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Non-emergency Telecardiology Consultation Services: Rapid Review of Clinical and Cost Outcomes

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Canadian Agency for Drugs and Technologies in Health

Non-emergency Telecardiology Consultation Services: Rapid Review of Clinical and Cost Outcomes

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October 2010

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EXECUTIVE SUMMARY

Context and Policy Issues

Telehealth programs involve the use of electronic information and communication technology to support health care when participants are separated by distance. Video conferencing and digitization of diagnostic examinations allow for consultation between patients or physicians in the patient's community and distant specialist teams. For patients living in remote or rural areas, telecardiology can be used to reduce travel time and expenses or reduce wait times for outreach clinics. This rapid review evaluated recent literature on the clinical and economic impact of non-emergency telecardiology consultation programs for jurisdictions considering the implementation of such services.

Research Questions

1. What is the diagnostic accuracy of telecardiology consultation compared with current practice in remote or rural areas?
2. What are the benefits of telecardiology consultation in regard to patient outcomes, transfers avoided, wait times, and patient satisfaction?
3. What are the economic impacts of telecardiology consultation for patients, their families, and the health care system?

Methods

MEDLINE, MEDLINE In-Process & Other Non-Indexed Citations, and EMBASE were searched through the Ovid interface, with parallel searches run in PubMed and The Cochrane Library. Filters were applied to limit the retrieval to health technology assessments, systematic reviews, meta-analyses, randomized controlled trials, controlled clinical trials, observational studies, and economic studies. The search was restricted to English language articles that were published between January 2005 and May 2010. Grey literature was also searched. Articles were selected by a reviewer for inclusion, and a second reviewer verified the final selection results.

Summary of Findings

Of the nine studies that met the inclusion criteria, three were diagnostic studies, one was an interrupted time series study, four reports described two cohort studies, and five reports included cost analyses. Pediatric telecardiology programs were evaluated in two clinical and four economic reports. Two studies evaluated the clinical and one study the economic aspects of telecardiology for adults.

Clinical findings

In a US-based interrupted time series study, no decrease in the rate of transfer to tertiary hospitals was found after the implementation of a remote neonatal echocardiography service, but a possible decrease in the rate of avoidable transfers was reported. A US study found that digital heart sound recordings that are evaluated using telemedicine can be used to distinguish normal or innocent murmurs from pathological murmurs in older children with a diagnostic accuracy of 85%. A Canadian study reported that cardiovascular risk reduction using telehealth is feasible for adult patients living in remote areas. In an Italian study, cardiologists conducting heart and lung examinations by remote or in-person auscultation agreed on findings in 92% of patients, leading the authors to conclude that after a period of training, remote cardiopulmonary examination seems to be feasible.

Economic findings

A UK study of neonates with suspected congenital heart defects found good agreement on diagnosis using remote compared with hands-on echocardiograms, and cost savings in the avoidance of patient transfers from regional to tertiary care hospitals. Three reports of a second UK study concluded that the telecardiology program that was used to detect congenital heart defects in fetuses, newborns, infants, and children was reliable with similar costs to those of usual care. A cost-minimization study from Sweden reported that the remote diagnosis of heart failure in adults reduced travel time for patients and had similar costs to those of standard care from a health care payer perspective.

Conclusions and Implications for Decision- or Policy-Making

Overall, the quantity and quality of studies comparing telecardiology consultation programs to usual care were low. In many studies, the patients in the telehealth and control groups were not equivalent, raising concerns about selection bias. One study was conducted in Canada, and the generalizability of the findings of economic studies that are conducted outside Canada is limited.

The literature suggests that the implementation of clinic- or hospital-based telecardiology programs is feasible in communities with limited access to cardiovascular specialists. Because of the limitations of the evidence, conclusions about diagnostic accuracy or impact on patient outcomes cannot be made.

Telecardiology programs reduce the number of patients who are required to travel to access care. This may reduce the travel costs of patients or health care payers. The cost of telecardiology programs is affected by the volume of patients using the service, with higher volumes reducing the per-patient cost of acquiring and operating telemedicine equipment.

None of the studies reported on wait times, and limited information was available on patient satisfaction with telecardiology programs. There is limited evidence available to guide decision-makers planning to implement telecardiology consultation services in their jurisdiction.

1 CONTEXT AND POLICY ISSUES

Telehealth programs involve the use of electronic information and communication technology to support health care when the participants are separated by distance.[1] The use of video conferencing allows for consultation among patients, families, and physicians in the patient's district with specialist teams that are located elsewhere. Diagnostic examinations such as echocardiograms, electrocardiograms, or heart and lung sounds may be digitized and forwarded to a specialist or evaluated in real time.[2]

In Canada, some telecardiology programs date back to 1987.[2,3] Pediatric teleconsultation, teleconference, or distant echocardiogram diagnosis services are available in eight provinces in Canada.[2] Telecardiology consultation programs for adult patients are available in some jurisdictions in Canada.[3] These programs, which are usually based in tertiary centres, offer specialty services to general hospitals or to sparsely populated communities.

Patients living in communities without access to cardiovascular specialists travel to tertiary centres for consultation, or, if a local outreach clinic is available, wait for the next visit by the specialist. Telecardiology programs can be used to reduce the travel time and expenses for these patients and reduce the wait times for outreach clinics.[2,4] They may also provide prompt access to specialist advice when urgent consultation is needed, thereby avoiding some inter-hospital transfers.[2] In 2004, a systematic review reported that, despite the long history of telecardiology, most studies do not provide evidence of benefit.[5] This rapid review evaluated literature on the clinical and cost impact of non-emergency telecardiology consultation programs for jurisdictions considering implementing such services.

Research Questions

1. What is the diagnostic accuracy of telecardiology consultation compared with current practice in remote or rural areas?
2. What are the benefits of telecardiology consultation in patient outcomes, transfers avoided, wait times, and patient satisfaction?
3. What are the economic impacts of telecardiology consultation for patients, their families, and the health care system?

2 METHODS

Literature Search

Peer-reviewed literature searches were conducted to obtain published literature for this review. All search strategies were developed by an information specialist with input from the project team.

The following bibliographic databases were searched through the Ovid interface: MEDLINE, MEDLINE In-Process & Other Non-Indexed Citations, and EMBASE. Parallel searches were run in PubMed and The Cochrane Library (Issue 3, 2010). The search strategy comprised controlled vocabulary, such as the National Library of Medicine's MeSH (Medical Subject Headings), and keywords. Methodological filters were applied to limit the retrieval to health technology assessments, systematic reviews, meta-analyses, randomized controlled trials, controlled clinical trials, observational studies, and economic studies. Appendix 1 shows the detailed search strategies.

