological condition, particularly acute seizures.[35] This survey clearly indicates that there will always be a perennial lack of neurological specialists worldwide.

Tele-neurology: Introduction to the global scenario

Deploying telemedicine would therefore partly resolve the acute "man power" shortage. Patients often travel far, at a considerable expense, when local treatment would have sufficed with teleconsultation. Smartphone apps in neurosurgery are increasingly being used. Zaki in Dec 2013 reviewed 111 apps.[36] Most publications based on telemedicine

Table 4: Distribution of IAN and NSI Members in rural areas

Rural	IAN	NSI	Pop. City
Akola (Maharashtra)	2	1	400,520
Annur (TN)	1	0	20,079
Arakkonam (TN)	1	0	101,626
Balasore (AP)	1	0	N/A
Bambolim (Goa)	2	3	N/A
Bardhaman (WB)	3	0	7,717,563
Bayad (Gujarat)	1	0	1826
Beshampr (Gujarat)	1	0	N/A
Bhagal (Gujarat)	1	0	398138
Bhatinda (Punjab)	1	0	1,388,525
Bhilai (Bihar)	1	2	625,697
Bhimavaram (AP)	1	0	142,280
Bhiwani (Haryana)	1	0	1634445
Bijapur (Karnataka)	2	2	2,177,331
Chandimandir (Haryana)	1	0	9,051
Chandrapur (Maharashtra)	1	0	2,204,307
Changanacherry (Kerala)	1	0	127,971
Davangere (Karnataka)	1	2	1945497
Dist. 24 Paragnas (North) (WB)	1	0	10,082,852
Etawah (UP)	1	2	1581810
Guna (MP)	1	0	1,241,519
Hazaribag (Jharkhand)	1	0	1734495
Hisar (Delhi)	1	5	1743931
Jagtial (AP)	1	0	103962
Jaunpur (U)	1	2	4494204
Junagadh (Gujarat)	1	0	2743082
Kadapa (AP)	3	3	2882469
Kallakurichi (TN)	1	0	52,507
Karur (TN)	1	0	1064493
Kelanda (Trichur Dist.)(Kerala)	1	0	N/A
Khammam (Telangana)	1	1	2797370
Kovilpatti (TN)	1	0	95,057
Krishna Dist.(AP)	1	0	4517398
Madhubani (Bihar)	1	0	4487379
Mandya (Karnataka)	1	2	1805769
Masjid Moth (Delhi)	1	0	N/A
Mehsana (Gujarat)	1	0	2035064
Naihati (WB)	1	1	221762
Nanded (Maharashtra)	3	3	3361292
Narasaraopet (AP)	1	0	116329
New Ashok Nagar (New Delhi)	1	0	845071
Nileshwar (Kerala)	1	0	54,787
Palghat (Kerala)	1	0	2809934
Panchkula (Haryana)	1	4	561293
Pandalam (Kerala)	1	0	22635
Rewa (MP)	1	0	2365106
Sikar (Rajasthan)	1	1	2677333
Tarakeswar (WB)	1	0	30,947
Tikamgarh (MP)	1	0	1445166
Tirupur (TN)	1	0	2479052
Tiswadi (Goa)	1	0	177,219
Twiruthyad (Kerala)	1	0	N/A
Vidisha (MP)	1	1	1458875
West Midnapur (WB)	1	0	5913457
	63	35	81,007,821

in neuroradiology, neuro-ophthalmology, stroke, neurotrauma, epileptology, movement disorders and pediatric neurology have been in the last five years. The author, in the last 15 years, conducted clinical examinations remotely in 1400 neurological patients [Figures 1, 2 and 5]. Patients were seen at peripheral telemedicine centers and also at their homes. Commercially available video conferencing (VC) systems were used. Laboratory reports and Digital Imaging and Communications in Medicine (DICOM) compatible images were uploaded in customised software, enabling remote digital manipulation by the teleconsultant. Histology slides were electronically sent to the neuropathologist when necessary. For complex arteriovenous malformations (AVMs), the author (a radiosurgery specialist) has had virtual joint meetings with other specialists with the patient physically located in another state or country.

