A systematic review of telemedicine projects in Colombia

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Summary

A systematic review of telemedicine projects in Colombia was conducted. We searched electronic databases, and also searched for relevant Internet websites. Each project manager was contacted by telephone to identify projects which had not actually been carried out. They were interviewed to request information about the projects they were managing, and whether they knew of other projects in Colombia. The search process identified 43 different projects, which were classified into two groups: telemedicine research initiatives and projects for providing health-care services via telemedicine. There were 32 projects which provided telemedicine services, of which 14 had been finished, 11 remained active, 4 were being implemented and no data were available about the state of the other 3. Health-care services had been provided using telemedicine to at least 550,000 patients. The projects had connected more than 650 health-care institutions, mainly in deprived areas of the country. Unfortunately, although many projects seem to have had a positive effect, none of them had been rigorously evaluated, and therefore in the absence of scientific evidence no general recommendations can be made. However, the methodology of the present study appears suitable for similar reviews of telemedicine in other developing countries.

Introduction

Telemedicine projects in Colombia were reviewed in studies conducted in 2001[1] and in 2003.[2] However, these previous compilations were not systematic reviews, and projects were listed without further analysis. We have therefore updated the previous work. The aim was to identify all the projects carried out in Colombia which provided services via telemedicine. This information may be helpful in future telemedicine work in developing countries.

Methods

The search strategy of the systematic review comprised four steps. In Step 1, relevant articles were identified from the following databases: MEDLINE, LILACS, Cochrane Library, Current Contents, CINAHL, CUIDEN, Telemedicine Information Exchange (TIE) and IEEExplore. Given the lack of articles from developing countries in indexed publications,[3] other documents were examined, such as references within retrieved articles, and other databases, such as the Centre for Reviews and Dissemination (CRD), the Scientific Electronic Library Online (Scielo), the Royal College of General Practitioners (RCGP), the Association of Telehealth Service Providers (ATSP), the American Telemedicine Association (ATA) and the International Society for Telemedicine (ISFT). The keywords used, in English and Spanish, were Colombia and Colombian and each of the following words: telemedicine, telehealth, ehealth and e-health. When a project was found, it was added to the list, together with the contact information of the project manager, or of an alternate person if the project manager could not be identified.

In Step 2, Internet search engines were used to retrieve more projects. The search engine Google was used with the keyword combination, and its translation into Spanish, shown in Table 1. When using any combination, the following basic rules were followed:

(1) For each combination of keywords, the first 10 hits were examined. When following the links, no more than four levels of navigation were considered;
(2) When a project was found, it was added to the list together with its contact information. In addition, two new keywords were added to the list, the first one

Accepted 28 December 2009
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 DOI: 10.1258/jtt.2009.090709

Table 1 Keywords used for the web search

1.	'Telemedicine in Colombia'
2.	'Telemedicine project' Colombia site:.org OR site:.co
3.	'Telemedicine project' Colombia
4.	Telemedicine project Colombia site:.org OR site:.co
5.	Telemedicine project Colombia
6.	'Telemedicine congress' Colombia
7.	Telemedicine congress Colombia site:.org OR site:.co
8.	Telemedicine congress Colombia
9.	'Health office' telemedicine Colombia site:.co OR site:.gob
10.	Medicine office OR health telemedicine Colombia site:.co OR site:.gob
11.	'Health office' telemedicine Colombia
12.	'Health office' Colombia
13.	'Faculty of medicine' telemedicine Colombia
14.	University OR faculty telemedicine Colombia site:.org OR site:.co
15.	University OR faculty telemedicine Colombia

containing the current combination but filtering the name of the project found, using the option '-' (in Google, to exclude pages where the current project was present in order to broaden the scope of our search) and the second one composed by the name of the project and Colombia (for acquiring specific information of each project prior to the interview);

(3) If after one search, less than 10 pages were retrieved and it was impossible to retrieve any new telemedicine project from them, then the next combination was used.

