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Increasing incidence of paediatric inflammatory bowel disease in Ontario, Canada: evidence from health administrative data

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Abbreviations: IBD: inflammatory bowel disease, CD: Crohn's disease, UC: ulcerative colitis, IBD-U: inflammatory bowel disease type undefined, ICD: International Statistical Classification of Diseases and Related Health Problems, ICES: Institute for Clinical Evaluative Sciences, SickKids: The Hospital for Sick Children, FY: fiscal year, PPV: positive predictive value, NPV: negative predictive value, CI: confidence intervals, LR+: positive likelihood ratio, LR-: negative likelihood ratio, AUROC: area under the receiver operating characteristic curve, OCCC: Ontario Crohn's and Colitis Cohort

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ABSTRACT

OBJECTIVE: Health administrative databases can be used to track chronic diseases. We aimed to validate a case ascertainment definition of paediatric-onset IBD using administrative data and describe its epidemiology in Ontario, Canada.

DESIGN: We used a population-based clinical database of IBD patients <15y to define cases and linked patient information to health administrative data to compare the accuracy of various patterns of healthcare use. We validated the most accurate algorithm with chart data of children <18y from twelve medical practices. We used administrative data from 1991-2008 to describe incidence and prevalence of IBD in Ontario children. We tested changes in incidence using Poisson regression.

RESULTS: Accurate identification of children with IBD required 4 physician contacts or 2 hospitalizations (with ICD codes for IBD) within 3 years if they underwent colonoscopy and 7 contacts or 3 hospitalizations within 3 years in those without colonoscopy (<12 year old children: sensitivity 90.5%, specificity >99.9%, <15y old children: sensitivity 89.6%, specificity >99.9%, <18y old children: sensitivity 91.1%, specificity 99.5%). Age- and sex-standardized prevalence per 100,000 population of paediatric IBD has increased from 42.1 (in 1994) to 56.3 (in 2005). Incidence per 100,000 has increased from 9.5 (in 1994) to 11.4 (in 2005). Statistically significant increases in incidence were noted in 0-4 year olds (5.0%/year, $p=0.03$) and 5-9 year olds (7.6%/year, $p<0.0001$), but not in 10-14 or 15-17 year olds.

CONCLUSION: Ontario has one of the highest rates of childhood-onset IBD in the world, and there is an accelerated increase in incidence in younger children.

INTRODUCTION

Inflammatory bowel disease (IBD) is an important childhood chronic disease, with 20-30% of patients presenting under 20 years old.[1] International data on trends in incidence and prevalence of childhood-onset IBD are conflicting. Some jurisdictions report increased rates of paediatric Crohn's disease (CD) (but not ulcerative colitis [UC]),[2, 3, 4] while others report increased rates of UC but not CD[5], or stable incidences.[6, 7] The incidence of CD in Canadian provinces studied to date is amongst the highest reported worldwide (13.4 per 100,000 in all age groups),[8] although there is little known about paediatric IBD. There are no data on IBD in Ontario, Canada's most populous province with 38% (12.2 million people) of the national population.[9]

Canada's single-payer health system, in which all legal residents have universal access to all healthcare services, represents a unique opportunity to capture all cases of IBD within a large jurisdiction. Ontario's health administrative databases are a large repository of all healthcare encounters for every legal resident and these data have been used to develop surveillance programs for multiple chronic diseases including diabetes[10] and asthma.[11] These population-based cohorts have been used to assess epidemiology, health services use and outcomes.[12, 13, 14] Critical to the accuracy of such data, however, is the rigorous validation of the best combination of health administrative data codes (known as a diagnostic algorithm) which most accurately define true disease.

Health administrative data have been used to describe epidemiologic trends among primarily adult populations of IBD patients in one Canadian study[8] as well as among privately insured American patients.[15, 16] All three studies used algorithms for assessment of disease predominantly validated in adults.[15, 16, 17] Administrative data algorithms have been reported to have differing accuracies across age groups,[18] and differing health care patterns in children necessitate validation of a paediatric-specific algorithm.[19]

Our goal was to develop and validate a diagnostic algorithm using health administrative data to identify individuals with childhood-onset IBD and then to use the algorithm to estimate the incidence and prevalence of paediatric IBD in Ontario.

METHODS

Administrative Data Sources

We used the health administrative databases available at the Institute for Clinical Evaluative Sciences (ICES; Toronto, Ontario, Canada). This study was approved by the research ethics boards of the Hospital for Sick Children (SickKids), Sunnybrook Health Sciences Centre and all institutions involved in the validation study. The databases used in this study included: hospital discharge abstract data mandatorily collected from all hospitals and reported to the Canadian Institute for Health Information, billing claims for all physician services provided from the Ontario Health Insurance Plan, and the Registered Persons Database (demographic data including region of residence). Hospital data prior to 2002 and all physician claims have diagnoses associated using codes from the International Classification of Disease (ICD)-9.[20] Hospitalizations after 2002 used ICD-10 codes.[21]

Algorithm Development Sample

We used the IBD clinical database from SickKids to identify patients with childhood-onset IBD in Toronto. The database, created in 1980 to prospectively track all cases of IBD seen at SickKids, contained an estimated 90% of patients aged 0-15 years old diagnosed with IBD and residing in the census metropolitan area of Toronto in fiscal years (FY) 1991-1995.[22] The database used Access® 2003 (Microsoft Corporation, Redmond, U.S.A.). Prior to 1996, all paediatric gastroenterologists in Toronto practised at SickKids, and an earlier survey of adult gastroenterologists suggested that fewer than 10% of children with IBD <15 years old were independently managed by them[22], and the database is therefore considered population-based for Toronto children <15 years diagnosed from 1991-1995. SickKids patient information was linked to the ICES administrative data by health card number. Patients were excluded if they did not reside within Toronto for the entire period of 1991-2000. The remaining population of that age residing within Toronto from 1991-1995 was assumed not to have IBD and used as the negative reference standard.

