Physicians' prevention practices and incidence of neonatal group B streptococcal disease in 2 Canadian regions

H. Dele Davies,[*†‡] Carol E. Adair,[‡] Anne Schuchat,[§] Donald E. Low,[¶] Reg S. Sauve,[*‡] Allison McGeer,[¶] the Alberta Neonatal Group B Streptococcal Network[**] and the Toronto Invasive Bacterial Diseases Network[**]

Abstract

Background: The impact of expert guidelines on the prevention of neonatal group B streptococcal (GBS) disease has not been studied in Canada. Our aim was to determine physician practices with regard to this condition before and after publication of Canadian guidelines and to monitor concurrent trends in the incidence of neonatal GBS disease.

Methods: We used repeat cross-sectional surveys, distributed by mail to all family practitioners and obstetricians attending deliveries in Alberta and in the Metropolitan Toronto and Peel region, Ontario, in 1994, 1995 and 1997, to document prevention practices. Audits were conducted for a subset of respondents to confirm reported practices. Population-based surveillance involving all microbiology laboratories in both regions for 1995–1998 was used to document rates of neonatal disease.

Results: The overall survey response rates were as follows: for 1994, 1128/1458 (77%); for 1995, 1054/1450 (73%); and for 1997, 1030/1421 (72%). During 1995 and 1997, significantly more obstetric care providers were screening at least 75% of pregnant women in their practices than had been the case in 1994 (747/916 [82%] and 693/812 [85%] v. 754/981 [77%]; $p < 0.001$). The percentage of obstetric care providers who reported practice that conformed completely with any of 3 consensus prevention strategies increased from 10% in 1994 to 29% in 1997 ($p < 0.001$). There was a concurrent overall significant decrease in incidence of neonatal GBS disease during the same period.

Interpretation: The adoption by Canadian obstetric care providers of neonatal GBS prevention practices recommended by expert groups was slow but improved significantly over time. These findings highlight the difficulties associated with achieving compliance with diverse and frequently changing recommendations. However, the associated incidence of neonatal GBS disease, which was low or declining, suggests that efforts to disseminate current GBS prevention guidelines have been moderately successful.

Group B streptococcus (GBS; causative organism *Streptococcus agalactiae*) is the most frequent cause of serious neonatal infection in North America.[1–5] Although there is agreement in the literature about the effectiveness of intrapartum antibiotic chemoprophylaxis,[6,7] controversy has arisen as to how best to identify which women should receive such therapy. Many different approaches have been presented.[8–12] In Canada the 1994 consensus policy statement by the Canadian Paediatric Society and the Society of Obstetricians and Gynaecologists of Canada[13,14] recommended 1 of 2 approaches (Table 1). The first was the risk-based approach first recommended by the American College of Obstetricians and Gynecologists,[15,19]

Research

Recherche

From the Departments of *Paediatrics, of †Microbiology and Infectious Diseases, and of ‡Community Health Sciences, University of Calgary, Calgary, Alta.; the §Centres for Disease Control and Prevention, Atlanta, Ga.; and the ¶Shared Department of Microbiology, Mount Sinai and Princess Margaret Hospitals, University of Toronto, Toronto, Ont.

****Members of the Alberta Neonatal Group B Streptococcal Network and the Toronto Invasive Bacterial Diseases Network are listed at the end of the article.**

This article has been peer reviewed.

CMAJ 2001;164(4):479-85

Return to February 20, 2001 Table of Contents

and the second was the screening-based approach of the American Academy of Pediatrics.[18] In 1997 the Society of Obstetricians and Gynaecologists of Canada[20] endorsed a US joint consensus guideline that recommended either later screening or a risk-based approach.[16]

Considerable evidence exists that implementation of any one of these guidelines significantly reduces the risk of early-onset neonatal GBS disease.[16] However, implementation is complex, and initial surveys of practice suggested that guideline adoption was slow.[21–25] We undertook this study to assess changes in obstetric practice and neonatal GBS disease in 2 Canadian regions after the introduction of guidelines.

Methods

All physicians providing obstetric care in Alberta (population 2 688 100, with 39 654 live births in 1994) and the Metropolitan Toronto and Peel region, Ontario (population 3 124 554, with 49 054 live births), were identified by contacting all hospitals serving residents of these 2 areas in 1994. The lists of physicians were updated in 1995 and 1997.

