The Internet and Childhood Immunizations in Canada

by

Jordan Tustin

A thesis submitted in conformity with the requirements for the degree of Doctor of Philosophy
Dalla Lana School of Public Health
Graduate Department of Public Health Sciences
University of Toronto

©Copyright by Jordan Tustin (2016)
ABSTRACT

THE INTERNET AND CHILDHOOD IMMUNIZATIONS IN CANADA

Jordan Tustin
Doctor of Philosophy, Epidemiology
Dalla Lana School of Public Health
Graduate Department of Public Health Sciences
University of Toronto
2016

The Internet has been identified as a potential determinant in parental fears of immunization and subsequent sub-optimal immunization coverage. Facebook is the most popular social media (SM) platform in Canada, and as more people abandon landlines, this platform presents an opportunity for novel recruiting of vaccine hesitant (VH) parents. In this thesis, I investigate Facebook as a tool to recruit VH Canadian parents and examine the determinants of vaccine hesitancy among Canadian parents, including the influence of the Internet. The aims are to describe the methods in studying health behaviours via SM; investigate Facebook as a tool to recruit VH parents compared to Random digit dialing (RDD) methods and describe their determinants of vaccine hesitancy; quantify the association between seeking vaccination information online and parental perception of risk on childhood immunization; and assess the vaccination sentiments and themes in an unsolicited online debate on immunization.

My systematic review revealed limited research using SM to study health behaviours and limitations in terms of representativeness and validity. Notwithstanding, SM was shown to be a useful tool in gathering data from targeted populations. I recruited Canadian parents by Facebook advertisements linked to an online survey on childhood immunization, and compared
methodological parameters, key demographics, and vaccine hesitancy indicators to a population-based RDD sample of Canadian parents. Facebook recruitment yielded a large sample size within a short time period and at lower costs compared to RDD recruitment, and was superior in reaching VH mothers with young children. Lack of knowledge/awareness and misperceptions on the risk of immunization were the most reported determinants of vaccine hesitancy.

Multivariate ordinal regression on both datasets revealed the odds of perceiving vaccines as less safe were significantly higher for parents who seek vaccination information online compared to parents who do not, after adjusting for income, Internet reliability, parental age and region. Analysis of online user-driven comments revealed the main themes in the anti-vaccination comments were inaccurate information and misperceptions on the risks of immunization. The majority of the pro-vaccination comments communicated the risks of not vaccinating, and judgments on the knowledge level of non-vaccinators.

The results provide evidence to inform the development of targeted interventions on immunization.
For two amazing moms, Lee and Erika Tustin
ACKNOWLEDGMENTS

This dissertation was possible due to several important individuals to whom I will be forever grateful for their contribution and support.

Dr. Natasha Crowcroft, you are the epitome of a PhD supervisor. You pushed me to think and create in developing this thesis and consistently supported me when I faced challenges (or even opportunities) that could impede its development. Thank you for your unwavering support and your expert guidance. And thank you Allison Crehore for your assistance and amazing organization skills.

Dr. Dionne Gesink and Dr. Ian Johnson, committee extraordinaire. Your expertise has been invaluable. Thank you for your commitment to my dissertation, but most importantly thank you for your honesty, thoroughness and encouragement.

Dr. Jennifer Keelan, former committee member extraordinaire- you were instrumental in the initial development of this dissertation, thank you.

Dr. Ken Allison, Dr. Nancy Kreiger, Dr. Jeff Kwong, Dr. Catherine Mah, and Dr. Gina Ogilvie: thank you for generously providing your time and expertise in reviewing this dissertation. Your input and revisions were significant and very much appreciated.

I would like to acknowledge the Public Health Agency of Canada for access to the secondary data, as well as the Canadian parents who provided the photographs of their children.

Thank you Barbara Lachapelle for contributing in the analysis as a second rater, but also for being my sounding board and cheerleader. And to so many other notable cheerleaders: Nicole Brown, Jocelyne Noël, Alicia Belvedere, Kimberly Pierson, Silvia Eliçagaray, Ben Lemieux, Trevor Lachapelle, Lisa Jensen, Tammy Stuart, Kate Zinszer, Michelyn Wood, Francois-William Tremblay, Susitha Wanigaratne, Sarah Edwards, Tim Sly, Bjorn Christensen, Mahmoud Remila, the Schrams, the Lensers, Ryerson faculty and staff, and so many more. Thank you all for supporting, encouraging, and tolerating me during this time.

To my idols, Lee and Steve Tustin – thank you for your constant encouragement and love. You have gone above and beyond to provide me with the tools to succeed in life and I am forever grateful for all of your efforts and sacrifice. To my sister, Erika Tustin, thank you for always being a true friend and confidante. To my awesome nephew and niece, Lear and Ever, you have been my most favourite distraction and your smiling faces always motivate me. And to my husband, Virgil Green, thank you for always supporting me and encouraging me to achieve my goals – this particular goal would not have been possible without your love, support, and patience. I know this process was not always easy, and I am truly lucky to have such amazing people by my side.

Lastly, I would like to thank all of the wonderful people in public health, here in Canada and globally, who have inspired or guided me in my academic and/or professional aspirations. Thank you to my former and present classmates, professors, colleagues, supervisors, and mentors. Je vous remercie sincèrement pour votre soutien et votre amitié.
TABLE OF CONTENTS

ABSTRACT II

ACKNOWLEDGMENTS V

LIST OF ABBREVIATIONS IX

LIST OF TABLES X

LIST OF FIGURES XI

CHAPTER 1 – BACKGROUND 1

1.0 Introduction 1

1.1 Thesis Purpose, Aims, and Justification of Research 2
  1.1.1 Aim 1: Methods used to study health behaviours via social media platforms 3
  1.1.2 Aim 2: Facebook vs. random digit dialing to recruit vaccine hesitant parents 5
  1.1.3 Aim 3: Seeking vaccination information online and Canadian parental perception of risk on childhood immunization 6
  1.1.4 Aim 4: Vaccination sentiments and themes in an unsolicited online debate on immunization 6

1.2 Literature Review 11
  1.2.1 Childhood Immunization in Canada 11
  1.2.2 The SAGE WG Matrix- Factors Affecting Vaccine Hesitancy 13
  1.2.3 The Influence of the Internet 22
  1.2.4 Theories 23
  1.2.5 Methods to Study Canadians’ Immunization Decisions 25

CHAPTER 2 – METHODS 27

2.0 Overall Research Design 27

2.1 Methods for Aim 1 28
  2.1.1 Search Strategy, Selection Criteria and Analysis of Review 28

2.2 Recruitment and Data Sources for Aims 2 and 3 29
  2.2.1 Online Survey Data 30
  2.2.2 Population-based Random Digit Dialing (RDD) Data 33

2.3 Data Source for Aim 4 34

2.4 Sample Size Considerations for Aim 3 34
### Table of Contents

2.4.1 Power Estimation for RDD data 34  
2.4.2 Sample Size Estimation for Online Data 35  

**2.5 Variable Definitions for Aim 2 and 3** 35  
2.5.1 Vaccine Hesitancy Indicators 36  
2.5.2 Internet Use as Source of Information on Vaccination (Exposure variable) 36  
2.5.3 The Parental Perception on the Safety of Childhood Vaccinations (Outcome variable) 37  
2.5.4 Demographic and Potential Confounding Variables 37  

**2.6 Statistical Analysis** 38  
2.6.1 Aim 2: Facebook vs. random digit dialing to recruit vaccine hesitant parents 39  
2.6.2 Aim 3: Seeking vaccination information online and Canadian parental perception of risk on childhood immunization 40  
2.6.3 Aim 4: Vaccination sentiments and themes in an unsolicited online debate on immunization 42  

**2.7 Ethical Considerations** 44  

2.8 Role of the Student 44  

**CHAPTER 3 – RESULTS** 46  

3.0 Overview of the results 46  

3.1 Aim 2 (Manuscript 1) 48  
Facebook recruitment of ‘vaccine hesitant’ Canadian parents 48  

3.2 Aim 3 (Manuscript 2) 76  
Internet exposure associated with parental perception of risk on childhood immunization 76  

3.3 Aim 4 (Manuscript 3) 97  
A content analysis of user-driven comments on a Facebook advertisement recruiting Canadian parents in a study on immunization 97  

**CHAPTER 4- DISCUSSION** 119  

4.0 Key Findings 119  

4.1 Potential Methodological Issues/Study Limitations 123  
4.1.1 Cross-sectional Study Design 123  
4.1.2 Selection Bias 124  
4.1.3 Information Bias 127  
4.1.4 Confounding 130  
4.1.5 Qualitative Analysis 130  
4.1.6 Health Behaviour Theory 132  

4.2 Strengths and Contributions of this Research 133
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>cNIS</td>
<td>childhood national immunization survey</td>
</tr>
<tr>
<td>CPC</td>
<td>cost per click</td>
</tr>
<tr>
<td>CPM</td>
<td>cost per impression</td>
</tr>
<tr>
<td>CTR</td>
<td>click-through-rate</td>
</tr>
<tr>
<td>HBM</td>
<td>Health Belief Model</td>
</tr>
<tr>
<td>HCWs</td>
<td>health care workers</td>
</tr>
<tr>
<td>IP</td>
<td>Internet Protocol</td>
</tr>
<tr>
<td>IQR</td>
<td>interquartile range</td>
</tr>
<tr>
<td>MMR</td>
<td>measles, mumps and rubella</td>
</tr>
<tr>
<td>PHAC</td>
<td>Public Health Agency of Canada</td>
</tr>
<tr>
<td>RDD</td>
<td>random digit dialing</td>
</tr>
<tr>
<td>SAGE WG</td>
<td>Strategic Advisory Group of Experts Working Group</td>
</tr>
<tr>
<td>SNS</td>
<td>social networking sites</td>
</tr>
<tr>
<td>TPB</td>
<td>Theory of Planned Behaviour</td>
</tr>
<tr>
<td>VPDs</td>
<td>vaccine preventable diseases</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
</tr>
</tbody>
</table>
LIST OF TABLES

CHAPTER 1
Table A. SAGE WG Determinants of vaccine hesitancy matrix 8
Table B. Thesis aims and associated research questions 10

CHAPTER 2
Table C. Sample size estimation based on estimated prevalence in the unexposed population 45

CHAPTER 3- Aim 2/Manuscript 1
Table 1. Facebook advertisement statistics 58
Table 2. Respondent demographic characteristics 59
Table 3. Respondent perception on safety of childhood vaccination, vaccination status of youngest child, and difficulty in making the decision to vaccinate youngest child 60
Table 4. Online survey respondent reasons for difficult or very difficult decision in deciding to vaccinate youngest child by youngest child vaccination status 62

CHAPTER 3- Aim 3/Manuscript 2
Table 1. Characteristics of both study samples 87
Table 2. Adjusted cumulative odds ratios of proportional odds logistic regression analysis for the association between parental Internet use to search for information on immunizations and parental perception on safety of childhood immunizations. 90
Table 3. Results of adjusted main effects for the ordinal logistic regression analysis on the multivariate model for the association between parental Internet use to search for information on vaccines and parental perception on safety of childhood immunizations. 91

CHAPTER 3 – Aim 4/Manuscript 3
Table 1. Claims made in negative/hesitant/ambiguous comments posted by Facebook users on Facebook advertisements, N=130 111
Table 2. Claims made in positive comments posted by Facebook users on Facebook advertisements (N=74)a 114
LIST OF FIGURES

CHAPTER 1
Figure A. Conceptual model (Aim 2) 9
Figure B. Overall research design 27
Figure C. Flow chart for search and selection of studies (Aim1/Systematic Review) 45

CHAPTER 3- Aim 2/Manuscript 1
Figure 1. Facebook advertisements in the English campaign 68
Figure 2. Facebook advertisement recruitment 69
Figure 3. Daily click rates compared to the cost per click for all campaigns from December 11, 2013 to January 11, 2014 70

CHAPTER 3 –Aim 3/Manuscript 2
Figure 1. Conceptual model on the association between using the Internet to search for information on vaccinations and parental perception on safety of vaccinations. 87
Figure 2. Perception of risk of childhood immunizations in parents who used the Internet to search for information on immunizations N= 1,086 Online Survey Data a; N= 1,713 RDD data) 89

CHAPTER 3 – Aim 4/Manuscript 3
Figure 1. Facebook advertisements posted to Canadian parents’ Newsfeeds from December 12, 2013 to January 11, 2014 110
CHAPTER 1 – BACKGROUND

1.0 Introduction

Immunization is widely considered one of the most important accomplishments in the global fight against morbidity and mortality from infectious disease (1). Globally, it is estimated that 2 to 3 million deaths per year are averted due to vaccines (1). In Canada, vaccines have significantly reduced or eliminated many vaccine preventable diseases (VPDs) that once harmed or killed members of our population. Measles was eliminated in 1998 and now occurs at a median rate of 0.87 cases per 1,000,000 population compared to an average annual incidence rate of 369.1 cases per 100,000 population from 1950-1954 (2,3). All infectious disease now represent less than 5% of Canadian mortality, compared to over 100 years ago when it was the leading cause of death (4). As such, the Canadian Public Health Association reported vaccinations as one of the top 12 public health achievements in Canada (4). Vaccines have been shown to be a cost-effective intervention in saving lives and improving quality of life (2). In addition, immunization has provided health care savings, increased life expectancy, and enhanced equity (5).

However, despite the effectiveness and availability of safe vaccines, VPDs such as measles are endemic in many parts of the developing world. Thus imported cases and subsequent transmission to unvaccinated or under-vaccinated individuals remain a viable threat to nations worldwide. High vaccination coverage rates are essential to successfully control or eliminate VPDs in a population. Sub-optimal immunization coverage rates threaten our protection from herd immunity and can lead to VPDs re-emerging in susceptible populations as evidenced by several recent VPD outbreaks in Canada and the United States (6-8).

The term ‘vaccine hesitancy’ describes individuals in a ‘period of indecision on accepting a vaccination’ (9). Many developed countries are currently experiencing issues with vaccine hesitancy (10), and research originating mostly from Europe and the Americas (9) has shown that the determinants of vaccine hesitancy can be complex, context- and population-driven, and vary over time (10-12). Immunization experts and WHO have expressed the need for country-
and population-specific research on understanding the magnitude and determinants of vaccine hesitancy in order to develop evidence-based public health interventions (9,11-14). Thus, strategies to increase childhood immunization rates in Canada need to be informed by evidence on the factors underlying vaccine hesitancy or non-acceptance. Furthermore, it is important to understand how the Internet or social media can influence parents’ decision-making processes prior to developing communication strategies on vaccination (13). The Internet has been identified as a potential determinant of parental fears regarding childhood vaccinations as it has become a vehicle for individuals to self-organize, create networks, seek health information and support, and share health knowledge and opinions (15,16). Moreover, there is a large presence of online anti-vaccination sentiment with the potential to be shared among parents and ultimately influence vaccination decisions (17-19). The ability to share and discuss health information online is possible due to the emergence and popularity of social media. Social media is a term used to describe the collection of Web 2.0 platforms. Web 2.0 platforms or more commonly referred to as social media platforms include wikis, blogs, Really Simple Syndication (RSS) feeds, microblogs, and video-sharing, photo-sharing, or social networking-sites (20). The social networking site Facebook is currently the most popular social media platform in Canada (21).

This thesis will examine the use of Facebook as a recruitment tool of vaccine hesitant parents, will quantify the influence of the Internet on parental perception on the safety of vaccines, and will identify determinants affecting vaccine hesitancy, refusal and acceptance, among Canadian parents. The overall goal of this thesis is to provide further data and information to public health professionals, clinicians, and researchers on the use and influence of the Internet on childhood immunization, with the ultimate goal of contributing to the effort in increasing the uptake of effective immunizations among Canadian children.

1.1 Thesis Purpose, Aims, and Justification of Research

The purpose of this research is to investigate the use of social media as a viable tool to recruit vaccine hesitant Canadian parents (18 years and older) and to examine the determinants of vaccine hesitancy among Canadian parents, including the influence of the Internet on parental perception of risk on childhood immunization. I will achieve this by addressing the four specific aims below.
1.1.1 Aim 1: Methods used to study health behaviours via social media platforms

Describe the methods used, as well as their strengths and limitations, in studying health behaviours via social media platforms

Public health research using social media platforms is in its infancy and no standard accepted methodology exists as the medium is unconventional and the characteristics of the many social media platforms vary. Therefore, I conducted a systematic review to inform the methods used in this thesis. I consolidated the methodologies from articles with a focus on the use of social media platforms in studying health behaviours or attitudes toward health behaviours. In this paper I review their work, focussing on the methods used and the reasons why the authors chose to study the health behaviours/attitudes of online populations via social media platforms. The objectives were to review: 1) the types of health behaviours or attitudes toward health behaviours; 2) the types of online populations (e.g. demographics) and social media platforms; 3) the methodologies in terms of online recruitment methods and sampling frames; and 4) the reasons why health behaviours or attitudes toward health behaviours have been studied via social media platforms in order to inform the methodology of the recruitment and primary data collection for this research. The systematic review was not included in the ‘Results’ section of this thesis as a more recent review was published prior to the completion of this research, thus precluding me from submitting my review for publication. The full systematic review can be found in Appendix 1. A summary of the results is presented here as they informed the subsequent aims of my thesis.

Out of over 1,500 potential relevant citations, I conducted a full-text review on sixty peer-reviewed studies. Upon full-text review, I excluded forty-three studies for not meeting the inclusion criteria, and included three more studies based on manual searches. I conducted a full review with the remaining twenty studies. The results showed that research in this area is limited with varied methodology. Researchers were able to study a wide variety of health behaviours or attitudes, from sexual health behaviours to dental pain, using a wide variety of social media platforms such as social networking sites, blogs and video-sharing sites. The majority of the studies were descriptive in nature, and three reviewed studies were either quasi-experimental or a randomized controlled intervention trial. Many benefits were reported by using social media platforms to study health behaviours or attitudes: the ability to easily access rich and real-time data with low cost, to target specific populations or large populations across
wide geographical range, to reach populations with stigmatized behaviours or conditions, and to eliminate recall bias and improve accuracy. Social media platforms also provided the potential to quickly identify important trends or identify at-risk populations for targeted interventions. The authors of the studies reported sampling bias and misclassification as important limitations in using social media platforms for recruitment. Although social media platforms allow us to reach high risk or isolated groups who may not be reachable via traditional methods or might not otherwise report their feelings, there are concerns with generalizability and representativeness. In addition, most studies used self-reported information or data thus data validation of the findings is an important issue, however this is an issue in most online and offline survey methods.

Notwithstanding the methodological limitations, the systematic review revealed the potential of recruitment and data collection via social media to meaningfully contribute to public health knowledge and practice in ways not possible via traditional methodologies. Most importantly, social media platforms provide a venue to gather rich, real-time self-reported data from high-risk or stigmatized populations and/or from individuals previously unreachable via traditional methods. The success of previous studies led me to pursue the use of social media as a tool to recruit and study Canadian parents for this research. Researchers have used social media to study a number of complex behaviours thus it is also suitable for vaccine hesitancy, and only two studies using this approach have examined immunization (22,23). Furthermore, the strengths and limitations reported by the twenty reviewed studies helped to guide the recruitment phase of this research as it informed my choice in social media platform for recruitment, helped me to understand the various limitations, and the need to implement measures to minimize the potential for bias. For example, for Aim 2 I chose the social media platform Facebook for recruitment partly due to its success in previous studies (24,25), and I implemented recruitment and control methods in an effort to prevent gaming and multiple responses. In addition, my methodology for Aim 4 was guided by the many studies that have used blogs and forums to assess individual rationale and arguments on health behaviour or health topics.
1.1.2 Aim 2: Facebook vs. random digit dialing to recruit vaccine hesitant parents

Investigate the social media platform Facebook as a tool to recruit vaccine hesitant parents compared to traditional telephone random digit dialing (RDD) and describe their main determinants of vaccine hesitancy.

In my thesis, I addressed this second aim by exploring the efficacy and effectiveness of Canada’s most popular social media platform, Facebook, as a tool to reach vaccine hesitant parents, and by comparing the differences in key parental demographics and vaccine hesitancy indicators between a Facebook survey of recruits and the most recent RDD survey of the Canadian population. In addition, I investigated the determinants of vaccine hesitancy of online respondents who had difficulty making the decision to vaccinate their youngest child.

No existing published study to my knowledge has investigated the potential of Facebook as an alternative or complement to RDD recruitment of vaccine hesitant Canadian parents, however, studies have been successful recruiting via Facebook to study other health behaviours and/or attitudes (26). Social media is increasing in popularity among generation X (individuals who are 35 to 50 years old) and millennial (individuals who are 18-34 years old) Canadian parents while the use of landlines is decreasing among these groups. In addition, experts have expressed a need to better understand the factors underlying vaccine hesitancy and to implement country-specific and population-specific and tailored evidence-informed strategies to address the determinants (9,12,13). Currently, there is very little Canadian research investigating the determinants of vaccine hesitancy (11,13). Factors associated with parental decisions to not vaccinate have been well studied but no study has focused specifically on the determinants of vaccine hesitancy among Canadian parents or applied the determinants of vaccine hesitancy matrix (Table A), developed by the WHO’s Strategic Advisory Group of Experts Working Group (SAGE WG), as described in the ‘Literature Review’ section of this thesis. The vaccine hesitancy determinants are dependent on context, population and time, thus as coverage rates remain sub-optimal and VPDs become more prevalent in Canadian children, there is a need to monitor and research the determinants affecting Canadian parents’ vaccination decisions. Furthermore, Facebook could prove to be a useful platform for delivering interventions on vaccination if it proves to be successful in recruiting vaccine hesitant parents.
1.1.3 Aim 3: Seeking vaccination information online and Canadian parental perception of risk on childhood immunization

Quantify the association between seeking vaccination information online and Canadian parental perception of risk on childhood immunization

In my thesis, I used the Health Belief Model (HBM) as a modified framework to explore whether information obtained online that clarifies one’s understanding of vaccination risks also affects perception of risk and thus the intent to vaccinate (Figure A). This issue was investigated by quantitatively assessing the association of reported online information seeking behaviours on perceived risk of childhood immunizations in the recruited online sample and the RDD sample of Canadian parents. I hypothesized that parents who report seeking vaccination information online will perceive vaccines as less safe compared to parents who do not seek information online.

It has been suggested that the Internet and social media are important influencers and ‘cues to action’ on parental beliefs and behaviours toward childhood immunization, thus it is important to investigate and understand this influence in order to inform public health interventions. Concerns have been emerging in the public health community that parental fears regarding childhood vaccines are growing largely due to rapid sharing of misinformation, and the increasing expression and empowerment of anti-vaccine communities and activists on social media. The Internet and social media have been reported as important influences on parental perception of risk on childhood immunizations, although to our knowledge no study has quantified the association between seeking vaccine information online and perception on safety of routine childhood immunizations among Canadian parents. Quantifying this association will increase our understanding of the impact of the Internet on parental perception of risk on childhood immunizations and help guide public health interventions in terms of the relative importance of the Internet.

1.1.4 Aim 4: Vaccination sentiments and themes in an unsolicited online debate on immunization

Describe the main vaccination sentiments and themes in an unsolicited online debate on immunization

In the recruitment phase of Aim 2, an unsolicited online debate on immunization occurred among the targeted participants. Thus, post-recruitment I developed this fourth aim to study
the themes and sentiments within the debate. In my thesis I addressed this fourth aim by conducting content analysis, informed by the SAGE WG’s determinants of vaccine hesitancy matrix (Table A), to qualitatively evaluate and quantify the content of an unsolicited online immunization debate of Facebook users in order to classify the type of arguments (e.g. positive/negative) and underlying themes. It is important to monitor and evaluate the content of online debates as it enables public health to identify misinformation or requests for information, and to better understand the current determinants among Canadian parents, in order to inform public health interventions (12,14).

The thesis aims and associated research questions are summarized in Table B.
### Table A. SAGE WG determinants of vaccine hesitancy (27) *

<table>
<thead>
<tr>
<th><strong>Contextual Influences</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Communication and media environment</td>
<td></td>
</tr>
<tr>
<td>B. Influential leaders, gatekeepers and anti- or pro- vaccination lobbies</td>
<td></td>
</tr>
<tr>
<td>C. Historical influences</td>
<td></td>
</tr>
<tr>
<td>D. Religion/culture/gender/socio-economic influences</td>
<td></td>
</tr>
<tr>
<td>E. Politics and or policies</td>
<td></td>
</tr>
<tr>
<td>F. Geographic barriers</td>
<td></td>
</tr>
<tr>
<td>G. Perception of the pharmaceutical industry</td>
<td></td>
</tr>
</tbody>
</table>

**Individual and Group Influences – Influences arising from Personal Perception of the Vaccine or Influences of the Social/Peer Environment**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Personal, family and/or community members’ experiences with vaccination, including pain</td>
<td></td>
</tr>
<tr>
<td>B. Beliefs, attitudes about health and prevention</td>
<td></td>
</tr>
<tr>
<td>C. Knowledge/awareness</td>
<td></td>
</tr>
<tr>
<td>D. Health system and providers- trust and personal experience</td>
<td></td>
</tr>
<tr>
<td>E. Risk/benefit (perceived, heuristic)</td>
<td></td>
</tr>
<tr>
<td>F. Immunization as a social norm vs. not needed/harmful</td>
<td></td>
</tr>
</tbody>
</table>

**Vaccine/Vaccination- Specific Issues Directly Related to Vaccine or Vaccination**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Risk/benefit (epidemiological and scientific evidence)</td>
<td></td>
</tr>
<tr>
<td>B. Introduction of a new vaccine or new formulation or a new recommendation for an existing vaccine</td>
<td></td>
</tr>
<tr>
<td>C. Mode of administration</td>
<td></td>
</tr>
<tr>
<td>D. Design of vaccination programme/Mode of delivery</td>
<td></td>
</tr>
<tr>
<td>E. Reliability and/or source of supply of vaccine and/or vaccination equipment</td>
<td></td>
</tr>
<tr>
<td>F. Vaccination schedule</td>
<td></td>
</tr>
<tr>
<td>G. Costs</td>
<td></td>
</tr>
<tr>
<td>H. Strength of the recommendation and/or knowledge base and/or attitude of healthcare professionals</td>
<td></td>
</tr>
</tbody>
</table>

* The term matrix is used by the SAGE WG as variables interact but is presented as a list
Contextual factors, strength of initial belief, access and logistics were hypothesized as important determinants in the final intent to vaccinate in the decisional stage yet were not tested as part of the association between seeking vaccination information online and parental perceived safety of childhood vaccines in the pre-decisional stage.
Table B. Thesis aims and associated research questions

<table>
<thead>
<tr>
<th>Aim #</th>
<th>Description of aim</th>
<th>Associated research questions</th>
</tr>
</thead>
</table>
| 1     | Describe the methods used, as well as their strengths and limitations, in studying health behaviours via social media platforms | 1.1. What are the methods used in studying health behaviours via social media platforms?  
1.2. What are the strengths and limitations of the methods? |
| 2     | Investigate the social media platform Facebook as a tool to recruit vaccine hesitant parents compared to traditional telephone random digit dialing (RDD) and describe their main determinants of vaccine hesitancy | 2.1. Is Facebook an effective platform to recruit and study vaccine hesitant Canadian parents?  
2.2. How does this method compare to telephone random digit dialing (RDD) methods?  
2.3. What are the main determinants of vaccine hesitancy in the online respondents? |
| 3     | Quantify the association between seeking vaccination information online and Canadian parental perception of risk on childhood immunization | 3.1. Is there an association between seeking information online and Canadian parental perception of risk on childhood immunizations?  
3.2. What is the strength and direction of the association? |
| 4     | Describe the main vaccination sentiments and themes in an unsolicited online debate on immunization | 4.1. What are the main vaccine sentiments (e.g. negative/positive/hesitant/ambiguous)?  
4.2. What are the main themes on vaccination by type of sentiment? |
1.2 Literature Review

1.2.1 Childhood Immunization in Canada

1.2.1.2 Vaccination coverage
Public funding and availability of vaccines are determined at the Provincial/Territorial level in Canada as health is a provincial/territorial responsibility. Although the schedules and funding vary, all provinces and territories provide the following routine childhood vaccines at no cost: diphtheria, tetanus, acellular pertussis, hepatitis B, *Haemophilus influenzae* type b, human papillomavirus, influenza, inactivated poliomyelitis, meningococcal conjugate (strain C), measles, mumps, rubella, varicella, and pneumococcal conjugate 13 valent (28). Canada does not have a national population-based immunization registry, and most P/Ts do not have registries either, thus coverage rates of routine childhood immunizations are estimated via the Childhood National Immunization Coverage Survey (cNICS). Vaccine schedules and coverage targets can vary across provinces; therefore, all coverage estimates are assessed using the vaccination schedule recommended by the National Advisory Committee on Immunization (29).

The cNICS has been conducted approximately every two years since 1994 with varied methodology. In 2002, sampling changed from a mailed-out questionnaire sent to targeted audiences to telephone questionnaires of self-selecting participants. In 2006, the methods changed from mail-outs to targeted self-selecting participants to randomly selected participants through telephone surveys conducted by random digit dialing of Canadian households (30). The 2009 survey also used RDD methodology but increased the sample size. According to the Public Health Agency of Canada, due to poor (yet unreported) response rates from RDD sampling, the 2011 survey aimed to increase representativeness with a larger sampling frame thought to represent 95% of Canadian households (30). Although it is reported to be more representative, the response rate yielded a smaller sample size than the 2009 survey, similar to the 2006 survey (30). For the most recent published results in 2011, the target respondents, parents or legal guardians of children who turned 2, 7, or 17 years within the previous 12 months, were contacted via telephone using RDD. In 2012, a sub-set of the 2011 surveys were validated against the child’s official immunization record at their doctor’s office and/or public health unit which resulted in an increase in some of the 2011 vaccine coverage estimates (30). Nonetheless, the results show that immunization coverage rates in Canadian children were
below the national immunization targets for several vaccines (30). It is not possible to compare the 2011 estimates to past trends in vaccine coverage due to the variations in methodology over the years.

The 2013 cNICS survey has been conducted, however the full report is yet to be released (31). The Government of Canada reported a larger investment in the 2013 cNICS survey resulting in the largest sample size (N=24,000) of any cNICS survey (31). Highlights of the survey were published online, and the preliminary results show that although the majority of children are immunized against VPDs, coverage remain sub-optimal (31). For example, the measles, mumps, rubella (MMR) vaccine had 89% coverage among two year olds in 2013, which falls far below the national target of 99% coverage (31). In Ontario, the most populated province in Canada, a 2012/2013 survey revealed that coverage among Ontario school pupils fall far below the coverage targets for most childhood immunizations (32). For example, measles coverage among 7 year olds was 89% (32). Furthermore, a recent report from UNICEF utilized early childhood immunization rates as ‘an indicator on the availability and effectiveness of a country’s basic health services’ (33). Coverage was defined as the percentage of 12- to 23-month-old children who had received at least one dose of measles vaccine and three doses of diphtheria, pertussis and tetanus/polio vaccines (33). Canada reported 84% coverage, ranking 28th out of 29 countries, and was one of only three countries with vaccine coverage below 90% (33). It is important to note that Canadian coverage figures are estimates because of the lack of registries, and need to be interpreted with caution. There are a number of potential limitations such as low representativeness, low response rates, and misclassification, leading to bias (30,31). In addition, we do not have an accurate understanding on the true vaccination coverage in Canada or how it compares globally, and it may be lower than what was reported due to limitations in the methodology. The suboptimal rates reveal the need to understand the determinants of vaccine hesitancy and refusal, and to subsequently implement interventions to improve immunization rates.

1.2.1.3 Vaccine Preventable Disease (VPD) outbreaks
Notwithstanding the limitations in the data, the reality of sub-optimal vaccination coverage in Canada became evident with several recent large measles outbreaks, including the largest measles outbreak in North America since 2002. Specifically, in 2011, over 750 children in the
province of Quebec were reported infected with measles (34), while one or two measles cases are typically reported per year. The majority of the 2011 reported measles cases were unvaccinated, too young to be vaccinated or with undocumented vaccination status (34). In 2013, there were nine measles outbreaks in Canada with more than half of the cases (42/71) linked to one outbreak in a non-immunizing community in the province of Alberta (7). In March 2014, PHAC released a public health notice warning Canadians of unusually high numbers of measles cases in five Canadian provinces (6,8). In 2015, another notice was released due to outbreaks in Ontario and Quebec, and a multi-state measles outbreak in the United States (35). The sub-optimal coverage and resulting outbreaks are an important concern that could lead to significant social and economic costs such as death and disability, time spent away from school or work, and burdens on the health care and public health systems. In 2011, sixteen measles outbreaks with 107 confirmed cases occurred in the United States (36). Ortega-Sanchez et al. (2014) estimated the total cost from these outbreaks in the range of $2.7 million to $5.3 million US dollars (36).

1.2.2 The SAGE WG Matrix- Factors Affecting Vaccine Hesitancy
A systematic review (2010) of factors underlying parental decisions on combination childhood vaccinations in developed countries revealed that vaccine-declining parents believe that vaccine preventable diseases are mild and rare, and that vaccines are unsafe and ineffective (37). In addition, lower vaccine uptake was associated with mistrust of government and health care professionals, but trust in media and non-official information sources (37). Parents also reported dissatisfaction with the content and timing of information (37). In the highlights published from the 2013 cNICS survey, 70% of the sampled Canadian parents reported concerns over potential side effects of vaccines, more than 30% believed the vaccine caused the disease in question, and approximately 5% believed in homeopathic methods as alternatives to vaccination (31).