Algorithm Development

We determined the diagnostic accuracy (sensitivity, specificity, positive predictive value [PPV] and negative predictive value [NPV]) of various combinations of physician office and procedure billings and hospital records using the diagnosis codes for CD (ICD-9: 555.x, ICD-10: K50.x) or UC (ICD-9: 556.x, ICD-10: K51.x). Ninety-five percent confidence intervals (CI) were calculated according to the efficient-score method corrected for continuity.[23] We determined whether sigmoidoscopy or colonoscopy prior to diagnosis improved the accuracy of the algorithm. The final algorithm was selected and agreed upon by a committee of five experts in the fields of paediatric and adult gastroenterology, health services research, epidemiology and biostatistics (E.I.B., A.G., A.M.G., L.R., T.T.). The committee decided on the algorithm with the highest possible PPV (to minimize false positive rate) while maximizing sensitivity over the shortest possible duration to achieve accurate diagnosis.

Algorithm Validation

To validate the algorithm for patients <18 years old from other regions of Ontario and those treated in a variety of practice settings, 31 practices across the province (3 academic paediatric gastroenterology, 3 community-based paediatric gastroenterology, 18 community-based adult gastroenterology, 3 adult surgery, 4 consultant paediatrics) were contacted to determine whether their providers diagnosed patients aged <18 years with IBD (to ensure accuracy of the algorithm for older age groups) from 2001-2005 (to ensure accuracy of the algorithm for patients diagnosed in a later time period). Sites approached included three tertiary care paediatric hospitals and other sites were randomly selected using a provincial directory of practices. The final choices of sites to contact were based on geographic and practice diversity to ensure representation from northern, central, southern and eastern Ontario with 3-4 practices from each region randomly selected from the directory. In participating centres, all available charts of patients diagnosed with IBD from 2001-2005 were reviewed to ensure accurate diagnosis based on published criteria,[24] using clinical, histological and radiological information. For every IBD chart, two charts of patients without IBD were randomly selected and reviewed to act as the negative reference standard. Preference in chart review was given to non-IBD patients who underwent colonoscopy because they were more likely to be misclassified as having IBD in the administrative data.

Chart extractions were conducted by two IBD specialists (E.I.B. and D.R.M.) and two experienced IBD research assistants. The research assistants were trained by the principal investigator (E.I.B.). Ten charts from each practice were blindly reviewed by both to ensure consistency of diagnosis. In the cases of both assistants, there was 100% agreement with the investigator on the diagnoses. Clinical information was linked to health administrative data by health card number. Using chart information as the reference standard, we determined the parameters of diagnostic accuracy of the previously developed algorithm (sensitivity, specificity, positive likelihood ratio [LR+], negative likelihood ratio [LR-]).

We determined whether patients had CD or UC using the latest clinical, histological and radiological information obtained from each chart. A diagnosis of CD, UC, or inflammatory bowel disease type undefined (IBD-U) was assigned by the data extractor based on published guidelines.[25] Patients with IBD-U were excluded. Chart-based diagnoses were compared with ICD codes and an algorithm developed by assessing the combination of most recent ICD codes best able to distinguish CD from UC. The number of health services records achieving the highest possible area under the receiver operating characteristic curve (AUROC) while minimizing unclassified patients was chosen and the point of best cut-off was determined.[26] Patients who could not be classified as CD or UC by our algorithm were labelled 'unclassifiable'.

Estimates of incidence and prevalence

The Ontario Crohn's and Colitis Cohort (OCCC) was created by using the validated algorithm to identify all children (6 months to 18 years) living in Ontario with IBD from 1994-2005, using data from 1991-2008. The date of incidence was assigned as the date of the first health services contact with a diagnosis of IBD within the cluster of health care utilization qualifying the patient as having IBD. A three-year look-back period (with no diagnoses of IBD at the time of physician contact or hospitalization) was used to ensure that cases were truly incident. This was based on the expert opinion of clinicians on the committee due to the unlikelihood that a child with IBD would be lost to follow-up for more than three years. Patients with previous diagnoses of IBD but which were not part of the diagnostic cluster of the algorithm were considered prevalent, but not incident cases.

The sex- and age-adjusted annual prevalence and incidence rates per 100,000 population were determined for 1994-2005, with corresponding 95% CI based on Gamma distribution.[27] We used the Canadian censuses from 1991, 1996, 2001 and 2006 to calculate annual intercensal population estimates of children <18 years.[28] Using multivariable Poisson regression, we modelled the relationship between year of diagnosis (as the main predictor variable) to changes in prevalence and incidence of over time, controlling for age group and sex. Due to a significant interaction between age group and year of incidence, we stratified the regression by age group. All statistical analysis was conducted using SAS® version 9.1.3 (SAS Institute Inc., Cary, U.S.A.).

RESULTS

Algorithm Development – Study Population

Within the SickKids IBD database, 183 Toronto children were identified as having IBD diagnosed between 1991-1995 and acted as the positive reference standard. Between 1991-1995, 936,514 children under 15 years old resided in Toronto and acted as the negative reference standard.

Algorithm Development – Diagnostic Properties

The most accurate algorithm consisted of two steps, based on whether sigmoidoscopy or colonoscopy was performed (see Table 1). Those that did not undergo endoscopy required more stringent criteria for accurate ascertainment. If a patient underwent endoscopy, 4 physician contacts or 2 hospitalizations with a CD or UC diagnosis within 3 years were required for accurate diagnosis. If a patient never underwent endoscopy, 7 physician contacts or 3 hospitalizations were required. This two step algorithm accurately predicted a true IBD diagnosis (sensitivity 89.6% [95% CI 84.0-93.5%], specificity >99.9% [95% CI 99.9-100%], PPV 59.2% [95% CI 53.1-65.0%], NPV >99.9% [95% CI 99.9-100%]). For patients <12 years old, the algorithm accurately predicted IBD with higher PPV (PPV 76.0% [95% CI 68.9-82.0%]). As some jurisdictions may not have endoscopic procedure data, we also determined the best single step algorithm, ignoring whether a patient underwent diagnostic endoscopy (see Table 2). A single healthcare encounter for IBD (either physician contact, procedure, or hospital admission) was a poor predictor of the positive diagnosis of IBD (PPV 7.9% [95% CI 6.8-9.0%]).