The search was restricted to English language articles that were published between January 2005 and March 2010. Regular alerts were established on Embase and MEDLINE, and information retrieved through alerts was current to May 6, 2010.

Grey literature (literature that is not commercially published) was identified by searching the websites of health technology assessment and related agencies, professional associations, and other specialized databases. Google and other Internet search engines were used to search for additional information. These searches were supplemented by handsearching the bibliographies and abstracts of key papers and through contacts with appropriate experts and agencies.

Article Selection

One reviewer (GM) screened the titles and abstracts against the inclusion and exclusion criteria and then evaluated the selected full-text publications for final article selection. The final selection was verified by a second reviewer (WP).

The inclusion and exclusion criteria were:

Population	Patients who live in remote, rural, or urban centres without access to cardiac specialists and who need non-emergency consultation for medical diagnosis or treatment.
Interventions	Telecardiology technologies (such as audio, video) used in place of face-to-face patient and primary care physician to cardiologist consultation.
Comparators	Usual care in which patient or physician travels for face-to-face consultation.
Outcomes	Mortality, hospitalization, hospital transfer, health-related quality of life, diagnostic accuracy, patient satisfaction, wait times, costs to patient or health care payer, and measures of cost-effectiveness.
Study design	Systematic reviews, meta-analyses, randomized controlled trials, controlled clinical trials, observational studies, economic studies.
Exclusions	Articles that focused on case management (such as heart failure disease management programs, home support programs, telemonitoring, or remote medication management programs), discharge planning, or emergency consultation. Telecardiology technologies that substitute for consultations not requiring face-to-face interaction (for example, radiology), focus on technical aspects of telehealth, or lack a control group. Studies that describe telehealth interventions for multiple specialties were excluded if information specific to cardiology could not be separated from other disciplines.

This report was peer-reviewed by two clinical experts and one economic expert.

3 SUMMARY OF FINDINGS

Of the 438 citations that were identified in the literature search, 387 were excluded after the screening of titles and abstracts, and 51 were retrieved for full-text screening. Nine publications were included in this report, and the remaining 42 articles were excluded (Appendix 2).

No health technology assessments, systematic reviews, meta-analyses, randomized controlled trials, or controlled clinical trials met the inclusion criteria for this review. Of the nine included studies, three were diagnostic studies,[6-8] four cohort studies,[1,4,9,10] one interrupted time-series study,[11] and five reports

included cost analyses.[4,8-10,12] Pediatric telecardiology programs were evaluated in two clinical and four economic reports. Two clinical reports and one economic report focused on telecardiology services for adult patients. A summary of the studies, methods, outcomes, results, perceived limitations, and conclusions appears in Table 1.

Clinical Studies

Pediatric

In 2008, Huang et al. from the US described the store-and-forward echocardiography teleconsultation program that was implemented at a community hospital with a level III neonatal intensive care unit.[11] The use of echocardiography and patient transfers to a tertiary hospital was reported for the three years before and after the implementation of the teleconsultation program. A total of 665 neonates with suspected congenital heart defects were evaluated. The rate of transfers to the tertiary centre was similar in each period (5.8% before, 7.0% after, $p = 0.33$). The appropriateness of the 48 transfers was evaluated retrospectively. The transfer was deemed to be avoidable for seven out of 24 patients (29%) in the "before" period and two out of 24 patients (8%) in the "after" period ($p = 0.06$). One incorrect diagnosis was reported during the period before the teleconsultation program was implemented, and none were reported after implementation. Because of the limited data that were reported on patient characteristics and the lack of a concurrent control group, it is not possible to draw conclusions on the impact of the telecardiology program.[11]

In a 2008 US study, Mahnke et al.[7] reported the feasibility and accuracy of using remote auscultation of heart sounds to distinguish pathological heart murmurs from innocent murmurs or normal heart sounds in 104 older children (mean age 10 years) with suspected congenital heart defects. All children underwent a standard examination by a pediatric cardiologist including an echocardiogram. Digital recordings of heart sounds (phonocardiograms) were recorded and evaluated by three cardiologists who were blinded to all clinical information. Phonocardiograms had a sensitivity of 82% and a specificity of 86% to detect murmurs compared with echocardiograms. The overall diagnostic accuracy was 85%, with 18 false negatives and eight false positives. The findings may not reflect the performance of remote auscultation in clinical practice, because the cardiologists did not have access to clinical information on the patient. The authors concluded that remote auscultation can be used to distinguish normal heart sounds or innocent murmurs from pathological murmurs.[7]

Adults

In a 2008 study, PausJenssen et al. assessed the feasibility of using video conferencing to provide multidisciplinary cardiovascular risk reduction care to patients in rural Saskatchewan.[1] During video consultations, patients met with a nurse, dietician, fitness consultant, and physician. Body measurements, blood pressure readings, laboratory tests, dietary logs, and exercise logs were completed before the consultations. For the first consultation, the clinic travelled to the patients' community. Subsequent consultations over the following year were performed using telehealth. Nine patients were enrolled in the telehealth program. They were compared with 15 retrospective control group members who had attended the cardiovascular risk reduction clinic outside the community. All patients in the telehealth group attended at least one follow-up visit, compared with 53% of control group patients. Both groups achieved a 2% reduction in the Framingham risk score. The telehealth patients reported that the video consultations were a positive experience. The study was limited by the small sample size. The authors concluded that it is feasible to offer cardiovascular risk reduction care using telehealth.[1]

In a 2007 study that was based at a heart failure clinic in Italy, Fragasso et al.[6] assessed the feasibility and accuracy of remote auscultation of heart and lung sounds in 50 patients with heart failure. Patients underwent a remote auscultation and video consultation with a cardiologist, followed by an in-person examination by a second physician. Both cardiologists had access to the patients' clinical information and were blinded to the findings from the other auscultation. The findings on remote and in-person examination

agreed in 92% of patients. In three patients, the interpretations of the remote lung examinations were incorrect. As a result, the treatment that was recommended by each physician differed. The study was limited by small sample size and by the failure to report sensitivity and specificity or kappa scores for all analyses. The authors concluded that remote cardiopulmonary examination seems feasible. A short period of training on conducting remote and in-person examinations of patients is useful to improve the remote auscultation technique, because all diagnostic errors occurred in the first few patients who were assessed.[6]