In Step 3, each project manager was contacted by telephone to identify and discard projects which had not actually been carried out. In a second contact, an interview was undertaken to request information about:

(1) The active projects that he or she was managing, including any available evaluations;
(2) Other telemedicine projects in the country;
(3) Telemedicine experts in Colombia.

If new projects were identified, Step 2(2) was conducted again.

In Step 4, an expert identified by the interviewees was contacted for confirmation about each project. An expert was somebody who was mentioned more times in Step 3(3). If new projects were identified through the expert, then Step 2 was conducted again.

In order to classify the projects, a previously published method[4] was adapted. The information retrieved from projects was classified according to feasibility and impact indicators[5] (see Table 2). The level of evidence for each indicator was rated according to the nine-level categorization[6] shown in Table 3, and recommendations were made by using previously suggested[7] criteria. That is, for levels 1 to 3, high scientific evidence for recommendation existed; for levels 4 to 7, sufficient evidence for recommendation existed; and for levels 8 or 9, the evidence was insufficient.

Table 2 Evaluated feasibility and impact indicators

Indicators	Label	Description
Feasibility		
Technical	I1	Effectiveness. Effectiveness indicates whether the technical features of a telemedicine system were sufficient to provide the health service they were designed for.
	I2	Reliability. Reliability refers to robustness and security. Robustness refers to the rate of system breakdown; while security refers to the avoidance of undesired side effects caused by the use of a telemedicine system, such as protection against data loss.
	I3	Ease of use. This refers to the simplicity of handling the telemedicine system and its adaptation to the daily work of the institutions where it has been deployed.
Institutional	I4	Acceptance. Acceptance is based on evidence from patients, health workers and health authorities about their satisfaction with the introduction of the telemedicine system.
Economic	I5	Sustainability. This concerns the financial evidence that a telemedicine system can be maintained by the health institution concerned.
Impact		
Clinical process	I6	Improvement in diagnosis capacity. This indicator is intended to measure whether a relationship exists between using a telemedicine system and improving the quality of diagnosis.
	I7	Changes in organization. This assesses whether a new system always brings changes in the way an institution is organized.
Patient health	I8	Utility. This refers to changes in the patient's mental and emotional welfare, i.e. anything which means an improvement of the patient's quality of life.
Accessibility	I9	Perception of isolation. This considers any reduction in the feeling of isolation experienced by patients and health-care workers.
	I10	Access to health care. This considers data showing that new disciplines have been extended to remote areas or the protocol for emergencies has been improved.
Economic	I11	Economic impact locally. This refers to the cost-benefit analysis of telemedicine.
	I12	Economic impact nationally. This takes into account studies or data referring to the economic impact of improving coverage through telemedicine at a national level.

Results

The search process identified 45 different projects. In Step 1, 20 scientific papers were obtained. After reading them, 15 telemedicine projects were identified. Information about Colombian legislation on telemedicine services was also obtained.[8,9]

Step 2 provided information about 16 additional projects, and also provided contact information for the ones that had already been identified. Step 3 allowed us to identify 13 more projects, and to discard two (ARCAL 007[10] and Ecopetrol[1,2]), because they were never carried out. Finally, in Step 4, a list of 42 projects was provided to an expert (an officer from the Communication Office), who confirmed each one and also added a new one, namely the telemedicine activities carried out by ITMS.[11,12]

The 43 resulting projects were classified into two groups: telemedicine research initiatives and projects for providing health-care services via telemedicine. The first group included research projects involving the development of

Table 3 Classification of findings

Level of evidence	Strength of evidence	Study design
I	Very good	Meta-analysis
II	Very good	Large sample randomized controlled trials
III	Good	Small sample randomized controlled trials
IV	Good	Non-randomized controlled prospective studies (multicentre)
V	Fair	Non-randomized controlled prospective studies
VI	Fair	Cohort studies
VII	Fair	Case-control studies
VIII	Poor	Non-controlled clinical series, descriptive studies
IX	Poor	Anecdotes or case reports

hardware and software (such as signal and image processing, telesurgery systems and telemonitoring equipment) for telemedicine projects, which had not yet been validated in patients. The second group consisted of projects in which patients had been managed via telemedicine. A third category was the project from the Colombian Association for Medicine, Informatics and Telehealth,[13] which aimed to create a forum where all those involved in telemedicine development in Colombia could exchange ideas and progress.

