Canadian Study of Health and Aging: study methods and prevalence of dementia

Canadian Study of Health and Aging Working Group

Objective: To estimate the prevalence of dementia and its subtypes by sex and age group for five regions of Canada.
Design: Prevalence survey.
Setting: Community and institutional settings in Canada, excluding those in the two territories, Indian reserves and military units.
Participants: Representative sample of people aged 65 and over interviewed between February 1991 and May 1992. Those in the community (9008 subjects) were chosen randomly from medicare lists in nine provinces or from the Enumeration Composite Record in Ontario. People in institutions (1255) were randomly selected from residents in stratified random samples of institutions in each region.
Interventions: Screening with the Modified Mini-Mental State (3MS) Examination to identify cognitive impairment. Clinical examination of all those in institutions, those in the community with a 3MS score of less than 78 and a sample of those in the community with a 3MS score of 78 or more to diagnose dementia. Dementia and Alzheimer's disease were defined according to established criteria.
Main outcome measures: Prevalence of dementia of all types, by region, sex and age group, the estimated number of cases in the population by type of dementia and the age-standardized rate per 1000 population.
Results: The prevalence estimates suggested that 252 600 (8.0%) of all Canadians aged 65 and over met the criteria for dementia (95% confidence interval [CI] 236 800 to 268 400). These were divided roughly equally between the community and institutional samples; the female:male ratio was 2:1. The age-standardized rate ranged from 2.4%, among those aged 65 to 74 years, to 34.5%, among those aged 85 and over. The corresponding figures for Alzheimer's disease were 5.1% overall (161 000 cases; 95% CI 148 100 to 173 900), ranging from 1.0% to 26.0%; for vascular dementia it was 1.5% overall, ranging from 0.6% to 4.8%. If the prevalence estimates remain constant, the number of Canadians with dementia will rise to 592 000 by 2021.
Conclusions: These Canadian estimates of the prevalence of dementia fall toward the upper end of the ranges in other studies, whereas the estimates for Alzheimer's disease fall in the middle of the ranges. This may suggest an unusual balance between Alzheimer's and other forms of dementia in the Canadian population.

Objectif : Évaluer la prévalence de la démence et de ses sous-types selon le sexe et l'âge dans cinq régions du Canada.
Conception : Enquête de prévalence.

The names of the study centres and investigators are provided in Appendix 1.

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Contexte : Contextes communautaires et institutionnels au Canada, à l'exclusion des deux territoires, des réserves indiennes et des unités militaires.
Participants : Échantillon représentatif de sujets de 65 ans et plus interviewés entre février 1991 et mai 1992. Les sujets des contextes communautaires (9008) ont été choisis au hasard à partir des listes de l'assurance-maladie de neuf provinces ou de la fiche détaillée de recensement de l'Ontario. Les sujets en milieu institutionnel (1255) ont été choisis au hasard par des échantillons aléatoires stratifiés parmi les résidents d'établissements de chaque région.
Interventions : Sélection à l'aide du mini examen modifié de l'état mental (3MS) afin d'établir la déficience cognitive. Examen clinique de tous les sujets institutionnalisés, de ceux des milieux communautaires qui ont obtenu un résultat 3MS de moins de 78, et d'un échantillon des sujets des milieux communautaires qui ont obtenu un résultat 3MS de plus de 78 au diagnostic de démence. La démence et la maladie d'Alzheimer ont été définies selon des critères établis.
Principales mesures de résultats : Prévalence de la démence de tous types, selon la région, le sexe et le groupe d'âge, nombre estimatif de cas dans la population selon le type de démence et taux sans strate d'âges par 1 000 habitants.
Résultats : Les estimations de la prévalence indiquent que 252 600 (8,0 %) Canadiens de 65 ans et plus satisfont aux critères relatifs à la démence (intervalle de confiance [IC] à 95 % de 236 800 à 268 400). Ces chiffres étaient répartis à peu près également entre les échantillons communautaires et institutionnels et le ratio femme:homme était de 2:1. Le taux sans strate d'âges s'est établi entre 2,4 % chez les 65 à 74 ans et 34,5 % chez les 85 ans et plus. Les chiffres correspondants dans le cas de la maladie d'Alzheimer étaient de 5,1 % dans l'ensemble (161 000 cas; IC à 95 % de 148 100 à 173 900), l'écart variant de 1,0 % à 26,0 %. Dans le cas de la démence vasculaire, le pourcentage s'est établi à 1,5 % dans l'ensemble, l'écart variant de 0,6 % à 4,8 %. Si les estimations de la prévalence demeurent constantes, il y aura 592 000 Canadiens atteints de démence en l'an 2021.
Conclusions : Ces estimations canadiennes relatives à la prévalence de la démence s'établissent à l'extrémité supérieure de l'intervalle enregistrée dans le cadre d'autres études, tandis que les estimations relatives à la maladie d'Alzheimer s'établissent au milieu de l'intervalle. Ces statistiques peuvent indiquer un équilibre inhabituel entre la maladie d'Alzheimer et d'autres formes de démence dans la population canadienne.

In 1991, 10.6% of the Canadian population was 65 years and over;[1] this proportion is expected to rise to 14.5% in 2011 and 21.8% in 2031.[2] Dementia is one of the most distressing and burdensome health problems to this group of patients and those who care for them.[3] Accurate estimates of the prevalence of dementia are a basic requirement for planning treatment and supportive services.

Canadian data on the prevalence of cognitive impairment and dementia come from a number of regional studies, with various methods of ascertainment and different definitions of cognitive impairment and dementia. An early community survey in Nova Scotia found the prevalence of "senility" to be 1% at ages 60 to 69 years and 11% at ages 70 and over.[4] The Manitoba Longitudinal Study on Aging[5] assessed elderly people in institutions and the community in 1971, 1976 and 1983. Estimates of the prevalence of mild cognitive impairment ranged from 12.9% to 17.0%; 6.8% suffered moderate or severe impairment. In a Saskatchewan study the prevalence of clinically significant cognitive impairment in institutions and the community was 7.8%.[6] Jeans and associates,[7] extrapolating data from an Ontario survey of the prevalence of moderate to severe dementia in institutions, estimated the rate for Canada to be 9.4%. In a small study in Edmonton,[8] involving 557 subjects, the prevalence of mild cognitive impairment was 3.3% among community residents and 29.1% among institutional residents; a further 39.7% of the institutional residents were found to have severe cognitive impairment.

