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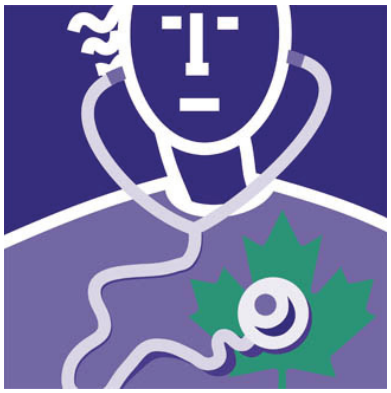
Canadian Health Measures Survey: Rationale, background and overview



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Canadian Health Measures Survey: Rationale, background and overview

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Abstract

The Canadian Health Measures Survey (CHMS) was developed to address important data gaps and limitations in existing health information by collecting directly measured indicators of health and wellness on a representative sample of approximately 5,000 Canadians aged 6 to 79 years. The survey entails an in-home general health interview followed by a visit to a mobile clinic, where direct physical measures of health are taken (anthropometry, spirometry, blood pressure, fitness, physical activity, oral health examination, blood and urine specimens). Reference laboratories analyze biological specimens for indicators of general health, chronic disease, infectious disease and environmental biomarkers. This important and ambitious survey provides comprehensive and robust health information to advance health surveillance and research in Canada, while providing training opportunities to enhance research capacity.

Keywords

health surveys, data collection, direct measures, health measurement, national survey

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The Canadian Health Measures Survey (CHMS) is a new, comprehensive, direct health measures survey that is being conducted by Statistics Canada in partnership with Health Canada and the Public Health Agency of Canada. This paper summarizes the background, history and rationale for the survey, and provides an overview of the objectives, methods and analysis plans.

Rationale and background

The principal objective of the CHMS is to collect new and important data on Canadians' health status. While Statistics Canada has been collecting health status and related data for many years, these data are generally limited in two important ways. First, many kinds of data, such as blood pressure and physical fitness, simply cannot be ascertained in an interview; they require direct physical measurement. Second, health information derived from self-report surveys or administrative records may be seriously biased for some variables.[1] For example, a recent review shows a consistent reporting bias of even simple measures like height and

weight, which has the potential to misinform data users.[2] Moreover, efforts to correct for self-reporting bias are complicated by the probability that bias for some measures may be unstable over time and susceptible to media attention and social marketing campaigns, among other influences.

Direct health measurements can be reported on continuous scales; provide more robust, objective measures; and allow for the assessment of variables that simply cannot be determined accurately through self-reports (for example, metabolic syndrome, environmental toxin exposure, lung function). Such data are needed for public health education, health promotion programs, health care planning, health surveillance and research.

Accordingly, several countries have a history of conducting surveys that include direct physical measures and that have yielded important findings. For example, the U.S. National Health and Nutrition Examination Survey (NHANES)[3] has provided data to construct standard growth charts for children, thereby allowing doctors and parents to better understand developmental health trajectories.[4] In the 1960s, the NHANES confirmed findings linking high cholesterol and heart disease. It also provided the first evidence that Americans had high blood lead levels, which motivated governments to phase out the use of lead as an additive in gasoline and paint.[5] In Australia, a health measures survey conducted from 1999 to 2001 found that for every known case of diabetes, there was one undiagnosed case, and that nearly 1 million Australians over age 25 have diabetes.[6] Finland, too, has a legacy of important public health and scientific findings from national direct health measures surveys.[7,8]

Table 1
Summary of Canadian direct health measures surveys, 1970 to 1972 to 2004

Survey	Year(s)	Direct measure sample	Age range (years)	Response rate to direct measures and biospecimen collection (if applicable) of eligible respondents	Direct health measures
Nutrition Canada Survey[9]	1970 to 1972	12,795	0+	46%	Biochemical blood tests: protein, albumin, calcium, phosphorous, bilibrubin, alkaline phosphate, iron, transferrin saturation, vitamins (A, C, E), cholesterol, folic acid, triglycerides. Biochemical urine tests: glucose, iodine, creatinine, urea nitrogen, riboflavin, thiamine, pyridoxine, hct, Hb; Physical measures: dental exam, standing and sitting height, height of anterior superior iliac spine, biacromial diameter, bi-ilio-cristal diameter, antero-posterior and transverse chest diameters, wrist breadth, bicondylar femur breadth, calf and upper arm circumferences, head circumference, upper arm and subscapular skinfolds, weight.
Canada Health Survey[10]	1978 to 1979	8,751	2+ Physical measures 3+ blood	28%	Biochemical tests: immune status (polio, measles, mumps, rubella, diphtheria, tetanus), zinc, copper, lead, cholesterol, uric acid, creatinine, transaminase, glucose, Hb. Physical measures: height, weight, upper arm length, arm midpoint, arm girth, upper arm skinfold, blood pressure, cardiorespiratory fitness.
Canada Fitness Survey[11]	1981	16,000	7 to 69	59%	Physical measures: height, weight, skinfolds, chest, waist, hip, thigh, calf and upper arm circumference, knee and elbow diameter, somatotype, blood pressure, resting heart rate, cardiorespiratory fitness, flexibility, push-ups, sit-ups, grip strength.
Campbell's Survey on Well- being[12,13]	1988	4,000	10 to 69	80%	Physical measures: height, weight, skinfolds, chest, waist, hip, thigh circumference, blood pressure, resting heart rate, cardiorespiratory fitness, flexibility, push-ups, curl- ups, grip strength.
Canadian Heart Health Surveys[14]	1988 to 1992	20,095	18 to 74	67%	Biochemical blood tests: cholesterol, triglycerides. Physical measures: height, weight, waist and hip circumference, blood pressure.
Canadian Study of Health and Aging[15]	1991 1996 2001	2,914 2,305 1,322	65+	82%, 90%, 91% institutionalized sample 74%, 85%, 89% community sample	Biochemical blood tests: complete blood count, glucose, folate, vitamin B12, genetic screen. Physical measures: height, weight, blood pressure, hearing, vision, vital signs, neurological and neuro-psychological exams, mobility, balance, CT scan.
Canadian Community Health Survey[16]	2004	31,925	2+	57.5%	Physical measures: height, weight.