Telemedicine research projects

The search algorithm provided information about 10 research projects. Strictly speaking, they were not projects, but research groups devoted to specific telemedicine activities. Therefore, they were not considered in the subsequent analysis. The 10 research groups were:

(1) The Telemedicine Centre from Universidad Nacional de Colombia (UNC). The UNC began its work in 1996 with Teleamazon,[14] a research project to identify those processes within the public health-care system in the Amazonas Department that could be improved using telemedicine;
(2) The R & D in New Telecommunication Technologies Group from Universidad del Cauca. In 1999, this group carried out a project that laid the foundations for other telemedicine projects in the university;[15]
(3) The Bioengineering Group from UNC. This group mainly conducts research in medical image processing, such as image compression and pattern recognition;[16–18]
(4) The Bioengineering Research Group (Grupo de Investigación en Bioingeniería – GIB) from Universidad EAFIT.[19] This group worked on a project for interchanging medical images using the national academic broadband network (Renata);
(5) The Colombian Telemedicine Centre (CTC). The CTC conducts research jointly with Universidad Javeriana, mainly related to the development of a virtual platform for educational purposes in surgery;[20–28]
(6) The Clinical Engineering Research Group of the Hospital Universitario La Samaritana. This group carried out a project for adapting the PACS and HIS of different Colombian hospitals;[10]
(7) The Biomedical Engineering Group (Grupo de Investigación Biomédica-GIB) from the Universidad de los Andes.[29] This group worked with Fundación Santa Fe de Bogotá (FSFB) to propose a methodology for evaluating procedures for digitizing radiology images, and researching on hospital information systems;
(8) The FSFB[30] conducted research on cost-effective methods for teleconsulting regarding suicide risk and sexually transmitted diseases in schools of Bogota;
(9) The Perception and Intelligent Systems Research Group from the Universidad del Valle. This group developed a system to handle second opinions and digital images through the Internet;[31]
(10) The Telehealth Research Group from the Universidad de Caldas. This group compared the efficiency of two methods for teaching the management of childhood illnesses, the conventional one and a virtual course designed by them.[32]

Projects for providing health-care services via telemedicine

A total of 32 projects which provided telemedicine services were identified. Out of them, 14 had been finished, 11 remained active, 4 were being implemented and no data were available about the state of the other 3 (see Table 4). Projects were ordered by their current state, and within each group they were ordered chronologically (the most recent first). Table 4 shows whether the indicators of Table 2 had been evaluated in each project, and reflects the level of evidence achieved for each of them (in relation to Table 3). Information about medical speciality and telemedicine services provided, patients attended and health-care centres connected, was also included; for further information see Rey-Moreno.[10]

A common feature of all the projects was the lack of studies assessing their performance and their real impact. Most of the entries in Table 4 show insufficient level of scientific evidence, because they came from descriptive articles (e.g. P8,[33] P15 or P16[34]) or from anecdotes that were mentioned in the interviews. The only two studies reporting sufficient evidence for recommendation consisted of a comparison of technical effectiveness (I1) between tele-ECG devices (developed by institutions 3 and 18, respectively) and traditional ECG. They were carried out in P4[12] and P30,[13] and both concluded that their devices had the same diagnostic accuracy as the conventional comparators. Some private companies, such as institutions 2, 4 and 18 (see Table 4), mentioned that they had conducted cost-benefit evaluations of their services, but the analyses could not be published for reasons of commercial confidentiality.

