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**Prevalence of alcohol consumption during pregnancy and Fetal Alcohol Spectrum Disorders among the general and Aboriginal populations in Canada and the United States**

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**ABSTRACT**

Prenatal alcohol exposure may cause a number of health complications for the mother and developing fetus, including Fetal Alcohol Spectrum Disorders (FASD). This study aimed to estimate the pooled prevalence of i) alcohol use (any amount) and binge drinking (4 or more standard drinks on a single occasion) during pregnancy, and ii) Fetal Alcohol Syndrome (FAS) and FASD among the general and Aboriginal populations in Canada and the United States, based on the available literature. Comprehensive systematic literature searches and meta-analyses, assuming a random-effects model, were conducted. It was revealed that about 10% and 15% of pregnant women in the general population consume alcohol in Canada and the United States, respectively, and that about 3% of women engage in binge drinking during pregnancy in both countries. However, the prevalence of alcohol use during pregnancy in the Aboriginal populations of the United States and Canada were found to be approximately 3 to 4 times higher, respectively, compared to the general population. Even more alarmingly, it was estimated that approximately one in five women in the Aboriginal populations in both countries engage in binge drinking during pregnancy. Further, among the general population of Canada, the pooled prevalence was estimated to be about 1 per 1,000 for FAS and 5 per 1,000 for FASD. However, compared to the general population, the prevalence of FAS and FASD among the Aboriginal population in Canada was estimated to be 38 times and 16 times higher, respectively. With respect to the United States, the pooled prevalence of FAS and FASD was estimated to be about 2 per 1,000 and 15 per 1,000, respectively, among the general population, and 4 per 1,000 and 10 per 1,000, respectively, among the Aboriginal population. However, the FAS and FASD prevalence estimates should be used with

caution due to the limited number of existing studies and their methodological limitations. Based on the results of the current study, it is evident that there is an urgent need for implementing more effective national prevention and surveillance strategies to monitor and lower the prevalence of alcohol consumption during pregnancy and FASD.

**KEYWORDS:** Fetal Alcohol Syndrome, Fetal Alcohol Spectrum Disorders, North America; Prenatal alcohol exposure, Prevalence

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## INTRODUCTION

In North America, alcohol consumption during pregnancy and as a result, Fetal Alcohol Spectrum Disorders (FASD) is well recognized as an important public health concern and the leading known cause of mental deficiency among North Americans. However, despite public health efforts to increase awareness of the risks associated with drinking during pregnancy, a significant proportion of pregnancies in North America are alcohol-exposed. Alcohol is a teratogen that can readily cross the placenta resulting in irreversible damage to the brain and other organs of the developing embryo and fetus. Therefore, women who consume alcohol during pregnancy place their child(ren) at risk of developing FASD, and can experience a number of other adverse pregnancy outcomes including stillbirth (Kesmodel et al., 2002), spontaneous abortion (Henriksen et al., 2004), premature birth (Albertsen et al., 2004; Kesmodel et al., 2000), intrauterine growth retardation (Yang et al., 2001), and low birth weight (O'Callaghan et al., 2003). FASD is an umbrella term, which includes Fetal Alcohol Syndrome (FAS), Partial FAS (pFAS), Alcohol-Related Neurodevelopmental Disorder (ARND), and Alcohol-Related Birth Defects (ARBD; depending on the classification system/diagnostic guidelines; see, for example, Chudley et al. [2005] and Stratton et al. [1996]). Very recently, it has been suggested that the term FASD be used as a diagnostic term, rather than just an umbrella term (Cook et al., 2015).

The manifestations of FASD include a broad array of congenital anomalies and growth impairments, along with cognitive, behavioural, emotional, and adaptive functioning deficits, all of which can have lifelong implications. Later in life, these deficits may lead to secondary disabilities, including academic failure, substance abuse,

mental health problems, contact with law enforcement, and an inability to live independently and obtain/maintain employment (Streissguth et al., 1996). When combined with the primary disabilities, these secondary disabilities increase the complexity of care the person requires and result in significant social and economic costs to society. In a recently conducted study in Canada, the cost associated with FASD totaled approximately \$1.8 billion (from about \$1.3 as the lower estimate up to \$2.3 billion as the upper estimate) in 2013 (Popova et al., 2015).

Determining the prevalence at which alcohol consumption during pregnancy and FASD occur is the first step towards truly understanding their scope and severity. Prevalence estimates are not only vital for informing policymakers of the impact of these conditions, but they are also integral to raising awareness of alcohol use during pregnancy and its potential consequences – that is, FASD. Therefore, the objectives of the current study were to estimate the pooled prevalence of i) alcohol use (any amount) and binge drinking (4 or more standard drinks on a single occasion) during pregnancy, and ii) FAS and FASD among the general and Aboriginal populations in Canada and the United States.

## **MATERIALS AND METHODS**

The main approaches taken were two independent comprehensive systematic literature searches and a number of meta-analyses, which were conducted and reported according to the standards set out in Preferred Reporting Items for Systematic Reviews and Meta-Analyses (Liberati et al., 2009).

## **I. Prevalence of Alcohol Use (Any Amount) and Binge Drinking During Pregnancy Among the General and Aboriginal Populations in Canada and the United States**

### **Comprehensive systematic literature search strategy**

A comprehensive systematic literature search was performed to identify all studies that have reported the prevalence of alcohol use (any amount) and/or binge drinking during pregnancy among the general and/or Aboriginal populations in Canada or the United States. The search was conducted in multiple electronic bibliographic databases, including (in alphabetical order): Canadian Centre on Substance Abuse Library Collection Database, Campbell Collaboration, CINAHL, Cochrane Database of Systematic Reviews, CSA Sociological Abstracts, Embase, ERIC, Google Scholar, Medline, National Institute on Alcohol Abuse and Alcoholism's Alcohol and Alcohol Problems Science Database, PsycINFO, Scopus, Social Work Abstracts, and Web of Science (including Science Citation Index, Social Sciences Citation Index, Arts and Humanities Citation Index). The search was conducted using the following key words: 1) alcohol, binge, OR ethanol; AND 2) behavi\*, consum\*, OR drink\*; AND 3) maternal, mother, primigravida, OR wom\*n; AND 4) pregnant, pregnanc\*, OR prenatal; AND 5) epidemiology, frequenc\*, occurrence, OR prevalence; AND 6) Canada, North America\*, United States\*, OR USA. The search was performed to identify studies published between January 1984 and June 2014 (i.e., in the last 30 years), without language restriction. Further, the content pages of the major epidemiological journals, as well as citations in the relevant articles were manually screened.

***Inclusion and exclusion criteria***

The following inclusion criteria were applied to determine study eligibility: i) consisted of original quantitative research published in a peer-reviewed journal or scholarly report; and ii) reported the prevalence of alcohol consumption and/or binge drinking during pregnancy in Canada or the United States. Articles were excluded if they i) did not include abstainers in their samples, ii) used a sample not generalizable to the general or Aboriginal populations of the respective country, or iii) reported a pooled estimate of alcohol use during pregnancy by combining several studies.

In cases where a study reported more than one prevalence estimate of alcohol use/binge drinking, preference was given to the estimate obtained: i) after pregnancy recognition (rather than prior to recognition), ii) during of the entire pregnancy (as opposed to during just one trimester), iii) within 6 weeks postpartum, and/or iv) using a validated tool for ascertainment of alcohol use.

***Data selection and extraction***

Study selection began by screening titles and abstracts for inclusion. Then, full-text articles of all studies screened as potentially relevant were considered. Two investigators conducted each study selection step independently; any disagreements were reconciled by team discussion. In cases where multiple studies used the same dataset or cohort, the study with the larger sample size was included.

All data were extracted by one investigator and then independently crosschecked by a second investigator for accuracy against the original studies. All discrepancies were reconciled by team discussion.



### **Meta-analysis**

In order to estimate the pooled prevalence of alcohol use (any amount) and binge drinking during pregnancy, meta-analyses were performed for each country assuming a random effects model (DerSimonian & Laird, 1986). Before performing the meta-analyses, prevalence estimates were transformed using a double arcsine transformation so that the data followed a normal distribution (Freeman & Tukey, 1950). Heterogeneity between estimates was assessed using the Cochran Q test (Cochran, 1954) and the  $I^2$  statistic (Higgins & Thompson, 2002). Publication bias was tested by: i) visually inspecting the funnel plot (standard error plotted against the point estimate) for a skewed distribution, ii) using a ranked correlation test (Begg & Mazumdar, 1994), and iii) employing a weighted regression test (Egger et al., 1997). However, it was decided that if publication bias were present it would not be adjusted for, since the authors of this paper believe that the prevalence estimates of interest would likely be published even if substantially different from previously reported estimates. The results of the meta-analyses were displayed using Forest plots.

## **II. Prevalence of FAS and FASD Among the General and Aboriginal Populations in Canada and the United States**

### **Comprehensive systematic literature search strategy**

A comprehensive systematic literature search was performed to identify all studies that have reported the prevalence of FAS and/or FASD among the general

population and/or Aboriginal population in Canada or the United States. The search was conducted in multiple electronic bibliographic databases, which included (in alphabetical order): CINAHL, Embase, ERIC, Medline, PsycINFO, Scopus, and Web of Science (including Science Citation Index, Social Sciences Citation Index, Arts and Humanities Citation Index). The search was conducted using the following key words: 1) epidemiolog\*, frequenc\*, incidence\*, morbidit\*, occurren\*, prevalence\*, probability, rate\*, OR statistic\*; AND 2) alcohol\* embryopath\*, alcohol\* related\* neurodevelopmental\* disorder\*, alcohol\* related\* birth defect\*, arnd, arbd, fetal\* alcohol\* effect\*, fae, fas, fasd, fetal alcohol syndrome\*, fetal alcohol spectrum disorder\*, foetal\* alcohol\* effect, foetal\* alcohol syndrome\*, foetal\* alcohol spectrum disorder\*, pfas, partial fetal alcohol syndrome, partial foetal alcohol syndrome, prenatal\* alcohol expos\*, OR pre-natal\* alcohol expos\*; AND 3) cohort stud\*, cross\* sectional stud\*, prospective cohort stud\* OR retrospective cohort stud\*; AND 4) Canada, North America\*, United States\*, OR USA. The search was not limited by language of publication, and was performed to identify all studies published from January 1973 (when FAS was first described; Jones & Smith, 1973) up to the end of June 2015. The search was limited to human studies in all databases that allow for this restriction to be specified. Manual reviews of the content pages of the major epidemiological journals were conducted, as well as citations in any of the relevant articles.

### ***Inclusion and exclusion criteria***

Articles were retained if they met the following inclusion criteria: i) consisted of original, quantitative research published in a peer-reviewed journal or scholarly report;

and ii) reported the prevalence of FASD (or any of the diagnoses within the spectrum) with a) a measure of uncertainty (confidence interval or standard error) or b) either the sample size or number of cases. Articles were excluded if they: i) used a sample not generalizable to the general or Aboriginal populations of the respective country, ii) reported a pooled estimate by combining several studies, or iii) were published in iteration.

#### ***Data selection and extraction***

Please see the details on study selection and data extraction provided above.

#### **Meta-analysis**

Articles identified in the comprehensive systematic literature search were included in the meta-analyses if they met the following inclusion criteria: i) used active case ascertainment or clinic-based methods, and ii) specified the diagnostic guideline/case definition to ascertain cases. In order to estimate the pooled prevalence of FAS and FASD, meta-analyses were performed for each country assuming a random effects model (DerSimonian & Laird, 1986). For more details on the meta-analysis methodology, please see above.

