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..	not available for a specific reference period
...	not applicable
0	true zero or a value rounded to zero
0^s	value rounded to 0 (zero) where there is a meaningful distinction between true zero and the value that was rounded
^{p}	preliminary
^{r}	revised
x	suppressed to meet the confidentiality requirements of the *Statistics Act*
^{E}	use with caution
F	too unreliable to be published
*	significantly different from reference category ($p < 0.05$)

Seroprevalence of hepatitis B and C virus infections: Results from the 2007 to 2009 and 2009 to 2011 Canadian Health Measures Survey

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Abstract

Background
Chronic hepatitis B (HBV) and C (HCV) virus infections can lead to liver failure, liver cancer, and death. In Canada, prevalence studies of HBV and HCV have been limited to regional and special populations.

Data and methods
Data are from cycles 1 (2007 to 2009) and 2 (2009 to 2011) of the Canadian Health Measures Survey. Socio-demographic, health and lifestyle information was obtained via a household questionnaire; blood samples collected at mobile examination centres were used to identify present and resolved HBV infections, vaccine-induced HBV immunity, and HCV infections.

Results
The seroprevalence of present HBV infection among the population aged 14 to 79 was 0.4%, representing an estimated 111,800 individuals. Another 4.2% had evidence of a previous HBV infection. Nearly 30% had vaccine-induced HBV immunity. The seroprevalence of HCV infection was 0.5%, representing an estimated 138,600. More than half of people with laboratory-confirmed HBV and 70% with laboratory-confirmed HCV were unaware of their infections.

Interpretation
This is the first Canadian study to report laboratory-confirmed seroprevalence of HBV and HCV infections based on a nationally representative household sample. Substantial percentages of younger Canadians have vaccine-induced HBV immunity.

Keywords
Biological specimens, data pooling, direct measures, disease notification, sexually transmitted diseases and blood-borne infections

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Chronic hepatitis B and C (HBV/HCV) viral infections challenge public health systems in Canada and around the world.[1] An estimated 5% of the world population is chronically infected with HBV,[1] and around 3%, with HCV.[2]

The likelihood of developing a chronic HBV infection varies by age at exposure. While 90% of those exposed during adulthood can expect to recover completely,[3] HBV infections acquired during childhood are much more likely to progress to chronic HBV. For example, some 90% of non-immunized children born to HBV-infected mothers develop chronic HBV infection.[2]

Transmission of HBV differs in countries where HBV infection is endemic, compared with countries where it is less common. In the former, transmission most often occurs "vertically" from infected mothers to infants in the peripartum period,[4] or "horizontally" through close family contacts.[5] In countries where HBV infection is less prevalent, transmission through sexual contacts and sharing injection drug equipment predominates.[3] HBV is also an occupational hazard for health care workers.[3]

In general, 75% to 80% of HCV-infected people develop chronic HCV infections, with some variability by age at infection,[6] sex,[7] race,[8] co-infection status,[9] co-morbidities,[10,11] and clinical manifestation of the disease.[2]

HCV is typically transmitted through blood, blood products, organs, tissues and cell transplants, and infected needles or other sharp objects, as well as from mother to infant during pregnancy and labour.[12] Sexual transmission of HCV is less common, but possible, especially among people with multiple sex partners[13,14] and those co-infected with other sexually transmitted infections, including Human Immunodeficiency Virus.[15,16]

Chronic HBV or HCV infection can lead to liver cirrhosis, liver cancer, decompensated liver disease, and premature death.[17-19] Effective treatments are available,[19,20] but access varies across Canadian jurisdictions[21] and infected populations.[22]

In Canada, information about the prevalence of HBV and HCV infections has generally been limited to laboratory data and national routine and enhanced surveillance,[17,23,24] findings of regional or provincial research studies,[25-28] serosurveys of selected subpopulations such as blood donors,[29-32] and modeled estimates.[33] These data sources have limitations, including under-reporting[34] and restricted generalizability.[30,31]

HBV and HCV infections are notifiable, meaning that newly diagnosed cases are reported to provincial/territorial and national public health agencies.[34]

However, the asymptomatic nature of these infections challenges accurate diagnosing and reporting. Consequently, prevalence estimates cannot be derived directly from reported cases.

This study presents seroprevalence estimates (prevalence based on blood samples) for HBV and HCV infections and vaccine-induced HBV immunity based on nationally representative data from the first and second cycles of the Canadian Health Measures Survey (CHMS). These data provide a baseline for monitoring trends in infection distribution, advancing public health policy, and making comparisons with other countries.