Table 4 Characteristics of selected studies and evaluated indicators

Project	Evaluation indicator 1	2	3	4	5	6	7	8	9	10	11	12	Institution	Date begun	Date completed*	Specialty	Telemedicine service(s)	No. of patients	No. of centres
P1 Basic services[35,36]								IX		IX			1	2008	Act	C, N, IM, P, G, U, O, D, I, OR	TC	3026	58
P2 Intermediate services[35,36]								IX		IX				2008	Act	GM	TM, TEI	245	11
P3 Medical management[37]		IX		IX			IX	IX					2	2007	Act	ND	TA	ND	2
P4 ITMS-Colombia[11,12]	VI			IX			IX						3	2007	Act	C, PN	TC,TM	30000	135
P5 Doctor Chat[38]				IX				IX		IX			4	2006	Act	GM	TEI	1200	1
P6 Leticia Clinic[39]			IX					IX		IX			5	2005	Act	C, IM, U, O, P, D, R, PA, H	TC	2082	1
P7 Teledermatology[40]			IX	IX	IX			IX		IX			6	2002	Act	D	TC	2727	25
P8 EHAS-Colombia[33]			VIII	VIII		VIII	VIII		VIII	VIII	IX	IX	7	2002	Act	GM	TC, TE, TA, O	ND	31
P9 Telemedicine Salud Coop[41]				IX			IX			IX			8	2002	Act	P, G, GA, C, N, ON, OR, E, PN	TC	21581	22
P10 Teleradiology[1]													6	ND	Act	R	TC	150	25
P11 Virtual clinics[30]													4	ND	Act	GM	TE, TEI	ND	3
P12 Teledermatology[30]				IX									4	2007	2008	D	TC	ND	29
P13 San José del Guaviare (now P1 and P2)[35]				IX				IX		IX		IX	5	2007	2008	C, IM, G, U, O, D, I, R, H	TC	3575	1
P14 Ríohacha[35]										IX				2007	2008	D, R, I	TC	1815	1
P15 T@lemed Guaviare (seed of P10 13 and P11)[42,34]	IX	IX	IX			IX		IX		IX	IX	IX		2005	2007	R, D, G, I	TC	1720	2
P16 T@lemed Costa Pacifica[42,34]	IX				IX	IX				IX			9	2005	2006	I	TC	439	3
P17 Teleradiology Medellín[43]	IX												10	2004	2005	R	TC	ND	2
P18 ReTaS[44]		IX		IX									7	2003	2004	I	TC, TEI	ND	8
P19 Bogóta-San Andrés-Providencia[1,2]										IX	IX		5	2000	2006	O, R, C, G, D	TC	ND	2
P20 Bogóta-Apaporis-Leticia[1,2]				IX						IX	IX			2000	2003	O, R, C, G, D	TC	ND	2
P21 Telematics Network[10]										IX			7	2000	2001	ND	TA	ND	1
P22 Teleradiology - VTG[1]													11	1999	2002	R	TC	300000	29
P23 Teleradiology-ISS[45]			IX								VIII			1997	1999	R	TC	173125	10
P24 Cundinamarca Telemedicine Network[10]				IX		IX	IX				IX		12	1995	1996	R	TC	2754	5
P25 Cardiac Telemetric Network[1]				IX		IX							13	1994	2002	C	TC	ND	113
P26 Telemap[10]													14	2008	Imp	P, OR, C	TC, TE, TM, TEI	DNA	DNA
P27 Health Management[46]													15	2008	Imp	ND	TA	DNA	DNA
P28 Rehab Land Mines Victims[47,48]													16	2004	Imp	PS, OR	TC, TM, TEI, O	DNA	DNA
P29 Antioquía Telemedicine Network Red de telemedicina de Antioquía[49]	IX												17	2000	Imp	GM	TC	DNA	DNA
P30 Galaxia Program[13,50]	VII									IX			18	2004	ND	C,R	TC	ND	50
P31 Telemedicine FCV[36]										IX				ND	ND	C, R	TC, TM	ND	103
P32 Dr Díaz[51]													19	ND	ND	C, IM, G, O, N, R	TE, TC	ND	ND

