

## ■ Pediatric Cochlear Implantation in Canada: Results of a Survey

## ■ Résultats d'une enquête sur l'implantation cochléaire pédiatrique au Canada

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### Abstract

This paper presents the results of a survey of Canadian pediatric cochlear implant centres. The survey was conducted in 2006 to determine the number of children who received cochlear implants and to examine trends in pediatric implantation in Canada between 1995 and 2005. All 12 Canadian programs, including nine surgical and three non-surgical centres, returned the questionnaire. The results showed that there has been significant growth in pediatric cochlear implantation since the previous survey was completed in 1995. A total of 1,406 children received implants in Canadian centres in the 11-year time period covered by this survey, with an average of 174 children being implanted annually from 2001 to 2005. Two major trends in recent years include the implantation of children at younger ages and the implantation of children with complex developmental disabilities. Primary issues of interest for clinicians included candidacy issues, outcome measures and bilateral implantation. These data provide baseline information about pediatric cochlear implant service provision that may assist in program planning and resource allocation.

### Abrégé

Cet article présente les résultats d'une enquête sur les centres pédiatriques canadiens d'implants cochléaires. Cette enquête a été menée en 2006 pour déterminer le nombre d'enfants qui ont reçu un implant cochléaire et pour examiner les tendances d'implantation chez les enfants au Canada de 1995 à 2005. Le personnel de douze programmes au Canada, soit les neuf centres de chirurgie et les trois centres qui ne pratiquent pas de chirurgie, a rempli le questionnaire. Les résultats montrent qu'il y a eu une croissance significative de l'implantation cochléaire pédiatrique depuis l'enquête précédente menée en 1995. Au total, 1 406 enfants ont reçu un implant dans les centres canadiens au cours de la période de 11 ans couverte par la présente enquête, avec en moyenne 174 enfants ayant reçu un implant cochléaire annuellement de 2001 à 2005. Deux grandes tendances des dernières années comprennent l'implantation chez des enfants de plus en plus jeunes et l'implantation chez des enfants ayant des déficiences complexes du développement. Les questions d'intérêt pour les cliniciens sont l'admissibilité des candidatures, les indicateurs de résultats et l'implantation bilatérale. Ces données fournissent des renseignements de base sur les services pédiatriques d'implantation cochléaire pouvant contribuer à la planification de programmes et à l'affectation des ressources.

**Key words:** cochlear implant, pediatric, survey, services

**C**ochlear implant technology has dramatically impacted the management of children with severe to profound hearing loss. Pediatric cochlear implantation was first approved by the Federal Drug and Administration Agency (FDA) in 1990 and has rapidly become a standard intervention in much of the world for children with significant hearing loss whose families choose spoken communication. A Canadian survey reported that 168 children from Canada had received cochlear implants by 1994 (Brewster & Fitzpatrick, 1995). As funding

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allocations increased and cochlear implant candidacy criteria expanded, the number of cochlear implants provided annually as well as the number of Canadian centres has grown. Although cochlear implantation has become standard care, the availability and practice of providing pediatric cochlear implants has varied throughout Canada with different programs being introduced and funded at different times in the past 10 to 15 years. In the absence of a national database, little systematic information is available about the number of children receiving cochlear implants in Canada, the growth in cochlear implantation in the past 10 to 15 years and the trends in cochlear implant candidacy.

A survey of pediatric cochlear implant centres was undertaken in 2006 to update a previous Canadian survey published in 1995 (Brewster and Fitzpatrick, 1995). The objectives of the survey were to provide 1) a profile of pediatric cochlear implantation in Canada including the numbers and ages of children receiving implants, 2) a description of cochlear implant teams and services provided in Canada, 4) a description of changes and trends in cochlear implantation and 5) current concerns and issues for clinicians providing pediatric implant services.

### Method

The current survey of Canadian cochlear implant centres was undertaken in 2006. Using the 1995 survey as a guideline, questions were developed with input from and reviewed by the Canadian Working Group on Cochlear Implants in Children, a group assembled by the Canadian Association of Speech-Language Pathologists and Audiologists (CASLPA) in 2003 to update the 1995 Position paper on cochlear implants in children (Canadian Association of Speech-Language Pathologists and Audiologists, 2006; Durieux-Smith, Delicati, Brewster, Fitzpatrick, & Phillips, 1995).