Methods

Data sources

The CHMS is an ongoing survey conducted by Statistics Canada in partnership with the Public Health Agency of Canada and Health Canada. It was designed to produce nationally representative estimates.[35] Cycle 1 took place from March 2007 through February 2009, and collected information from respondents aged 6 to 79 living in private households in 15 locations across Canada. Cycle 2 took place from August 2009 through November 2011, and collected data from respondents aged 3 to 79 living in private households in 18 locations. Ethics approval was obtained from Health Canada's Research Ethics Board.[36] The CHMS excludes people living on reserves and other Aboriginal settlements in the provinces, full-time members of the Canadian Forces, the institutionalized population, and residents of some remote regions. Together, these exclusions represent less than 4% of the target population.[37,38] Detailed information about the content and sample design of the CHMS is available elsewhere.[35,37,38]

As well as an in-person interview to gather socio-demographic, health and lifestyle information, the CHMS involved a subsequent visit to a mobile examination centre for direct physical measures, including blood collection. Respondents unable to visit the centre could have their direct measures taken at home.[39]

Of households selected for cycles 1 and 2, 72.7% agreed to participate, and 88.5% of selected household members aged 14 to 79 completed the household questionnaire. A total of 8,665 respondents (82.6% of those who responded to the household questionnaire) completed the mobile examination centre component. After adjustments for the sampling strategy, the final response rate for 14- to 79-year-olds for both cycles combined was 52.8%.

The HBV and HCV estimates in this article are based on data from 8,434 respondents aged 14 to 79 from cycles 1 and 2 of the CHMS. Because preliminary analyses of the individual cycles suggested power was an issue for some of the outcomes of interest, data from cycles 1 and 2 were combined.

The total population for the combined datasets was derived from the average population total for each collection period (cycle 1: 2007 to 2009 / 23 months; cycle 2: 2009 to 2011 / 28 months). Each cycle was adjusted based on the number of collection sites by cycle and region. The combined estimates, therefore, reflect the average Canadian household population during the study timeframe (2007 to 2011). Quality assurance measures were applied at each stage of data collection and processing, including testing and correcting for bias.[37] More information about combining data from cycles 1 and 2 of the CHMS is available elsewhere.[38]

Because of the possibility that seroprevalence rates of HBV and HCV infection might be relatively high among the foreign-born, the combined CHMS sample was examined to assess whether this group was adequately represented (Appendix Table A). According to the 2007 to 2011 CHMS results, 23% (95% CI: 17.8-29.2) of the population were foreign-born, which is comparable to estimates of about 20% in the 2006 Canadian Census[40] and the 2011 National Household Survey[40] (data not shown). As well, CHMS representation of the foreign-born from areas with high levels of HBV and HCV infection,[41,42] such as China, Africa and some South American countries, is also comparable to 2006 Census estimates, perhaps, in part reflecting the inclusion of areas with high foreign-born concentrations (Vancouver, Toronto and Montreal) among the collection sites.[37,38]

Although HBV and HCV are notifiable diseases, CHMS data, including survey responses and laboratory testing of blood, are protected by the confidentiality provisions of the *Statistics Act.* To respect these competing requirements, before they were tested, CHMS respondents were asked for permission to share positive test results with health authorities.

Respondents were excluded from this study if:

- they were aged 6 to 13 (not tested for hepatitis).
- blood was not collected for medical reasons, such as hemophilia ($n < 10$) or receipt of chemotherapy in the past four weeks (n=11).
- the test(s) was (were) not performed because the respondent did not consent to disclosure (n=62); results were incomplete (HBV: n=11; HCV: n=11); or samples were unavailable or insufficient for both HBV and HCV (n=130).

Blood collection

At the mobile examination centre, blood was collected by venipuncture into vacutainers and processed within four hours of collection. Standardized procedures for the collection, handling, processing, aliquoting and shipping of the biospecimens ensured the quality and comparability of the test results.[38] Blood samples were processed at the National Microbiology Laboratory in Winnipeg, Manitoba.

Hepatitis B and C (HBV/HCV) infection markers

For this analysis, HBV infection and vaccine-induced immunity, as well as HCV infections, were defined according to positive (+) and negative (–) infection

marker test results (Text table 1). Present, previous and resolved HBV infections and HCV infections were defined using the national surveillance case definitions, if applicable.[43]

Serum samples from respondents aged 14 to 79 were tested for markers of HBV and HCV infection, past HBV exposure and vaccine-induced HBV immunity using the fully automated, random access VITROS EciQ Immuno-diagnostic System (ORTHO-Clinical Diagnostics).

For HBV, the VITROS Anti-HBc, HBsAg, and anti-HBs assays were used (Text table 1). When results for antibodies to the hepatitis B core antigen (anti-HBc) were positive, samples were tested for hepatitis B surface antigen (HBsAg) to identify *present* HBV infection. *Previous* HBV infections were defined as being anti-HBc positive, excluding those that were also HBsAg positive (that is, *present* HBV). A total of 67 cases positive for *anti-HBc only* were included in the "previous" HBV category. All samples were tested for antibodies to HBV surface antigen (HBsAg) to establish vaccine-induced HBV immunity and resolved HBV infections. Cases positive for anti-HBc and HBV surface antibody (anti-HBs) were classified as *resolved*, whereas those positive for anti-HBs only were defined as the *vaccine-induced immunity* cases.