Table 1. Summary of expert screening guidelines for prevention of early-onset neonatal group B streptococcal (GBS) infections

Prevention strategy	Groups endorsing strategy
(A) No universal screening, but intrapartum chemoprophylaxis for all women with identified risk factors*	American College of Obstetricians and Gynecologists (in 1993)[15] Canadian consensus group† (in 1994)[13,14] Centers for Disease Control and Prevention, American College of Obstetricians and Gynecologists, and American Academy of Pediatrics‡ (in 1996)[16,17]
(B) Universal antenatal screening at 26–28 weeks gestational age with a single combined vaginal–anorectal swab and selective intrapartum chemoprophylaxis for GBS culture-positive women with identified risk factors or women with risk factors and unknown colonization status	American Academy of Pediatrics (in 1992)[18] Canadian consensus group† (in 1994)[13,14]
(C) Universal antenatal screening at 35–37 weeks gestational age with a single combined vaginal–anorectal swab and intrapartum chemoprophylaxis for all GBS carriers, and all women with preterm delivery, a prior infant with GBS or GBS bacteriuria	Centers for Disease Control and Prevention, American College of Obstetricians and Gynecologists, and American Academy of Pediatrics‡ (in 1996)[16,17]

*Risk factors: preterm labour (< 37 weeks gestational age), term labour (≥ 37 weeks gestational age) with either prolonged rupture of membranes (> 18 hours) or maternal fever (temperature > 38.0°C), previous delivery of a newborn with GBS disease, and previously documented GBS bacteriuria.

†Either strategy A or B is acceptable. The antibiotic regimen of choice is ampicillin (2 g intravenously initially, followed by 1–2 g intravenously every 4–6 hours) or penicillin G (5 million units every 6 hours) until delivery or until labour is stopped. Women with allergy to penicillin may be given clindamycin (300–600 mg intravenously every 8 hours). The Canadian consensus group consisted of the Canadian Paediatric Society and the Society of Obstetricians and Gynaecologists of Canada.

‡Either strategy A or C is acceptable. Antibiotic regimen of choice is penicillin G (5 million units intravenous load, followed by 2.5 million units intravenously every 4 hours until delivery) or ampicillin (2 g initially, followed by 1 g every 4 hours) or until delivery or until labour is stopped. Women with allergy to penicillin may be given clindamycin (900 mg intravenously every 8 hours) or erythromycin (500 mg intravenously every 6 hours) until delivery.

The survey instrument was developed by a group of pediatricians, obstetricians and epidemiologists, all of whom were members of one of the investigating networks, and included questions related to knowledge of neonatal GBS disease and to attitudes and practices related to screening and intrapartum prophylaxis. The survey was pretested on a sample of physicians from both regions (45 in total). Surveys were conducted in 1994, 1995 and 1997. The surveys were distributed by means of 2 mailings and a reminder card.[26] Toronto physicians preferring anonymity could tear off an identifying number.

All microbiology laboratories serving residents of Alberta (n = 38) and the Metropolitan Toronto and Peel region (n = 32) participated in active surveillance for invasive early-onset GBS disease, defined as isolation of GBS from a normally sterile site in infants younger than 7 days of age. Monthly telephone calls and annual audits were used to ensure that no cases were missed.

A subset of 400 deliveries was randomly selected from all births to mothers resident in Metropolitan Toronto and Peel region in 1995–1996. For each delivery, maternal and neonatal charts were reviewed, and abstracted data were compared with reported practice of the care provider who had most responsibility for prenatal care.

All study elements were approved by the ethics boards of the Universities of Calgary and Toronto.

Responses to specific questions were combined to identify practice patterns congruent with 3 preventive strategies (strategies A, B and C in Table 1). Practice was defined as congruent with strategy A if the physician reported no routine screening, provision of prophylaxis to all women with risk factors and correct identification of risk factors. Practice congruent with strategy B involved screening of more than 95% of pregnant women by means of vaginal or combined vaginal–anorectal swabs at 26–28 weeks, with prophylaxis given to women with colonization and risk factors or to women with risk factors and unknown colonization status. Practice congruent with strategy C involved screening of more than 95% of pregnant women by means of vaginal or combined swabs at 35–37 weeks, with antibiotics given to all women with colonization, as well as women with preterm delivery, those with a prior infant with GBS and those with GBS bacteriuria.

We used χ^2 tests to test differences in proportions. The χ^2 approximation for Poisson counts was used to compare rates of GBS disease across years. For Alberta data, generalized estimating equations[27] were used to model correlates of conformity to practice patterns, while adjusting for the correlations in data resulting from the same individuals responding up to 3 times. This analysis could not be performed for the Toronto data, because 25% of the surveys were returned anonymously.

Results

The overall survey response rates were 77% in 1994 (675/884 [76%] for Alberta and 453/574 [79%] for Toronto), 73% in 1995 (651/888 [73%] for Alberta and 403/562 [72%] for Toronto) and 72% in 1997 (655/855 [77%] for Alberta and 375/566 [66%] for Toronto). Family practitioners accounted for 89% of obstetric providers in

Alberta and 64% in Toronto. Most family practitioners (more than 94%) attended fewer than 100 deliveries annually, whereas most obstetricians (more than 80%) attended more than 100 deliveries per year.