Studies from other countries have been reviewed in several meta-analyses. In 47 studies published between 1945 and 1985 the estimated prevalence of severe dementia among people aged 65 and over varied from 0.6% to 5.1%.[9] Estimates for mild dementia ranged from 1.6% to 13.1%. Despite these wide variations, data from 22 of these studies showed consistently that the prevalence of dementia doubled with every 5.1 years of age over 65. Results from European studies in the 1980s suggested that the prevalence of dementia ranged from 1.0% at ages 60 to 64 to 32.2% at ages 90 to 94; the rates of dementia of the Alzheimer type (hereafter referred to as Alzheimer's disease) ranged from 0.3% at ages 60 to 69 to 10.8% at ages 80 to 89.[10,11] The combined results of 13 European, North American and Japanese studies conducted since 1980 suggested that the prevalence of senile dementia increased from 0.9%, at age 62.5, to 36.7%, at age 95;[12] the corresponding figures for Alzheimer's disease were 0.2% at 62.5 and 21.0% at age 91.5. By contrast, Evans and collaborators[13] found higher estimates of prevalence of Alzheimer's disease in a community survey of elderly

people in Massachusetts: from 3.0% at 65 to 74 years to 47.2% at 85 and over. Kokmen and colleagues[14] and Beard and coworkers,[15] extracting data from health care records in Minnesota, estimated the prevalence of dementia to be 3.9% in 1975 and 4.0% in 1980; the prevalence of Alzheimer's disease was 2.6% in both years. In two large surveys in Japan the prevalence of moderate or severe dementia among people 65 years and over was 2.7%.[16,17] Studies involving Chinese people 65 and over in Singapore[18] and Beijing[19] found the prevalence of dementia to be 1.8%.

In 1987 an advisory committee to the Department of National Health and Welfare recommended the application of standard screening and diagnostic criteria in a nation-wide prevalence study of dementia, including Alzheimer's disease. The committee also urged that analytic studies of risk factors and of caregiving for patients with dementia be undertaken and that a longitudinal study be set up.

Canadian Study of Health and Aging (CSHA)

To meet these goals the Department of National Health and Welfare funded a coordinating study centre linking the University of Ottawa's Department of Epidemiology and Community Medicine and the federal government's Laboratory Centre for Disease Control. Early in 1989, 18 centres across Canada agreed to participate in developing and implementing the study. The study centres were grouped into five geographic regions: British Columbia (Victoria and Vancouver), the Prairies (Calgary, Edmonton, Saskatoon and Winnipeg), Ontario (London, Hamilton, Toronto and Ottawa), Quebec (Montreal, Sherbrooke, Quebec City and Chicoutimi) and the Atlantic region (Fredericton, Halifax, Charlottetown and St. John's).

Four objectives relating to dementia were identified as follows.

- To estimate the prevalence of dementia among elderly Canadians with the use of a common research protocol.
- To determine the risk factors for Alzheimer's disease.
- To describe the current patterns of caring for patients with dementia in Canada and to assess the burden on caregivers and their need for support.
- To establish a uniform database for performing subsequent studies of the natural history of dementia and for planning and evaluating interventions.

The coordinating centre developed the research protocol during 1989 and 1990 with the guidance of a series of working groups involving investigators from the study centres. It became clear that the scope of the study should be broadened to include a range of health issues concerning elderly people. Thus, the screening interview was extended to include questions about general health problems, the presence of specific disorders and limitations in performing activities of daily living.

The coordinating centre developed the study questionnaires, assessment forms and manuals, oversaw training, monitored the implementation of the study, performed the data entry and preliminary analyses and drafted the initial reports. A steering committee, consisting of representatives from the five geographic regions, resolved difficulties not readily handled by the coordinating centre. A policy advisory committee, comprising experts not involved in the study, met periodically to review issues and to propose solutions. Ethical approval of the study was obtained from the ethics review board in each of the 18 study centres. Data collection began in February 1991 and was completed by May 1992.

In addition to the four basic objectives each centre was encouraged to perform substudies of particular interest to it. This paper describes the study design, methods of data collection and the results of the prevalence study.

Methods

Study design

The CSHA was a prevalence survey to which two analytic studies were appended (Fig. 1). In the community, randomly selected groups of people aged 65 years and over were interviewed; the interview included general health questions and a psychometric test for cognitive impairment. Those screening positive for cognitive impairment and a randomly selected sample of those screening negative were asked to undergo a clinical assessment to determine the presence of dementia and to provide a diagnosis. Clinical examination of the cognitively intact subjects permitted estimation of the negative predictive value of the screening test. In institutions the high prevalence of dementia made screening redundant, and all subjects underwent the clinical assessment. The results of all clinical examinations were used to estimate the prevalence of subtypes of dementia (Fig. 1, upper part) by residence (community or institution), region, age group and sex.

Subjects found on clinical examination to have Alzheimer's disease of less than 3 years' duration were included in a case–control study of risk factors (Fig. 1, lower part). Control subjects were drawn from those found to be cognitively normal after clinical examination. Control subjects in the community were recruited from a randomly selected sample of those screening negative, who were then clinically examined. The study of patterns of caregiving involved caregivers of subjects with dementia and those of a sample of people without cognitive impairment in community and institutional settings.

Eligibility criteria

The study excluded the Yukon Territory and the

Northwest Territories, Indian reserves and military units. Subjects had to be 65 years or more on Oct. 1, 1990. Those with a life-threatening illness (e.g., a condition necessitating life support or terminal cancer) were excluded. Subjects unable to complete the screening test because of conditions such as deafness, stroke, mental retardation or current illness were included in the clinical examination. All subjects had to be fluent in either English or French. To be eligible for the community sample, subjects had to be living at home (i.e., not in a long-stay hospital or living outside the area) at some time during the recruitment phase of the study.

