

## ABSTRACT

**Background:** Cesarean section (CS) rates in developed countries have been on the rise for the last two decades: in the United States, there was an 11.3% increase in CS deliveries between 1996 and 2007. This is a concern due to the possible short- and long-term health effects. **Objective:** The purpose of this structured literature review was to assess the association between CS births and childhood obesity when compared to vaginal delivery. **Methods:** A structured literature review of seven North American articles was conducted after selection via specific inclusion criteria. **Results:** Some studies found an association between cesarean section and childhood obesity whilst others showed the association was not statistically significant due to the influence of confounders. **Conclusion:** The results indicate that a majority of the studies found a positive association between CS birth and obesity. Further studies need to be conducted to further determine this relationship and to identify the underlying reasons behind this possible relationship.

## BACKGROUND

**Introduction:** There are now more than 1.3 million CS performed each year in the US alone<sup>1</sup>. This continuous rise in CS delivery rates is a great concern for future health implications, as this mode of delivery can invoke numerous health complications for both the mother and the newborn. It is suspected that higher risk of obesity in childhood may be associated with cesarean births as a result of exposure to certain microbiota, a key factor in future health outcomes<sup>2</sup>. Infants delivered via CS are mainly exposed to skin microbiota and to external environmental bacteria at birth, whereas vaginal deliveries expose the infant to the mother's vaginal and gastrointestinal microbiota<sup>2,3</sup>. Childhood obesity can be a precursor to developing additional life-debilitating diseases like cardiovascular diabetes and strokes which may progress to adulthood<sup>4</sup>. For this purpose, the body mass index (BMI) is used to define obesity versus overweight. The classification to be considered obese is  $\geq 30$ , while overweight is  $\geq 25$  to  $< 30$ <sup>5</sup>. Children are classified at 3 to 12 years. **Rationale:** Due to the difference in gut bacteria acquisition, there may be an effect on future childhood obesity. This allows policy makers and clinicians to revise their regulations and recommendations. **Purpose:** To determine any association between delivery via CS and development of childhood obesity.

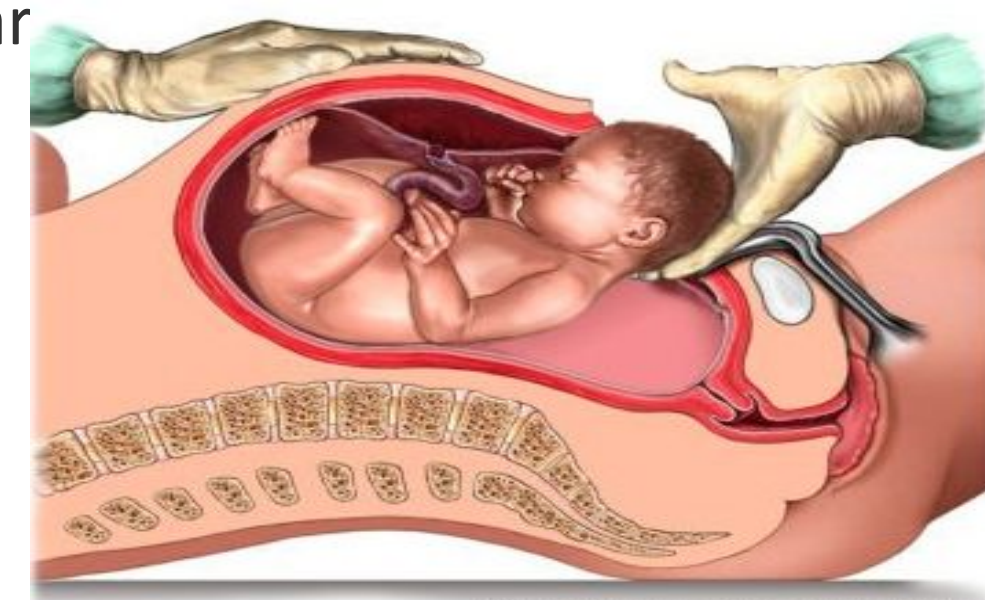


Figure 1: Depiction of CS delivery

## METHODOLOGY

- Application of search terms:** "(child\* or pediatric) AND (obes\* OR overweight) AND (C-section OR Cesarean Section OR Caesarean Section)" in uOttawa Online Library and PubMed
- Application of inclusion criteria:** peer-reviewed; published between 2002-2017; English language
- Application of exclusion criteria:** duplicates; non-human subjects; full text unavailable; publications outside North America
- Remaining articles:** studies relevant to research question

Keywords searched in the following databases: uOttawa Online Library and PubMed. For PubMed, the article types; clinical trials, meta-analysis, RCT, review articles and systematic reviews were included in search criteria. After the application of inclusion and exclusion criteria, the remaining articles were judged by their titles and abstracts for relevance to research question. The degree of agreement (Kappa) was 0.87.