In 1994, 754/981 (77%) of physicians reported screening at least 75% of their pregnant patients for GBS. During 1995 and 1997, significantly more physicians were screening at least 75% of their pregnant patients (747/916 [82%] in 1995, 693/812 [85%] in 1997, $p < 0.001$). Family practitioners were more likely to report routine antenatal screening than obstetricians (in 1994, 618/776 [80%] v. 136/205 [66%]; in 1997, 544/622 [87%] v. 149/190 [78%], $p < 0.001$), Alberta physicians more likely to report screening than those from Toronto (in 1994, 498/613 [81%] v. 257/371 [69%]; in 1997, 472/530 [89%] v. 225/286 [79%], $p < 0.001$), and in 1995 and 1997 all physicians were more likely to report screening than in 1994 (754/981 [77%] in 1994, 747/916 [82%] in 1995 and 687/816 [84%] in 1997; $p < 0.001$). In 1994 and 1995, but not 1997, those who had been attending deliveries for up to 15 years were more likely to screen routinely than those who had been attending for more than 15 years (in 1994, 558/731 [76%] v. 227/389 [58%], $p < 0.001$; in 1997, 420/545 [77%] v. 289/398 [73%], $p = 0.12$).

The most common reasons given for not screening (multiple reasons allowed) were use of risk factors alone to guide prophylaxis (41% of nonscreeners in 1994, 74% in 1995 and 87% in 1997), and beliefs that there were no clear guidelines (52% in 1994, 35% in 1995 and 24% in 1997), that screening was not cost-effective (44% in 1994, 44% in 1995 and 31% in 1997) and that screening was not useful (42% in 1994, 44% in 1995 and 35% in 1997). The proportions of physicians citing these reasons were similar for the 2 regions.

Most physicians (602/990 [61%]) who reported performing prenatal screening in 1994 used vaginal swabs. The proportion using combined vaginal–anorectal swabs increased from 252 (25%) of 990 providers in 1994 to 499 (61%) of 822 providers in 1997 ($p < 0.001$), whereas the proportion using cervical swabs decreased from 317 (32%) of 990 providers in 1994 to 99 (12%) of 822 providers in 1997 ($p < 0.001$). There was no change in the proportion of practitioners using cervical swabs exclusively (133/990 [13%] in 1994 and 100/822 [12%] in 1997).

During all survey years, screening was reported for every interval of gestation (Table 2). Although reported screening at the first prenatal visit declined between 1994 and 1997, 23% of Alberta and 31% of Toronto area providers reported screening at the first visit in 1997 (data not shown). About one-third of all practitioners indicated that they screened more than once (no change from 1994 to 1997; data not shown).

About 30% of physicians reported that they gave antibiotics antenatally to some or all women with GBS colonization, with the proportion increasing between 1994 and 1997 (Table 3). The most common reasons given were GBS colonization, patient request or GBS disease in a previous neonate. Use of intrapartum chemoprophylaxis also increased between 1994 and 1997 (Table 3). In 1994 physicians who had been attending deliveries for a longer period were less likely to give prophylactic antibiotics (176/209 [84%] of those who had been attending for less than 5 years, 403/524 [77%] of those who had been attending for 5–15 years and 223/388 [57%] of those who had been attending for more than 15 years, $p < 0.001$). In 1997 this difference was no longer present (131/135 [97%], 378/410 [92%] and 362/398 [91%] respectively; $p = 0.07$). Although physicians in Alberta and Toronto were equally likely to recommend prophylaxis to women with risk factors and unknown colonization status, Alberta physicians were more likely than those in Toronto to recommend prophylaxis to all women with colonization ($p < 0.001$ for all years), whereas Toronto physicians were more likely to recommend prophylaxis to all women with risk factors without screening during the latter years (in 1994, $p = 0.17$; in 1995, $p = 0.05$; in 1997, $p < 0.001$) (Table 3). In both regions, 88% of all physicians who prescribed prophylaxis correctly identified appropriate antibiotics (as described in Table 1). In general, obstetricians were more likely than family practitioners to correctly identify risk factors (Table 4).

In 1994 only 103/1051 (10%) of respondents reported practices congruent with any guideline. By 1997 this had increased to 279/979 (29%) of respondents (Fig. 1) ($p < 0.001$). In the generalized estimating equations model for Alberta, later year of survey (odds ratio [OR] for guideline compliance in 1997 compared with 1994 3.5; 95% confidence limits [CL] 2.4, 5.0; $p < 0.001$), training as an obstetrician (OR for obstetricians compared with family practitioners 2.1, 95% CL 1.3, 3.6; $p = 0.004$) and fewer years of practice (OR for less than 5 years compared with more than 15 years 1.6; 95% confidence limits 1.1, 2.4; $p = 0.015$) were significant predictors of practice congruent with a guideline.