In 2011, the Strategic Advisory Group of Experts Working Group (SAGE WG) on immunization (11), a group of acknowledged experts appointed by the Director General of the World Health Organization (WHO) to provide guidance on vaccines and immunization (38), realized that various countries were identifying issues of mistrust and non-acceptance of vaccines and it became evident that vaccine hesitancy was posing a global threat to the integrity and acceptance of vaccines and immunization programs (38). Thus, vaccine hesitancy became a
priority topic for the SAGE WG and led to research in understanding the determinants of vaccine hesitancy (38). Larson et al (2014) conducted a more recent systematic review of research focused on issues of vaccine hesitancy such as public attitudes, perceptions and beliefs on childhood immunization (11).

The review identified the determinants of vaccine hesitancy, and informed the development of a matrix for assessing determinants of vaccine hesitancy. At the time of the systematic review (2014) vaccine hesitancy was defined as:

‘A behaviour, influenced by a number of factors including issues of confidence [do not trust vaccine or provider], complacency [do not perceive a need for a vaccine, do not value the vaccine], and convenience [access]. Vaccine-hesitant individuals are a heterogeneous group who hold varying degrees of indecision about specific vaccines or vaccination in general. Vaccine-hesitant individuals may accept all vaccines but remain concerned about vaccines, some may refuse or delay some vaccines, but accept others; some individuals may refuse all vaccines.’(11).

After deliberations by the SAGE WG, the definition of vaccine hesitancy was further refined and a matrix of vaccine hesitancy was developed based on the determinants identified in the systematic review, experience (e.g. survey of immunization managers in 13 different countries, personal observations and experiences by different organizations and by the SAGE WG members) and from expert opinion (27). Vaccine hesitancy was then defined as:

‘Vaccine hesitancy refers to the delay in acceptance or refusal of vaccination despite availability of vaccination services. Vaccine hesitancy is complex and context specific, varying across time, place and vaccines. It is influenced by factors such as complacency, convenience and confidence’ (27).

In my thesis, this definition was operationalized by measuring the non-immunization or under-immunization of parents’ youngest child, parental perception of risk on vaccine safety, and difficulty in making a decision to vaccinate their youngest child. The SAGE WG vaccine hesitancy matrix (Table A) groups the determinants of vaccine hesitancy into three categories: contextual; individual and group; and vaccine/vaccination specific influences (11,27). The SAGE WG experts have extensively researched and documented the determinants affecting vaccine hesitancy (10, 11,38). In my thesis, this matrix was used as a framework to classify the determinants of vaccine hesitancy among the respondents. A summary description of each determinant as organized and defined by the SAGE WG, with examples, is presented below.
1.2.2.1 SAGE WG Matrix- Contextual Influences

The contextual factors identified by the SAGE WG highlight the importance of historical, political and socio-cultural influences in vaccination decisions (10). The SAGE WG organized the contextual factors into the following sections: communication and media environment; influential leaders, gatekeepers and anti- or pro-vaccination lobbies; historical influences; religion/culture/socio-economic; politics/policies; geographic barriers; and perception of the pharmaceutical industry. These sections are further described below.

Communication and media environment

Communications on immunization through the media and social media can negatively and positively affect parental vaccinations decisions (11). For example, an online experiment by Betsch et al. (2010) found that five to ten minutes of exposure to websites criticizing vaccines significantly increased the perception of risk of vaccinating and significantly decreased their perception on the negative consequences of not vaccinating and the participants’ intent to vaccinate (39). A study on Canadian mothers reported that exposure to news stories on rotavirus negatively impacted their intent to vaccinate (40). Within the HBM, media information is a potential ‘cue to action’ which can prompt action or inaction in terms of immunization decisions.

Influential leaders, gatekeepers and anti- or pro-vaccination lobbies

Community leaders, celebrities, and religious leaders are also examples of ‘cues to action’ as they can be significant influencers of vaccine acceptance or hesitancy (27). Influential celebrities such as Jenny McCarthy and Jim Carrey have become spokespersons for the anti-vaccination movement with mass social marketing campaigns. A 2009 national study of American parents on sources of perceived credibility for vaccination information found that almost 25% of the respondents indicated they trusted celebrities (41).

Historical influences

Past events can influence the public trust in vaccine acceptance (11,27). For example, polio eradication efforts have been impeded by several past events. In the early eradication efforts, distrust in the vaccine was tied to an incident in the early 1950s when thousands of Americans developed vaccine-induced polio after receiving a polio vaccine containing live polio virus (42).
The 1996 Trovan clinical trial in northern Nigeria, an alleged illegal clinical trial of an unregistered drug in Nigeria, was reported to have influenced the 2003 boycott of the polio vaccine in northern Nigeria (43). In addition, the United States Central Intelligence Agency (CIA)’s fake vaccination campaign using Pakistani polio workers to find and execute Osama Bin Laden could be influencing vaccine refusal in Pakistan (44).

Religion/culture/gender/socio-economic

Individual-level factors such as religion, gender, income and level of education are considered as modifying factors in the HBM as they can impact vaccination decisions. In some religions, vaccines are prohibited or discouraged. In Canada, religious beliefs recently led to an outbreak in a non-immunizing religious community in Northern Alberta (45). In a review of gender discrepancies conducted for the SAGE WG, it was reported that more boys may be vaccinated than girls in some cultures with known gender inequities and son preferences (46). In their systematic review on factors affecting vaccine hesitancy, Larson et al. (2014), found that level of income or socio-economic status was a significant factor in two studies conducted in the developed world (11): 1) Wei et al. (2009) found that vaccine refusers were more likely to come from well-educated and higher income areas (47); and 2) Wu et al. (2008) reported that mothers with low income were less likely to trust vaccination (48). Larson et al. (2014) also reported two studies in the developed world that identified education as an important determinant of vaccine hesitancy. The two studies report contradictory results as Stockwell et al. (2011) reported an association between maternal low education and having an under-immunized child (49) while Kim et al. (2007) reported that children from less educated mothers were more likely to be up-to-date in their immunizations (50). In a systematic review of factors specifically related to parental decisions on the MMR vaccine, Brown et al (2010) found that lower vaccine uptake was associated with lower parental income and lower parental education (37).

Politics/policies

Some countries, including Canada, have introduced public health legislation that requires children to be vaccinated before school entry. Public health mandates (e.g. school policies) and the simplicity or difficulty in obtaining exemptions to the mandates can positively influence vaccine acceptance (51,52) but can also lead to vaccine hesitancy due to forced vaccination. For example, policies on mandatory vaccination vary across Canada and it has been reported that
vaccination sceptics believe that parents should have the right to choose (53). In the United States, a reported increase in the rate of exemptions has raised concerns over an increasing trend of opposition to mandatory vaccinations (51). Australia is currently trying to limit the number of parents opting out of vaccination by denying child benefits to Australians who do not vaccinate their children. Furthermore, exemptions will be limited by restricting them to families registered to religious organizations with strict religious beliefs. In Canada, other important policies include public funding for routine childhood immunizations. Kwong et al. (2008) studied the impact of publicly funded varicella vaccines in Ontario and reported an association with increased declines in varicella-related health care use compared to privately available varicella vaccines (54).

**Geographic barriers**

The HBM identifies perceived barriers as important to behavioural change, where access and availability of health care could prevent parents from vaccinating their children regardless of their intentions (37,55). For example, travel time to vaccine delivery health care posts has been reported as an important barrier to vaccination and associated with low immunization coverage in hard to reach populations (56).

**Perception of the pharmaceutical industry**

Distrust in the motives of the pharmaceutical industry and/or the transparency of the government has been identified as a determinant of vaccine hesitancy (11,27). Wilson et al. (2008) conducted parent focus groups in Toronto, Canada, to study their views on paediatric vaccination and reported distrust in the financial motives of the pharmaceutical industry by all focus groups (57). A study on Canadian views during the H1N1 pandemic reported general mistrust of the government, including mistrust in the government’s claims on vaccine safety as important themes (58).

**1.2.2 SAGE WG Matrix – Individual and Group Influences**

The individual and group influences represent psychosocial factors affecting vaccine acceptance at the individual level (10). The SAGE WG organized the individual and group influences into the following sections: personal, family and or community members’ experience with vaccination, including pain; beliefs, attitudes and health and prevention; knowledge/awareness; health
system and providers-trust experience; risk/benefit (perceived, heuristic); and immunization as a social norm vs. not needed or harmful. These sections are further described below.

**Personal, family and/or community members’ experience with vaccination, including pain**
Knowledge of personal, family, friends or friends of friends, past negative or positive experiences with vaccinations may be a modifying factor or perceived barrier that can influence vaccine acceptance. For example, in a national survey of American parents their child’s pain from a previous vaccination was reported as an important concern and potential barrier (59). Not only personal experiences, but also narratives and stories of others’ negative vaccination experiences are believed to be a powerful tool of the anti-vaccine movement in eliciting fear among parents (60,61).

**Beliefs, attitudes about health and prevention**
The perceived benefit of vaccines in maintaining health or in preventing VPDs has been identified by the HBM as an important influencer on vaccine acceptance. For example, a study investigating the association between parental beliefs on vaccinations and vaccine acceptance found that parents who delayed and refused vaccines were significantly less likely to believe that vaccines are necessary in protecting children’s health or that their unimmunized child may get a VPD (62). Studies have also shown the influence of theories on immunity such as, a belief in natural immunity; in the need for children to get infected with VPDs to develop immunity; and in the power of behaviours or practices (e.g. breastfeeding, naturopathy) in preventing VPDs (11,37,63).

**Knowledge/awareness**
Decisions to vaccinate can be made due to one particular factor or a combination of factors influenced by an individual’s level and accuracy of knowledge and information on specifics such as the ‘where’, ‘who’, ‘when’, ‘what’, and ‘why’. Furthermore, parents may estimate they have sufficient or acceptable information to make a decision when it may not be accurate or complete (11,64). Knowledge/awareness is a complex modifying factor and the relationship between knowledge and acceptance of immunization may not be direct. Limited knowledge/awareness on vaccinations has been shown to be associated with vaccine acceptance due to parents simply complying with the recommendations, and some studies have
reported individual interest in an abundance of health information as a determinant of vaccine refusal (64). Inaccuracies on vaccination within the available health information is increasingly a concern as online anti-vaccination activists have propagated misperceptions on vaccinations via postmodern arguments in which everyone is an expert, and that reject scientific facts and shift hypotheses (19, 65).

*Health system and providers-trust experience*

The level of trust in western health care workers (HCWs), the health care system, and/or government can impact vaccination decisions. Past experiences with the health care system (e.g. quality of the services and interactions with HCWs can also influence vaccine acceptance) (37, 64, 66). Approaches in discussions between HCW and vaccine hesitant parents have been reported as an important determinant (64); for example, Busse et al. (2011) found that pressure from HCWs to vaccinate was significantly associated with unimmunized or under-immunized children among Ontario parents attending a naturopathic clinic (67).

*Risk/benefit (perceived, heuristic)*

The HBM assumes that individuals must perceive risk in order to take preventive action (68). Perceptions of risk of vaccination are based on the perceived susceptibility to disease and the perceived risk of adverse events (39, 69). In a study on risk perceptions of prescription drugs, including vaccines, Slovik (1992) found that vaccines are generally considered beneficial, however individuals associating negative meanings to vaccines would generally consider vaccines as having higher risks and lower benefits than individuals who associated positive meanings (70). Smith et al. (2011) found that parents were more likely to delay or not vaccinate their child if they believed vaccines are not necessary to prevent disease, that non-immunized children will not become infected with a disease, or that vaccines are not safe (62).

*Immunization as a social norm vs. not needed or harmful*

The importance of social norms and the opinion of people that parents respect on whether to vaccinate their children has been shown to be an important factor in the Theory of Planned Behaviour and in immunization studies in influencing vaccine hesitancy or acceptance (11, 71). For example, Dubé et al (2012) found that individual perception of significant others’ approval of vaccination was a significant factor in Canadian parents’ intention to vaccinate their child.
against rotavirus (72). Evidence on the influence of social pressure to vaccinate was reported in a review of psychological factors associated with individual uptake of the A (H1N1) influenza vaccine during the 2009 pandemic (73).

1.2.2.3 SAGE WG Matrix – Vaccine/Vaccination Specific Issues
Vaccine/vaccination specific issues are directly related to vaccines or vaccinations (10). The SAGE WG organized the vaccine/vaccination specific issues into the following sections: risk/benefit (epidemiological and scientific evidence); introduction of a new vaccine or new formulation or a new recommendation for an existing vaccine; mode of administration; design of vaccination program/mode of delivery; reliability and/or source of vaccine supply; vaccination schedule; costs; and role of healthcare workers (HCWs). These sections are further described below.

Risk/benefit (epidemiological and scientific evidence)
Scientific evidence of the risks and benefits of vaccination and the history of vaccine safety issues can impact vaccine hesitancy even when empirical evidence has clarified any safety issues (64). A well-known example is the 1998 publication of Dr. Andrew Wakefield’s now retracted study linking the measles, mumps, and rubella (MMR) vaccine to autism. This study created public distrust in the MMR vaccine and continues to feed the anti-vaccine movement (16,65). In 2010, the same year Lancet issued a full formal retraction of the Wakefield study, Seeman (2010) investigated the beliefs of the Canadian public on the safety of the MMR vaccine (74). He found that 65% of Canadian women and 72% of Canadian men believed the vaccine was not safe or they were not sure if the vaccine caused autism (74).

Introduction of a new vaccine or new formulation or a new recommendation for an existing vaccine
New vaccines or recommendations may influence vaccine hesitancy due to individual beliefs that the vaccine has not been tested or used long enough to know all the side-effects or effectiveness of the vaccine. A review on the factors influencing the uptake of the new A (H1N1) vaccine found that perceived concerns on the efficacy and safety of the novel vaccine impacted uptake (73). Ogilvie et al (2010) reported concerns on the safety of a new publicly funded human papillomavirus vaccine as an important reason for Canadian parents to not vaccinate.
their daughter (75). Gowda et al. (2012) reported parental frustrations and concerns due to new recommendations and changing immunization schedules (76).

**Mode of administration**
Different modes of vaccine administration (e.g. oral versus nasal versus needle injection) can influence vaccine acceptance and hesitancy. For example, a cross-sectional study of Canadian parents and children reported fear of needles as an important factor in immunization non-compliance (77).

**Design of vaccination program/Mode of delivery**
The design and delivery of the immunization program can impact vaccine acceptance. For example, a review of interventions to increase vaccination demand in developing countries found that home visits (vs. health clinic delivery) increased vaccine uptake (78). Bearden and Holt (2005) reported an increase in influenza vaccination coverage after state-wide availability of pharmacist-delivered vaccinations (79).

**Reliability and/or source of vaccine supply**
Confidence in the availability of the vaccine and in the source of the vaccine can influence vaccine acceptance (11). Brewer and Hallman (2006) examined the reasons for not vaccinating against influenza during the 2003-2004 influenza shortage in the United States (80). They found that approximately 25% of the respondents reported the shortage discouraged them from vaccinating. High-risk individuals were more likely to report being discouraged by the shortage (80).

**Vaccination schedule**
Parents may be hesitant to comply with the current vaccination schedules due to the number and timing of recommended vaccines (66). Belief in the safety of single vaccines, dangers of immune overload, and belief that children receive too many shots have been reported as parental concerns (37,66). Emigration or immigration out of province or country may add to confusion due to varying and disrupted schedules.
Costs
Routine childhood immunizations are publicly funded in Canada and easily accessible, however other countries have reported financial and time costs as barriers to vaccination (11,55).

Role of healthcare workers (HCWs)
The advice of HCWs can be a ‘cue to action’ as HCWs can influence an individual’s decision to vaccinate. Hesitation or concern on behalf of the HCW can cause vaccine hesitancy among parents (37,66). A review of nurses’ knowledge and attitudes on influenza vaccination found an association between nurses’ vaccination status and vaccine promotion to their patients (81). HCWs have been reported as the most trusted sources for vaccine information and are generally strong supporters of vaccination (41,64), however Dubé et al. (2013) reported that a study conducted on HCWs in Québec, Canada, revealed that a significant proportion of respondents reported concerns that children are receiving too many vaccines and that a healthy lifestyle is sufficient to prevent VPDs (64).

The determinants detailed above were identified and organized by the SAGE WG experts (Table A) and also have close linkages with theoretical frameworks, specifically the HBM. Therefore, the determinants will be used in this thesis as a framework to identify and classify determinants of vaccine hesitancy within our respondents.

1.2.3 The Influence of the Internet
The SAGE WG identified the Internet as an important contextual factor affecting vaccination decisions (11,27,64). The public health community has also raised concerns around the role of the internet, including hypothesizing that parental fears about childhood vaccines are growing largely due misinformation propagated by social media as it gains in popularity. This hypothesis will be tested in my thesis by looking at the association between searching for vaccination online and parental perception on risk of vaccination. Therefore, further information on the role of the Internet is presented below.

The Internet is an important vehicle for individuals seeking health information and support, and sharing health knowledge, opinions, and experiences (15,16). For example, in Canada, 80% of Canadians 16 years of age or older use the Internet (82); 64% of these Internet users search for
medical or health related information, with the majority of these Internet users between the ages of 16 to 44 years (83). A study investigating parents’ confidence in childhood vaccines in the United States found that both vaccine-decliners and vaccine-accepting parents have questions, concerns, or misperceptions about them (84). Most parents reported seeking information about vaccine safety prior to vaccinating their children. The Internet and less commonly the media (radio, TV, newspapers) were identified as important sources of information (84).

With the increasing popularity of social media, the public appears to be sidestepping conventional sources of health information and looking for the ‘wisdom of the crowd’, where health decisions can depend on other Internet users’ experiences (20). The Internet allows for rapid sharing of opinions and information, self-organization, the creation of social networks, and empowerment of online groups or people such as anti-vaccine communities or activists (16). The large presence of online anti-vaccination sentiment together with individual mistrust in conventional sources and the medical community has led to an environment of parents seeking and sharing immunization information online (19). Studies analyzing the content of anti-vaccination websites or platforms have identified themes such as vaccine safety and effectiveness, alternative medicine, civil liberties, conspiracy theories, morality and misinformation as the predominant arguments in the anti-vaccine movement (19,85). Techniques such as skewing science, shifting hypotheses and attacking critics have been reported as online tactics in arguing against vaccination (65).

1.2.4 Theories
Several social cognition models such as the Health Belief Model (HBM) and the Theory of Planned Behaviour (TPB), have been used to study health behaviours including immunization practices (86). In a systematic review on the use of health behaviour theories when using the Internet to promote behaviour change, Webb et al. (2010) found that online studies that extensively used theory tended to have larger effects on behaviour than studies that made less or no use of theory (87). The HBM model is the most widely used and tested model in the study of immunization while the other models have been used to a much lesser extent (86).
The HBM has been widely applied as an underlying theory in determining how individuals make decisions on vaccination (86). The theory suggests that individuals make health behaviour decisions based on perceived susceptibility to illness/disease, the perceived severity of the illness/disease, the perception of benefits versus costs and external cues to action (88). In terms of immunization, the decision to vaccinate is balanced by the perceived risk of contracting a VPD and the perceived risk of vaccine adverse events. The HBM model has proven to remain relevant in vaccination decisions as Smith et al. (2011) recently used methods based on the HBM model to demonstrate that parents who delayed or refused vaccines were more likely to have concerns on vaccine safety and to perceive fewer benefits associated with vaccines (62).

The theory of planned behaviour (TPB) has been suggested as a good model to identify determinants of health behaviour, but is used mostly in longitudinal studies where the intent to perform the behaviour is dependent on individual attitudes, perceived behavioural control, normative beliefs, and subjective norms (71). Using the TPB, Dubé et al. (2012) conducted a longitudinal study investigating the determinants of parents’ decision to vaccinate children against rotavirus (72). The study found that parental knowledge, attitudes, and beliefs significantly influenced acceptability of the vaccine, and also demonstrated that parents who reported receiving vaccination information from a health professional were less likely to report using the Internet (72). TPB has been utilized successfully in immunization research, however it was not chosen as the appropriate model for this study as the theoretical constructs do not fully capture the antecedents of behavioural intentions or the perceived susceptibility/severity as well as the HBM. Furthermore, the TPB is not specifically structured to address contextual influences such as the impact of the Internet on parental perception of risk.

Although the HBM has been criticized as being simplistic compared to other models such as the TPB (86), it was best suited in this thesis to use as a basis for testing the association between seeking vaccination information online (a ‘cue to action’) and parental perception of risk on childhood immunization (Aim 3). Due to the abundance and availability of anti-vaccination sentiment online and the relatively low prevalence of VPD in the population, it has been suggested that individuals may perceive a higher risk of suffering from vaccination side effects than from being infected with a VPD (89). Therefore, any information on vaccination obtained online during the pre-decisional stage that influences an individual’s perceived risk of
vaccination could affect the individual’s intentions in the decisional phase. In this thesis, I hypothesized that seeking vaccination information online would increase the perceived risk of childhood immunization, thus ultimately impacting vaccination decisions. The conceptual model (Figure A) is based on a modified HBM as I did not account for the perceived risks of contracting a VPD, and measured the impact of information online (a ‘cue to action’) on the perceived risks of vaccination in the pre-decisional stage while also accounting for important modifying socio-demographic factors.

1.2.5 Methods to Study Canadians’ Immunization Decisions
Immunization data are typically collected via telephone random digit dialing (RDD) of Canadian households. However, Statistics Canada reports that more Canadian households are abandoning their traditional landline telephones, falling from 66% of households in 2010 to 56% in 2013 (90). In the province of Quebec only 43% of households report using a landline (90). As more people abandon landlines, the validity of traditional population telephone surveys is compromised with low response rates and potentially non-representative samples (30,91). The limitations in RDD methodology are well known, however there is currently no new gold standard for data collection and alternative methods need to be investigated. In contrast to landline use, Internet use has been steadily increasing over the years and as of 2010, 80% of Canadians between the ages of 16 years and older use the Internet at home at least once per day (92). In 2012, this increased to 83% (82). Due to the increasing presence of Canadians online, recruiting Canadians via the Internet should be investigated as a complementary or alternate strategy to recruit study participants.

Public health research using social media platforms is still in its infancy and there is no standard accepted methodology as the medium is unconventional and the characteristics of the many social media platforms vary. Nonetheless, social media platforms present a novel opportunity as a recruitment tool in the study of Canadian parents’ immunization decisions as the majority (58%) of Internet users are using social media including over 86% of those under the age of 35 (92), i.e. those in their peak reproductive, childbearing, and small child rearing years. In my systematic review on the use of social media to study health behaviours (Appendix 1) many benefits were reported by authors who utilized this media to recruit participants and/or collect and analyze online data: the ability to easily access rich and real-time data with low cost; to
target specific populations or large populations across wide geographical range; to reach populations with stigmatized behaviours or conditions; and to eliminate recall bias and improve accuracy. Furthermore, social media platforms also provide the potential for public health practice to quickly identify important trends and/or at-risk populations for targeted interventions. Alshaikh et al. (2013) conducted a systematic review of articles using social media for health research and reported that despite the risk of sampling bias, social media platforms are a useful tool in health research (93). In terms of recruiting parents in Canada, Quach et al. (2013) found that using multiple online strategies including social media (Facebook and Twitter) to recruit Ontario parents for participation in focus groups on influenza immunization programs was a useful recruitment method as long as the potential risks (e.g. multiple submissions) are adequately managed (94).

In my thesis, I will explore the usefulness of a social media platform as a tool to recruit Canadian parents compared to RDD methods, in order to examine the determinants of vaccine hesitancy among Canadian parents, including the influence of the Internet on parental perceptions of risk on childhood immunization.
CHAPTER 2 – Methods

2.0 Overall Research Design
Figure B outlines the overall research design of my thesis. I initially conducted a systematic review to inform the methods of my primary data collection. I then recruited a convenience sample of Canadian parents via advertisements on the social media platform Facebook. From the recruited sample, I collected cross-sectional primary data on immunization beliefs and practices via an online survey. The Public Health Agency of Canada (PHAC) provided me with cross-sectional secondary data on Canadian parents’ immunization practices and beliefs previously collected via telephone random digit dialing (RDD). I then conducted quantitative analyses on closed and open-ended responses for both data sources.

Figure B. Overall research design
2.1 Methods for Aim 1

At the onset of this research, the use of social media in health research was in its infancy. Therefore, I conducted a systematic review to inform the methods of this PhD research by consolidating the methodologies from articles with a focus on the use of social media platforms in studying health behaviours or attitudes toward health behaviours. The systematic review was conducted to address Aim 1 and the associated questions:

**Aim 1: Describe the methods used, as well as their strengths and limitations in studying health behaviours via social media platforms**

1) What are the methods used in studying health behaviours via social media platforms?
2) What are the strengths and limitations of the methods?

The review focused on the methods used and the reasons why the authors chose to use social media platforms to study the specific health behaviours/attitudes of an online population(s). The objectives were to review: 1) the types of health behaviours or attitudes toward health behaviours; 2) the types of online populations (e.g. demographics) and social media platforms; 3) the methodologies in terms of online recruitment methods and sampling frames; and 4) the reasons why health behaviours or attitudes toward health behaviours have been studied via social media platforms; in order to inform the methodology of the recruitment and primary data collection for this research. (Appendix 1 full report and complete search strategy).

**2.1.1 Search Strategy, Selection Criteria and Analysis of Review**

I identified relevant literature through systematic searches of electronic databases covering health and social sciences literature. The databases included: Medline, Embase, PsycINFO, CINAHL, Scopus, Academic Search Premier, LISTA, Health Business Elite, Psychology and Behavioural Sciences Collection, Cochrane Database of Systematic Reviews, Health Technology Assessments, SocIndex with Full Text, and Child Development and Adolescent Studies. I also searched the Internet via Google Scholar. Keywords and MeSH terms represented the Internet and social media platforms, and health behaviours or attitudes. I harvested the terms from relevant papers, by discussion with my committee and in consultation with health librarians. The search was limited to peer-reviewed full research articles published in English between 2000

---

1 Following the completion of this review, a similar systematic review was published in the Journal of Medical Internet Research. Thus, it was decided to not submit the systematic review as a manuscript for publication.
and January 2012, however searches without limits on the year of publication would not change the results as Web 2.0 did not exist prior to the year 2000. Web 2.0 platforms are called social media and allow users to share and discuss health information online. I hand-searched the bibliographies of key articles, and conducted searches of articles for recurring authors. Grey literature and review articles were not included in the review. I evaluated the titles and abstracts of all identified articles. To be included in the final review studies had to meet the following criteria: (1) be conducted in an online population; (2) obtain data on the public’s health behaviours and/or attitudes toward a specific health behaviour(s) as part of the study objectives; and (3) collect data via a social media platform. Social media was defined as an interactive Web 2.0 platform with user-generated content (e.g. social networking sites, blogs, micro-blogs, and discussion forums). I reviewed full-text articles for inclusion if the title and abstract did not provide sufficient information to evaluate inclusion criteria (Figure C). For each study, I categorized the type of online population and health attitudes/behaviours studied, the methodology used and the reasons for collecting data over the Internet. Categories were derived from the studies, rather than a set of predefined themes. This review did not assess the quality of the studies.

2.2 Recruitment and Data Sources for Aims 2 and 3

I conducted the analyses in aims 2-3 using two datasets on parental immunization beliefs and practices collected from Canadian parents via two different cross-sectional recruitment methods.

One dataset was primary data that I collected via on-line survey from Canadian parents recruited through the social media platform Facebook. I collected these data as there was no previously collected dataset that could address the research questions associated with Aim 2:

1) Is Facebook an effective platform to recruit and study vaccine hesitant Canadian parents?
2) How does this method compare to telephone RDD?

The other dataset was secondary data that the Public Health Agency of Canada (PHAC) commissioned from a research company and was a population-based telephone survey that recruited Canadian parents through random digit dialing (RDD). I chose this dataset as it was
very comprehensive, was collected by a trusted source, and was the most recently collected data on Canadian parents’ immunization practices and beliefs.

The inclusion criteria for both data sources were: (1) over 18 years of age, (2) having at least one child under 18 years, (3) living in Canada, and (4) able to respond to questions in English &/or French.

Both data sources were analyzed to address the following aims and answer the associated questions:

**Aim 2: Investigate the social media platform Facebook as a tool to recruit vaccine hesitant parents compared to traditional RDD and describe their main determinants of vaccine hesitancy**

1) Is Facebook an effective platform to recruit and study vaccine hesitant Canadian parents?

2) How does this method compare to telephone RDD?

3) What are the main determinants of vaccine hesitancy in the online respondents?

**Aim 3: Quantify the association between seeking vaccination information online and Canadian parental perception of risk on childhood immunization**

1) Is there an association between seeking information online and Canadian parental perception of risk on childhood immunization?

2) What is the strength and direction of the association?

Both data sources are described in further detail in the following subsections.

**2.2.1 Online Survey Data**

I collected primary data via an online survey from self-selected respondents recruited via the social media platform, Facebook. I chose Facebook as the recruitment tool because 1) it is the most popular social media platform in Canada (21,95); 2) the majority of Canadian social media users are under the age of 35 (82), i.e. those in their peak reproductive, childbearing, and small
child rearing years; and 3) previous studies reported success in using Facebook as a recruitment platform (24,25).

**Recruitment**

I created six different advertisements (three in English and three in French) which were displayed on the Newsfeed of Canadian parents’ Facebook page whose profiles met the inclusion criteria: (1) Located in Canada, (2) 18 years or older, (3) Parent of a child aged 0 to 15 years, and (4) Displaying a profile in English or French. The advertisements did not target parents with children aged 16-19 years as they are self-consenting to immunization and their inclusion would significantly increase the target audience and dilute the advertisements. This would not exclude those parents who also had children under the age of sixteen. Facebook determines users’ location based on information on their timeline, verified by their Internet Protocol (IP) address and by examination of the user’s friends’ locations (96). A user’s age is determined by their year of birth, required by Facebook for all personal accounts (96). Parents are identified based on activity or information on their timeline and language via the language of their profile (96).

Three different images were used in the advertisements (Appendix 2). I chose the images and wording in the advertisements with guidance from communications consultants and two Facebook consultants. The parents of the children depicted in the images provided the photographs and their consent. The Facebook advertisement campaign was launched on December 12, 2013 at 14:00 and ended on January 11, 2014 at 14:00.

The optimal delivery mechanism of advertisements on Facebook is determined by many factors such as the target audience, the marketplace competition, the bid and the ad performance history (97). Facebook provided the option of being charged each time the advertisement is displayed or cost-per-thousand-impressions (CPM) or each time the advertisement link is clicked or cost-per-click (CPC) (97). With advice from the Facebook consultants, I chose to pay via CPM as Facebook ensures the advertisement is optimized to the people most likely to click on the advertisement (e.g. the most active and engaging users) and remains in the optimal bid range. In addition Facebook paces the ad based on the budget, goal and period of time specified (97).
began with a lifetime budget of $1500 over a period of one month, as this would grant access to a Facebook consultant during the campaign.

Based on sample size calculations for Aim 3 (see section 2.4.2) and the budget for survey incentives, the aim was to recruit a minimum of 800 Canadian parents to complete the online survey (Table C). At the time of our advertisement launch, there was a potential to reach 300,000 Canadian parents on Facebook (260,000 English users and 40,000 French users). Therefore the money was allocated based on this distribution with approximately 85% of the budget allocated to the English campaign. Fifty dollars gifted by Facebook was later added to the French campaign budget.

Survey content development and validation

Facebook users who clicked on the advertisement were linked to a secure online survey. The user could also be directed to the study’s Facebook page titled ‘Parents, tell us what you think about vaccines’ by clicking on the advertisement’s profile user as opposed to the link. Further information on the study and links to the online survey were provided on the official Facebook Page. I developed an online semi-structured survey in French and English (Appendix 3). Survey items included questions on demographics, methods of seeking information on immunization, parental perceived safety of immunization, vaccination status of youngest child, parental difficulty in deciding to vaccinate, agreement to specific statements on immunization, use of social media, and preferred methods to receive health information.

The questions on the main outcome, exposure, confounders and vaccine hesitancy indicators were identical to the RDD survey, yet some needed formatting for an online survey as opposed to a telephone survey. For example, a link to the vaccination schedule for each Province and Territory was provided in the online survey for the question on the vaccination status of the youngest child due to the inability to prompt via telephone, and open-ended questions in the RDD on reasons for not vaccinating or for difficulty in deciding to vaccinate were made close-ended questions in the online survey. I did not include all of the questions from the RDD survey as they were not pertinent to my research. I did include several questions not present in the RDD survey, specifically questions on social media use, and respondent preferences for how and from whom they would like to receive vaccination information. In addition, the online survey
had to contain all the ‘telephone script’ typically read by the telephone interviewer. I ensured the online informed consent and instructions were clear in French and English. I am fluent in French and English (oral and written), but I did not solely rely on my language skills and used a professional translator to review and revise the questions not taken directly from the French RDD survey as well as the preamble and informed consent in the French online survey.

The English and French surveys were piloted with a convenience sample of the author’s ‘Facebook friends’ and a snowball sample of their ‘Facebook friends’ who met the inclusion criteria (n=20; 10 English and 10 French). The pilot respondents completed the online questionnaire and provided written and verbal feedback. Revisions such as the sequence of questions, issues in survey flow (e.g. skip questions), and grammar or confusing wording, were made to the online survey based on the feedback from the pilot phase and from pre-test feedback received from vaccinology and epidemiology experts in Canada. The experts confirmed the survey represented the key themes on immunization.