#### ***Sensitivity Analysis***

A sensitivity analysis was conducted in order to estimate the pooled prevalence of FAS and FASD using less restrictive inclusion criteria. That is to say, studies that utilized

passive surveillance methods and/or did not specify the diagnostic guideline/case definition used were also included.

## **RESULTS**

### **I. Prevalence of Alcohol Use (Any Amount) and Binge Drinking During Pregnancy Among the General and Aboriginal Populations in Canada and the United States**

Initially, the search strategy for the prevalence of alcohol use (any amount) and binge drinking during pregnancy yielded a total of 5,142 studies; of which, 125 studies contained relevant data and were retained for data extraction (Figure 1). In total, 115 studies reported the prevalence of alcohol use during pregnancy among the general population in Canada (n=14) and the United States (n=103); one study reported the prevalence among a sample drawn from both countries. Of these 115 studies, 20 reported the prevalence binge drinking during pregnancy in Canada (n=1) and the United States (n=19). Ten studies in total reported the prevalence of alcohol use during pregnancy among the Aboriginal populations in Canada (n=6) and the United States (n=4). Of these ten studies, four reported the prevalence of binge drinking during pregnancy in Canada (n=2) and the United States (n=2).

- Insert Figure 1 about here -

### **Pooled prevalence of alcohol use (any amount) and binge drinking during pregnancy among the general population**

The pooled prevalence of alcohol use during pregnancy among the general population was estimated to be 10.0% (95% confidence interval [CI]: 5.2%–16.2%) in Canada and 14.8% (95% CI: 12.0%–18.0%) in United States. The pooled prevalence of binge drinking during pregnancy among the general population was estimated to be 3.3% (95% CI: 2.6%–4.2%; based on only one study) in Canada and 3.1% (95% CI: 1.7%–4.9%) in United States. See Table 1 for the study characteristics and prevalence of alcohol use and binge drinking during pregnancy among the general population reported in the individual studies. For the pooled prevalence of alcohol use and binge drinking during pregnancy among the general population and the results of the heterogeneity and publication bias tests see Table 2. The forest plots and funnel plots are presented in the Appendix.

- Insert Table 1 about here -

- Insert Table 2 about here -

### **Pooled prevalence of alcohol use (any amount) and binge drinking during pregnancy among the Aboriginal population**

The pooled prevalence of alcohol use during pregnancy among the Aboriginal population was estimated to be 36.5% (95% CI: 24.7%–49.1%) in Canada and 42.9% (95% CI: 27.1%–59.4%) in United States. The pooled prevalence of binge drinking during pregnancy among the Aboriginal population was estimated to be 22.1% (95% CI: 0.0%–52.9%) in Canada and 14.6% (95% CI: 6.6%–24.8%) in United States. See Table 3 for the study characteristics and prevalence of alcohol use and binge drinking during

pregnancy among the Aboriginal population reported in the individual studies. For the pooled prevalence of alcohol use and binge drinking during pregnancy among the Aboriginal population and the results of the heterogeneity and publication bias tests see Table 2. The forest plots and funnel plots are presented in the Appendix.

- Insert Table 3 about here -

## **II. Prevalence of FAS and FASD Among the General and Aboriginal Populations in Canada and the United States**

The search strategy for the prevalence of FAS/FASD yielded a total of 3,481 studies initially; yet, only 36 studies contained relevant data and were retained for data extraction (Figure 2). Twenty-seven studies contained data on the prevalence of FAS/FASD among the general population in Canada (n=2) and the United States (n=25), and 13 studies reported on the prevalence of FAS/FASD among the Aboriginal population in Canada (n=5) and the United States (n=8).

- Insert Figure 2 about here -

### **Pooled prevalence of FAS and FASD among the general population**

The pooled prevalence of FAS and FASD among the Canadian general population was estimated to be 1.1 per 1,000 (95% CI: 0.0–3.5 per 1,000) and 5.3 per 1,000 (95% CI: 4.5–6.1 per 1,000; based on only one study), respectively. In the United States, the pooled prevalence of FAS and FASD among the general population was estimated to be

2.3 per 1,000 (95% CI: 0.8–4.3 per 1,000) and 15.2 per 1,000 (95% CI: 7.5–25.3 per 1,000), respectively. See Table 4 for the study characteristics and prevalence of FAS and FASD among the general population reported in the individual studies. For the pooled prevalence of FAS/FASD among the general population and the results of the heterogeneity and publication bias tests see Table 5. The forest plots and funnel plots are presented in the Appendix.

- Insert Table 4 about here -

- Insert Table 5 about here -

#### **Pooled prevalence of FAS and FASD among the Aboriginal population**

The pooled prevalence of FAS and FASD among the Aboriginal population was estimated to be 41.6 per 1,000 (95% CI: 0.0–133.4 per 1,000) and 86.8 per 1,000 (95% CI: 0.0–198.7 per 1,000), respectively, in Canada. In the United States, the pooled prevalence of FAS and FASD among the Aboriginal population was estimated to be 3.8 per 1,000 (95% CI: 0.0–8.0 per 1,000) and 9.5 per 1,000 (95% CI: 0.0–27.6 per 1,000), respectively. See Table 6 for the study characteristics and prevalence of FAS and FASD among the Aboriginal population reported in the individual studies. For the pooled prevalence of FAS/FASD among the Aboriginal population and the results of the heterogeneity and publication bias tests see Table 5. The forest plots and funnel plots are presented in the Appendix.

- Insert Table 6 about here -

### **Sensitivity analysis**

The pooled prevalence of FAS among the general population was estimated to be 1.1 per 1,000 (95% CI: 0.0–3.5 per 1,000) in Canada and 0.9 per 1,000 (95% CI: 0.5–1.5 per 1,000) in the United States. The pooled prevalence of FASD among the general population in Canada and the United States was estimated to be 5.3 per 1,000 (95% CI: 4.5–6.1 per 1,000) and 9.8 per 1,000 (95% CI: 3.2–19.5 per 1,000), respectively. The pooled prevalence of FAS among the Aboriginal population was estimated to be 41.6 per 1,000 (95% CI: 0.0–133.4 per 1,000) in Canada and 2.4 per 1,000 (95% CI: 1.4–3.7 per 1,000) in the United States. The pooled prevalence of FASD among the Aboriginal population in Canada and the United States was estimated to be 54.0 per 1,000 (95% CI: 0.0–154.1 per 1,000) and 9.5 per 1,000 (95% CI: 0.0–27.6 per 1,000), respectively. See Table 5 for the results of the sensitivity analysis; the respective forest plots and funnel plots are presented in the Appendix.

### **CONCLUSIONS**

Despite public health efforts to reduce alcohol consumption during pregnancy in North America, the results of the current study revealed that about 10% and 15% of women in the general population consume alcohol during pregnancy in Canada and the United States, respectively, and that about 3% of women engage in binge drinking during pregnancy in both countries. However, it was estimated that a much higher proportion (approximately 40%) of women in the Aboriginal populations in North America consume alcohol during pregnancy. Even more alarmingly, approximately 22% and 15% of



Aboriginal women in Canada and the United States, respectively, binge drink during pregnancy.

Although the prevalence of alcohol consumption during pregnancy in the general population of North America is significant, it is still lower than in other parts of the world. For instance, the pooled prevalence of alcohol consumption (any amount) during pregnancy in some countries of Eastern Europe (e.g., 25.0% in Lithuania, 34.0% in Ukraine, and 36.5% in Russia) and Western Europe (e.g., 27.0% in France, 33.1% in Italy, and 60.4% in Ireland) have been estimated to be notably higher (based on unpublished data of the authors of this paper). However, the pooled prevalence of consuming alcohol during pregnancy among Aboriginal women in North America is slightly higher (36% in Canada and 43% in the United States) as compared to the pooled prevalence in Australia (34%; based on unpublished data of the authors of this paper).

Further, the pooled prevalence in the general population in Canada was estimated to be about 1 per 1,000 for FAS and 5 per 1,000 for FASD; however, in the Aboriginal population it was about 38 and 16 times higher, respectively. It must be acknowledged that these pooled prevalence estimates are based on a limited number of outdated studies with numerous acknowledged methodological limitations such as being conducted in small communities and excluding individuals who did not meet the criteria for a diagnosis of full FAS. These estimates are not only out of date, but also, as a result of the limitations listed above, are not generalizable to the Canadian population or applicable for decision-making purposes. Moreover, the majority of the existing studies have used clinic- or record-based systems without active recruitment of subjects; therefore, such prevalence estimates are likely to be underestimated in any given population (May &

Gossage, 2001).

With respect to the United States, the pooled prevalence of FAS and FASD was estimated to be about 2 per 1,000 and 15 per 1,000, respectively, among the general population, and 4 per 1,000 and 10 per 1,000, respectively, among the Aboriginal population. However, the pooled prevalence of FASD among the Aboriginal population was estimated to be lower (based on only two studies) than the pooled prevalence of FASD among the general population. This is unlikely given that the pooled prevalence of alcohol consumption during pregnancy among Aboriginal women is almost three times higher as compared to the prevalence among the general population in the United States.

As expected, the pooled prevalence estimates of FAS and FASD among the general and Aboriginal populations calculated in the sensitivity analysis with less restrictive inclusion criteria were lower than those obtained in the main analysis. This is due to the inclusion of studies that utilized passive surveillance (a method known to produce lower prevalence estimates; May & Gossage, 2001). Based on the results obtained, it is obvious that more rigorous epidemiological studies, using active case ascertainment, are needed in both countries in order to obtain reliable FASD prevalence estimates. The current FAS and FASD prevalence estimates in both countries should be used with caution due to the limited number of existing studies and their methodological flaws.

Strengths of the current study include the comprehensive search strategies, strict inclusion and exclusion criteria, rigorous identification of dual publications, and the analytical strategy. However, there are some limitations to acknowledge. Some studies included in meta-analyses of the prevalence of alcohol use during pregnancy utilized non-

representative sampling strategy, and did not use validated tools to ascertain alcohol use. Further, self-reported use of alcohol during pregnancy is sensitive to bias (e.g., social desirability bias, recall bias, and/or fear that the child may be taken away; Lange et al., 2014) and for to this reason, the estimated pooled prevalence of alcohol consumption during pregnancy may be underestimated in both the general and Aboriginal populations. Further, in regard to the FAS and FASD prevalence estimates in the Aboriginal population, the data from individual reserves/communities might not be generalizable to the Aboriginal population as a whole.

Moreover, the majority of studies included in this analysis acknowledged that the reported FAS/FASD prevalence was most likely underestimated. The main reason is that, unfortunately, many individuals with FASD are unrecognized and/or misdiagnosed (Elias, 2013; O'Connor et al., 2006). A recently conducted study reported that within their sample 87% of youths with FASD had never been previously diagnosed or had been misdiagnosed (Chasnoff et al., 2015). There are several barriers to the early recognition and accurate diagnosis of individuals with FASD. Firstly, despite the fact that most pediatricians in North America are aware of FASD and its diagnostic features (Clarke et al., 2005; Gahagan et al., 2006), a survey by the American Academy of Pediatrics revealed that pediatricians are not adequately trained for actual clinical diagnosis, referral, and management of patients with FASD (Gahagan et al., 2006; only half of the survey respondents felt prepared to make a diagnosis, and only 34% felt prepared to manage and coordinate the treatment of children with FASD). A national survey of health care providers in Canada has also identified lack of training as a barrier to the diagnosis of FASD (see Clarke et al., 2005). Secondly, a large number of comorbid conditions have

been found to co-occur in individuals with FASD, which likely “mask” the FASD diagnosis (Popova et al., 2016). For instance, studies have reported that from 40% to 75% of children with FASD were incorrectly diagnosed, and that ADHD was the most common referral diagnosis for children who were ultimately diagnosed with FASD (Fryer et al., 2007; Rasmussen et al., 2010).