Table 2: Reported timing of screening of pregnant women in 2 Canadian regions (Alberta and Toronto), 1994–1997

	No. (and %) of physicians reporting screening*		
Timing of screening	1994 *n = 991*	1995 *n = 919*	1997 *n = 822*
At first prenatal visit	402 (41)	322 (35)	210 (26)
Between first visit and 25 weeks	46 (5)	40 (4)	38 (5)
26–28 weeks	277 (28)	257 (28)	133 (16)
29–37 weeks	356 (36)	391 (43)	529 (64)†
> 37 weeks	86 (9)	67 (7)	50 (6)
At delivery	55 (6)	27 (3)	5 (1)

*Column totals exceed 100% because more than one response was permitted, and one-third of physicians reported screening more than once during pregnancy.
†In 1997, after the release of the new US consensus guidelines, the period 29–37 weeks was further broken down into 29–34 weeks and 35–37 weeks. Fifty percent of physicians reported screening between 35 and 37 weeks, and 14% reported screening between 29 and 34 weeks.

Written comments on the surveys suggested that physicians were reluctant to adopt the strategy of screening at 26–28 weeks gestational age and selectively administering prophylaxis to culture-positive women with risk factors because of medicolegal concerns about the consequences of not intervening during a pregnancy with an adverse outcome when the mother was known to have GBS colonization, reluctance to introduce a vaginal examination during the visit at 26–28 weeks and concerns about insufficient evidence for effectiveness.

Table 3. Specific GBS prophylactic practices in Alberta and Toronto, 1994–1997

	Year; no. (and %) of physicians*			
Prophylactic practice	1994	1995	1997	*p* value
Give antenatal antibiotics				
Alberta	157/674 (23)	194/645 (30)	173/558 (31)	< 0.01
Toronto	126/449 (28)	125/392 (32)	132/383 (34)	0.08
Give intrapartum antibiotics				
Alberta	500/674 (74)	505/566 (89)	483/515 (94)	< 0.001
Toronto	305/449 (68)	310/351 (88)	315/338 (93)	< 0.001
Pattern of intrapartum chemoprophylaxis†				
All women with GBS colonization				
Alberta	275 (55)	290 (57)	318 (66)	< 0.01
Toronto	82 (27)	81 (26)	124 (39)	< 0.001
All women with risk factors				
Alberta	147 (30)	220 (44)	204 (42)	< 0.01
Toronto	104 (34)	162 (52)	178 (56)	< 0.001
Women with both GBS colonization and risk factors				
Alberta	207 (42)	244 (48)	211 (44)	< 0.001
Toronto	197 (65)	196 (63)	169 (53)	< 0.001
Women with risk factors and unknown colonization status				
Alberta	202 (41)	282 (56)	293 (61)	< 0.001
Toronto	129 (43)	180 (58)	198 (62)	< 0.001
Total no. of physicians giving intrapartum chemoprophylaxis				
Alberta	496	505	483	
Toronto	303	309	319	

*Where sums of percentages exceed 100, more than one response was allowed.
†For practitioners who gave intrapartum prophylaxis.

Table 4. Knowledge of known risk factors for neonatal GBS disease by specialty*

	Year; specialty; no. (and %) of physicians			
	1994		1997	
Known risk factor	FP *n = 600*	Obstetrician *n = 199*	FP *n = 648*	Obstetrician *n = 206*
Onset of labour at < 37 weeks gestational age	346 (58)	135 (68)	435 (67)	161 (78)
Rupture of membranes at < 37 weeks gestational age	360 (60)	148 (74)	455 (70)	152 (74)
Rupture of membranes for >18 hours	371 (62)	121 (61)	436 (67)	147 (71)
Maternal fever > 37.5°C	470 (78)	157 (79)	539 (83)	188 (91)
GBS bacteriuria during pregnancy	278 (46)	129 (65)	391 (60)	166 (81)
Previous history of neonatal GBS disease	434 (72)	174 (87)	514 (79)	184 (89)

Note: FP = family practitioner.
*The results within specialties were similar in the 2 regions. The data from the 1995 survey were intermediate between the data for 1994 and those for 1997.

In the validation chart review (for Toronto only), 157 of the 400 charts involved deliveries by 77 attending physicians whose surveys were returned anonymously or were not returned at all. Among the remaining 243 charts (115 physicians), information on actual screening practices was available for 239, and reported and actual screening practices were congruent for 154 (64%) of the these. Intrapartum prophylaxis practice matched reported practice for 168 (76%) of 221 charts.

The incidence of early-onset neonatal GBS disease was lower in Alberta than Toronto and decreased from 1995 to 1998($p < 0.01$, Fig. 2).