Informed consent was requested on the first page of the survey and respondents had to click ‘yes’ to continue to the next page of the survey. The online survey would automatically terminate if the respondent did not provide informed consent or did not meet the eligibility criteria. The average time to complete the online survey was 17 minutes. For ethical purposes in promoting childhood vaccination, the respondents were immediately directed to the PHAC’s website on immunization in Canada once they exited the survey (via exclusion, incompletion or completion of the survey). Respondents who fully completed the survey were eligible to participate in a draw with an estimated 1 in 90 chance to win an iPad mini (value of $375).

2.2.2 Population-based Random Digit Dialing (RDD) Data
The population-based RDD data are secondary data de-identified and extracted from a survey collected by a research company, Ekos Research Associates, contracted by the Public Health Agency of Canada (PHAC). Experts in immunization and epidemiology at PHAC worked with the reputable research company in the development and testing of the questionnaire. During a period of three weeks in March 2011, the researchers randomly selected a sample of Canadian households with a landline via RDD and administered a telephone survey in French or English. The telephone survey consisted of questions on demographic data, Canadian parents’
knowledge, awareness, attitudes and behaviours related to immunization (98). The researchers attempted contact with each household in the sample eight times prior to retiring the phone number (98). Researchers of the RDD sample reported a participation rate of 23·4% (N=1,745). The research company provided a detailed report available online (98), however the researchers did not conduct a full epidemiological analysis or investigate specific research questions.

2.3 Data Source for Aim 4
In the primary data collection for Aim 2 and 3 (see section 2.2), I posted six different Facebook advertisements to the Newsfeeds of Canadian parents Facebook profiles. The ‘Comments’ section below the advertisements was accessible and self-selecting Facebook users posted comments on the two most popular advertisements (Appendix 2, Advertisement A and B) resulting in an unsolicited online debate on immunization. All comments in English or French containing information on immunization and/or the survey (N=117) were captured at the end of the online recruitment campaign on January 11, 2014.

2.4 Sample Size Considerations for Aim 3

2.4.1 Power Estimation for RDD data
The RDD data are secondary data with a fixed number of observations (N=1,745). Therefore, it was important to determine whether the available sample would have sufficient power to test the association that respondents who report using Internet sources for decision-making on childhood immunization will be more likely to report childhood immunization as ‘Not Safe or Moderately Safe’ compared to those who do not seek information via the Internet (Aim 3). Within the data, the prevalence of exposed respondents reporting childhood vaccines as not safe to moderately safe was 39.1% and the prevalence for unexposed respondents was 31.6%. The power was estimated to detect an odds ratio of 1.5 with 95% two-sided significance level. This yielded an estimated power of 90% to detect that the odds of respondents reporting childhood immunization as ‘Not Safe or Moderately Safe’ are 1.5 times higher in those who report using the internet for information on childhood vaccinations compared to those who do not seek information via the internet. The value of 1.5 was felt to be a meaningful increase from a public health standpoint and reasonable from an operational research standpoint.
2.4.2 Sample Size Estimation for Online Data
The primary data needed to have sufficient sample size to test the hypothesis that respondents who report using Internet sources for decision making on childhood immunization will be more likely to report childhood immunization as ‘Not Safe or Moderately Safe’ compared to those who do not seek information via the internet (Aim 3). As no previous research existed to inform the estimated prevalence of our outcome among self-selecting social media respondents, the sample size was estimated using a range of estimated prevalence in the unexposed population, including the RDD results. The sample sizes were estimated to detect an odds ratio of 1.5 (i.e. the odds of respondents reporting childhood immunization as ‘Not Safe or Moderately Safe’ are 1.5 times higher in those who report using the internet for information on childhood vaccinations compared to those who do not seek information via the internet) with 95% two-sided significance level and ratio of exposed to unexposed of 0.7 (based on the ratio within the RDD household survey data). The odds ratio of 1.5 was used for two reasons: 1) to ensure sufficient sample size should the exposure be mildly but statistically associated with the outcome (99); and 2) it is meaningful from a public health standpoint. Determining relevance for public health required judgement and was based on discussion with experience public health practitioners. With a relative risk of 1.5, this would provide an attributable risk of 33%. Thus, if we assume a causal association between x and y and no confounding or bias, the cessation of the exposure would decrease the risk in the exposed group by 33%. In context of most public health interventions, a reduction in an outcome by 33% would warrant public health action and potential implementation of intervention. This indicated a sample size ranging from 792 to 1901 respondents (Table C). Based on this calculation and the allotted budget for recruitment and incentives, I aimed to recruit a minimum of 800 Canadian parents to complete the online survey. If necessary, I had planned to expand the online recruitment (e.g. using free platforms such as Twitter to micro-blog the survey to ‘mommy groups’) should the Facebook recruitment not provide a suitable sample size. I did not try to recruit the same sample size as the RDD data as the objective of aim 3 was not to compare the two datasets statistically, but to have sufficient power to test the association in each dataset.

2.5 Variable Definitions for Aim 2 and 3
I measured the exposure, outcome, vaccine hesitancy indicators and confounding variables in the online survey in the same manner as the RDD survey to ensure comparability of the two
data sources. The differences lie in the formatting of the question to suit an online versus a telephone survey (see section 2.2.1.1). The measurement of the variables was therefore limited to the methods used to collect the RDD secondary data.

2.5.1 Vaccine Hesitancy Indicators
Vaccine hesitancy can be difficult to measure and at the time of this research, no standard definition or measurement tools existed (100). For this thesis, I defined “vaccine hesitancy” via three indicators based on previous research (11) and questions posed in the RDD survey: parental perception on the safety of childhood vaccinations, measured on a 7 point ordinal scale from ‘Not at all safe’ (1) to ‘Moderately safe’ (4) to ‘Extremely safe’ (7); Vaccination status of youngest child classified as ‘Completely up-to-date’ or ‘Partially or Not at all up-to-date’ (note the online survey respondents were provided with their province’s vaccination schedule to account for the lack of prompting compared to the RDD survey and to increase accuracy); and difficulty in making the decision to vaccinate (or not) their youngest child, measured as ‘Very easy’, ‘Easy’, ‘Difficult’ or ‘Very difficult’.

2.5.2 Internet Use as Source of Information on Vaccination (Exposure variable)
Respondents who sought out information on childhood vaccines and reported the Internet as one of their top three sources used for information on vaccines were classified as ‘used the Internet’ (RDD data: 41%; online data: 39%) and those who do not seek out information on childhood vaccines or do not report the Internet as one of their top three sources were classified as ‘did not use the Internet’. Those who reported to not seek information on vaccination (RDD data: 10%; online data: 33%) and those who reported to seek information but not from the Internet (RDD data: 26%; online data: 50%) were combined together as ‘did not use the Internet’ as the non-exposed group was classified as not using the Internet as a source for vaccination information. Therefore, I was interested in the influence of the Internet regardless if respondents were also seeking out other sources of information on vaccination or not actively seeking any information at all. This variable is the exposure variable for Aim 3 and was defined based on the variable’s measurement in the RDD survey.
2.5.3 The Parental Perception on the Safety of Childhood Vaccinations (Outcome variable)
Parental perception on the safety of childhood vaccinations is a vaccine hesitancy indicator for Aim 2 but also the outcome variable for Aim 3. The variable is measured on a 7 point ordinal scale from ‘Not at all safe’ (1), to ‘Moderately safe’ (4) to ‘Extremely safe’ (7). This outcome variable for Aim 3 was defined based on the variable’s measurement in the RDD survey.

2.5.4 Demographic and Potential Confounding Variables
Variables described in manuscript 1 and hypothesized as confounders for manuscript 2 include parental education level and income, parental age and sex, age of youngest child, number of children (i.e. parity), place of residence and the perceived reliability of the Internet relative to the importance of family, friends and/or a health care professional as sources of information.

- Parental education level has been associated with Internet use (89) and decisions on childhood immunizations (11,37,66). Parental education level was measured using 6 categories: No high school, high school diploma, trade or vocational school, some university, professional certification, and bachelors/graduate degree. To ensure sufficient sample size in each category and to follow Statistics Canada definition of education as per the Census survey, the variable was grouped into four levels: High school or less, trade or vocational school, some university, and bachelors/graduate degree/professional certification. Household income or socioeconomic status has been associated with parental Internet use (89) and childhood immunization decisions (11,37,66). Household income level was measured in $10,000 increments ranging from under $30,000 to over $120,000 and categorized into four levels (under $30,000, $30,000 – $59,999, $60,000 - $99,000, and over $100,000) in order for sufficient sample size in each category and to make comparisons among intermediary groups from lowest to highest income.

- Parental age has been associated with Internet use (89) and parental childhood immunization decisions (55), and was measured as a continuous variable (years) in the online survey and as a categorical variable in the RDD survey (under 30 years, 30-34 years, 35-39 years, 40-44 years and 45 years and older). Parental age was left as continuous in the online sample as the data were complete and grouping the variable would result in a loss of information, however the RDD sample had a significant amount
of missing data in the continuous measurement of this variable, thus the categorical measurement was utilized.

- Parental sex is a hypothesized confounder and was measured as male, female or unknown.

- Age of youngest child and parity (e.g. the number of children) has been associated with parental vaccination decisions (40,55), and was measured as continuous (years), and the number of children was measured as categorical (1, 2, 3, 4, 5, and 6 or more) in the online survey and as continuous in the RDD survey. The online data was categorical due to including ‘6 or more children’ as a potential response whereas the RDD data provided integers.

- The perceived reliability of the Internet relative to family, friends, or health care professionals is a hypothesized confounder based on evidence on the relative importance of trust in different sources in parental vaccination decisions (41), and was classified based on the measurement in the RDD data and was defined as (1) ‘reported as most reliable and trustworthy source on vaccines’, (2) ‘reported as second most reliable and trustworthy source on vaccines’, (3) ‘reported as third most reliable and trustworthy source on vaccines’, and (4) ‘not reported in respondent’s top three choices as a reliable source of information on vaccines’.

- Place of residence is a hypothesized confounder due to the influence of media and health system delivery on parental vaccination decisions (11,37,40) and potential regional variations in Internet use (92). Place of residence was categorized into 6 regions to reflect the regions reported in the RDD data: British Columbia, Alberta, Saskatchewan or Manitoba, Ontario, Québec, and Atlantic or Territories. The Atlantic and Territories regions were combined into one category due to very low numbers.

2.6 Statistical Analysis

All quantitative analyses were conducted with Microsoft ® Office Excel ® 2007 and SAS software, Version 9.3 (SAS Institute Inc., Cary, NC, USA). All qualitative analyses were conducted with QSR International’s NVivo 10 qualitative data analysis software.
2.6.1 Aim 2: Facebook vs. random digit dialing to recruit vaccine hesitant parents

Aim 2 explores the effectiveness of Canada’s most popular social media platform, Facebook, as a tool to reach vaccine hesitant parents, and the differences in key parental demographics and vaccine hesitancy indicators between the online sample and the RDD sample of Canadian parents. I reported the response rate, methodological parameters on the number of impressions (i.e. views of Facebook advertisements), the number of clicks on the Facebook advertisements, demographics of users who clicked on advertisements, timelines of data collection, and the costs for the Facebook campaign. As research using social media platforms for recruitment is limited, no standardized response rate calculation was available. Response rate was based on the definitions and recommendations provided by the American Association for Public Opinion Research (AAPOR) (101). In non-probability self-selecting samples, the Association recommends to simply calculate the participation rate (# completed surveys/# of invitations) (101). Thus, the response rate calculation was the number of completed surveys divided by the total number surveys (complete, partial and terminated) plus the remaining unique clicks of unknown eligibility. This response rate calculation (#completed surveys/# unique clicks) has been used in several other studies using Facebook as a recruitment tool (93).

I conducted univariate analyses for both data sources (online and the RDD sample) on individual level variables for respondent characteristics and the three vaccine hesitancy indicators: perception on safety of childhood vaccinations, vaccination status of youngest child, and difficulty in making the decision to vaccinate (or not) their youngest child. Respondents who reported difficulty in making the decision to vaccinate (or not) their youngest child were asked to describe the reasons in an open-ended question. A primary and secondary rater independently coded qualitative data from the open-ended responses according to a preconceived framework on the determinants of vaccine hesitancy: the WHO’s SAGE WG on Immunization’s matrix of determinants of vaccine hesitancy (11,102). As discussed in Chapter 1, the SAGE WG matrix organizes vaccine sentiment around three domains: contextual influences such as socio-economic barriers, mistrust in the pharmaceutical industry or religious values; individual/social group influences such as personal knowledge or perceptions of risk; and vaccination and vaccination specific issues such as the vaccination schedule or characteristics of the vaccine (11,102). I chose the SAGE WG matrix as experts developed the coding framework, it is current, and it includes all potential determinants of vaccine hesitancy based on a thorough
review of the relevant literature, experiences from the field and expert opinion (11,27,100). Two raters independently coded all responses with a high level of agreement (percent agreement >90%). We resolved any discrepancies via consensus and reached 100% agreement. The coding scheme for the quantitative analysis of the open-ended questions is available in Appendix 4.

2.6.2 Aim 3: Seeking vaccination information online and Canadian parental perception of risk on childhood immunization

Aim 3 investigates the impact of reported online information seeking behaviours on perceived immunization risk in the online sample and the RDD sample of Canadian parents. As detailed in section 2.4, the predictor variable is seeking information online on childhood immunization and is defined as ‘used the Internet’ if the respondent sought out information on childhood immunization and reported the Internet as one of their top three sources used for information. Those who do not seek out information on childhood vaccines or do not report the Internet as one of their top three sources were classified as ‘did not use the Internet’. The outcome variable was defined as respondent perception on vaccine safety and measured as a 7-point ordinal scale variable from (1) ‘Not at all safe’, to (4)’Moderately safe’, and (7) ‘ Extremely safe’. I defined the predictor and the outcome variables as measured in the RDD survey in order to compare both data sources. Hypothesized confounders (defined in section 2.5) included parental education level and income, parental age and sex, age of youngest child, number of children (e.g. parity), place or residence and the reliability of the Internet relative to the importance of family, friends and/or a health care professional as sources of information (conceptual model presented in Chapter 1, Figure B).

Analytic Strategy

The outcome variable was measured on a 7-point ordinal scale, thus I used ordinal logistic regression to test the association between using the Internet to seek out information on childhood immunization and parental perception of risk on vaccines for both the online survey data and the RDD data. I also chose ordinal regression because it is more efficient than a logistic binary model or a polytomous model as long as the proportional odds assumption is not violated, which it was not (103). The proportional odds model (a.k.a. Cumulative logit regression, ordinal logistic regression, cumulative odds regression, ordered logistic regression or constrained cumulative logit model) models the cumulative logit across the categories of an
ordinal outcome. With proportional odds ratio we can assess the relationship between use of Internet for vaccination information and all possible cut-points of parental perception on vaccine safety (e.g. not at all safe (1) to extremely safe (7)) and estimate one logit representing an average of the logits of the different cut-off points rather than six different estimates for each cut-off point. The proportional odds regression assumes that all coefficients for the independent variable would be the same regardless of the cut-off point of the ordinal outcome (104).

First, I conducted univariate ordinal logistic regression to assess associations between each variable and the outcome, respondent perception of vaccine safety. For categorical variables, I chose the category with the largest sample size as the reference category in order to decrease standard errors and increase precision of the estimates (99). I then conducted multivariate ordinal logistic regression modeling to assess the association between Internet use and respondent perception of vaccine safety. The regression modeled the cumulative odds of perceiving vaccines as ‘Not Safe’. I utilized the purposeful selection algorithm, as proposed by Hosmer and Lemeshow (105), to select covariates to retain in the final predictive models. The method uses purposeful variable entry and retention parameters that retain significant covariates but also important confounding variables (105,106). As suggested by Bursac et al. (2008) in their description of purposeful selection, I included all variables significant at P≤0.25 in the multivariate analyses as more traditional levels such as 0.05 can miss important confounding variables (107). I tested interaction terms of all possible two-way interaction terms against a reduced model using the likelihood ratio test (LRT), and in the first analysis I considered all interaction terms for removal from the model as a block and contrasted against the model with all of the main effects but without interaction terms (108). I removed covariates from the multivariate model if they were not statistically significant at the 0.1 alpha level and not a confounder. I measured confounding as a 15% or greater change in the parameter estimate of our main association in the reduced model compared to the full model (105). I utilized purposeful entry and retention parameters, including the choice of the 15% change-in-parameter-estimate criterion, due to the lack of prior information on known confounders for the investigated association (109). At the end of this iterative process, I added any variable not entered into the original full model back in one at a time, to further assess confounding (105).
This step can help to identify confounders that may not have been significant independently, yet make an important contribution in the presence of other variables (106).

I performed model diagnostics to rule out multi-collinearity among covariates, to test for departure from linearity, and to examine the effect of influential observations and variables on our final models. The score test for the proportional odds assumption can be over conservative with large sample sizes or in multivariate analyses, thus I tested the proportional odds assumption by comparing the cumulative odds ratios (ORs) in a series of six binary logistic models (110). The assumption held as the ORs were all in the same direction and of approximately similar magnitude (110).

I further validated the two models (online survey data model and RDD data model) by conducting binary logistic regression with a dichotomized outcome variable: not safe to moderately safe (levels 1-4) and safe to extremely safe (levels 5-7). I utilized these cut-offs as levels 1 to 4 could be indicative of vaccine hesitancy and concerns with vaccination whereas levels 5 to 7 indicated confidence in vaccines. I assessed model fit with Pearson and Deviance goodness-of-fit statistics (and the Hosmer-Lemeshow test for the binary models) (99). Although multivariate analyses using non-weighted data produced similar results, I utilized Complex Sampling procedures available in SAS version 9.3 for descriptive and multivariate analyses of the RDD data to reflect the complex survey design and population weights. I conducted the data analysis for this paper using SAS Version 9.3 (SAS Institute Inc., Cary, NC, USA).

2.6.3 Aim 4: Vaccination sentiments and themes in an unsolicited online debate on immunization
In Aim 4, I qualitatively evaluate and quantify the content of an online immunization debate of Facebook users who commented on our posted advertisements, in order to better understand the arguments and to determine the underlying themes of vaccine hesitancy. On January 11, 2014, I captured all user comments posted in the ‘Comments’ section of the Facebook advertisements. I included all comments in French or English that contained any message on immunization or the online survey. I extracted and coded information on the type of message, the sex of the user, the main message of the comment and the claims made in the comment. I developed the coding scheme mostly based on a preconceived framework based on the SAGE
WG matrix (Appendix 5), however the raters also utilized inductive coding when we identified themes not present in the framework.

I measured user interaction by the number of ‘likes’ for specific comments. I defined the type of comment as ‘comment only’, ‘comment with link to accurate information and/or trustworthy source’, ‘comment with link to inaccurate information and/or non-trustworthy source’. Trustworthy sources included links to government or reputable associations and/or scientists, and accurate information was classified as websites with valid information on immunization (i.e. information and/or statistics from government sources or peer-reviewed studies). I classified the remaining links as non-trustworthy and/or inaccurate. I determined commentator gender using the user’s name, photo and/or comment. I defined gender as ‘not clear’ if there was any uncertainty.

Based on previous research of web-based immunization comments, I categorized the main message of the comments as ‘positive’, ‘negative’, ‘hesitant’, or ‘ambiguous’ (23). I categorized comments as positive if the central message supported immunizations, portraying it positively (e.g. describing benefits and/or safety of immunization, promoting immunizations, describing the risks of not vaccinating or low risk of vaccinating) (23). I categorized comments as negative if the central message portrayed immunization negatively (e.g. emphasizing risk of immunization, advocating against immunizing, promoting distrust in vaccine science, making allegations of conspiracy or collusion) (23). I classified the comments as hesitant if the central message portrayed indecision/uncertainty on the risks or benefits of immunization (e.g. questions/concerns about risk or safety, requests for information or links, questions re others decision to vaccinate). I classified the main message as ‘ambiguous’ if it was not clear.

I analyzed negative, hesitant and ambiguous comments using content analysis based on the pre-conceived themes of determinants of vaccine hesitancy suggested by the WHO’s SAGE WG matrix (11,27) (Appendix 4). As mentioned in the methods for Manuscript 1, the SAGE WG matrix was chosen as the coding framework as it was developed by experts and includes all potential determinants of vaccine hesitancy based on a thorough review of the relevant literature, experiences, and expert opinion (11,100). As the comments were not directed by a specific question on immunization, not all of the comments fit into pre-conceived themes. Thus,
the other rater and I coded any themes not covered in the SAGE WG matrix within an ‘Other’ category (111). Upon review of the positive comments, I realized the preconceived themes in the SAGE matrix were not suited for categorization of the positive comments, thus the two raters developed a coding scheme based on broad themes in the data (111) (Appendix 5). The two raters independently coded all comments with a high level of agreement (percent agreement >95%). We resolved discrepancies via consensus to reach 100% agreement.

2.7 Ethical Considerations
I obtained ethical approval for this research from University of Toronto’s Office of Research Ethics [REF# 29309].

2.8 Role of the Student
I developed the purpose of the research, the aims and the research questions in consultation with the co-authors. In terms of the primary data, I was responsible for conducting a systematic review to inform the methods; developing and implementing recruitment methods; designing, translating and implementing the online survey; training the second rater; and data cleaning, manipulation and analysis. In terms of the secondary data, I acquired access to the survey tools and the data; and conducted data manipulation and analysis. In addition, I wrote the first drafts of the systematic review and three manuscripts and revised the papers based on suggestions from the co-authors.
Figure C. Flow chart for search and selection of studies (Aim 1/Systematic Review)

Table C. Sample size estimation based on estimated prevalence in the unexposed population

<table>
<thead>
<tr>
<th>Estimated Prevalence in Unexposed (%)</th>
<th>Estimated Sample Size Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.0</td>
<td>1901</td>
</tr>
<tr>
<td>15.0</td>
<td>1369</td>
</tr>
<tr>
<td>20.0</td>
<td>1112</td>
</tr>
<tr>
<td>25.0</td>
<td>968</td>
</tr>
<tr>
<td>30.0</td>
<td>881</td>
</tr>
<tr>
<td>35.0</td>
<td>830</td>
</tr>
<tr>
<td>40.0</td>
<td>801</td>
</tr>
<tr>
<td>45.0</td>
<td>792</td>
</tr>
<tr>
<td>50.0</td>
<td>799</td>
</tr>
</tbody>
</table>
Chapter 3 – Results

3.0 Overview of the results

The results for Aims 2, 3 and 4 are presented in manuscript format consisting of 3 independent manuscripts. The results of the systematic review, Aim 1, are not included in the results section and are summarized in the background (Appendix 1 full results) as a similar systematic review was recently published in the Journal of Medical Internet Research. Thus, it was decided to not submit the systematic review as a manuscript for publication. The three manuscripts included in the results are to be submitted for publication and have been prepared according to the author guidelines of each specific journal. The manuscripts have co-authors, however I developed the research questions, completed recruitment and data collection, conducted the analyses, and wrote each manuscript.

In the first manuscript, I explore the effectiveness of Canada’s most popular social media platform, Facebook, as a tool to reach vaccine hesitant parents, and the differences in key parental demographics and vaccine hesitancy indicators between a Facebook survey of recruits and the most recent RDD survey of the Canadian population. In addition, I investigate the determinants of vaccine hesitancy among recruited Canadian parents who had difficulty making the decision to vaccinate their youngest child (Aim 2). We successfully recruited a large sample of our target population at low cost, and achieved a high survey completion rate with little missing data using targeted recruitment via Facebook. Compared to the RDD sample, we reached more vaccine hesitant parents and younger parents with younger children, a population more likely to be making decisions on childhood immunizations.
In the second manuscript, I quantitatively assess the association of reported online information seeking behaviours on perceived risk of childhood immunizations in the recruited online sample and the RDD sample of Canadian parents (Aim 3). After adjusting for income level, Internet reliability, age of parent and region, the odds of perceiving vaccines as less safe rather than more safe were 1.6 times higher (95% CI: 1.3 - 2.1) for parents who used the Internet to search for vaccine information compared to parents who do not search the Internet in the online sample, and 2.0 times higher (95% 1.6 – 2.5) in the population-based RDD sample.

In the third manuscript, I quantitatively evaluate the content of an unsolicited online immunization debate of Facebook users (Aim 4). Most of the messages were positive, followed by negative, ambiguous, and hesitant. Inaccurate knowledge and misperceptions of risk were most prevalent in the non-positive comments. Other claims included distrust of pharmaceutical/government distrust of the health care system/providers (and past negative experiences with vaccination). Most of the positive comments communicated the risks of not vaccinating, followed by judgments on the knowledge level of non-vaccinators. The large number of unsolicited user-driven comments on a platform not intended for discussion nor providing any information on immunization, illustrated the strong sentiments associated with immunization, and the arbitrariness of the online platforms used for immunization debates.
3.1 Aim 2 (Manuscript 1)

Original Paper

Prepared for: Journal of Medical Internet Research (http://www.jmir.org/index)

Facebook recruitment of ‘vaccine hesitant’ Canadian parents

Jordan Tustin\textsuperscript{1,2}, Natasha S. Crowcroft\textsuperscript{1,3,4}, Dionne Gesink\textsuperscript{1}, Ian Johnson\textsuperscript{1,3}, Jennifer Keelan, Barbara Lachapelle\textsuperscript{5}

\textsuperscript{1}Dalla Lana School of Public Health, University of Toronto, Toronto, Ontario, Canada
\textsuperscript{2}Ryerson University, School of Occupational and Public Health, Toronto, Ontario, Canada
\textsuperscript{3}Public Health Ontario, Toronto, Ontario, Canada
\textsuperscript{4}Laboratory Medicine and Pathobiology, University of Toronto, Toronto, Ontario, Canada
\textsuperscript{5}Toronto Public Health, City of Toronto, Toronto, Ontario, Canada

Corresponding author:

Jordan Tustin
School of Occupational and Public Health, Ryerson University
350 Victoria Street, POD 249
Toronto, Ontario
M5B 2K3
jtustin@ryerson.ca
Abstract

Background
There is concern over the potential increase in ‘vaccine hesitant’ parents contributing to under-vaccinated populations and reduced herd immunity. Traditional studies investigating parental immunization beliefs and practices have relied on random digit dialing (RDD) yet this method presents increasing limitations. Facebook is the most utilized social media platform in Canada and as more people abandon landlines, this platform presents an opportunity for novel recruiting of vaccine hesitant parents.

Objective
To explore the use of Canada’s most popular social media platform, Facebook, as a tool to reach vaccine hesitant parents compared to RDD methods.

Methods
We recruited Canadian parents over 4 weeks in 2013-14 via targeted Facebook advertisements linked to an online survey. We compared methodological parameters, key parental demographics and three vaccine hesitancy indicators (perception on safety of childhood immunization, vaccination status of youngest child and difficulty in deciding to vaccinate youngest child) for the online survey data and a population-based RDD sample of Canadian parents. Two raters categorized respondent reasons for difficulties in deciding to vaccinate according to the World Health Organization’s Strategic Advisory Group of Experts on Immunization’s model of determinants of vaccine hesitancy.

Results
The Facebook campaign received a total of 4,792 clicks from unique users with 1,696 (35%) starting the online survey. The total response rate of fully completed unique online surveys was 23% and the survey completion rate was 65% (N=1,097). The total cost including incentives was reasonable ($4,861.19). The online sample yielded younger parents with 70% under the age of 40 yrs compared to 23% under 40 in the RDD sample; 90% of Facebook respondents were female compared to 60% through RDD. Facebook respondents also had a lower median age of their youngest child (one year vs. eight years for RDD). Compared to the RDD sample, the
Facebook sample yielded a significantly higher proportion of respondents reporting vaccines as moderately safe to not safe (27% vs. 19%), partially or not at all up-to-date vaccination status of youngest child (22% vs. 10%), and difficulty in making the decision to vaccinate their youngest child (21% vs. 10%). Difficulties in deciding to vaccinate were mostly attributed to lack of knowledge or trust due to conflicting and contradictory information (37%), and perception of risk of vaccine adverse events being higher than the risk of acquiring the disease (24%).

Conclusions
We successfully recruited a large sample of our target population at low cost, and achieved a high survey completion rate with little missing data using targeted recruitment via Facebook. Compared to the RDD sampling strategy, we reached more vaccine hesitant parents and younger parents with younger children, a population more likely to be making decisions on childhood immunizations. Social media is a promising economical modality for reaching vaccine hesitant parents for studies on the determinants of vaccine uptake.

Keywords: Immunization, Vaccine hesitancy, Facebook, Social media, Canada, Parents
Introduction

Immunization is one of the most important accomplishments in the global fight against infectious disease. In Canada, vaccines have saved more lives than any other public health intervention [1]. Despite this success, a 2011 Canadian national survey on immunization coverage reported sub-optimal coverage rates for recommended childhood vaccination [2]. This low coverage among Canadian children is of concern as vaccine preventable diseases (VPDs) endemic in other parts of the world could be imported into Canada and lead to outbreaks due to transmission among unvaccinated or under-vaccinated individuals in low coverage areas. [3]. Measles is still common in developing countries and remains one of the leading causes of death in young children [4]. The import of measles into Canada was made evident with several recent outbreaks [3]. For example in 2011, the province of Québec reported the largest North American outbreak of measles since 2002 with 776 cases compared to a usual annual average of zero to two cases [5,6]. In 2013, there were nine measles outbreaks in Canada with more than half of the cases (42/71) linked to one outbreak in a non-immunizing community in Alberta [7]. In March 2014, the Public Health Agency of Canada (PHAC) released a public health notice, warning Canadians of unusually high numbers of measles cases in five Canadian provinces [8,9]. In 2015, another notice was released due to outbreaks in Ontario and Quebec, and the multi-state measles outbreak in the United States [10]. Outbreaks of VPDs such as measles are an imminent threat to Canadians and experts have suggested that lower vaccine coverage rates are an “impending crisis” [11].

Vaccine hesitant individuals are a ‘heterogeneous group in the middle of a continuum ranging from total acceptors to complete refusers’ [12]. These individuals are of interest as they are undecided about vaccination and may decide to accept, refuse or delay all or some vaccines for themselves or their children [12]. A recent systematic review by Larson et al. (2014) on vaccine hesitancy found factors affecting vaccine hesitancy include confidence in the vaccine or the provider, complacency regarding the need or effectiveness of the vaccine, and convenience in terms of access to health care or vaccines [12]. The Strategic Advisory Group of Experts Working Group (SAGE WG) on Immunization recently built on this definition by organizing vaccine hesitancy around three domains: contextual influences such as socio-economic barriers or communications via media/social media; individual/social group influences such as personal
knowledge or perceptions of risk; and vaccination and vaccination specific issues such as the vaccination schedule or characteristics of the vaccine [12-14]

There is a critical need to better understand the factors underlying vaccine hesitancy in Canada in order to implement interventions to help parents in their decision to vaccinate and increase vaccine coverage. Random digit dialing (RDD) surveys have historically been the ‘Gold Standard’ in the collection of Canadian immunization study data. However, Statistics Canada reports that more Canadian households are abandoning their traditional landline telephones, falling from 66% of households in 2010 to 56% in 2013 [15]. In the province of Quebec only 43% of households reported a landline [15]. In contrast, Internet use has been steadily increasing over the years and as of 2010, 80% of Canadians 16 years of age and older use the Internet at home at least once per day [16]. In 2012, this increased to 83% [17]. In addition, the majority (58%) of Internet users are using social media including over 86% of those under the age of 35 [16], i.e. those in their peak reproductive, childbearing, and small child rearing years. Concerns have been emerging in the public health community that parental fears regarding childhood vaccines are growing largely due to rapid sharing of misinformation, and the increasing expression and empowerment of anti-vaccine communities and activists on social media [11,18]. Therefore, recruiting via social media platforms for online surveys should be investigated as a viable alternative or complement to RDD to reach self-selecting higher risk populations, such as vaccine hesitant parents.

This study aims to explore the effectiveness of Canada’s most popular social media platform, Facebook, as a tool to reach vaccine hesitant parents, and will explore the differences in key parental demographics and vaccine hesitancy indicators between a Facebook survey of recruits and the most recent RDD survey of the Canadian population [19]. To date, no study has investigated the value of social media surveys compared to RDD traditional household surveys in the study of parental immunization practices and beliefs.
Methods

Study design
In this observational study, we used two datasets that included data on parental immunization beliefs and practices collected from Canadian parents via two different cross-sectional methods. The inclusion criteria for both populations were: (1) over 18 years of age, (2) having at least one child under 18 years, (3) living in Canada, and (4) able to respond to questions in English &/or French.

Population-based data were de-identified and extracted from a survey collected by a research company contracted by PHAC. During a period of three weeks in March 2011, the researchers randomly selected a sample of Canadian households with a landline via random digit dialing (RDD) and administered a telephone survey in French or English. The telephone survey consisted of questions on demographics and Canadian parents’ knowledge, awareness, attitudes and behaviours related to immunization [19]. The researchers attempted contact with each household in the sample 8 times prior to retiring the phone number [19]. The average time to complete the survey was 18 minutes and 30 seconds [19]. Researchers of the RDD sample reported a participation rate of 23.4% (N=1,745) and a total cost of $163,398. The average cost per completed survey was $93.64.