HCV infections were detected with VITROS Anti-HCV Assay Version 3.0; all samples positive on screening for anti-HCV were confirmed by INNO-LIA HCV Score immunoblot assay (Innogenetics, Fugirebio Inc., GA, US).

Text table 1
Defining hepatitis B (HBV) and C (HCV) infections and hepatitis B vaccine-induced immunity

Type of hepatitis infection	Biomarkers
HBV	
Present	HBsAg (+)
Previous	anti-HBc (+)†
Resolved	anti-HBc (+) and anti-HBs (+)
Vaccine-induced immunity	anti-HBc (-) and anti-HBs (+)
HCV	anti-HCV (+)

† excluding HBsAg (+) cases

Table 1
Seroprevalence and estimated number with present hepatitis B infection, by selected characteristics, household population aged 14 to 79, Canada, 2007 to 2011

	Present infection HBsAg (+)					
		95% confidence interval			95% confidence interval	
Characteristic	%	from	to	Number '000	from	to
Total	0.4[E]	0.2	0.8	111.8[E]	42.8	180.8
Sex						
Female	<0.8†	...	...	<87.1†	...	...
Male	<1.0†	...	...	<116.2†	...	...
Age group						
14 to 49	0.4[E]	0.2	0.7	60.2[E]	18.2	102.1
50 to 79	<1.3†	...	...	<98.9†	...	...
Household income						
Higher	<0.5†	...	...	<73.4†	...	...
Lower	<2.4†	...	...	<88.4†	...	...
Missing	F	...	...	F	...	...
Education						
Less than postsecondary graduation	<0.9†	...	...	<59.7†	...	...
Postsecondary graduation	<0.9†	...	...	<133.3†	...	...
Race						
White	F	...	...	F	...	...
Non-White	1.8[E]	0.9	3.4	92.8[E]	28.2	157.4
Immigrant status						
Canadian-born	F	...	...	F	...	...
Foreign-born	1.6[E]	0.9	2.9	101.6[E]	33.9	169.4

† if coefficient of variation of estimate exceeds 33.3%, estimate is indicated as being less than upper limit of 95% confidence interval
[E] use with caution
F too unreliable to be published
... not applicable
Source: 2007 to 2009 and 2009 to 2011 Canadian Health Measures Survey, combined.

Covariates

Hepatitis prevalence was examined by sex, age group, household income, education, racial background, immigration status, and prior knowledge of their HBV/HCV infection status.

Because of small sample sizes, only two age groups were specified: 14 to 49 and 50 to 79.

Household income, adjusted for household size, was classified into two categories: higher and lower, as well as a "missing" category when income level could not be established (about 17% of the sample). Households were considered to be lower income if their total earnings in the past year were less than $30,000 (one or two household members), less than $40,000 (three or four members), or less than $60,000 (five or more members).[38]

Education was dichotomized as less than postsecondary graduation or at least postsecondary graduation. For 14- to 24-year-olds, highest level of education in the household was used.

Because HBV and HCV prevalence varies globally,[1,2] racial background and birthplace were included in the analysis. CHMS respondents were asked to indi-

cate their racial background, based on an extensive list; individuals selecting "White" were classified as such; all others were combined into "non-White." Birthplace was dichotomized as foreign- or Canadian-born. The small number (34) of Canadian citizens born abroad were classified as Canadian-born.

Quantifying the accuracy of infection status by comparing self-reported to laboratory-confirmed cases is useful for public health promotion and prevention. For example, individuals aware of their sexually transmitted and blood borne infection (STBBI) status have been shown to modify their behaviours in order to minimize transmission risk to their partners.[44] For many diseases, individuals can be unaware of their infection status. CHMS respondents were asked if they had hepatitis, and if so, which type.

Analytical techniques

The seroprevalence of HBV and HCV was estimated using data from cycles 1 and 2 of the CHMS. To account for survey design effects, coefficients of variation and 95% confidence intervals were estimated with the bootstrap technique.[45,46] Differences between seroprevalence estimates were calculated using t-tests. All analyses were conducted in SUDAAN v.10 (RTI International, Research Triangle Institute, NC, USA), using weighted data and DDF=24 in the procedure statements to account for the degrees of freedom of the combined datasets.

Results

Hepatitis B and C

The seroprevalence of *present* HBV infection among 14- to 79-year olds was 0.4% (95% CI: 0.2-0.8), representing 111,800 (95% CI: 42,773-180,803) individuals (Table 1). *Present* HBV infection seroprevalence was 1.8% (95% CI: 0.9-3.4) among the non-White population, and 1.6% (95% CI: 0.9-2.9) among the foreign-born.