Most importantly, FASD has to be widely recognized as a preventable disorder, and as such, there is an urgent need for prevention programs aimed to change the behaviour of consuming alcohol during pregnancy, as well as pre-pregnancy (as it greatly affects the likelihood of prenatal drinking; Floyd et al., 1999; Tough et al., 2006). However, it must be acknowledged that FASD prevention involves much more than simply providing information about the risks of alcohol use during pregnancy. As such, in Canada, the Public Health Agency of Canada has developed the Four-Part Model of Prevention; the first level involves board awareness building and health promotion efforts, the second level involves a discussion of alcohol use and the related risks with all women of child bearing age and their support networks, the third level involves specialized, holistic support of pregnant women with alcohol and other health/social problems, and the fourth level involves postpartum support for new mothers assisting them to maintain/initiate changes in their health and social networks and to support the development of their children (Poole, 2008). Similar plans of action have been proposed in the United States (Barry et al., 2009) and Australia (Elliott, 2015). Such strategies are in line with the international charter on prevention of FASD, published in *The Lancet Global Health* in 2014, calling on governments to take action to raise awareness of FASD and the risks of alcohol use during pregnancy (Jonsson et al., 2014). It is also in line with

the WHO global strategy to monitor and reduce the harmful use of alcohol, endorsed by the 63<sup>rd</sup> World Health Assembly (WHO, 2010), which highlights the importance of prevention and identification of the harmful use of alcohol among pregnant women and women of childbearing age in all countries. Accordingly, the World Health Organization (WHO) recently developed guidelines for identification and management of substance use in pregnancy are available (WHO, 2014).

Finally, it is also very important to establish national surveillance systems in order to monitor the prevalence of FASD. The Fetal Alcohol Syndrome Surveillance Network II (FASSNetII, 2009–2014) is an example of an FASD surveillance system that currently exists in the United States, in which three states participate: Arizona, Colorado, and New York (O’Leary et al., 2015). More like this need to be established in Canada and the United States.

The harmful effects of alcohol on the fetus and FASD should be well recognized by health workers and other professionals, and prevention, treatment and care interventions should be effectively implemented at the policy and program levels in all countries in order to achieve alcohol-free pregnancies in future.

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**Table 1.** Study characteristics and the prevalence of alcohol use (any amount) and binge drinking during pregnancy among the general population in Canada and the United States reported in the identified studies

| Reference                        | Country<br>(State/Province/<br>Territory) | Study<br>year(s) | Timing of data<br>collection               | Sample<br>size | Setting          | Instrument<br>used to obtain<br>alcohol use<br>data | Prevalence of<br>alcohol use (any<br>amount) during<br>pregnancy<br>(n [%]) | Prevalence of<br>binge drinking<br>during pregnancy<br>(n [%]) |
|----------------------------------|---|------------------|--|----------------|------------------|---|---|--|
| Armstrong et al., 1992           | Canada (Quebec)                           | 1982-84          | Retrospective                              | 47,146         | Hospital-based   | Questionnaire                                       | 13,982 (29.7%)  | n/a  |
| Burstyn et al., 2010             | Canada (Alberta)                          | 2001-05          | Retrospective                              | 191,686        | Hospital-based   | Medical charts/records                              | 3,768 (2.0%)  | n/a  |
| Caldeira & Woodin, 2012          | Canada (British Columbia)                 | 2012             | During pregnancy                           | 98             | Population-based | AUDIT   | 11 (11.2%)  | n/a  |
| Chalmers et al., 2008            | Canada                                    | 2006             | Retrospective (post-partum period)         | 6,421          | Population-based | Questionnaire                                       | 674 (10.5%)   | n/a  |
| Gareri et al., 2008              | Canada (Ontario)                          | 2004-05          | Retrospective (post-partum period)         | 1,019          | Hospital-based   | Questionnaire                                       | 5 (0.5%)  | n/a  |
| Hicks et al., 2014               | Canada (Alberta)                          | 2001-04          | During pregnancy                           | 1,929          | Hospital-based   | T-ACE   | 430 (22.3%)   | 64 (3.3%)  |
| Holmes et al., 2011 <sup>a</sup> | Canada & United States                    | 1997-2010        | During pregnancy (TT)                      | 406            | Population-based | Questionnaire                                       | 122 (30.0%)   | n/a  |
| Lange et al., 2015               | Canada                                    | 2003-10          | Retrospective ( $\leq 5$ years postpartum) | 18,612         | Population-based | Questionnaire                                       | 1,791 (9.6%)  | n/a  |
| Stewart & Streiner, 1994         | Canada (Ontario)                          | 1992-93          | During pregnancy (ST & TT)                 | 466            | Hospital-based   | Questionnaire                                       | 68 (14.6%)  | n/a  |
| Stoll et al., 2014               | Canada (British Columbia)                 | 2003-08          | Retrospective                              | 5,031          | Hospital-based   | Medical charts/records                              | 28 (0.6%)   | n/a  |
| Tough et al., 2001               | Canada (Alberta)                          | 1994-96          | Retrospective                              | 106,306        | Population-based | Medical charts/records                              | 7,970 (7.5%)  | n/a  |
| Weeks et al., 2014               | Canada                                    | 1994-97          | Retrospective (4-5 years postpartum)       | 6,337          | Population-based | Questionnaire                                       | 1,065 (16.8%)   | n/a  |
| Wenman et al., 2002              | Canada (Alberta)                          | 1994-95          | During pregnancy (FT/ST)                   | 1,991          | Hospital-based   | Questionnaire                                       | 348 (17.5%)   | n/a  |
| Xiong et al.,                    | Canada (Alberta)                          | 1995-98          | Retrospective (time of                     | 55,542         | Population-based | Medical   | 1,104 (2.0%)  | n/a  |

| Reference                      | Country<br>(State/Province/<br>Territory)                | Study<br>year(s) | Timing of data<br>collection  | Sample<br>size | Setting          | Instrument<br>used to obtain<br>alcohol use<br>data | Prevalence of<br>alcohol use (any<br>amount) during<br>pregnancy<br>(n [%]) | Prevalence of<br>binge drinking<br>during pregnancy<br>(n [%]) |
|--------------------------------|--|------------------|---|----------------|------------------|---|---|--|
| 2000                           |  |                  | delivery)   |                |                  | charts/records                                      |   |  |
| Adams et al.,<br>1995          | United States  | 1987-90          | Retrospective   | 1,768          | Hospital-based   | Medical<br>charts/records                           | 175 (9.9%)  | n/a  |
| Alderete et al.,<br>1995       | United States<br>(California)                            | 1959-66          | During pregnancy  | 1,341          | Hospital-based   | Questionnaire                                       | 518 (38.6%)   | 137 (10.2%)  |
| Aliyu et al.,<br>2010          | United States<br>(Missouri)                              | 1989-<br>2005    | Retrospective   | 1,221,677      | Hospital-based   | Medical<br>charts/records                           | 15,914 (1.3%)   | n/a  |
| Altfeld et al.,<br>1997        | United States<br>(Illinois)                              | 1990             | Retrospective (post-<br>partum period)                              | 378            | Hospital-based   | Questionnaire                                       | 89 (23.5%)  | n/a  |
| Arfsten et al.,<br>2004        | United States<br>(Maryland)                              | 2004             | Retrospective ( $\leq 1$ year<br>postpartum)                        | 993            | Population-based | Questionnaire                                       | 242 (24.4%)   | n/a  |
| Arria et al.,<br>2006          | United States<br>(California, Iowa,<br>Oklahoma, Hawaii) | 2006             | Retrospective (post-<br>partum period)                              | 1,632          | Hospital-based   | Questionnaire                                       | 372 (22.8%)   | n/a  |
| Astley, 2004                   | United States<br>(Washington)                            | 1993-95          | Retrospective (2-6<br>months postpartum)                            | 5,740          | Population-based | Questionnaire                                       | 544 (9.5%)  | n/a  |
| Bailey &<br>Daugherty,<br>2007 | United States (North<br>Carolina)                        | 2007             | During pregnancy (TT)   | 104            | Hospital-based   | Questionnaire                                       | 2 (1.9%)  | n/a  |
| Bailey et al.,<br>2008         | United States<br>(Washington)                            | 1996-99          | Retrospective   | 24             | Population-based | Timeline<br>follow-back                             | n/a   | 8 (33.3%)  |
| Barrett et al.,<br>1993        | United States<br>(Illinois)                              | 1990             | During pregnancy  | 32             | Population-based | Questionnaire                                       | 6 (18.8%)   | n/a  |
| Bauer et al.,<br>2002          | United States  | 1993-95          | Retrospective (24<br>hours after delivery)                          | 9,444          | Hospital-based   | Questionnaire                                       | 3,659 (38.7%)   | n/a  |
| Bobo et al.,<br>2006           | United States  | 1982-95          | Retrospective   | 6,676          | Population-based | Questionnaire                                       | 2,130 (31.9%)   | n/a  |
| Breslow et al.,<br>2007        | United States  | 1993-94          | During pregnancy (TT)<br>and retrospective (3<br>months postpartum) | 1,548          | Population-based | Questionnaire                                       | 95 (6.1%)   | n/a  |
| Brown et al.,<br>2010          | United States  | 2001             | Retrospective (6-22<br>months postpartum)                           | 10,700         | Population-based | Questionnaire                                       | 300 (2.8%)  | n/a  |