Today's VC systems are so sophisticated that the body language of several groups of people can be viewed simultaneously on a screen. Acquiring high-quality video and transferring it with minimal loss of data is crucial in the assessment of gait and movement disorders. However, even low-cost cameras and email/chat are sufficient for the management of many neurological disorders. An ophthalmoscope may be connected directly to a PC/laptop at the remote end and the fundus seen by a teleconsultant. Remotely elicited reflexes may be viewed by the specialist. All tele-neurological examinations can be recorded. Replaying the video enables one to study clinical signs in greater details.

Neurological teleconsultations benefit family physicians, ultimately avoiding unnecessary investigations and consultations. The internet is changing the relationship of neurologists with other professionals and is positively influencing the management of stroke, movement disorders and seizures. In a large telemedicine project in the USA, transfer of patients could be avoided in 83% cases, reducing the cost by 50%. Eventually, the standard of neurological care in suburban and rural areas will increase. Preliminary trials have revealed a high levels of satisfaction amongst all stakeholders using the telemedicine facility.

Tele-stroke

Neurologists are increasingly using telemedicine in emergency stroke care.[37–48] A web-based telestroke system facilitates rapid treatment of patients suffering from acute ischemic stroke in the rural emergency departments.[49] Tele-rehabilitation is now a reality.[50] Community stroke tele-rehabilitation programs have improved balance and physical functioning of patients. Long-term effects of specialized stroke care with telemedicine support in community hospitals have been evaluated.[51] One also has to consider the liability policies in deploying