Notes: Some participants were screened out of participation - proportion unknown. Hb = haemoglobin; hct = haematocrit; RBC = red blood cell.

Despite the advantages for surveillance and research, population-representative direct health measures surveys have been rare in Canada. As the summary in Table 1 indicates, no comprehensive, national health measures survey has been conducted in Canada since the 1978/1979 Canada Health Survey.

Since then, however, the need for such a survey has been discussed, with varying degrees of intensity, although the cost proved to be a difficult barrier. Early preparations for the 1994/1995 National Population Health Survey, for instance, included direct physical measures that were eventually dropped. Between 1998 and 2001, an Expert Working Group for the Cardiovascular Disease Surveillance System of Health Canada met periodically to discuss the content of a potential survey that would collect direct measures. Support, endorsement and encouragement for such a survey came from several government departments and scientific groups. Technical improvements and decreased costs for biospecimen analyses gave the project added momentum. A number of program and policy initiatives that occurred from 2001 to 2006 (Table 2) further demonstrated the need for surveillance of public health indicators and provided direct or indirect impetus for the creation and ongoing support of a direct health measures survey.

In response to growing demands for the surveillance of public health indicators and to address long-standing limitations in Canada's health information system, Health Canada and the Public Health Agency of Canada supported Statistics Canada in obtaining funding for a direct measures health survey. This support was announced in the 2003 federal budget as part of an extension of the Health Information Roadmap Initiative.[17,18]

The Canadian Health Measures Survey (CHMS) aims to advance the Health Information Roadmap Initiative[17,18] by addressing important data gaps and

Table 2
Program and policy initiatives instrumental in development of Canadian Health Measures Survey

Program or policy initiative	Role / Mandate	Year
Physical Measures Survey Proposal Working Document prepared by Health Statistics Division at Statistics Canada[19]	Initial guiding document for the conceptualization and development of the Canadian Health Measures Survey.	2001
Creation of the Chronic Disease Prevention Alliance of Canada (www.cdpac.ca)	Advocacy for integrated research, surveillance, policies and programs, and the resources needed to positively influence the determinants of health and reduce incidence of the chronic diseases that account for the largest burden of morbidity, mortality and cost in Canada, namely, cardiovascular disease, diabetes and cancer.	2001
The Canadian Sport Policy (www.canadianheritage.gc.ca/progs/sc/pol/^pcs-csp/Index_e.cfm)	Vision of enhanced participation with a significantly higher proportion of Canadians from all segments of society involved in quality sport activities at all levels and in all forms of participation. Monitoring required.	2002
Building on Values: The Future of Health Care in Canada (Romanow Report) (www.hc-sc.gc.ca/english/care/romanow/hcc0086.html)	Report of the Commission on the Future of Health Care in Canada, which reported on consultations with Canadians on the future of Canada's public health care system and recommended policies and measures that offer quality services to Canadians and strike an appropriate balance between investments in prevention and health maintenance and those directed to care and treatment.	2002
Federal Budget (www.fin.gc.ca/budget03/pdf/bp2003e.pdf)	Included the initial $20 million funding for the CHMS.	2003
Creation of Health Council of Canada (www.healthcouncilcanada.ca)	Mandated to monitor and report on the progress of health care renewal in Canada.	2004
Creation of the Public Health Agency of Canada (www.phac-aspc.ca)	Mission to promote and protect the health of Canadians through leadership, partnership, innovation and action in public health. Monitoring required.	2005
Development of Public Health Goals for Canada (www.phac-aspc.gc.ca/hgc-osc/pdf/goals-e.pdf)	Overarching goal is that, as a nation, we aspire to a Canada in which every person is as healthy as they can be—physically, mentally, emotionally, and spiritually. Monitoring required.	2005
Integrated Pan-Canadian Healthy Living Strategy (www.phac-aspc.gc.ca/hl-vs-strat/pdf/hls_e.pdf)	A conceptual framework for sustained action based on a population health approach. Its vision is a healthy nation in which all Canadians experience the conditions that support the attainment of good health. Monitoring required.	2005
Conference of F/P/T Deputy Ministers of Health[20]	Report identified that surveillance is an essential tool for planning and evaluating policies and programs to address chronic disease risk factors and determinants.	2006
Review of Human Biomonitoring Studies of Environmental Contaminants in Canada 1990-2005 Final Report released[21]	Provided strong evidence of a need for more comprehensive and intensive biomonitoring of environmental contaminants in Canada.	2006