Algorithm Validation by Chart Review

Of the 31 sites contacted, seven practitioners failed to respond, three refused to participate and nine practices had not diagnosed a child <18 years with IBD during the relevant time period. Twelve medical practices participated in the validation study (3 academic paediatric gastroenterology, 3 community paediatric gastroenterology, 5 adult gastroenterology, 1 consultant general paediatrics). With chart review, 599 patients were confirmed to have IBD, of which 593 could be linked to administrative data (342 with CD, 226 with UC, 26 with IBD-U). 551/593 (92.9%) underwent diagnostic sigmoidoscopy/colonoscopy. Of patients without IBD, 1251 charts were reviewed, of which 1241 could be linked to administrative data. Of these, 370 (29.8%) had sigmoidoscopy/colonoscopy. Based on chart review at 11/12 participating centres, the most common non-IBD diagnosis given was gastroesophageal reflux disease (18.2%), with other common diagnoses including idiopathic/functional abdominal pain (15.7%), irritable bowel syndrome (10.3%) and chronic constipation (9.4%). The diagnostic properties achieved for each algorithm using chart information from the different centers is provided in Tables 1 and 2. The two step algorithm achieved a sensitivity of 91.1% (95% CI 88.4-93.2%), specificity of 99.5% (95% CI 98.9-99.8%), LR+ of 188.3 (95% CI 84.7-418.6), and LR- of 0.0898 (95% CI 0.0694-0.116).

The most recent seven available physician billing claims accurately determined a diagnosis of CD (AUROC 0.9618). CD patients were distinguished from UC patients if five of their last seven diagnoses were for CD (sensitivity 95.1%, specificity 86.0%, PPV 92.0%, NPV 91.2%). Conversely, UC patients were labeled such if five of their last seven physician claims had a diagnosis of UC. Otherwise, patients were labeled unclassifiable. Using this strategy, 5.4% of patients diagnosed with CD or UC were inaccurately deemed to be unclassifiable compared with their charts. If patients did not have record of seven physician contacts, they were labeled CD if all of their diagnostic codes were for CD, UC if all of their diagnoses were UC, or unclassifiable.

Estimates of incidence and prevalence

Table 3 describes prevalence and incidence among children <18 years by year of diagnosis. Table 4 presents crude incidence and prevalence stratified by sex, age group and diagnosis (total IBD, CD or UC). Figures 1 and 2 illustrate trends over time from 1994 to 2005. Age- and sex-standardized prevalence of IBD per 100,000 population has increased from 42.1 (95% CI 39.6-44.8) in 1994 to 56.3 (95% CI 53.6-59.1) in 2005 ($p<0.0001$). Prevalence of CD has increased from 23.9 (95% CI 22.0-25.9) to 31.6 (95% CI 29.6-33.7) ($p<0.0001$). Prevalence of UC has increased from 16.2 (95% CI 14.6-17.8) to 19.7 (95% CI 18.1-21.4) ($p<0.0001$).

The OCCC contains 3169 incident cases of paediatric IBD diagnosed between 1994-2005. The incidence of IBD per 100,000 population has increased from 9.5 (95% CI 8.4-10.8) in 1994 to 11.4 (95% CI 10.2-12.7) in 2005 ($p=0.03$). The incidence of CD has changed from 5.0 (95% CI 4.1-5.9) to 6.0 (95% CI 5.2-7.0) ($p=0.19$). The incidence of UC has remained comparatively unchanged from 4.1 (95% CI 3.3-5.0) to 4.2 (95% CI 3.5-5.1) ($p=0.55$).

Results of the adjusted regression models stratified by age group and diagnosis (CD or UC) are presented in Table 5. Significant increases in incidence are seen in IBD patients in 6 month to 4 year olds (5.0% per year, $p=0.03$) and 5-9 year olds (7.6% per year, $p<0.0001$). When stratified by age group and diagnosis, the only group with a statistically significant increase in incidence was CD patients aged 5-9 (8.7% per year, $p<0.0001$). No statistically significant interaction existed between sex and year of diagnosis. Table 5 also describes the male predominance of CD patients in the younger age groups (5-9 years and 10-14 years), with a balanced incidence between males and females in 15-17 year olds. UC is more likely in males at younger ages (<10 years), while it is more common in females in pre-adolescents and adolescents.

DISCUSSION

Canadian health administrative data provide an outstanding resource for population-based chronic disease surveillance. We developed a novel algorithm for identifying children with IBD within Ontario's administrative data. The strengths of our algorithms include an accurate determination of PPV in light of the population-based sample with accurate estimation of prevalence in Toronto, specific applicability to children and its validation across paediatric age ranges, in both ambulatory and hospitalized populations, in multiple geographic regions and across different practice types. The higher PPVs seen in younger patients emphasize the need to validate algorithms in all age groups to which they will be applied. Our development and validation of a definition specific for children and youth should allow for better case ascertainment in Canada and other jurisdictions with comparable physician claims and hospitalization data.

To our knowledge, the OCCC is the largest population-based cohort of paediatric IBD patients in the world. We found an increased prevalence and incidence over the 12 years of surveillance. This is in keeping with population-based studies from other jurisdictions which have reported increased rates of IBD in children, particularly in CD.[2, 3, 4] A recent

Norwegian study demonstrated a doubling of the incidence of IBD over 15 years in children <16 years old compared to a historical cohort.[29] One other study reported incidence trends by age in paediatric IBD. Armitage et al.[30, 31] reported significantly increased incidence rates between 1981 and 1995 in both CD and UC, with females 7-11 years and both sexes 12-16 years at higher risk in later years. Our study was sufficiently powered to examine incidence trends in all age groups including the youngest children, despite the rarity of IBD in that population. We were also able to determine the ages at which gender ratio and CD:UC ratio changes and found no difference in the rate of increase in incidence by sex. The preponderance of male children with IBD has been well-documented, and we demonstrated that an adult pattern, in which females are slightly more likely to develop IBD, occurs after the onset of puberty. Changes in gender ratio after puberty has previously been demonstrated in other immune-mediated conditions such as myasthenia gravis[32] and type 1 diabetes.[33]

Ontario appears to have higher rates of IBD than those reported in other large and well-designed population-based studies from the United States[34], Scotland[35] and other parts of the United Kingdom.[30] The incidence and prevalence rates for children <18 years are lower than those reported for some other Canadian provinces, although those provinces reported rates for <20 year olds.[8] Given the peak ages of occurrence of IBD, inclusion of 18 and 19 year olds would be expected to increase rates for any "paediatric" cohort that includes these older adolescents. Additionally, the observed difference may be influenced by environmental factors, migration patterns or the accuracy of the diagnostic algorithm, which was validated primarily in adults[17] and may have performed differently in the <20 year age group.