Interpretation

Intrapartum chemoprophylaxis substantially reduces the risk of early-onset neonatal GBS disease.[28] Hospital-based series have demonstrated that the implementation of any one of several strategies to deliver antibiotics to women at risk reduces infection rates.[29,30] However, no strategy will prevent all disease, antibiotics are associated with side effects and selection for resistance, and implementation of any strategy requires coordinated changes in practice in physicians' offices, case rooms, laboratories and nurseries. Not surprisingly, surveys of practice in the early 1990s demonstrated that few physicians complied with guidelines. Our data, extending into 1997, show that, despite substantial improvements in practice, less than one-third of physicians in 2 large geographic areas of Canada reported practice in compliance with any guideline. In addition, a significant minority continued inappropriate practices such as screening at the first prenatal visit, use of cervical swabs and prescription of antenatal prophylaxis. If we expect to minimize the risk of early-onset neonatal GBS sepsis, more systematic approaches are clearly necessary. One possibility is implementation and monitoring of hospital-based GBS prevention policies.[29,30]

The issue of self-reporting naturally limits the interpretation of surveys. The modest agreement between reported and actual practice in our survey is not surprising. Disagreement may occur because results of screening (particularly negative results) may not be transferred to the hospital chart or because the delivering physician is not the attending physician, and personal practices differ. In addition, intended prophylaxis may not always be administered (e.g., if labour is short), and intrapartum antibiotics may be required for indications other than GBS prophylaxis. The finding that actual practice in this sample generally reflected reported practice supports the validity of our data.

The lack of consistency in practice highlights the confusion relating to multiple existing guidelines.[15,18,19] The tendency for practitioners to adopt strategy C (see Table 1) may reflect greater comfort with that strategy or may relate to the endorsement by the Society of Obstetricians and Gynaecologists of Canada. However, there remain substantial variations in practice between the 2 regions, perhaps because of factors such as locally influential experts or hospital or group practice policies. Identification of these regional or local influences may be important in understanding variation in compliance with existing or future guidelines.

If prevention is to be cost-effective, it must be coupled with correct identification of risk factors for neonatal GBS and with reduction in suboptimal practices such as antenatal prophylaxis[31–33] and repeated screening during pregnancy.[34–37] Obstetricians and those more recently trained were more likely to correctly identify risk factors and to comply with components of guidelines. Greater awareness because of recent training or better access to education may explain these differences: by 1997 the differences between physicians with different practice duration had disappeared, but differences between specialties persisted.

The slow adoption of evidence-based practice patterns,

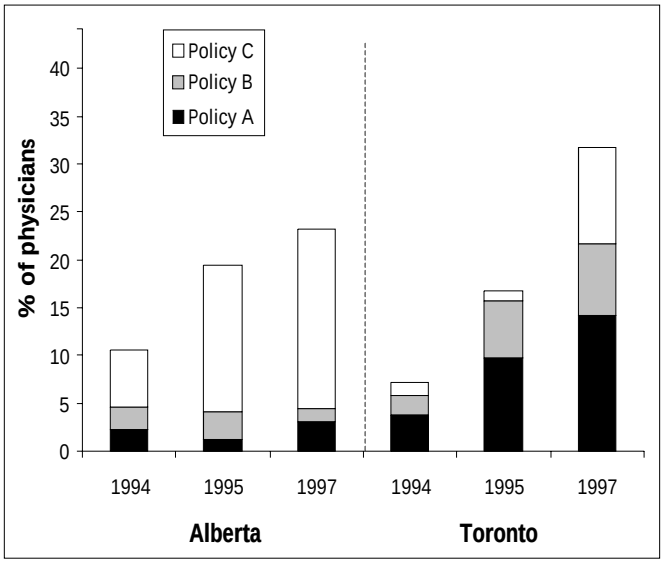

Fig. 1: Percentage of all physicians whose reported practice conformed with guidelines for prevention of group B streptococcal infection by region and year.

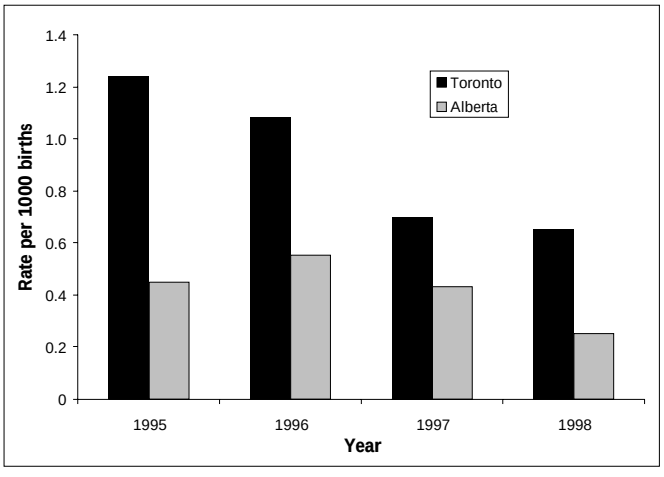

Fig. 2: Annual rates of early-onset neonatal GBS disease in Alberta ($p = 0.35$) and Toronto ($p = 0.01$).

despite support for their cost-effectiveness,[8–11,38] suggests that barriers to their use remain.[22,25,39] It is, however, important to note that there has been substantial improvement in practice components (e.g., timing of screening, types of specimen and use of prophylaxis) over time. We have also reported an improvement in practice in Alberta laboratories processing GBS screening swabs.[40] These changes have been temporally associated with a substantial reduction in the incidence of early-onset neonatal disease. In addition, although the reasons for lower neonatal disease rates in Alberta than in Toronto are unclear, they may be related to the reported greater use of intrapartum prophylaxis in Alberta for the period covered by the first survey. Both hospital-based series[29,41] and US surveillance[28] have supported an association between improvements in preventive practice and substantial reductions in early-onset disease. The low and declining incidence of GBS disease in these 2 regions supports continued attempts to increase compliance with preventive practice.