Economic Studies

Pediatric

In 2010, Grant et al.[8] described the diagnostic accuracy and costs that were associated with a teleconsultation service in Northern Ireland when 124 neonates were evaluated for congenital heart defects over an eight-year period. The patients were evaluated at district general hospitals and had an echocardiogram performed during a real-time video consultation with a pediatric cardiologist. Based on the diagnosis that was reached during the teleconsultation, patients were transferred to the tertiary care centre or had their diagnosis confirmed at an outreach clinic. The costs included all health care resources that were used in the initial assessment and transfer of patients, as well as outpatient assessments (equipment, operating costs, clinicians, echocardiograms, and ambulance transfers). Resource use and costs were obtained from the prospective clinical study and expert opinion. The analysis excluded the costs and consequences of diagnostic inaccuracy.[8]

The use of teleconsultation had a sensitivity of 97% and a specificity of 96% compared with face-to-face consultation, and showed good agreement with a kappa score of 0.89.[8] The diagnostic accuracy may have been overestimated because the analysis excluded five patients who had a poor quality echocardiogram during the teleconsultation. Also, the accuracy may have been biased, because the teleconsultation was not compared with a blinded independent test. Without access to teleconsultation, all infants would have been transferred to the tertiary care centre. The use of teleconsultation avoided transfers for 75% of babies (93/124). The authors reported that the teleconsultation service saved £608 to £1,822 per patient, depending on the referring hospital. The cost differences were mainly affected by transfer costs and telemedicine utilization rates for each referring hospital. The authors concluded that the teleconsultation service can accurately diagnose congenital heart defects and may save the costs of inter-hospital transfers.[8]

In 2009,[4] 2008,[10] and 2007,[9] Dowie et al. published three studies that described the costs and outcomes of the first 15 months of a telecardiology service in four district hospitals near London, UK. The populations included newborns, infants, and children[4,9] with suspected congenital heart defects, as well as pregnant women[9,10] undergoing screening for fetal heart defects. Patients in the telemedicine group underwent diagnostic tests and assessment locally, and then the test images were transmitted to the pediatric or neonatal cardiologist for assessment at virtual video consultations. The usual-care patients travelled to London for assessment or were seen at regularly scheduled outreach clinics in the district hospitals. The costs of the first consultation, first 14 days of care, and first six months of care were collected. The authors included operating costs as well as the costs of telemedicine equipment, inpatient or outpatient visits, diagnostic tests, drugs, health care professional resources, and inter-hospital transfers. The patients' costs for travel and loss of income were collected for a subgroup of 32 pregnant women.[9]

Many of the patients who were included in the 2007 publication[9] seem to have been included in subsequent reports.[4,10] There were imbalances in the ages and disease severity of patients in the telecardiology and usual-care groups that were not accounted for in the analysis. This may have biased the cost estimates. In the report on pregnant women, the services that were provided in the usual-care group were not always the same as in the teleconsultation group. For example, patients who travelled to London had a longer appointment with the specialist and received counselling at the first appointment if an anomaly was detected.[9] It is unclear if the costs of counselling were included for the teleconsultation group.[9]

In the study of pediatric patients with suspected congenital heart defects, the mean per patient costs to the health care system were higher in the telecardiology group compared with the usual-care group on the first consultation day, the first 14 days, and first six months of care. The differences were not statistically significant.[4] No cases of incorrect diagnosis occurred.[4]

Among pregnant women undergoing screening for fetal cardiac anomalies, the health care costs of the first consultation were statistically significantly higher in the teleconsultation group compared with the usual-care group (mean difference £132).[10] No differences in health care costs were found at 14 days or until delivery. The mean costs of the first consultation were statistically significantly higher for the telecardiology versus usual-care groups in the analysis that included patients' costs (mean difference £105).[10] The median travel and lost wages costs for patients were £12.59 for teleconsultation and £50.36 for usual-care patients (p= 0.002).[9]

The key cost components of the telecardiology service were the purchase of telemedicine equipment, rental of the integrated services digital network (ISDN) line, and call charges.[4,9,10] For newborns with suspected congenital heart defects, some costs of the telecardiology service were offset by a reduction in the number of urgent ambulance transfers.[9] This was not the case for the pregnant women or older children in the study. The need for consultation was less urgent for these patients, and patients were not transferred by ambulance. Therefore, the travel costs were lower and did not offset the telecardiology consultation costs.[9]

The authors reported that the cost per telecardiology consultation was reduced as the volume of patients increased.[9] Sharing the telemedicine equipment with other specialties helped to offset the initial set up and ongoing operating costs.[9] The authors concluded that telecardiology consultation provided timely and efficient access to specialists that was cost neutral to the health care system.[9]

Adults

In a 2009 Swedish cost-minimization study, Lofgren et al. estimated the societal and health care payer costs of a mobile robotic echocardiography technology.[12] A theoretical cohort of patients with suspected heart failure attended a primary health care centre for ultrasound and video consultation with cardiologists at the regional hospital. Patients in the usual-care group travelled to the regional hospital for diagnosis and consultation. The study assumed the diagnostic quality and access to care were the same for each group, but no data were provided to support this assumption. The costs included were those of capital equipment, maintenance, equipment transport between health care centres, staff time, overhead, and subsidized patient travel. The societal analysis included the patients' hospital fees as well as travel and time costs (e.g., lost wages). The authors assumed that 10% of remote echocardiograms were inadequate for diagnosis, thus requiring the patient to travel.[12]

In this model, the societal costs for the telecardiology service were lower than those of usual care (difference of −€17,800).[12] From the health care payer perspective, telecardiology was more expensive (difference of €4,100). The main savings from using the telecardiology service benefited patients, with reductions in travel time costs and hospital fees. From the health care payer perspective, savings on subsidized patient travel expenses did not offset the capital costs and loss of patient fees. Sensitivity analyses were done by varying the number of patients who were assessed and the distance from the regional hospital. The telecardiology program was less expensive than usual care from the societal perspective if the number of patients seen annually was 55 or more, or 105 patients from the payer perspective. The authors concluded that the telecardiology service reduced travel time for patients, with similar health care costs compared with usual care.[12]