It is noteworthy that the increased incidence demonstrated by this study appears to have occurred primarily after 2001 (see Figure 2). This may be explained by an as yet undetermined environmental change or by evolving immigration patterns in recent years. In fact, the proportion of immigrants to Ontario from South Asia (India, Pakistan, Sri Lanka, etc.) has more than doubled between 1981 and 2000[36], and this group was reported to have increased rates of IBD following arrival to Canada.[37] The proportion of immigrants to Ontario from other regions of the world including China, the Middle East, Europe and Africa has remained stable or decreased.[36] This changing pattern of immigration may explain the stable rates of paediatric IBD in other jurisdictions (with smaller proportions of South Asian patients).

A number of limitations to this study exist. These include the lack of medication data to aid in the identification of IBD patients. We were unable to determine whether medication data improved the test properties of our algorithm, and we would encourage jurisdictions with such data to assess whether it improves identification of children with IBD. We were able to identify that a physician billing for colonoscopy improves the confidence with which we can identify children with IBD within health administrative data. Published guidelines allow for the diagnosis of IBD without colonoscopy (using radiology or surgical pathology),[25] however the vast majority of young patients in Ontario underwent colonoscopy. However, should the investigation of IBD change in the future (and the frequency of colonoscopy decrease), the two-step algorithm may no longer apply. As such, we have reported the accuracy of algorithms excluding colonoscopy (Table 2). Unlike other studies validating IBD diagnostic algorithms, we accurately reported PPV values because we attempted to identify all patients with and without IBD within a jurisdiction using administrative data. The lower PPVs seen in older patients from the Toronto cohort can be explained in a number of ways. Our algorithm may be less robust in older adolescents, however this was not observed in the chart validation portion of this study. More likely, the reference standard SickKids IBD database contains a lower percentage of midadolescent IBD patients residing in Toronto than had previously been documented.[22] We feel this is more likely because no matter how restrictive our algorithm, we were unable to achieve a PPV of greater than 59.8% in <15 year olds. To be certain of the accuracy of our algorithm, we therefore confirmed it with a second reference standard: patient charts from multiple practices across the province. We achieved excellent accuracy in this sample, providing reassurance that the algorithm would accurately identify children with IBD when applied to administrative data.

It is important to view our data as physician-identified prevalence. It is possible that the reported increase in IBD may not be due to more prevalent disease but rather due to improved physician detection of the disease due to changes in physician practice patterns, improved access to diagnostic procedures or more awareness of the possibility of early-onset IBD. However, if our findings were due to earlier diagnosis of IBD (without increased overall incidence), we would expect that the incidence trends in the >10 year old groups would have decreased as they increased in the <10 year old groups, which was not the case.

In summary, we have reported on the development and rigorous validation of an algorithm to allow accurate identification of a population-based cohort of Ontario children with IBD using health administrative data from multiple sources. We report a significant rise in the prevalence and incidence of IBD, especially in children under the age of 10 years. Overall, the quality and availability of health administrative data is improving in North America and elsewhere. We encourage researchers to apply this algorithm to administrative data from other jurisdictions after validation, which will allow for future collaborative research examining paediatric IBD internationally. The population-based nature of the OCCC makes it ideal to act as an IBD surveillance program in order to track trends over time and answer important epidemiologic and health services questions about patients with childhood-onset IBD.

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COMPETING INTERESTS
The authors have no conflict of interest (financial or otherwise) to disclose.

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FIGURE LEGENDS

Figure 1: Age- and sex-standardized prevalence of IBD, CD, UC and unclassifiable IBD per 100,000 population in Ontario, Canada. Vertical whisker lines represent 95% CI using Gamma distribution. P values presented are from age- and sex-controlled Poisson models without stratification by age group.

Figure 2: Age- and sex-standardized incidence of IBD, CD, UC and unclassifiable IBD per 100,000 population in Ontario, Canada. Vertical whisker lines represent 95% CI using Gamma distribution. P values presented are from age- and sex-controlled Poisson models without stratification by age group.

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Table 1: Examples of test characteristics of multiple two-step algorithms to ascertain children with IBD using physician claims and hospitalization data. The selected algorithm is highlighted in grey.