Sampling

Thirty-six cities and their surrounding rural areas were selected for the study; representative samples of individuals from each of these were drawn. Criteria for selecting study areas included accessibility to the study centres and feasibility of arranging for clinical assess-

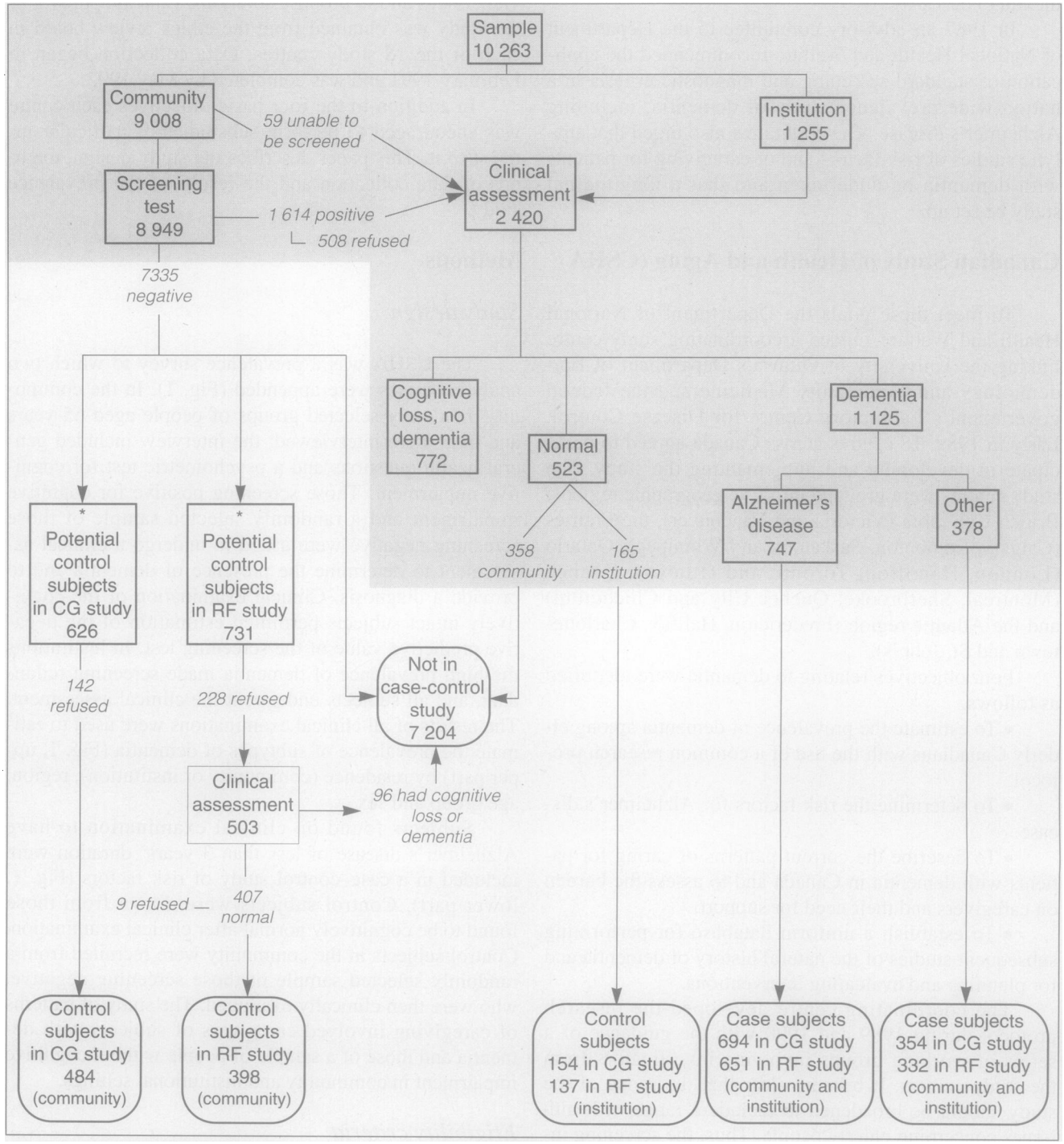

Fig. 1: Flow of subjects through components of the Canadian Study of Health and Aging, showing sample sizes in each. Unscreened portion indicates case–control studies of caregiving (CG) and risk factors (RF). * = random selection.

ments. Roughly 60% of Canadians 65 and over lived in the sample areas.

We obtained the community sample from the databases of the provincial health insurance plans except in Ontario, where we used the Enumeration Composite Record, an aggregate list based on election and other municipal records. Subjects were randomly selected by computer in the following age groups: 65 to 74 years, 75 to 84 and 85 and over. Since both the size of the population and the expected rates of dementia vary by age, we used an optimal allocation procedure to reduce variance estimates. This resulted in oversampling the older groups: the sampling fraction among the subjects 75 to 84 was twice that among those 65 to 74, and the fraction among those 85 and more was 2.5 times that among those 65 to 74.

The institutional sample comprised subjects in nursing homes, chronic care facilities and collective dwellings such as convents. Three study centres randomly selected people from the insurance plan lists. This was not considered feasible in the other 15 centres, because permission for interviews would have to have been obtained from large numbers of institutions. For these centres we created a sampling frame by merging available lists of institutions; this was verified in each community through consultation with local experts. We stratified institutions into small (up to 25 beds for people aged 65 and over), medium (26 to 100 beds) and large (more than 100 beds). A stratified sample of 17 institutions was randomly selected in each region; people in these institutions were then randomly selected.

For community and institutional samples, subjects who could not be contacted or who refused to participate were replaced by another person of the same sex, age group and geographic region. The target samples in each region were 1800 people in the community and 250 in institutions. Assuming a community prevalence of 5%, we determined that the sample size offered 95% confidence that the regional prevalence estimates would be within 1% of the true rate. Assuming an institutional prevalence of 50%, we calculated that the institutional sample size offered 95% confidence that the estimates would be within 6% of the true value. To make population estimates we derived sample weights to correct for the different populations in each sampling area and for the oversampling of the older groups.

Compliance

We used several techniques to encourage participation in the study. Subjects received a letter and brochure introducing the study and indicating the types of questions to be asked; often copies of newspaper articles were included describing the study. Interviewers then contacted subjects by telephone or in person; interviewers wore identification badges and carried letters of support from local and national organizations. All components of the study could be implemented in the home. Beyond these techniques each centre was encouraged to develop its own approach to ensure a high response rate; experience showed that different tactics worked in different areas.

Logistic regression analysis was used to search for differences in rates of participation in the clinical examination between the regions. We compared the proportions in each region of those screening positive who underwent the examination using unweighted data, taking into account age and sex.