Competing interests: None declared.

Contributors: Dr. Davies was the principal investigator, writing the grant proposal and conducting and overseeing all aspects of the study, as well as having primary responsibility for manuscript preparation. Dr. Adair was a coapplicant for the original grants, provided substantial input into study design and analyses, and contributed to the manuscript before submission. Drs. Schuchat and Low were coinvestigators, providing epidemiologic input into the study and contributing to the manuscript before submission. Dr. Sauve provided epidemiologic input into the study and contributed to the manuscript before submission. Dr. McGeer was a coapplicant for the grants and was the primary investigator in Toronto, providing substantial input into the study design and analyses and contributing to the manuscript before submission.

Acknowledgements: We thank the physicians in Alberta and Toronto for their cooperation in responding to the surveys and all the microbiology laboratories for their cooperation in surveillance for neonatal GBS disease. We also thank research assistants and medical students Debbie Buser, Jeanette Huberty-Edwards, Lisa Landry, Nancy Martin, Arati Mokashi and Patricia Jaroslawski, for their assistance and valuable contributions to different aspects of this study. This work was supported in part by grants from the National Health Research Development Program, Canada, the Alberta Health Services Research Innovation Fund and the Alberta Heritage Foundation for Medical Research. Dr. Davies is a Medical Scholar of the Alberta Medical Foundation for Medical Research.

Presented in part at the 35th Interscience Conference on Antimicrobial Agents and Chemotherapy, Sept. 17–20, 1995, San Francisco (abstract 1879), and the 39th Interscience Conference on Antimicrobial Agents and Chemotherapy, Sept. 26–29, 1999, San Francisco (abstract 1731).