Table 1: Study Characteristics and Results					
Objectives	**Design, Approach**	**Setting, Patients**	**Outcomes**	**Limitations**	**Conclusions, Policy Implications**
Huang, 2008[11]					
Evaluate echocardiogram use and patient transfers 3 years before and after implementation of store-and-forward echocardiography teleconsultation service.	Interrupted time series. Echocardiograms were forwarded to pediatric cardiologists at tertiary children's hospital. Usual-care group comprised patients evaluated before implementation of telecardiology service.	665 neonates with suspected congenital heart defects admitted to level III NICU at a US community hospital. Age and gender not reported.	Rate of all NICU admissions transferred to tertiary centre before 60/1,029 (5.8%), after 67/963 (7%) (p = 0.33). Avoidable transfers before 7/24 (29%), after 2/24 (8%) (p = 0.06). Incorrect diagnoses before 1/280 (0.4%), after 0/385 (0%) (p value not reported). Neonates who had an echocardiogram before 280/1,029 (27%), after 385/963 (40%) (p < 0.001).	No concurrent control group, so factors other than telemedicine service (such as severity of illness) may be related to change in use or transfer patterns over time. Patient characteristics not reported. Appropriateness of transfer was determined retrospectively based on subjective criteria.	Authors concluded that the telecardiology service was associated with an increase in echocardiography, an increase in percentage of babies with cardiac pathology detected, and similar number of transfers to tertiary centres.
Mahnke, 2008[7]					
Assess feasibility and diagnostic accuracy of store-and-forward digital recordings of heart sounds (phonocardiograms) compared with echocardiography.	Diagnostic study. Standard in-person examination, ECG, echocardiogram, and phonocardiograms obtained by pediatric cardiologist. Phonocardiograms	104 children with suspected congenital heart defects evaluated at US pediatric cardiology clinic. Mean age 10.2 years (range 2 years to 19.5 years); gender not reported.	Diagnostic accuracy 85% for correct classification of normal or innocent versus pathological murmur (compared with echocardiogram). Diagnosis of murmur. Sensitivity 82% (range 76% to 91%), Specificity 86% (range	Cardiologists assessing digital recordings did not have access to patients' clinical data. Digital recordings obtained by cardiologist, not GP, as may occur in daily practice	Authors concluded that digital heart sound recordings evaluated using telemedicine can distinguish normal or innocent murmurs from pathological murmurs.

Table 1: Study Characteristics and Results					
Objectives	**Design, Approach**	**Setting, Patients**	**Outcomes**	**Limitations**	**Conclusions, Policy Implications**
	assessed by 3 cardiologists blinded to all patient data.		82% to 90%). Of 18 false negatives, 9 would not have been referred for more evaluation. 8 false positives. Agreement between 3 reviewers moderate (kappa 0.6 to 0.65). Hands-on examination recommended by blinded physician for 44% of cases. 63% of parents agreed teleconsultation more convenient than visiting specialist in-person.	involving use of teleconsultation. Analysis excluded 2.6% of cases with poor quality recordings.	
PausJenssen, 2008[1]					
Assess feasibility of using telehealth to provide multidisciplinary cardiovascular risk reduction care to patients in rural area.	Prospective cohort with historical control group. Study patients underwent cardiovascular risk reduction consultation using telehealth compared with retrospective control group members who	24 adults with risk factors for cardiovascular disease living in a remote rural community in Canada. Follow-up: 1 year. Mean age 47 years (range 24 years to 71 years), 83% male.	Number of follow-up visits. Telehealth 9/9 (100%) completed ≥ 1 visit, 2/9 (22%) completed 4 visits; Controls 8/15 (53%) completed ≥ 2 face-to-face visits. Similar reduction in Framingham risk score in each group (~ 2%).	Potential for selection bias due to unclear participant selection methods and use of retrospective control group. Because of small sample size, conclusions limited to feasibility of telehealth services.	Cardiovascular risk reduction using telehealth feasible for patients living in remote areas.

Table 1: Study Characteristics and Results					
Objectives	**Design, Approach**	**Setting, Patients**	**Outcomes**	**Limitations**	**Conclusions, Policy Implications**
	received face-to-face consultation outside the community.		Patients reported that teleconsultation was a positive experience, with no travel needed. No concerns voiced about privacy. Health care team thought program was worthwhile but had concerns about privacy.		
Fragasso, 2007[6]					
Assess technical feasibility and accuracy of remote auscultation of heart and lung sounds.	Diagnostic study. Patients underwent remote auscultation and consultation using videophone. Patients were then examined in person by second blinded cardiologist.	50 patients with heart failure (NYHA Class II-IV) attending heart failure clinic in Italy. Mean age 71 years (SD 10), 74% male.	Findings on heart and lung examination based on remote and in-person auscultation agreed in 92% of patients. Agreement on grade of heart murmur 76%. Lung examination. Sensitivity 88%; specificity 97%. Incorrect interpretation of remote lung examination in 3/50 (6%) patients resulted in different treatment recommendations by remote and in-person examining physician. Sound disturbances in 44% of tele-auscultations. In 6% of examinations, disturbance could not be resolved; however,	Small sample of patients, limited to 2 cardiologists. Kappa score more appropriate measure of agreement. Incomplete reporting of results.	Remote cardiopulmonary examination seems feasible. Physicians need short period of training combining remote and in-person auscultation.

Table 1: Study Characteristics and Results					
Objectives	**Design, Approach**	**Setting, Patients**	**Outcomes**	**Limitations**	**Conclusions, Policy Implications**
			examination continued successfully.		
Grant, 2010[8]					
Determine diagnostic accuracy, impact on transfers, and costs of real-time echocardiography teleconsultation service.	Diagnostic study and cost analysis. First examination and echocardiogram by local pediatrician followed by real-time tele-echocardiogram reviewed by pediatric cardiologist. All patients underwent subsequent face-to-face evaluation and echocardiogram by pediatric cardiologist. Cost analysis compared telemedicine with hypothetical standard care where all patients would be transferred to a tertiary centre for urgent consultation.	124 neonates with suspected congenital heart defects seen in 3 district general hospitals in UK. Median age 3 days (IQR 1 day to 12 days), gender not reported.	Tele-echocardiogram versus hands-on echocardiogram. Sensitivity 97%, specificity 96%, kappa 0.89 (95% CI 0.71 to 1.0) (3 false-negatives, 1 false-positive). 93/124 (75%) transfers avoided by teleconsultation. Diagnostic quality image not obtained by pediatrician in 5/124 (4%) of teleconsultations. From health care payer perspective, cost savings per patient assessed using teleconsultation ranged from £608 to £1,822 depending on referring hospital. Cost differences mainly driven by transfer costs and telemedicine use rates in each referring hospital.	Diagnostic accuracy assessment excluded patients with poor quality echocardiograms. Potential for expectation bias because interpretation of confirmatory echocardiogram unblinded. Costs or consequences of diagnostic inaccuracy not included in cost analysis.	Congenital heart defects may be accurately diagnosed using real-time transmission of echocardiograms. Cost savings may be achieved from avoidance of patient transfers between regional and tertiary care hospitals.