Another 4.2% (95% CI: 2.9-6.0), approximately 1.1 million, had serological evidence of a *previous* HBV infection, with 79% of these resolving completely and developing protective immunity (853,400) (Tables 2 and 3). Statistically equal percentages of males and females had evidence of prior infection. The seroprevalence of *previous/resolved* HBV infections was nearly twice as high among people aged 50 or older, compared with younger people. *Previous/Resolved* HBV infections were also more common among people identified as non-White rather than White, and among those who were foreign-born rather than Canadian-born. No statistically significant associations between education and *previous/resolved* HBV infection were apparent. Because of high sampling variability, the prevalence of *present* HBV infection by education and by other socio-demographic factors were inconclusive. Together, 4.6% (95% CI: 3.2-6.5) either had or were currently infected with HBV (data not shown).

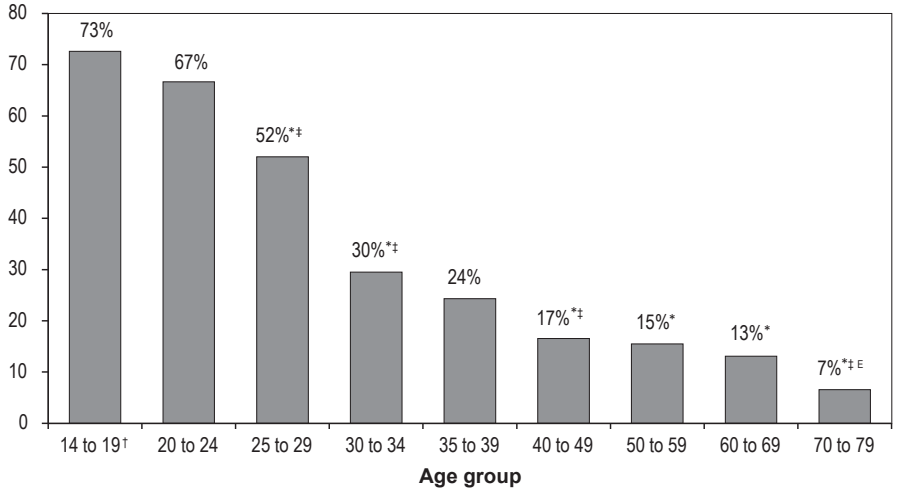
Almost one-third of 14- to 79-year-olds had vaccine-induced HBV immunity. Vaccine-induced immunity was negatively associated with age, falling from 72.6% (95% CI: 69.6-75.4) at ages 14 to 19 to 6.5% (95% CI: 4.5-9.4) at ages 70 to 79 (Figure 1).

An estimated 0.5% (95% CI: 0.3-0.9) or 138,600 (95% CI: 55,800-221,300), had laboratory evidence of an HCV infection, identified as being positive for the HCV antibody (anti-HCV) (Table 4). HCV infection was more common in the older age group, and among individuals living in lower-income households. Because of high sampling variability, HCV seroprevalence by other covariates was inconclusive.

Infection awareness

During the household interview, CHMS respondents were asked if they have HBV or HCV. These results were compared with laboratory findings. Just under half (46%) of respondents who tested positive for a *present* HBV infection and 30% of those with a sero-confirmed HCV infection reported having been diagnosed with those infections (Table 5).

Figure 1
Prevalence of hepatitis B vaccine-induced immunity, by age group, household population aged 14 to 79, Canada, 2007 to 2011



† reference category
* significantly different from reference category (p < .05)
‡ significantly different from previous age group (p < .05)
E use with caution
Note: Overall prevalence of hepatitis B vaccine-induced immunity in population aged 14 to 79 was 29%.
Source: 2007 to 2009 and 2009 to 2011 Canadian Health Measures Survey, combined.

Discussion

With data from the combined cycles 1 and 2 of the CHMS, this article examined the seroprevalence of HBV (present, previous/resolved infections and vaccine-induced immunity) and HCV infection among Canadians aged 14 to 79. This is the first study to analyze direct measures of these infections from a nationally representative Canadian household sample.

The combined 2007 to 2011 CHMS estimates for HBV (0.4% present; 4.2% previous) are consistent with results of the National Health and Nutrition Examination Survey (NHANES) in the United States. For instance, based on the 1999 to 2006 NHANES, 0.28% (95% CI: 0.21-0.36) tested positive for an HBV infection, and 4.8% (95% CI: 4.3-5.3), for past/present infection.[47]

HBV infection risk factors identified by the CHMS were also similar to NHANES results. For example, according to NHANES, chronic/previous HBV infections were higher among older than younger age groups and less common among American-born than foreign-born individuals.[47]

The prevalence of HBV infections tends to be high in sub-Saharan Africa and Southeast Asia.[18,48] Consistent with other research,[17,29,47,48] this analysis found relatively high rates of *present* HBV infections among the non-White population and the foreign-born.