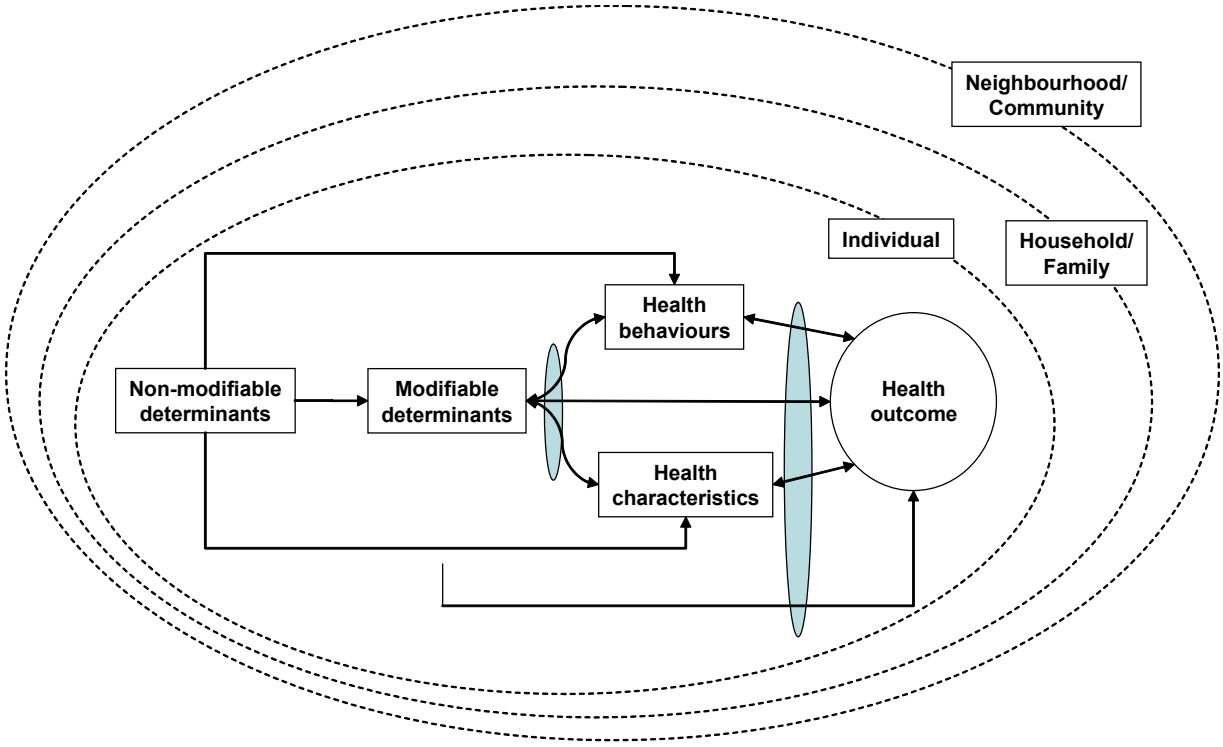
limitations in existing health information through direct physical measures of Canadians' health. The information will be used to establish national baseline data for a range of important health indicators such as obesity, hypertension, cardiovascular disease, exposure to infectious diseases, and exposure to environmental contaminants. In addition, the survey will provide insight into the fitness of the nation and the extent of undiagnosed disease.

The CHMS design has been informed by a conceptual framework that recognizes the importance of both individual- and non-individual-level measures of health. The concentric circles in Figure 1 illustrate the importance of measuring variables at other levels that may be mediators or moderators of individual health. Such variables could include reported or direct measures of geography, culture, climate, social inequality, workplace or school health policies, air quality, water quality, food access, local land use, green space availability, public safety (crime), traffic patterns, health care availability, and population density. Although most of these variables are not being collected in the CHMS at this time, it should be possible in some cases to collect these data and add them in the future.

Additionally, the CHMS anticipates the linkage of interview and clinic data, given respondents' consent, to their provincial health care records. This kind of linkage will provide unprecedented new information enabling, for example, the relationships between obesity and physical fitness to health care costs to be directly assessed.

The development and design of the CHMS entailed a comprehensive consultation process involving Health Canada, the Public Health Agency of Canada, expert advisory committees, professional

Figure 1
Conceptual framework for Canadian Health Measures Survey



Notes: Shaded circles indicate interactions among the arrows. Examples of non-modifiable population health determinants include: age, sex, ethnicity, genotype; examples of modifiable population health determinants include: income, education, social environment, physical environment, health care system; examples of health behaviours include: physical activity, nutrition, alcohol and substance abuse, smoking status, medication use, sex behaviours, stress exposures; examples of health characteristics include functional status, immunization status, stress reactivity, body weight, cardiovascular fitness, musculoskeletal fitness, metabolic fitness; examples of health outcomes include detectable disease, health care system contact, disability.

and scientific stakeholder groups, the National Centre for Health Statistics in the U.S., federal and provincial privacy commissioners, the Health Canada Research Ethics Board, and several Statistics Canada committees. Because of the invasiveness of some of the measures, many complicated and delicate ethical, legal and social issues required investigation, discussion, consultation and compromise; details of these issues are provided in Day et al.[22]

The early development of the CHMS coincided with substantial interest and activity around the creation of large representative cohort studies designed to include comprehensive direct measures of health (for example, Canadian Longitudinal Survey on Aging, CARTaGENE, Multi-generational Cohort Study, Canadian National Children's Study, Ontario Cohort Consortium). The opportunity for the CHMS to contribute to and learn from the discussions surrounding these studies not only assisted the development of the CHMS, but also expanded the base of support for the survey.