For the purposes of this survey, a cochlear implant centre/program was defined as a hospital program that provided cochlear implantation including candidacy evaluation, surgery and follow-up or a program that provided cochlear implant services without on-site surgery. Although it was recognized that several other programs in Canada provide educational management services for children with cochlear implants, a decision was made to limit the survey to those non-surgical centres that were specifically responsible for cochlear implant evaluation and management, in an effort to avoid duplication in the information collected. Prior to undertaking the survey, we identified nine cochlear implant programs located in six provinces that provided a surgical component and three additional cochlear implant programs where surgery was accessed in other provinces. These 12 centres constituted the sample for this study.

The final questionnaire, entitled, "CASLPA Pediatric Cochlear Implant Survey", was a five-page survey that

requested information from each centre on the cochlear implant team composition, numbers of children implanted per year from 1995 to the end of 2005, the age categories of patients, the number of children with additional disabilities, and services provided by the implant program. In addition, the survey contained questions that probed concerns, issues and topics of interest in pediatric cochlear implantation. The research received ethics approval from the Children's Hospital of Eastern Ontario Research Ethics Board. The survey was sent to the 12 program coordinators (or designated individuals) in May 2006 followed by two reminder notices.

### Results

A total of 12 centres returned the survey resulting in a response rate of 100%. All but two of the provinces reported that pediatric cochlear implants are provided through one provincial cochlear implant centre. Ontario has three regional centres in Toronto, London and Ottawa and Alberta has two centres located in Edmonton and Calgary. Four provinces, Prince Edward Island, New Brunswick, Manitoba, and Saskatchewan, do not provide surgical services within the province. However, all provinces except Prince Edward Island identified a dedicated cochlear implant service. There are no known cochlear implant centres in Canada's three northern territories. The nine surgical centres and three non-surgical centres are detailed in Table 1, along with the number of children implanted from 1995 to 2005.

All nine hospital surgical programs are publicly funded through their respective provincial ministries of health. Surgeries performed out of province are funded through reciprocal funding agreements. Two non-surgical programs also reported that services are partially funded through other agencies and/or private fundraising. As shown in Table 1, the majority of the nine surgical centres reported that implants are allocated on a quota system. In some cases, the quota system was reported as a total number of implants for both adults and children. The four pediatric only centres all reported that a specific annual quota system is applied. Newfoundland and Saskatchewan identified a specific provision for the upgrading of equipment through public funding sources. In addition, Ontario provides partial financial assistance for speech processor upgrades. Other centers indicated that families were referred to charitable organizations or were provided financial support on a case-by-case basis.

### Team Composition and Services

Cochlear implant programs reported the provision of a wide range of services including candidacy evaluation, surgery, speech processor programming, therapy services and consultation services to schools and other intervention programs. As detailed in Table 2, the cochlear implant teams continue to consist of a wide range of professionals. In addition to the surgeon and on-site audiologist, all hospital programs included a family/social worker and/or psychologist with seven of the nine surgical centres

**Table 1**  
*Description of Canadian Cochlear Implant Centers and number of pediatric implants*

Center	Total Implants to 1995 <sup>1</sup>	Pediatric Implants 1995- 2005	Annual Quota
B.C. Children's Hospital	13	126	Yes
Glenrose Rehabilitation Hospital	33	61	No
Alberta Children's Hospital	9	64	Set annually
London Health Sciences Centre	18	75	Yes
Hospital for Sick Children	20	483	Yes
Children's Hospital of Eastern Ontario	8	207	Yes
L'Hotel Dieu de Quebec	49	260	Quota for children/adults
Nova Scotia Cochlear Implant Program	0 <sup>2</sup>	42	Yes
Newfoundland Health Care Corporation	0 <sup>2</sup>	11	Yes
Saskatchewan Cochlear Implant Program	6 <sup>3</sup>	77 <sup>3</sup>	No quota
Central Speech and Hearing Clinic	2 <sup>4</sup>	36 <sup>4</sup>	No quota
New Brunswick Cochlear Implant Program	0 <sup>5</sup>	0 <sup>6</sup>	No quota