People infected with HBV during childhood are at greatest risk of serious health consequences.[17] In the early to mid-1990s, Canada implemented universal hepatitis B vaccination programs targeting infants and school-aged children.[49-51] The seroprevalence of vaccine-induced immunity, particularly at younger ages (the group most likely to have been vaccinated), was evident in the CHMS data. This is consistent with previously observed reductions in reported hepatitis B infections based on Canadian surveillance data,[17] and with the age-related declining gradient of vaccine-induced immunity in the United States.[47]

The CHMS seroprevalence estimate of HCV (0.5%) for 2007 to 2011 was lower than the 1999 to 2002 NHANES estimate of 1.6% (95% CI: 1.3-1.9),[52] but largely consistent with estimates of 0.5% from the 1991 to 2002 Manitoba linked

Table 2
Seroprevalence of previous and resolved hepatitis B infection, by sex and selected characteristics, household population aged 14 to 79, Canada, 2007 to 2011

	Previous infection anti-HBc (+) (excluding cases HBsAg(+))									Resolved infection anti-HBc (+) and anti-HBs (+)								
	Total			Males			Females			Total			Males			Females		
		95% confidence interval			95% confidence interval			95% confidence interval			95% confidence interval			95% confidence interval			95% confidence interval	
Characteristic	%	from	to	%	from	to	%	from	to	%	from	to	%	from	to	%	from	to
Total	4.2[E]	2.9	6.0	4.5[E]	3.0	6.7	3.8[E]	2.6	5.7	3.3[E]	2.2	4.8	3.4[E]	2.1	5.6	3.1[E]	2.1	4.8
Age group														…				
14 to 49†	3.2[E]	2.1	4.8	2.9[E]	1.6	5.3	3.5[E]	2.2	5.4	2.7[E]	1.7	4.3	2.5[E]	1.3	5.0	2.9[E]	1.8	4.7
50 to 79	5.8*[E]	3.9	8.6	7.3*[E]	4.7	11.3	4.5[E]	2.7	7.4	4.2*[E]	2.7	6.5	5.0*[E]	3.2	8.0	3.5[E]	2.0	6.2
Household income																		
Higher†	2.8[E]	1.7	4.5	3.0[E]	1.7	5.1	2.6[E]	1.6	4.2	2.2[E]	1.3	3.7	2.2[E]	1.2	3.9	2.2[E]	1.3	3.7
Lower	9.1*[E]	6.0	13.6	10.0*[E]	6.1	15.9	8.4*[E]	4.9	14.1	7.7*[E]	4.9	11.8	8.4*[E]	4.7	14.4	7.2*[E]	4.0	12.4
Missing	4.7[E]	2.5	8.6	<13.8‡	…	…	<6.8‡	…	…	<7.1‡	…	…	<13.9‡	…	…	<4.4‡	…	…
Education																		
Less than postsecondary graduation	4.8[E]	3.0	7.6	4.5[E]	2.8	7.0	5.2[E]	2.9	9.2	3.9[E]	2.4	6.3	3.1[E]	1.8	5.6	4.7[E]	2.5	8.4
Postsecondary graduation†	3.6[E]	2.4	5.2	3.9[E]	2.5	6.0	3.2[E]	2.0	5.0	2.7[E]	1.8	3.9	3.0[E]	1.9	4.6	2.4[E]	1.5	3.7
Race																		
White†	1.9[E]	1.3	2.8	2.3[E]	1.3	3.8	1.5[E]	0.9	2.6	1.4[E]	0.9	2.4	1.9[E]	1.0	3.6	1.0[E]	0.5	1.8
Non-White	13.1*	10.2	16.7	13.0*[E]	9.0	18.3	13.3*	10.0	17.4	10.6*	8.2	13.5	9.4*[E]	5.9	14.5	11.9*	9.1	15.2
Immigrant status																		
Canadian-born†	1.4[E]	0.8	2.2	1.6[E]	0.8	3.0	1.1[E]	0.7	2.0	0.9[E]	0.5	1.7	<2.7‡	…	…	0.6[E]	0.3	1.0
Foreign-born	12.8*	9.8	16.6	13.1*[E]	9.2	18.3	12.6*	9.6	16.3	10.6*	7.9	14.0	9.9[E]	6.2	15.5	11.3*	8.7	14.6

† reference category
* significantly different from reference category ($p < 0.05$)
‡ if coefficient of variation of estimate exceeds 33.3%, estimate is indicated as being less than upper limit of 95% confidence interval
[E] use with caution
... not applicable
Source: 2007 to 2009 and 2009 to 2011 Canadian Health Measures Survey, combined.

administrative data study,[27] 0.7% from a 1996 England and Wales sero-survey,[53] and 0.78% from a Canadian model.[33] Given that the CHMS excludes some populations with higher HCV rates, exact agreement was not expected.