The online survey is primary data collected from self-selected online respondents recruited via the social media platform, Facebook. Facebook has been reported as the most popular social media platform in Canada with more than half of the population logging into Facebook at least once per month, and daily Facebook usage reported as higher than global and US averages [20,21]. The online semi-structured survey was available in French and English and contained questions similar to the RDD survey on demographics, and parents’ knowledge, awareness, attitudes and behaviours related to immunization. Trusted website links with reliable information on childhood immunizations appeared immediately after terminating or completing the survey to ensure there was no prior influence on the respondents. We piloted the survey with a convenience sample of the primary researcher’s ‘Facebook friends’ and a snowball sample of their ‘Facebook friends’ who met the inclusion criteria.
The online survey would automatically terminate if the respondent did not provide informed consent or did not meet eligibility criteria. We used a Canadian online survey company (now owned by an American company), Fluid Surveys to capture online survey data. Fluid Surveys stored all of its data in Canada and used the latest in firewall and encryption technology to protect private information. We exported, encrypted and password protected the survey responses, and did not collect any identifying information on respondents. Upon completion of the survey, respondents were eligible to participate in a draw with an estimated 1 in 90 chance (based on an estimated sample size of 800 respondents participating in the draw) to win an iPad mini (value of $375). We kept all email addresses of participating respondents confidential, and destroyed them at the end of the draw. We obtained ethical approval from University of Toronto’s Office of Research Ethics (REF# 29309).

Recruitment

We displayed Facebook advertisements on the Newsfeed of Facebook users whose profiles matched our inclusion criteria: (1) Located in Canada, (2) 18 years or older, (3) Parent of a child aged 0 to 15 yrs, and (4) Displaying a profile in English or French. Our advertisements did not target parents with children aged 16-19 yrs as they are self-consenting to immunization and their inclusion would significantly increase the target audience and dilute our advertisements, however they would be included if they had younger children. Facebook determines users’ location based on information in their timeline, verified by their Internet Protocol (IP) address and by examination of the user’s friends’ location [22]. A user’s age was determined by their year of birth, required by Facebook for all personal accounts [22]. Parents were identified based on activity or information on their timeline and language was determined via the language of their profile [22].

The optimal delivery mechanism of advertisements on Facebook is determined by many factors such as the target audience, the marketplace competition, the bid and the ad performance history [23]. Facebook provides the option of being charged each time the advertisement is displayed or CPM (cost-per-thousand-impressions) or each time the advertisement is clicked or CPC [23]. We chose to pay via CPM as Facebook ensures the ad will be optimized to the people most likely to click on your ad (e.g. most active and engaging users) and remains in the optimal bid range. In addition Facebook paces the rate at which the ad is displayed based on the budget,
goal and period of time specified [23]. We set a goal to reach a minimum of 800 participants based on power calculations and our budget for survey incentives. We began with a lifetime budget of $1500 over a period of one month as this would grant us access to a Facebook consultant. At the time of our advertisement launch, there was a potential to reach 300,000 Canadian parents on Facebook (260,000 English users and 40,000 French users). Therefore the money was allocated based on this distribution with approximately 85% of the budget allocated to the English campaign. Fifty dollars gifted by Facebook was later added to the French campaign budget. The Facebook advertisement campaign was launched on December 12, 2013 at 14:00 and ended on January 11, 2014 at 14:00. Three different images were used in our advertisement (Figure 1).

Facebook provided several ad statistics such as the number of clicks (e.g. likes, comments, click to our Facebook page, and click to our online survey), the number of impressions (placements on users’ Newsfeed), the CPM, and the CPC. Based on these statistics, Facebook optimized the ad(s) with the highest click-through-rate (CTR) (the # of clicks received/number of impressions) to serve the most users. We removed advertisements that fell below the Facebook average CTR of 1-1.5 % from the campaign.

The objective of the campaign was for targeted Facebook users to click on the advertisement linked to our secure online survey. The user could also be directed to our Facebook page titled ‘Parents, tell us what you think about vaccines’ by clicking on the advertisement’s profile user as opposed to the link. We provided further information on the study and links to the online survey on our official Facebook Page.

**Statistical analysis**

**Campaign and recruitment**

We investigated methodological parameters on the number of impressions, the number of clicks, demographics of users who clicked the advertisement, timelines of data collection, and the costs for both the English and French campaigns. The response rate calculation for the online sample is a derivation from definitions provided by the American Association for Public Opinion Research [24], and is the number of completed surveys divided by the total number of
surveys (completed, partially completed and terminated) plus the remaining unique clicks of unknown eligibility.

**Respondent characteristics and vaccine hesitancy**

We validated online sample data for single questionnaire response and accuracy of eligibility criteria by verifying IP addresses and demographic information. We conducted univariate analyses for the online and the RDD sample on individual level variables for respondent characteristics and vaccine hesitancy indicators. Respondent characteristics included age group, sex, income and education level, median age of youngest child, birthplace, and place of residence. We investigated vaccine hesitancy via three indicators: perception on safety of childhood vaccinations, measured on a 7 point scale from ‘Not safe’ (1) to ‘Moderately Safe’ (4) to ‘Extremely Safe’ (7); Vaccination status of youngest child classified as ‘Completely up-to-date’ or ‘Partially or Not at all up-to-date’; and difficulty in making the decision to vaccinate (or not) their youngest child, measured as ‘Very Easy’, ‘Easy’, ‘Difficult’ or ‘Very Difficult’. We conducted all descriptive analyses using Microsoft® Office Excel® 2007 and SAS Version 9.3 (SAS Institute Inc., Cary, NC, USA).

A primary and secondary rater independently coded qualitative data from the online survey on the difficulties in deciding to vaccinate youngest child according to the SAGE model of determinants of vaccine hesitancy [13]. Two raters independently coded all responses with a high level of agreement (percent agreement >90%). Discrepancies were resolved via consensus to reach 100% agreement. The raters could not code the pre-categorized open-ended responses from the RDD data. However, raters classified the pre-coded categories according to best fit in the SAGE model. Raters conducted all qualitative analyses with QSR International’s NVivo 10 software.

**Results**

**Campaign and recruitment**

During the one-month campaign, our ads made 280,485 impressions yielding 8,557 total clicks on our ads. The overall campaign click-through rate was 3·1%, with the English campaign yielding a higher click rate of 3·6% compared to 1.0% for the French campaign. Over seventy-five per cent of the impressions (215,770/280,485) were among women. Women aged 25-34 yrs
were reached the most with 40% of the overall impressions (109,808/280,485). Thus, the majority (87%) of the clicks on the advertisements were also women (7,449/8,557) with the highest average CTR among women aged 35-44 yrs (2.8%), followed closely by women aged 45-54 yrs (2.6%) and women aged 25-34 years (2.5%). In terms of unique Facebook users, our campaign reached 32.5% of our target population on Facebook (97,598 people) with 4.9% (4,792 unique Facebook users) clicking on the advertisement. Out of the 4,792 unique clicks on our advertisements, 35.4% started the online survey. Only fully completed surveys were counted as part of our sample resulting in 1,097 unique respondents. Thus, the response rate was 22.9% (1,097/1,696 +3,086) and the survey completion rate was 64.7% (1,097/1,696) with very little missing data (Figure 2). The average time to complete the survey was 17 minutes.

Advertisement success varied by language and image displayed. All advertisements produced clicks; however, advertisement A (Figure 1) produced the highest reach and click-through rate, and had the lowest cost (Table 1). The CTR was consistently higher over time and the cost per click (CPC) consistently lower for the English campaign compared to the French campaign. CTRs and CPCs were variable over time for both campaigns; however the English campaign experienced a substantial drop in the CTR during the holidays from December 23 to 25, 2013. In periods of CTR decrease, there was a corresponding increase in CPC (Figure 3). For the English campaign, the average cost per 1,000 impressions (CPM) was $5.59 and $5.28 for the French campaign. Translated into CPC, the English campaign cost an average of $0.16 and the average for the French campaign was $0.52. The total research cost was $4,861.19 ($1,500 campaign cost - $50 Facebook credit + $3,361.19 incentives cost).
**Table 1. Facebook advertisement statistics.**

a French advertisements B and C were removed from the campaign on January 3, 2014

<table>
<thead>
<tr>
<th>Campaign</th>
<th>Reach (# of unique Facebook users)</th>
<th># of impressions</th>
<th># of clicks</th>
<th>CTR (%)</th>
<th># of unique clicks</th>
<th>Unique CTR (%)</th>
<th>Average cost per CPM ($)</th>
<th>Average CPC ($)</th>
<th>Average cost per unique click ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>English ads</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>74,572</td>
<td>153,217</td>
<td>5,767</td>
<td>3.76</td>
<td>3,346</td>
<td>4.49</td>
<td>5.39</td>
<td>0.14</td>
<td>0.25</td>
</tr>
<tr>
<td>B</td>
<td>38,643</td>
<td>51,647</td>
<td>1,778</td>
<td>3.44</td>
<td>1,189</td>
<td>3.10</td>
<td>6.05</td>
<td>0.18</td>
<td>0.26</td>
</tr>
<tr>
<td>C</td>
<td>16,919</td>
<td>18,773</td>
<td>436</td>
<td>2.32</td>
<td>368</td>
<td>2.18</td>
<td>5.98</td>
<td>0.26</td>
<td>0.30</td>
</tr>
<tr>
<td><strong>French ads</strong> a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>15,767</td>
<td>36,327</td>
<td>393</td>
<td>1.08</td>
<td>338</td>
<td>2.14</td>
<td>5.18</td>
<td>0.48</td>
<td>0.56</td>
</tr>
<tr>
<td>B</td>
<td>9,178</td>
<td>15,891</td>
<td>150</td>
<td>0.94</td>
<td>128</td>
<td>1.40</td>
<td>5.39</td>
<td>0.57</td>
<td>0.67</td>
</tr>
<tr>
<td>C</td>
<td>3,811</td>
<td>4,630</td>
<td>33</td>
<td>0.71</td>
<td>33</td>
<td>0.87</td>
<td>5.63</td>
<td>0.79</td>
<td>0.79</td>
</tr>
</tbody>
</table>

**Respondent Characteristics**

The majority of the respondents were born in Canada in both the online survey (91.9%) and the population-based RDD survey (83.6%). The distribution across place of residence was similar except the online sample had a lower proportion of respondents from Québec compared to the RDD sample (10.9% vs. 24.5%) and higher proportion of respondents from Alberta (23.6% vs. 11.5%). The age distribution differs with almost 70% of the online respondents under the age of 40 yrs compared to 23-4% in the RDD sample; however, the age for 38·0% of the RDD respondents is not known. For both samples, the median number of children is two (IQR 1.0) with the median age of the youngest child at one year (IQR 1.50) in the online sample and eight years (IQR 10.0) in the RDD sample. The online sample was predominantly female respondents (91.4%) compared to 60·0% in the RDD sample. Both samples had similar distribution of education and income level with almost half of the respondents completing some level of higher education, following the education distribution of Canadian adults [25] and the majority lying close to or above the 2012 median total household income for Canadian families of $74, 540 [26] (Table 2).
Table 2. Respondent demographic characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Online survey (N=1,097)</th>
<th>Population-based RDD survey, unweighted (N=1,745)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age group (yrs)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under 30</td>
<td>395</td>
<td>57</td>
</tr>
<tr>
<td>30-34</td>
<td>356</td>
<td>129</td>
</tr>
<tr>
<td>35-39</td>
<td>189</td>
<td>222</td>
</tr>
<tr>
<td>40 - 44</td>
<td>96</td>
<td>244</td>
</tr>
<tr>
<td>45 +</td>
<td>56</td>
<td>430</td>
</tr>
<tr>
<td>Unknown</td>
<td>5</td>
<td>663</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>80</td>
<td>711</td>
</tr>
<tr>
<td>Female</td>
<td>1003</td>
<td>1034</td>
</tr>
<tr>
<td>Unknown</td>
<td>14</td>
<td>7</td>
</tr>
<tr>
<td>Education level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did not graduate high school</td>
<td>25</td>
<td>83</td>
</tr>
<tr>
<td>High school diploma</td>
<td>147</td>
<td>275</td>
</tr>
<tr>
<td>Trade or vocational school</td>
<td>286</td>
<td>514</td>
</tr>
<tr>
<td>Some university</td>
<td>110</td>
<td>144</td>
</tr>
<tr>
<td>Bachelor’s degree</td>
<td>277</td>
<td>404</td>
</tr>
<tr>
<td>Professional certification</td>
<td>123</td>
<td>97</td>
</tr>
<tr>
<td>Graduate degree</td>
<td>101</td>
<td>221</td>
</tr>
<tr>
<td>Unknown</td>
<td>28</td>
<td>7</td>
</tr>
<tr>
<td>Income level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under $30,000</td>
<td>85</td>
<td>157</td>
</tr>
<tr>
<td>$30,000-$70,000</td>
<td>236</td>
<td>522</td>
</tr>
<tr>
<td>$70,000-$79,999</td>
<td>92</td>
<td>125</td>
</tr>
<tr>
<td>$80,000-$119,999</td>
<td>316</td>
<td>381</td>
</tr>
<tr>
<td>Over $120,000</td>
<td>256</td>
<td>374</td>
</tr>
<tr>
<td>Unknown</td>
<td>112</td>
<td>186</td>
</tr>
<tr>
<td>Province or Territory of residence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>British Columbia</td>
<td>160</td>
<td>175</td>
</tr>
<tr>
<td>Alberta</td>
<td>259</td>
<td>200</td>
</tr>
<tr>
<td>Saskatchewan</td>
<td>95</td>
<td>101</td>
</tr>
<tr>
<td>Manitoba</td>
<td>42</td>
<td>96</td>
</tr>
<tr>
<td>Ontario</td>
<td>336</td>
<td>486</td>
</tr>
<tr>
<td>Quebec</td>
<td>120</td>
<td>427</td>
</tr>
<tr>
<td>New Brunswick</td>
<td>26</td>
<td>62</td>
</tr>
<tr>
<td>Nova Scotia</td>
<td>31</td>
<td>70</td>
</tr>
<tr>
<td>Prince Edward Island</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>Newfoundland</td>
<td>16</td>
<td>46</td>
</tr>
<tr>
<td>Yukon</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>Northwest Territories</td>
<td>2</td>
<td>23</td>
</tr>
<tr>
<td>Nunavut</td>
<td>-</td>
<td>14</td>
</tr>
<tr>
<td>Unknown</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Birthplace</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>1008</td>
<td>1459</td>
</tr>
<tr>
<td>Outside of Canada</td>
<td>61</td>
<td>286</td>
</tr>
<tr>
<td>Unknown</td>
<td>28</td>
<td>-</td>
</tr>
</tbody>
</table>
Vaccine Hesitancy

Twenty-seven percent (292/1,097) of the online respondents perceive childhood immunizations to be not safe to moderately safe compared to 19% of the RDD sample (324/1,745), twenty-two percent (242/1,097) reported the vaccination status of their youngest child to be not up-to-date compared to 10% (167/1,745) in the RDD sample, and 21% (231/1,097) of the online sample reported the decision to vaccinate their youngest child to be difficult or very difficult compared to 10% (176/1,745) in the RDD sample. In the online sample, more than half of those not up-to-date reported their youngest child had not received any vaccinations (126/242) with approximately 6·0% reporting the child was too young for vaccinations (Table 3). In total, 20.2% (49/242) of the respondents with their youngest child not up-to-date reported concerns over autism and/or sudden infant death syndrome as important reasons for deciding not to vaccinate their youngest child.

Of those who found the decision difficult or very difficult, 54·8% (125/228) of the online sample and 36·3% (64/176) of the RDD sample reported their youngest child to be not-up-to-date. No significant trends were found when stratifying by parental age, parity and sex.

Table 3. Respondent perception on safety of childhood vaccination, vaccination status of youngest child, and difficulty in making the decision to vaccinate youngest child

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Online survey (N=1,097)</th>
<th>Population-based RDD Survey, Un-weighted (N=1,745)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Perception on safety of childhood immunizations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1- Not at all safe</td>
<td>49</td>
<td>4·47</td>
</tr>
<tr>
<td>2</td>
<td>48</td>
<td>4·38</td>
</tr>
<tr>
<td>3</td>
<td>64</td>
<td>5·83</td>
</tr>
<tr>
<td>4- Moderately safe</td>
<td>131</td>
<td>11·94</td>
</tr>
<tr>
<td>5</td>
<td>134</td>
<td>12·22</td>
</tr>
<tr>
<td>6</td>
<td>338</td>
<td>30·81</td>
</tr>
<tr>
<td>7- Extremely safe</td>
<td>327</td>
<td>29·81</td>
</tr>
<tr>
<td>Unknown</td>
<td>6</td>
<td>0·55</td>
</tr>
<tr>
<td>Vaccination status of youngest child</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Completely up-to-date</td>
<td>851</td>
<td>77·58</td>
</tr>
<tr>
<td>Somewhat-up-to-date or not at all up-to-date</td>
<td>242</td>
<td>22·1</td>
</tr>
<tr>
<td>Unknown</td>
<td>4</td>
<td>0·36</td>
</tr>
</tbody>
</table>
In the online sample, approximately 80.0% of the reasons for difficulty in their decision making were reported as individual and group influences with knowledge/awareness of vaccination information reported as the most important determinant for both those with their youngest child up-to-date (35.4%) and those who reported their child as not-up-to-date (39.1%) (Table 4). In terms of knowledge, the majority reported difficulties with too much controversial or contradicting information, and not enough unbiased or trustworthy information. The second highest determinant reported was the perception of the risks/benefits of vaccination, reported by 23.9% of parents with an up-to-date child and 23.6% in those whose child is not up-to-date. Most struggled with the risk of adverse events or side effects versus the risk of acquiring the disease, where 23% (n=12) specifically expressed concern for the risk of autism. Approximately 6.0% in the up-to-date and 10% in the not-up-to-date group reported pressure from society, family/friends or physicians to vaccinate or not. To a lesser extent, other individual or group influences included personal experience or knowledge of someone who subsequently experienced side effects or developed autism after vaccination, distrust in the government, and belief that vaccines are not necessary for health. Vaccine or vaccination specific issues were reported as reasons in twelve percent of the sample. The majority in both groups reported issues with the vaccination schedule in terms of multiple vaccines or age of vaccination, followed by issues with lack of research or testing of new vaccines. Nine percent of the reasons were reported as contextual with respondents reporting distrust of the pharmaceutical industry, controversial coverage or fear mongering by the media, and forced vaccination via mandatory vaccination policies in schools. Based on the pre-coded categories in the RDD sample, the majority of both up-to-date and not up-to-date parents also reported perception of risks/benefits and knowledge/awareness as the most important reasons their decision to vaccinate was difficult or very difficult.
Table 4. Online survey respondent reasons for difficult or very difficult decision in deciding to vaccinate youngest child by youngest child vaccination status

<table>
<thead>
<tr>
<th>SAGE Model Determinant of Vaccine Hesitancy</th>
<th>Vaccination Status of Youngest Child</th>
<th>Up-to-date</th>
<th>Not up-to-date</th>
<th>Total</th>
<th>Total %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Contextual Influences</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communication and media environment</td>
<td>3</td>
<td>2·65</td>
<td>1</td>
<td>0·91</td>
<td>4</td>
</tr>
<tr>
<td>Influential leaders, gatekeepers and anti- or pro-vaccination lobbies</td>
<td>1</td>
<td>0·88</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Pharmaceutical industry</td>
<td>3</td>
<td>2·65</td>
<td>4</td>
<td>3·64</td>
<td>7</td>
</tr>
<tr>
<td>Politics, policies</td>
<td>3</td>
<td>2·65</td>
<td>3</td>
<td>2·73</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>10</td>
<td>8·85</td>
<td>8</td>
<td>7·27</td>
<td>18</td>
</tr>
<tr>
<td><strong>Individual and Group Influences</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experience with past vaccination</td>
<td>6</td>
<td>5·31</td>
<td>5</td>
<td>4·55</td>
<td>11</td>
</tr>
<tr>
<td>Beliefs, attitudes about health and prevention</td>
<td>4</td>
<td>3·54</td>
<td>2</td>
<td>1·82</td>
<td>6</td>
</tr>
<tr>
<td>Knowledge/awareness</td>
<td>40</td>
<td>35·40</td>
<td>43</td>
<td>39·09</td>
<td>83</td>
</tr>
<tr>
<td>Health system and providers-trust and personal experience</td>
<td>3</td>
<td>2·65</td>
<td>5</td>
<td>4·55</td>
<td>8</td>
</tr>
<tr>
<td>Risk/benefit (perceived, heuristic)</td>
<td>27</td>
<td>23·89</td>
<td>26</td>
<td>23·64</td>
<td>53</td>
</tr>
<tr>
<td>Immunization as a social norm vs. not needed/harmful</td>
<td>7</td>
<td>6·19</td>
<td>10</td>
<td>9·09</td>
<td>17</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>87</td>
<td>76·99</td>
<td>91</td>
<td>82·73</td>
<td>178</td>
</tr>
<tr>
<td><strong>Vaccine/Vaccination Specific Issues</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk/Benefit (scientific evidence)</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>0·91</td>
<td>1</td>
</tr>
<tr>
<td>Introduction of a new vaccine or new formulation</td>
<td>6</td>
<td>5·31</td>
<td>5</td>
<td>4·55</td>
<td>11</td>
</tr>
<tr>
<td>Mode of administration</td>
<td>2</td>
<td>1·77</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Vaccination schedule</td>
<td>8</td>
<td>7·08</td>
<td>3</td>
<td>2·73</td>
<td>11</td>
</tr>
<tr>
<td>Costs</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>0·91</td>
<td>1</td>
</tr>
<tr>
<td>Role of healthcare professionals</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>0·91</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>16</td>
<td>14·55</td>
<td>11</td>
<td>10·00</td>
<td>27</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td>113</td>
<td>100·00</td>
<td>110</td>
<td>100·00</td>
<td>223</td>
</tr>
</tbody>
</table>

**Discussion**

Overall, Facebook was a successful recruitment method for parents to complete an on-line survey about vaccination. We were able to exceed our ideal sample size within a short timeframe, at low cost and with one researcher running the campaign and data collection. The cost ($4,861 vs. $163,398), timeliness and sample size of this study achieved comparable or better results than other recent health studies using targeted recruitment via Facebook [27,28].

For both online and RDD survey methods, data collection spanned the same time frame and
individual surveys took approximately the same amount of time, however the costs were 97% lower using online recruitment. The quality of the data was evident with a rich pool of qualitative and quantitative data, a high completion rate and little missing data.

In both populations, the majority of the respondents were Canadian born, followed similar distribution patterns in terms of province/territory of residence, had mostly higher education levels and higher household income levels than the median total household income. We did not compare our data to census data as we were not trying to generalize to the Canadian population. In addition, census data is not available specifically for Canadian parents, our target population. The high response from residents of Alberta in the online sample could be the result of higher engagement due to a large measles outbreak in Alberta that occurred in the month before our campaign launch [7]. The lower number of Québec responses was surprising as Québec has the second highest Facebook usage next to Ontario [21], experienced a large measles outbreak in 2011 and we specifically targeted French Facebook users. Due to the lower success of our French campaigns, it is possible the advertisements were not as attractive to French-speaking Québec users, Québec users do not interact online in the same manner as Ontario users, or a higher percentage of the budget needed to be allocated to the French campaign to reach more French-speaking Facebook users.

The online sample demographics differed by recruiting a majority female population, and a younger population with younger children compared to the RDD sample that had fairly equal representation of males and females, an older population (even if we assumed all of the unknowns were below 35 years) and older median age of the youngest child. As evidenced by the impression demographics, the Facebook campaign biased the recruitment toward a younger and female population, however the advertisements were intended to target parents with younger children as this would be the demographic engaging online and making decisions on childhood immunizations. Furthermore, Dubé et al. (2012) reported no difference between mothers and fathers in intentions to vaccinate [29]. Combined, both methods produce the greatest spectrum of respondents; however, the Facebook campaign recruited more parents with young children at the most important stage of the vaccination process. Some of the differences we observed may be due to cohort effects since vaccine hesitancy may have been increasing and be more prevalent in the younger parents recruited through Facebook.
According to our indicators, the online strategy was successful in recruiting a higher number of vaccine hesitant parents: more respondents perceived childhood immunizations to be not safe to moderately safe, more reported their youngest child’s vaccination status as not-up-to-date and more had difficulty in making the decision to vaccinate their youngest child. In addition, out of those reporting difficulty in the decision to vaccinate, more than half in the online sample reported their youngest child’s vaccination status as not up-to-date. Moreover, 1/5th of the respondents who reported their child as not-up-to-date reported concerns over autism and/or sudden infant death syndrome as important reasons for deciding to not vaccinate their youngest child, even though it has been proven that neither disorders are associated with vaccination [30,31,32]. No significant contributions were observed when stratifying by age, sex or parity, however low numbers in some categories prevented reliable comparisons. The factors associated with parental decisions to not vaccinate have been well studied [12,33,34] but no study has focused on vaccine hesitant Canadian parents. We found the main reasons reported for difficulty in decision-making were the inability to decipher and/or trust all the information available and difficulties in weighing the risks and benefits of immunization with concerns over side effects and adverse events. The contextual influence of media, social media or other sources of communication may have played more of an important role in contributing to respondent concerns regarding their own knowledge or risk perception, however this could not be further probed due to the inherent limitations of online surveys.

Limitations
As more people abandon landlines, the validity of traditional population telephone surveys is compromised with low response rates and potentially non-representative samples [35]. Representativeness and validity concerns are also relevant for online surveys as research relies on the collection of self-reported data by self-selected participants [36]. However, there are more and more people on popular social media platforms such as Facebook and possibly different people than those reached by RDD. For example, active social media users may be mostly represented by educated females in higher income brackets [17,37,38], which is also the demographic most often looking for health information online [18]. Furthermore, active social media users may be potentially viewing an abundance of online anti-vaccination sentiment, and may be the people that need to be reached most to combat vaccine hesitancy [39,40].
Purposive Facebook targeted recruitment to self-selected respondents was not intended to provide a sample representative of the RDD sample or the Census population, but to determine if we could recruit more ‘at risk’ vaccine hesitant parents compared to the standard sampling technique. Reaching a higher proportion of vaccine hesitant respondents proved successful; however, there are several inherent biases in using Facebook as a recruiting platform and in targeted sampling to self-selectors. For example, the low recruitment of male respondents could be the result of Facebook’s targeting criteria and/or the visuals or content of the advertisements. Selection bias is inevitable as Facebook identifies your desired target population, targets the most active and engaged users, and the number of impressions depends on factors such as the amount spent, the CTR, and market competition. However, for the purpose of our research this proved to be a strength as this was the group we intended to target and would likely reach with any online intervention. There is a potential for volunteer bias and without a sampling frame we cannot calculate a true participation rate, nor can we characterize users who did not see the advertisement or did not engage. The timing of the advertisement (December) may have affected the type of respondent, however this could not be verified without data from Facebook on who may be more likely to respond at different periods in time. Duplicate responses and gaming are also an important concern in online recruitment [41]. Although difficult to prevent, safety measures as recommended in the Checklist for Reporting Results of Internet E-Surveys (CHERRIES) [42], were implemented to prevent and/or evaluate repeat respondents.

As with any online recruitment strategy, there are concerns with the ‘digital divide’. Statistics Canada recently reported that Canadians over the age of 65 years are responsible for the lag in Internet use in lower income households [17]. This population is not expected to represent a large proportion of our target population of vaccine hesitant parents. In addition, the online sample neglected to recruit many foreign-born parents or children yet nearly 20% of Canadians were born outside of Canada. This might represent a significant bias that is difficult to quantify, as the Facebook activity of foreign-born residents is not known. Moreover recent immigrants may not be a priority group to address for vaccine hesitancy as they are more likely to arrive with immunity due to previous infection, and more likely to become immunized as citizens [43,44]. Notwithstanding the inherent biases, we were able to obtain a large sample size for the recruitment period at a low cost, and achieved a high survey completion rate with very little
missing data. Furthermore, we reached younger Canadian mothers with younger children, and more vaccine hesitant parents compared to the RDD sample.

Conclusions
Targeted recruitment via Facebook was successful in reaching a population more likely to be engaging in health discussions online and making decisions on childhood immunizations, and was superior to RDD methodology in reaching ‘at-risk’ vaccine hesitant parents. Engaged respondents also provided us with insights into the most important determinants of vaccine hesitancy, providing valuable information in directing any future intervention efforts. With more Canadians abandoning landlines and engaging online with potential exposure to an abundance of anti-vaccination sentiment, popular social media platforms should be considered as part of any recruitment strategy or study on the determinants of vaccine hesitant parents but also in the implementation of interventions to address these determinants. Future research should consider studies to investigate data reliability, and to better examine the relative importance of contextual influences, such as the Internet, as determinants of vaccine hesitancy.
Acknowledgments
The authors wish to thank the Public Health Agency of Canada (PHAC) for providing the RDD sample data, the Facebook consultants for their advice and expertise, and the parents of the children pictured in the advertisements for their permission to use the photographs. We would also like to thank the Canadian parents who participated in this study. Funding was provided by Public Health Ontario, Toronto, ON and the Dalla Lana School of Public Health, Toronto, ON.

Conflicts of Interest
None declared.

Abbreviations

CPC cost-per-click
CPM cost-per-impression
CTR click-through-rate
IQR interquartile range
IP Internet Protocol
PHAC Public Health Agency of Canada
RDD random digit dialing
SAGE WG Strategic Advisory Group of Experts Working Group
VPD vaccine preventable disease
Figure 1. Facebook advertisements in the English campaign.

Advertisement A.

Advertisement B.

Advertisement C.
Figure 2. Facebook advertisement recruitment

- N = 300,000
  Facebook estimated reach for English and French Canadian parents on Facebook

- N = 97,598
  Unique Facebook users reached via Facebook advertisements

- N = 4,792
  Unique Facebook users who clicked on Facebook advertisement

- N = 1,697
  Unique Facebook users who started the online survey
    - n = 12 Did not provide informed consent
    - n = 38 Did not meet inclusion criteria
    - n = 1 Duplicate IP

- N = 1,646
  Respondents who meet online survey criteria
    - n = 549 Did not fully complete survey

- N = 1,097
  Fully complete the online survey
Figure 3. Daily click rates compared to the cost per click for all campaigns from December 11, 2013 to January 11, 2014
References


3.2 Aim 3 (Manuscript 2)

Primary Research Paper
Prepared for: Vaccine (http://www.journals.elsevier.com/vaccine/)

Internet exposure associated with parental perception of risk on childhood immunization

Jordan Tustin¹, ², Natasha S Crowcroft¹, ³, ⁴, Dionne Gesink¹, Ian Johnson¹, ³, Jennifer Keelan

¹ Dalla Lana School of Public Health, University of Toronto, Toronto, Ontario, Canada
² Ryerson University, School of Occupational and Public Health, Toronto, Ontario, Canada
³ Public Health Ontario, Toronto, Ontario, Canada
⁴ Laboratory Medicine and Pathobiology, University of Toronto, Toronto, Ontario, Canada

Corresponding author:

Jordan Tustin
School of Occupational and Public Health, Ryerson University
350 Victoria Street
Toronto, Ontario
M5B 2K3
jtustin@ryerson.ca
Abstract
This study investigates the potential association between seeking vaccine information on the Internet and Canadian parents’ perception of risk on childhood immunization. We analyzed this association in two population samples: a self-selecting online sample of Canadian parents recruited through Facebook (N=966) and a population-based sample of parents recruited by random-digit-dialing (RDD) (N=951). The outcome was parental perception on vaccine safety on a seven point ordinal scale from ‘Not safe’ to ‘Extremely safe’. An ordinal regression model was used to investigate if Internet information seeking on childhood vaccination predicted parental perception on vaccine safety. After adjusting for income level, perceived reliability of the Internet, age of parent and region, the odds of perceiving vaccines as less safe rather than more safe were 1.6 times higher (95% CI: 1.3 - 2.1) for parents who used the Internet to search for vaccine information compared to parents who do not search the Internet in the online sample, and 2.0 times higher (95% 1.6 – 2.5) in the population-based RDD sample. This suggests the Internet may be increasing Canadian parents’ negative perception of vaccine risk. Governmental and scientific sectors should consider the development and implementation of online vaccine interventions to promote confidence in immunization.

Keywords: Canadian parents, vaccination, immunization, Internet, vaccine safety

Highlights
- Novel evidence on the significant association between seeking vaccination information online and parental perceptions of vaccine safety
- Canadian parents searching the Internet for vaccine information are less likely to perceive vaccines as safe
- Study results support directing efforts towards on-line vaccine interventions to promote confidence in immunization
Introduction

A decrease in public confidence in the safety of vaccines and subsequent lower vaccine uptake is an impending crisis in the developed world [1,2]. As more parents are wary of vaccinations, more communities are at risk of vaccine preventable disease (VPD) outbreaks with potentially devastating consequences for children, pregnant women, immune-compromised individuals, and communities. In Canada, the public’s fear and confusion over the measles/mumps/rubella (MMR) vaccine was highlighted by a 2010 study reporting that 65% of women and 72% of men believe the vaccine is unsafe, or are unsure whether or not the vaccine could cause autism [3]. In addition, a 2015 survey revealed that two in five Canadians believe ‘the science on vaccinations isn’t quite clear’ [4]. In 2011, a national survey of Canadians revealed sub-optimal coverage rates for childhood immunizations [5], and several measles outbreaks have been reported across Canada from 2011 to 2014 [6,7]. In March 2014, the Public Health Agency of Canada (PHAC) released a public health notice, warning Canadians of the unusually high number of measles cases in five Canadian provinces [8,9].