			<12y old **(n=147 with IBD, n=771,534 controls)**				<15y old **(n=183 with IBD, n=936,514 controls)**				<18y old (validation) **(n=593 with IBD, n=1241 controls)**			
Patients with Scope Claim	**Patients without Scope Claim**	**Duration (years)**	**Sens**	**Spec**	**PPV**	**NPV**	**Sens**	**Spec**	**PPV**	**NPV**	**Sens**	**Spec**	**LR+**	**LR-**
3 contacts or 1 hosp.	5 contacts or 2 hosp.	2	91.2%	>99.9%	66.7%	>99.9%	90.2%	>99.9%	51.2%	>99.9%	92.9%	98.5%	60.7	0.072
		3	91.8%	>99.9%	65.8%	>99.9%	91.3%	>99.9%	50.8%	>99.9%	93.9%	98.4%	58.3	0.062
		4	92.5%	>99.9%	65.4%	>99.9%	92.4%	>99.9%	50.8%	>99.9%	94.3%	98.4%	58.5	0.058
		5	93.2%	>99.9%	65.2%	>99.9%	92.9%	>99.9%	50.6%	>99.9%	94.4%	98.4%	58.6	0.057
4 contacts or 2 hosp.	7 contacts or 3 hosp.	2	86.4%	>99.9%	75.2%	>99.9%	84.2%	>99.9%	57.7%	>99.9%	89.4%	99.5%	184.9	0.107
		3	**90.5%**	**>99.9%**	**76.0%**	**>99.9%**	**89.6%**	**>99.9%**	**59.2%**	**>99.9%**	**91.1%**	**99.5%**	**188.3**	**0.090**
		4	92.5%	>99.9%	76.0%	>99.9%	91.8%	>99.9%	57.8%	>99.9%	91.7%	99.3%	126.5	0.083
		5	92.5%	>99.9%	74.7%	>99.9%	91.8%	>99.9%	57.9%	>99.9%	91.9%	99.5%	190.1	0.081
5 contacts or 2 hosp.	7 contacts or 3 hosp.	2	81.6%	>99.9%	76.0%	>99.9%	79.2%	>99.9%	58.0%	>99.9%	87.2%	99.5%	180.3	0.129
		3	85.7%	>99.9%	75.5%	>99.9%	84.2%	>99.9%	59.5%	>99.9%	88.9%	99.5%	183.8	0.112
		4	88.4%	>99.9%	77.4%	>99.9%	88.5%	>99.9%	59.8%	>99.9%	89.5%	98.3%	123.5	0.105
		5	89.1%	>99.9%	75.3%	>99.9%	89.1%	>99.9%	59.1%	>99.9%	90.6%	99.5%	186.3	0.100

N.B. "Contacts" refers to physician contacts with diagnostic code for IBD. "Hosp." refers to hospitalizations with diagnostic code for IBD. "Scope" refers to either sigmoidoscopic or colonoscopic examination of the large bowel.

Table 2: Examples of test characteristics of multiple single-step algorithms to ascertain children with IBD using physician claims and hospitalization data. The selected single-step algorithm is highlighted in grey.

		<12y old (n=147 with IBD, n=771,534 controls)				<15y old (n=183 with IBD, n=936,514 controls)				<18y old (validation) (n=593 with IBD, n=1241 controls)			
Algorithm	**Duration (years)**	**Sens**	**Spec**	**PPV**	**NPV**	**Sens**	**Spec**	**PPV**	**NPV**	**Sens**	**Spec**	**LR+**	**LR-**
Any contact or hosp. for IBD		99.3%	99.8%	7.7%	>99.9%	99.5%	99.8%	7.9%	>99.9%	98.5%	89.2%	9.1	0.017
3 contacts	2	91.8%	>99.9%	51.1%	>99.9%	92.4%	>99.9%	42.9%	>99.9%	95.6%	99.0%	98.9	0.044
	3	93.2%	>99.9%	48.9%	>99.9%	94.0%	>99.9%	41.5%	>99.9%	96.1%	99.0%	91.8	0.039
	4	93.9%	>99.9%	47.8%	>99.9%	94.5%	>99.9%	40.8%	>99.9%	96.5%	99.0%	92.1	0.036
	5	93.9%	>99.9%	46.8%	>99.9%	94.5%	>99.9%	40.2%	>99.9%	96.5%	99.0%	92.1	0.036
3 contacts or 1 hosp.	2	94.6%	>99.9%	48.6%	>99.9%	95.6%	>99.9%	40.5%	>99.9%	96.5%	94.5%	17.6	0.038
	3	95.2%	>99.9%	46.5%	>99.9%	96.2%	>99.9%	39.0%	>99.9%	96.8%	94.5%	17.7	0.034
	4	95.2%	>99.9%	45.3%	>99.9%	96.2%	>99.9%	38.3%	>99.9%	97.0%	94.5%	17.7	0.032
	5	95.2%	>99.9%	44.6%	>99.9%	96.2%	>99.9%	37.9%	>99.9%	97.0%	94.5%	17.7	0.032
3 contacts or 2 hosp.	2	92.5%	>99.9%	50.8%	>99.9%	92.9%	>99.9%	42.7%	>99.9%	95.8%	98.3%	56.6	0.043
	3	95.2%	>99.9%	49.3%	>99.9%	95.6%	>99.9%	41.8%	>99.9%	96.3%	98.2%	54.3	0.038
	4	95.2%	>99.9%	48.0%	>99.9%	95.6%	>99.9%	41.1%	>99.9%	96.6%	98.2%	54.5	0.034
	5	95.2%	>99.9%	47.0%	>99.9%	95.6%	>99.9%	40.7%	>99.9%	96.6%	98.2%	54.5	0.034
5 contacts	2	82.3%	>99.9%	71.2%	>99.9%	80.3%	>99.9%	55.1%	>99.9%	90.9%	99.7%	282.0	0.091
	3	84.4%	>99.9%	70.9%	>99.9%	83.1%	>99.9%	55.3%	>99.9%	92.1%	99.6%	228.5	0.080
	4	86.4%	>99.9%	71.4%	>99.9%	87.4%	>99.9%	56.1%	>99.9%	92.4%	99.6%	229.4	0.076
	5	88.4%	>99.9%	70.3%	>99.9%	89.1%	>99.9%	55.8%	>99.9%	92.9%	99.6%	230.6	0.071
5 contacts or 1 hosp.	2	89.1%	>99.9%	64.8%	>99.9%	89.6%	>99.9%	50.0%	>99.9%	93.4%	94.9%	18.4	0.069
	3	90.5%	>99.9%	64.6%	>99.9%	90.8%	>99.9%	50.0%	>99.9%	93.8%	94.9%	18.5	0.066
	4	91.2%	>99.9%	64.7%	>99.9%	92.4%	>99.9%	50.2%	>99.9%	93.9%	94.9%	18.5	0.064
	5	91.8%	>99.9%	63.7%	>99.9%	92.9%	>99.9%	49.7%	>99.9%	94.3%	94.9%	18.6	0.060
5 contacts or 2 hosp.	2	84.4%	>99.9%	69.7%	>99.9%	83.1%	>99.9%	54.7%	>99.9%	91.6%	98.9%	81.2	0.086
	3	87.8%	>99.9%	70.1%	>99.9%	86.9%	>99.9%	55.6%	>99.9%	92.6%	98.7%	71.8	0.075
	4	**89.8%**	**>99.9%**	**70.6%**	**>99.9%**	**90.2%**	**>99.9%**	**56.3%**	**>99.9%**	**92.8%**	**98.7%**	**71.9**	**0.074**
	5	90.5%	>99.9%	69.3%	>99.9%	90.7%	>99.9%	55.9%	>99.9%	93.2%	98.7%	72.3	0.068

Table 3: Age-sex adjusted prevalence and incidence rates of inflammatory bowel disease in children and youth in Ontario (Fiscal Years 1994-2005).