Notes. <sup>1</sup> Extracted from 1995 survey (Brewster & Fitzpatrick, 1995); <sup>2</sup>Program established in 2001; <sup>3</sup>Surgeries were performed at other centres but were not reported in other centres' numbers; <sup>4</sup>Surgeries were performed at other centres and included in other centres' numbers; <sup>5</sup>Program established in 2005; <sup>6</sup>Surgeries performed at other centres and were not reported separately.

including both of these disciplines as part of the cochlear implant centre team. All programs reported that specific resources were allocated to coordination of the cochlear implant program and all identified some level of administrative support consisting of program assistance or administrative personnel; one program identified technical support personnel. Three programs specifically reported dedicated research personnel although in some cases, this appeared to be funded outside the cochlear implant program budgets, for example, through a university. The three non-surgical programs in Saskatchewan, Manitoba, and New Brunswick all included an audiologist and administrative support. Saskatchewan also reported additional psychosocial support services. New Brunswick did not report therapy services. The time allocated per professional varied greatly across clinics and did not seem to reflect the number of annual implants and/or total number of children serviced. This may be because the frequency of the therapy varies as a function of the time since implantation and because various components of service are provided through other resources, for example, the educational system.

As indicated by several respondents, cochlear implant services now extend well beyond the specific provincial cochlear implant centres to include service provision in the community and school system particularly with

respect to rehabilitation/therapy. For example, while early implant programs assumed the major responsibility for the rehabilitation of children with implants, in the current survey, several programs reported that children were primarily managed through community and school resources. Seven of the 12 centres reported that pre-school rehabilitation is primarily managed through the implant center. However, rehabilitation for school age children is managed primarily outside the clinical program either through the school system or in conjunction with school services. In two programs, a specific 2-year time period for post-implant rehabilitation at the clinic was identified. The Quebec program reported that it provides a 12-week intensive rehabilitation service for all recipients, following which services are provided by the various rehabilitation and school resources.

### Patient Selection Criteria

Patient selection criteria were provided by 8 of the 12 centres. Two of these centres indicated that they followed device manufacturers' candidacy criteria. The primary change in selection criteria from the 1995 survey involved lower age at implantation and the implantation of children with more residual hearing. The majority of centres reported the following common criteria: 1) age 12 months to 18 years, 2) severe to profound (or profound hearing loss for younger children) bilateral sensorineural

**Table 2**  
*Composition of Pediatric Cochlear Implant Teams*

Center	Surgeon	Audiologist	Therapist <sup>1</sup>	Social Worker	Psychologist	Other <sup>2</sup>
B.C. Children's Hospital	✓	✓	✓	✓	✓	Admin Support
Glenrose Rehabilitation Hospital	✓	✓	✓	✓	✓	- Program Assistant - Parent Liaison
Alberta Children's Hospital	✓	✓	✓	✓	✓	Program Assistant
London Health Sciences Centre	✓	✓	✓	✓	✓	-Admin Support -Psychiatrist
Hospital for Sick Children	✓	✓	✓	✓		- Program Assistant - Admin Support - Researcher
Children's Hospital of Eastern Ontario	✓	✓	✓	✓	✓	-Program Assistant - Nurse - Researcher
L'Hotel Dieu de Quebec	✓	✓	✓	✓	✓	-Technical Support Researcher
Nova Scotia Cochlear Implant Program	✓	✓	✓	✓		Admin Support
Newfoundland Health Care Corporation	✓	✓	✓		✓	- Admin Support
Saskatchewan Cochlear Implant Program		✓	✓	✓	✓	Program Assistant
Central Speech and Hearing Clinic		✓	✓			- Program Assistant - Admin Support
New Brunswick Cochlear Implant Program		✓				- Program Assistant

*Notes.* <sup>1</sup>The term therapist is used to identify professionals involved in providing rehabilitation services (other than programming of the speech processor) and may include auditory-verbal therapists, teachers/educators of the hearing-impaired, and speech-language pathologists. <sup>2</sup>In this survey, the term program assistant was used to refer to specific support in audiology or speech-language pathology, the term 'admin support' includes administrative support service, coordination, and management (e.g., director).