| Reference                | Country<br>(State/Province/<br>Territory)              | Study<br>year(s) | Timing of data<br>collection   | Sample<br>size | Setting          | Instrument<br>used to obtain<br>alcohol use<br>data   | Prevalence of<br>alcohol use (any<br>amount) during<br>pregnancy<br>(n [%]) | Prevalence of<br>binge drinking<br>during pregnancy<br>(n [%]) |
|--------------------------|--|------------------|--|----------------|------------------|---|---|--|
| Burd et al., 2003        | United States (North<br>Dakota)                        | 2003             | During pregnancy   | 1,081          | Hospital-based   | TWEAK   | 43 (4.0%)   | n/a  |
| Caetano et al.,<br>2006  | United States  | 2001-02          | During pregnancy and<br>retrospective ( $\leq 1$ year<br>postpartum) | 1,515          | Population-based | Alcohol Use<br>Disorder and<br>Associated<br>Disabilities<br>Interview<br>Schedule-IV<br>(AUDADIS-IV) | 139 (9.2%)  | n/a  |
| CDC, 1994                | United States  | 1991             | During pregnancy   | 1,067          | Population-based | Questionnaire   | 147 (13.8%)   | 14 (1.3%)  |
| CDC, 1995a               | United States  | 1988             | During pregnancy   | 8,396          | Population-based | Questionnaire   | 1,738 (20.7%)   | n/a  |
| CDC, 1997a               | United States  | 1995             | During pregnancy   | 1,313          | Population-based | Questionnaire   | 214 (16.3%)   | 38 (2.9%)  |
| CDC, 2002a               | United States  | 1997             | During pregnancy   | 1,429          | Population-based | Questionnaire   | 163 (11.4%)   | 26 (1.8%)  |
| CDC, 2002a               | United States  | 1999             | During pregnancy   | 1,888          | Population-based | Questionnaire   | 242 (12.8%)   | 51 (2.7%)  |
| CDC, 2009                | United States  | 2001-05          | During pregnancy   | 13,820         | Population-based | Questionnaire   | 1,548 (11.2%)   | 249 (1.8%)   |
| CDC, 2012                | United States  | 2006-10          | During pregnancy   | 13,880         | Population-based | Questionnaire   | 1,055 (7.6%)  | 194 (1.4%)   |
| Chang et al.,<br>2011    | United States<br>(Massachusetts)                       | 2011             | During pregnancy (ST)  | 30             | Hospital-based   | T-ACE,<br>CRAFFT,<br>medical<br>charts/record   | 8 (26.7%)   | n/a  |
| Chasnoff et al.,<br>2005 | United States<br>(California, Illinois,<br>New Jersey) | 2005             | During pregnancy   | 4,865          | Hospital-based   | 4P's Plus<br>Screen   | 512 (10.5%)   | n/a  |
| Chung et al.,<br>2010    | United States<br>(Pennsylvania)                        | 2000-02          | Retrospective (3<br>months postpartum)                               | 1,476          | Hospital-based   | Questionnaire   | 99 (6.7%)   | n/a  |
| Coleman et al.,<br>1989  | United States  | 1989             | During pregnancy (TT)  | 153            | Hospital-based   | Questionnaire   | 60 (39.2%)  | n/a  |
| D'Angelo et al.,<br>2012 | United States  | 2008             | Retrospective (2-6<br>months postpartum)                             | 35,446         | Population-based | T-ACE, CAGE,<br>MAST  | 2,320 (6.5%)  | n/a  |
| Declercq et al.,<br>1995 | United States  | 1989-92          | Retrospective  | 82,210         | Population-based | Medical<br>charts/records   | 2,302 (2.8%)  | n/a  |
| Derauf et al.,           | United States  | 1999             | Retrospective  | 436            | Hospital-based   | Medical   | 23 (5.3%)   | n/a  |



| Reference                      | Country<br>(State/Province/<br>Territory)  | Study<br>year(s) | Timing of data<br>collection                  | Sample<br>size | Setting          | Instrument<br>used to obtain<br>alcohol use<br>data | Prevalence of<br>alcohol use (any<br>amount) during<br>pregnancy<br>(n [%]) | Prevalence of<br>binge drinking<br>during pregnancy<br>(n [%]) |
|--------------------------------|--|------------------|---|----------------|------------------|---|---|--|
| 2003<br>Detjen et al.,<br>2007 | (Hawaii)<br>United States<br>(Massachusetts)   | 2000-04          | During pregnancy (FT<br>& TT)                 | 1,130          | Hospital-based   | charts/records<br>Questionnaire                     | 16 (1.4%)   | n/a  |
| Dew et al., 2007               | United States<br>(Missouri)  | 1990-<br>2002    | Retrospective                                 | 82,856         | Hospital-based   | Medical<br>charts/records                           | 2,140 (2.6%)  | n/a  |
| Dlugosz et al.,<br>1996        | United States<br>(Connecticut)   | 1988-92          | During pregnancy (FT<br>& ST)                 | 2,839          | Hospital-based   | Questionnaire                                       | 1,429 (50.3%)   | n/a  |
| El-Khorazaty et<br>al., 2007   | United States<br>(Washington)  | 2001-03          | During pregnancy (ST)                         | 1,070          | Hospital-based   | Questionnaire                                       | 229 (21.4%)   | n/a  |
| El-Sayed &<br>Galea, 2012      | United States<br>(Michigan)  | 1989-<br>2006    | Retrospective                                 | 2,377,661      | Population-based | Questionnaire                                       | 38,710 (1.6%)   | n/a  |
| Ethen et al.,<br>2009          | United States<br>(Arkansas,<br>California, Georgia,<br>Iowa, Massachusetts,<br>New Jersey, New<br>York, Texas) | 1997-<br>2002    | Retrospective ( $\leq 2$ years<br>postpartum) | 4,088          | Population-based | Questionnaire                                       | 1,239 (30.3%)   | 338 (8.3%)   |
| Erickson et al.,<br>1987       | United States<br>(Minnesota)   | 1980-82          | Retrospective                                 | 923            | Hospital-based   | Medical<br>charts/records                           | 125 (13.5%)   | n/a  |
| Faden &<br>Graubard, 1994      | United States  | 1979-86          | Retrospective                                 | 4,409          | Population-based | Questionnaire                                       | 1,506 (34.2%)   | n/a  |
| Fenster et al.,<br>1997        | United States<br>(California)  | 1990-91          | During pregnancy (FT)                         | 5,144          | Hospital-based   | Questionnaire                                       | 397 (7.7%)  | n/a  |
| Fortner et al.,<br>2011        | United States<br>(Massachusetts)   | 2006-09          | During pregnancy (FT<br>& ST)                 | 916            | Hospital-based   | Questionnaire                                       | 130 (14.2%)   | n/a  |
| Flynn et al.,<br>2003          | United States<br>(Michigan)  | 1998-99          | During pregnancy                              | 1,116          | Hospital-based   | Abbreviated<br>TWEAK                                | 169 (15.1%)   | 10 (0.9%)  |
| Gardosi &<br>Fancis, 2000      | United States  | 1988-95          | During pregnancy                              | 21,069         | Hospital-based   | Medical<br>charts/records                           | 6,655 (31.6%)   | n/a  |
| Gavin et al.,<br>2011          | United States<br>(Washington)  | 2011             | n/a   | 136            | Population-based | Questionnaire                                       | 24 (17.6%)  | n/a  |
| Getahun et al.,                | United States  | 1989-97          | Retrospective                                 | 156,475        | Hospital-based   | Medical   | 3,599 (2.3%)  | n/a  |

| Reference                       | Country<br>(State/Province/<br>Territory)                | Study<br>year(s) | Timing of data<br>collection           | Sample<br>size | Setting          | Instrument<br>used to obtain<br>alcohol use<br>data | Prevalence of<br>alcohol use (any<br>amount) during<br>pregnancy<br>(n [%]) | Prevalence of<br>binge drinking<br>during pregnancy<br>(n [%]) |
|---------------------------------|--|------------------|--|----------------|------------------|---|---|--|
| 2006<br>Goebert et al.,<br>2007 | (Missouri)<br>United States<br>(Hawaii)                  | 2007             | n/a                                    | 84             | Hospital-based   | charts/records<br>TWEAK                             | 11 (13.1%)  | n/a  |
| Grant et al.,<br>2009a          | United States<br>(Washington)                            | 1989-91          | Retrospective                          | 7,178          | Hospital-based   | Questionnaire                                       | 2,125 (29.6%)   | 248 (3.5%)   |
| Grant et al.,<br>2009b          | United States<br>(Washington)                            | 1991-92          | Retrospective                          | 2,230          | Hospital-based   | Questionnaire                                       | 524 (23.5%)   | n/a  |
| Grant et al.,<br>2009c          | United States<br>(Washington)                            | 2002-04          | Retrospective                          | 3,124          | Hospital-based   | Questionnaire                                       | 372 (11.9%)   | 44 (1.4%)  |
| Grewal et al.,<br>2008          | United States<br>(California)                            | 1999-<br>2003    | Retrospective                          | 700            | Hospital-based   | Questionnaire                                       | 39 (5.6%)   | 9 (1.3%)   |
| Havens et al.,<br>2009          | United States  | 2002-03          | During pregnancy                       | 1,800          | Population-based | Questionnaire                                       | 180 (10.0%)   | n/a  |
| Haynes et al.,<br>2003          | United States<br>(Montana, North and<br>South Dakota)    | 2003             | During pregnancy                       | 232            | Hospital-based   | n/a   | 24 (10.3%)  | n/a  |
| Hobbs et al.,<br>2010           | United States<br>(Arkansas)                              | 1998-<br>2006    | Retrospective                          | 363            | Population-based | Questionnaire                                       | 114 (31.4%)   | n/a  |
| Hoffman &<br>Hatch, 2000        | United States (New<br>York, Pennsylvania)                | 1987-89          | During pregnancy                       | 662            | Population-based | Questionnaire &<br>medical<br>charts/records        | 41 (6.2%)   | n/a  |
| Hoyert, 1996                    | United States  | 1989-90          | During pregnancy                       | 3,850,653      | Hospital-based   | Medical<br>charts/records                           | 131,716 (3.4%)  | n/a  |
| Huang & Reid,<br>2006           | United States  | 1998-<br>2002    | Retrospective (post-<br>partum period) | 4,854          | Hospital-based   | Questionnaire                                       | 534 (11.0%)   | n/a  |
| Hueston et al.,<br>2003         | United States  | 1996             | Retrospective                          | 2,958,309      | Hospital-based   | Medical<br>charts/records                           | 38,899 (1.3%)   | n/a  |
| Jagodzinski &<br>Fleming, 2007  | United States<br>(Wisconsin)                             | 2002-05          | Retrospective (post-<br>partum period) | 8,283          | Hospital-based   | CAGE  | 447 (5.4%)  | n/a  |
| Jesse & Reed,<br>2004           | United States<br>(Kentucky, West<br>Virginia, Tennessee, | 2004             | During pregnancy (ST)                  | 120            | Hospital-based   | Questionnaire                                       | 2 (1.7%)  | n/a  |

| Reference                  | Country<br>(State/Province/<br>Territory) | Study<br>year(s) | Timing of data<br>collection                                     | Sample<br>size | Setting          | Instrument<br>used to obtain<br>alcohol use<br>data | Prevalence of<br>alcohol use (any<br>amount) during<br>pregnancy<br>(n [%]) | Prevalence of<br>binge drinking<br>during pregnancy<br>(n [%]) |
|----------------------------|---|------------------|--|----------------|------------------|---|---|--|
| Johnson et al.,<br>1994    | Virginia<br>United States<br>(Washington) | 1994             | During pregnancy   | 234            | Hospital-based   | Questionnaire                                       | 8 (3.4%)  | n/a  |
| Jones-Webb et<br>al., 1999 | United States<br>(Minnesota)              | 1993             | Retrospective (post-<br>partum period)                           | 683            | Population-based | Questionnaire                                       | 171 (25.0%)   | n/a  |
| Kearney et al.,<br>2004    | United States<br>(Massachusetts)          | 2004             | Retrospective (post-<br>partum period)                           | 1,940          | Hospital-based   | Questionnaire &<br>medical<br>charts/records        | 258 (13.3%)   | n/a  |
| Kelly et al.,<br>2001      | United States<br>(California)             | 2001             | During pregnancy   | 186            | Hospital-based   | CAGE  | 31 (16.7%)  | n/a  |
| Klein et al.,<br>1997      | United States<br>(California)             | 1997             | During pregnancy   | 401            | Population-based | CAGE  | 193 (48.1%)   | 55 (13.7%)   |
| Knopik et al.,<br>2005     | United States<br>(Missouri)               | 1995-98          | Retrospective<br>(postpartum period)                             | 1,936          | Population-based | Modified<br>SSAGA                                   | 533 (27.5%)   | 67 (3.5%)  |
| Lagiou et al.,<br>2006     | United States<br>(Massachusetts)          | 1994-95          | During pregnancy (end<br>of ST)                                  | 270            | Hospital-based   | Questionnaire                                       | 214 (79.3%)   | n/a  |
| Li et al., 2012            | United States<br>(Alabama)                | 1997-<br>2001    | During pregnancy (ST)  | 3,046          | Hospital-based   | Questionnaire                                       | 156 (5.1%)  | 18 (0.6%)  |
| Little et al.,<br>1990     | United States<br>(Washington)             | 1982-84          | During pregnancy (ST)<br>& retrospective (1<br>month postpartum) | 463            | Hospital-based   | Questionnaire                                       | 186 (40.2%)   | 12 (2.6%)  |
| Lundsberg et<br>al., 1997  | United States<br>(Connecticut)            | 1988-92          | During pregnancy   | 2,714          | Hospital-based   | Questionnaire                                       | 1,354 (49.9%)   | n/a  |
| Martin et al.,<br>1997     | United States (North<br>Carolina)         | 1987-91          | Retrospective  | 4,708          | Population-based | Medical<br>charts/records                           | 212 (4.5%)  | n/a  |
| McPheeters et<br>al., 2005 | United States                             | 1995-<br>2001    | During pregnancy (ST<br>& TT)                                    | 2,534          | Hospital-based   | Questionnaire                                       | 1,017 (40.1%)   | n/a  |
| Merewood et<br>al., 2009   | United States<br>(Massachusetts)          | 2005-07          | Retrospective (within<br>72 hours after delivery)                | 252            | Hospital-based   | Questionnaire                                       | 17 (6.7%)   | n/a  |
| Meschke et al.,<br>2003    | United States<br>(Minnesota)              | 2000-03          | During pregnancy (first<br>prenatal visit)                       | 1,704          | Hospital-based   | Questionnaire                                       | 334 (19.6%)   | n/a  |
| Meschke et al.,            | United States                             | 2001-03          | During pregnancy (first  | 4,272          | Hospital-based   | Questionnaire                                       | 1,137 (26.6%)   | n/a  |