The public health community has raised concerns that parental fears about childhood vaccines are growing largely due to the popularity of social media as the Internet is an important vehicle for individuals seeking health information and support, and sharing health knowledge, opinions, and experiences [10]. For example, in Canada, 80% of Canadians 16 years of age or older use the Internet [11]; 64% of these Internet users search for medical or health related information, with the majority of these Internet users between the ages of 16 to 44 years [12]. With the increasing popularity of social media, the public appears to be bypassing conventional sources of health information and looking for the ‘wisdom of the crowd’, where health decisions depend on other Internet users’ experiences [13]. The Internet allows for rapid sharing of opinions and information, self-organization, the creation of social networks, and empowerment of online groups or people such as anti-vaccine communities or activists [2]. The large presence of online anti-vaccination sentiment together with the current pattern of mistrust in the medical community has led to an environment of parents seeking and sharing immunization information [14]. A recent study investigating parents’ confidence in childhood vaccines in the United States found that both vaccine-declining and vaccine-accepting parents have questions, concerns, or misperceptions about vaccines [15]. The majority of parents reported seeking information about vaccine safety prior to vaccinating their children, and identified the Internet as an important
source of information. The authors reported a need for the public health community to have a more informed understanding of parents’ Internet use, and how social media interactions with recognized public health organizations can address parents’ vaccine questions. Given the increasing popularity of social media platforms in Canada among generation X and millennial parents, as well as the suggested influence of social media on parental beliefs and behaviours toward childhood immunization, it is important to investigate and understand this influence in order to inform online interventions that could influence hesitant or undecided parents.

The Health Belief model is widely applied to determine what factors influence individuals when making vaccination decisions. In terms of immunization, the decision to vaccinate is balanced by the perceived risk of contracting a VPD and the perceived risk of vaccine adverse events. Due to the abundance and availability of anti-vaccination sentiment online and the relatively low prevalence of VPD in the population, it is suggested that individuals may perceive a greater risk of suffering from vaccination side-effects than from contracting a VPD (13). Therefore, information obtained online that clarifies one’s understanding of vaccination risks should also affect the intent to vaccinate (Figure 1). This study investigates the impact of reported online information seeking behaviours on perceived immunization risk in two different samples of Canadian parents. Examining this association will increase our understanding on the impact of the Internet on parental perception of risk in the context of childhood immunization and help guide public health interventions.

Methods

Data Sources and Collection
This study examines the potential association between seeking vaccine information on the Internet and Canadian parents’ perception of risk on childhood immunization data on two different data sources: primary data collected via online survey and secondary data collected via population-based random digit dialing (RDD). The two data sources contain the same variables, and thus were both utilized in order to investigate the repeatability of the results. The online survey data were collected via targeted advertisement recruitment on Canada’s most popular social media platform, Facebook (Tustin et al., unpublished results). French and English advertisements invited Canadian parents to click on the advertisement and participate in an
online survey on childhood immunization with a chance to win an iPad mini. The survey was piloted with a convenience sample of twenty Facebook users and their ‘friends’ before being advertised to the larger Facebook population. For four weeks in December 2013 and January 2014, advertisements were displayed on the Newsfeed of users who were 1) located in Canada; 2) 18 years or older; and 3) Parents of a child aged 0 to 15 years. Users who clicked on the advertisement were re-directed to a secure online survey website, which contained details on the study, eligibility criteria and informed consent. The survey automatically terminated if the respondent did not provide informed consent or did not meet eligibility criteria. Ethical approval was obtained from the University of Toronto’s Office of Research Ethics (REF#29309).

The survey response rate was 22·9% and the survey completion rate was 64·7% with little missing data, resulting in a sample size of 1,097 Canadian parents.

A research company contracted by PHAC collected the population-based RDD sample of Canadian parents through telephone survey. During a period of three weeks in March 2011, attempts to contact Canadian parents were made via RDD to household landlines at least eight times prior to retiring the phone number. Researchers reported a participation rate of 23·4% resulting in a sample size of 1,745 Canadian parents [16].

To be included in this study sample the respondent had to: 1) be over 18 years of age; 2) have at least one child under 18 years; 3) reside in Canada; 4) be able to respond to questions in English or French, and 5) have responded to one of the two online or RDD surveys. Both surveys contained questions on respondent demographics, and knowledge, awareness, attitudes and behaviours related to immunization.

Primary Exposure
Respondents who sought out information on childhood vaccines and reported the Internet as one of their top three sources used for information on vaccines were classified as ‘used the Internet’ and those who do not seek out information on childhood vaccines or do not report the Internet as one of their top three sources were classified as ‘did not use the Internet’.
**Outcome**

Respondent perception on vaccine safety was measured as an ordinal variable from 1-7: (1) ‘Not at all safe’, to (4) ‘Moderately safe’, and (7) ‘Extremely safe’.

**Potential confounders**

Hypothesized confounders include parental education level and income, parental age and sex, age of youngest child, number of children, place or residence and the relative importance of the Internet relative to the importance of family, friends and/or a health care professional as sources of information. Education level was measured according to four levels: High school or less, trade or vocational school, some university, and bachelors/graduate degree/professional certification. Household income level was measured in $10,000 increments ranging from under $30,000 to $120,000 and categorized into four levels (under $30,000, $30,000 – $59,999, $60,000 - $99,000, and over $100,000) in order for sufficient sample size in each category and to make comparisons among intermediary groups from lowest to highest income. Parental age was measured as continuous (years) in the online survey and as categorical variable in the RDD survey (under 30 yrs, 30-34 yrs, 35-39 yrs, 40-44 yrs and 45 yrs and older). Age of youngest child was measured as continuous (years), and the number of children was measured as categorical (1, 2, 3, 4, 5, and 6 or more) in the online survey and as continuous in the RDD survey. The perceived reliability of the Internet relative to family, friends, or health care professionals were classified as (1) ‘reported as most reliable and trustworthy source on vaccines’ to (4) ‘not reported in respondent’s top three choices as a reliable source of information on vaccines’. Place of residence was categorized into 6 regions due to low numbers and to reflect the regions reported in the RDD data: British Columbia, Alberta, Saskatchewan or Manitoba, Ontario, Québec, and Atlantic or Territories.

**Statistical analysis**

Univariate ordinal logistic regression was used to assess associations between each variable and the outcome, respondent perception of vaccine safety. For categorical variables, the largest category size was chosen as the reference category [17]. Multivariate ordinal logistic regression modeling was used to assess the association between Internet use and respondent perception of vaccine safety. The regression modeled the cumulative odds of perceiving vaccines as ‘Not Safe’. The purposeful selection algorithm, as proposed by Hosmer and Lemeshow [18], was
utilized to select covariates to retain in the final predictive models. The method uses purposeful variable entry and retention parameters that retain significant covariates but also important confounding variables [18,19]. All variables significant at $P \leq 0.25$ were included in the multivariate analyses as more traditional levels such as 0.05 can miss important confounding variables [20]. Interaction terms of all possible two-way interaction terms were tested against a reduced model using the likelihood ratio test (LRT), and in the first analysis all interaction terms were considered for removal from the model as a block and contrasted against the model with all of the main effects but without interaction terms [21]. Covariates were removed from the multivariate model if they were not statistically significant at the 0.1 alpha level and not a confounder. Confounding was measured as a 15% or greater change in the parameter estimate of our main association in the reduced model compared to the full model [18]. Purposeful entry and retention parameters, including the choice of the 15% change-in-parameter-estimate criterion, were utilized due to the lack of prior information on known confounders for the investigated association [22]. At the end of this iterative process, any variable not entered into the original full model was added back in one at a time, to further assess confounding [18]. This step can help to identify confounders that may not have been significant independently, yet make an important contribution in the presence of other variables [19]. Model diagnostics were performed to rule out multi-collinearity among covariates, to test for departure from linearity, and to examine the effect of influential observations and variables on our final models. The score test for the proportional odds assumption can be over conservative with large sample sizes or in multivariate analyses, thus the proportional odds assumption was tested by comparing the cumulative odds ratios (ORs) in a series of six binary logistic models [23]. The assumption held as the ORs were all in the same direction and of approximately similar magnitude [23]. Conducting binary logistic regression with a dichotomized outcome variable further validated models: not safe to moderately safe (levels 1-4) and safe to extremely safe (levels 5-7). Pearson and Deviance goodness-of-fit statistics (and the Hosmer-Lemeshow test for the binary models) assessed model fit [17]. Although multivariate analyses using non-weighted data produced similar results, Complex Sampling procedures available in SAS version 9.3 were utilized for descriptive and multivariate analyses of the RDD data to reflect the complex survey design and population weights. The data analysis for this paper was conducted using SAS Version 9.3 (SAS Institute Inc., Cary, NC, USA).
Results

Descriptive statistics

Both samples had similar education and income level distributions with almost half of the respondents completing some level of higher education [24], and the majority being close to or above the 2012 median total household income of $74,240 for Canadian families [25] (Table 1). In the online sample, approximately half of respondents reported higher education with a university degree or professional certification, and almost 40% reported an income over $100,000 (39%), followed by 36% reporting an income of $60,000 to $99,999. In the population-based RDD sample, approximately 40% of respondents reported a bachelor’s degree or higher, and almost 35% reported an income over $100,000 (34%), followed by 32% reporting an income of $60,000 to $99,999. The distribution on place of residency was similar in both samples, however the online sample had a lower proportion of Quebec residents (10.9% vs. 24.5%) and a higher proportion of Alberta residents (23.6% vs. 11.5%). In both samples more than 30% of the respondents were Ontario residents, which corresponds to the Canadian geographic distribution as it is estimated that 38.7% of Canadians reside in Ontario [26]. There were noted differences in the distributions of parental age and sex, and age of youngest child in the two samples. In the online sample, the mean age of respondents was 32 years and the median age of their youngest child was 2 years.

The majority of respondents (69%) were under the age of 35 years, female (93%) and reported two or less children (82%). In the population-based RDD survey, the majority of respondents (63%) were 40 years or older and the mean age of their youngest child was 8.3 years. In addition, forty percent were male and the median number of children per respondent was two. For both data sources approximately 25% of the respondents reported the Internet to be a reliable source for information on vaccines or vaccination, and approximately 40% reported using the Internet to search for information on vaccines. In terms of perception on safety of childhood immunizations, 27% of the online survey respondents and 19% of the RDD survey respondents reported childhood immunizations as not at all safe to moderately safe. A significant linear trend (Cochrane Armitage Tests for Trend p<0.05) was found between looking for information on the Internet and perception of risk of childhood immunizations for both data sources (Figure 2).
**Multivariable analysis**

**Online survey data**
Complete data were available for 966 respondents. The variables sex of parent and age of youngest child were removed from the multivariate analysis due to non-significance in bivariate analyses (P>0.25). Multi-collinearity was not present and no interactions terms were retained due to non-significance of the LRT between the model with all possible covariates and two-way interaction terms and the reduced model without interaction terms (p>0.2). Thus, ordinal logistic regression was performed with the following full model: Internet use, education level, income level, age of parent, age of youngest child, region and reliability of the Internet. Non-significant variables (education level, number of children, and income level) were tested for potential confounding with only income level being retained in the model due to a significant change (26%) in the predictor’s estimate compared to the full model excluding education level and number of children. Originally excluded variables (sex of parent and age of youngest child) were individually re-entered into the model and were not found to be significant confounders. The covariates income level, Internet reliability, age of parent and regions of residence remained in the final model (Table 2). After adjusting for income level, Internet reliability, age of parent and region, the odds of perceiving vaccines as less safe rather than safe are 1.6 times higher (95% CI: 1.3 - 2.1) for parents who use the Internet to search for vaccinate information compared to parents who do not search the Internet (Table 3). Chi-square statistics (Deviance p>0.10; Pearson p>0.10) indicated model fit. Binary logistic regression produced similar estimates and precision (OR= 1.6; 95% CI= 1.1-2.3), and good model fit (Hosmer and Lemeshow P>0.10).

**Population-based RDD data**
Complete data were available for 951 RDD respondents. The variables sex of parent and income level were removed from the multivariate analysis due to non-significance in bivariate analyses (P>0.25). Multicollinearity was not present and all interactions terms were removed from the model. No interactions terms were retained due to non-significance of the LRT between the model with all possible covariates and two-way interaction terms and the reduced model without interaction terms (p>0.10). Thus, ordinal logistic regression was performed with the following full model: education level, age group of parent, age of youngest child, number of kids,
region and reliability of the Internet. Non-significant variables in the full model (education level, number of children, age of youngest child and age group of parent) were tested for potential confounding with only age group of parent being retained in the model due to a significant change (21.7%) in the predictor’s estimate compared to the full model excluding education level, number of children and age of youngest child. All originally excluded variables (sex of parent and income level) were individually re-entered into the reduced model to check for confounding, and income level was then retained in the final model due to a significant change (16%) of the predictor’s estimate. (Table 2). After adjusting for income level, Internet reliability, age of parent and region, the odds of perceiving vaccines as less safe rather than safe are 2.0 times higher (95% CI: 1.6-2.5) for parents who use the Internet to search for vaccination information compared to parents who do not search the Internet. (Table 3). Chi-square statistics (Deviance p>0.10; Pearson p>0.10) indicated model fit. Binary logistic regression produced similar estimates and precision (OR = 2.2; 95% CI= 1.5 – 3.1), and good model fit (Hosmer and Lemeshow p>0.10).

Discussion
Although the Internet has been reported as an important influence on parental perception of risk on childhood immunizations, to our knowledge no study has quantified the association between seeking vaccine information online and perception on safety of childhood immunizations among Canadian parents. This study utilized two different data sources on Canadian parents, sampled via different methods and at different times. The findings from both data sources confirm the assumed relationship between Internet use and perception of risk on vaccine safety, with both samples revealing higher likelihood of perceiving vaccines as ‘Not safe’ in parents who used the Internet to search for information on vaccines compared to parents who did not use the Internet for vaccine information. These results are consistent with a before and after Internet-experiment study where participants exposed to short searches on vaccine critical websites reported an increase perceived risk of vaccinating [27]. Due to incomplete and unreliable data, our study could not account for the reliability of the websites parents searched or in the web-based communications they were exposed to; however, several studies have shown an abundance of anti-vaccination messaging via Internet searching for information on vaccines [28-31]. In addition, this study did not take into account the respondent’s perception
of risk on vaccine safety prior to the Internet search, and if the Internet altered prior perception of risk or acted to support previously held beliefs.

As more people abandon landlines, the validity of traditional population telephone surveys is compromised with low response rates and potentially non-representative samples. This is evidenced by the RDD sample that primarily reached older parents (over 40) with older children. Representativeness and validity concerns are also relevant for online surveys as research relies on the collection of self-reported data by self-selected online participants [32]. Both sampling techniques produced low response rates of 23% which could produce biased samples; however, analysis of the two different samples via two different regression methods produced similar models and conclusions indicating the results were likely not due to chance. In addition, the intent of the study was not to generalize the results to Canadian parents but to have sufficient power to examine the relationship between the predictor and the outcome.

Current initiatives aiming to reach and influence parents’ decision to vaccinate have not adequately abated the influence of the online anti-vaccination movement. Government organizations currently have an online presence; however, public health has been slow to fully adopt the true nature of social media platforms and communication is often by top-down dissemination of information [13,33]. However, studies have shown that health communication in the form of stories or testimonials are important influences on risk perception [27,34]. As evidenced in this study, using the Internet for vaccination information and the relative importance of the Internet as a trustworthy and reliable source are important factors in individual perception of vaccine safety. The evidence provided here suggests the need for increased efforts in online interventions that promote confidence in immunization. In Canada, search terms of ‘vaccine’, ‘vaccination’ and ‘immunization’ via Google will produce more pro-vaccination websites than anti-vaccination [14] and lead to highly placed sites with significant authority. However, these sites do not meet user expectation of more complex interaction tools and engagement. In addition, trusted authorities could work with other popular websites and platforms (such as “Mommy blogs”) to provide information supportive of immunization. Health authorities need to tackle the negative influence of online vaccine information or communications, and better utilize social media for positive communication to reach and influence vaccine hesitant Canadian parents searching for information online. The Internet has
become an important risk factor for vaccine hesitancy, with exposure nearly doubling the risk that parents will question the value of immunization. Action needs to be taken to mitigate this risk.

**Figure 1. Conceptual model on the association between using the Internet to search for information on vaccinations and parental perception on safety of vaccinations.**

### Table 1. Characteristics of both study samples

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Online Survey (N=1,097)</th>
<th>Population-based RDD Survey, (N=1,745)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Standard Error (SE)</td>
</tr>
<tr>
<td>Age of Parent (years)</td>
<td>32.24</td>
<td>6.69</td>
</tr>
<tr>
<td>Age of Youngest Child (years)</td>
<td>2.5</td>
<td>3.78</td>
</tr>
<tr>
<td>Number of Children</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Age Group of Parent (years)</td>
<td>Missing n= 5</td>
<td></td>
</tr>
<tr>
<td>Under 30</td>
<td>395</td>
<td>36.17</td>
</tr>
<tr>
<td>30-34</td>
<td>356</td>
<td>32.60</td>
</tr>
<tr>
<td>35-39</td>
<td>189</td>
<td>17.31</td>
</tr>
<tr>
<td>Age Group</td>
<td>Count</td>
<td>Percentage of Population</td>
</tr>
<tr>
<td>-----------</td>
<td>-------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>40 - 44</td>
<td>96</td>
<td>8.79</td>
</tr>
<tr>
<td>45 +</td>
<td>56</td>
<td>5.13</td>
</tr>
</tbody>
</table>

**Number of Children**

<table>
<thead>
<tr>
<th>Number of Children</th>
<th>Count</th>
<th>Percentage of Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td>492</td>
<td>44.85</td>
</tr>
<tr>
<td>Two</td>
<td>402</td>
<td>36.65</td>
</tr>
<tr>
<td>Three</td>
<td>147</td>
<td>13.40</td>
</tr>
<tr>
<td>Four</td>
<td>44</td>
<td>4.01</td>
</tr>
<tr>
<td>Five</td>
<td>5</td>
<td>0.46</td>
</tr>
<tr>
<td>Six or more</td>
<td>7</td>
<td>0.64</td>
</tr>
</tbody>
</table>

**Sex of Parent**

<table>
<thead>
<tr>
<th>Sex of Parent</th>
<th>Count</th>
<th>Percentage of Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>80</td>
<td>7.39</td>
</tr>
<tr>
<td>Female</td>
<td>1003</td>
<td>92.61</td>
</tr>
</tbody>
</table>

**Education Level**

<table>
<thead>
<tr>
<th>Education Level</th>
<th>Count</th>
<th>Percentage of Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>High school or less</td>
<td>172</td>
<td>16.09</td>
</tr>
<tr>
<td>Trade or vocational</td>
<td>286</td>
<td>26.75</td>
</tr>
<tr>
<td>Some university</td>
<td>110</td>
<td>10.29</td>
</tr>
<tr>
<td>Bachelor’s or graduate degree or professional certification</td>
<td>501</td>
<td>46.87</td>
</tr>
</tbody>
</table>

**Household Income Level**

<table>
<thead>
<tr>
<th>Household Income Level</th>
<th>Count</th>
<th>Percentage of Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under $30,000</td>
<td>85</td>
<td>8.63</td>
</tr>
<tr>
<td>$30,000 to $59,999</td>
<td>170</td>
<td>17.26</td>
</tr>
<tr>
<td>$60,000 to $99,999</td>
<td>351</td>
<td>35.63</td>
</tr>
<tr>
<td>Over $100,000</td>
<td>379</td>
<td>38.48</td>
</tr>
</tbody>
</table>

**Region of Residence**

<table>
<thead>
<tr>
<th>Region of Residence</th>
<th>Count</th>
<th>Percentage of Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>British Colombia</td>
<td>160</td>
<td>14.61</td>
</tr>
<tr>
<td>Alberta</td>
<td>259</td>
<td>23.65</td>
</tr>
<tr>
<td>Saskatchewan and Manitoba</td>
<td>137</td>
<td>12.51</td>
</tr>
<tr>
<td>Ontario</td>
<td>336</td>
<td>30.68</td>
</tr>
<tr>
<td>Québec</td>
<td>120</td>
<td>10.96</td>
</tr>
<tr>
<td>Atlantic/Territories</td>
<td>83</td>
<td>7.58</td>
</tr>
</tbody>
</table>

**Use of Internet to Search for Information on Vaccines (exposure)**

<table>
<thead>
<tr>
<th>Use of Internet to Search for Information on Vaccines (exposure)</th>
<th>Count</th>
<th>Percentage of Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Used the Internet</td>
<td>427</td>
<td>39.10</td>
</tr>
<tr>
<td>Did not use the Internet</td>
<td>665</td>
<td>60.90</td>
</tr>
</tbody>
</table>

**Perception on Safety of**

<table>
<thead>
<tr>
<th>Perception on Safety of</th>
<th>Count</th>
<th>Percentage of Population</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

88
### Childhood Immunizations (outcome)

<table>
<thead>
<tr>
<th>Level</th>
<th>Online Survey Data</th>
<th>RDD Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1- Not at all safe</td>
<td>49</td>
<td>43</td>
</tr>
<tr>
<td>2</td>
<td>48</td>
<td>24</td>
</tr>
<tr>
<td>3</td>
<td>64</td>
<td>50</td>
</tr>
<tr>
<td>4- Moderately safe</td>
<td>131</td>
<td>207</td>
</tr>
<tr>
<td>5</td>
<td>134</td>
<td>275</td>
</tr>
<tr>
<td>6</td>
<td>338</td>
<td>500</td>
</tr>
<tr>
<td>7- Extremely safe</td>
<td>327</td>
<td>630</td>
</tr>
</tbody>
</table>

### Perceived Reliability of Internet Relative to Family/Friends/Health Care/Other

<table>
<thead>
<tr>
<th>Level</th>
<th>Online Survey Data</th>
<th>RDD Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most reliable</td>
<td>64</td>
<td>149</td>
</tr>
<tr>
<td>Second most reliable</td>
<td>97</td>
<td>282</td>
</tr>
<tr>
<td>Third most reliable</td>
<td>123</td>
<td>30</td>
</tr>
<tr>
<td>Not in top three choices</td>
<td>805</td>
<td>1247</td>
</tr>
</tbody>
</table>

Figure 2. Perception of risk of childhood immunizations in parents who used the Internet to search for information on immunizations (N= 1,086 Online Survey Data \(^a\); N= 1,713 RDD data \(^b\))

\(^a\) 11 respondents not included due to missing data

\(^b\) 32 respondents not included due to missing data
Table 2. Adjusted cumulative odds ratios of proportional odds logistic regression analysis for the association between parental Internet use to search for information on immunizations and parental perception on safety of childhood immunizations.

<table>
<thead>
<tr>
<th>Predictor of interest</th>
<th>Online Survey (N= 966)</th>
<th>Population-based RDD Survey (N=951)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cumulative OR</td>
<td>95% Confidence Interval</td>
</tr>
<tr>
<td>Use of the Internet</td>
<td>1.61</td>
<td>1.25 – 2.09</td>
</tr>
<tr>
<td>Did not use the Internet</td>
<td>1.00</td>
<td>Reference</td>
</tr>
<tr>
<td><strong>Confounders</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Income Level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under $30,000</td>
<td>1.42</td>
<td>0.91 – 2.21</td>
</tr>
<tr>
<td>$30,000 to $59,999</td>
<td>1.67</td>
<td>1.20 – 2.33</td>
</tr>
<tr>
<td>$60,000 to $99,999</td>
<td>1.23</td>
<td>0.94 – 1.62</td>
</tr>
<tr>
<td>Over $100,000</td>
<td>1.00</td>
<td>Reference</td>
</tr>
<tr>
<td>Perceived Internet Reliability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Most reliable</td>
<td>4.77</td>
<td>2.88 – 7.91</td>
</tr>
<tr>
<td>Second most reliable</td>
<td>3.96</td>
<td>2.58 – 6.07</td>
</tr>
<tr>
<td>Third most reliable</td>
<td>1.12</td>
<td>0.78 – 1.62</td>
</tr>
<tr>
<td>Not in top three choices</td>
<td>1.00</td>
<td>Reference</td>
</tr>
<tr>
<td>Age of Parent (continuous)</td>
<td>0.98</td>
<td>0.96 – 0.99</td>
</tr>
<tr>
<td>Age of Parent (categorical)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under 30</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>30-34</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>35-39</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>40 - 44</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>45 +</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Region of Residence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>British Colombia</td>
<td>0.93</td>
<td>0.65 – 1.33</td>
</tr>
<tr>
<td>Alberta</td>
<td>0.77</td>
<td>0.56 – 1.06</td>
</tr>
<tr>
<td>Saskatchewan and Manitoba</td>
<td>0.64</td>
<td>0.43 – 0.95</td>
</tr>
<tr>
<td>Ontario</td>
<td>1.0</td>
<td>Reference</td>
</tr>
<tr>
<td>Québec</td>
<td>1.89</td>
<td>1.27 – 2.83</td>
</tr>
<tr>
<td>Atlantic/Territories</td>
<td>1.00</td>
<td>0.63 – 1.60</td>
</tr>
</tbody>
</table>
Table 3. Results of adjusted main effects for the ordinal logistic regression analysis on the multivariate model for the association between parental Internet use to search for information on vaccines and parental perception on safety of childhood immunizations.

<table>
<thead>
<tr>
<th>Main Effect</th>
<th>Online Survey (N=966)</th>
<th>Population-based RDD Survey (N=951)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cumulative OR</td>
<td>95% CI</td>
</tr>
<tr>
<td>Used the Internet (Reference= Did not use the Internet)</td>
<td>1.6</td>
<td>1.3 – 2.1</td>
</tr>
</tbody>
</table>
Abbreviations
CI confidence interval
RDD random digit dialing
MMR measles/mumps/rubella
OR(s) odds ratio(s)
PHAC Public Health Agency of Canada
SE standard error
VPD vaccine preventable disease

Source of Funding
Funding for this research was provided by Public Health Ontario, Toronto, ON, Canada and the Dalla Lana School of Public Health, Toronto, ON, Canada.

Conflicts of Interest
None
References


A content analysis of user-driven comments on a Facebook advertisement recruiting Canadian parents in a study on immunization

Jordan Tustin\textsuperscript{1, 2}, Natasha S Crowcroft\textsuperscript{1, 3, 4}, Dionne Gesink\textsuperscript{1}, Ian Johnson\textsuperscript{1, 3}, Jennifer Keelan, Barbara Lachapelle\textsuperscript{5}

\textsuperscript{1} Dalla Lana School of Public Health, University of Toronto, Toronto, Ontario, Canada
\textsuperscript{2} Ryerson University, School of Occupational and Public Health, Toronto, Ontario, Canada
\textsuperscript{3} Public Health Ontario, Toronto, Ontario, Canada
\textsuperscript{4} Laboratory Medicine and Pathobiology, University of Toronto, Toronto, Ontario, Canada
\textsuperscript{5} Toronto Public Health, Toronto, Ontario, Canada

Abstract

Our objective was to understand the sentiments and themes behind online debates on immunization. We analyzed 117 user-driven comments on immunization posted on a Facebook advertisement targeting Canadian parents for recruitment into a larger study on immunization. Two raters coded all comments using thematic analysis. Out of 117 comments, 85 were unique commentators with the majority being female (76.5%). Most of the messages were positive (43.6%), followed by negative (35.0%), ambiguous (17.1%), and hesitant (4.3%). Inaccurate knowledge (20.8%) and misperceptions of risk (18.0%) were most prevalent in the non-positive comments. Other claims included distrust of pharmaceutical industry/government (14.6%), distrust of the health care system/providers (11.5%) and past negative experiences with vaccination (7.7%). Almost 40% of the positive comments communicated the risks of not
vaccinating, followed by judgments on the knowledge level of non-vaccinators (17.6%). Ten positive comments (13.5%) specifically refuted the link between autism and immunization. The large number of unsolicited user-driven comments on a platform not intended for discussion nor providing any information on immunization illustrates the strong sentiments associated with immunization, and the arbitrariness of the online platforms used for immunization debates. Health authorities should be more pro-active in refuting misinformation and misperceptions currently propagating uncontested online. Online debates and communications on immunization need to be identified by continuous monitoring in order for health authorities to understand the current themes and trends, and to engage in the discussion.

**Keywords: Facebook, immunization, anti-vaccination, social media**
Introduction

The World Health Organization and its group of experts have identified vaccine hesitancy as an important issue facing immunization programs in the developed world [1]. There are many factors influencing vaccine hesitancy; however, the role of the Internet due to the abundance of online anti-vaccination sentiment and activists has been reported as an important concern [2-5]. More people are searching for health information online, including information on immunization [6,7]. Health professionals are concerned that parents seeking vaccine information online are being exposed to misinformation and anti-vaccine sentiment via websites and online communications on social media platforms [5,8-10]. Over the past decade, social media sites have gained popularity in Canada, where 67% of Canadian Internet users are using social media on a daily basis [7] with the majority of users under the age of 35 years [11]. Health information communicated in interactive platforms is of questionable accuracy as it is often exchanged without the participation of health professionals or health organizations [8,12]. This exchange of misinformation online has the potential to influence parents’ decision to vaccinate their children [13,14] and may be contributing to suboptimal vaccine coverage among Canadian children [15] and increases in vaccine preventable disease rates [16-18].

Studies analyzing the content of anti-vaccination websites or platforms have identified themes such as vaccine safety and effectiveness, alternative medicine, civil liberties, conspiracy theories, morality and misinformation as the predominant arguments in the anti-vaccine movement [4,19]. Techniques such as skewing science, shifting hypotheses and attacking critics have been reported as tactics of the online anti-vaccination community arguing against vaccination [5]. A content analysis of an online measles-mumps-rubella (MMR) immunization debate reported that one third of the participants were critical of the vaccine with the risk of adverse effects and...
autism, and concerns with vaccine ingredients as the major themes [12]. Themes underlying vaccine hesitancy can change over time and by place [20], therefore as coverage rates remain suboptimal in Canada and if outbreaks of VPDs become more prevalent, it is critical that we continue to build on previous research by analyzing themes in anti-vaccination arguments. This will help the public health community to actively counter negative content and increase coverage rates. Furthermore, there is a need to better understand vaccine sentiments of Canadian parents.

From December 12, 2013 to January 11, 2014 we posted six different Facebook advertisements linked to an online survey on childhood immunizations to the Facebook ‘Newsfeeds’ of Canadian parents as part of a larger research study (Tustin et al., unpublished results). The advertisements targeted English and French speaking Canadian parents who had at least one child under the age of 18 years, and were not posted, liked, or promoted by the researchers. The ‘Comments’ section of the advertisements was accessible and users posted comments on immunization to the two most viewed advertisements (Figure 1). Our objective is to summarize the qualitative content of an online immunization debate of Facebook users who commented on our posted advertisements, in order to better understand the vaccination debate and to identify underlying themes within the group of commentators. The results will assist health professionals in understanding some of the content on vaccine information being shared online in order to help guide messaging and the development of online interventions. The study aims to quantify and describe the main vaccination sentiments and themes in an unsolicited online debate on immunization. We will accomplish this by answering two questions: 1) what are the main vaccination sentiments (e.g. anti- or pro-vaccination) in the online debate? 2) what are the main themes of the reported by type of sentiment?
Methods

In this study, we qualitatively analyzed and quantified the content of open-ended comments by Facebook users. On January 11, 2014, all user comments posted in the ‘Comments’ section of the Facebook advertisements were captured. We included all comments in French or English that contained any message on immunization or the online survey.

Data extraction

We extracted information on the type of message and the sex of the user. We measured user interaction by the number of ‘likes’ for specific comments. Commentators either simply made comments or provided a link to vaccine information online. Thus, we classified the type of comment as ‘comment only’, ‘comment with link to accurate information and/or trustworthy source’, ‘comment with link to inaccurate information and/or non-trustworthy source’.

Trustworthy sources included links to government or reputable associations and/or scientists, and accurate information was classified as websites with information and/or statistics from government sources or peer-reviewed studies. Remaining links were classified as non-trustworthy and/or inaccurate. We determined the sex of the commentator by using the user’s name, photo and/or comment. Sex was classified as ‘not clear’ if there was any uncertainty.

Data analysis

We determined the main message of the comments as ‘positive’, ‘negative’, ‘hesitant’, or ‘ambiguous’. Comments were categorized as positive if the central message supported immunizations, portraying it positively (e.g. describing benefits and/or safety of immunization, promoting immunizations, describing the risks of not vaccinating or low risk of vaccinating) [21]. We categorized comments as negative if the central message portrayed immunization
negatively (e.g. emphasizing risk of immunization, advocating against immunizing, promoting distrust in vaccine science, making allegations of conspiracy or collusion) [21]. If the central message portrayed indecision/uncertainty on the risks or benefits of immunization (e.g. questions/concerns about risk or safety, requests for information or links, questions re others decision to vaccinate), the comments were classified as hesitant. The main message was classified as ‘ambiguous’ if it was not clear. Two raters independently classified the comments and resolved any differences to reach 100% consensus. We then used two separate coding schemes to sub-classify the content of the negative/hesitant/ambiguous comments and the positive comments.