hearing loss, 3) minimal progress with conventional amplification, 4) no medical/radiologic contraindications, and 5) appropriate family and child (where applicable) expectations and motivation. There was some variation in other criteria; for example, two programs specified that children were required to enroll in an auditory-verbal therapy program post-implantation and to attend an educational program with a focus on auditory development. Three programs specifically stated that older children (e.g., 6 years) who used sign language as their primary communication mode were not eligible for implantation. Other centres elaborated on the functional ability of the child in some detail. For example, one centre reported that it had identified and was refining a list of specific criteria with indicators in order to develop consistent evidence-based criteria for candidate selection.

### Growth in Pediatric Cochlear Implantation

The number of children who received cochlear implants in Canada from 1995 to 2005 are displayed in Figure 1 for the entire country and grouped by four regions: Atlantic provinces (Newfoundland, Nova Scotia, and New Brunswick programs), Quebec, Ontario and Western Canada (Manitoba, Saskatchewan, Alberta and British Columbia). These data reflect the number of children who received cochlear implants, rather than the number of cochlear implant devices. It is important to note that at the time this survey was developed, bilateral cochlear implantation was not typically available in the Canadian clinical context and therefore data were not collected on bilateral implant surgeries. Amalgamating the data from the 1995 survey (Brewster & Fitzpatrick, 1995), 1,562 children had received cochlear

implants in Canada by the end of 2005 (156 surgeries to 1994 and 1406 surgeries from 1995 to 2005). At least 12 additional children as reported in the 1995 survey have received implants outside Canada. No additional data were captured in the current survey on the number of children undergoing surgery outside Canada.

As seen in Figure 1, while there was significant and steady annual growth in the total numbers of surgeries from 1995 through 2001, the number of children implanted in the last 5 years appears to have stabilized between 163 to 184 (median, 174) children annually. The most significant growth was in the period 1998 to 2001 when the number of annual surgeries more than doubled from 72 in 1997 to 165 in 2001.

### Changes in age at cochlear implantation

Figure 2 displays the number of children implanted in Canadian centres between 1995 and 2005 by age and year of implantation. Consistent with expanded FDA/Health Canada criteria for age of implantation, important differences are apparent in the age at implantation over the past 11 years captured in this survey. Prior to 2000, no children under the age of 12 months received cochlear implants in Canada. About 25 to 30% of the population (e.g., 36 of 118 in 1999) was implanted before the age of 3 years. In contrast, since 2000, children under age 12 months have been implanted at four different Canadian centers. Almost 50% of the children implanted between 2000 and 2005 received their implants by 3 years of age. Despite the trend towards earlier age at implantation, each year an additional 30 to 40% of children receive cochlear implants after 5 years of age. Since 2000, 50 to 65 of the children implanted annually are in the 5 to 18 year age range. Children over age 11 account for 9 to 17% of the children implanted annually since 2000. This may reflect the change in selection criteria to include children with more residual hearing.

### Children with additional disabilities

The questionnaire specifically requested centers to report the number of children with disabilities, defined for this survey as a disability, in addition to hearing impairment that would interfere with typical communication development. Between 1995 and 2005, 77 children (5.5%) of the children implanted in Canada presented with additional disabilities. One centre reported having implanted no children with additional disabilities and one centre did not provide this information. The number of children with additional disabilities as a proportion of the total number of children implanted varied across centres, ranging from 4 to 36%. Two centres reported the first implantations of children with