| Reference                           | Country<br>(State/Province/<br>Territory)   | Study<br>year(s) | Timing of data<br>collection                                  | Sample<br>size | Setting          | Instrument<br>used to obtain<br>alcohol use<br>data | Prevalence of<br>alcohol use (any<br>amount) during<br>pregnancy<br>(n [%]) | Prevalence of<br>binge drinking<br>during pregnancy<br>(n [%]) |
|-------------------------------------|---|------------------|---|----------------|------------------|---|---|--|
| 2008<br>Meschke et al.,<br>2013     | (Minnesota)<br>United States<br>(Minnesota,<br>Montana, North and<br>South Dakota)      | 2001-03          | prenatal visit)<br>During pregnancy (first<br>prenatal visit) | 9,004          | Hospital-based   | Questionnaire                                       | 1,983 (22.0%)   | n/a  |
| Mills et al.,<br>1993               | United States<br>(Illinois,<br>Massachusetts, New<br>York, Pennsylvania,<br>Washington) | 1980-85          | During pregnancy<br>(throughout)                              | 423            | Hospital-based   | Questionnaire                                       | 367 (86.8%)   | n/a  |
| Mohllajee et al.,<br>2007           | United States   | 1996-99          | Retrospective (2-6<br>months postpartum)                      | 87,087         | Population-based | Questionnaire                                       | 5,229 (6.0%)  | n/a  |
| Nayak &<br>Kaskutas, 2004           | United States   | 1999-<br>2001    | During pregnancy  | 72             | Population-based | Questionnaire                                       | 4 (5.6%)  | n/a  |
| Nolan et al.,<br>2010               | United States (Ohio)  | 2003-05          | Retrospective   | 1,548          | Hospital-based   | Medical<br>charts/records                           | 6 (0.4%)  | n/a  |
| Pegues et al.,<br>1994              | United States<br>(Alabama)  | 1991             | During pregnancy  | 3,554          | Hospital-based   | Medical<br>charts/records                           | 175 (4.9%)  | n/a  |
| Perham-Hester<br>& Gessner,<br>1997 | United States<br>(Alaska)   | 1991-94          | Retrospective (2-8<br>months postpartum)                      | 6,973          | Population-based | Questionnaire                                       | 616 (8.8%)  | n/a  |
| Piper & Corbett,<br>2012            | United States (Idaho,<br>Oregon, Washington)  | 2012             | Retrospective (5-18<br>years postpartum)                      | 357            | Population-based | Questionnaire                                       | 65 (18.2%)  | n/a  |
| Pirie et al., 2000                  | United States<br>(Minnesota,<br>Washington)   | 1993-95          | During pregnancy (FT)   | 7,489          | Hospital-based   | Questionnaire                                       | 389 (5.2%)  | n/a  |
| Poser et al.,<br>1986               | United States   | 1985             | Retrospective   | 67             | Population-based | Questionnaire                                       | 16 (23.9%)  | n/a  |
| Raymond &<br>Mills, 1993            | United States<br>(California)   | 1974-77          | During pregnancy (first<br>prenatal visit)                    | 30,583         | Hospital-based   | Questionnaire                                       | 14,546 (47.6%)  | n/a  |
| Reed et al.,<br>2005                | United States<br>(Colorado)   | 1998-99          | Retrospective   | 118,904        | Hospital-based   | Medical<br>charts/records                           | 1,486 (1.3%)  | n/a  |

| Reference                | Country<br>(State/Province/<br>Territory)   | Study<br>year(s) | Timing of data<br>collection | Sample<br>size | Setting          | Instrument<br>used to obtain<br>alcohol use<br>data | Prevalence of<br>alcohol use (any<br>amount) during<br>pregnancy<br>(n [%]) | Prevalence of<br>binge drinking<br>during pregnancy<br>(n [%]) |
|--------------------------|---|------------------|------------------------------|----------------|------------------|---|---|--|
| Sastry &<br>Hussey, 2003 | United States<br>(Illinois)   | 1990             | Retrospective                | 48,416         | Hospital-based   | Medical<br>charts/records                           | 1,355 (2.8%)  | n/a  |
| Savage et al.,<br>2002   | United States (Ohio)  | 2002             | During pregnancy             | 10             | Hospital-based   | Timeline<br>follow-back                             | 5 (50.0%)   | n/a  |
| Serdula et al.,<br>1991  | United States<br>(Arizona, California,<br>Florida, Georgia,<br>Idaho, Illinois,<br>Indiana, Kentucky,<br>Minnesota, Montana,<br>New York, North<br>Carolina, North<br>Dakota, Ohio, Rhode<br>Island, South<br>Carolina, Tennessee,<br>Utah, District of<br>Columbia, West<br>Virginia, Wisconsin) | 1985-88          | During pregnancy             | 1,712          | Population-based | Questionnaire                                       | 429 (25.1%)   | 4 (2.8%)   |
| Shiono et al.,<br>1995   | United States<br>(Louisiana, New<br>York, Oklahoma,<br>Texas, Washington)   | 1984-89          | During pregnancy (ST)        | 7,470          | Hospital-based   | Questionnaire                                       | 2,549 (34.1%)   | n/a  |
| Shu et al., 1995         | United States (New<br>York, Pennsylvania)   | 1987-89          | During pregnancy             | 504            | Hospital-based   | Questionnaire                                       | 170 (33.7%)   | n/a  |
| Silveira et al.,<br>2010 | United States<br>(Maryland)   | 2005-08          | During pregnancy             | 2,104          | Hospital-based   | Medical<br>charts/records                           | 66 (3.1%)   | n/a  |
| Silveira et al.,<br>2012 | United States<br>(Massachusetts)  | 2006-11          | During pregnancy             | 953            | Hospital-based   | Questionnaire                                       | 24 (2.5%)   | n/a  |
| Stitely et al.,<br>2010  | United States (West<br>Virginia)  | 2009             | Retrospective                | 1,074          | Hospital-based   | Medical<br>charts/records                           | 13 (1.2%)   | n/a  |
| Sung, 2012               | United States   | 2004-08          | During pregnancy             | 6,499          | Population-based | Questionnaire                                       | 694 (10.7%)   | n/a  |
| Vassilev et al.,         | United States (New  | 1990-91          | Retrospective                | 209,560        | Population-based | Medical   | 6,220 (3.0%)  | n/a  |

| Reference                     | Country<br>(State/Province/<br>Territory) | Study<br>year(s) | Timing of data<br>collection             | Sample<br>size | Setting          | Instrument<br>used to obtain<br>alcohol use<br>data | Prevalence of<br>alcohol use (any<br>amount) during<br>pregnancy<br>(n [%]) | Prevalence of<br>binge drinking<br>during pregnancy<br>(n [%]) |
|-------------------------------|---|------------------|--|----------------|------------------|---|---|--|
| 2001<br>Veach et al.,<br>1995 | Jersey<br>United States (Las<br>Vegas)    | 1995             | During pregnancy (ST)                    | 134            | Hospital-based   | charts/records<br>CAGE                              | 29 (21.6%)  | n/a  |
| Vinikoor et al.,<br>2010      | United States (North<br>Carolina)         | 2000-05          | During pregnancy (FT<br>& ST)            | 1,457          | Hospital-based   | Questionnaire                                       | n/a   | 7 (0.5%)   |
| Wells et al.,<br>2006         | United States<br>(Colorado)               | 2000-02          | Retrospective                            | 4,528          | Population-based | Questionnaire                                       | 485 (10.7%)   | n/a  |
| Windham et al.,<br>1995       | United States<br>(California)             | 1986-87          | Retrospective (8-9<br>months postpartum) | 1,233          | Hospital-based   | Questionnaire                                       | 662 (53.7%)   | n/a  |
| Windham et al.,<br>1997       | United States<br>(California)             | 1990-91          | During pregnancy (FT)                    | 5,142          | Hospital-based   | Questionnaire                                       | 387 (7.5%)  | n/a  |
| Woods et al.,<br>2010         | United States<br>(Washington)             | 2004-08          | During pregnancy (ST<br>& TT)            | 1,440          | Hospital-based   | T-ACE   | 212 (14.7%)   | n/a  |
| Zender et al.,<br>2001        | United States<br>(Colorado)               | 1996-97          | During pregnancy                         | 71             | Hospital-based   | Questionnaire                                       | 3 (4.2%)  | n/a  |

FT: First Trimester; n/a: Not available; ST: Second Trimester; TT: Third Trimester

<sup>a</sup> Included in the meta-analysis for both Canada and the United States (Holmes et al., 2011)

**Table 2.** Pooled prevalence of alcohol use (any amount) and binge drinking during pregnancy among the general population and Aboriginal population in Canada and the United States, based on the available literature, and the results of the heterogeneity and publication bias<sup>a</sup> tests

| Country  | Number of studies | Estimate (%) | Lower 95% CI (%) | Upper 95% CI (%) | Heterogeneity tests |             |                  | Publication bias tests |                     |                           |
|--|-------------------|--------------|------------------|------------------|---------------------|-------------|------------------|------------------------|---------------------|---------------------------|
|  |                   |              |                  |                  | I <sup>2</sup> test | Q statistic | df (Q statistic) | p-value (Q statistic)  | p-value (rank test) | p-value (regression test) |
| <b>Prevalence of alcohol use (any amount) during pregnancy among the general population</b>    |                   |              |                  |                  |                     |             |                  |                        |                     |                           |
| Canada   | 14                | 10.0%        | 5.2%             | 16.2%            | 100.0%              | 34,725.2    | 13               | 0                      | 0.667               | 0.442                     |
| United States  | 103               | 14.8%        | 12.0%            | 18.0%            | 100.0%              | 198,478.0   | 102              | 0                      | <0.001              | 0.022                     |
| <b>Prevalence of binge drinking during pregnancy among the general population</b>              |                   |              |                  |                  |                     |             |                  |                        |                     |                           |
| Canada   | 1                 | 3.3%         | 2.6%             | 4.2%             | -                   | -           | -                | -                      | -                   | -                         |
| United States  | 19                | 3.1%         | 1.7%             | 4.9%             | 99.1%               | 861.5       | 18               | <0.001                 | 0.238               | <0.001                    |
| <b>Prevalence of alcohol use (any amount) during pregnancy among the Aboriginal population</b> |                   |              |                  |                  |                     |             |                  |                        |                     |                           |
| Canada   | 6                 | 36.5%        | 24.7%            | 49.1%            | 96.3%               | 130.1       | 5                | <0.001                 | 0.469               | 0.944                     |
| United States  | 4                 | 42.9%        | 27.1%            | 59.4%            | 96.3%               | 124.8       | 3                | <0.001                 | 0.750               | 0.083                     |
| <b>Prevalence of binge drinking during pregnancy among the Aboriginal population</b>           |                   |              |                  |                  |                     |             |                  |                        |                     |                           |
| Canada   | 2                 | 22.1%        | 0.0%             | 52.9%            | 96.9%               | 31.7        | 1                | <0.001                 | -                   | -                         |
| United States  | 2                 | 14.6%        | 6.6%             | 24.8%            | 79.7%               | 4.9         | 1                | 0.027                  | -                   | -                         |

CI: Confidence Interval; df: degrees of freedom

<sup>a</sup> For those countries with more than one available study.