Fiscal year	Number of children (<18 years) with IBD living in Ontario†	Age-/sex-standardized prevalence rate per 100,000 (95% CI)	Number of children and youth with new diagnosis of IBD	Age-/sex-standardized incidence rate per 100,000 (95% CI)
1994	1034	42.1 (39.6 – 44.8)	235	9.54 (8.4 – 10.8)
1995	1117	44.8 (42.2 – 47.5)	229	9.17 (8.0 – 10.4)
1996	1194	46.9 (44.3 – 49.7)	246	9.65 (8.5 – 10.9)
1997	1278	49.2 (46.6 – 52.0)	264	10.15 (9.0 – 11.5)
1998	1398	52.8 (50.1 – 55.7)	264	9.95 (8.8 – 11.2)
1999	1448	53.8 (51.1 – 56.7)	252	9.36 (8.2 – 10.6)
2000	1478	53.8 (51.1 – 56.7)	270	9.85 (8.7 – 11.1)
2001	1498	53.6 (50.9 – 56.4)	267	9.57 (8.5 – 10.8)
2002	1519	53.7 (51.0 – 56.4)	248	8.76 (7.7 – 9.9)
2003	1510	53.1 (50.5 – 55.9)	270	9.51 (8.4 – 10.7)
2004	1553	53.4 (51.7 – 57.1)	297	10.42 (9.3 – 11.7)
2005	1621	56.3 (53.6 – 59.2)	327	11.43 (10.2 – 12.7)

† Represents the number of children and youth (<18 years old) with IBD alive and living in Ontario, Canada on July 1 of the noted year. This number does not include patients with childhood-onset IBD who turned 18 years of age before July 1 of the noted year, and therefore does not represent the cumulative prevalence.

Table 4: Crude incidence and prevalence (per 100,000 population) of paediatric IBD by age group and sex for Ontario in 2005.

Sex	**Age Group**	**TOTAL IBD Incidence**	**TOTAL IBD Prevalence**	**CD Incidence†**	**CD Prevalence†**	**UC Incidence‡**	**UC Prevalence‡**
F	6 mo – 4 years	0.6	3.3	0.3 – 0.4	0.9 - 1.1	0 – 0.2	1.8 – 2.2
	5-9 years	4.5	18.5	2.9	8.7 - 10.5	1.6	7.1 – 8.0
	10-14 years	16.0	64.5	7.1 – 8.9	32.1 - 37.4	6.1 – 7.0	24.5 – 27.2
	15-17 years	26.3	146.7	13.5 – 15.2	78.7 - 85.2	10.3 – 11.1	58.2 – 61.4
	TOTAL	10.9	51.7	5.5 – 6.3	26.4 - 29.7	4.1 – 4.6	20.2 – 22.0
M	6 mo – 4 years	2.9	6.7	0.3 – 0.4	1.5 – 1.7	2.3 – 2.5	4.4 – 5.0
	5-9 years	8.7	24.8	4.9 – 5.2	12.3 – 13.3	3.3 – 3.5	11.0 - 11.5
	10-14 years	16.8	84.0	10.7 – 11.8	54.2 – 59.0	4.4 – 5.0	22.6 – 25.1
	15-17 years	24.6	170.7	12.9 – 14.1	103.8 – 113.7	9.7 – 10.4	52.1 – 57.0
	TOTAL	12.6	64.7	7.0 – 7.7	38.9 – 42.5	4.6 – 5.0	20.4 – 22.3
Both Sexes	6 mo – 4 years	1.8	5.1	0.3 – 0.4	1.2 – 1.4	1.2 – 1.4	3.1 – 3.6
	5-9 years	6.6	21.7	3.9 – 4.1	10.5 – 11.9	2.5 – 2.6	9.1 – 9.8
	10-14 years	16.4	74.5	9.0 – 10.4	43.4 – 48.5	5.3 – 6.0	23.6 – 26.1
	15-17 years	25.4	159.0	13.2 – 14.6	91.6 – 99.8	10.0 – 10.7	55.1 – 59.2
BOTH SEXES	**All AGE GROUPS**	11.8	58.3	6.2 – 7.0	32.8 – 36.2	4.4 – 4.8	20.3 – 22.1

† Lower number in range represents incident/prevalent cases of CD excluding unclassifiable patients. Upper range of incidence/prevalence represents incident/prevalent of CD including 2/3 of unclassifiable patients (except in 6mo – 4 year age group, where 1/3 of unclassifiable patients are included as possible CD cases).

‡ Lower number in range represents incident/prevalent cases of UC excluding unclassifiable patients. Upper range of incidence/prevalence represents incident/prevalent of UC including 1/3 of unclassifiable patients (except in 6mo – 4 year age group, where 2/3 of unclassifiable patients are included as possible UC cases).

Table 5: Time trends in incidence stratified by age group. "Year" refers to the year of diagnosis.