Screening interview

The community screening interview included questions about demographic information and social support, the Older Americans Resources and Services Activities of Daily Living scale,[20,21] questions on current health problems and a screening test for cognitive impairment. After reviewing 18 screening tests for cognitive impairment we selected the Modified Mini-Mental State (3MS) Examination[22] because of its coverage of relevant aspects of cognitive impairment, the quality of its documentation and its validity. The 3MS exam expands the scope of the Mini-Mental State Exam (MMSE);[23] it uses a more sophisticated scoring system but still permits the derivation of MMSE scores. The 3MS exam appears to be more sensitive than the MMSE,[24] and we used a high cut-off point of 77/78 to increase sensitivity. This cut-off point was selected on the basis of Teng and Chui's original work, modified by the results of our pilot study.[25]

The test results were scored by the interviewer; lower scores indicated increased likelihood of impairment. Subjects with a score below 78, those who could not be screened because of hearing or other difficulties and a random sample of those with a score of 78 or more were invited to undergo the clinical examination. The French adaptation of the 3MS exam[26] was tested on 83 subjects and showed test–retest and interrater reliability coefficients similar to those of the original version.

Clinical examination

The clinical examination assessed the presence of cognitive impairment and provided a differential diagnosis of dementia. This formed the case definition for the studies of prevalence, risk factors and caregiving. Our diagnostic criteria for dementia followed the third revision of the Diagnostic and Statistical Manual of Mental Disorders (DSM-III-R),[27] and those for Alzheimer's disease were based on the criteria of the National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer's Disease and Related Disorders Association.[28] A draft of the 10th revision of the International Classification of Diseases[29] was used to define subcategories of vascular and other dementias.

The clinical examination was developed in collaboration with the US Consortium to Establish a Registry for Alzheimer's Disease[30] (of which the Quebec study centres form a part) and the World Health Organization consortium led by Dr. Luigi Amaducci. The examination took 4 to 5 hours and was held in a hospital or clinic or, if necessary, in the institution or the subject's home. Clinical team members were unaware of the 3MS score obtained at the screening interview.

The examination was in four parts. First, a nurse registered the subjects and completed consent forms, administered the 3MS exam, tested hearing, vision and vital signs, recorded height, weight and medication use, and obtained the subject's cognitive and family history from a relative, using section H of the Cambridge Mental Disorders of the Elderly Examination (CAMDEX).[31] Second, a psychometrician, blind to the 3MS score from the interview, administered the neuropsychologic tests listed in Table 1 to subjects with a score of 50 or more for the 3MS exam given by the nurse. A total of 640 subjects were excluded because their score was less than 50. A neuropsychologist evaluated the test results in conjunction with the results of the CAMDEX and the 3MS exam administed by the nurse. Third, a physician reviewed the information collected by the nurse and examined the patient, performing a mental status assessment as well as physical and neurologic examinations. The physician then made a preliminary diagnosis before seeing the neuropsychologist's evaluation. Finally, subjects suspected of having dementia or delirium were sent for hematologic and biochemical tests. A case conference was then held to arrive at a consensus diagnosis in one of the following categories: no cognitive loss, cognitive loss but no dementia (eight subcategories were specified), Alzheimer's disease (probable or possible, divided into four subcategories), vascular dementia (four subcategories), other specific dementia (six subcategories) or unclassifiable dementia.

Table 1: Neuropsychologic tests administered to people 65 years of age and over as part of a clinical examination of dementia, by DSM-III-R criteria for dementia*

Criteria	Tests
A. Memory	Buschke Cued Recall
	Wechsler Memory Scale: Information Subtest
	Rey Auditory–Verbal Learning Test
	Benton Visual Retention Test (Revised)
	WAIS-R Digit Span
	Working Memory Test
B1. Abstract thinking	WAIS-R Similarities (Short Form)
B2. Judgement	WAIS-R Comprehension (Short Form)
B3. Aphasia	Token Test (11 items)
	Lexical Fluency (Words)
	Semantic Fluency (Animals)
Apraxia	WAIS-R Digit Symbol
Agnosia	Buschke Visual Component
Construction	WAIS-R Block Design (Short Form)
	Clock Test (optional)

*DSM-III-R = the third edition of the revised Diagnostic and Statistical Manual of Mental Disorders.[27]

A total of 2923 clinical examinations were performed. For the community sample, the median time between screening and clinical examination was 61 days. Diagnostic consistency was examined according to the approach described in Appendix 2, which also includes details of staff training and data handling.

Prevalence estimates

The prevalence of the various categories of dementia, expressed as population estimates and numbers per 1000 population, were calculated for each region and for Canada. Rates were estimated separately by sex and age group for the community and institutional populations with the use of 1991 census enumerations for the denominators. We corrected prevalence estimates in the community to account for people screening positive who did not attend the clinical examination, assuming they had the same prevalence as those who did attend. The impact of imperfect sensitivity of the community screening test was evaluated. The method of estimating prevalence was based on that described by Newman, Shrout and Bland.[32] For regional comparisons we calculated standardized rates using direct standardization to a standard population reflecting the age structure of the five regions combined. Full details are available from the corresponding author upon request.

The precision of the prevalence estimates can be indicated by the coefficient of variation (CV). This expresses the standard error of the estimate as a percentage of the estimate. The CV for all cases (male and female, community and institutional) for all dementias is 3.2%, for Alzheimer's disease 4.1% and for vascular dementia 8.0%. The study was designed to provide equal precision within each region, and the CV for any region is 6.3% for all dementias, 8.1% for Alzheimer's disease and 17.2% for vascular dementia. The CVs can be applied to the estimated number of cases or to the prevalence per 1000 population. For example, the number of cases of Alzheimer's disease in the Atlantic region is estimated to be 9500. The CV for this estimate is 8.1%, giving a standard error of 770. Similarly, the estimated prevalence of all dementia across all regions is 80 per 1000; the CV is 3.2%, so the standard error is approximately 2.6 per 1000.

We used logistic regression analysis to examine differences in the proportions of people with each type of dementia by region, age and sex, while controlling for the other factors; the χ^2 test was used to assess the significance of differences between odds ratios derived from unweighted logistic regression analyses.