*Note.* Please see Tables 1 and 3 for the references of the studies included in each meta-analysis.

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**Table 3.** Study characteristics and the prevalence of alcohol use (any amount) and binge drinking during pregnancy among the Aboriginal population in Canada and the United States reported in the identified studies

| Reference                | Country<br>(State/Province/Territory) | Study<br>year(s) | Timing of data<br>collection                                     | Sample<br>size | Setting          | Instrument<br>used to obtain<br>alcohol use<br>data | Prevalence of<br>alcohol use (any<br>amount) during<br>pregnancy<br>(n [%]) | Prevalence of<br>binge drinking<br>during pregnancy<br>(n [%]) |
|--------------------------|---------------------------------------|------------------|--|----------------|------------------|---|---|--|
| Fraser et al., 2012      | Canada (Nunavut)                      | 1995-2000        | Mid-pregnancy (ST)   | 215            | Hospital-based   | Timeline follow-back                                | 130 (60.5%)   | 82 (38.1%)   |
| Godel et al., 1992       | Canada (Northwest Territories)        | 1987-1990        | n/a  | 145            | Hospital-based   | Questionnaire                                       | 50 (34.5%)  | 18 (12.4%)   |
| Godel et al., 2000       | Canada (Northwest Territories)        | 2000             | Retrospective (6-11 years postpartum)                            | 70             | School-based     | Questionnaire                                       | 17 (24.3%)  | n/a  |
| Kelly et al., 2011       | Canada (Ontario)                      | 2009-10          | Retrospective  | 458            | Hospital-based   | Medical charts/records                              | 116 (25.3%)   | n/a  |
| Williams & Gloster, 1999 | Canada (Manitoba)                     | 1994-95          | Retrospective  | 242            | Population-based | Questionnaire                                       | 123 (50.8%)   | n/a  |
| Williams et al., 1999    | Canada (Manitoba)                     | 1994             | Retrospective  | 745            | Hospital-based   | Medical charts/records                              | 196 (26.3%)   | n/a  |
| Bull et al., 1999        | United States                         | 1994-95          | During pregnancy (first prenatal visit; FT), and retrospectively | 208            | Hospital-based   | T-ACE and medical charts/records                    | 111 (53.4%)   | n/a  |
| Khan et al., 2013        | United States (Alaska)                | 2013             | During pregnancy (TT)  | 125            | Hospital-based   | Questionnaire                                       | 54 (43.2%)  | 25 (20.0%)   |
| Kvigne et al., 1998      | United States                         | 1998             | During pregnancy (first prenatal visit; FT)                      | 177            | Hospital-based   | Questionnaire                                       | 99 (55.9%)  | 19 (10.7%)   |
| Westphal, 2000           | United States                         | 1988             | Retrospective (post-partum period)                               | 763            | Population-based | Questionnaire                                       | 169 (22.1%)   | n/a  |

FT: First Trimester; n/a: Not available; ST: Second Trimester; TT: Third Trimester

**Table 4.** Study characteristics and prevalence of FAS and FASD among the general population reported in the studies identified and included in the meta-analyses, in Canada and the United States

| Reference                   | Country<br>(State/Province<br>/Territory)               | Study<br>year(s) | Sample<br>size | Number<br>of cases<br>of FAS | Prevalence<br>of FAS (per<br>1,000) | Number<br>of cases<br>of FASD | Prevalence<br>of FASD<br>(per 1,000) | Diagnostic<br>guidelines/Case<br>definition  | Sex<br>(%<br>male) | Age range<br>(years) | Method                      |
|-----------------------------|---|------------------|----------------|------------------------------|-------------------------------------|-------------------------------|--------------------------------------|--|--------------------|----------------------|-----------------------------|
| Asante & Nelms-Matzke, 1985 | Canada<br>(Northwest<br>British<br>Columbia &<br>Yukon) | 1983-<br>84      | 33,485         | 82                           | 2.45                                | 176                           | 5.26                                 | Guidelines established by the Fetal Alcohol Study Group of the RSA (Rosett, 1980)  | 63.0               | 0-16                 | ACA                         |
| Habbick et al., 1996        | Canada<br>(Saskatchewan)                                | 1992-<br>94      | 331,475        | 194                          | 0.59                                | n/a                           | n/a                                  | Guidelines established by the Fetal Alcohol Study Group of the RSA (Rosett, 1980) and the criteria by Sokol & Clarren (1989) | n/a                | 0.5-28.3             | Mixed methods<br>(ACA & PS) |
| Barr & Streissguth, 2001    | United States<br>(Washington)                           | 1974-<br>75      | 1,439          | n/a                          | n/a                                 | 36                            | 25.02                                | Case definitions provided  | n/a                | 0-7                  | CB                          |
| Burd et al., 1999           | United States<br>(North Dakota)                         | n/a              | 1,013          | 6                            | 5.92                                | n/a                           | n/a                                  | Criteria by Sokol & Clarren (1989)   | n/a                | 3-14                 | ACA                         |
| CDC, 1995b                  | United States   | 1979-<br>93      | 9,434,560      | 2,032                        | 0.22                                | n/a                           | n/a                                  | n/a  | n/a                | n/a                  | PS                          |
| CDC, 1997b                  | United States<br>(Georgia)                              | 1981-<br>89      | 285,538        | 29                           | 0.10                                | 70                            | 0.25                                 | IOM criteria (Stratton et al., 1996)   | n/a                | 3-10                 | PS                          |
| CDC, 2002b                  | United States<br>(Alaska,<br>Arizona,<br>Colorado)      | 1995-<br>97      | 348,463        | 145                          | 0.42                                | n/a                           | n/a                                  | IOM criteria (Stratton et al., 1996)   | n/a                | n/a                  | PS                          |
| Clarren et al., 2001        | United States<br>(Washington)                           | n/a              | 3,740          | 7                            | 1.87                                | 26                            | 6.95                                 | 4-digit diagnostic code (Astley & Clarren, 1999)   | n/a                | 6-7                  | ACA                         |
| Druschel & Fox,             | United States   | 1995-            | 106,336        | 63                           | 0.59                                | n/a                           | n/a                                  | IOM criteria   | n/a                | 0-4                  | PS                          |

| Reference               | Country<br>(State/Province<br>/Territory)                                 | Study<br>year(s) | Sample<br>size | Number<br>of cases<br>of FAS | Prevalence<br>of FAS (per<br>1,000) | Number<br>of cases<br>of FASD | Prevalence<br>of FASD<br>(per 1,000) | Diagnostic<br>guidelines/Case<br>definition   | Sex<br>(%<br>male) | Age range<br>(years) | Method                        |
|-------------------------|---|------------------|----------------|------------------------------|-------------------------------------|-------------------------------|--------------------------------------|---|--------------------|----------------------|-------------------------------|
| 2007                    | (New York)  | 99               |                |                              |                                     |                               |                                      | (Stratton et al., 1996)   |                    |                      |                               |
| Egeland et al.,<br>1998 | United States<br>(Alaska)   | 1977-<br>92      | 176,765        | 137                          | 0.78                                | n/a                           | n/a                                  | Case definition<br>provided   | n/a                | 0-16                 | PS                            |
| Fox et al., 2015        | United States<br>(Arizona,<br>Colorado, New<br>York)                      | 2010             | 472,457        | 161                          | 0.34                                | n/a                           | n/a                                  | Case definition<br>based on IOM<br>criteria (Stratton et<br>al., 1996)                        | 51.0               | 7-9                  | PS                            |
| Fox & Druschel,<br>2003 | United States<br>(New York)   | 1995-<br>98      | 111,197        | 36                           | 0.32                                | n/a                           | n/a                                  | IOM criteria<br>(Stratton et al., 1996)   | n/a                | 0-2                  | PS                            |
| Hansen et al.,<br>2014  | United States<br>(Georgia)  | 2006-<br>12      | 143,393        | 276                          | 1.92                                | n/a                           | n/a                                  | Case definition<br>based on IOM<br>criteria (Stratton et<br>al., 1996)                        | n/a                | 0-12                 | PS                            |
| Hingson et al.,<br>1982 | United States<br>(Boston)   | 1977-<br>79      | 1,690          | 1                            | 0.59                                | 37                            | 21.89                                | Guidelines<br>established by the<br>Fetal Alcohol Study<br>Group of the RSA<br>(Rosett, 1980) | n/a                | 0 (live<br>births)   | CB                            |
| Little, 1977            | United States<br>(Washington)   | n/a              | 801            | 0                            | 0.0                                 | n/a                           | n/a                                  | n/a   | n/a                | 0-1<br>(newborns)    | CB                            |
| Little et al.,<br>1990  | United States<br>(Texas)  | 1977-<br>80      | 5,602          | 6                            | 1.07                                | 17                            | 3.03                                 | n/a   | n/a                | n/a                  | PS                            |
| May et al., 2014        | United States<br>(Midwestern)   | 2010-<br>11      | 1,433          | 12                           | 8.37                                | 48                            | 33.50                                | Clarification of the<br>IOM criteria (Hyome<br>et al., 2005)                                  | 51.8               | 6-7                  | ACA                           |
| May et al., 2015        | United States<br>(Northern<br>Plains)                                     | 2007-<br>09      | 2,334          | 7                            | 3.0                                 | 26                            | 11.14                                | Clarification of the<br>IOM criteria (Hyome<br>et al., 2005)                                  | 54.5               | 6-7                  | ACA                           |
| Moberg et al.,<br>2014  | United States<br>(Colorado,<br>Michigan,<br>Minnesota,<br>Missouri, North | 2001-<br>06      | 1,322,831      | 422                          | 0.32                                | n/a                           | n/a                                  | Case definition<br>provided   | n/a                | n/a                  | Mixed<br>method<br>(ACA & PS) |