Table 1: Study Characteristics and Results					
Objectives	**Design, Approach**	**Setting, Patients**	**Outcomes**	**Limitations**	**Conclusions, Policy Implications**
Dowie, 2009[4]					
Compare caseload and relative costs of pediatric telecardiology consultation service with usual care.	Cohort study and cost analysis. Patients who underwent diagnostic assessment and video consultation at remote telecardiology clinic compared with patients who underwent specialist consultation at tertiary care centre or outreach clinic (usual care).	266 newborns, infants, and children with suspected congenital heart defects at district general hospitals (with level II or III NICU) in UK (telecardiology 75 patients, usual care 191 patients).	Patients referred to telecardiology younger (49% versus 32% < 1 year old, p = 0.025) and less likely to have severe symptoms (8% versus 22%, p = 0.005) versus usual-care group. 5/75 (7%) versus 30/191 (16%) in teleconsultation and usual-care groups needed cardiac intervention (p value not reported). No cases of incorrect diagnosis occurred. From health care payer perspective, mean costs per patient on first consultation £839 (95% CI 717 to 999) and £587 (95% CI 431 to 843) in teleconsultation and usual-care groups respectively (NS). After 14 days or 6 months, mean costs £1,132 and £2,043 higher in teleconsultation group versus usual care (NS).	Selection of patients for teleconsultation at physician's discretion led to imbalances in age and severity between groups. Cost analysis did not adjust for this selection bias. No sensitivity analyses conducted. Generalizability of cost analysis to Canadian health care system may be limited.	Authors concluded that teleconsultation services cost-neutral from health care payer perspective.

Table 1: Study Characteristics and Results					
Objectives	**Design, Approach**	**Setting, Patients**	**Outcomes**	**Limitations**	**Conclusions, Policy Implications**
Dowie, 2008[10]					
Assess cost impact of store-and-forward fetal telecardiology and virtual outreach service compared with face-to-face consultation.	Cohort study and cost analysis. Fetal echocardiograms done at district general hospital and reviewed by perinatal cardiologists at monthly virtual outreach videoconferences. Usual-care group travelled to London for in-person consultation.	76 pregnant women in UK assessed for suspected fetal heart defects (telemedicine 52 patients, usual care 24 patients).	7/24 (29%) and 5/52 (10%) women in usual-care and teleconsultation groups had ultrasound abnormality detected ($p = 0.047$). No incorrect diagnoses. From health care payer perspective, costs of first consultation £206 (SD 12) and £74 (SD 20) in teleconsultation and usual-care groups ($p < 0.001$). In teleconsultation versus usual-care group, difference in mean costs from first consultation to 14 days −£81 and to delivery £288 (NS). Mean cost of first consultation including patients' travel costs £213 (SD 13) and £108 (SD 27) in teleconsultation and usual-care groups ($p < 0.001$).	Imbalances between groups on proportion of women with comorbidities and proportion with ultrasound abnormalities, which may have impact on overall costs. Limited sensitivity analyses. Generalizability of cost analysis to Canadian health care system may be limited.	Authors concluded that telecardiology provided timely specialist consultation to patients and efficient use of perinatal cardiologist resources.

Table 1: Study Characteristics and Results					
Objectives	**Design, Approach**	**Setting, Patients**	**Outcomes**	**Limitations**	**Conclusions, Policy Implications**
Dowie, 2007[9]					
Compare costs and outcomes of patients referred to pediatric telecardiology service with those of patients referred conventionally.	Cohort study and cost analysis. Patients underwent diagnostic assessment and video consultation at telecardiology clinic. Comparison group travelled to tertiary care centre for consultation with cardiologist or seen at local outreach clinic.	40 newborns and 216 infants and children with suspected congenital heart defects; 248 pregnant women with suspected fetal heart defects. District general hospitals (with level II or III NICU) in UK.	From health care payer perspective, mean costs of first consultation, first 14 days of care, or first 6 months of care higher in telecardiology versus usual-care group by £134, £574, and £1,178 respectively (NS). For pregnant women and older children, costs of telecardiology higher than usual care. For newborns, telecardiology costs lower than usual care for all 3 time points (first consultation $p < 0.05$, 14 days and 6 months) (NS). Patients' median travel and loss of income costs higher for women who travelled to receive care (£50.36 IQR 38 to 77) versus those treated locally (£12.59 IQR 3 to 16) ($p = 0.002$).	Seems to include same telecardiology patients as other 2 papers.[4,10] Patients' age and disease severity differed between groups, suggesting selection bias. Services included in cost analysis not always same for each group. Sample size for some comparisons was small, and confidence intervals on cost estimates often wide. Limited generalizability to Canadian health care system.	Authors concluded that telecardiology services were reliable and efficient with equivalent six-month costs to health care payer.

Table 1: Study Characteristics and Results					
Objectives	**Design, Approach**	**Setting, Patients**	**Outcomes**	**Limitations**	**Conclusions, Policy Implications**
			Time needed for visit 2.5 hours at local clinic or 5.5 hours at tertiary centre in London.		
Löfgren, 2009[12]					
Determine societal and health care system costs of robotic echocardiography and real-time video consultation service compared with usual care.	Cost-minimization study. Patients underwent real-time echocardiography using robotic technology controlled remotely by hospital sonographer followed by video consultation with cardiologist. Usual-care patients travelled to hospital for diagnosis and consultation.	Patients with heart failure at 3 remote primary care health care centres in Sweden (90 km to 135 km from regional hospital).	From societal perspective, costs of remote diagnosis €101,100 compared with €118,900 for usual care (difference −€17,800). Main savings for patients were reduced hospital fees and travel time costs (e.g., lost wages). From health care system perspective, cost of remote diagnosis €81,200 versus €77,100 for usual care (difference €4,100). Costs sensitive to patients' travel and time costs, distance between patient and hospital, and volume of patients assessed.	Study assumed diagnostic quality and access to treatment equivalent, but provided no evidence to support this claim. Limited generalizability to Canadian health care system.	Remote diagnosis of heart failure reduced travel time for patients. Costs similar for remote and in-hospital diagnosis from perspective of health care payer.

CI = confidence interval; ECG = electrocardiogram; GP = general practitioner; IQR = interquartile range; NICU = neonatal intensive care unit; NS = not statistically significant; NYHA = New York Heart Association; SD = standard deviation.