Results

Participation rates

Of 19 398 people on the community sample lists, 5307 (27.4%) were ineligible. These included 3753 who had died, were the wrong age, had left the study area or had been placed in an institution, 1020 who could not speak English or French and 534 who were away during the study period or were in hospital. Table 2 provides information on the remaining 14 091 subjects. Fig. 1 shows the numbers who participated in the various components of the study. Of those who screened positive 5.0% were unavailable to undergo the clinical examination, and a further 26.5% refused to undergo it. The participation rates did not differ significantly between the regions.

The institutional sample comprised 1817 subjects. Of these, 154 had died, had been assigned to the wrong age group or had left the study area or the institution, 46 could not speak English or French, and 31 were in hospital. Table 2 gives information on the 1586 eligible subjects.

Prevalence of dementia

Weighted estimates of the prevalence of dementia of all types by region, sex and residence are given in Table 3. To avoid spurious accuracy the numbers of cases in this and subsequent tables were rounded to the nearest 100. We estimated that there were just over a quarter of a million elderly people with dementia in Canada, almost equally divided between the community and institutions and about twice as many women as men. The prevalence among men in Ontario was low because of an apparent anomaly among men aged 65 to 74: dementia was not found in the 26 subjects examined.

Table 4 shows the prevalence of all types of dementia by age and sex. In terms of the estimated number of cases in the population (ENP) 18% of all cases involved people aged 65 to 74, 44% those 75 to 84 and 39% those 85 and over. The female:male ratio was 2.1 overall but was 2.9 in the oldest group. The number of cases was almost equally divided between community and institution, although among those 85 and over, two thirds of the cases involved people in an institution. The female:male ratio for those with dementia was higher in the institutional sample than in the community sample. In terms of proportions, the prevalence increased with age in both samples, but the gradient with age was much steeper in the community sample. The female:male ratio for the prevalence figures per 1000 population was 1.5 at ages 65 to 74, 1.1 at ages 75 to 84 and 1.3 at ages 85 and over.

Tables 5 and 6 show estimates of the prevalence of Alzheimer's disease. The 161 000 cases of Alzheimer's disease represented 64% of all cases of dementia. The patterns of regional prevalence and the distribution by residence, sex and age were similar to those for all dementias.

The distribution of cases of vascular dementia is shown in Tables 7 and 8; this form of dementia accounted for 19% of all cases. In terms of the ENP vascular dementia was nearly equally divided between the sexes, but the rate per 1000 population was about 40% higher among men than among women.

The remaining 174 cases of dementia included 27 for which the cause was Parkinson's disease, 52 for which other specified causes were listed and 95 for which no cause could be identified. Prevalence estimates

Table 2: Geographic distribution of subjects in the community and in institutions who were eligible to participate in the Canadian Study of Health and Aging

Sample; region	No. (and %) of subjects			
	Eligible	Could not be contacted	Refused to participate*	Participated*
Community				
Atlantic provinces	2 509	307 (12.2)	403 (18.3)	1 799 (81.7)
Quebec	2 957	408 (13.8)	749 (29.4)	1 800 (70.6)
Ontario	2 556	199 (7.8)	557 (23.6)	1 800 (76.4)
Prairies	2 651	192 (7.2)	655 (26.6)	1 804 (73.4)
British Columbia	3 418	495 (14.5)	1 118 (38.2)	1 805 (61.8)
Total	14 091	1 601 (11.4)	3 482 (27.9)	9 008 (72.1)
Institutional				
Atlantic provinces	274	1 (0.4)	23 (8.4)	250 (91.6)
Quebec	307	0	58 (18.9)	249 (81.1)
Ontario	281	0	33 (11.7)	248 (88.3)
Prairies	375	42 (11.2)	77 (23.1)	256 (76.9)
British Columbia	349	7 (2.0)	90 (26.3)	252 (73.7)
Total	1 586	50 (3.2)	281 (18.3)	1 255 (81.7)

*Percentages reflect the proportion of people who could be contacted.

for the 174 mixed dementias are available from the corresponding author upon request.

Imperfect sensitivity of the community screening test may have led to an underestimate of the true prevalence of dementia. Of the subjects who had a normal 3MS score at screening, 494 underwent a clinical examination. Seven (1.4%) were found to have dementia; four were 75 to 84 years of age, and three were 85 or over. Applying these false-negative rates to the community population in Canada suggests that we would have missed 9500 subjects with dementia aged 75 to 84 and 2700 aged 85 or more. Using the figures in Table 4, we

Table 3: Prevalence of dementia (all types) for 1991 among people 65 years and over, estimated number of cases in the population (ENP), in thousands, and age-standardized rate per 1000 population (ASR), by region, sex and residence*

	Community			Institution			Total		
Region	No. of cases	ENP	ASR	No. of cases	ENP	ASR	No. of cases	ENP	ASR
Atlantic provinces									
Male	34	5.7	53	50	3.3	608	84	9.0	82
Female	64	8.0	50	94	6.6	565	158	14.6	84
Total	98	13.7	51	144	9.8	594	242	23.6	84
Quebec									
Male	31	13.7	53	27	8.1	476	58	21.8	83
Female	63	21.0	49	79	19.2	440	142	40.2	84
Total	94	34.7	52	106	27.4	448	200	62.0	84
Ontario									
Male	18	8.9	22	33	11.5	532	51	20.4	50
Female	52	33.3	51	115	36.5	599	167	69.8	93
Total	70	42.2	38	148	48.0	580	218	90.2	77
Prairies									
Male	33	10.1	48	48	8.6	694	81	18.7	86
Female	30	8.2	29	127	18.2	660	157	26.4	79
Total	63	18.3	37	175	26.8	679	238	45.1	83
British Columbia									
Male	33	7.2	43	42	4.1	564	75	11.3	67
Female	37	7.8	34	115	12.6	660	152	20.4	79
Total	70	15.0	37	157	16.7	634	227	31.7	75
All									
Male	149	45.6	39	200	35.6	555	349	81.2	69
Female	246	78.3	45	530	93.1	572	776	171.4	86
Total	395	123.9	42	730	128.7	569	1125	252.6	80

*Some figures do not add up to totals indicated because of rounding.