| Reference                 | Country<br>(State/Province<br>/Territory)  | Study<br>year(s) | Sample<br>size | Number<br>of cases<br>of FAS | Prevalence<br>of FAS (per<br>1,000) | Number<br>of cases<br>of FASD | Prevalence<br>of FASD<br>(per 1,000) | Diagnostic<br>guidelines/Case<br>definition   | Sex<br>(%<br>male) | Age range<br>(years) | Method                        |
|---------------------------|--|------------------|----------------|------------------------------|-------------------------------------|-------------------------------|--------------------------------------|---|--------------------|----------------------|-------------------------------|
| NBDPN, 1997               | Dakota, Oregon,<br>South Dakota,<br>and Wisconsin)<br>United States<br>(Arizona,<br>Arkansas,<br>Hawaii, Iowa,<br>Massachusetts,<br>Missouri,<br>Oklahoma) | 1985-<br>95      | 1,090,440      | 182                          | 0.17                                | n/a                           | n/a                                  | n/a   | n/a                | 0-1<br>(newborns)    | PS                            |
| NBDPN, 2000               | United States<br>(21 States)   | 1989-<br>95      | 10,683,535     | 2,455                        | 0.23                                | n/a                           | n/a                                  | n/a   | n/a                | 0-1<br>(newborns)    | PS                            |
| NBDPN, 2003               | United States<br>(24 States)   | 1996-<br>2000    | 7,711,455      | 1,150                        | 0.15                                | n/a                           | n/a                                  | n/a   | n/a                | 0-1<br>(newborns)    | PS                            |
| Ouellette et al.,<br>1977 | United States<br>(Boston)  | 1974             | 322            | 1                            | 3.11                                | n/a                           | n/a                                  | n/a   | n/a                | 0-1<br>(newborns)    | CB                            |
| Poitra et al.,<br>2003    | United States  | 1992-<br>2000    | 1,384          | 6                            | 4.34                                | 7                             | 5.06                                 | Criteria by Sokol &<br>Clarren (1989)   | n/a                | 5-6                  | ACA                           |
| Sokol et al.,<br>1980     | United States<br>(Ohio)  | 1973-<br>79      | 12,127         | 5                            | 0.41                                | n/a                           | n/a                                  | Criteria by Clarren &<br>Smith (1978)   | n/a                | 0 (live<br>births)   | PS                            |
| Sokol et al.,<br>1986     | United States<br>(Ohio)  | 1979-<br>81      | 8,331          | 25                           | 3.00                                | n/a                           | n/a                                  | Guidelines<br>established by the<br>Fetal Alcohol Study<br>Group of the RSA<br>(Rosett, 1980) | n/a                | 0 (live<br>birth)    | CB                            |
| Weiss et al.,<br>2004     | United States<br>(Wisconsin)   | 1998-<br>99      | 56,257         | 13                           | 0.23                                | n/a                           | n/a                                  | IOM criteria<br>(Stratton et al., 1996)   | n/a                | 21m-41m              | Mixed<br>method<br>(ACA & PS) |

ACA: Active case ascertainment; CB: Clinic-based; FAS: Fetal Alcohol Syndrome; FASD: Fetal Alcohol Spectrum Disorder; IOM:

Institute of Medicine; PS: Passive surveillance; RSA: Research Society on Alcoholism

**Table 5.** Pooled prevalence of FAS/FASD among the general population and Aboriginal population in Canada and the United States, based on the available literature, and the results of the heterogeneity and publication bias<sup>a</sup> tests

| Country   | Number of studies (References)  | Estimate<br>(per<br>1,000) | Lower<br>95% CI<br>(per 1,000) | Upper<br>95% CI<br>(per 1,000) | Heterogeneity tests |                |                     | Publication bias tests   |                        |                                 |
|---|---|----------------------------|--------------------------------|--------------------------------|---------------------|----------------|---------------------|--------------------------|------------------------|---------------------------------|
|   |   |                            |                                |                                | I <sup>2</sup> test | Q<br>statistic | df (Q<br>statistic) | p-value (Q<br>statistic) | p-value<br>(rank test) | p-value<br>(regression<br>test) |
| <b>Prevalence of FAS among the general population</b>     |   |                            |                                |                                |                     |                |                     |                          |                        |                                 |
| Canada  | 2 (Asante & Nelms-Matzke, 1985; Habbick et al., 1996)   | 1.1                        | 0.0                            | 3.5                            | 98.7%               | 78.7           | 1                   | <0.001                   | -                      | -                               |
| United States   | 9 (Burd et al., 1999; Clarren et al., 2001; Hingson et al., 1982; May et al., 2014, 2015; Moberg et al., 2014; Poitra et al., 2003; Sokol et al., 1986; Weiss et al., 2004) | 2.3                        | 0.8                            | 4.3                            | 97.9%               | 135.4          | 8                   | <0.001                   | 0.119                  | <0.001                          |
| <b>Prevalence of FASD among the general population</b>    |   |                            |                                |                                |                     |                |                     |                          |                        |                                 |
| Canada  | 1 (Asante & Nelms-Matzke, 1985)   | 5.3                        | 4.5                            | 6.1                            | -                   | -              | -                   | -                        | -                      | -                               |
| United States   | 6 (Barr & Streissguth, 2001; Clarren et al., 2001; Hingson et al., 1982; May et al., 2014, 2015; Poitra et al., 2003)   | 15.2                       | 7.5                            | 25.3                           | 93.4%               | 71.6           | 5                   | <0.001                   | 0.272                  | 0.240                           |
| <b>Prevalence of FAS among the Aboriginal population</b>  |   |                            |                                |                                |                     |                |                     |                          |                        |                                 |
| Canada  | 3 (Kowlessar, 1997; Robinson et al., 1987; Williams et al., 1999)   | 41.6                       | 0.0                            | 133.4                          | 94.2%               | 39.0           | 2                   | <0.001                   | 0.333                  | <0.001                          |
| United States   | 3 (Duimstra et al., 1993; May et al., 1983; Quaid et al., 1987)   | 3.8                        | 0.0                            | 8.0                            | 66.8%               | 5.8            | 2                   | 0.056                    | 0.333                  | 0.021                           |
| <b>Prevalence of FASD among the Aboriginal population</b> |   |                            |                                |                                |                     |                |                     |                          |                        |                                 |
| Canada  | 3 (Asante & Nelms-Matzke, 1985; Kowlessar, 1997; Robinson et al., 1987)   | 86.8                       | 0.0                            | 198.7                          | 95.2%               | 46.9           | 2                   | <0.001                   | 0.333                  | <0.001                          |

|   |   |      |     |       |       |        |    |        |       |        |
|---|---|------|-----|-------|-------|--------|----|--------|-------|--------|
| United States   | 2 (May et al., 1983; Quaid et al., 1993)  | 9.5  | 0.0 | 27.6  | 90.7% | 10.8   | 1  | 0.001  | -     | -      |
| <b>Sensitivity Analysis: Prevalence of FAS among the general population</b>     |   |      |     |       |       |        |    |        |       |        |
| Canada  | 2 (Asante & Nelms-Matzke, 1985; Habbick et al., 1996)   | 1.1  | 0.0 | 3.5   | 98.7% | 78.7   | 1  | <0.001 | -     | -      |
| United States   | 24 (Burd et al., 1999; CDC, 1995b, 1997b, 2002b; Clarren et al., 2001; Druschel & Fox, 2007; Egeland et al., 1998; Fox et al., 2015; Fox & Druschel, 2003; Hansen et al., 2014; Hingson et al., 1982; Little, 1977; Little et al., 1990; NBDPN, 1997, 2000, 2003; May et al., 2014, 2015; Moberg et al., 2014; Ouellette et al., 1977; Poitra et al., 2003; Sokol et al., 1980, 1986; Weiss et al., 2004) | 0.9  | 0.5 | 1.5   | 99.9% | 1191.1 | 23 | <0.001 | 0.902 | <0.001 |
| <b>Sensitivity Analysis: Prevalence of FASD among the general population</b>    |   |      |     |       |       |        |    |        |       |        |
| Canada  | 1 (Asante & Nelms-Matzke, 1985)   | 5.3  | 4.5 | 6.1   | -     | -      | -  | -      | -     | -      |
| United States   | 8 (Barr & Streissguth, 2001; CDC, 1997b; Clarren et al., 2001; Hingson et al., 1982; Little et al., 1990; May et al., 2014, 2015; Poitra et al., 2003)  | 9.8  | 3.2 | 19.5  | 98.4% | 579.6  | 7  | <0.001 | 0.109 | <0.001 |
| <b>Sensitivity Analysis: Prevalence of FAS among the Aboriginal population</b>  |   |      |     |       |       |        |    |        |       |        |
| Canada  | 3 (Kowlessar, 1997; Robinson et al., 1987; Williams et al., 1999)   | 41.6 | 0.0 | 133.4 | 94.2% | 39.0   | 2  | <0.001 | 0.333 | <0.001 |
| United States   | 8 (CDC, 1995c; Chávez et al., 1988; Duimstra et al., 1993; Egeland et al., 1998; Fox et al., 2015; May et al., 1983; NBDPN, 2003; Quaid et al., 1987)   | 2.4  | 1.4 | 3.7   | 94.7% | 203.2  | 7  | <0.001 | 0.905 | 0.016  |
| <b>Sensitivity Analysis: Prevalence of FASD among the Aboriginal population</b> |   |      |     |       |       |        |    |        |       |        |

|               |  |      |     |       |       |       |   |        |       |        |
|---------------|--|------|-----|-------|-------|-------|---|--------|-------|--------|
| Canada        | 4 (Asante & Nelms-Matzke, 1985;<br>Kowlessar, 1997; Robinson et al., 1987;<br>Werk et al., 2013) | 54.0 | 0.0 | 154.1 | 99.6% | 222.6 | 3 | <0.001 | 0.750 | <0.001 |
| United States | 2 (May et al., 1983; Quaid et al., 1993)   | 9.5  | 0.0 | 27.6  | 90.7% | 10.8  | 1 | 0.001  | -     | -      |

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CI: Confidence Interval; df: degrees of freedom; FAS: Fetal Alcohol Syndrome; FASD: Fetal Alcohol Spectrum Disorder

<sup>a</sup> For those countries with more than one available study.