Like the 1999 to 2006 NHANES data, CHMS data suggest that low income and older age are correlates of HCV infection.[52]

The Canadian Enhanced Hepatitis Strain Surveillance System,[54,55] NHANES 1999 to 2006,[47] NHANES 1999 to 2002,[52] the Canadian Notifiable Diseases Surveillance System,[23] and a 1996 to 1998 Australian sero-survey[56] all found that males were more likely than females to be infected with HBV or HCV. CHMS samples were not large enough to test for statistically significant differences between the sexes, but as more cycles become available, HBV/HCV sample sizes and statistical power will be improved.

Many sexually transmitted and blood-borne infections are asymptomatic, which may explain why substantial percentages of infected people are not aware, and as a result, fail to accurately report their infection status.[42] HCV infection awareness levels ranging from 40% to 60% have been found in Canadian studies of adult blood donors,[57] men who have sex with men,[58] prison inmates,[59] and injection drug users.[60] Much lower infection awareness—under 10%—has been found among street youth.[61] The comparatively low HCV infection awareness among CHMS respondents may reflect the survey's exclusion of high-risk groups and the inclusion of younger, undiagnosed individuals with typically shorter HCV disease histories.

Limitations

Logistical and budget constraints limited the number of CHMS collection sites and overall sample size.[37,38] As a result, this analysis sometimes used broader variable definitions than would have been desirable. As well, the CHMS was designed to produce national estimates and is not recommended for subnational analyses (possible exceptions may be Ontario- and Quebec-level analyses using data from at least two cycles).[38]

Table 3
Estimated number with previous or resolved hepatitis B infection, by sex and selected characteristics, household population aged 14 to 79, Canada, 2007 to 2011

	Previous infection anti-HBc (+) (excluding cases HBsAg(+))									Resolved infection anti-HBc (+) and anti-HBs (+)								
	Total			Males			Females			Total			Males			Females		
Characteristic	Number '000	95% confidence interval from	to	Number '000	95% confidence interval from	to	Number '000	95% confidence interval from	to	Number '000	95% confidence interval from	to	Number '000	95% confidence interval from	to	Number '000	95% confidence interval from	to
Total	1,085.7[E]	654.2	1,517.1	583.5[E]	327.7	839.3	502.1[E]	284.7	719.6	853.4[E]	493.3	1,213.5	444.5[E]	211.6	677.3	408.9[E]	225.1	592.7
Age group																		
14 to 49†	527.6[E]	292.6	762.6	248.7[E]	88.7	408.7	278.9[E]	142.8	415.0	447.5[E]	232.0	663.1	214.2[E]	57.8	370.5	233.4[E]	114.4	352.4
50 to 79	558.0[E]	325.1	790.9	334.8[E]	180.8	488.8	223.2[E]	100.8	345.7	405.9[E]	222.4	589.3	230.3[E]	121.9	338.8	175.5[E]	66.2	284.8
Household income																		
Higher†	488.4[E]	245.4	731.5	272.5[E]	120.6	424.3	215.9[E]	106.4	325.5	381.0[E]	169.7	592.2	197.6[E]	74.2	321.1	183.3[E]	80.3	286.4
Lower	390.0[E]	201.4	578.7	185.6[E]	73.0	298.2	204.5[E]	91.3	317.6	329.9[E]	162.0	497.8	155.8[E]	51.1	260.5	174.2[E]	73.5	274.8
Missing	207.2[E]	74.3	340.1	<238.0[‡]	…	…	<141.8[‡]	…	…	<260.2[‡]	…	…	<204.1[‡]	…	…	<90.7[‡]	…	…
Education																		
Less than postsecondary graduation	417.8[E]	227.3	608.3	187.0[E]	107.6	266.4	230.8[E]	92.7	368.9	338.6[E]	177.6	499.7	132.0[E]	57.4	206.7	206.6[E]	77.3	335.9
Postsecondary graduation†	599.4[E]	342.9	855.9	333.4[E]	170.3	496.6	266.0[E]	133.3	398.6	447.9[E]	247.3	648.6	251.0[E]	122.5	379.4	196.9[E]	98.8	295.1
Race																		
White†	395.7[E]	235.8	555.5	234.2[E]	102.2	366.2	161.4[E]	77.4	245.5	297.4[E]	144.6	450.2	192.7[E]	59.2	326.2	104.7[E]	42.3	167.0
Non-White	690.0[E]	317.8	1062.2	349.3[E]	125.2	573.5	340.7[E]	162.0	519.4	556.0[E]	274.9	837.1	251.8[E]	83.8	419.7	304.2[E]	151.4	457.1
Immigrant status																		
Canadian-born†	267.0[E]	135.2	398.8	153.8[E]	48.9	258.7	113.2[E]	49.7	176.7	176.9[E]	57.9	295.9	< 222.0[‡]	…	…	58.9[E]	26.6	91.2
Foreign-born	818.7[E]	421.6	1,215.8	429.7[E]	196.0	663.4	389.0[E]	197.7	580.3	676.5[E]	349.8	1,003.3	326.5[E]	127.8	525.2	350.0[E]	181.7	518.4