Table 4: Prevalence of dementia (all types) for 1991 by age group, sex and residence

	Community			Institution			Total		
Age group, yr	No. of cases	ENP	ASR	No. of cases	ENP	ASR	No. of cases	ENP	ASR
65–74									
Male	17	8.6	10	45	7.2	437	62	15.8	19
Female	22	20.2	20	56	8.7	406	78	28.9	28
Total	39	28.8	16	101	15.8	419	140	44.7	24
75–84									
Male	83	25.8	71	93	14.8	536	176	40.6	104
Female	107	36.4	68	190	33.2	532	297	69.6	116
Total	190	62.2	69	283	48.0	533	473	110.2	111
≥ 85									
Male	49	11.1	173	62	13.6	618	111	24.8	287
Female	117	21.7	180	284	51.2	673	401	72.9	371
Total	166	32.9	178	346	64.9	660	512	97.7	345
All									
Male	149	45.6	39	200	35.6	555	349	81.2	69
Female	246	78.3	45	530	93.1	572	776	171.4	86
Total	395	123.9	42	730	128.7	569	1125	252.6	80

found that the estimated overall number of cases would go from 252 600 to 264 800, an increase of 4.8%, and the community prevalence would go from 42 to 46 per 1000 population.

Table 9 shows the age-standardized prevalence ratios by sex and type of dementia for each region. For all dementias combined, there was little variation between the regions except for the low ratio among men in Ontario. The variation was more marked with respect to the prevalence of particular types of dementia: for example, the high ratios for Alzheimer's disease in Quebec and the Atlantic region, the high ratio for vascular dementia in Quebec and the low ratio for Alzheimer's disease and vascular dementia in Ontario. However, the low ratios for other types of dementia in Quebec and the Atlantic region and the high ratios in Ontario suggest that part of the differences between the three eastern regions may be due to variations in the interpretation of the diagnostic criteria.

Table 5: Prevalence of Alzheimer's disease for 1991 by region, sex and residence

	Community			Institution			Total		
Region	No. of cases	ENP	ASR	No. of cases	ENP	ASR	No. of cases	ENP	ASR
Atlantic provinces									
Male	21	3.3	31	28	2.0	398	49	5.3	50
Female	49	6.2	39	77	5.5	467	126	11.7	67
Total	70	9.5	35	105	7.5	451	175	17.0	60
Quebec									
Male	21	8.4	34	11	3.3	214	32	11.7	46
Female	46	15.2	36	60	14.9	339	106	30.1	63
Total	67	23.6	35	71	18.2	303	138	41.8	57
Ontario									
Male	8	3.8	10	17	5.4	273	25	9.2	24
Female	36	20.4	31	76	23.7	376	112	44.0	58
Total	44	24.2	22	93	29.1	346	137	53.2	45
Prairies									
Male	18	5.3	25	26	4.9	411	44	10.2	48
Female	24	6.3	22	96	13.8	490	120	20.1	59
Total	42	11.6	23	122	18.7	469	164	30.3	55
British Columbia									
Male	20	4.1	25	22	2.2	316	42	6.3	39
Female	27	5.3	22	64	7.1	368	91	12.4	47
Total	47	9.4	23	86	9.3	351	133	18.7	44
All									
Male	88	24.9	22	104	17.8	300	192	42.7	38
Female	182	53.4	30	373	65.0	394	555	118.3	58
Total	270	78.3	27	477	82.8	367	747	161.0	51

Table 6: Prevalence of Alzheimer's disease for 1991 by age group, sex and residence

	Community			Institution			Total		
Age group, yr	No. of cases	ENP	ASR	No. of cases	ENP	ASR	No. of cases	ENP	ASR
65–74									
Male	6	3.0	4	13	1.3	81	19	4.3	5
Female	14	11.2	11	26	3.6	169	40	14.7	14
Total	20	14.1	8	39	4.9	131	59	19.0	10
75–84									
Male	46	14.2	39	47	7.3	264	93	21.5	55
Female	74	24.5	46	133	22.5	360	207	47.0	78
Total	120	38.7	43	180	29.8	331	300	68.5	69
≥ 85									
Male	36	7.7	121	44	9.2	417	80	16.9	196
Female	94	17.7	147	214	38.9	511	308	56.6	288
Total	130	25.5	138	258	48.1	490	388	73.5	260
All									
Male	88	24.9	22	104	17.8	300	192	42.7	38
Female	182	53.4	30	373	65.0	394	555	118.3	58
Total	270	78.3	27	477	82.8	367	747	161.0	51

Logistic regression analysis revealed that overall the differences in the prevalence estimates for all dementias and for Alzheimer's disease varied significantly by age group ($p < 0.001$) (Table 10); Alzheimer's disease was more common among women (controlling for differences in age between the sexes), whereas vascular dementia was more common among men. The prevalence of dementia in the institutional sample differed significantly across the regions ($p < 0.001$), perhaps because of different regional policies on admission to institutions. The absence of cases of dementia among men aged 65 to 74 in Ontario, although surprising, did not deviate significantly from the pattern in other regions, mainly because of the very small number of cases (three to five) in each region.

Table 11 shows the estimated number of cases of dementia if the age-specific prevalence estimates from this study are applied to the projected Canadian population over the next 40 years.[2]

Table 7: Prevalence of vascular dementia for 1991 by region, sex and residence

	Community			Institution			Total		
Region	No. of cases	ENP	ASR	No. of cases	ENP	ASR	No. of cases	ENP	ASR
Atlantic provinces									
Male	10	1.7	15	9	0.5	80	19	2.2	19
Female	11	1.1	7	12	0.8	70	23	1.9	10
Total	21	2.8	10	21	1.3	78	42	4.1	15
Quebec									
Male	8	4.2	15	13	3.8	199	21	8.0	28
Female	11	3.9	9	13	3.1	72	24	6.9	15
Total	19	8.1	12	26	6.9	110	45	14.9	20
Ontario									
Male	5	2.4	6	10	3.7	161	11	6.1	15
Female	5	2.3	3	21	7.0	119	29	9.3	12
Total	10	4.7	4	31	10.7	132	41	15.4	13
Prairies									
Male	6	2.1	10	14	2.4	189	20	4.5	20
Female	1	0.8	3	15	2.1	81	16	3.0	10
Total	7	3.0	6	29	4.5	117	36	7.5	14
British Columbia									
Male	11	2.7	16	5	0.5	57	16	3.2	17
Female	5	1.4	6	19	2.1	111	24	3.5	14
Total	16	4.1	10	24	2.6	98	40	6.7	16
All									
Male	40	13.1	11	51	10.9	157	91	24.0	19
Female	33	9.5	5	80	15.1	94	113	24.6	12
Total	73	22.7	7	131	26.0	115	204	48.6	15