Institutions: Pu (public); Pr (private), (1) Caprecom (Pu); (2) Esoft Ltd (Pr), (3) ITMS-Colombia (Pr), (4) Fundación Santa Fe de Bogotá (Pr), (5) Telemedicine Centre-Universidad Nacional de Colombia (Pu), (6) Telehealth Research Group(GIT)-Universidad de Caldas (Pu), (7) Universidad del Cauca (Pu), (8) SaludCoop (Pr), (9) Universidad de Cali (Pr), (10) Bioengineering Research Group (GIB)-Universidad EAFIT (Pr), (11) Vision Technology Group (Pr), (12) Hospital Universitario La Samaritana (Pr), (13) Cardiobip Ltd (Pr), (14) Medicine Faculty-Universidad de Antioquía (Pu), (15) Telemedicine Research Group (GITEM)- Universidad Francisco José de Caldas (Pu), (16) Colombian Telemedicine Centre (Pr), (17) Interdisciplinary Telemedicine Team (EIT) - Universidad Pontificia Bolivariana (Pr), (18) Fundación CardioVascular de Colombia (Pr), (19) Dr. Díaz (Pr)

*Status; Act = Active, Imp = Implementation

Medical specialties: C (cardiology); R (radiology); D (dermatology), N (neurology), PS (psychiatry), G (gynaecology); PN (respiratory); U (urology); O (otorhinolaringology); EN (endocrinology); OR (orthopaedics); ON (oncology); GA (gastroenterology); IM (internal medicine); P (paediatrics); GM (general medicine), I (infectious diseases); PA: pathology and H: haematology

Telemedicine services: TC: teleconsultation between medical staff; TM: telemonitoring of vital signs of patients with chronic diseases (at home or in hospital); TEI: tele-education in health for people/patients; TE: tele-education (remote training, support to medical students/health-care staff, continuing education); TA: teleadministration (remote administration process as citation management); O: other telemedicine services (e.g. epidemiology surveillance)

Others: ND: No data; DNA: Did not apply

The most commonly assessed indicator was I10 (16 projects), showing that many projects in Colombia aimed at improving accessibility to health care for people in deprived areas. Also I8 and I4 had been considered often. Eight projects showed the reduction produced by telemedicine in the time a patient has to wait, and 12 projects showed that telemedicine services are well accepted, although some telemedicine projects (P3, P9) were not accepted initially. It is important to note that despite P18 and P24 reporting initial institutional acceptance, the projects stopped working once they were transferred to the respective health-care institutions.

Very few studies (5 projects) had analysed the improvement in diagnostic capacity (I6) from telemedicine. In P8, an evaluation showed that the availability of second opinions avoided six urgent admissions a year in each health centre. In P15, the manager stated that by using the teleconsultation system, 170 hospital admissions were avoided during 12 months of operation. The isolated conditions of the hospital produced savings of more than US $300,000 per year for the state administration. On the other hand, in P16, thousands of dollars were invested and only 0.7% of the diagnoses were changed.

There was a lack of data assessing the effect of telemedicine on the rest of the indicators, and very few conclusions could be drawn. It is remarkable, for instance, that a poor initial evaluation of the existing technologies had led to P29 remaining in the implementation phase for eight years. In other cases, unforeseen circumstances ruined some projects, such as P22 and P25, which were affected by the economic crisis that struck Colombia at the end of the 1990s.

Institutions providing telemedicine services in Colombia were mostly private. However, public institutions, such as the Colombian government, were also involved in some, for example P1 and P2, which were financed by the Health Office and entrusted to institution 5, 6 and 18 (see Table 4). These projects aimed to improve access to health care.

There was a wide variety of services provided by the projects, ranging from those typical in industrialised countries, such as telecardiology or teleradiology, to those specific to developing regions, such as telemicroscopy for malaria or tuberculosis. Most of the services of telecardiology, teledermatology or teleradiology were provided by teleconsultation using software developed by each institution. In addition, some services, such as those for respiratory medicine in P4, had developed their own hardware.