Age Group	Variable	Estimate	95% CI of the Estimate	P-value
IBD				
6 mo – 4 y	Year	0.050	0.0048 – 0.1051	**0.03**
	Sex (M)	0.256	0.0628 – 0.4499	**0.009**
5-9 y	Year	0.076	0.0436 – 0.1083	**<0.0001**
	Sex (M)	0.091	-0.026 – 0.209	**0.13**
10-14 y	Year	0.0063	-0.0086 – 0.0213	**0.41**
	Sex (M)	0.1339	0.0776 – 0.1903	**<0.0001**
15-17 y	Year	-0.0021	-0.013 – 0.009	**0.72**
	Sex (M)	0.0174	-0.025 – 0.0598	**0.42**
CD				
6 mo - 4 y	Year	0.009	-0.048 – 0.066	**0.76**
	Sex (M)	0.207	-0.011 – 0.425	**0.06**
5-9 y	Year	0.087	0.047 – 0.127	**<0.0001**
	Sex (M)	0.173	0.027 – 0.320	**0.02**
10-14 y	Year	0.006	-0.008 – 0.020	**0.41**
	Sex (M)	0.235	0.182 – 0.289	**<0.0001**
15-17 y	Year	-0.006	-0.024 – 0.011	**0.47**
	Sex (M)	0.048	-0.017 – 0.114	**0.15**
UC				
6 mo - 4 y	Year	0.037	-0.019 – 0.093	**0.20**
	Sex (M)	0.207	-0.012 – 0.425	**0.06**
5-9 y	Year	0.045	-0.007 – 0.098	**0.09**
	Sex (M)	0.028	-0.165 – 0.221	**0.78**
10-14 y	Year	-0.027	-0.060 – 0.007	**0.12**
	Sex (M)	-0.047	-0.173 – 0.079	**0.47**
15-17 y	Year	-0.007	-0.026 – 0.011	**0.45**
	Sex (M)	-0.047	-0.116 – 0.022	**0.18**

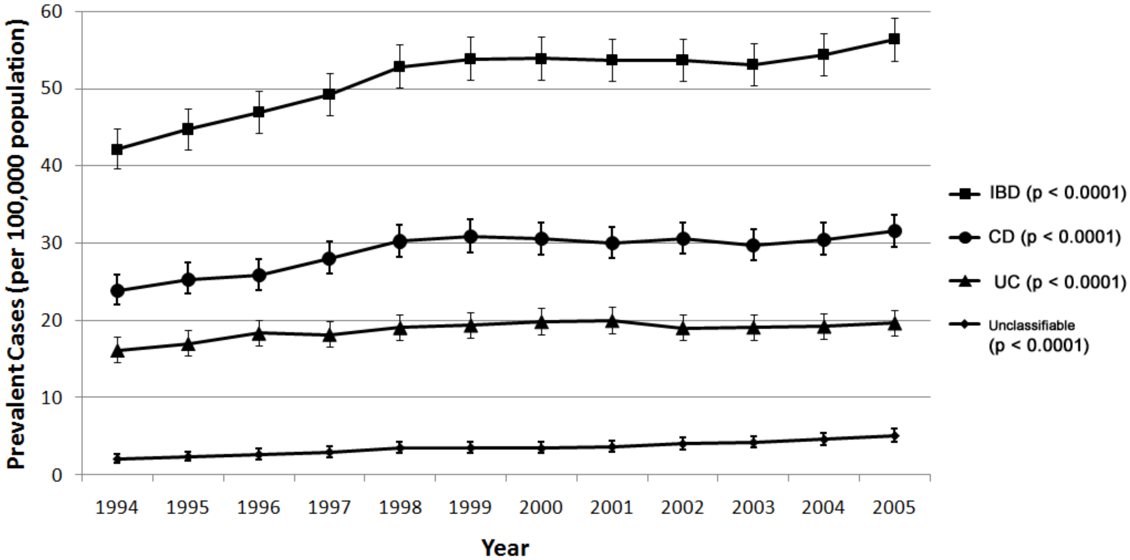

Figure 1: Age- and sex-standardized prevalence of IBD, CD, UC and unclassifiable IBD per 100,000 population in Ontario, Canada. Vertical whisker lines represent 95% CI using Gamma distribution. P values presented are from age- and sex-controlled Poisson models without stratification by age group.