Table 8: Prevalence of vascular dementia for 1991 by age group, sex and residence

	Community			Institution			Total		
Age group, yr	No. of cases	ENP	ASR	No. of cases	ENP	ASR	No. of cases	ENP	ASR
65–74									
Male	7	3.8	5	16	3.4	207	23	7.2	8
Female	3	2.3	2	12	1.8	84	15	4.1	4
Total	10	6.1	3	28	5.2	137	38	11.2	6
75–84									
Male	26	7.6	21	26	4.8	173	52	12.3	31
Female	14	4.5	8	34	6.9	110	48	11.4	19
Total	40	12.1	13	60	11.7	129	100	23.8	24
≥ 85									
Male	7	1.7	27	9	2.7	124	16	4.5	52
Female	16	2.7	23	34	6.4	84	50	9.1	46
Total	23	4.5	24	43	9.1	93	66	13.6	48
All									
Male	40	13.1	11	51	10.9	157	91	24.0	19
Female	33	9.5	5	80	15.1	94	113	24.6	12
Total	73	22.7	7	131	26.0	115	204	48.6	15

Discussion

We succeeded in administering a complex protocol to a large sample of elderly Canadians. The sample represented a broader spectrum of people than those in previous studies, which have been local rather than national in scope. The response rates in our study compare favourably with those in smaller, less complex studies.[33,34] The methodologic contributions of the CSHA include a large-scale test of the validity of the screening test and the development of a diagnostic approach that proved acceptable to neurologists, psychiatrists and geriatricians. The agreement among the clinicians who made a blind reassessment of the diagnoses was strong. Also, the study will provide Canadian norms for the neuropsychologic tests used. In terms of prevalence estimation this is the largest population-based study to have used a standard approach to ascertain cases and diagnose dementia and to have included community and institutional components. Indeed, a weakness of many studies has been their lack of clinical assessment and sole reliance on psychometric testing. This design weakness has led to active debate over the value of the resulting estimates, the common argument being that they are low because of imperfect sensitivity.[35–39]

Certain limitations in the CSHA may affect the ac-

Table 9: Age-standardized prevalence ratios of dementia by sex and region*

Type of dementia	Region; ratio				
	Atlantic provinces	Quebec	Ontario	Prairies	British Columbia
Alzheimer's disease					
Male	132	121	63	126	103
Female	116	109	100	102	81
Total	118	112	88	108	86
Vascular dementia					
Male	100	147	79	105	89
Female	83	125	100	83	117
Total	100	133	87	93	107
Other					
Male	108	67	92	150	92
Female	40	47	160	67	113
Total	64	50	129	93	107
All types					
Male	119	120	72	125	97
Female	98	98	108	92	92
Total	105	105	96	104	94

*The age-standardized prevalence ratio for a region is the ASR for that region expressed as a percentage of the ASR for all regions. The prevalence ratio for all regions is 100.

Table 10: Logistic regression analysis of the differences in prevalence estimates for dementia by sex, age group and region

Variable	Characteristic; χ^2 value*		
	Sex	Age group	Region
Community sample			
Subjects examined clinically	0.3	5.3	1.3
Subjects with			
Dementia (all types)	3.1	34.6†	11.8‡
Alzheimer's disease	9.1†	42.0§	4.3
Vascular dementia	4.9‡	2.9	3.1
Other dementia	0.4	3.4	21.5§
Institutional sample			
Subjects with			
Dementia (all types)	0.0	43.5§	30.0§
Alzheimer's disease	7.3†	81.8§	21.5§
Vascular dementia	6.7†	2.6	3.9
Other dementia	2.7	6.1	34.7§

*One degree of freedom (df) for sex, 2 df for age group and 4 df for region.
†$0.001 < p < 0.01$.
‡$0.01 < p < 0.05$.
§ $p < 0.001$.

curacy of our estimates. First, the people included may not be truly representative of all elderly Canadians since (a) only those with reasonable access to one of the study centres were included, (b) the screening procedures were available only in English and French and (c) elderly people living in the Yukon Territory, the Northwest Territories or on Indian reserves were not included. The first restriction led to underrepresentation of elderly people in rural areas; existing studies rarely indicate whether the prevalence differs between rural and urban areas, although Forbes and Barham[40] suggested that it is higher in urban areas. There are more institutions in urban than in rural areas, which would slightly exaggerate the true prevalence. The exclusion of the territories would exert a very minor effect: only 0.06% of all Canadians aged 65 and over live in the territories.[1]

The second limitation was the absence of an accessible, accurate sampling frame of elderly Canadians. Old Age Security files were not accessible. There were problems in using the medicare lists (e.g., 19.3% of the elderly people listed had moved or died). The use of the Enumeration Composite Record in Ontario may have contributed to the lower than average estimated community prevalence in that region, if people with cognitive impairment were underrepresented on the list.

Third, the compliance rates of 72.1% for screening, 73.1% for clinical examination among those screening positive and 81.7% for clinical examination among those in institutions, although comparable to rates achieved elsewhere,[40] are less than ideal.

Fourth, the method of estimating the prevalence assumed that the 3MS exam for screening was completely sensitive (i.e., all possible cases were detected). Although this was not correct, small numbers prevented us from deriving accurate estimates of false-negative rates by diagnosis to correct the figures in the tables. However, the error appears small: an underestimation by 4.8% of the estimate. By contrast, Evans and collaborators[13] found that correcting for false-negative screens elevated their prevalence estimate. O'Connor and associates[37] also corrected for false-negative screens as well as for subjects who refused (for whom they obtained information on cognitive status from medical records). Unfortunately, they did not report the prevalence among those refusing to participate.