Discussion

The present systematic review of telemedicine projects in Colombia allowed us to update and extend earlier studies with new information, hence increasing the number of identified projects from 8 to 45. The search strategy was efficient and it served to find almost all the telemedicine projects developed in Colombia up to May 2008. Under Colombian legislation, it is compulsory to report to the government on the start-up of projects which aim at managing patients through telemedicine, and the expert who was selected in the search strategy was the civil servant responsible for the management of those reports. Therefore, we can consider that the results of the search strategy were validated at least for the second group of projects. Thus, the proposed search strategy may be useful for future systematic reviews of telemedicine projects in countries where information is not easily accessible.

The systematic review shows that many institutions in Colombia, both private and public, are involved in the development of telemedicine through several projects. Across these projects, telemedicine services have been provided to at least 550,000 patients, and the projects have connected more than 650 health-care institutions, mainly in deprived areas of the country. Unfortunately, although many projects seem to have had a positive effect, none of them have been rigorously evaluated, and therefore in the absence of scientific evidence no general recommendations can be made. In future, therefore, it would be advisable that financing agencies consider funding only projects which include a well-designed plan for evaluating their feasibility and impact.

Acknowledgements: This work was partially supported by grant TEC2007-68096-C02 from the Spanish Government.

References

1 Organismo Andino de Salud. Aplicaciones de telecomunicaciones en salud en la subregión andina: Telemedicina. See http://www.comunidadandina.org/telec/Documentos/Telecomunicaciones_salud.pdf (last checked 7 September 2009)
2 Urtubey X, Prieto E, Hope H, Rodrigues R, Van West-Charles R. *Telehealth in the Americas*. Washington DC: Inter-American Telecommunication Commission, Organization of American States, 2004
3 Moser PL, Hauffe H, Lorenz IH, *et al*. Publication output in telemedicine during the period January 1964 to July 2003. *J Telemed Telecare* 2004;**10**:72–7
4 Martínez A, Everss E, Rojo-Alvarez JL, Figal DP, García-Alberola A. A systematic review of the literature on home monitoring for patients with heart failure. *J Telemed Telecare* 2006;**12**:234–41
5 Martınez A, Rodrigues RJ, Infante A, Campillo C, Gattini C. *Bases Metodológicas Para Evaluar la Viabilidad y el Impacto de Proyectos de Telemedicina*. [Methodological Bases for Evaluating Viability and Impact of Telemedicine Projects] Washington DC: Pan American Health Organization, 2001 [Spanish]
6 Jovell AJ, Navarro-Rubio MD. Evaluation of scientific evidence. *Med Clin (Barc)* 1995;**105**:740–3 [Spanish]
7 Jovell AJ, Navarro-Rubio MD, Aymerich M, Serra-Prat M. Methodology for the design and development of clinical practice guidelines in primary care. *Aten Primaria* 1997;**20**:259–62, 264–6 [Spanish]
8 Matiz Camacho H. The future of medicine with equity in Colombia: Telemedicine. *Revista Colombiana de Cardiología* 2007;**14**:1–8
9 Ministerio de la Protección Social. Resolución 2182. [Social Protection Ministry, Resolution 2182] *Diario Oficial* 2004;**45611**:1–13 Colombia [Spanish]
10 Rey-Moreno C. *A Systematic Review of Telemedicine Projects in Colombia*. Master Thesis Dissertation, Aalborg University, Denmark, 2008
11 ITMS. See http://www.itms.cl (last checked 7 September 2009)
12 Escobar E, Adriazola P, Castro P, *et al*. Tele-electrografía experiencia preliminar. In: Congreso Chileno de Medicina Interna, 2003 [Spanish]