**Table 6.** Study characteristics and prevalence of FAS and FASD among the Aboriginal population reported in the studies identified and included in the meta-analyses for Canada and the United States

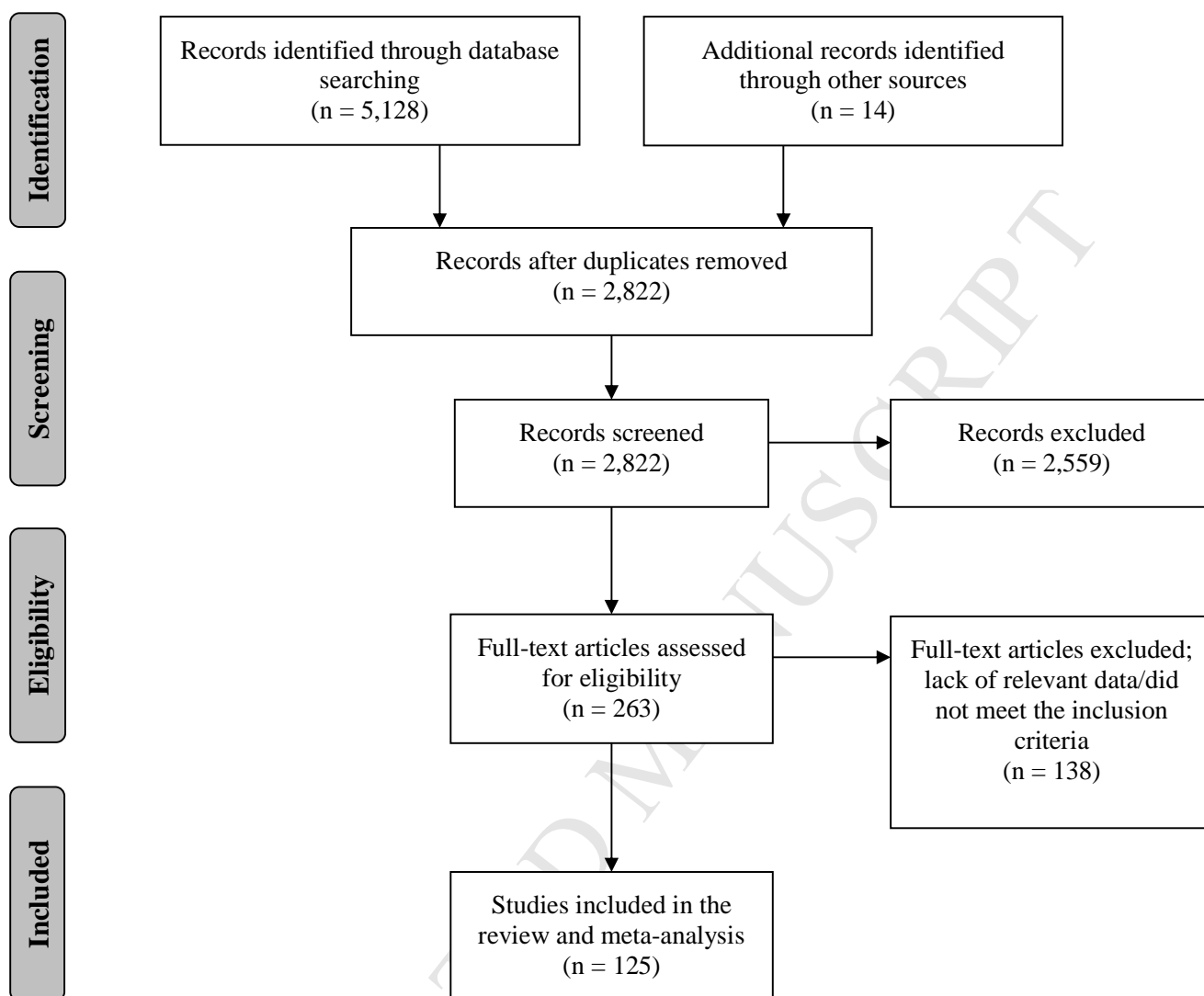
| Reference                   | Country (State/Province/Territory)                         | Study year(s) | Sample size | Number of cases of FAS | Prevalence of FAS (per 1,000) | Number of cases of FASD | Prevalence of FASD (per 1,000) | Diagnostic guidelines/Case definition   | Sex (% male) | Age range (years) | Method                   |
|-----------------------------|--|---------------|-------------|------------------------|-------------------------------|-------------------------|--------------------------------|---|--------------|-------------------|--------------------------|
| Asante & Nelms-Matzke, 1985 | Canada (Northwest British Columbia & Yukon)                | 1983-84       | 5,065       | n/a                    | n/a                           | 166                     | 32.77                          | Guidelines established by the Fetal Alcohol Study Group of the RSA (Rosett, 1980) | 63.0         | 0-16              | ACA                      |
| Kowlessar, 1997             | Canada (Manitoba)  | 1981-90       | 178         | 11                     | 61.80                         | 19                      | 101.12                         | IOM criteria (Stratton et al., 1996)  | n/a          | 5-15              | ACA                      |
| Robinson et al., 1987       | Canada (British Columbia)                                  | 1984-85       | 116         | 14                     | 120.69                        | 22                      | 189.66                         | Guidelines established by the Fetal Alcohol Study Group of the RSA (Rosett, 1980) | 49.6         | 3-18              | ACA                      |
| Werk et al., 2013           | Canada   | 2006          | 11,868      | n/a                    | n/a                           | 83                      | 7.00                           | n/a   | n/a          | 0-5               | PS (survey)              |
| Williams et al., 1999       | Canada (Manitoba)  | 1994-96       | 696         | 5                      | 7.18                          | n/a                     | n/a                            | IOM criteria (Stratton et al., 1996)  | n/a          | n/a               | Mixed methods (ACA & PS) |
| Chávez et al., 1988         | United States  | 1981-86       | 19,412      | 58                     | 2.99                          | n/a                     | n/a                            | n/a   | n/a          | 0-1 (newborns)    | PS                       |
| CDC, 1995c                  | United States (Iowa, Nebraska, North Dakota, South Dakota) | 1981-92       | 22,222      | 60                     | 2.70                          | n/a                     | n/a                            | Criteria by Sokol & Clarren (1989)  | n/a          | 0-31              | PS                       |
| Duimstra et al., 1993       | United States (Northern Plains)                            | 1987-90       | 1,022       | 4                      | 3.91                          | n/a                     | n/a                            | Guidelines established by the Fetal Alcohol Study                                 | n/a          | 5m-18m            | ACA                      |



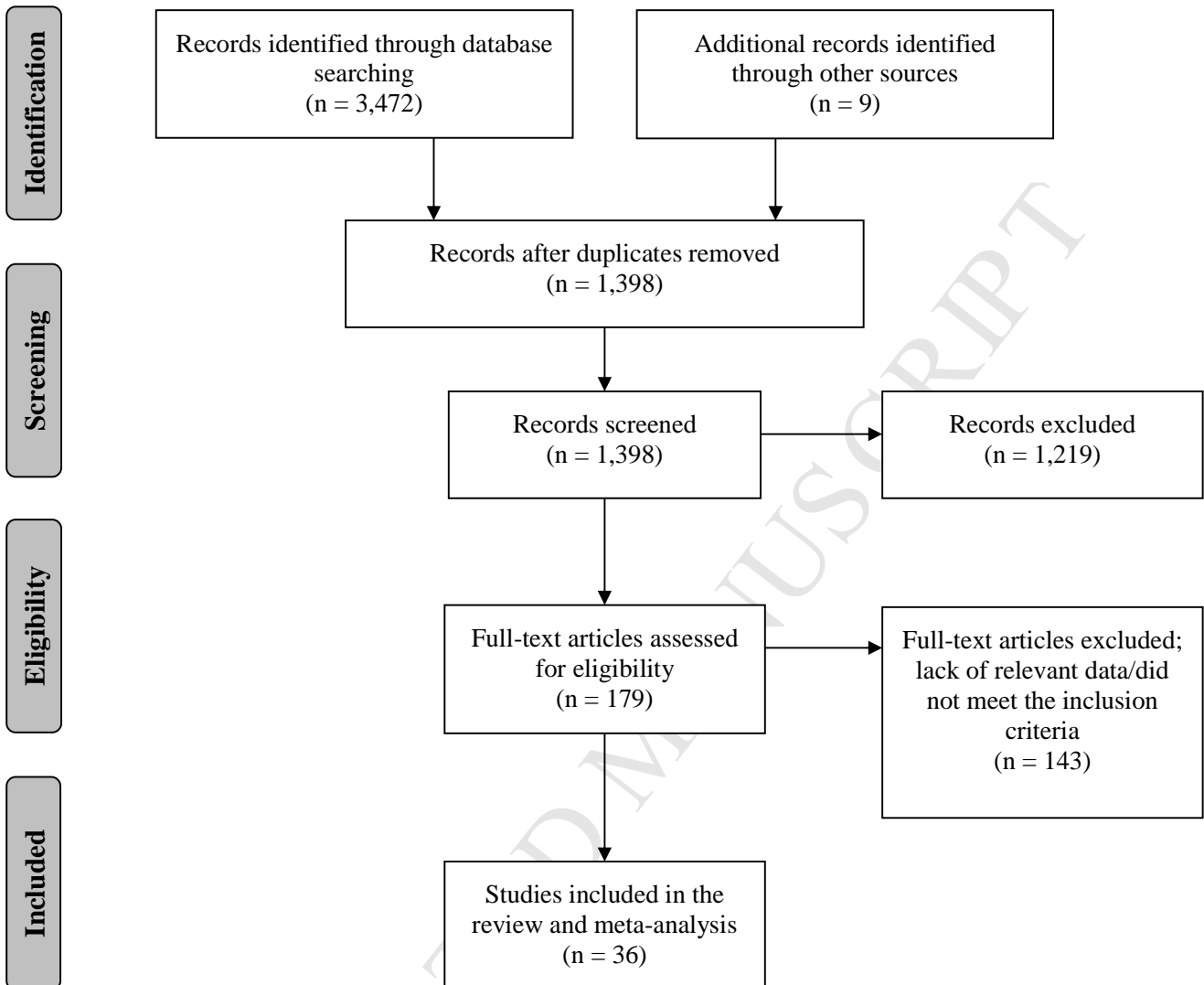
| Reference               | Country<br>(State/Province/<br>Territory)  | Study<br>year(s) | Sample<br>size | Number<br>of cases<br>of FAS | Prevalence<br>of FAS (per<br>1,000) | Number<br>of cases<br>of FASD | Prevalence<br>of FASD<br>(per 1,000) | Diagnostic<br>guidelines/Case<br>definition                            | Sex<br>(%<br>male) | Age range<br>(years) | Method |
|-------------------------|--|------------------|----------------|------------------------------|-------------------------------------|-------------------------------|--------------------------------------|--|--------------------|----------------------|--------|
| Egeland et al.,<br>1998 | United States<br>(Alaska)  | 1977-<br>92      | 37,346         | 114                          | 3.05                                | n/a                           | n/a                                  | Group of the RSA<br>(Rosett, 1980)<br>Case definition<br>provided      | n/a                | 0-16                 | PS     |
| Fox et al., 2015        | United States<br>(Arizona,<br>Colorado, New<br>York)   | 2010             | 13,938         | 28                           | 2.01                                | n/a                           | n/a                                  | Case definition<br>based on IOM<br>criteria (Stratton et<br>al., 1996) | n/a                | 7-9                  | PS     |
| May et al., 1983        | United States<br>(Southwestern<br>United States:<br>New Mexico,<br>Southern<br>Colorado,<br>Southern Utah,<br>Northern<br>Arizona) | 1980-<br>82      | 22,963         | 55                           | 2.40                                | 85                            | 3.70                                 | Case definition<br>provided  | 55.6               | 0-14                 | ACA    |
| NBDPN, 2003             | United States<br>(24 States)   | 1996-<br>2000    | 77,630         | 32                           | 0.41                                | n/a                           | n/a                                  | n/a  | n/a                | 0-1<br>(newborns)    | PS     |
| Quaid et al.,<br>1993   | United States<br>(Central<br>Oregon)   | 1991             | 429            | 4                            | 9.32                                | 8                             | 18.65                                | Criteria by Sokol &<br>Clarren (1989)                                  | n/a                | 0-3                  | ACA    |

ACA: Active case ascertainment; FAS: Fetal Alcohol Syndrome; FASD: Fetal Alcohol Spectrum Disorder; IOM: Institute of

Medicine; PS: Passive surveillance; RSA: Research Society on Alcoholism



**Figure 1.** Schematic diagram depicting the search strategy employed for the prevalence of alcohol use (any amount) and binge drinking during pregnancy among the general and Aboriginal populations in Canada and the United States



**Figure 2.** Schematic diagram depicting the search strategy employed for the prevalence of FAS and FASD among the general and Aboriginal populations in Canada and the United States