In the fall of 2004, a pre-test was conducted to assess costs and response rates, examine processes and procedures, and evaluate operations and planning assumptions.[23] The pre-test findings provided important direction for the ultimate design of the CHMS.[23]

Two months before data collection began, a dress rehearsal was held. Approximately 120 volunteers from selected age groups underwent the full survey collection procedures and laboratory testing. This dress rehearsal was an opportunity to simulate both normal and emergency situations and interruption procedures. Several minor modifications to procedures, processes and applications were made based on the dress rehearsal.

To prepare the CHMS, new computer applications, processes and procedures needed to be developed; measurement spaces and infrastructures built; data security features tested and confirmed; sampling strategies created; communications strategies developed and implemented; logistical and operational procedures tested; staff hired and trained; biospecimen and statistical analysis planning completed; biorepository established; data processing procedures instituted; ethical, legal, privacy and social issues resolved; and financial planning completed.[22-25] Approximately 3.5 years of development were needed before data collection started, with a staff that began as one, growing to nearly 70 when the survey went into the field in March, 2007.

Survey overview

Objectives

The objectives of the CHMS are to:

- estimate the numbers of people with selected health conditions, characteristics and exposures;
- estimate the distribution of selected diseases, risk factors and protective characteristics;
- assess the validity of prevalence estimates based on self- and proxy-reported information;
- monitor temporal trends of directly measured variables to the extent possible with available survey data;
- ascertain relationships among risk factors, health promotion and protection behaviours, and health status;
- explore emerging public health issues and new measurement technologies;
- establish a biorepository of biospecimens (urine, plasma, serum, isolated genomic DNA) from a representative sample of Canadians to be used for future research and surveillance;
- provide a data collection platform and infrastructure for ongoing physical measures surveys and add-on studies;
- provide training opportunities for staff, students and researchers interested in direct health measures data collection operations and data analysis;
- share experiences and expertise with others domestically and internationally.

Survey sampling

The CHMS was designed to provide nationally representative estimates (for conditions that have a prevalence of 10% or more, with a coefficient of variation of 16.5%) from a sample of approximately 5,000 Canadians aged 6 to 79 years, with roughly

500 females and 500 males in each of the following age groups: 6 to 11, 12 to19, 20 to 39, 40 to 59, and 60 to 79 years. The Labour Force Survey area frame, supplemented by the 2006 Census, was used as the sampling frame. The use of mobile clinics required a clustered sample design. Logistical and financial considerations limited the number of sites to 15. Collection sites were selected so as to contain a population of at least 10,000 respondents, with a maximum travel distance of 100 km to a site without crossing census metropolitan area boundaries. This sampling protocol covers approximately 96% of the Canadian population and resulted in data collection sites in five provinces. Further details of the sampling strategy are provided elsewhere in this publication.[25]

Within each site, dwellings were stratified and randomly selected using the sampling frame. Initial contact with selected dwellings is made through a mail-out containing information about the CHMS. Subsequently, a roster of all residents from each participating dwelling is obtained, and one or two eligible respondents are selected per dwelling. The probability of a respondent being chosen varies by stratum, depending on the age group being targeted, and is designed to achieve the desired age and sex stratification. The CHMS is voluntary and includes only respondents who agree to participate.

Field operations staff

The field interviewer staff consists of 10 or 11 Statistics Canada interviewers and an interviewer manager. The clinic staff consists of a manager, two senior health measures specialists, four health measures specialists, four laboratory technicians or technologists, four clinic coordinators, two licensed dentists, two dental recorders, and a site logistics officer. All health measurement specialists are Certified Exercise Physiologists.[26] As part of contingency planning, trained replacement staff are available.

The staff travel from site to site and live at each location for 6 to 7 weeks. The advance arrangements staff orchestrate living arrangements at each site.[24] The clinic staff work as two teams (morning shift and afternoon shift). The survey shuts down for holidays.[24]

Statistics Canada staff at head office in Ottawa provide central support for advance arrangements; public relations and communications; technical support; training and retraining; data capture and processing; quality assurance and quality control; survey management and administration; and data analysis.

Survey methods

Data collection is performed in two stages: a health questionnaire administered in the respondents' home by a Statistics Canada interviewer (computer-assisted personal interview—CAPI), and, one day to six weeks later, direct physical measurements and biospecimen collection in a mobile clinic.

Consent for participation in the health interview is implied when respondents answer questions. However, a comprehensive consent process is employed for the physical measures at the clinic. Specific written consent is obtained for participation in the physical measures (including biospecimen collection); receipt of lab results; measurement and reporting of reportable diseases; storage of biospecimens (except DNA); and separately for DNA storage. In addition to consent from their parent or guardian, assent is obtained from children.

Table 3
Summary of household questionnaire content, Canadian Health Measures Survey

Theme areas	Modules
Health status	general health; sleep; height and weight; weight change; Health Utility Index; chronic conditions; hepatitis; family medical history; oral health; phlegm; pregnancy; birth information; breast-feeding information
Nutrition and food	grains consumption; fruit and vegetable consumption; meat and fish consumption; dietary fat; salt; water and soft drink consumption; milk and diary product consumption
Medication use	medications; other health products and herbal remedies
Health behaviours	physical activities; sedentary activities; smoking; alcohol use; illicit drug use; sexual behaviour; maternal breast-feeding; strengths and difficulties
Environmental factors	exposure to second-hand smoke; sun exposure; housing characteristics; grooming product use
Socio-economic information	socio-demographic characteristics; education; labour force activity; income

Details of the consent process are provided by Day et al.[22]

The household questionnaire has 46 modules containing 722 questions (Table 3). The questionnaire was designed to provide background and contextual information for the direct measurements. For most respondents, the household interview takes 60 to 90 minutes, including an introduction to the clinic visit (flash video) and the consent process. Immediately after the household interview, respondents are encouraged to call to make an appointment for the physical measurements.