13 Miserque NIC, Camacho P, Arenas W, Quiroz R, Rueda J. Estudio Símil ECG: Estudio de Concordancia entre la Electrocardiografía Convencional y la Electrocardiografía Digital utilizando Internet y la Web como medio de transmisión en Telemedicina. [Study on concordance between traditional and digital electrocardiography using Internet and the Web as a mean for Telemedicine transmission] *Revistaesalud.com* 2006;**2**(7) [Spanish]
14 Campos J. Proyecto andino-europeo de telemedicina para la amazonía. [Andean-european telemedicine project for Amazonia] *Revista de Salud Pública* 2001;**3**:182–6 [Spanish]
15 Castillo E, Solarte V. Programa de investigación y desarrollo en redes de acceso universal para la teleeducación y la telemedicina. [Research and development program in universal access network for tele-education and telemedicine] *Telecomunicaciones & Sociedad* 2004;**2**:28–40 [Spanish]
16 Caicedo JC, González FA, Romero E. Content-based medical image retrieval using low-level visual features and modality identification. *Lecture Notes in Computer Science* 2008;**5152**:615–22
17 Caicedo JC, González FA, Romero E. A semantic content based retrieval method for histopathology images. *Informational Retreival Technology* 2008;**4993**:51–60
18 Caicedo JC, González FA, Triana E, Romero E. Design of a medical image database with content-based retrieval capabilities. In: Mery D, Rueda L. *Advances in Image and Video Technology.* Berlin: Springer, 2007:919–31
19 GIB-EAFIT. See http://www.eafit.edu.co/EafitCn/Investigacion/Grupos/Ingenieria/GIB/IndexGIB.htm (last checked 7 September 2009)
20 Vélez Beltrán JA, Newball AA. A virtual educational strategy on telemedicine and medical simulation. *Telemed J E Health* 2005;**11**:496–9
21 Vélez JA, Navarro AA. Una perspectiva de e-salud en Colombia. [An e-health perspective in Colombia] *RevistaeSalud.com* 2005;**1**(4) [Spanish]
22 Navarro AA, Vélez JA, Satizabal JE, Múnera LE, Bernabe G. Virtual surgical tele-simulations in ophthalmology. *International Congress Series* 2003;**1256**:145–50
23 Navarro AA, Vélez JA, Múnera LE, Bernabe G. Arquitectura de software basada en la internet para la simulación virtual de cirugía endoscópica otorrinolaringológica. [Internet-based software architecture for virtual simulation of otorhynolaringological endoscopic surgery] *Sistemas & Telemática* 2003;**1**:35–45 [Spanish]
24 Navarro Newball AA, Hernández CJ, Velez JA, *et al*. Virtual surgical telesimulations in otolaryngology. *Stud Health Technol Inform* 2005;**111**:353–5
25 Vélez JA, Navarro AA, Múnera LE, Kopec A, García GB. Methodological basis for distributed web testing of surgical simulators prototypes in a telemedicine latin american network (TLAN). *Telemed J E Health* 2002;**10**(Suppl. 1):116
26 Vélez JA, Navarro AA, Múnera LE, García GB. A software architecture for virtual simulation of endoscopic surgery. *Telemed J E Health* 2002;**8**:267
27 Vélez JA, Gamboa C. Virtual surgery model: fundamentals on electronic endoscopic otolaryngology web-based scenario. *Telemed J E Health* 2001;**7**:195
28 Navarro AA, Hernández CJ, Vélez JA, Múnera LE, García GB. A virtual telesimulation scenario for otolaryngologic surgery skills training. *Telemed J E Health* 2004;**10**(Suppl. 1):71
29 GIB-Universidad de los Andes. See http://ingbiomedica.uniandes.edu.co (last checked 7 September 2009)
30 Fundación Santa Fe de Bogotá. See http://www.fsfb.org.co (last checked 7 September 2009)
31 Percepción y Sistemas Inteligentes, Universidad del Valle, Colombia. See http://psi.univalle.edu.co/ (last checked 7 September 2009)