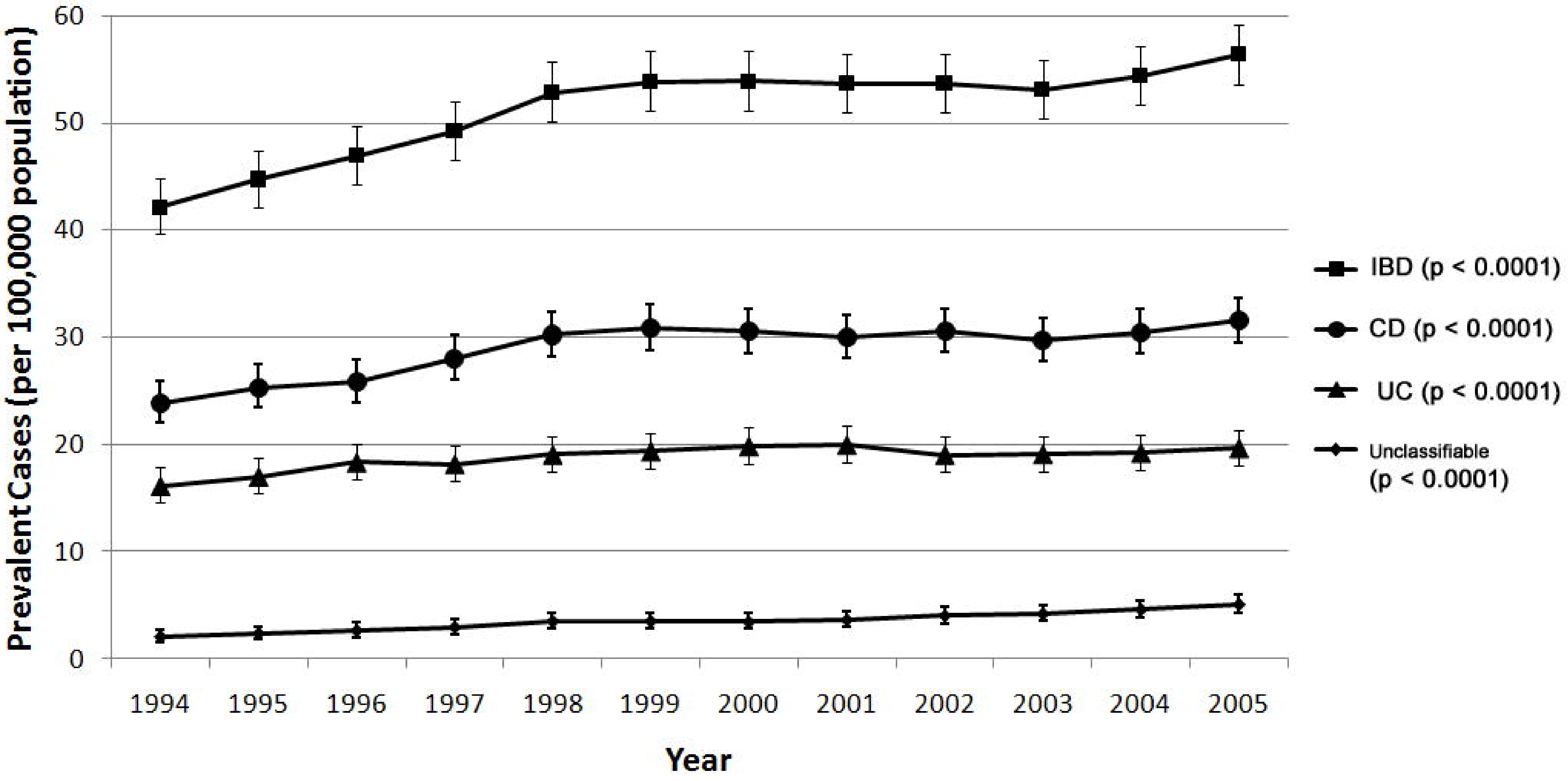

Figure 1: Age- and sex-standardized prevalence of IBD, CD, UC and unclassifiable IBD per 100,000 population in Ontario, Canada. Vertical whisker lines represent 95% CI using Gamma distribution. P values presented are from age- and sex-controlled Poisson models without stratification by age group.

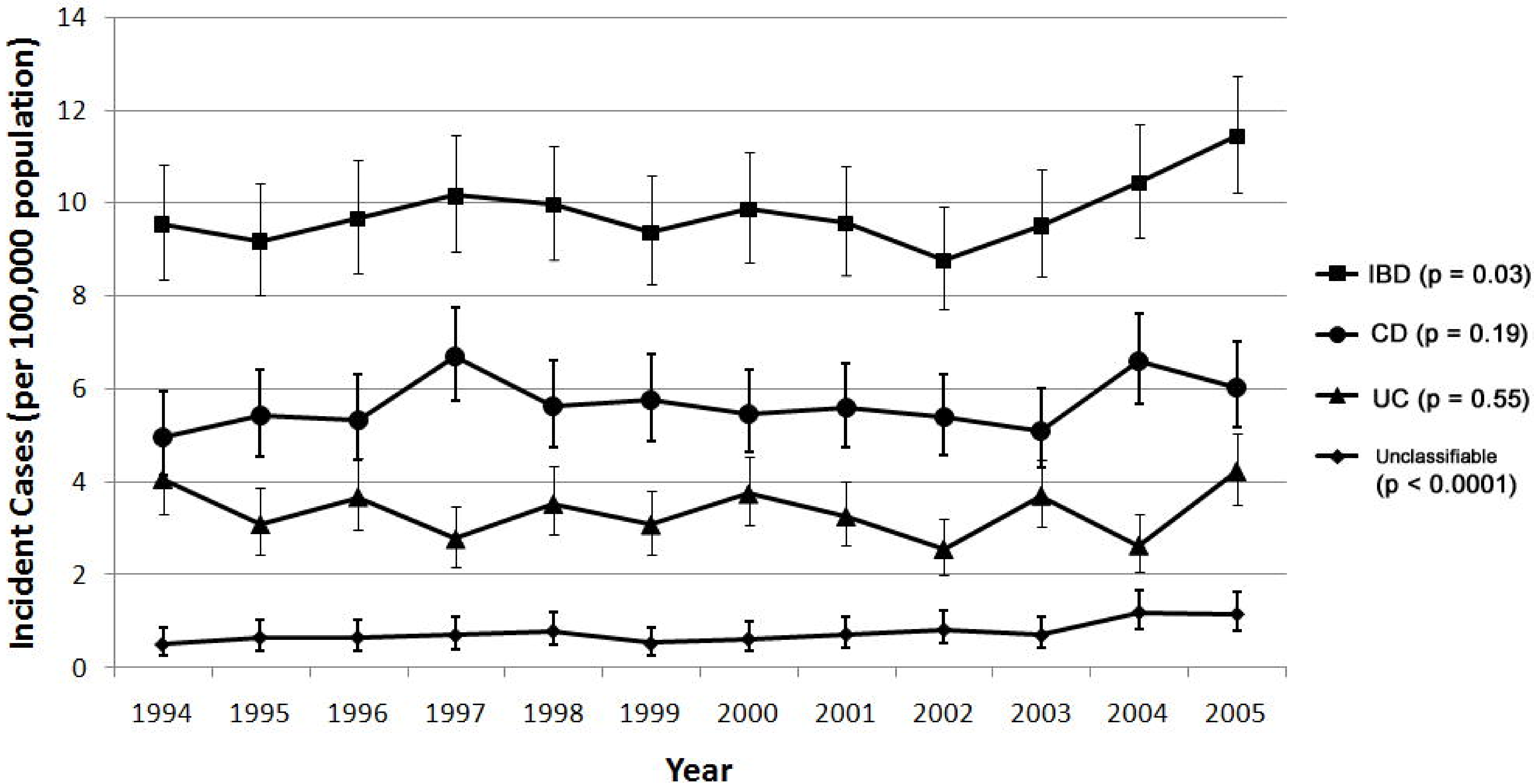

Figure 2: Age- and sex-standardized incidence of IBD, CD, UC and unclassifiable IBD per 100,000 population in Ontario, Canada. Vertical whisker lines represent 95% CI using Gamma distribution. P values presented are from age- and sex-controlled Poisson models without stratification by age group.