Negative, hesitant and ambiguous comments were categorized based on the themes of determinants of vaccine hesitancy suggested by the World Health Organization’s Strategic Advisory Group of Experts Working Group (SAGE WG) on Immunization [20,22]. The SAGE WG matrix organizes vaccine sentiment around three domains: contextual influences such as socio-economic barriers, mistrust in the pharmaceutical industry or religious values; individual/social group influences such as personal knowledge or perceptions of risk; and vaccination and vaccination specific issues such as the vaccination schedule or characteristics of the vaccine [20,22,23]. The SAGE WG matrix was chosen as the coding framework as it was developed by experts to include all known and potential determinants of vaccine hesitancy based on a thorough systematic review and expert opinion [20,22]. Any claims not covered by the SAGE WG matrix were extracted by two raters (J.T. and B.L) and later categorized within an ‘Other’ category [24].
The SAGE WG framework did not accurately capture the themes in the positive comments, thus the positive comments were categorized based on broad themes in the data with the final coding scheme developed by both raters [24]. No new codes arose after approximately 40% of the comments were assessed. Two raters independently coded all comments with a high level of agreement (percent agreement >95%). Discrepancies were resolved via consensus to reach 100% agreement. Raters conducted content analysis with QSR International’s NVivo 10 qualitative data analysis software. We calculated descriptive statistics using Microsoft ® Office Excel ® 2007 to summarize the proportion of comments within each category.

Results

Respondent characteristics, main messages and user interaction

The advertisements generated 117 comments by 85 unique Facebook users after excluding 9 comments not meeting the inclusion criteria. Out of the 85 commentators 76.5% were female, 14.1% male and for 9.4% the gender was not clear. The majority posted comments only (87.1%), and approximately 10% posted comments with links to websites. Out of the 14 website links, one linked to a trustworthy source with accurate information (a government website with official statistics) and one linked to an online news story with accurate information posted from a government source. The main message of 51 comments (43.6%) was positive, followed by 41 (35.0%) negative, 20 (17.1%) ambiguous and 5 (4.3%) hesitant. Comments with the most interaction (20 or more ‘likes’) had mostly positive main messages (n=8) and one negative. The redacted positive comments below had the most user interaction (43 and 40 ‘likes’ respectively) and highlighted the most predominant theme within the positive comments: the benefits of vaccines versus the risk for children and/or others in becoming infected with the disease. In
addition, the two other most identified themes are represented within the comments: parents who do not vaccinate are uneducated, and vaccines do not cause autism.

‘Vaccinating your children is the best way to prevent them (and others) from getting viruses and diseases....you are essentially protecting them from the awful signs and symptoms of the disease....the benefits out way the risks. Why do you think small pox was eradicated? Bc enough people around the world got the vaccine for it and it had no one to spread to, therefore: eradicated!!! There is NOT as many people unvaccinated as vaccinated, 80% of the population vaccinate their children... that # is decreasing bc of people’s lack of knowledge.... ...Your[sic] not idiots for not vaccinating your children you are just uneducated about biomedical facts!’

‘What about the infants and people who are immuno-compromised who CANT [sic] vaccinate? They depend on those people who CAN vaccinate to be protected and not spread these things!! I have a child with autism, and do NOT believe vaccines have ANYTHING to do with it! That has been disproven!’

Lack of knowledge/awareness was the most prevalent theme in the negative comments, as evidenced by the misinformation and misperception on immunity and transmission of disease contained within the following ‘most liked’ (40 ‘likes’) negative redacted comment:
‘If their [sic] was a breakout of tuberculosis, polio.. the vaccinated children would not be amune [sic]! If a vaccine protects you & your children, why... are all the vaccinated children catching it? There is absolutely no evidence that outbreaks start from unvaccinated people! ...Every time there's an outbreak there's as many vaccinated as unvaccinated people catching the disease. There is absolutely no protection from a disease from taking a vaccine!’

Claims made in negative/hesitant/ambiguous comments

Of the 66 negative, hesitant or ambiguous comments, 130 claims were made on factors affecting vaccination decisions and 6 commented on the survey promoted on the Facebook advertisement. Individual/social group influences were the predominant theme in the posted comments. Within this theme, 20.8% of the comments displayed lack of knowledge/awareness on immunization with the majority (81.4%) providing inaccurate information/misperceptions on vaccination and some explicitly stating their belief in the credibility or accuracy of their knowledge and/or research (18.5%). Approximately 18% of the comments revealed low perception of the risk of disease and need for the vaccine and/or high perception of risk of adverse events associated with vaccination. Other important individual/group influences included distrust in the health system or health care providers (11.5%) and negative past experiences with vaccinations (7.7%). Mistrust of pharmaceutical companies and/or governmental transparency was the most reported (13.8%) contextual influence. Four percent of the comments had vaccine/vaccination specific issues: 2.3% reported their health professionals recommending against vaccination and 1.3 % reported concerns with the vaccination schedule (1.3%) (Table 1).
Claims made in positive comments

Of the 51 positive comments (and 2 hesitant comments with positive claims) 74 claims were identified on factors affecting vaccination decisions. The majority (39.2%) of the positive comments stated concerns over non-vaccinating parents putting their children and others at risk of disease and death and/or stated how the benefits outweigh the potential risks, followed by claims that non-vaccinating parents are uneducated, unintelligent and/or selfish (17.6%). Commentators also provided advice on where to get informed (16.2%) by suggesting the advice of health care professionals and trustworthy sources. Several comments (13.5%) aimed to debunk the myth of any link between vaccines and autism specifically. Other comments encouraged others to vaccinate or stated they are pro-vaccine (13.5%).

Discussion

The majority of comments were clearly pro- (43.6%) or anti- (35.0%) vaccination with few comments vocalizing vaccine hesitancy (4.3%). Themes in the online debate followed those identified in the literature and captured in the SAGE model [20]. As reported in other studies analyzing online vaccination messages [19,20,25], information in the negative comments was often inaccurate and the risks of immunization were misperceived. Mistrust in the pharmaceutical industry, the government, and health system was also a recurring theme in the online debate and previously identified as an important theme in studies analyzing vaccine critical websites [4,12,19]. The right to choose without being judged was expressed within many non-positive comments. This theme could have emerged in response to several judgments made within the positive comments on the level of intelligence or education of non-vaccinators. However the theme of civil liberties or ‘parents’ right to choose’ has been reported in previous studies analyzing vaccine opposition website content [4, 19, 25]. Slightly more positive
comments were posted than negative or hesitant, and positive comments received the most interaction. Although the majority of the positive comments did not provide any links or obvious information from health authorities, there was encouragement to seek out trusted sources and/or people. No commentator self-identified as a health professional indicating a possible lack of online monitoring, and/or engagement, or self-identification. The debate also highlighted the persistence of the myth linking vaccines to autism. This persistent inaccuracy on the safety of the MMR vaccines was also reported by Seeman et al. in an online survey of Canadian parents [26] and by Nicholson and Leask’s (2012) analysis of an online MMR debate [12].

As the advertisements were targeted to Canadian parents, the majority of the commentators likely represented this demographic. Most of the commentators were female, however this was expected as the Facebook campaign biased the advertisement reach toward a female population (Tustin et al., unpublished results). The two advertisements reached over 100,000 Canadian parents on Facebook (Tustin et al., unpublished results), thus the posted comments would have been visible to other targeted and potentially vaccine-hesitant Canadian parents who chose not to respond, as well as an unknown number of individuals not targeted by the campaign. These online debates should be of concern to public health authorities as the spread of misinformation and misperceptions can reach large audiences with the potential to negatively influence vaccine hesitant and/or pro-vaccine individuals [13].

In addition, the analysis of the online debate revealed the lack of knowledge and spread of misinformation on a platform not intended to solicit discussion. Currently, the presence of public health authorities online is limited to top-down dissemination of information with limited
engagement in online debates. This lack of public health expertise and involvement online has the potential to enable the unabated spread of anti-vaccination sentiment and misinformation that potentially affect vaccination decisions among hesitant and/or pro-vaccine Canadian parents.

Identified themes such as the perceived risk of adverse events versus the risk of disease, and misinformation on autism and other disorders, immunity, and vaccine ingredients, could be addressed with more communication messages tailored to the issues in the online discussions. Although some anti-vaccine activists may never be swayed by evidence, it is important for health authorities to provide information to those with genuine concerns or questions, and engage in online debates rapidly in a non-judgmental and transparent manner. Passive interventions such as increasing knowledge or reminder-recalls have been shown to be the least effective in addressing vaccine hesitancy [27], and there is a need for more dialogue-based approaches targeted to specific sub-populations with an intended focus on social networks [27]. However, communication strategies via social media are still not well understood and caution must be used to prevent legitimizing vaccine hesitancy [28]. Social media can be an important communication tool for public health, however the content of online debates needs to be better monitored to identify the predominant themes, the type of misinformation or misperceptions, and specific requests for information [28,29]. This study adds to this body of research and highlights the major themes in one online debate, as well as the need for ongoing monitoring due to the extent of misinformation being shared.

Although online monitoring is essential, we need to better understand who should be engaging online to rebut misinformation and spread accurate and scientifically valid information on
immunization. Mistrust in health care professionals and the government has been reported as an important determinant in vaccine hesitancy [20,30,31], thus alternate spokespeople (e.g. influential mommy bloggers or celebrities) may need to be considered. Further research is needed to determine the extent of public health involvement, and what interventions and/or messaging would have the most impact. Furthermore, health authorities and researchers should consider the ethical implications of non-engagement when using interactive online platforms for public health communications and/or interventions.

This study is limited in that the analysis is of one online debate and not necessarily representative of the main themes in all online immunization debates. The themes underlying vaccine hesitancy can be context-specific, varying across time, place and/or vaccine [20]. Thus, it is imperative the online conversation is continually monitored in order to identify current themes and trends to tailor public health communications on vaccination. The large number of comments posted on advertisements not intended as a discussion forum illustrates not only the strong sentiments associated with immunization but also the arbitrariness of platforms used for online debates. The random nature of online debates will present a challenge for health authorities in terms of monitoring and engagement. Monitoring will need to include data mining with algorithms for key words on immunization to quickly identify and engage in all public online communications on immunization. Health authorities need to identify methods to better leverage online platforms and networks in order to build trust, increase knowledge and/or access to information, and contest misinformation and misperceptions.
Figure 1. Facebook advertisements posted to Canadian parents’ Newsfeeds from December 12, 2013 to January 11, 2014
Table 1. Claims made in negative/hesitant/ambiguous comments posted by Facebook users on Facebook advertisements, N=130

<table>
<thead>
<tr>
<th>Claims</th>
<th>N</th>
<th>%</th>
<th>Examples of Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Contextual Influences</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mistrust in pharmaceutical industry/Government transparency</td>
<td>19</td>
<td>14.6</td>
<td>‘...Pharma wanna [sic] make money... Bottom line is that vaccination is all about $$$$$...’&lt;br&gt;‘...The chances of your child dying from these diseases is highly unlikely. There is SO much gov involvement. ..’</td>
</tr>
<tr>
<td>Religious values</td>
<td>1</td>
<td>0.8</td>
<td>‘I come from a Mennonite background where we were not vaccinated.’</td>
</tr>
<tr>
<td><strong>Individual and Group Influences</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lack of knowledge or awareness</td>
<td>85</td>
<td>65.4</td>
<td>‘Lmao the courts admitted to vaccines causing autism.. But they did it quietly! If I find the article I will post it on here ..I do not vaccinate my children and never will..liquid mercury is metal you are injecting into your children...’&lt;br&gt;‘...The argument that an epidemic would break out if children were not vaccinated is proven incorrect by every Amish/Mennonite community that is thriving today.’&lt;br&gt;‘Recent studies have shown startling evidence that links autism directly to vaccines along with decreased brain function. If you would like sources to this I can provide them’&lt;br&gt;‘All sorts of diseases have been directly linked to vaccines including and especially autism...I hope wise people everywhere choose to educate themselves before making this decision.&lt;br&gt;‘From my observations, limited as they are, the immunized ones tend to be the ones lacking basic immunity.’</td>
</tr>
<tr>
<td>Risk/benefit of vaccination (perceived, heuristic)</td>
<td>23</td>
<td>17.7</td>
<td>‘...so in my opinion he still would have a chance of getting these illnesses if I vaccinated him so I don’t see the point in giving him something that WILL harm him for a CHANCE that he might not get sick...’</td>
</tr>
</tbody>
</table>
‘...There are some vaccinations that (my) children will not get (like chicken pox) as I think it is an unnecessary risk...’

‘...There is absolutely no protection from a disease from taking a vaccine! But there are many people who die from vaccines every year!...’

...Don't fool yourself. EVERY TIME you vaccinate there is a risk, even of death. It is up to you to decide if that risk is what is right for your child. For some children it might be worth it, but for other children it isn't worth it...There are risks and there are children that are much better off without vaccines.,,

<table>
<thead>
<tr>
<th>Health system and providers (trust and personal experience)</th>
<th>15</th>
<th>11.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Ask your doctor?! No Doctor is God. They are all trained to say the same thing. The truth is none of us know the truth’.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘Any health care professional will side with pro vaccine idea. I will not vaccinate my son. Do you even know what your injecting in your kid?...’</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Beliefs, attitudes about health and prevention</th>
<th>10</th>
<th>7.7</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘My children have needed to see a doc approximately never in their lives. They are a testament to a holistic lifestyle and natural immunity. My observations of most kids that have been vaccinated is that they seem to be endlessly ill and have had multiple courses of antibiotics in their short lives!’</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Experience with past vaccination</th>
<th>10</th>
<th>7.7</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘My son had convulsions after getting vaccinated, that was 19 years ago and no vaccines again.’</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vaccine/Vaccination Specific Issues</th>
<th>5</th>
<th>3.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Role of healthcare professionals</td>
<td>3</td>
<td>2.3</td>
</tr>
<tr>
<td>‘...my paediatrician &amp; general practitioner both disagree with vaccinating...’</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vaccination schedule</td>
<td>2</td>
<td>1.5</td>
</tr>
<tr>
<td>‘None of this 3 in 1... Dangerous injecting 2-4 shots in a kid at one time...’</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other</th>
<th>21</th>
<th>16.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parents right to choose and not be judged</td>
<td>18</td>
<td>13.8</td>
</tr>
<tr>
<td>‘I think every parent has the right to chose what is best for their child. I don't think it's right for other parents or people to judge others for what they decide!!!’</td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘I find it incredibly interesting that so many people are bothered by someone else's choice to vaccinate or not vaccinate. If you get vaccinated, who cares if someone else doesn't, it's not your life....Everyone needs to take a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Requesting information or sources</td>
<td>3</td>
<td>2.3</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>---</td>
<td>-----</td>
</tr>
<tr>
<td>&quot;chill pill...’&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘...Defend your vaccines all you want but don't call us idiots for not taking them!’</td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘Do you have any sources for your input?’</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 2. Claims made in positive comments posted by Facebook users on Facebook advertisements (N=74)\textsuperscript{a}

<table>
<thead>
<tr>
<th>Claims</th>
<th>N</th>
<th>%</th>
<th>Examples of Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vaccines prevent disease-risk/benefit</td>
<td>29</td>
<td>39.2</td>
<td>‘No vaccine is 100% but those vaccinated can fight the illness more effectively. Herd immunity only works when we vaccinate. I wonder if some peoples opinions would change if we lived in a country where vaccination was not common, and these diseases were common.’</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>‘Some parents have chosen to opt out and Polio, Whooping Cough and Diphtheria are recurring. This puts us all at risk. The benefits outweigh the risks. We do not want these diseases to return with a vengeance!’</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>‘...I personally could not live with myself if my child got very sick or died from a preventable disease to which we have access to free immunizations for...’</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>‘...Now of course I vaccinated my kids because they can protect them from death... If they were bad... Or caused autism they would have been out of the market and not given by doctors don’t you think?...’</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>‘...I have 4 kids ranging from 18 to ten months. It’s worth the risk getting vaccinated. I’ve seen what whooping cough and polio do to people. I promise, those who’ve had polio will probably get their kids vaccinated.’</td>
</tr>
<tr>
<td>Parents who do not vaccinate are uneducated/unintelligent</td>
<td>13</td>
<td>17.6</td>
<td>‘...If you’re going to be an idiot and not immunize, at least make sure you’re a well educated idiot...’</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>‘... Wow, it never ceases to amaze me how ignorant and just plain dumb some people are....’</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>‘It's idiots who don't vaccinate their kids that cause outbreaks ... people think that they know more than the medical community.’</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>‘I find people who don’t vaccinate are some of the most uneducated nut jobs....’</td>
</tr>
<tr>
<td>Follow the advice of health care providers and trustworthy sources</td>
<td>12</td>
<td>16.2</td>
<td>‘...get your information from reputable sites ie health canada or the cdc. Stay away from those ’crunchy granola’ opinion- based websites....’</td>
</tr>
</tbody>
</table>
‘...Research does not include google off siting [sic] an article you found on Facebook. These people don’t even know the definition of a peer reviewed research paper or study...and if you can’t tell the difference you should try and trust that the medical professionals who do know…’

‘...everyone should read official statistics and not internet mumbo jumbo. The internet has so much bs that it can make anyone's perception a reality…’

‘...Yup our society rallies around a former porn star/actress looking to continue her 15 minutes of fame instead of putting our trust in our medical and science community... Sad state of society I'd say!...’

<table>
<thead>
<tr>
<th>Vaccines do not cause autism</th>
<th>10</th>
<th>13.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘...Jenny McCarthy made the Hollywood rounds stating her son got autism from his vaccines... Since then it has been proven her son doesn't even have autism nor do vaccines cause autism...’</td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘...I have a child with autism, and do NOT believe vaccines have ANYTHING to do with it! That has been disproven!...’</td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘The jury is not out on autism. The verdict is no link...’</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>I am pro-vaccine or vaccinate</th>
<th>10</th>
<th>13.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Be smart...Vaccinate’</td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘...Myself, I am a believer in vaccinations but that’s just what I believe is right for my kids, ...’</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Two hesitant comments with positive claims were included in the analysis.
References


Chapter 4 - Discussion

4.0 Key Findings

This thesis aimed to explore the use of the Internet in recruiting vaccine hesitant parents, identify determinants of vaccine hesitancy among recruited Canadian parents, and explore the role of the Internet on parental decision-making on childhood immunizations. To accomplish this, I addressed the following aims and associated questions posed in Chapter 1.

Aim 1: Describe the methods used, as well as their strengths and limitations in studying health behaviours via social media platforms

1.1 What are the methods used in studying health behaviours via social media platforms?

The results of my systematic review revealed that until January 2012 there had been limited research using social media platforms to study health behaviours or attitudes toward health behaviours. In the twenty studies reviewed, a wide variety of health behaviours were studied using several different social media platforms including micro blogs (e.g. Twitter), video-sharing sites (e.g. YouTube), and social networking sites (e.g. Facebook). On-line methodologies varied from manual or automated data extraction or content analysis, to on-line surveys and in-depth interviews. Authors chose to research health behaviours/attitudes via social media platforms due to increased access and popularity of social media, the influence of social media on individual health behaviours/attitudes, the potential impact on public health practice, the ability to gather rich, real-time self-reported data from high-risk or stigmatized populations and from individuals previously unreachable via traditional methods, and the ease of data collection and low cost of research compared to the generally labour intensive and high cost of traditional methodologies.

1.2 What are the strengths and limitations of the methods?

Methodological limitations such as the representativeness and validity of data were evident in all studies. Representativeness can be compromised by the lack of sampling frames and information on non-users and non-participatory users of the platform. Furthermore, the platform itself may impose certain logarithms or restrictions that produce bias. Generalizability
is also an issue as none of the reviewed studies could confidently apply their results to the ‘offline’ population. Moreover, the type of populations accessing a particular platform may change over time due to new technologies or changes in popularity. When collecting data via data extraction of public posts, the validity of the data may be in question. The information posted by users was treated as accurate and valid, however it is not known if the information posted was true, or if the displayed health behaviours or intended health behaviours translate into real-life behaviours. Validity is also a concern with online surveys as it may not be possible to prevent multiple responses from the same users. Although this is difficult to prevent in anonymous online surveys, methods exist to minimize this potential threat to validity (112).

Notwithstanding the methodological limitations, the review highlighted the role of social media platforms as novel tools (and perhaps one of our main tools in the future) to gather rich data from targeted populations who may not be accessible via traditional methods or be different from those typically reached via those methods. This review informed the methodology for the Facebook recruitment and online data collection for this thesis; the success and limitations of previous studies helped to guide the choice of social media platform, as well as the recruitment and data collection in terms of methodology to prevent bias and promote study participation. The results of the systematic review were supported by a more recent review conducted by Alshaikh et al. (2014) (26). Alshaikh et al. (2014) found that social networking sites (SNS) are powerful research tools that can reach wide audiences and participants, simplify data collection, and capture good quality data (26). However, self-selection bias, sampling bias, and generalizability issues are important limitations (26).

**Aim 2: Investigate the social media platform Facebook as a tool to recruit vaccine hesitant parents compared to traditional telephone random digit dialing (RDD) and describe their main determinants of vaccine hesitancy**

2.1 *Can we use Facebook to recruit and study vaccine hesitant Canadian parents?*

The results of Chapter 3 (Manuscript 1 – Facebook recruitment of vaccine hesitant parents) show that Facebook was a successful tool for recruiting parents, specifically mothers with young children.
2.1 How does this method compare to telephone RDD methods?

Facebook was superior to traditional RDD methods in reaching vaccine hesitant parents. Facebook recruitment yielded a large sample size (N=1,097) within a short time period and at a much lower cost than RDD recruitment. The research highlighted the potential of social media platforms to complement traditional methodologies in the study of childhood immunizations. Combined, both methods produce the greatest spectrum of respondents, however independently the Facebook campaign recruited more parents with young children at the most important stage of the vaccination process. Furthermore, the online survey was successful with a high completion rate and little missing data.

2.2 What are the main determinants of vaccine hesitancy in the online respondents?

Several vaccine hesitancy determinants were reported; however, the main determinants of vaccine hesitancy in respondents who reported difficulty in the decision to vaccinate were individual/group influences. Specifically, respondents mostly reported lack of knowledge or awareness on childhood immunization due to conflicting and/or contradictory information, and a perception that the risk of vaccine adverse events (including autism) is higher than the risk of acquiring the disease. Respondents also reported pressure from society, family/friends or physicians to vaccinate (or not) as an important influencer. To a lesser extent, some respondents reported vaccine or vaccination specific issues or contextual factors as important determinants. Vaccine or vaccination specific issues included concerns with the vaccine schedule in terms of multiple vaccines or age of vaccination, and with the lack of research or testing of new vaccines. Distrust of the pharmaceutical industry, controversial coverage or fear mongering by the media, and forced vaccination via mandatory vaccination policies in schools were reported as contextual determinants of vaccine hesitancy.

Aim 3: Quantify the association between seeking vaccination information online and Canadian parental perception of risk on childhood immunization

3.1 Is there an association between seeking information online and Canadian parental perception of risk on childhood immunizations?
The results from Chapter 4 (Manuscript 2 - Internet exposure increases parental perception of risk on childhood immunization) revealed a significant association between seeking immunization information on the Internet and perceived safety of childhood immunization for both Facebook-recruited (N= 966) and RDD-recruited Canadian parents (N=951). The analyses on both datasets resulted in the same conclusion with similar effect sizes not significantly different from each other. Thus, along with several modifying factors (income level, age of parent, perceived reliability of the Internet, region of residence), the Internet was an important ‘cue to action’ impacting the perceived risk of vaccination and ultimately the likelihood of behaviour change.

3.1 What is the strength and direction of the association?

For the Facebook-recruited Canadian parents, the odds of perceiving vaccines as less safe rather than safe are 1.6 times higher (95% CI: 1.3 - 2.1) for parents who use the Internet to search for vaccination information compared to parents who do not search the Internet after adjusting for income level, Internet reliability, age of parent and region. For the RDD-recruited Canadian parents, the odds of perceiving vaccines as less safe rather than safe are 2.0 times higher (95% CI: 1.6 -2.5) for parents who use the Internet to search for vaccinate information compared to parents who do not search the Internet after adjusting for income level, Internet reliability, age of parent and region.

Aim 4: Describe the main vaccination sentiments and themes in an unsolicited online debate on immunization

4.1 What are the main vaccine sentiments (e.g. negative/positive/hesitant/ambiguous?)

The results from Chapter 5 (Manuscript 3- A content analysis of user-driven comments on a Facebook advertisement recruiting Canadian parents in a study on immunization) revealed both anti- or pro-vaccination comments, with slightly more pro-vaccination comments, posted in an unsolicited online debate.
5.1 What are the main themes reported by type of sentiment?

The main themes in the non-positive (i.e. negative, ambiguous and hesitant) comments were in the category of individual/group influences specifically inaccurate information posted in the anti-vaccination comments and misperceptions on the risks of immunization. The right to choose without judgment was also expressed within many non-positive comments. Other themes included mistrust in the pharmaceutical industry and/or government transparency, mistrust in the health care system and/or health care providers and past negative experiences with vaccination. The majority of the positive comments communicated the risks of not vaccinating, followed by judgments on the knowledge level of non-vaccinators.

4.1 Potential Methodological Issues/Study Limitations

This section will detail the potential methodological issues in terms of the study designs, data collection, and analysis for all data sources: online and RDD data and extracted online commentary data. The methodological issues will center on the study design and the three most important types of error: 1) Selection bias, 2) Information bias, and 3) Confounding (113,114), as well as issues specific to content analysis of open-ended comments (115).

4.1.1 Cross-sectional Study Design

Temporal bias can occur in cross-sectional studies when information on the exposure and the outcome are collected at the same time and a temporal sequence has not been established (113). Both the primary online data and the secondary RDD data are cross-sectional data collected over the period of one month. This could lead to temporal bias in investigating the association between parents searching for vaccine information online and perception of risk on childhood immunization. Although prospective data collection was explored, I could not feasibly collect the data prospectively due to timeline and budget constraints. Furthermore, the online survey questions were developed to replicate the RDD survey for comparison purposes, thus limiting my ability to establish a temporal sequence in the questionnaire. However, the primary exposure was measured in the online and RDD questionnaires by asking the respondents: ‘Have you ever looked for information about vaccines?’ and ‘If yes, where did you look or whom did you talk to?’ Thus, the exposure happened in the past while the outcome (perception of risk on childhood immunization) was measured at the time of the survey. Nonetheless, due to the lack
of prospective data collection, respondent perception of risk prior to exposure could not be examined and it is possible that the outcome, perception of risk, did not change pre- and post-exposure for some respondents. For example, individuals could have perceived vaccines as not safe before searching for information on the Internet and continued to perceive vaccines as not safe after searching for information on the Internet. Thus, I can establish an association between parents seeking vaccine information online and perception of risk on childhood immunizations, however I cannot establish causality or direction of causality.

The RDD data was collected in March 2011 and the online data was collected during December 2013/January 2014, thus the results represent a specific period in time. The impact of contextual influences such as a change in policies or media coverage on immunization was not taken into account when comparing the data sources. However, respondents were asked about factors influencing vaccination decisions and there was no significant difference in time-related contextual influences reported. To my knowledge, there have been no significant policy changes and although several measles outbreaks have occurred since early 2011, both populations would have been exposed to media coverage. Furthermore, I received similar results in both samples, thus the bias introduced by time-varying contextual influences is likely non-differential.

However, I cannot rule out cohort effects resulting in differences in the vaccine hesitancy indicators between our two samples. Combined, both methods produce the greatest spectrum of respondents; however, the Facebook campaign recruited more parents with young children at the most important stage of the vaccination process. Some of the differences I observed may be due to cohort effects (i.e. different experiences or exposures of a group of subjects as they move through time) since vaccine hesitancy may have been increasing and be more prevalent in the younger parents recruited through Facebook. Moreover, people who start a family at an older age may be different from people who start a family at a younger age. In a cross-sectional design it is difficult to separate the effects of age versus the effects of belonging to a particular cohort.

### 4.1.2 Selection Bias

The most commonly reported limitation in collecting data online is the potential for self-selection bias (26). Self-selection can lead to sampling bias and issues with generalizability and
representativeness. Due to issues with self-selection from online recruitment methods, the online data was not aiming to be representative of the Canadian population but to investigate an online recruited population. Thus, results can only be applied to our sampled online population and not generalizable to the Canadian population. Nonetheless, I had similar results in the online sample as the RDD sample, which was intended to be representative of Canadian parents. As opposed to the RDD sample, the online sample was not successful in recruiting men. Social media platforms may not be the best recruitment method for males as the majority of Canadian social media users are female (116). In addition, several studies have shown that women are more likely to seek health information online (117-119). However, in terms of parental decisions on immunizations, Dubé et al. (2012) found no difference between mothers and fathers on the decision to vaccinate (72). Furthermore, intuitively and via anecdotal evidence, it is conceivable that mothers are most often the primary decision-makers in terms of health decisions for their children. Thus, the impact of over-representing women is likely not a concern. The timing of the advertisement (December) may have affected the type of respondent, however this could not be verified without data from Facebook on who may be more likely to respond at different periods in time.

There were some differences in the provincial distributions between the two samples. The high response from residents of Alberta in the online sample could be the result of higher engagement due to a large measles outbreak in Alberta that occurred in the month before our campaign launch (7). The lower number of Québec responses was surprising as Québec has the second highest Facebook usage next to Ontario (21), experienced a large measles outbreak in 2011 and we specifically targeted French Facebook users. Due to the lower success of our French campaigns, it is possible the advertisements were not as attractive to French-speaking Québec users, Québec users do not interact online in the same manner as Ontario users, or a higher percentage of the budget needed to be allocated to the French campaign to reach more French-speaking Facebook users.

The online recruitment failed to recruit many foreign-born parents yet nearly 20% of Canadians (all Canadians, not just Canadian parents) were born outside of Canada. This might represent a significant bias that is difficult to quantify, as the Facebook activity of foreign-born residents is not known. Moreover recent immigrants may not be a priority group to address for vaccine
hesitancy as they are more likely to arrive with immunity due to previous infection, and more likely to become immunized as citizens (120,121). The potential for ‘digital divide’ was not a major concern as Statistics Canada reported that Canadians over the age of 65 years are responsible for the lag in Internet use in lower income households. Canadians over the age of 65 years would not represent a significant percentage of our source population since we were targeting Canadian parents with at least one child under the age of 18 years (82). The reproductive window for women is generally considered to be from 15 years of age to 45 years of age, however in recent decades Canadian women are having fewer children and later in life due to social changes such as delayed marriage and new reproductive technologies (122).

Statistics Canada reports 30 years as the average age of Canadian mothers with newborns in 2011, with approximately 0.18% (n=708) of the mothers in the 40 – 49 years age group (123). Thus, the oldest mothers meeting our inclusion criteria could be 64 years of age, but they would represent a small proportion of the source population. Although the intent of my online recruitment was not to be representative of the general Canadian population, it is important to note that online recruitment likely under-represents certain vulnerable populations. For example, certain religious groups and indigenous groups, and remote populations who may not have access to the Internet or have poor connectivity, and have limited access to health services, may be under-represented.

Without a sampling frame for the online sample, it is difficult to calculate a true response rate. Using a conservative formula, I achieved similar or better response rates to other studies using online recruitment (26), as well as the RDD sample, however it would have been preferable to reach a higher response rate to avoid non-response bias. Similarly, the RDD survey has a low response rate, and the increase in cell phone utilization and call display presents a challenge in preventing non-coverage bias (124). Due to a low response rate in the RDD and a somewhat unknown response rate in the online survey, the samples should be compared with caution. The response rate was higher compared to several other studies using Facebook recruitment and the online survey was more successful in reaching vaccine hesitant parents. However there is minimal information on the respondents who viewed the advertisement but did not click-through and those who did not complete the survey. Based on Facebook metrics on the number of impressions, the advertisement reached mostly women between 25 to 44 years of age (50%), followed by men aged 25 to 44 years (20%) and females aged 18-24 years (10%). Women aged
18 – 44 years had the highest click-through-rate (CTR) and the CTR was more than double that of males the same age. Therefore, I was not successful in recruiting men as they represented 7% of those who completed the survey yet 20% of the sample who viewed the advertisement. Moreover, most non-respondents were likely women aged 18 – 44 years old as they had the highest number of impressions. Other information on non-responders was requested yet not available. This is a significant limitation that requires further inquiry and/or research. Additional data on non-respondent characteristics are likely accessible to the developers of the social media platform, thus specific metric contracts should be explored prior to study implementation.

Although Facebook is a popular social media platform among our target population, it would be important to monitor the popularity and user demographics of various social media platforms prior to online recruitment as this has the potential to change quickly over time. Depending on the social media trends among the study population, Facebook may not be the optimal platform for future research.

4.1.3 Information Bias

4.1.3.1 Misclassification – Exposure identification bias

Exposure identification bias can occur if exposure data is not properly collected or defined and can often be the result of recall or interviewer bias (113). In this thesis, the exposure variable was defined as ‘Used the Internet to search for information online’, and ‘Did not use the Internet’. Respondents self-reported if they ever looked for information on vaccination and if yes, where they looked or who they spoke to (with the Internet being one of the options). The response was open-ended in the RDD survey without prompting, and categories of all possible responses were presented in the online survey. To minimize recall bias and to ensure respondent confidence on having searched online for vaccination information, respondents were then immediately asked to specify the type of websites searched. The measurement of the variable was defined based on the definition previously developed for the RDD survey, however the online and the RDD survey were both pilot tested prior to implementation. There is no evidence to suggest recall would differ among individuals who perceive vaccines as safe versus those who perceive vaccines as not safe.
4.1.3.2 Misclassification – Outcome identification bias

Outcome identification bias can occur due to an imperfect definition of the outcome or errors in data collection and can often be the result of observer or respondent bias (113). In this thesis, vaccine hesitancy was defined by three indicators: parental perception on the safety of childhood vaccinations, measured on a 7-point ordinal scale from ‘Not at all safe’ [1] to ‘Moderately safe’ [4], to ‘Extremely safe’ [7]; vaccination status of youngest child classified as ‘Completely-up-to-date’ or ‘Partially or not at all up-to-date’; and difficulty in making the decision to vaccinate (or not) their youngest child measured as ‘Very easy’, ‘Easy’, ‘Difficult’, or ‘Very difficult’. Three separate indicators were utilized as vaccine hesitancy was known to be difficult to measure and no standard or validated measurement tool existed (100). These three variables were chosen to represent vaccine hesitancy as they represent parental immunization behaviour, beliefs and hesitancy, and were indicators utilized in previous studies (11,100). The exact variables developed and implemented in the RDD survey were utilized in the online survey. Although the variables were not validated, both surveys were pilot-tested prior to implementation. Recently, a survey tool to measure vaccine hesitancy was developed by the SAGE WG on vaccine hesitancy (100). The survey was developed based on previously validated questionnaires and expert opinion. Although measured on different scales, the vaccine hesitancy survey includes the same indicators: immunization status of the youngest child, parental perception of risk, and hesitancy in vaccinating their child (100).