Table 11: Projected prevalence of dementia in Canada from 1991 to 2031

Year	Type of dementia; no. of cases, × 1000		
	All	Alzheimer's disease	Vascular dementia
1991	253	161	49
2001	364	238	68
2011	475	314	86
2021	592	387	109
2031	778	509	144

Compared with the prevalence estimates reviewed above,[4–19] and with results quoted by Rockwood and Stadnyk,[41] our prevalence estimates for dementia of all types fall toward the upper end of the ranges in other studies, while the rates for Alzheimer's disease fall in the middle. This may suggest an unusual balance between Alzheimer's and other forms of dementia in our study. The ratio of the prevalence of Alzheimer's disease to that of vascular dementia in our study was 3.3 (Tables 5 and 7). Jorm[42] compared the frequency of Alzheimer's disease and vascular dementias in studies from various countries. These showed a preponderance of Alzheimer's disease in Caucasian populations, and of vascular dementia in Oriental populations: the ratios were 3.0 in Britain, 2.0 in Italy, 1.3 in Scandinavia and 0.6 in Japan and in China.[42]

If the prevalence estimates remain unchanged, the number of cases of dementia in Canada will almost triple by 2031, whereas the total population will increase only by a factor of 1.4. The assumption of constant prevalence implies that the incidence rate and the mean length of survival remain unchanged (or that changes in the two rates will balance each other out). Based on studies in Minnesota,[15] the assumption of constant prevalence is reasonable, unless a modifiable cause can be found. In the absence of a cure, the effect of treatment would, if anything, prolong survival. The prospect of caring for such a large increase in the number of patients with dementia is challenging, although little different from the reality already facing Western European countries.

The data reported in this article were collected as part of the Canadian Study of Health and Aging. The study was coordinated through the University of Ottawa and the Laboratory Centre for Disease Control. We are grateful for the guidance of the members of our Policy Advisory Committee: Denis Evans, MD, Center for Research on Health and Aging, Chicago; Joseph Foley, MD, Department of Neurology, University Hospitals, Cleveland; Gerda Fillenbaum, PhD, Duke University Medical Center, Durham, NC; Paul Levy, PhD, School of Public Health, University of Illinois at Chicago; Jim Mortimer, MD, Veteran's Administration Medical Center, Minneapolis; and Rachel Pruchno, PhD, Menorah Park Center for the Aging, Beachwood, Ohio.

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Appendix 1: Study centres and investigators involved in the Canadian Study of Health and Aging

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- Albert Kozma, PhD, Department of Psychology

Appendix 2: Methods of staff training, data handling and assessment of diagnostic consistency

Staff training

Separate manuals and training materials were developed for study centre coordinators, interviewers, physicians, nurses, psychometricians and neuropsychologists to standardize procedures across the study centres. All of the study-centre coordinators met for a 1-week session in Ottawa; they had a refresher session 7 months later and a debriefing session at the end of the study. Questionnaires and manuals were available in English and French. Training of the interviewers in using the questionnaire lasted 5 days and was undertaken in each study centre. Training packages for physicians included a manual and a videotape. A 1-week training program was held centrally for the nurses. A manual and a videotape were used by the neuropsychologists to train the psychometricians in administering the neuropsychologic tests (Table 1). During the field work the national coordinator visited all study centres to ensure uniform implementation of the study protocol.

Data handling

Data were entered centrally to ensure uniformity and to achieve economies of scale. We used the data entry system of the SPSS software for microcomputers;[43] double entry was used until the error rate fell below one error per 500 variables. Many of the remaining errors were then detected by a set of data-checking programs that searched for implausible combinations of variables; anomalies were checked at the appropriate study centre. File manipulation and preliminary analyses were performed with the use of SAS[44] and SPSS;[43] programs were written in BASIC to produce prevalence estimates with the appropriate weighting.

Assessment of diagnostic consistency

At the end of the study the consistency of diagnoses among the study clinicians was assessed in two ways. First, computer algorithms, written to reflect the diagnostic criteria,[27,28] were used to check consistency between the clinical findings and the consensus diagnosis. Discrepant cases were returned to the diagnosticians for comment. After their comments were incorporated, the rate of agreement between the computer classification and the final diagnosis for the distinction between dementia and non-dementia was 97.6%. The rate of agreement on the distinction between probable Alzheimer's disease and other dementias was 95.0%. Second, 210 clinical assessment forms were selected at random, and batches of 14 assessments were sent for blind reassessment to each of 15 study clinicians. Because the second clinician did not see the patient, the estimate of agreement was probably conservative. The kappa index of agreement was 0.70 (95% confidence interval [CI] 0.62 to 0.78) for the classification into four diagnostic categories (no cognitive loss, cognitive loss but not dementia, Alzheimer's disease and all other types of dementia). Classification into dementia or no dementia yielded a kappa index of 0.81 (95% CI 0.73 to 0.89).

Conferences
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June 24–25, 1994: 6th World Congress of Ergophthalmology
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6th World Congress of Ergophthalmology, c/o Venue West Conference Services, 645–375 Water St., Vancouver, BC V6B 5C6; tel (604) 681-5226, fax (604) 681-2503

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Du 9 au 14 oct. 1994 : 10e Symposium international sur l'athérosclérose
Montréal
Date d'échéance pour les résumés : le 15 avr. 1994
Secrétariat général, Gerry Lou et associés, 211–1224, rue Stanley, Montréal, QC H3B 2S7; tél (514) 878-2530, fax (514) 878-2532

Oct. 9–14, 1994: 10th International Symposium on Atherosclerosis
Montreal
Abstract deadline: Apr. 15, 1994
General Secretariat, Gerry Lou et associés, 211–1224 Stanley St., Montreal, PQ H3B 2S7; tel (514) 878-2530, fax (514) 878-2532

Oct. 19, 1994: Clinical Day '94: Mid-Life Health Promotion/ Advocacy and Substitute Decision Making Legislation
Toronto
Cindy Stolarchuk, conference coordinator, Sunnybrook Health Science Centre, 2075 Bayview Ave., North York, ON M4N 3M5; tel (416) 480-6100, ext. 5904

Oct. 20–21, 1994: Gairdner Foundation Lectures
Toronto
Sally-Anne Hrica, executive director, Gairdner Foundation, 220–255 Yorkland Blvd., Willowdale, ON M2J 1S3; tel (416) 493-3101, fax (416) 493-8158

Mar. 16–17, 1995: 3rd European Congress on Ambulatory Surgery and 1st International Congress on Ambulatory Surgery
Brussels, Belgium
Official language: English
Dr. Claude De Lathouwer, Brussels One Day Clinic, ave. Duc Jean 71-23, 1080 Brussels, Belgium; tel 011-322-422-4271, fax 011-322-425-7076

May 11–14, 1995: American Association for the History of Medicine 68th Annual Meeting
Pittsburgh
Abstract deadline: Oct. 15, 1994
Dr. Jonathon Erlen, local arrangements chair, 123 Northview Dr., Pittsburgh, PA 15209