References

1. Allardice JG, Baskett TF, Seshia MM, Bowman N, Malazdrewicz R. Perinatal group B streptococcal colonization and infection. *Am J Obstet Gynecol* 1982;142(6 Pt 1):617-20.
2. Vesikari T, Isolauri E, Tuppurainen N, Renlund M, Koivisto M, Janas M, et al. Neonatal septicaemia in Finland 1981–85. Predominance of group B streptococcal infections with very early onset. *Acta Paediatr Scand* 1989;78(1):44-50.
3. Schuchat A, Wenger JD. Epidemiology of group B streptococcal disease. Risk factors, prevention strategies, and vaccine development. *Epidemiol Rev* 1994;16(2):374-402.
4. Eickhoff T, Klein J, Daly A, Ingall D, Finland M. Neonatal sepsis and other infections due to group B beta hemolytic streptococci. *N Engl J Med* 1964;271:1221-8.
5. Lloyd DJ, Reid TM. Group B streptococcal infection in the newborn. Criteria for early detection and treatment. *Acta Paediatr Scand* 1976;65(5):585-91.
6. Allen UD, Navas L, King SM. Effectiveness of intrapartum penicillin prophylaxis in preventing early-onset group B streptococcal infection: results of a meta-analysis. *CMAJ* 1993;149(11):1659-65.
7. Ohlsson A, Myhr TL. Intrapartum chemoprophylaxis of perinatal group B streptococcal infections: a critical review of randomized controlled trials. *Am J Obstet Gynecol* 1994;170(3):910-7.
8. Rouse DJ, Goldenberg RL, Cliver SP, Cutter GR, Mennemeyer ST, Fargason C Jr. Strategies for the prevention of early-onset neonatal group B streptococcal sepsis: a decision analysis. *Obstet Gynecol* 1994;83(4):483-94.
9. Strickland DM, Yeomans ER, Hankins GD. Cost-effectiveness of intrapartum screening and treatment for maternal group B streptococci colonization. *Am J Obstet Gynecol* 1990;163(1 Pt 1):4-8.
10. Mohle-Boetani JC, Schuchat A, Plikaytis BD, Smith JD, Broome CV. Comparison of prevention strategies for neonatal group B streptococcal infection. A population-based economic analysis. JAMA 1993;270(12):1442-8.
11. Garland SM, Kelly N. Early-onset neonatal group B streptococcal sepsis: economics of various prevention strategies. *Med J Aust* 1995;162(8):413-7.
12. Benitz W, Gould J, Druzin M. Preventing early-onset group B streptococcal sepsis: strategy developing using decision analysis [abstract]. *Pediatrics* 1999;103(6):e76 (1-17).
13. Society of Obstetricians and Gynaecologists of Canada and Canadian Paediatrics Society. National consensus statement on the prevention of early onset group B streptococcal infections in the newborn. *J Soc Obstet Gynaecol Can* 1994;16(10):2271-8.
14. Canadian Paediatric Society, Infectious Diseases and Immunization Committee. The prevention of early-onset group B streptococcal infections in the newborn [consensus statement]. *Can J Infect Dis* 1994;5(6):251-6.
15. American College of Obstetricians and Gynecologists. Universal antepartum screening for maternal GBS not recommended. *Am Coll Obstet Gynaecol Newsl* 1993;Sect 1-2.
16. Revised guidelines for prevention of early-onset group B streptococcal (GBS) infection. American Academy of Pediatrics Committee on Infectious Diseases and Committee on Fetus and Newborn. *Pediatrics* 1997;99(3):489-96.
17. Prevention of perinatal group B streptococcal disease: a public health perspective. Centers for Disease Control and Prevention. *MMWR Morb Mortal Wkly Rep* 1996;45(RR-7):1-24.
18. American Academy of Pediatrics Committee on Infectious Diseases and Committee on Fetus and Newborn. Guidelines for prevention of group B streptococcal (GBS) infection by chemoprophylaxis. *Pediatrics* 1992;90(5):775-8.
19. Group B streptococcal infections in pregnancy. ACOG Technical Bulletin Number 170—July 1992. *Int J Gynaecol Obstet* 1993;42(1):55-9.
20. Society of Obstetricians and Gynaecologists of Canada. Statement on the prevention of early onset group B streptococcal infections in newborns. *J Soc Obstet Gynaecol Can* 1997;19:419-20.
21. Lieu TA, Mohle-Boetani JC, Ray GT, Ackerson LM, Walton DL. Neonatal group B streptococcal infection in a managed care population. Perinatal Group B Streptococcal Infection Study Group. *Obstet Gynecol* 1998;92(1):21-7.
22. Jafari HS, Schuchat A, Hilsdon R, Whitney CG, Toomey KE, Wenger JD. Barriers to prevention of perinatal group B streptococcal disease. *Pediatr Infect Dis J* 1995;14(8):662-7.
23. American College of Obstetricians and Gynecologists: survey shows continued confusion over management of GBS in pregnancy. *Am Coll Obstet Gynecol Newsl* 1994;38:1,10.
24. Gibbs R, McGregor JA, Mead P, Eschenbach D, Hager W, Sweet R. A survey of practices in infectious diseases by obstetrician–gynecologists. *Obstet Gynecol* 1994;83(4):631-6.
25. Gigante J, Hickson GB, Entman SS, Oquist NL. Universal screening for group B streptococcus: recommendations and obstetricians' practice decisions. *Obstet Gynecol* 1995;85(3):440-3.
26. Dillman D. *Mail and telephone surveys: the total design method*. New York: Wiley Interscience; 1978.
27. Liang ST, Lau SP, Chan SH, Fok TF, Murai T, Kaneko Y. Perinatal colonization of group B streptococcus — an epidemiological study in a Chinese population. *Aust N Z J Obstet Gynaecol* 1986;26(2):138-41.
28. Schrag S, Zywicki S, Farley M, Reingold A, Harrison L, Lefkowitz L, et al. Group B streptococcal disease in the era of intrapartum antibiotic prophylaxis. *N Engl J Med* 2000;342:15-20.
29. Adoption of hospital policies for prevention of perinatal group B streptococcal disease — United States, 1997. *MMWR Morb Mortal Wkly Rep* 1998;47 (32):665-70.
30. Goldenberg E, Davies H, Landry L, Toronto GBS study Group, Toronto Bacterial Invasive Diseases Network, McGeer A. Hospital prevention policies and the incidence of early onset group B streptococcal (GBS) disease [abstract L-96]. In: *38th Interscience Conference on Antimicrobial Agents and Chemotherapy*; 1998 Sep 24–27; San Diego (CA). City: American Society for Microbiology; 1998.
31. Lewin E, Amstey M. Natural history of group B streptococcus colonization and its therapy during pregnancy. *Am J Obstet Gynecol* 1981;139:512-5.
32. Hall R, Barnes W, Krishnan L, Harris D, Rhodes P, Fayez J, et al. Antibiotic treatment of parturient women colonized with group B streptococci. *Am J Obstet Gynecol* 1976;124:630-4.
33. Klebanoff MA, Regan JA, Rao AV, Nugent RP, Blackwelder WC, Eschenbach DA, et al. Outcome of the vaginal infections and prematurity study: results of a clinical trial of erythromycin among pregnant women colonized with group B streptococci. *Am J Obstet Gynecol* 1995;172(5):1540-5.
34. Hoogkamp-Korstanje JA, Gerards LJ, Cats BP. Maternal carriage and neonatal acquisition of group B streptococci. *J Infect Dis* 1982;145(6):800-3.