In this thesis, parental perception of risk from immunization (measured on a 7-point Likert scale) was the outcome variable and was defined based on the measurement utilized in the RDD survey. Although the outcome measurement was restricted by the variable defined in the RDD survey, perceptions of the safety vaccinations are measured via a 5-point Likert agreement scale in the survey tool developed by SAGE WG (100).

4.1.3.3 Duplicate responses and gaming

Gaming occurs when unique users send multiple (i.e. duplicate) responses to maximize their chance of winning an incentive. Gaming is difficult to prevent as users can create multiple IP addresses, thus it is important to ensure methods are in place for the collection of authentic and valid data (94). Although impossible to prevent and completely evaluate, several recommendations made in the Checklist for Reporting Results of Internet E-Surveys (CHERRIES)
were taken into consideration to prevent and detect multiple responses (112). The following safety measures were implemented to prevent and/or evaluate repeat respondents and gaming:

1) Quach et al. (2013) recommended offering an appealing and accessible incentive to the geographical target (94). Email addresses were required to participate in the incentive, thus allowing for manual check of duplicate email addresses. The incentive (an iPad mini) would need to be mailed to a postal address, which may have helped to deter multiple responses from the same residential address.

2) The online survey software can restrict participation by location of IP addresses to prevent gaming from non-Canadian residents. I decided to not restrict non-Canadian IP addresses as Canadian residents may have been traveling when responding or the IP address may not be representative of their location due to factors such as mobile networks or web proxies. Locations of the IP addresses were tracked via Fluid Survey settings. Unknown (i.e. blank) locations or locations identified as outside of Canada (n=91) were verified for self-reported stated place of residence in the online survey. In addition, the survey link was only advertised to Canadian parents as defined by Facebook’s algorithm. The survey link was not shared nor distributed via the researchers. The majority of the respondents received the survey directly from their Facebook Newsfeed: 73·3% (791/1,079) of the respondents were directed to the survey via the advertisement in the Facebook Newsfeed, 14·2% via a Facebook friend who posted the survey, 11·2% via a Facebook friend who shared or liked the Facebook page, and 1·1% accessed the survey via a Twitter post of the survey link. Two respondents reported to be directed via other methods: an email of the survey link and a post of the survey link on a local mom Facebook group.

3) Duplicate IP addresses can be restricted within software settings. I decided to not restrict duplicate IP addresses as parents may share the same IP address. IP addresses were tracked via Fluid Survey settings. Duplicate IP addresses (n=12) were verified in terms of demographics (e.g. birth date, residence, number of children, ages of children, etc.) and time to complete. Two responses matched in terms of demographics and responses, and the second entry (according to the date/time stamp) had a shorter completion time. The second entry was deleted.

4) Multiple responders may not fully complete the survey or take less time to complete it due to familiarity with the questions (94). Therefore only fully completed surveys were
included in the research. Furthermore, only fully completed surveys were eligible for the incentive draw and the respondent had to opt-in with an email address at the end of the survey.

5) In an effort to reduce gaming from respondents not meeting study inclusion criteria, the survey would terminate automatically for several logic questions (e.g. reside outside of Canada, no children, children over the age of 18 years, not a parent or guardian). In addition, respondents were asked their age in years and their date of birth for validation.

Further to this, the majority of the respondents in the online survey were female; in a study on online recruitment of Ontario-based Canadian parents for health-related focus groups, Quach et al. (2013) found that incentives had the least impact on female response rates (94).

4.1.4 Confounding
In this thesis, I tested the association between using the Internet to look for vaccine information and parental perception of risk on childhood immunization. No previous information existed on potential confounders, thus all theoretical and hypothesized confounders were included in the conceptual model (Figure A) and tested in the multivariate analysis. It is possible unknown confounders were not tested leading to residual confounding. For example, information on race or ethnicity and religion was not collected in the surveys. Although Kontos et al. (2014) reported that race/ethnicity is not associated with Internet use for health information (117); it is not known if religion is associated with seeking vaccination information online. Due to the lack of information on historical confounding variables, purposeful variable selection was utilized to ensure all potentially significant confounders were retained in the model (105,106). Although the results were statistically significant, the effect sizes were relatively small and thus should be interpreted with caution as the significant associations could be the result of residual confounding.

4.1.5 Qualitative Analysis
Two raters (B Lachapelle and I) qualitatively coded and quantified the content of open-ended comments according to a preconceived framework and by inductive coding in the development
of a coding scheme (111). Content analysis is often challenging and Dierckx et al. (2011) reported six major problems with content analysis of qualitative data (115):

1) Over-reliance on qualitative software packages
Researchers may be too quick to code the data without reflecting on the content and themes (115). Although the qualitative analysis in Manuscripts 1 and 3 was performed using qualitative software, the material was read several times before coding in order to ensure the material fit the preconceived framework and to identify any other themes. Definitions of the framework categories were researched and discussed between the raters prior to coding. Material from a random sample of respondents was coded manually by both researchers prior to entering the codes into qualitative software, and the themes in the data were discussed by the raters prior to coding.

2) Word overload due to line-by-line approaches
This can occur when researchers attach lines to data without an understanding of the whole meaning of the text (115). We did not use line-by-line coding. I instructed the second rater to code the full response for each label so we did not miss the context or richness of the response.

3) Coding using a preconceived framework
Using a preconceived framework can exclude alternate ways of organizing the data that may be more interesting and researchers may run the risk of premature analytic closure (115). I chose to use a preconceived framework, the SAGE WG Matrix, as the determinants in the matrix were well researched, well defined and all encompassing. However, inductive coding was also utilized in the content analysis when the matrix did not fit the data. In this instance, I developed an ‘Other’ category as suggested by Gale et al. (2013) (111). Open coding was utilized to inductively code the positive (e.g. pro-vaccination) comments as it was determined by both raters that the preconceived framework was not suitable. Both raters developed the final working coding scheme. When no new codes emerged after several iterations of the working coding scheme(111), the final framework was applied to code all positive comments.
4) Difficulty retaining the integrity of each respondent’s story
Retaining the integrity of each response can be an important challenge in content analysis (115). I feel that we were able to capture the integrity and uniqueness of each respondent’s response as we ensured we coded the full response for each category coded, and we captured all potential determinants within the response. In addition, I have provided examples of respondent responses within each category.

5) Full potential of data is not exploited
The full potential of the data may not be exploited if the analysis is simply a descriptive account and merely lists themes and sub-themes (115). The purpose was to quantitatively describe the content of the open-ended comments, however I also provided definitions and interpretation of the themes and sub-themes within the frameworks, along with examples. In addition, I did not solely rely on deductive coding in an effort to fully capture the themes in the data.

6) Data analysis as an individual process
A team approach increases the ability to capture the real meaning of the data, to correct miscoding or misinterpretations, and to gather rich insight (115). I did not analyze the data alone. I trained a second rater, a public health professional with a graduate degree, and we developed the final coding schemes together. We discussed the coding of each respondent’s response and reached 100% consensus in our final results.

4.1.6 Health Behaviour Theory
There may be some limitations in applying a traditional health behaviour theory or model, such as the HBM, to Internet studies. For example, the conceptual model did not include aspects on the acceptability of the Internet for health information. Adhadzadeh et al (2015) reported the HBM to be insufficient in explaining the process of using the Internet for health reasons and suggested integrating dimensions of the Technology Acceptance Model (125). However, there is insufficient evidence on the limitations in applying traditional theories to Internet intervention studies as few studies discuss the underlying health behaviour theories or attempt to evaluate the theoretical components (87,126). Furthermore, online interventions have produced moderate behaviour change without addressing an underlying theory (126). Although HBM does not include specific theoretical constructs on the acceptability of the Internet, the HBM is a
simple and flexible model thus it was extended to include respondent perceived reliability of the Internet. Future research should consider adding theoretical constructs on the perceived usefulness or attitudes toward the Internet for health information. For online interventions, Ritterband et al. (2009) proposed an Internet Intervention Model that takes into account the influence of environmental factors, user characteristics, website use and adherence, and website characteristics on behaviour change (127).

4.2 Strengths and Contributions of this Research
The recruitment via Facebook was successful in achieving our desired sample size within a short time frame and limited costs. The response rate of 23% was similar to that of the RDD response rate and comparable or higher than response rates achieved by other studies using social media platforms for recruitment (93). Furthermore, the online survey had a high completion rate (65%) with little missing data. Facebook proved to be an effective and efficient recruitment platform. The effectiveness of social media platforms, particularly Facebook, in recruitment and the ability to collect rich qualitative and quantitative valid data has also been reported in other research using social media platforms for recruitment and/or data collection (93) but this was the first time it was used to recruit Canadian parents. Facebook was particularly useful as a recruitment tool as it allowed us to specifically target Canadian parents and we were successful in recruiting a population most likely to be making decisions on childhood vaccinations, a population that may be difficult to reach using traditional methods. These findings are of increasing relevance because 1) traditional methodologies such as RDD are becoming more challenging due to non-coverage bias, and 2) Canadian expert groups on immunization have identified vaccine hesitancy among Canadian parents as a research priority.

Although the research on vaccine hesitancy is still in its infancy and limited within Canada (9-11,13), the Canadian Immunization Research Network has deemed it a research priority. Understanding the root causes of vaccine hesitancy in Canada is important in the development of evidence-based tailored interventions (9, 10, 12, 13). This thesis provided rich qualitative data on the determinants of vaccine hesitancy among Canadian parents from three different data sources: the online survey data, the RDD data, and the extracted Facebook data. This information will add to the body of research by providing evidence needed to develop
interventions targeted at the vaccine hesitancy determinants of Canadian women of childbearing age.

To our knowledge no study has quantified the assumed association between seeking vaccine information online and Canadian parents’ perception of risk on childhood immunizations. This research provided quantitative evidence that the odds of perceiving vaccines as less safe rather than more safe were higher for Canadian parents who used the Internet to search for vaccination information compared to parents who do not search the Internet. I was able to validate this association as two different data sources with fairly large sample sizes resulted in the same model with similar effect sizes. This evidence is important in informing public health authorities on the significance of the Internet in vaccination decisions and the potential need for tailored on-line interventions.

4.3 Future Directions for Research and Public Health Practice
This research significantly contributes to the body of knowledge on the use and influence of the Internet on Canadian parents’ childhood immunization decisions. The following are recommendations for implementation in public health practice based on the results of this research.

1) Monitor and engage in the online conversation on childhood immunization
This research provided evidence on the importance of the Internet in influencing Canadian parents’ perception of risk on childhood immunization. In addition, the analysis of an online debate on immunization revealed the lack of knowledge and spread of misinformation on a platform not intended to solicit discussion. Currently, the presence of public health authorities online is limited to top-down dissemination of information and limited engagement in online debates. This lack of public health expertise and involvement online has the potential to enable the unabated spread of anti-vaccination sentiment and misinformation that potentially affect vaccination decisions among hesitant and/or pro-vaccine Canadian parents. Passive interventions such as increasing knowledge or reminder-recalls have been shown to be the least effective in addressing vaccine hesitancy (9). Although some anti-vaccine activists may never be swayed by evidence, it is important for health authorities to provide information to those with genuine concerns or questions, and engage in online debates rapidly in a non-judgmental and
transparent manner. Parents’ right to choose and not be judged was a theme identified in the online conversation yet not a determinant identified in the SAGE WG framework. The issue of freedom and individual rights versus the notion of social good is a fundamental ethical issue in immunization and needs to be given careful thought in our communications on issues such as mandatory immunization and exemption rights.

There is a need for more dialogue-based approaches targeted to specific sub-populations with an intended focus on social networks (9). However, communication strategies via social media are still not well understood and caution must be used to prevent legitimizing vaccine hesitancy (14). Social media should be an important communication tool for public health, however the content of online debates needs to be better monitored to identify misinformation or requests for information, and to understand the current determinants among Canadian parents (12, 14). In addition, we need to better understand who should be engaging online to rebut misinformation and spread accurate and scientifically valid information on immunization. Mistrust in health care professionals and the government has been reported as an important determinant in vaccine hesitancy (11,41,57), thus alternate spokespeople (e.g. influential mommy bloggers or celebrities) may need to be considered as ‘cues to action’ for behavioural change. The unsolicited online debate analyzed in Chapter 5 is evidence of the importance of monitoring online discussions and in using technology capable of identifying immunization discussions among Canadian parents, as interactions are not just limited to anti-vaccination websites or threads and can occur via several platforms. Health agencies should consider data mining technology for real-time and sensitive surveillance of online conversations, websites, and posts. It would also be important to consider appropriate jurisdictional responsibilities for surveillance and communications.

2) Expand on vaccine hesitancy research in Canada

There is limited research on the determinants of vaccine hesitancy among Canadian parents and how public health can positively engage and impact Canadian parents’ vaccination decisions. This research provides evidence on the importance of the Internet in influencing parents’ perception of risk and has contributed to the body of knowledge on the various determinants of vaccine hesitancy and the content of online debates among Canadian parents. Furthermore, it highlighted the use of social media as a recruitment tool and the potential of social media to
reach Canadian parents despite some of the inherent limitations of online recruitment and data collection. However, the results presented here on the determinants of vaccine hesitancy need to be validated. Further research is needed for a more comprehensive picture, and research should be ongoing as vaccine hesitancy determinants can change with time and within populations (9-11). Recently (and post-implementation of this research) the SAGE WG has developed tools to assist countries dealing with vaccine hesitancy, including a survey designed to measure vaccine hesitancy that could be used to expand on this research and to gather information globally in a systematic fashion (100). The SAGE WG also developed a guide to ‘Tailoring Immunization Programs’ (TIP) to assist countries in identifying vaccine hesitant individuals and to diagnose the particular barriers (128). Both tools could prove useful in the further study of vaccine hesitancy in Canada and should be investigated as we expand research and develop strategies.

Although systematic survey tools could assist in measuring vaccine hesitancy, currently there is no ‘vaccine hesitancy scale’ that combines several important indicators of vaccine hesitancy. Globally, several indicators have informed vaccine hesitancy, thus a combined scale could be useful in providing a more comprehensive picture at the individual level. Moreover, vaccine hesitancy is context- and population-specific, thus standard global indicators may not be appropriate depending on the population and location. A validated and uniform Canadian ‘vaccine hesitancy scale’ could provide better measurements, thereby reducing measurement error, and allow for comparisons across sub-groups and studies.

3) Revise SAGE WG Matrix

Overall, I found the SAGE WG Matrix to be a valuable tool in identifying and organizing vaccine hesitancy determinants in my open-ended survey responses and unsolicited online comments. However, I would suggest several changes to improve the intuitiveness of the matrix and to better capture all potential factors of vaccine hesitancy. The matrix is intended as a global tool and it could be useful to further refine it to specifically capture current Canadian determinants.

As detailed in Table A and Chapter 1, the SAGE WG vaccine hesitancy matrix groups the determinants of vaccine hesitancy into three categories: contextual; individual and group; and vaccine/vaccination specific issues, and each category has several sub-categories. I found the
titles of some categories and sub-categories to be uninformative and difficult to report in my thesis. I have provided suggestions below.

**Contextual factors**

- *Communication and media environment*: this is a very broad category. As demonstrated in this research and in the current literature, social media plays an important role in vaccine hesitancy. Thus, it would be useful to distinguish between the type of media and communications influencing vaccine sentiment by providing sub-categories (e.g. Social media; print materials from government, naturopaths, physicians, other; radio, TV); and type of communications (e.g. story (narrative) on vaccination; statistical data; scientific/peer reviewed study, etc.).

- *Geographic barriers*: The title does not include issues of access but rather geography. I would suggest the title: ‘Access and geographic barriers’.

- *Pharmaceutical industry*: The title does not include the issue of mistrust in the industry or in government transparency. I would suggest the title: ‘Mistrust in the pharmaceutical industry and government transparency’.

**Individual and group influences**

Individual and group influences interact with each other, however in terms of categorizing and reporting, it would be useful to have two separate categories of individual and then group influences or further categorization of the sub-categories to be able to distinguish between the individual factors and the group factors. For example, it would be useful to know if an individual’s decision to vaccinate was based on his or her own knowledge or influenced by knowledge disseminated by others. Similarly, was it the individual’s personal experience with past vaccination influencing their decision or was it someone else’s personal past experience.

- *Belief, attitudes about health and prevention*: I find the title to be very ambiguous and could be better stated as: ‘Beliefs, attitudes about immunity and efficacy of vaccines’. Two sub-categories could be included: 1) Belief in natural immunity; 2) Belief that vaccines do not work.

- *Knowledge/Awareness*: The title would be more informative as ‘Lack of knowledge/awareness’. In addition, this was the most prevalent determinant in my
research and several subcategories would be useful to further detail the gap in knowledge: 1) Inaccurate knowledge/misperception on immunity and disease transmission; 2) Inaccurate knowledge/misperception on the vaccine and adverse events (with a specific sub-category on autism); 3) Belief in their knowledge and research (with a specific sub-category on where they acquired the information);

- **Health system and providers-trust experience:** it would be useful to further categorize this to: 1) Mistrust in government; and 2) Mistrust in health care workers (with specific sub-categories on the type of healthcare workers - nurses, doctors, pharmacists, etc.).

- **Risk/benefit (perceived/heuristic):** This sub-category was the second most prevalent determinant in my research and would also benefit from specific sub-categories: 1) Not all vaccines are necessary; 2) Risk of disease or death are unlikely; 3) Vaccines are not safe

**Vaccine and vaccination specific issues**

- **Role of healthcare professionals:** I found difficulty in separating mistrust in health systems and providers (in the individual and group influences category) versus this category, which pertains to the influence of the personal beliefs on vaccines of the health care professional. I feel this could be a sub-category under the ‘Health system and providers-trust experiences’ within the group influences category and titled ‘Influence of health care professionals to vaccinate or not’.

In my research respondents frequently reported parents’ right to choose and not be judged as an important reason to not vaccinate or to have difficulty in deciding to vaccinate. In addition, many pro-vaccination sentiments judged the non-vaccinators as uneducated or ignorant. I categorized this into a category outside of the SAGE WG matrix, as I did not feel this particular determinant was represented within the matrix. This could be a subcategory within the group influence ‘Immunization as a social norm vs. not needed/harmful’ or as a separate category.

Finally, I did not feel the matrix captured the sentiments of pro-vaccinators. I feel this is an issue as pro-vaccinators are influencing the online conversation and can also become vaccine
hesitant. It would be useful to develop a common matrix that captures the arguments presented online by those trying to influence non-vaccinators and vaccine hesitant individuals.

4) **Develop and evaluate evidence-based interventions**

Vaccine hesitancy research should also include the design, implementation and evaluation of interventions tailored to specific vaccine hesitancy determinants and populations. Currently, there is limited evidence on the effectiveness of strategies implemented to address vaccine hesitancy (13), and most of the implemented strategies have occurred in the United States, which limits generalizability due to the context and population driven applicability of vaccine hesitancy determinants (13). Online interventions should be investigated as this research shows the impact of the Internet and the existence of online debates and spread of misinformation. Currently, no online intervention has shown to be effective in minimizing vaccine hesitancy and further research is needed (9,13). Furthermore, there are no interventions implemented in Canada specifically addressing vaccine hesitancy and few interventions internationally where the impact was measured and reported (9). According to the systematic review conducted by Jarrett et al. (2015) on strategies implemented to address vaccine hesitancy, the most successful have used multiple methods, directly targeted unvaccinated or under-vaccinated populations, aimed to increase knowledge and attitudes, improved convenience or access to vaccines, implemented mandated vaccination, and engaged religious or influential leaders (9). However, the determinants of vaccine hesitancy are dependent on many factors and vaccine hesitancy determinants have been reported to not be generalizable across populations and time due to their complex nature, thus it is important to understand the drivers of vaccine hesitancy within Canada and to implement evidence-based tailored interventions (9,12). Dubé et al. (2015) reported that most interventions have been targeted to diverse populations using diverse approaches (13). The majority of the strategies used traditional educational based approaches (e.g. pamphlets) with little impact on vaccine hesitancy (13). Dubé et al. (2015) highlighted the need to understand the role of social media and its influence on parental decision-making (13).

Based on the results of this thesis, there is a need to implement strategies specifically addressing the abundance of misinformation online and the lack of knowledge among Canadian parents. Furthermore, this research has shown that Facebook may be a useful platform to reach and study vaccine hesitant Canadian parents. Moving forward, interventions need to be
developed based on the known vaccine hesitancy determinants of Canadian parents, as opposed to assumptions, with a focus on the influence of online information and social networks (9). Lack of confidence in vaccines due to misperceptions or lack of knowledge was a predominant determinant discovered in this research. Betsch et al (2015) report that there are limited informational interventions that are effective for those who lack confidence in vaccines, however it is important that interventions aim to debunk vaccine myths (129). Passive methods such as non-interactive top-down dissemination of information via various communication tools have proven to be non-effective (9) thus more interactive and engaging methods such as direct online communications need to be investigated and evaluated. Jarrett et al. (2015) reported that multi-component and dialogue based approaches have been the most effective in responding to issues of vaccine hesitancy (9). Mass Communication strategies utilizing the principles and practices of commercial and social marketing have also shown evidence in promoting vaccine acceptance (13,130). However, very few strategies have directly targeted vaccine hesitant individuals (9,13). Methodical, proactive and tailored communication strategies have proven to be effective tools and should be an important part of any immunization program in addressing the specific determinants of the targeted population (14). The SAGE WG suggests that communication tools should be used thoughtfully, monitored and evaluated for their impact, and discontinued if the objectives are not being achieved (14). Furthermore, caution should be used when using social media and the impact should be carefully monitored (14). However, due to the complexity of vaccine hesitancy and the limited evidence on effective strategies, any strategy should be carefully tailored to the specific context, the target population and their determinants of vaccine hesitancy (9). In addition, it is important to thoroughly evaluate the impact of the strategy on vaccine hesitancy or vaccine acceptance (13).

Based on this, future research in Canada should consider the following questions:
1) What are the ongoing determinants of vaccine hesitancy among Canadian parents? Do they change over time and within subgroups?
2) How can we better utilize social media platforms in research and in online engagement in regards to childhood immunization?
3) Can evidence based-interventions (based on Canadian-specific vaccine hesitancy determinants) positively impact vaccination decisions among Canadian parents?
4.4 Conclusion

This thesis significantly contributes to Canadian research on childhood immunization by successfully showing the value of alternate methods of recruitment and data collection, by quantifying the association between seeking information online and parental perception of risk on childhood immunizations, and by identifying important determinants in vaccination decisions and the content of online debates.
References


(61) Shelby A, Ernst K. Story and science: how providers and parents can utilize storytelling to combat anti-vaccine misinformation. Hum vaccin Immunother 2013 Aug;9(8):1795-1801.


APPENDICES

Appendix 1- Systematic Review/Aim 1

Using Social Media to Study Health Behaviours – How and Why?
A Systematic Review

by Jordan Tustin
PhD candidate, Epidemiology
Dalla Lana School of Public Health, University of Toronto

Abstract
Social media platforms have become an important venue for people to connect, share health information and discuss health issues in an open forum. As such, the impact of social media on individual health behaviours, and the ability to use social media as a means to study health behaviour is of growing interest worldwide. This review aimed to inform the development of future research by consolidating the methodologies from articles with a focus on the use of social media platforms in studying health behaviours or attitudes toward health behaviours. The objectives were to review: 1) the types of health behaviours or attitudes toward health behaviours; 2) the types of online populations and social media platforms; 3) the methodologies; and 4) the reasons why health behaviours or attitudes toward health behaviours have been studied via social media platforms. The results show that research in this area is limited with varied methodology. The majority of the studies were descriptive and utilized different types of social media platforms such as social networking sites, blogs and video-sharing sites, to study a wide variety of health behaviours/attitudes ranging from sexual health to dental pain behaviours. Data were extracted by manual or automated data extraction, on-line survey or online in-depth interview. Reasons cited for studying health behaviours/attitudes via social media platforms included increased access and popularity of social media, influence of social media on individual health behaviours/attitudes, the potential impact on public health practice, and the ability to gather rich, real-time self-reported data from high-risk or stigmatized populations and from individuals previously unreachable via traditional methods.
methodological limitations were noted in terms of the representativeness and validity of data collected. Notwithstanding these limitations, data collection via social media has the potential to meaningfully contribute to public health knowledge and practice in ways not possible via traditional methodologies. Social media platforms are the information gateways of the present and future, thus public health research needs to evolve in order to identify better online mechanisms to study and change health behaviours, and to determine how best to reach specific populations to implement online interventions.

Keywords
Attitude to health, health promotion, Internet, public health, social media platforms

Background
Most people are on-line or getting on-line. The United Nations Agency on telecommunications reports the number of Internet users in the developed world has increased from 53.5 per 100 inhabitants in 2006 to 73.8 in 2011 (26.3/100 in the developing world in 2011). In 2011, 71.4% of households in the developed world (20.5% in the developing world) had Internet access at home (International Telecommunication Union, 2011). Not only do more individuals have access to the Internet, they are using the Internet to help with important life decisions (Fox, 2011). Since the inception of Web 2.0, the Internet and new forms of social media have not only allowed for quick sharing of information, but also for new ways of self-organization, social networking, and empowerment of online groups such as anti-vaccine communities (Larson et al., 2011). The Internet’s capacity to help maintain and support social networks is a relatively new phenomenon. In the past, the Internet (Web 1.0) was a platform for one-way, static dissemination of information without dynamic user-generated content. However, by approximately 2002, the advent of Web 2.0 (‘the social web’) enabled individuals to establish online connections by facilitating discussions and interaction. Web 2.0 has provided a forum for interactivity and user-generated content, where on-line users can be creators, contributors, commentators, and followers of web content. The many social media tools that have since evolved have provided the necessary platforms for user-generated discussions and postings with Internet content created by the ‘user-up’ and information sought not only from web content but also directly from fellow internet users.
Social media platforms have also become novel vehicles for individuals to seek health information and support and to share health knowledge and opinions (Fox, 2011; Schein et al., 2010). People are posting their thoughts, opinions or actions, or discussing issues in an open public forum, thus creating new possibilities in the study of health behaviour. A recent Pew study indicated that 80% of internet users seek health information online, 34% have accessed user-generated health content, 25% have watched online health videos, and 18% have gone online to find others who might have similar health concerns (Fox, 2011). Research has shown that health behaviours such as obesity or smoking appear to be affected by social networks (Christakis and Fowler, 2007; Christakis and Fowler, 2008) where individuals make health decisions or exhibit health behaviours based on ‘people like me’. The increasing popularity of social media has led to the creation of online social networks and increased exposure or access to ‘people like’. As such, the public appears to be sidestepping traditional gateways of health information and putting more value in the ‘wisdom of the crowd’, where individual health behaviours or decisions take into account other online users’ experiences (Schein et al., 2010).

Public health use of social media has largely concentrated on communications and health promotion strategies with one-way static messages to the public from public health agencies. However, there is growing acceptance that top-down dissemination of health information is unlikely to change health behaviour, and a need exists for more dialogue-oriented approaches (Schein et al., 2010). Public health professionals are no longer considered the ‘authoritative voice’ and traditional experts have little effect on individual health decisions specifically in controversial topics such as immunization (Kata, 2010). Social media platforms are being used to seek out health information and share experiences, and reading online posts can influence the public’s health behaviours and attitudes towards health issues (Schein et al., 2010). As such, these platforms provide novel opportunities for public health to connect with populations who have abandoned traditional technologies or who have changed how they interact with health professionals, in order to increase the public’s trust in public health professionals, and to implement tailored messages or interventions in an effort to influence health behaviour. Social media platforms facilitate the dissemination of health information and the creation and maintenance of individual social networks, thus the influence of social media on health behaviour should be an important component of public health research. Not only in terms of the
influence of social media on health behaviour, but also on the use of social media platforms to gather knowledge on individuals’ health behaviours.

Public health research using social media platforms is in its infancy and no standard accepted methodology exists as the medium is unconventional and the characteristics of the many social media platforms vary. This review aims to inform the development of future research by consolidating the methodologies from articles with a focus on the use of social media platforms in studying health behaviours or attitudes toward health behaviours. In this paper we review their work, focussing on the methods used and the reasons why the authors chose to study the health behaviours/attitudes of online populations via social media platforms. The objectives were to review: 1) the types of health behaviours or attitudes toward health behaviours; 2) the types of online populations and social media platforms; 3) the methodologies; and 4) the reasons why health behaviours or attitudes toward health behaviours have been studied via social media platforms; in order to inform future research

Methods

Search Strategy and Selection Criteria
Relevant literature was identified via systematic searches of electronic databases covering health and social sciences literature. The databases include: Medline, Embase, PsycINFO, CINAHL, Scopus, Academic Search Premier, LISTA, Health Business Elite, Psychology and Behavioural Sciences Collection, Cochrane Database of Systematic Reviews, Health Technology Assessments, SocIndex with Full Text, and Child Development and Adolescent Studies. The internet was also searched via Google Scholar. Keywords and MeSH terms represented the internet and social media platforms, and health behaviours or attitudes. Terms were harvested from relevant papers, and by discussion with the research team and professional health librarians. The search was limited to peer-reviewed full research articles published in English between 2000 and January 2012, however searches without limits on the year of publication did not change the results as Web 2.0 did not exist prior to the year 2000. Grey literature was not included. To ensure relevant articles were not missed, a sensitivity check was implemented whereby a set of known important papers was sought within the articles, bibliographies of key
articles were hand-searched, and specific author searches were conducted for recurring authors.

The titles and abstracts of all identified articles were evaluated. To be included in the final review studies had to meet all of the following criteria: (1) be conducted in an online population; (2) obtain data on the public’s health behaviours and/or attitudes toward a health behaviour(s) as part of the study objectives; and (3) collect data via a social media platform. A social media platform was defined as an interactive Web 2.0 platform with user-generated content (e.g. social networking sites, blogs, micro-blogs, and discussion forums). Full-text articles were reviewed for inclusion if the title and abstract did not provide sufficient information to evaluate inclusion criteria.

**Analysis**

For each study, the type of online population and health attitudes/behaviours studied, the methodology and the reasons for collecting data via social media were listed and categorized. Categories were derived from the studies, rather than a set of predefined themes. This review did not assess the results of the studies.

**Results**

*Study Selection and Characteristics*

Figure 1 displays the steps in the study selection process. Overall, there were 1538 potentially peer-reviewed relevant articles resulting from the search of all thirteen electronic databases and the Google Scholar search engine. Upon title and abstract review, 1478 articles were excluded for not meeting all three inclusion criteria. Due to the sensitivity of the search, many of the excluded studies were captured based on a simple reference to a social media platform in the article’s body of text. Full-text review was conducted on sixty studies. Forty-three of the sixty studies were excluded for the following reasons: 1) did not collect data/information on a health behaviour or attitude towards a health behaviour; 2) did not use online methods or did not study an online population; 3) did not utilize a social media platform; 4) were conference abstracts with limited information or were not yet published; or 5) were missed duplicates. Three additional articles that met the inclusion criteria were retrieved based on a manual
reference search of relevant articles. A full review was conducted with the remaining twenty studies.

Sixty-five percent (n=13) of included studies were conducted in the United States. Other countries contributing to the body of research include Canada, New Zealand, Australia, and England. The publication year ranged from 2003 to 2012.

**Types of Health Behaviours or Attitudes toward Health Behaviours**

Table 1 presents the type of health behaviours or attitudes toward health behaviours studied. The majority of the articles collected data on high-risk sexual or HIV-related health behaviours (n=8), followed by attitudes or behaviours associated with alcohol or substance abuse (n=6), and attitudes toward immunization (n=4). Other behaviours or attitudes studied include: dental health behaviour, healthy dietary behaviours, depression treatment behaviours, misuse of antibiotics and attitudes toward organ donation.
Types of Online Populations and Social Media Platforms

Eight studies looked at users of social networking sites via the social media platforms MySpace, Facebook, Bebo or Gaydar (Bolding et al., 2004; Griffiths and Casswell, 2010; Lord et al., 2011; Moreno et al., 2007; Moreno et al., 2010; Moreno et al., 2010). Five studies conducted research on members of chat room or discussion forums via men who have sex with men chat rooms, MSN messenger and depression communities (Bolding et al., 2004; Couch and Liamputtong, 2007; Powell et al., 2003; Rhodes et al., 2008; Rhodes et al., 2011). Three studies targeted video-sharing users from the video sharing website YouTube (Ache and Wallace, 2008; Keelan et al., 2010; Tian, 2010), users of the micro-blogging service Twitter were studied in three studies (Heaivilin et al., 2011; Salathé and Khandelwal, 2011; Scanfeld et al., 2010), and two studies focussed on bloggers in a food blogging community and MySpace blogs (Keelan et al., 2010; Lynch, 2010). See Table 2.