Each of the two mobile clinics used for performing the physical measures is comprised of two 53-foot trailers joined by a pedway.[24] Advance arrangements staff ensure that the clinics are set up in safe locations at each site and that all services are connected (for example, power, water, sewer, telephone, internet, waste disposal, parking, wheelchair access, etc.).[24] Each site operates for approximately 6 weeks, 7 days a week, with morning, afternoon and evening appointments. Measurements of 18 respondents can be completed each day. At each site, 330 to 350 respondents are measured. Data collection is being performed over a two-year period (March 2007 to March 2009).

Clinic operations

A detailed description of the mobile clinic logistics and procedures is provided in the accompanying paper by Bryan et al.[24] Briefly, respondents arrive at the mobile clinic for their scheduled appointment; their identity is verified; consent is obtained; screening procedures are employed; physical measures are taken; and biospecimens collected. (The list of physical measures obtained is provided in Table 4; the list of analytes assessed in blood and urine is provided in Table 5; and the specific measurement equipment used is summarized in Table 6). Respondents selected for morning appointments arrive at the mobile clinic after a 12-hour fast; those with afternoon or evening appointments require only a 2-hour fast. All respondents follow specific pre-testing guidelines.[24]

Table 4
Physical measures included in Canadian Health Measures Survey

Measure	Age group	Sample size
Anthropometry	All ages	5,000
Standing height		
Sitting height		
Weight		
Waist circumference		
Hip circumference		
Skinfolds		
Blood pressure	All ages	5,000
Resting heart rate	All ages	5,000
Accelerometry (physical activity monitoring)	All ages	5,000
Spirometry (lung functioning)	All ages	5,000
Cardiovascular fitness (mCAFT step test)	6 to 69 years	4,525
Muscular strength, endurance and flexibility		
Hand grip strength	All ages	5,000
Partial curl-ups	6 to 69 years	4,525
Sit and reach	6 to 69 years	4,525
Oral health exam	All ages	5,000
Blood sample	All ages	5,000
Urine sample	All ages	5,000
Storage of blood and urine	All ages	5,000
Storage of DNA	20 years or older	3,000

Note: Answers to the screening/consent questions, as well as respondents' withdrawal of consent for some or all parts of the survey, affect which physical measures are taken and captured (that is, for each measure, the number of test results could be less than the targeted sample size).

Home visit

Surveys in Finland demonstrated that giving individuals who are unable (for a variety of reasons) to attend the mobile clinic an opportunity to have the physical measures performed in their home reduces bias, especially among the elderly. The CHMS, therefore, offers a home visit option, as described in detail by Bryan et al.[24]

Reporting results

A major motivation for individuals to participate in the CHMS is the opportunity to receive the results of a variety of measurements of health and wellness. At the mobile clinic, respondents can have immediate results of the physical measurements that can be interpreted quickly (for example, blood pressure, oral health, and physical fitness).

Table 5
Laboratory tests on blood and urine, Canadian Health Measures Survey

Blood	Age group	Sample size
General		
Complete blood count (CBC) (White blood count, lymphocytes, monocytes, neutrophils, eosinophils, basophils, red blood count, haemoglobin, haematocrit, mean corpuscular volume (MCV), mean corpuscular haemoglobin concentration (MCHC), mean corpuscular haemoglobin (MCH), red cell distribution width, (RDW), platelets)	All ages	5,000
Blood chemistry panel (Alanine aminotransferase (ALT), albumin, alkaline phosphatase, aspartate aminotransferase (AST), bicarbonate, calcium, chloride, creatinine, gamma- glutamyltransferase (GGT), lactate dehydrogenase (LDH), phosphate, potassium, sodium, total bilirubin, total protein, urea, uric acid)		
Heart health		
Homocysteine, high sensitivity C-reactive protein	All ages	5,000
Total cholesterol, total cholesterol/HDL ratio, high and low density lipoproteins (HDL and LDL cholesterol), triglycerides, apolipoproteins A1and B	All ages	2,500
Fibrinogen	12 years or older	4,000
Diabetes		
Glycohaemoglobin (HbA1c)	All ages	5,000
Glucose (fasting or random), fasting insulin	All ages	2,500
Nutritional status		
Red blood cell folate, vitamin B12, vitamin D	All ages	5,000
Infectious disease measures		
Hepatitis A (anti-HAV) Hepatitis B (anti-HBs and anti-HBc) Hepatitis C (anti-HCV)	14 years or older	3,750
Hepatitis B (HBsAg for subsample that tests positive for anti-HBc; polymerase chain reaction used to verify positives)	14 years or older	200 (estimate)
Environmental exposure		
Metals: arsenic, copper, molybdenum, nickel, selenium, uranium, zinc, lead, cadmium, mercury (total), manganese	All ages	5,000
Inorganic mercury	All ages	1,000
Non-coplanar PCBs/organochlorine pesticides/ Polybrominated diphenyl ethers, Perfluorinated compounds	20 years or older	1,500
Urine		
Kidney health		
Creatinine, microalbumin, microalbumin/creatinine ratio	All ages	5,000
Nutritional status		
Iodine	All ages	5,000
Environmental exposure		
Metals: antimony, arsenic, cadmium, copper, inorganic mercury, manganese, molybdenum, nickel, lead, selenium, uranium, vanadium, zinc	All ages	5,000
Cotinine	All ages	5,000
Organophosphate pesticides, Dialkyl phosphate metabolite diethylphosphate pesticides and metabolites, phenoxy herbicide (2,4-Dichlorophenoxyacetic acid and the metabolite 2,4 dichlorophenol), pyrethroid pesticide metabolites, bisphenol A	All ages	2,400
Phthalate metabolites	6 to 49 years	3,000