Figure 2: Overview of our literature search where the selection methodology of articles is listed on the right and the number of articles is listed on the left.

## Research Question: Is there a statistically significant association between childhood obesity and delivery via cesarean section in North America ?

## RESULTS

Table 1: Summary of results obtained from the articles reviewed

Study	Study Design	Major Findings	Association
Constantine, (2014) <sup>6</sup>	Cohort study United States n = 1843	- Cesarean delivery is not associated with childhood obesity (OR 0.88; 95% CI 0.61 to 1.27) - Maternal BMI at entry to care was associated with childhood obesity	No*
Flemming et al., (2012) <sup>7</sup>	Retrospective Cohort Canada n = 2988	- CS associated with overweight children (OR 1.42; 95% CI 1.15 to 1.77) even after adjusting for maternal pre-pregnancy weight (OR 1.29; 95% CI 1.03 to 1.64). - CS associated with childhood obesity (OR 1.49; 95% CI 1.10 to 2.00) until adjusting for maternal pre-pregnancy weight (OR 1.19; 95% CI 0.85 to 1.67).	Inconclusive*
Huh et al., (2012) <sup>8</sup>	Prospective cohort United States n = 1255	- Children delivered by CS were more likely to be obese (15.7% vs. 7.5%) - OR 2.10; 95% CI 1.36 to 3.23	Yes*
Mueller et al., (2015) <sup>9</sup>	Prospective cohort United States n = 436	- CS was associated with 46% higher risk of obesity (RR 1.53; 95% CI 1.04 to 2.25)	Yes*
Rooney et al., (2010) <sup>10</sup>	Prospective cohort United States n = 359	- Children delivered via CS are more likely to be obese during childhood (RR 2.49; 95% CI 1.10 to 5.62). This relationship was still significant after adjusting for birth weight.	Yes
Wang et al., (2013) <sup>11</sup>	Cohort study United States n = 917	- Children delivered by CS had approximately twice the likelihood of being overweight (OR 1.86; 95% CI 1.27 to 2.73) or obese (OR 1.87; 95% CI 1.19 to 2.95) - The relationship between risk of childhood overweight status varied by child sex	Yes
Yaun et al., (2016) <sup>12</sup>	Prospective cohort United States n=4921	- Infants delivered by CS were 15% more likely to become obese (RR 1.15; CI, 1.06 to 1.26)	Yes*

**OR:** Odds ratio **RR:** Relative risk **CI:** Confidence interval

\*Adjusted for maternal pre-pregnancy weight

Table 2: Quality indicator of reviewed articles

Study	Constantine, M. (2014) <sup>6</sup>	Flemming et al. (2012) <sup>7</sup>	Huh et al. (2012) <sup>8</sup>	Mueller et al. (2015) <sup>9</sup>	Rooney et al. (2010) <sup>10</sup>	Wang, L. et al. (2013) <sup>11</sup>	Yaun et al. (2016) <sup>12</sup>
Confounders		✓	✓	✓			✓
Control	✓	✓	✓	✓	✓	✓	✓
n > 1000	✓	✓	✓				✓
Overall Quality	Adequate	Strong	Strong	Adequate	Poor	Poor	Strong

## DISCUSSION

### Key Findings:

- Out of 7 publications researched, 5 showed a statistically significant association between CS delivery and childhood obesity, 1 remained inconclusive, and 1 found no significant association.
- 5 publications adjusted for major confounders.
- A majority of the publications indicated a need for further research.
- 2 of the 3 studies with the largest sample size did not find a significant association, which may be more representative of the general population.

### Strengths:

- Primarily cohort studies were included in the structure literature review.
- All the studies were conducted North-America to decrease certain limitations.
- All studies have a control group (vaginal births).
- Majority studies had well-adjusted data for confounding variables (maternal pre-pregnancy BMI, antibiotic usage). Majority of the articles obtained large sample sizes.