35. Philipson EH, Palermino DA, Robinson A. Enhanced antenatal detection of group B streptococcus colonization. *Obstet Gynecol* 1995;85(3):437-9.
36. Boyer KM, Gadzala CA, Kelly PD, Burd LI, Gotoff SP. Selective intrapartum chemoprophylaxis of neonatal group B streptococcal early-onset disease. II. Predictive value of prenatal cultures. *J Infect Dis* 1983;148(5):802-9.
37. Dillon HJ, Gray E, Pass M, Gray B. Anorectal and vaginal carriage of group B streptococci during pregnancy. *J Infect Dis* 1982;145(6):794-9.
38. Yancey MK, Duff P. An analysis of the cost-effectiveness of selected protocols for the prevention of neonatal group B streptococcal infection. *Obstet Gynecol* 1994;83(3):367-71.
39. Mercer BM, Ramsey RD, Sibai BM. Prenatal screening for group B streptococcus. I. Impact of antepartum screening on antenatal prophylaxis and intrapartum care. *Am J Obstet Gynecol* 1995;173(3 Pt 1):837-41.
40. Davies H, Adair C, Partlow E, Ma D, Chan J, Hofmiester M, et al. Two-year survey of Alberta laboratories processing of antenatal group B streptococcal (GBS) screening programs. *Diagn Microbiol Infect Dis* 1999;35:169-76.
41. Isaacs D, Royle J, Australasian Study Group for Neonatal Infections. Intrapartum antibiotics and early onset neonatal sepsis caused by group B streptococcus and by other organisms in Australia. *Pediatr Infect Dis J* 1999;18:524-8.

Reprint requests to: *H. Dele Davies, Division of Infectious Diseases, Child Health Research Unit, Alberta Children's Hospital, 1820 Richmond Rd. SW, Calgary AB T2T 5C7; fax 403 541-7508; dele.davies@crhs-health.ab.ca*

Members of Alberta Neonatal Group B Streptococcal Network: *E.S. Partlow, D. Ma, L. Kowalsky, S. Robertson, M. Logue and M. Hofmeister, Alberta Children's Hospital, Calgary; D. Church, Calgary Laboratory Services, Calgary; J. Talbot, J. Robinson and R. Rennie, University of Alberta Hospitals, Edmonton; O. Huhn, Mineral Springs Hospital, Banff, Alta.; M. Wendelboe, Bonnyville Hospital, Bonnyville, Alta.; J. Galbraith, Dynacare-Kasper Laboratories, Edmonton and Grand Prairie, Alta.; V. Boras, Lethbridge Regional Hospital, Lethbridge, Alta.; W. Chow, Medicine Hat Regional Hospital, Medicine Hat, Alta.; J. Nigrin, Dynacare-Kasper Medical Laboratories, Peace Health Region, Alta.; P. Visser, Wainwright and District Hospital, Wainwright, Alta.; W.S. Jamieson, Westlock Healthcare Centre, Westlock, Alta.*

Members of Toronto Invasive Bacterial Diseases Network: *A. Matlow and U. Allen, Hospital for Sick Children, Toronto; A. Ohlsson and K. Green, Mount Sinai Hospital, Toronto; J. Boulton, St. Joseph's Health Centre, London, Ont.; I.N. Gaid, Ajax and Pickering General Hospital, Ajax, Ont.; J.L. Platt, Centenary Health Centre, Scarborough, Ont.; F. Smaill, Chedoke-McMaster Hospital, Hamilton, Ont.; J. Henning, Credit Valley Hospital, Mississauga, Ont.; P. O'Brien, Etobicoke General Hospital, Rexdale, Ont.; J. Cullen, Humber River Regional Hospital, Weston, Ont.; P. Shokry, Markham Stouffville Hospital, Markham, Ont.; K. Ostrowska, Trillium Health Centre, Mississauga, Ont.; E. Szentgyorgi, North York Branson Hospital, Toronto; P. Garrod, Oakville Trafalgar Memorial Hospital, Oakville, Ont.; B. Mederski, North York General Hospital, Toronto; Z. Moloo, Peel Memorial Hospital, Brampton, Ont.; A.C. Kilby, Providence Villa and Hospital, Toronto; A. Gryfe, Trillium Health Centre, Etobicoke, Ont.; D. Sturman, Riverdale Hospital, Toronto; S. Krajden, St. Joseph's Health Centre, Toronto; R.M. Bannatyne, St. Michael's Hospital, Toronto; A. Gelbloom, Scarborough General Hospital, Toronto; D. Noria, Scarborough Grace Hospital, Toronto; A.E. Simor and M. Vearncombe, Sunnybrook and Women's College Health Sciences Centre, Toronto; P. DaCamara, Toronto East General and Orthopaedic Hospital, Toronto; I. Campbell, Toronto General Hospital, Toronto; H.R. Devlin, St. Michael's Hospital — Wellesley-Central Site, Toronto; B. Oliver, Humber River Regional Hospital — Finch Site, Toronto; P. Van Nostrand, The Toronto Rehabilitation Institute, Toronto; M. Krajden, BC Centre for Disease Control, Vancouver; M. Naus, Ontario Ministry of Health, Toronto.*