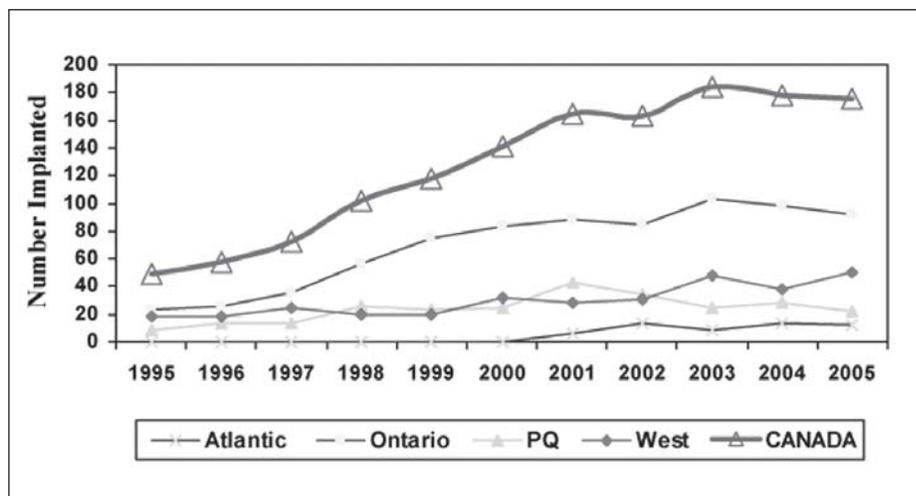


Figure 1. Pediatric cochlear implant surgeries in Canada by region (1995-2005)

other disabilities prior to 2000; however, in most centres, there seemed to be a trend towards implantation of children with additional disabilities in 2000 to 2001 with the number increasing in subsequent years as shown in Figure 3. In 2005, a total of 16 children with additional disabilities were reported to have been implanted in 8 centres, representing 9.1 % of the total number of children receiving implants. Overall, children with additional disabilities represented a diverse group, the largest numbers being children with 1) cerebral palsy accompanied by developmental delay, 2) CHARGE syndrome, and 3) developmental/cognitive delays. Other disabilities included blindness, autism and a variety of other syndromes.

### Clinical Considerations

Several questions on the survey looked at the centres' practices with respect to recommendations for immunizations, FM technology, and changes or new developments in cochlear implant technology generally. All but one cochlear implant program (which strongly recommended it) required specific immunization against meningitis pre-surgery. The use of FM technology is routinely recommended by all centers, the majority identifying the personal FM system as the system of choice; however, two centres reported that they recommend a personal and soundfield FM system, while others prescribe one or the other depending on the particular situation. The majority of centres prioritized the selection of an FM device based on the following three factors: auditory sophistication of child, educational setting, and age of child. Cost did not seem to be an important consideration in the choice of FM devices. The centres' views on important device changes or developments were classified into three main categories: 1) improved troubleshooting capabilities for clinician and parent (e.g., built-in

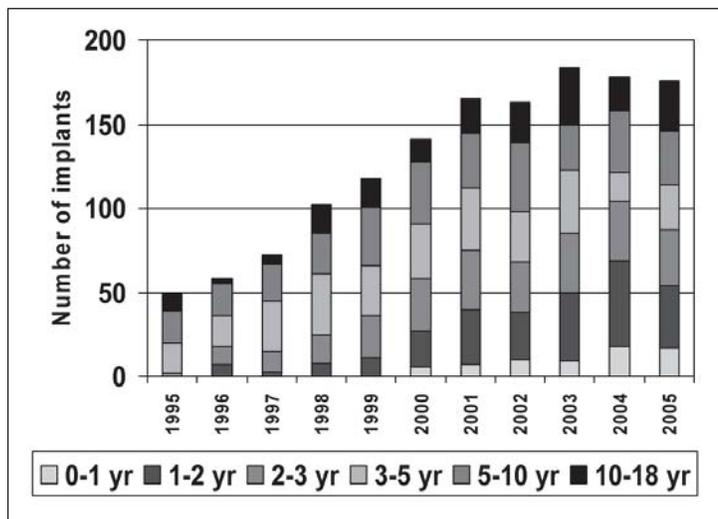


Figure 2. Age of implantation by year (n=1,406)

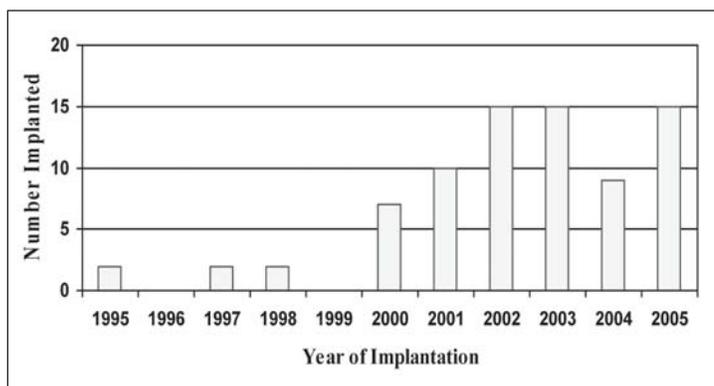


Figure 3. Cochlear implants: children with additional disabilities (n=77)

telemetry, alarms, etc.), 2) esthetic changes (e.g., smaller behind-the-ear speech processor), and 3) improved battery technology (e.g., smaller and longer battery life).