† reference category
* significantly different from reference category ($p < 0.05$)
‡ if coefficient of variation of estimate exceeds 33.3%, estimate is indicated as being less than upper limit of 95% confidence interval
[E] use with caution
... not applicable
Source: 2007 to 2009 and 2009 to 2011 Canadian Health Measures Survey, combined.

Although combining CHMS cycles increased the sample size, the problem of small sample sizes was not eliminated for HBV and HBC infections, whose prevalence is low. Sample size also precluded examination of potential covariates such as Aboriginal identity, sexual orientation, exposure to contaminated blood, and injection drug use. Small sample sizes may have also reduced the ability to identify statistical significance.

Because of the cross-sectional nature of the CHMS and the laboratory algorithms used to detect HBV and HCV infections, chronicity could not be determined. Nonetheless, most of the present infections detected by the CHMS are likely chronic.[3]

The HBV and HCV seroprevalence results from the CHMS may be underestimates. Unlike surveillance efforts directed toward at-risk populations,[31,58,62] which deliberately target groups potentially affected by hepatitis, the CHMS sampling strategy uses random selection. Moreover, the CHMS is based on a household sample, and therefore, excludes some populations at high risk for these infections: people who are homeless,[31] First Nations people living on reserves,[54] inmates,[30,59] and residents of long-term and/or mental health institutions.[63] The prevalence of viral hepatitis risk behaviours such as injection drug[64] use tends to be relatively high in some of these populations. But despite the sampling strategy and these exclusions, CHMS results are generalizeable to the overall population aged 14 to 79.[37,38]

The combined response rate of 52.8% for the 14 to 79 age group means that in nearly half of households contacted, arrangements could not be made for a resident to participate. Survey weights are calculated to ensure that in terms of socio-demographic characteristics, the sample is representative of the target population, but differences in health status (specifically, hepatitis infection) could not be taken into account. Therefore, bias may exist if the hepatitis infection status of non-respondents differed systematically from that of respondents.

The CHMS collects a combination of self-reported, clinic, and laboratory data. Self-reported data are prone to social desirability and recall biases. The quality of laboratory data may also be

Table 4
Seroprevalence of hepatitis C infection, by sex and selected characteristics, household population aged 14 to 79, Canada, 2007 to 2011

	Total						Males						Females					
		95% confidence interval		Number	95% confidence interval			95% confidence interval		Number	95% confidence interval			95% confidence interval		Number	95% confidence interval	
Characteristic	%	from	to	'000	from	to	%	from	to	'000	from	to	%	from	to	'000	from	to
Total	0.5[E]	0.3	0.9	138.6[E]	55.8	221.3	0.4[E]	0.2	0.7	48.5[E]	19.7	77.3	<1.4[‡]	...	...	<157.4[‡]	...	...
Age group																		
14 to 49[†]	0.4[E]	0.2	0.7	60.4[E]	21.6	99.2	F	...	...	F	...	...	<1.2[‡]	...	...	<83.2[‡]	...	...
50 to 79	0.8*[E]	0.4	1.5	78.1[E]	24.4	131.8	0.8[E]	0.4	1.5	<61.2[‡]	...	...	<2.1[‡]	...	...	<83.6[‡]	...	...
Household income																		
Higher[†]	0.4[E]	0.2	0.7	70.0[E]	24.4	115.6	<0.6[‡]	...	...	<42.5[‡]	...	...	<1.2[‡]	...	...	<83.6[‡]	...	...
Lower	1.2*[E]	0.7	2.2	51.1[E]	20.0	82.2	1.3[E]	0.7	2.5	24.4[E]	7.3	41.4	<2.6[‡]	...	...	<51.0[‡]	...	...
Missing	F	...	...	F	...	...	F	...	...	F	...	...	F	...	...	F	...	...
Education																		
Less than postsecondary graduation	<1.9[‡]	...	...	<136.4[‡]	...	...	<1.4[‡]	...	...	28.7[E]	7.8	49.7	<2.8[‡]	...	...	<96.9[‡]	...	...
Postsecondary graduation[†]	<0.8[‡]	...	...	<111.8[‡]	...	...	<0.5[‡]	...	...	<37.6[‡]	...	...	<1.4[‡]	...	...	<86.6[‡]	...	...
Race																		
White[†]	0.5[E]	0.3	0.8	104.5[E]	51.8	157.3	0.4[E]	0.2	0.7	38.5[E]	14.6	62.5	0.6[E]	0.3	1.2	66.0[E]	25.1	107.0
Non-White	F	...	...	F	...	...	F	...	...	F	...	...	F	...	...	F	...	...
Immigrant status																		
Canadian-born[†]	0.5[E]	0.3	1.0	102.2[E]	35.5	168.9	0.3[E]	0.2	0.7	33.6[E]	10.1	57.1	<1.5[‡]	...	...	<121.2[‡]	...	...
Foreign-born	F	...	...	F	...	...	F	...	...	F	...	...	F	...	...	F	...	...