Laboratory results and results from measurements that require further assessment are provided in a final report sent to respondents 8 to 12 weeks after their clinic visit. Urgent (potentially dangerous) laboratory findings and positive results from hepatitis B and C analyses are reported more rapidly. The process of reporting to respondents, including early reporting and the reporting of infectious disease, is detailed by Day et al.[22]

Quality assurance and quality control

Because the CHMS aims to provide the highest quality data possible, quality assurance and quality control procedures are comprehensive. These procedures are outlined elsewhere.[24] Detailed manuals describe quality assurance and quality control procedures for each measure. A quality assurance/quality control advisory committee, composed of experts from each area of measurement included in the CHMS, has been established. Regular observations are made of the measurement staff, and feedback is provided. Repeat measures are performed on a subset of respondents to test both intra-tester and inter-tester reliability. Standard quality control procedures for laboratory measures are used (controls, external quality control programs, blanks, blind samples, regular equipment calibration) and monitored regularly.

Biorepository

The biological specimen flow, which has been described in detail by Bryan et al.,[24] is summarized in Figure 2. Biospecimens (whole blood, plasma, serum, urine) are sent regularly (once or more per week) from the mobile clinic to each of the testing laboratories. Surplus samples from the testing laboratories are sent to the National Microbiology Laboratory (NML) in Winnipeg, which is the biorepository for the CHMS. Deliberate over-sampling is carried out in order to obtain pristine samples for storage in the biorepository. Biospecimens are stored (with consent) for all ages, but isolated genomic DNA is stored only for consenting respondents aged 20 to 79 years. The

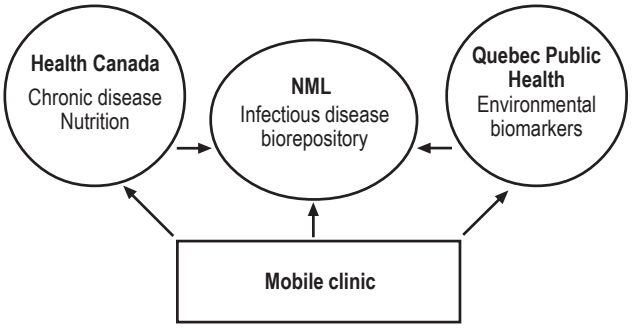
Table 6
Measurement equipment used for Canadian Health Measures Survey

Measure	Principal equipment used (manufacturer)
Anthropometry	
Standing height	Proscale 200 stadiometer (Accurate Technology Inc., Fletcher, NC)
Sitting height	Custom-built sitting height block with stadiometer
Weight	Mettler Toledo scale with Panther Plus digit readout (Mettler Toledo Canada, Mississauga, ON)
Waist and hip circumference	Gulick tape measure
Skinfolds	Harpenden skinfold caliper (Baty International, West Sussex, UK)
Blood pressure	VSM MedTech BpTRU BPM-300 (Health Check Systems, Inc., Brooklyn, NY)
Resting heart rate	Polar FS1 heart rate monitor and straps (Polar Electro Canada Inc., Lachine, QC)
Accelerometry (physical activity monitoring)	Actical Activity Monitor with Step Count (Mini Mitter, a Respironics, Inc. Company, Bend, Oregon)
Spirometry (lung functioning)	Respironics KoKo spirometers (PDS Instrumentation, Louisville, CO)
Cardiovascular fitness (mCAFT step test)	Custom-built steps, CD Player
Muscular strength, endurance and flexibility	
Hand grip strength	T-18 Smedley III hand dynamometer (Takei Instruments Ltd., Tokyo, Japan)
Partial curl-ups	Generic floor mats; metal distance indicator; goniometer; metronome
Sit and reach	Flexometer (Fitsystems Inc., Calgary, AB)
Oral health exam	Patient chair and oral health exam equipment and probes
Lab	
Complete blood count	Beckman Coulter HMX analyzer (Beckman Coulter, Mississauga, ON)
Centrifuge	Brinkman Eppendorf 5702R centrifuge (Eppendorf Canada, Ltd., Mississauga, ON)
Biosafety cabinet	NuAire 425-200 biosafety cabinet (NuAire Inc., Plymouth, MN)

biorepository is an important feature of the CHMS because:

- It provides future research and surveillance opportunities on a nationally representative sample of Canadians.

Figure 2
CHMS biospecimen (whole blood, plasma, serum, urine) flow from mobile clinic to reference laboratories and biorepository, Canadian Health Measures Survey



NML – National Microbiology Laboratory; Québec Public Health - L'Institut National de Sante Publique du Quebec (INSPQ)

- It enables current surveillance priorities, for which resources for analysis are not immediately available, to be conducted as soon as resources can be made available.
- The frontier of large-scale genetic and genomic research has arrived, offering enormous possibilities for future health benefits from such research.
- Having stored samples available to researchers reduces the burden on Canadians, since it will not be necessary to repeat a national survey, taking samples from another group of Canadians.
- Stored samples could provide important baseline information for the future by providing an indication of what existed when the CHMS was conducted.
- New technology and testing techniques (often more sensitive and less expensive) are advancing at a rapid pace, particularly in genetic and genomic research. Storing samples gives

the CHMS the opportunity to wait for new analytical procedures to be developed and for costs to decrease.