4 LIMITATIONS

This rapid review is potentially limited by the scope of the literature search and the study selection methods. English language reports that were published since 2005 were searched for relevant articles. The selection of studies was completed by one reviewer. The final selection was verified by a second reviewer. The report did not address all telecardiology programs but was restricted to non-emergency teleconsultation services. Home telehealth for chronic disease management was reviewed in a previous Canadian Agency for Drugs and Technologies in Health (CADTH) report.[13]

The number of studies that were identified was low, and most had methodological limitations. The studies mainly provided information about the feasibility of telecardiology programs instead of the clinical impact in daily practice. In many studies, the patients in the telehealth and control groups were not equivalent, raising concerns of selection bias. It was unclear if the patients who were studied were representative of those seen in clinical practice. In two diagnostic studies, patients with poor-quality images or recordings were excluded from the analysis, biasing the results in favor of telecardiology. Only one of the three diagnostic studies compared the experimental test with an independent blinded gold-standard test. For some studies, it was unclear if the statistical methods that were used were appropriate for data collected over many time points or from hospital clusters.

One clinical study was conducted in Canada. Economic analyses that were conducted in other countries can have limited generalizability to the Canadian health care system. The cost analyses reported on the use and costs of telecardiology services compared with usual care, without considering differences in clinical outcomes.

5 CONCLUSIONS AND IMPLICATIONS FOR DECISION- OR POLICY-MAKING

Most of the studies that were included in this rapid review evaluated pediatric patients with suspected congenital heart defects. Two reports included patients with heart failure, and one report evaluated adults at risk for cardiovascular disease. The literature suggests that the implementation of clinic- or hospital-based telecardiology programs is feasible for communities with limited access to cardiovascular specialists. Because of the limitations of the evidence, conclusions about the diagnostic accuracy or impact on patient outcomes cannot be made. Some studies stated that the skill of the person performing the echocardiogram or auscultation affected the diagnostic quality of the test available to the cardiologist at the teleconsultation, and additional training may be needed.

Telecardiology programs reduce the number of patients who are required to travel to access care, and thus may reduce travel costs for patients or health care payers. The cost of telecardiology programs is affected by the volume of patients using the service, with higher volumes reducing the per-patient cost of acquiring and operating telemedicine equipment.

None of the studies reported wait times, and limited information was available on patient satisfaction with telecardiology programs.

Overall, the quantity and quality of studies comparing telecardiology consultation programs with usual care were low. In addition, only one study was conducted in Canada. There is limited evidence available to guide decision-makers planning to implement telecardiology consultation services in the jurisdictions.

6 REFERENCES

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APPENDIX 1: LITERATURE SEARCH STRATEGY

Effectiveness Studies

OVERVIEW	
Interface:	OVID
Databases:	EMBASE <1996 to 2010 Week 13>; Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations < April 02, 2010>; Ovid MEDLINE(R) <1966 to March Week 4 2010> * Note: Subject headings have been customized for each database.
Date of Search:	April 5, 2010
Alerts:	Monthly search updates began April 5, 2010, and ran to May 6, 2010.
Study Types:	Systematic reviews; meta-analyses; health technology assessments; randomized controlled trials; controlled clinical trials; cohort studies; cross-over studies; case control studies; comparative studies; observational studies; economic studies.
Limits:	Publication years 2005–present English
SYNTAX GUIDE	
/	At the end of a phrase, searches the phrase as a subject heading
.sh	At the end of a phrase, searches the phrase as a subject heading
MeSH	Medical Subject Heading
fs	Floating subheading
exp	Explode a subject heading
$	Truncation symbol, or wildcard: retrieves plural or variations of a word
*	Indicates that the marked subject heading is a primary topic
?	Truncation symbol for one or no characters only
ADJ	Requires words are adjacent to each other (in any order)
ADJ#	Adjacency within # number of words (in any order)
.ti	Title
.ab	Abstract
.hw	Heading Word; usually includes subject headings and controlled vocabulary
.pt	Publication type
.rn	CAS registry number
emef	EMBASE 1996 to present
prmz	Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations and Ovid MEDLINE(R) 1950 to Present

MULTI-FILE STRATEGY	
#	**Searches**
1	Telecardiology/ use emef
2	(telecardiology or telecardiological or telecardiologist or televascular or teleauscultation or tele cardiology or tele cardiological or tele cardiologist or telecardiologic or tele cardiologic or tele vascular or tele auscultation or kardionet or tele ECG or teleECG).ti,ab.
3	1 or 2
4	exp Cardiology/ use prmz
5	exp Hospital Cardiology Service/ use prmz

MULTI-FILE STRATEGY	
#	**Searches**
6	exp *Heart diseases/ use prmz
7	exp Heart Function Tests/ use prmz
8	*Cardiology/ use emef
9	*Pediatric cardiology/ use emef
10	*coronary care unit/ use emef
11	exp *heart disease/ use emef
12	exp Heart Function Test/ use emef
13	(cardiology or cardiologist or cardiologists).ti,ab.
14	(heart disease* or heart failure or cardiac disease* or coronary disease* or heart valve disease*).ti,ab.
15	or/4-14
16	exp Telemedicine/ use prmz
17	Telemetry/ use prmz
18	exp *Telehealth/ use emef
19	(videoconferencing or videoconference or videoconferences or telecommunication or teletransmission or transtelephonic or trans telephonic or telehealth or tele-health or telecare or telemedic* or tele-medic* or telemonitor* or tele-monitor* or teleconsult* or teleconsult* or telematic or tele-matic or telemanagement or tele-management or teleconferenc* or tele-conferenc* or telefax or e-health* or ehealth* or teleservic* or tele-servic* or telediagnos* or tele-diagnos*).ti,ab.
20	(m-health* or mobile health*).ti,ab.
21	(teleconferenc* or tele-conferenc* or videoconferenc* or video conferenc* or webconference* or web conferenc*).ti,ab.
22	(telemed* or eHealth).jn.
23	((remote or wireless or mobile or rural) adj2 (assessment* or monitor* or consult* or auscultation or screening or surveillance)).ti,ab.
24	or/16-23
25	15 and 24
26	remove duplicates from 25
27	meta-analysis.pt.
28	meta-analysis/ or systematic review/ or meta-analysis as topic/ or exp technology assessment, biomedical/
29	((systematic* adj3 (review* or overview*)) or (methodologic* adj3 (review* or overview*))).ti,ab.
30	((quantitative adj3 (review* or overview* or synthes*)) or (research adj3 (integrati* or overview*))).ti,ab.
31	((integrative adj3 (review* or overview*)) or (collaborative adj3 (review* or overview*)) or (pool* adj3 analy*)).ti,ab.
32	(data synthes* or data extraction* or data abstraction*).ti,ab.
33	(handsearch* or hand search*).ti,ab.
34	(mantel haenszel or peto or der simonian or dersimonian or fixed effect* or latin square*).ti,ab.
35	(met analy* or metanaly* or health technology assessment* or HTA or HTAs).ti,ab.
36	(meta regression* or metaregression* or mega regression*).ti,ab.