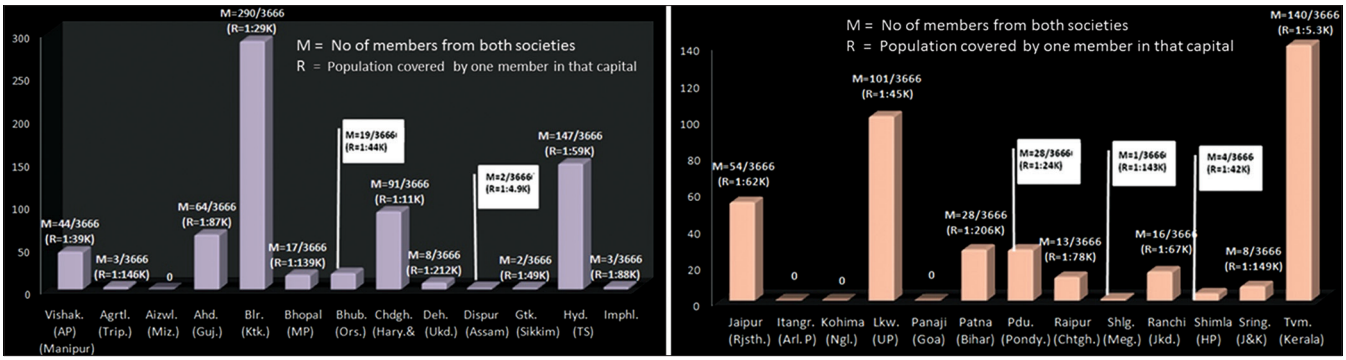

Figure 9: Distribution of neurologists and neurosurgeons in state capitals

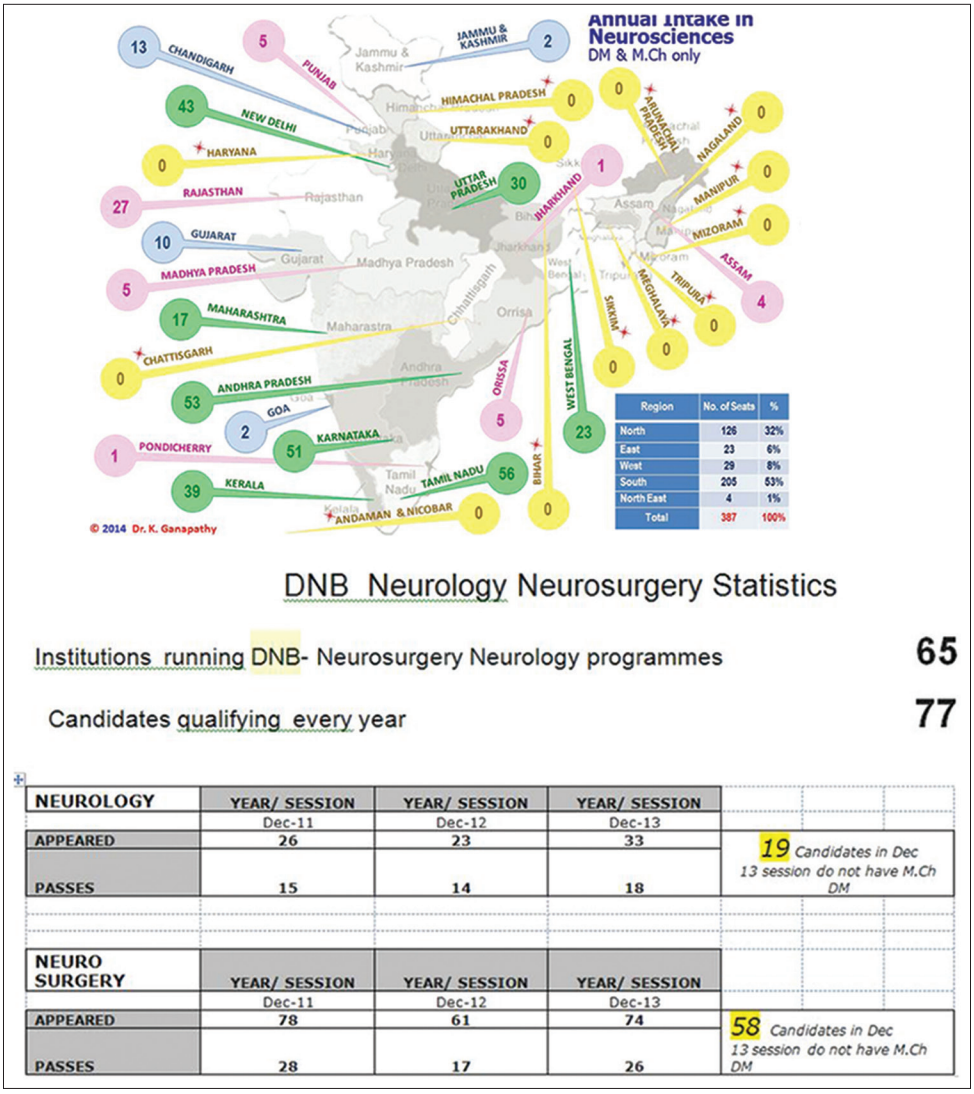

Figure 10: Annual PG Training in Neurology and Neurosurgery in India

telemedicine-based therapeutics, for example, the decision making regarding whether or not to administer thrombolysis for acute stroke is a prominent cause of malpractice claims.[52-54] More private insurers are starting to cover telemedicine based treatments including the management of tele-stroke. Twenty one states in the US and Washington, D.C. permit insurance coverage of the service and offer reimbursement on par with in-person visits. Necessity for access to high quality tele-stroke care has been emphasised.[55] The stroke expert at the hub hospital can interact with the patient and

Table 5: Details of neuro tele-consults at Apollo Hospitals Chennai

Year	Total consultations	Neurology	Neuro surgery	Paed neuro	Paed neuro surgery	Total	% of all consults
2005	1903	376	6	50		432	
2006	3225	640	45	98		783	
2007	3629	690	52	146		888	
2008	3968	628	83	254		965	
2009	3811	585	26	240		851	
2010	4513	551	20	285		856	
2011	4515	518	10	153		681	
2012	5615	570	33	375	3	981	
2013	5264	695	169	439	9	1312	
2014	5684	579	112	390	10	1091	
	42127					8840	21%