[†] reference category
* significantly different from reference category ($p < 0.05$)
[‡] if coefficient of variation of estimate exceeds 33.3%, estimate is indicated as being less than upper limit of 95% confidence interval
[E] use with caution
... not applicable
Source: 2007 to 2009 and 2009 to 2011 Canadian Health Measures Survey, combined.

What is already known on this subject?

- Chronic hepatitis B (HBV) and C (HCV) virus infections can lead to liver failure, liver cancer and death.
- Information about the prevalence of HBV and HCV infections in Canada has generally been limited to routine and enhanced surveillance, findings of regional and provincial studies, and sero-surveys of selected populations.
- In the early to mid-1990s, universal hepatitis B vaccination programs targeting infants and school-aged children were implemented in Canada.

What does this study add?

- This study reports seroprevalence estimates of HBV and HCV infections and vaccine-induced HBV immunity based on nationally representative data from the first and second cycles of the Canadian Health Measures Survey.
- The seroprevalence of HBV among the population aged 14 to 79 was 0.4%; another 4.2% had evidence of a previous HBV infection; and nearly 30% had vaccine-induced HBV immunity.
- The seroprevalence of HCV infection was 0.5%.
- More than half of people with laboratory-confirmed HBV and 70% with HCV were unaware of their infections.

Table 5
HBV and HCV infection awareness among those with laboratory-confirmed hepatitis, by type of hepatitis, household population aged 14 to 79, Canada, 2007 to 2011

	Aware			Not aware		
		95% confidence interval			95% confidence interval	
Type of hepatitis	%	from	to	%	from	to
Present HBV	45.5[E]	21.3	72.1	54.5[E]	27.9	78.7
HCV	30.5[E]	15.7	50.7	69.5	49.3	84.3

[E] use with caution
Source: 2007 to 2009 and 2009 to 2011 Canadian Health Measures Survey, combined.

imperfect because most laboratory tests fail to correctly identify some percentage of true positives and negatives.[65] The anti-HCV test may miss some HCV infections in immune-compromised individuals.[66] In the general population, about 20% of those infected with HCV can spontaneously clear the virus and lose the anti-HCV antibody.[67] Because HCV RNA testing was not done, it is not possible to distinguish present from past HCV infections.[68]

Without HBV DNA testing, some anti-HBc-only positive cases, of which there were 67, were included in the "previous HBV" infection category, although a small percentage of them may have been chronic "occult HBV." Starting with cycle 3 of the CHMS, new definitions that require additional DNA testing will be used to more accurately classify anti-HBc-only positive cases. [34]

Conclusion

Results of this analysis suggest that the seroprevalence of HBV and HCV in Canada is similar to that in other Western countries. As anticipated, markers of HBV vaccine-induced immunity were common at younger ages. Accurate infection awareness is important for health-care-seeking, receipt of treatment, vaccination uptake, and disease prevention, but more than half of respondents who tested positive for HBV and HCV did not know that they were infected. These HBV/HCV results serve as baseline data to monitor prevalence trends. As additional waves of CHMS data become available, it may be possible to combine successive cycles for a fuller investigation of risk factors for laboratory-confirmed HBV/HCV infections. ■

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Appendix

Table A
Foreign-born population, by selected birthplace, 2006 Census of Population and combined cycles 1 and 2 (2007 to 2011) of Canadian Health Measures Survey

	2006 Census of Population		Canadian Health Measures Survey			
					95% confidence interval	
Birthplace	Weighted number	% of foreign-born	Weighted number	% of foreign-born	from	to
South America[†]	152,775	2.5	248,235	3.6[E]	2.3	5.8
Africa	374,565	6.1	390,442	5.7[E]	4.0	8.1
China + Hong Kong	682,370	11.0	897,314	13.2[E]	7.7	21.6

[†] excludes Argentina, Chile, Colombia, Uruguay, Paraguay
[E] use with caution
Note: Selected birthplaces have high prevalence of HBV or HCV.[41,42]
Sources: 2006 Census of Population; 2007 to 2009 and 2009 to 2011 Canadian Health Measures Survey, combined.