- It allows for exploration of explanatory factors in the future once the health outcomes of CHMS participants are known, through possible linkages with hospital data, cancer registries, mortality databases, etc.

An overview of the process to utilize the de-identified samples stored in the biorepository is provided by Day et al.[22]

Communications

To ensure respondents are informed and to maximize response rates, a comprehensive array of communications materials was prepared (Table 7). All materials are available in French and English; some core materials were translated into languages common at some sites (for example, Mandarin and Punjabi).

A proactive communication strategy is important to the success of the survey. Immediately before operations begin at each site, a media launch is held to allow local media to see the mobile clinic, obtain pictures of staff performing tests, and publicize the survey. The media launch is coordinated with the Medical Officer of Health in each region to ensure that local public health officials are aware and involved. Local dignitaries and celebrities (mayor, councillors, athletes, medical officials, etc.) are invited to tour the trailers and be tested. This coverage lends credibility to the survey and encourages participation

Table 7
Respondent relations support materials, Canadian Health Measures Survey

Timing of distribution	Material	Purpose
Submitted before collection	Introductory letter	Prepare respondent for visit from interviewer
	Introductory brochure	Explain purpose of survey; encourage participation
Provided at time of interview	Information and consent booklet	Introduce survey to respondent; outline survey goals; inform respondent about scope of tests; explain consent procedures
	Information for 6- to 13- year-olds (assent folder)	Explain purpose of survey and prepare child for collection process
	Measure sheets and activity monitor sheet	Prepare respondent for collection process and explain tests and measures
	Note to parents and guardians (ages 6 to 11, 12 to 17)	Give more information to respondent's parents/guardians
	Pre-testing guidelines	Instruct respondent re: diet, exercise, and other preparations for test day
	Map to site	Show directions to site
	Flash video presented via interviewer's laptop	Inform respondent using visual images
	Survey endorsement letters	Demonstrate validity and benefits of survey
	Press clippings of news articles about survey	Inform respondent and establish validity of survey
	Absence from work/school letter	Official record of survey participation
Provided after clinic visit	Preliminary report	Provide test results of physical measures to respondent
	Activity monitor letters	Remind respondent to return activity monitor
	Early reports or test results and letters to physicians	Inform respondent of test results outside normal range that should be brought to a physician's attention
	Final reports of test results	Provide all test results to respondent

Analysis planning

The expertise and logistical constraints required to manage, collect, analyse and interpret information from health measures surveys make them resource-intensive. Relying on traditional analytical capacity and funding mechanisms may limit the use of such data by focusing on classic, risk factor and outcome relationships, rather than on more complex interactions. To minimize these limitations and exploit the full potential of the CHMS, an analytical plan was developed.

The plan is a strategic document describing the multidisciplinary analytical strategy until 2010. It is intended to be a living document that defines the broad analysis objectives, as well as the specific analytical activities related to the survey, including those that support analytical activities.

The strategic analytical goals are to:

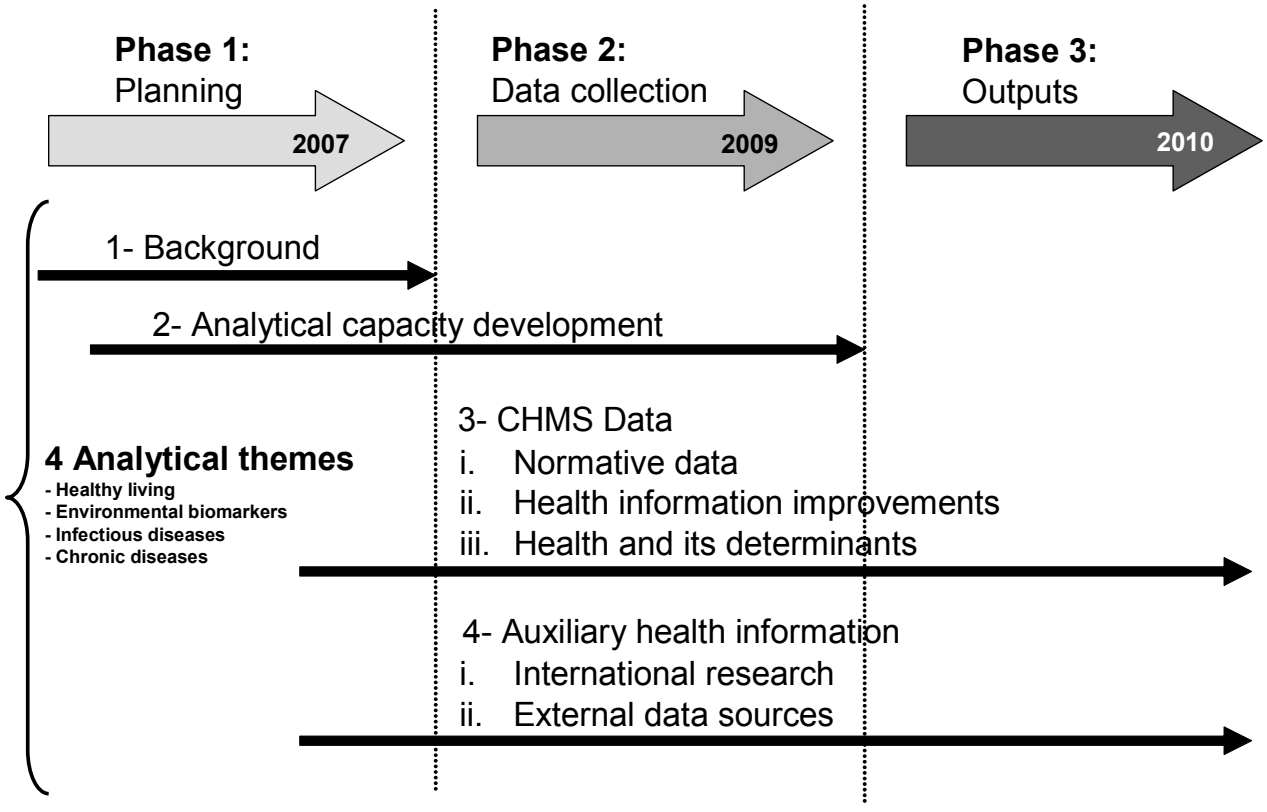
- Ensure that the priority health information needs that led to the funding of the CHMS are met.
- Conduct sufficient advance planning to ensure extensive use of the data for scientific publications, research training, policy development, and knowledge creation.
- Enhance the research process by promoting good practices, collaborative multidisciplinary partnerships, knowledge translation, and innovative funding mechanisms.
- Build capacity in Canada related to the appropriate analysis of results of direct physical measures surveys.
- Develop a specific, comprehensive and timely dissemination strategy directed to all partners.
- Monitor the progress and the quality of all analytical activities involving CHMS data.