21% of teleconsultations at Apollo Hospitals, Chennai, are in Medical and Surgical Neurology (numbering 8840 till Oct 31st 2014)

the bedside physician, and swiftly, accurately and remotely perform the National Institutes of Health (NIH) Stroke Scale assessment and review images.[56] The cost-effectiveness of "hub-and-spoke" telestroke networks for the management of acute ischemic stroke has been documented.[57] 12% of acute care hospitals in Texas, by using telestroke care, covered an additional 2 million patient population.[58] Prehospital Utility of Rapid Stroke Evaluation Using In-Ambulance Telemedicine (PURSUIT) was a pilot feasibility study that used actors performing pre-scripted stroke scenarios of varying stroke severity to simulate live acute stroke assessments in the field and the ambulance. This served to check the reliability of using mobile telemedicine technology in the prehospital setting to help identify, triage, and evaluate acute ischemic stroke patients.[59] Studies have shown that a stroke center 'Vascular Neurology Nurse Practitioner' (VNNP) may administer an intravenous tissue plasminogen activator for stroke-in-evolution even if the patient is far away from a neurologist, provided telemedicine facilities are available.[60] VNNP in partnership with a vascular neurologist, could deliver timely telemedicine consultations, accurate diagnoses, and correct treatments in patients suffering from acute stroke, who presented to remotely located rural emergency departments within a 'hub and spoke' network.[61]

Advantages of deploying telemedicine in neurology

Seizures have been managed in rural communities[62,63] remotely with no difference in the frequency of consultation for repeated seizures, hospitalization or emergency room visits when compared to face-to-face management. Email triages by neurologists[64] of new referrals from general practitioners have reduced the physical visits by about half. In 2015, unfamiliarity with the use of email, video conferencing or non-availability of connectivity at the consultant's end are usually not the constraining issues. Occasionally, unfamiliarity of these techniques at the level of the patient/the peripheral hospital could be the factors that prevent the adequate use of this technology. The relative unwillingness of specialists to dispense with a face-to-face consultation is an important limiting factor. The belief that hands-on neurological examination is essential is more often a belief rather than a fact based on actual evidence. The author has carried out even a detailed sensory examination remotely, with the patient himself/herself touching different dermatomes. The medico legal implications (that are in fact virtually non-existent) are another concern. The American Telemedicine Association has listed the names of states that allow out-of-state teleconsults.[65] Globalization and outsourcing are now in the neurologist's telemedicine vocabulary.[66] Wound infections were monitored via cell phone images in a pediatric neurosurgery teleconsulting centre.[67]

International teleneuroradiology services

In 1998, a teleradiology system was established in Croatia connecting 34 computed tomograms (CT), magnetic resonance imaging (MRI) and digital subtraction angiogram (DSA) scanners in 29 hospitals to a referral neurosurgery center in Zagreb. In the first three years, the network saved 400,000 km of patient transportation (i.e., without a teleconsultation, all the patients included in this study would have had to be transported this overall distance).[68] In 1997, the national neurosurgical teleradiology system in Ireland connected six major referring hospitals to the only two neurosurgical departments serving a population of 3.5 million.[69] Of the 750 emergency CT scans transmitted, transmission failures occurred in 6% cases. As CT and MRI scanners were not DICOM compatible, the films were scanned and sent for teleconsultation. Poon[70] from Hong Kong has discussed the possibility of teleradiology improving inter-hospital management of head-injury. Apollo Telehealth Services, Telerad Solutions and other health consortiums now provide teleneuroradiology services in India.

Neuro-traumatology

Telemedicine is particularly useful in neurotrauma by helping in the institution of therapeutic measures *before* the transfer

of patients, and, in reducing their unnecessary transfers. Successful use of telemedicine in the remote management of head trauma in India has been reported.[71] The author, in the last 15 years, remotely evaluated 335 patients with head trauma. Several serious head injuries were successfully managed. Tele-discussions of treatment options were conducted when transfer was recommended. Tele-consultation was used for the subsequent follow-up of these patients. A general surgeon, tele-mentored by the author remotely, operated upon three cases of compound depressed skull fractures. Interestingly, there was a subsequent drop in neurosurgical tele-referrals from telemedicine-enabled centers. The doctor at these remote center had acquired the confidence to manage most cases of simple head trauma without the need for further tele-consulting.