32 Telesalud Universidad de Caldas. See http://telesalud.ucaldas.edu.co/ (last checked 7 September 2009)
33 Rendón A, Martínez A, Dulcey MF, *et al*. Rural telemedicine infrastructure and services in the Department of Cauca, Colombia. *Telemed J E Health* 2005;**11**:451–9
34 Sachpazidis I, Konnis G, Kiefer S, *et al*. T@lemed: Medical imaging tele-cooperation technologies providing medical services in Latin America. In IEEE Engineering in Medicine and Biology Society: *International Special Topic Conference on Information Technology in Biomedicine, ITAB*. October, 2006. Ioannina, Greece
35 Centro de Telemedicina-Universidad Nacional de Colombia. See http://www.unal.edu.co/telemedicina/ (last checked 7 September 2009)
36 Fundación CardioVascular de Colombia. See http://www.fcv.org (last checked 7 September 2009)
37 E Ltda. See http://www.esoftltda.com (last checked 7 September 2009)
38 Valenzuela J, Arguello A, Cendales JG, Rizo CA. Web-based asynchronous teleconsulting for consumers in Colombia: a case study. *J Med Internet Res* 2007;**9**:e33
39 Angel DI, Alfonso R, Faizal M, *et al*. Cutaneous tuberculosis diagnosis in an inhospitable Amazonian region by means of telemedicine and molecular biology. *J Am Acad Dermatol* 2005;**52**(5 Suppl. 1):S65–8
40 Arbelaez M. El aporte de la telemedicina de la Universidad de Caldas en el fortalecimiento de redes sociales y académicas en el marco de la sociedad del conocimiento. [Telemedicine contribution from Caldas University to social and academic networks in the Knowledge Society Framework] In: V Foro Académico de Diseño 2008, Manizales, Colombia [Spanish]
41 SaludCoop. See http://www.saludcoop.com.co (last checked 7 September 2009)
42 Sachpazidis I, Kiefer S, Selby P, Ohl R, Sakas G. A medical network for teleconsultations in Brazil and Colombia. In: *Second IASTED International Conference on Telehealth*. Banff, AB, Canada, 2006;16–21
43 García A, Isaza J, Zapata U, Roldán A. Ejecución de un sistema piloto de tele-radiología en Medellín. [A tele-radiology pilot system asessment in Medellin] *Colombia Médica* 2006;**37**:183–8 [Spanish]
44 Castillo E, Solarte V. Red piloto de teleasistencia sanitaria. [Health teleassistance pilot network] *Telecomunicaciones & Sociedad* 2004;**2**:5–27 [Spanish]
45 Benítez H. Experiencia del seguro social colombiano en telerradiología. [Colombian Social Security experience in teleradiology] *Revista de Salud Pública* 2001;**3**(Suppl. 1):187–93 [Spanish]
46 GITEM-Universidad Francisco José de Caldas. See http://gemini.udistrital.edu.co/comunidad/grupos/gitem/ (last checked 7 September 2009)
47 Velez Beltran JA, Newball AA. A Latin American telemedicine social perspective from a Colombian telemedicine center initiative. *Telemed J E Health* 2005;**11**:616–9
48 Vélez BJA, Navarro Newball AA, Ricur G. Telemedicine in the Latin American and Caribbean regions: the Cartagena telemedicine conference. *J Telemed Telecare* 2007;**13**:210–1
49 Cardona O, Mejía S, Castrillón J, Giraldo D, Jaramillo A, Bustamante J. Interfaz para equipos de monitoreo médico (Red de Telemedicina de Antioquía). [Interface for medical monitoring equipments (Antioquia Telemedicine Network)] In: VI Congreso de la Sociedad Cubana de Bioingeniería 2005, Habana, Cuba [Spanish]
50 Miserque NIC. Programa Galaxia Fundación Cardiovascular de Colombia. [Galaxy Program, Colombian Cardiovascular Foundation] *Revistaesalud.com* 2005;**1**(4) [Spanish]
51 Díaz D. See http://www.drgdiaz.com (last checked 7 September 2009)