### Limitations:

- There were several possible confounders in the research (SES, marital status, gestational age, offspring gender, breastfeeding, smoking, etc.).
- Misclassification bias: self-reported surveys.
- Selection bias: loss to follow-up.
- This association cannot be applied to different cultures or lifestyles.
- Confirmation bias, foreign language exclusion bias, ease of access bias

### Future Directions:

Future studies should aim at isolating and evaluating all potential confounders separately as well as determining possible underlying mechanisms. They should consider cultural practices that women may engage in during pregnancy. Larger emphasis should be placed on maternal diet and child diet.

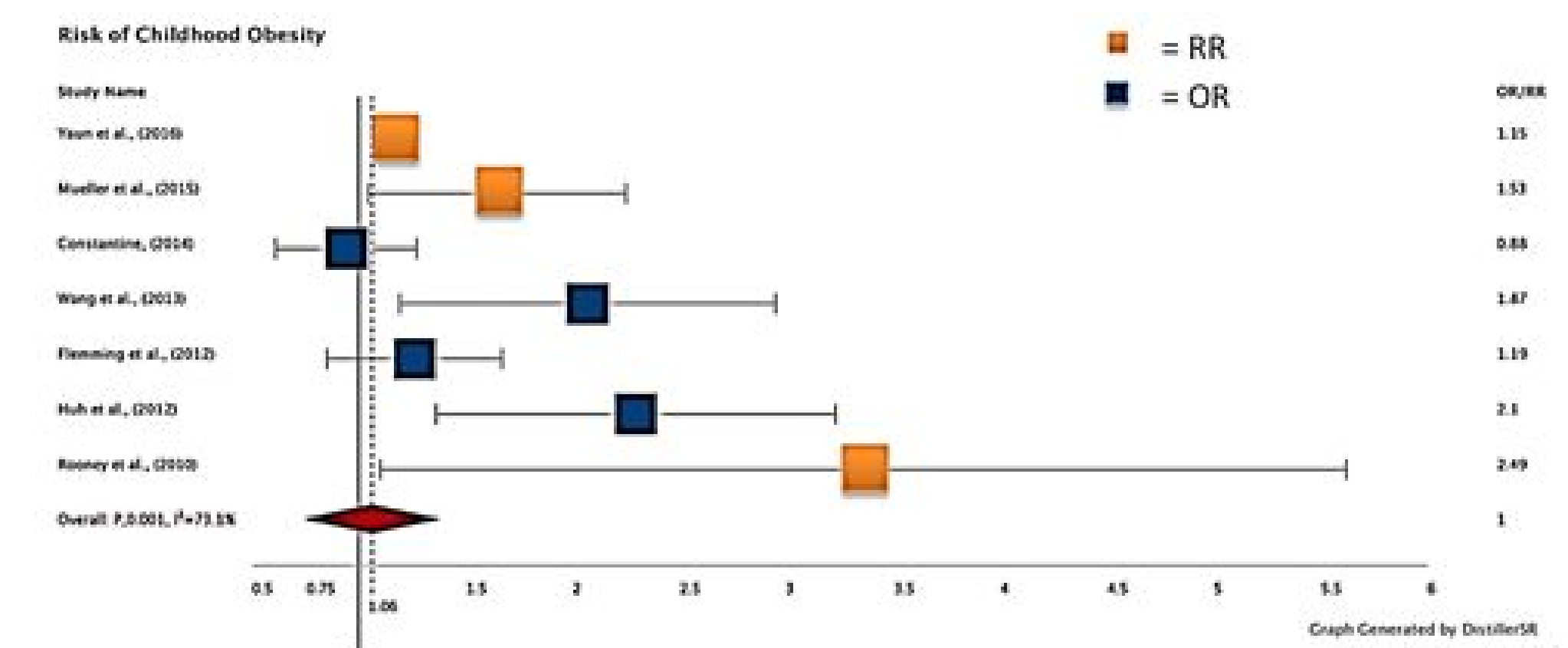


Figure 3: Forest plot analyzing OR/RR

## CONCLUSION

Although many studies found a statistically significant association between cesarean section delivery and subsequent childhood obesity, some of the results were no longer significant after adjusting for major confounders. While 5 studies claimed to have found a significant association, only 3 of these actually adjusted for major confounders, which seems to have an effect on the association. As a result, we conclude there is not strong enough evidence to determine this association.

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