MULTI-FILE STRATEGY	
#	**Searches**
37	(meta-analy* or metaanaly* or systematic review* or biomedical technology assessment* or bio-medical technology assessment*).mp,hw.
38	(medline or Cochrane or pubmed or medlars).ti,ab,hw.
39	(cochrane or health technology assessment or evidence report).jw.
40	(meta-analysis or systematic review).md.
41	or/27-40
42	(Randomized Controlled Trial or Controlled Clinical Trial).pt.
43	(Clinical Trial or Clinical Trial, Phase II or Clinical Trial, Phase III or Clinical Trial, Phase IV).pt.
44	Multicenter Study.pt.
45	Randomized Controlled Trial/
46	Randomized Controlled Trials as Topic/
47	Controlled Clinical Trial/
48	Controlled Clinical Trials as Topic/
49	Clinical Trial/ or Phase 2 Clinical Trial/ or Phase 3 Clinical Trial/ or Phase 4 Clinical Trial/
50	Clinical Trials as Topic/ or Clinical Trials, Phase II as Topic/ or Clinical Trials, Phase III as Topic/ or Clinical Trials, Phase IV as Topic/
51	Multicenter Study/ or Multicenter Study as Topic/
52	Randomization/
53	Random Allocation/
54	Double-Blind Method/
55	Double Blind Procedure/
56	Double-Blind Studies/
57	Single-Blind Method/
58	Single Blind Procedure/
59	Single-Blind Studies/
60	Placebos/
61	Placebo/
62	Control Groups/
63	Control Group/
64	Cross-Over Studies/ or Crossover Procedure/
65	(random* or sham or placebo*).ti,ab,hw.
66	((singl* or doubl*) adj (blind* or dumm* or mask*)).ti,ab,hw.
67	((tripl* or trebl*) adj (blind* or dumm* or mask*)).ti,ab,hw.
68	(control* adj3 (study or studies or trial*)).ti,ab,hw.
69	(clinical adj3 (study or studies or trial*)).ti,ab,hw.
70	(Nonrandom* or non random* or non-random* or quasi-random* or quasirandom*).ti,ab,hw.
71	(phase adj3 (study or studies or trial*)).ti,ab,hw.
72	((crossover or cross-over) adj3 (study or studies or trial*)).ti,ab,hw.
73	((multicent* or multi-cent*) adj3 (study or studies or trial*)).ti,ab,hw.
74	(allocated adj1 to).ti,ab,hw.
75	((open label or open-label) adj5 (study or studies or trial*)).ti,ab,hw.

MULTI-FILE STRATEGY	
#	**Searches**
76	trial.ti.
77	or/42-76
78	exp animals/
79	exp animal experimentation/
80	exp models animal/
81	exp animal experiment/
82	nonhuman/
83	exp vertebrate/
84	animal.po.
85	or/78-84
86	exp humans/
87	exp human experiment/
88	human.po.
89	or/86-88
90	85 not 89
91	77 not 90
92	epidemiologic methods.sh.
93	epidemiologic studies.sh.
94	cohort studies/
95	cohort analysis/
96	longitudinal studies/
97	longitudinal study/
98	prospective studies/
99	prospective study/
100	follow-up studies/
101	follow up/
102	followup studies/
103	retrospective studies/
104	retrospective study/
105	case-control studies/
106	exp case control study/
107	cross-sectional study/
108	observational study/
109	quasi experimental methods/
110	quasi experimental study/
111	(observational adj3 (study or studies or design or analysis or analyses)).ti,ab.
112	(cohort adj7 (study or studies or design or analysis or analyses)).ti,ab.
113	(prospective adj7 (study or studies or design or analysis or analyses or cohort)).ti,ab.
114	((follow up or followup) adj7 (study or studies or design or analysis or analyses)).ti,ab.
115	((longitudinal or longterm or (long adj term)) adj7 (study or studies or design or analysis or analyses or data or cohort)).ti,ab.
116	(retrospective adj7 (study or studies or design or analysis or analyses or cohort or data or

MULTI-FILE STRATEGY	
#	**Searches**
	review)).ti,ab.
117	((case adj control) or (case adj comparison) or (case adj controlled)).ti,ab.
118	(case-referent adj3 (study or studies or design or analysis or analyses)).ti,ab.
119	(population adj3 (study or studies or analysis or analyses)).ti,ab.
120	(descriptive adj3 (study or studies or design or analysis or analyses)).ti,ab.
121	((multidimensional or (multi adj dimensional)) adj3 (study or studies or design or analysis or analyses)).ti,ab.
122	(cross adj sectional adj7 (study or studies or design or research or analysis or analyses or survey or findings)).ti,ab.
123	((natural adj experiment) or (natural adj experiments)).ti,ab.
124	(quasi adj (experiment or experiments or experimental)).ti,ab.
125	((non experiment or nonexperiment or non experimental or nonexperimental) adj3 (study or studies or design or analysis or analyses)).ti,ab.
126	(prevalence adj3 (study or studies or analysis or analyses)).ti,ab.
127	case series.ti,ab.
128	case reports.pt.
129	case report/
130	case study/
131	(case adj3 (report or reports or study or studies or histories)).ti,ab.
132	organizational case studies.sh.
133	or/92-132
134	(economic adj2 model*).mp.
135	(cost minimi* or cost-utilit* or economic evaluation* or economic review* or cost outcome or cost analys?s or economic analys?s).ti,ab.
136	(cost-effective* or pharmacoeconomic* or pharmaco-economic* or cost-benefit).ti.
137	(life year or life years or qaly* or cost-benefit analys?s or cost-effectiveness analys?s).ab.
138	(cost or costs or economic*).ti. and (costs or cost effectiveness or markov).ab.
139	or/134-138
140	41 or 91 or 133 or 139
141	26 and 140
142	141 or 3
143	limit 142 to english language
144	limit 143 to yr="2005 -Current"

OTHER DATABASES	
PubMed	Same MeSH, keywords, limits, and study types used as per MEDLINE search, with appropriate syntax used.
Cochrane Library Issue 3, 2010	Same MeSH, keywords, and date limits used as per MEDLINE search, excluding study types and Human restrictions. Syntax adjusted for Cochrane Library databases.

Grey Literature and Hand Searches

Dates for Search:	April 7, 2010
Keywords:	Included terms for telecardiology, telemedicine
Limits:	Publication years 2005–present

This section lists the main agencies, organizations, and websites searched; it is not a complete list.