The CHMS analysis structure is divided into three classification systems that have been further subdivided into analytical activities (Figure 3).

1. *A chronological system: Three phases*

   The analysis activities are divided into three

Figure 3
Data analysis strategy, Canadian Health Measures Survey



phases between 2005 and 2010. The first phase, "Planning," lasted until the Spring of 2007 when data collection began. "Data collection," the second phase, will take two years. The third phase, "Outputs," will begin during data collection and will include the official CHMS data release; it will end in 2010.

2. *A subject-matter system: Four themes*
   Analytical outputs can be classified into one of four themes: Healthy Living, Environmental Bio-markers, Infectious Diseases, and Chronic Diseases. This classification system was employed to ensure that analytical outputs capture the comprehensive array of variables in the CHMS.
3. *A priority-based system: Four categories*
   To ensure that the analytical objectives are met and to facilitate analysis management, the analytical activities are divided into four categories: Background, Analytical Capacity Development, CHMS Data, and Auxiliary Health Information, with time-sequenced priority in this order.

   Background research refers to reference documents such as this series of papers, which can be used by research, policy and professional communities across the country. We hope that the availability of these documents will reduce the burden for authors of subsequent papers that use CHMS data.

   Building capacity and expertise for CHMS staff and partners in physical measures is the focus of analytical capacity development. Analytical work in this component will not use CHMS data, but will support analyses when CHMS data are available. Examples include a series of systematic reviews comparing the discrepancy between self-reported and measured values of health indicators,[2] and validity testing of the Actical accelerometer/pedometer.[27]

   Analytical efforts using partial datasets will intensify as collection nears completion in 2009. The focus then will be on normative data analysis to establish representative national distributions of the measures in the survey. Normative data will, in most cases, be stratified by age and sex, and where applicable, by other health determinants.

   Analyses falling under the themes of "health information improvements" and "health and its determinants" will examine associations between various determinants and health, and compare the validity and reliability of self-reporting to direct measures in order to inform public health programs and policies.

   Information collected as part of the auxiliary health information theme will increase analytical potential by building partnerships with international researchers to share data and examine the comparability of international data. The most important external data source will be health care encounter data from provincial administrative data sources, such as hospital and doctor visits. The linkage of these data at the individual level (subject to respondents' consent) will open major new areas of analysis, in particular, direct associations between risk factors and health care utilization. Additionally, the feasibility of appending other external sources of data to the CHMS database is being explored so that the influence of variables such as temperature and air and water quality can be investigated.

Unique challenges

The CHMS faces challenges rarely experienced by Statistics Canada surveys. These include: a much higher respondent burden (travel, time, expense, physical exertion, discomfort); data transfer complexity (interviewer→clinic→lab→Statistics Canada→respondent report); privacy and ethical considerations (age range for testing, consent, data flow security, storing biospecimens for future analysis, collecting DNA samples); communications (reporting to respondents, reportable diseases, media, public); and the potential for adverse events (phlebitis, cardiac event during fitness testing) or

adverse findings (previously undiagnosed infectious disease). Details about these unique challenges are provided elsewhere.[28]

Conclusion

The CHMS aims to overcome important data gaps in Canada's health information system through the collection of direct measures of health and wellness. The survey will create a unique and nationally representative dataset, including stored samples of serum, plasma, isolated genomic DNA and urine, for future research. The complex and intricate data collection platform and infrastructure provide opportunities for ongoing, direct physical measures surveys. The CHMS has the endorsement of the Canadian Medical Association, Canadian Dental Association, Canadian Hypertension Society, Canadian Lung Association, Canadian Red Cross, Dieticians of Canada, Heart and Stroke Foundation of Canada and the support of the Canadian Public Health Association, and the College of Family Physicians of Canada.

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Additional information on the CHMS is available at www.statcan.ca/chms.

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