A final component of the questionnaire probed clinicians' perspectives on current clinical issues and concerns for Canadian centres. Specifically, respondents were asked to list topics which could be addressed in a Canadian discussion forum. Four primary topic areas emerged: 1) evidence-based outcome, 2) candidacy issues, 3) bilateral implantation, and 4) equipment/technical issues. Outcome issues related to outcome for various populations including complex cases, non-users, and outcome in children who use sign language. As well, respondents identified broader definitions of outcome as well as quality of life outcomes as areas of interest. Candidacy issues included the following: candidates with 'borderline' hearing, children with additional disabilities, choice of ear to ear implant, and the implantation of older children who sign. Bilateral implantation was

identified as a topic of interest, particularly regarding the selection of appropriate candidates. Finally, a variety of technical issues were raised including objective speech processor programming and FM systems with cochlear implants. In addition to these main topics, other items of interest included transitioning to adult rehabilitation and university programs.

### Discussion

This paper summarizes the results of a survey that examined the status of pediatric cochlear implantation in Canada. Building on an early Canadian survey reported in 1995 (Brewster & Fitzpatrick, 1995), the questionnaire collected information from 12 Canadian cochlear implant centres in nine provinces. The survey was intended to provide a snapshot of service provision in pediatric implantation from 1995 to 2005. Currently pediatric cochlear implant surgical services are available in nine centres and three other programs provide candidacy evaluation, and/or cochlear implant management. The majority of centres were already providing services prior to 1995 but two new surgical centres in Nova Scotia and Newfoundland and one satellite program in New Brunswick were established since 2001. In addition to the 156 children who had received cochlear implants in Canada by 1994 (Brewster & Fitzpatrick, 1995), 1,406 children were implanted in the 11-year period covered by this survey, resulting in a total of 1,562 children in the 0 to 18 year old age range who had undergone cochlear implantation in Canadian centres by 2005. Currently, about 174 children are implanted annually in Canada.

Two trends emerged in the data: 1) the implantation at an earlier age including an increasing number of children under age 12 months in recent years and 2) the implantation of an increasing number of children with additional disabilities since 2000. Despite the increase in earlier age of implantation, it is noteworthy that a significant number of children over age 5 continue to be implanted in all centres. This may reflect a lack of access to cochlear implantation at earlier ages, changes in criteria (e.g., implantation of children with residual hearing) or a significant number of children with progressive or later onset of profound hearing loss. Program changes consisted primarily of a broadening out to the larger community of care for children with hearing impairment such that rehabilitation services are frequently provided outside the specific cochlear implant centres.

An important limitation of this research is that given the time required to collect and analyze the information, new issues and practices in cochlear implantation have not been captured in this questionnaire, which documents services to the end of 2005. A particularly noteworthy fact is that certain

Canadian centres are now providing bilateral implantation either as standard clinical care or through research programs. Finally, the questionnaire was completed by program coordinators who are audiologists, and therefore may not reflect fully the views and concerns of other team members.

Notwithstanding, as the only survey of its type in Canada, we believe the data presented here reflect a fairly accurate picture of the Canadian situation and highlight issues and concerns raised by clinicians working in pediatric implantation in a publicly funded context. Although this survey is limited by the rapid changes in cochlear implantation technology, candidacy criteria, and standards of practice, we suggest that the findings will be of interest to service providers and to those who make health policy decisions. This information provides a baseline of Canadian pediatric cochlear implant services to the year 2005, against which future program development and growth can be measured. The insights from this survey are a starting point for informed discussions and can be used to identify key areas of clinical and research needs in pediatric cochlear implantation.

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### Author Note

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