Health Technology Assessment Agencies

Alberta Heritage Foundation for Medical Research (AHFMR)
http://www.ahfmr.ab.ca

Agence d'évaluation des technologies et des modes d'intervention en santé (AETMIS), Quebec
http://www.aetmis.gouv.qc.ca

Canadian Agency for Drugs and Technologies in Health (CADTH)
http://www.cadth.ca

Centre for Evaluation of Medicines (Father Sean O'Sullivan Research Centre, St. Joseph's Healthcare Hamilton, and McMaster University, Faculty of Health Sciences, Hamilton, Ontario)
http://www.thecem.net/

Centre for Health Services and Policy Research, University of British Columbia
http://www.chspr.ubc.ca/cgi-bin/pub

Health Quality Council of Alberta (HQCA)
http://www.hqca.ca

Health Quality Council, Saskatchewan
http://www.hqc.sk.ca/

Institute for Clinical Evaluative Sciences (ICES), Ontario
http://www.ices.on.ca/

Institute of Health Economics (IHE), Alberta
http://www.ihe.ca/

Manitoba Centre for Health Policy (MCHP)
http://www.umanitoba.ca/medicine/units/mchp/

Ontario Ministry of Health and Long-Term Care, Health Technology Assessment Series
http://www.health.gov.on.ca/english/providers/program/mas/tech/tech_mn.html

The Technology Assessment Unit of the McGill University Health Centre
http://www.mcgill.ca/tau/

Therapeutics Initiative, University of British Columbia
http://www.ti.ubc.ca

Health Technology Assessment International (HTAi)
http://www.htai.org

International Network for Agencies for Health Technology Assessment (INAHTA)
http://www.inahta.org

WHO Health Evidence Network
http://www.euro.who.int/HEN

Australian Safety and Efficacy Register of New Interventional Procedures – Surgical (ASERNIP-S)
http://www.surgeons.org/Content/NavigationMenu/Research/ASERNIPS/default.htm

Centre for Clinical Effectiveness (Monash University)
http://www.med.monash.edu.au/healthservices/cce/

Medicare Services Advisory Committee (Department of Health and Ageing)
http://www.msac.gov.au/

National Prescribing Service Ltd. (NPS), Rational Assessment of Drugs and Research (RADAR)
http://www.npsradar.org.au/site.php?page=1&content=/npsradar%2Fcontent%2Farchive_alpha.html

ITA — Institute of Technology Assessment
http://www.oeaw.ac.at/ita/index.htm

Federaal Kenniscentrum voor de Gezondheidszorg
http://www.kenniscentrum.fgov.be

Danish Centre of Health Technology Assessment (DACEHTA), National Board of Health
http://www.dihta.dk/

Danish Institute for Health Services Research (DSI)
http://www.dsi.dk/frz_about.htm

Finnish Office for Health Technology and Assessment (Finohta), National Institute for Health and Welfare
http://finohta.stakes.fi/EN/index.htm

L'Agence nationale d'accréditation et d'évaluation en santé (ANAES), Ministère de la santé, de la famille et des personnes handicapées
http://www.anaes.fr/anaes/anaesparametrage.nsf/HomePage?ReadForm

Committee for Evaluation and Diffusion of Innovative Technologies (CEDIT)
http://cedit.aphp.fr/english/index_present.html

German Institute of Medical Documentation and Information (DIMDI), Federal Ministry of Health
http://www.dimdi.de/static/de/hta/db/index.htm

Health Service Executive
http://www.hse.ie/

College voor zorgverzekeringen / Health Care Insurance Board (CVZ)
http://www.cvz.nl

Health Council of the Netherlands
http://www.gezondheidsraad.nl/

New Zealand Health Technology Assessment (NZHTA)
http://nzhta.chmeds.ac.nz/

Norwegian Knowledge Centre for the Health Services
http://www.kunnskapssenteret.no/forsiden

Agencia de Evaluación de Tecnologías Sanitarias (AETS), Instituto de Salud "Carlos III" / Health Technology Assessment Agency
http://www.isciii.es/htdocs/investigacion/Agencia_quees.jsp

Basque Office for Health Technology Assessment (OSTEBA), Departemento de Sanidad
http://www.osasun.ejgv.euskadi.net/r52-2536/es/

Catalan Agency for Health Technology Assessment and Research (CAHTA)
http://www.gencat.cat/salut/depsan/units/aatrm/html/ca/Du8/index.html

CMT — Centre for Medical Technology Assessment
http://www.cmt.liu.se

Swedish Council on Technology Assessment (SBU)
http://www.sbu.se/sv

Swiss Network for Health Technology Assessment
http://www.snhta.ch

International Information Network on New and Emerging Health Technologies (EuroScan), University of Birmingham, National Horizon Scanning Centre
http://www.euroscan.bham.ac.uk

National Horizon Scanning Centre (NHSC)
http://www.pcpoh.bham.ac.uk/publichealth/horizon

NHS National Institute for Health and Clinical Excellence (NICE)
http://www.nice.org.uk

NHS Quality Improvement Scotland
http://www.nhshealthquality.org

Centre for Reviews and Dissemination (CRD), University of York
http://www.york.ac.uk/inst/crd

The Wessex Institute University of Southampton
http://www.wihrd.soton.ac.uk/

West Midlands Health Technology Assessment Collaboration (WMHTAC)
http://www.wmhtac.bham.ac.uk

Agency for Healthcare Research and Quality (AHRQ)
http://www.ahrq.gov/

US Department of Veterans Affairs, Research & Development, general publications
http://www.research.va.gov/resources/pubs/default.cfm

VA Technology Assessment Program (VATAP)
http://www.va.gov/vatap/

ECRI Institute
http://www.ecri.org/

Institute for Clinical Systems Improvement
http://www.icsi.org/index.asp

Technology Evaluation Center (TEC), BlueCross BlueShield Association
http://www.bluecares.com/tec/index.html

University HealthSystem Consortium (UHC)
http://www.uhc.edu/

Health Economic

Centre for Health Economics and Policy Analysis (CHEPA), Department of Clinical Epidemiology and Biostatistics, Faculty of Health Sciences, McMaster University
http://www.chepa.org

Health Economics Research Group (HERG), Brunel University
http://www.brunel.ac.uk/about/acad/herg

Health Economics Research Unit (HERU), University of Aberdeen
http://www.abdn.ac.uk/heru/

The Hospital for Sick Children (Toronto), PEDE Database
http://pede.ccb.sickkids.ca/pede/index.jsp

University of Connecticut, Department of Economics, RePEc database
http://ideas.repec.org

Conferences

American Telemedicine Association
2009–onwards

Canadian Society of Telehealth
2009–onwards

Search Engines

Google
http://www.google.ca/

APPENDIX 2: SELECTION OF PUBLICATIONS