Telemedicine in neurosciences in India

Clinical telemedicine was formally initiated in South Asia when the world's first Very Small Aperture Terminal (VSAT; a two-way satellite ground station with a small dish antenna) was commissioned on March 24th 2000 by the then US President Bill Clinton in a village hospital at Aragonda in Andhra Pradesh. A tele-neurological demonstration in February 2002 by the author convinced the then chairman of ISRO (Indian Space Research Organisation) to set up VSAT's in super speciality and peripheral hospitals. Published reports of the formal usage of telemedicine in neurosciences are few.[72-79] Of the 400 virtual grand rounds carried out between the various tertiary Apollo Hospitals, using multi-point video conferencing, 95 were in neurosciences. 21% of teleconsultations (8840 out of 42,127) at Apollo Hospitals, Chennai, till Oct 31st 2014 were in neurology and neurosurgery [Table 5]. Two hundred of the 2500 CME lectures delivered for doctors in 45 countries under the Government of India Pan African e-Network project have been in neurosciences [Figure 3].[80] Misra has pointed out that the use of telemedicine in the treatment of status epilepticus and stroke have a high potential for improving patient management.[81] The impact of telemedicine in the postoperative care of 3000 neurosurgery patients in a virtual Outpatient Clinic has been reported from Bengaluru.[82] Awareness of the value of telemedicine in neurosciences in India is slowly increasing.[83] More than 500 tele-consultations were given in neurosciences from the year 2000 to 2002 from Aragonda. Video clippings are available of pseudo-seizures, involuntary movements, Parkinsonism, myopathy, etc., In all these cases, the teleconsultant was able to carry out a neurological examination that was in sufficient details to assist the local doctor. The quality of CT images received were adequate to give an expert opinion.

Patient empowerment in rural India: Relevance to neurosciences

Promoting health literacy is critical in improving health outcomes. By deploying multi-point video-conferencing, the author has initiated a knowledge empowerment programme at the internet enabled Village Resource Centers of the MS Swaminathan Research Foundation in rural Tamilnadu.[84,85] Over a 19 month period, consultants spoke on forty-four topics and interacted with 9800 villagers in 18 villages. The lectures were based on different topics including "Recognising the dangerous headache," "Management of head injuries," "Management of brain tumours," etc., Many neurological conditions are eminently preventable and e-Lectures by specialists go a long way in providing necessary awareness quickly and cost effectively.

The information and communication technology scenario in India

In an interview with the Wharton School of Business[86] and at other forums,[87-89] the author has argued that deployment of ICT alone will make available, secondary and tertiary health care to suburban and rural India. Rural tele-density is currently estimated at 65%. The Ministry of Health, Government of India has linked 150 government medical colleges through a high-speed optical fibre National Medical College Network (NMCN). A bandwidth of up to 1 Gigabyte per second is available.[90-91] Super-specialists will thus be virtually available in smaller medical colleges. The health implications as a result of the rise of internet usage in India have been documented. As rural India will soon be *internet ready*, a mandatory "Virtual Rural Postings" has been advocated for doctors. Urban doctors would thus gain an insight into the problems occurring in rural areas. Incentives and disincentives have to be introduced. The implications of proper implementation of this project for the delivery of neurosciences to the remotest corners of India would be considerable.

Conclusion

Neurologists and neurosurgeons need to embrace telemedicine to extend their reach to their patients. Deployment of ICT can make neurological services available in regions where proper medical facilities do not exist. Our services should be universally available to anyone, anytime and anywhere.

Acknowledgment

I am grateful to Ms. R Geethanjali Asst Manager ATNF for her role as a Research Assistant and for her secretarial help in compiling this article. The then Secretary NSI, Dr RC Mishra, the Secretary IAN, Dr Gagandeep Singh, and Dr Bipin Batra, Executive Director NBE provided raw data for the analysis.

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How to cite this article: Ganapathy K. Distribution of neurologists and neurosurgeons in India and its relevance to the adoption of telemedicine. Neurol India 2015;63:142-54.

Source of Support: Nil, **Conflict of Interest:** None declared.