Study Design

Table 3 summarizes the methodology for each reviewed article. Seventeen of the studies were cross-sectional (Ache and Wallace, 2008; Bolding et al., 2004; Couch and Liamputtong, 2007; Griffiths and Casswell, 2010; Heaivilin et al., 2011; Keelan et al., 2007; Keelan et al., 2010; Lord et al., 2011; Lynch, 2010; Moreno et al., 2007; Moreno et al., 2009; Moreno et al., 2010; Moreno et al., 2010; Powell et al., 2003; Rhodes et al., 2008; Salathé and Khandelwal, 2011; Scanfeld et al., 2010; Tian, 2010), one study was quasi-experimental pre-test post-test (Rhodes et al., 2011), one study was quasi-experimental two group comparison (Rhodes et al., 2008), and one was a randomized controlled intervention trial (Moreno et al., 2009). Out of the cross-sectional designs, four studies were purely qualitative (Couch and Liamputtong, 2007; Griffiths and Casswell, 2010; Lord et al., 2011; Lynch, 2010).

Data Collection and Analysis

Data were mostly extracted by manual or automated data extraction (Ache and Wallace, 2008; Griffiths and Casswell, 2010; Heaivilin et al., 2011; Keelan et al., 2007; Keelan et al., 2010; Lynch, 2010; Moreno et al., 2007; Moreno et al., 2009; Moreno et al., 2009; Moreno et al., 2010; Moreno et al., 2010; Salathé and Khandelwal, 2011; Scanfeld et al., 2010; Tian, 2010), followed by on-line survey (Bolding et al., 2004; Lord et al., 2011; Powell et al., 2003; Rhodes et al., 2008; Rhodes et al., 2011) and online in-depth interview (Couch and Liamputtong, 2007). Of the
fourteen studies utilizing data extraction, six studies collected data via public profile content (Griffiths and Casswell, 2010; Moreno et al., 2007; Moreno et al., 2009; Moreno et al., 2010; Moreno et al., 2010; Moreno et al., 2011), three via video content or comments (Ache and Wallace, 2008; Keelan et al., 2007; Tian, 2010) and two via blog content (Keelan et al., 2010; Lynch, 2010). Data extracted on health behaviours or attitudes were then categorized based on pre-defined categories (Ache and Wallace, 2008; Heaivilin et al., 2011; Keelan et al., 2007; Keelan et al., 2010; Moreno et al., 2009; Moreno et al., 2009; Moreno et al., 2010; Moreno et al., 2010; Salathé and Khandelwal, 2011) or based on the content of the data extracted (Couch and Liamputtong, 2007; Griffiths and Casswell, 2010; Lord et al., 2011; Lynch, 2010; Moreno et al., 2007; Scanfeld et al., 2010; Tian, 2010). Multiple reviewers and inter-rater reliability calculations were reported in eleven of the fourteen studies using data extraction and content analysis methods (Ache and Wallace, 2008; Heaivilin et al., 2011; Keelan et al., 2007; Keelan et al., 2010; Moreno et al., 2009; Moreno et al., 2009; Moreno et al., 2010; Moreno et al., 2010; Salathé and Khandelwal, 2011; Scanfeld et al., 2010; Tian, 2010). Data on demographics or risk factors were captured in 50% of the studies (n=10), with five collecting these data via online survey (Bolding et al., 2004; Lord et al., 2011; Powell et al., 2003; Rhodes et al., 2008; Rhodes et al., 2011) and five via data extraction of social networking site profiles (Griffiths and Casswell, 2010; Keelan et al., 2010; Moreno et al., 2009; Moreno et al., 2009; Moreno et al., 2010).

For the four qualitative studies, sample size ranged from 15 individuals via on-line in depth interviews to 698 individuals via online survey. For the remaining studies, the sample size ranged from 142 public profiles to 318, 379 public tweets. A sample size calculation was reported in two studies (Moreno et al., 2009; Moreno et al., 2010). For studies collecting data via data extraction of posts, sampling techniques included searching keyword terms and including all relevant posts/profiles/videos/tweets (Ache and Wallace, 2008; Heaivilin et al., 2011; Keelan et al., 2007; Keelan et al., 2010; Salathé and Khandelwal, 2011; Tian, 2010) or taking a sample of all relevant posts/profiles/videos/tweets identified from the keyword search (Griffiths and Casswell, 2010; Lynch, 2010; Moreno et al., 2007; Moreno et al., 2009; Moreno et al., 2009; Moreno et al., 2010; Moreno et al., 2010; Moreno et al., 2011; Scanfeld et al., 2010). Random sampling techniques were reported in four studies (Moreno et al., 2009; Moreno et al., 2009; Moreno et al., 2010; Scanfeld et al., 2010). Convenience sampling was reported in studies using online surveys for data collection (Bolding et al., 2004; Lord et al., 2011; Powell et al.,
2003; Rhodes et al., 2008; Rhodes et al., 2011) and snowball sampling in the study collecting data via online in-depth interview (Couch and Liamputtong, 2007). Timelines for data collection ranged from one day (Ache and Wallace, 2008; Keelan et al., 2007; Keelan et al., 2010) to eleven months (Moreno et al., 2010). All studies restricted searching or sampling to English language platforms, discussions, videos or posts.

In the studies using data extraction methods, six were restricted to univariate analysis (Heaivilin et al., 2011; Keelan et al., 2007; Keelan et al., 2010; Moreno et al., 2007; Scanfeld et al., 2010; Tian, 2010), four reported bivariate analysis (Ache and Wallace, 2008; Moreno et al., 2010; Moreno et al., 2010; Salathé and Khandelwal, October 2011), two multivariate analysis (Moreno et al., 2009; Moreno et al., 2009) and two qualitative thematic analysis (Griffiths and Casswell, 2010; Lynch, 2010). For those collecting data via online survey or interview, three reported bivariate analysis (Powell et al., 2003; Rhodes et al., 2008; Rhodes et al., 2011), one multivariate analysis (Bolding et al., 2004), and two reported qualitative thematic analysis (Couch and Liamputtong, 2007; Lord et al., 2011).

Reasons Given for Using Social Media Platforms

Table 4 summarizes the authors’ reasons for using social media platforms to study health behaviours/attitudes for each reviewed article.

1) **Increased access and popularity of social media platforms**

Seventeen of the twenty studies cited the rise in the access, use, and popularity of social media to find, discuss and disseminate health information as an important reason for using social media platforms in health behaviour studies (Ache and Wallace, 2008; Bolding et al., 2004; Couch and Liamputtong, 2007; Griffiths and Casswell, 2010; Keelan et al., 2010; Lord et al., 2011; Lynch, 2010; Moreno et al., 2007; Moreno et al., 2009; Moreno et al., 2009; Moreno et al., 2010; Powell et al., 2003; Rhodes et al., 2008; Rhodes et al., 2011; Salathé and Khandelwal, October 2011; Scanfeld et al., 2010; Tian, 2010).

2) **Influence on individual health behaviours/attitudes**

More individuals are forming online networks and sharing information on health behaviours and attitudes, thus thirteen studies noted the importance of social media platforms as influencers on
individual health behaviour and attitudes (Bolding et al., 2004; Couch and Liamputtong, 2007; Keelan et al., 2010; Lynch, 2010; Moreno et al., 2007; Moreno et al., 2009; Moreno et al., 2009; Moreno et al., 2010; Moreno et al., 2010; Rhodes et al., 2008; Rhodes et al., 2008; Rhodes et al., 2011; Salathé and Khandelwal, 2011; Scanfeld et al., 2010). For example, Moreno et al. (2010) concluded that sexual references displayed by adolescents on social networking platforms might influence the behaviour of younger teens.

3) **Novel vehicles to study health behaviours/attitudes**

The abundance of publicly available rich data, the ability to reach large populations across wide geographic areas, and the unique methods and platforms available in conducting health research online were reported as reasons to study health behaviours via social media platforms by eleven studies (Heavilin et al., 2011; Keelan et al., 2010; Lynch, 2010; Moreno et al., 2007; Moreno et al., 2009; Moreno et al., 2009; Powell et al., 2003; Rhodes et al., 2011; Salathé and Khandelwal, 2011; Scanfeld et al., 2010; Tian, 2010).

4) **Influence/impact on public health practice**

Ten of the studies identified the great potential for this type of research to inform public health practice in terms of communications and interventions to various populations (Ache and Wallace, 2008; Bolding et al., 2004; Moreno et al., 2009; Moreno et al., 2009; Moreno et al., 2010; Powell et al., 2003; Rhodes et al., 2011; Salathé and Khandelwal, October 2011; Scanfeld et al., 2010; Tian, 2010). For example, Moreno et al. (2009) reported that social networking sites would be an important and innovative venue to identify adolescents with risky public health behaviours and ultimately intervene. In another study, Moreno et al. (2009) noted the lack of online interventions to reduce risky behaviour and the promise of such interventions in reaching populations otherwise unreachable via traditional methods. Rhodes et al. (2011) noted the potential for new strategies to increase HIV testing behaviours of online men who have sex with men.

5) **Ability to find study populations**

The ability to reach and study traditionally unreachable populations and specific sub-populations was an important reason cited by ten studies (Bolding et al., 2004; Couch and Liamputtong, 2007; Griffiths and Casswell, 2010; Moreno et al., 2007; Moreno et al., 2009;
Moreno et al., 2009; Moreno et al., 2010; Powell et al., 2003; Rhodes et al., 2008; Rhodes et al., 2011). Populations such as adolescents with low socio-economic status or individuals with risk behaviours may be unlikely to seek out health information or advice from health professionals. In addition, the social media platforms provide a forum for specific populations to find each other (e.g. depression communities). Study populations such as online daters (Couch and Liamputtong, 2007), adolescents of specific ages or low socio-economic status (Griffiths and Casswell, 2010; Moreno et al., 2007; Moreno et al., 2009; Moreno et al., 2009; Moreno et al., 2010), individuals with dental pain (Powell et al., 2003), and men who have sex with men (Rhodes et al., 2008; Rhodes et al., 2011) were easily found via searches of social media platforms.

6) **Little or no research exists**

The need for research on specific health behaviours or attitudes via social media platforms was reported in eight studies (Ache and Wallace, 2008; Couch and Liamputtong, 2007; Griffiths and Casswell, 2010; Keelan et al., 2007; Keelan et al., 2010; Lynch, 2010; Moreno et al., 2009; Moreno et al., 2009; Moreno et al., 2010). For example, Keelan et al. (2010) noted that no study had investigated the role of bloggers in disseminating information about immunization. Griffiths and Casswell (2010) reported that research into online social networking sites is limited and no research has investigated the influence of social networking information on youth alcohol consumption.

7) **Online context encourages information reveal**

Several studies (Couch and Liamputtong, 2007; Lynch, 2010; Moreno et al., 2009; Moreno et al., 2009; Rhodes et al., 2011; Scanfeld et al., 2010; Tian, 2010) mentioned that being online encourages users to reveal more information than traditional methods such as interviewing. One author noted that self-disclosures and uninhibited personal expression via social media platforms could support the notion that disclosures made on social media platforms represent actual behaviours or behavioural intent (Moreno et al., 2009). In addition, the anonymity offered by online surveys or online community discussions can lead to increased disclosure (Couch and Liamputtong, 2007; Rhodes et al., 2011).
8) Easy and cost effective

In three of the studies, the researchers noted the ease of data collection and low cost of research via social media platforms compared to the generally labour intensive and high cost of traditional methodologies (Heavilin et al., 2011; Lord et al., 2011; Salathe and Khandelwal, 2011). For example, Salathé and Khandelwal (2011) were able to collect a sample of over 300,000 tweets by simply searching keywords in the Twitter search engine.

9) Reduction of stigma

Researchers in three of the studies viewed social media platforms as a means to reach people who may feel embarrassed or stigmatized by their behaviours or condition (Lord et al., 2011; Powell et al., 2003; Rhodes et al., 2011). The anonymity and convenience afforded by social media platforms allowed researchers to effectively reach and study stigmatized populations such as online individuals with substance use issues (Lord et al., 2011) and depression (Powell et al., 2003), and online men who have sex with men (Rhodes et al., 2011).

10) Other reasons

Two studies noted the importance in the ability to gather frequently updated real-time data (Heavilin et al., 2011; Keelan et al., 2010) and one study analyzing the content of real-time tweets reported that recall bias can be eliminated, and accuracy and sensitivity improved (Heavilin et al., 2011).
<table>
<thead>
<tr>
<th>Primary Author and Year of Publication</th>
<th>Health Behaviour(s) or Attitude(s)</th>
<th>Online Study Population(s) and Social Media Platform(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ache and Wallace 2008</td>
<td>Attitudes and beliefs about HPV vaccination</td>
<td>Videos and comments of HPV vaccination related videos posted by users of a video-sharing website (‘YouTube’)</td>
</tr>
<tr>
<td>Bolding et al. 2004</td>
<td>High-risk sexual health behaviours</td>
<td>Men who have sex with men (MSM) using online chat-rooms or two most popular gay social networking sites (‘gaydar’ and ‘gay.com’)</td>
</tr>
<tr>
<td>Couch and Liamputtong 2007</td>
<td>Attitudes towards sex and sexual behaviours</td>
<td>Online dating contacts using a chat software programme (‘MSN messenger’)</td>
</tr>
<tr>
<td>Griffiths and Casswell 2010</td>
<td>Alcohol use</td>
<td>Unrestricted personal profiles of New Zealand youth (16 – 18 yrs old) on a social networking site (‘Bebo’)</td>
</tr>
<tr>
<td>Heavilin et al. 2011</td>
<td>Actions taken or contemplated regarding dental pain (dental health behaviour)</td>
<td>Public posts (tweets) on dental pain from users of an online micro-blogging service (‘Twitter’)</td>
</tr>
<tr>
<td>Keelan et al. 2010</td>
<td>Attitudes towards HPV immunization</td>
<td>Blogs on HPV created by users of a social networking site (‘MySpace’)</td>
</tr>
<tr>
<td>Keelan et al. 2007</td>
<td>Attitudes towards immunization</td>
<td>Videos on immunization posted by users of a video-sharing website (‘YouTube’)</td>
</tr>
<tr>
<td>Lord et al. 2011</td>
<td>Attitudes associated with nonmedical prescription opioid analgesic and stimulant use</td>
<td>Students who self-reported prescription opioid or stimulant use aged 18-25 yrs and members of a social networking site (‘Facebook’)</td>
</tr>
<tr>
<td>Lynch 2010</td>
<td>Attitudes and behaviours associated with healthy dietary behaviours</td>
<td>Blogs created by young women on a photography-based food blogging community</td>
</tr>
<tr>
<td>Moreno et al. 2010</td>
<td>Alcohol use</td>
<td>Unrestricted active personal profiles of American adolescents (17-20 yrs old) on a social networking site (‘MySpace’)</td>
</tr>
<tr>
<td>Moreno et al. 2010</td>
<td>Sexual behaviour</td>
<td>Unrestricted active profiles of American adolescents (18 yrs old) on a social networking site (‘MySpace’)</td>
</tr>
<tr>
<td>Moreno et al. 2009</td>
<td>Health risk behaviours (sexual behaviour, substance use and violence)</td>
<td>Unrestricted active personal profiles of American adolescents (18 yrs old) on a social networking site (‘MySpace’)</td>
</tr>
<tr>
<td>Moreno et al. 2009</td>
<td>Sexual behaviour and substance abuse</td>
<td>Unrestricted active personal profiles of American adolescents (18-20 yrs old) on a social networking site (‘MySpace’)</td>
</tr>
<tr>
<td>Primary Author, Year (Reference)</td>
<td>Health Behaviour(s) or Attitude(s)</td>
<td>Online Study Population(s) and Social Media Platform(s)</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-----------------------------------</td>
<td>-----------------------------------------------------</td>
</tr>
<tr>
<td>Moreno et al. 2007</td>
<td>Sexual behaviour and substance use</td>
<td>Unrestricted active personal profiles of American adolescents (16-17 yrs old) on a social networking site (‘MySpace’) and belonging to a MySpace group (‘Class of 2008 group’)</td>
</tr>
<tr>
<td>Powell et al. 2003</td>
<td>Depression treatment behaviour</td>
<td>Members of six Internet depression discussion communities hosted in six different European countries</td>
</tr>
<tr>
<td>Rhodes et al. 2011</td>
<td>HIV testing behaviours</td>
<td>Members of an MSM internet chat room in northwestern North Carolina</td>
</tr>
<tr>
<td>Rhodes et al. 2008</td>
<td>HIV risk behaviours</td>
<td>Members of five MSM internet chat rooms in central North Carolina</td>
</tr>
<tr>
<td>Salathé et al. 2011</td>
<td>Sentiment towards influenza A(H1N1) vaccine</td>
<td>Public posts (tweets) on A(H1N1) vaccine from users in the United States of an online micro-blogging service (‘Twitter’)</td>
</tr>
<tr>
<td>Scanfeld et al. 2010</td>
<td>Misuse and/or misunderstanding of antibiotics</td>
<td>Public posts (tweets) on antibiotics from users of an online micro-blogging service (‘Twitter’)</td>
</tr>
<tr>
<td>Tian 2010</td>
<td>Attitudes towards organ donation</td>
<td>Videos and comments on organ donation posted by users on a video-sharing website (‘YouTube’)</td>
</tr>
</tbody>
</table>

**Table 2. Summary of Online Populations and Social Media Platforms**

<table>
<thead>
<tr>
<th>Online population</th>
<th>No. of studies*</th>
<th>Social media platforms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Users of social networking sites</td>
<td>8</td>
<td>MySpace, Facebook, Bebo, Gaydar</td>
</tr>
<tr>
<td>Members of chat rooms/discussion forums</td>
<td>5</td>
<td>MSM chat rooms, MSN Messenger, Depression communities</td>
</tr>
<tr>
<td>Video-sharing users</td>
<td>3</td>
<td>YouTube</td>
</tr>
<tr>
<td>Users of micro-blogging service</td>
<td>3</td>
<td>Twitter</td>
</tr>
<tr>
<td>Bloggers</td>
<td>2</td>
<td>Food blogging community, MySpace blogs</td>
</tr>
</tbody>
</table>

* Number of studies does not equal 20 as one study investigated more than one online population (Bolding et al. 2004)
<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Type of Study</th>
<th>Sampling</th>
<th>Timeframe</th>
<th>Sample Size</th>
<th>Data Extraction</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ache and Wallace 2008</td>
<td>Cross-sectional</td>
<td>All relevant YouTube videos via keyword search</td>
<td>One day (February 8, 2008)</td>
<td>146 videos</td>
<td>User comments and video content</td>
<td>- Content analysis and coding (pre-established categories)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Quantitative (univariate and bivariate)</td>
</tr>
<tr>
<td>Bolding et al. 2004</td>
<td>Cross-sectional</td>
<td>Convenience sampling via pop-ups and banners in social media platforms</td>
<td>One month (May-June 2002)</td>
<td>4,974 men</td>
<td>Online survey</td>
<td>- Quantitative (univariate and multivariate)</td>
</tr>
<tr>
<td>Couch and Liamputtong 2007</td>
<td>Cross-sectional</td>
<td>Snowball sampling from online dating contacts of author</td>
<td>(n.d)</td>
<td>15 individuals</td>
<td>Online in-depth interviews</td>
<td>- Content analysis</td>
</tr>
<tr>
<td>Griffiths and Casswell 2010</td>
<td>Cross-sectional</td>
<td>Convenience sampling of Bebo profiles</td>
<td>Four weeks (October 2008)</td>
<td>150 public profiles</td>
<td>User comments</td>
<td>- Thematic analysis</td>
</tr>
<tr>
<td>Heaivilin et al. 2011</td>
<td>Cross-sectional</td>
<td>Sample of all relevant tweets via keyword search</td>
<td>Seven non-consecutive days (n.d.)</td>
<td>1,000 tweets</td>
<td>User posts (tweets)</td>
<td>- Content analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Thematic qualitative analysis</td>
</tr>
<tr>
<td>Keelan et al. 2010</td>
<td>Cross-sectional</td>
<td>All relevant MySpace blogs via keyword search</td>
<td>One day search (May 6, 2008)</td>
<td>303 blogs</td>
<td>Blog content</td>
<td>- Content analysis and coding (pre-established categories)</td>
</tr>
<tr>
<td>Keelan et al. 2007</td>
<td>Cross-sectional</td>
<td>All relevant videos via keyword search</td>
<td>One day search (February 20, 2007)</td>
<td>153 videos</td>
<td>Video content</td>
<td>- Quantitative (univariate)</td>
</tr>
<tr>
<td>Lord et al. 2011</td>
<td>Cross-sectional</td>
<td>Convenience sampling via Facebook advertisement</td>
<td>Two weeks (Fall 2005)</td>
<td>698 college students</td>
<td>Online survey</td>
<td>- Content analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Qualitative analysis of open-ended questions</td>
</tr>
</tbody>
</table>

Table 3. Methodology of Reviewed Articles
<table>
<thead>
<tr>
<th>Study (Year)</th>
<th>Design</th>
<th>Sample Description</th>
<th>Time Period</th>
<th>Sample Size</th>
<th>Content Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lynch 2010</td>
<td>Cross-sectional</td>
<td>Sample of blogs via search term in Google search engine</td>
<td>(n.d)</td>
<td>45 blogs</td>
<td>Blog content</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Content analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Thematic qualitative analysis</td>
</tr>
<tr>
<td>Moreno et al. 2010</td>
<td>Cross-sectional</td>
<td>Random sample of MySpace profiles via MySpace search criteria</td>
<td>11 months (January 20 – December 20, 2008)</td>
<td>400 public profiles</td>
<td>Profile content</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Content analysis and coding (pre-established categories)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Quantitative (univariate and bivariate)</td>
</tr>
<tr>
<td>Moreno et al. 2010</td>
<td>Cross-sectional</td>
<td>Sample of MySpace profiles</td>
<td>3 months (June - August 2008)</td>
<td>160 public profiles</td>
<td>Profile content</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Content analysis and coding (pre-established categories)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Quantitative (univariate and bivariate)</td>
</tr>
<tr>
<td>Moreno et al. 2009</td>
<td>Cross-sectional</td>
<td>Random sample of MySpace profiles via MySpace search criteria</td>
<td>2.5 months (July 15 – September 30, 2007)</td>
<td>500 public profiles</td>
<td>Profile content</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Content analysis and coding (pre-established categories)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Quantitative (univariate and multivariate)</td>
</tr>
<tr>
<td>Moreno et al. 2009</td>
<td>Randomized controlled intervention trial</td>
<td>Random sample of public MySpace profiles via MySpace search criteria</td>
<td>4 months (April 2 – July 31, 2007)</td>
<td>190 public profiles (95 intervention, 95 control)</td>
<td>Profile content</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Content analysis of control group and intervention group at baseline and 3 months after baseline, and coding (pre-established categories)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Quantitative (univariate, bivariate, multivariate)</td>
</tr>
<tr>
<td>Moreno et al. 2007</td>
<td>Cross-sectional</td>
<td>Sequential sampling (most recent activity to least) of public MySpace profiles via search in a MySpace group</td>
<td>(n.d)</td>
<td>142 public profiles</td>
<td>Profile content</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Content analysis and coding (categories established based on content of pilot profiles)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Quantitative (univariate)</td>
</tr>
<tr>
<td>Study (Year)</td>
<td>Design</td>
<td>Sample Methodology</td>
<td>Time Frame</td>
<td>Sample Size</td>
<td>Data Collection Method</td>
</tr>
<tr>
<td>-------------</td>
<td>--------</td>
<td>---------------------</td>
<td>------------</td>
<td>-------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>Powell et al. 2003</td>
<td>Cross-sectional</td>
<td>Convenience sampling via pop-up display in community forum</td>
<td>4 weeks (May-June 2002)</td>
<td>2307 community members</td>
<td>Online survey</td>
</tr>
<tr>
<td>Rhodes et al. 2008</td>
<td>Cross-sectional quasi-experimental 2 group comparison</td>
<td>Convenience sampling via recruitment in five chat-rooms</td>
<td>Summer period (Summer 2004)</td>
<td>448 chat-room members (passive intervention group: 210; active group: 238)</td>
<td>Online survey</td>
</tr>
<tr>
<td>Salathé et al. 2011</td>
<td>Cross-sectional</td>
<td>Sample of relevant tweets via keyword search in Twitter</td>
<td>6 months (August 2009 – January 2010)</td>
<td>318,379 posts (tweets)</td>
<td>Tweet content</td>
</tr>
<tr>
<td>Scanfeld et al. 2010</td>
<td>Cross-sectional</td>
<td>Random sample of all tweets via keyword search in Twitter</td>
<td>4.5 months (March 13 – July 31, 2009)</td>
<td>1,000 posts (tweets)</td>
<td>Tweet content</td>
</tr>
<tr>
<td>Author Year</td>
<td>Reasons Given for Using Social Media Platforms</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ache and Wallace 2008</td>
<td>- Increased access and popularity&lt;br&gt;- Influence/impact on public health practice&lt;br&gt;- Little or no research on exists</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bolding et al. 2004</td>
<td>- Ability to find study populations&lt;br&gt;- Increased access and popularity&lt;br&gt;- Influence on health behaviours/attitudes&lt;br&gt;- Influence/impact public health practice</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Couch and Liamputtong 2007</td>
<td>- Ability to find study populations&lt;br&gt;- Increased access and popularity&lt;br&gt;- Influence of SM on health behaviours/attitudes&lt;br&gt;- Little or no research exists&lt;br&gt;- Online context encourages information reveal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Griffiths and Casswell 2010</td>
<td>- Ability to find study populations&lt;br&gt;- Increased access and popularity&lt;br&gt;- Little or no research exists</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heaivilin et al. 2011</td>
<td>- Easy and cost-effective&lt;br&gt;- Elimination of recall bias&lt;br&gt;- Frequently updated real-time data&lt;br&gt;- Novel vehicle to study health behaviours and/or attitudes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Author, Year</td>
<td>Reasons Given for Using Social Media Platforms</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------</td>
<td>-----------------------------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Keelan et al. 2010 | - Frequently updated real-time data  
- Increased access and popularity  
- Influence of SM on health behaviours/attitudes  
- Little or no research exists  
- Novel vehicle to study health behaviours and/or attitudes |
| Keelan et al. 2007 | - Little or no research exists |
| Lord et al. 2011 | - Easy and cost-effective  
- Increased access and popularity  
- Reduction of stigma |
| Lynch 2010 | - Increased access and popularity  
- Influence on health behaviours/attitudes  
- Little or no research exists  
- Novel vehicle to study health behaviours and/or attitudes  
- Online context encourages information reveal |
| Moreno et al. 2010 | - Ability to find study populations  
- Increased access and popularity  
- Influence on health behaviours/attitudes |
| Moreno et al. 2010 | - Influence/impact public health practice  
- Influence on health behaviours/attitudes |
| Moreno et al. 2009 | - Ability to find study population  
- Increased access and popularity  
- Influence/impact public health practice  
- Influence on health behaviours/attitudes  
- Little or no research exists  
- Novel vehicle to study health behaviours and/or attitudes  
- Online context encourages information reveal |
<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Reasons Given for Using Social Media Platforms</th>
</tr>
</thead>
</table>
| Moreno et al. 2009 | - Ability to find study population  
- Increased access and popularity  
- Influence/impact public health practice  
- Influence on health behaviours/attitudes  
- Little or no research exists  
- Novel vehicle to study health behaviours and/or attitudes  
- Online context encourages information reveal |
| Moreno et al. 2007 | - Ability to find study population  
- Increased access and popularity  
- Influence on health behaviours/attitudes  
- Novel vehicle to study health behaviours and/or attitudes |
| Powell et al. 2003 | - Ability to find study population  
- Increased access and popularity  
- Influence/impact on public health practice  
- Novel vehicle to study health behaviours and/or attitudes  
- Reduction of stigma |
| Rhodes et al. 2011 | - Ability to find study population  
- Increased access and popularity  
- Influence/impact on public health practice  
- Influence on health behaviours/attitudes  
- Online context encourages information reveal  
- Reduction of stigma |
| Rhodes et al. 2008 | - Ability to find study population  
- Increased access and popularity  
- Influence on health behaviours/attitudes |
| Salathé et al. 2011 | - Easy and cost-effective  
- Increased access and popularity  
- Influence on health behaviours/attitudes |
<table>
<thead>
<tr>
<th>Source</th>
<th>Influence/impact on public health practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scanfeld et al. 2010</td>
<td>- Increased access and popularity</td>
</tr>
<tr>
<td></td>
<td>- Influence/impact on public health practice</td>
</tr>
<tr>
<td></td>
<td>- Novel vehicle to study health behaviours and/or attitudes</td>
</tr>
<tr>
<td></td>
<td>- Online context encourages information reveal</td>
</tr>
<tr>
<td>Tian 2010</td>
<td>- Increased access and popularity</td>
</tr>
<tr>
<td></td>
<td>- Influence/impact on public health practice</td>
</tr>
<tr>
<td></td>
<td>- Novel vehicle to study health behaviours and/or attitudes</td>
</tr>
<tr>
<td></td>
<td>- Online context encourages information reveal</td>
</tr>
</tbody>
</table>
Discussion

This review identified and synthesized the methodology and reasons given for using social media platforms to study online health behaviours or attitudes toward health behaviours. The results show that research in this area is limited with varied methodology. Researchers were able to study a wide variety of health behaviours or attitudes, from sexual health behaviours to dental pain, using different social media platforms such as social networking sites, blogs and video-sharing sites. The majority of the studies were descriptive in nature, two reviewed studies were quasi-experimental and one was a randomized controlled intervention trial.

Many benefits were reported by using social media platforms to study health behaviours or attitudes such as the ability to easily access rich and real-time data with low cost, to target specific population or large populations across wide geographical range, to reach populations with stigmatized behaviours or conditions, and to eliminate recall bias and improve accuracy. Social media platforms also provide the potential for public health practice to quickly identify important trends or identify at-risk populations for targeted interventions. In addition, as demonstrated by two of the studies (Moreno et al., 2010; Salathé and Khandelwal, 2011), social media platforms provide the capability to study how behaviour or attitudes influence or transmit through social networks.

The need for research in this novel field and the many benefits of social media platforms were cited by the researchers as rationale for studying health behaviours or attitudes via social media platforms, however it is important to note that many limitations exist in the methodology of the reviewed studies. The representativeness of the data is an important limitation for several reasons. Sampling methods and sample sizes varied by data collection methods (data extraction vs. online survey) and by the social media platform (i.e. YouTube vs. Facebook). Regardless of the population size or the social media platform, the number of users fluctuates daily. Therefore it was not possible for the studies to determine ‘true denominators’, subsequently excluding calculations of real participation, prevalence and incidence rates in that population. In addition, the population posting content to social media platforms or participating in online surveys may differ significantly from non-participatory users of the social media platform. None of the studies reviewed had the ability to characterize non-posters or ‘lurkers’ or those who may have
viewed the online survey link but did not click on the link, or clicked on the link but did not respond to the survey. Moreover, some social media platforms have privacy settings that allow users to restrict public access to specific content thereby preventing data collection from ‘blocked’ content. One study noted that those who decide to display risky health behaviours on the Internet might actually represent a higher-risk population who are willing to showcase those behaviours in a public forum (Moreno et al., 2009). Furthermore, representativeness may have been further compromised by studies restricting data collection to the English language and to one (or two) social media platforms. One author also noted the proprietary search engines of the social media platforms’ could be a potential source of selection bias if the search engine systematically searches its database from your query (Moreno et al., 2009).

When collecting data via data extraction of public posts, the validity of the data may be in question. The information posted by users was treated as accurate and valid, however it is not known if the information posted was true, or if the displayed health behaviours or intended health behaviours translate into real-life behaviours. However for some studies it was possible to assess the validity of the results by comparison to national data or to results of previous studies (Bolding et al., 2004; Lord et al., 2011; Salathé and Khandelwal, 2011). To date the real-life translation of online displayed behaviours has not been sufficiently evaluated in research. Although the displayed behaviours may be fabricated, it is important to note that adverse effects such as attracting attention from cyber-bullies or sexual predators have been reported as real-life impacts associated with displaying certain behaviours on social media platforms (Moreno et al., 2009) and could also have an adverse effect on other users’ health decisions regardless of the authenticity of the displayed behaviour. The validity of information posted on demographics and risk factors was also unknown, however three (out of the ten) studies that were able to capture information on demographics and/or risk factors attempted to validate users’ posted age by evaluating user profiles for corroborating evidence (Moreno et al., 2009; Moreno et al., 2009; Moreno et al., 2010). Using data extraction methodology also restricted the ability to capture data on demographics and risk factors depending on the social media platform; some social media platforms may facilitate the capture of demographics and co-variates while others may provide little to no information. For example, in MySpace it is possible to search for adolescents who identify themselves as drinkers or smokers, however YouTube provides little to no information on demographics or risk factors. The ability to capture these
data is further limited by users’ decisions to block public access to data, but also on the applicability and popularity of the particular social media platform. For example, MySpace provides more user information than most platforms but may not be the most popular or interesting social networking site at the time of study or may not represent your target population. The inability to capture data on demographics or risk factors also restricts generating multivariate statistics. Misclassification via measurement bias may also threaten the validity of the studies using content analysis methodology. The categorizing of content can be subjective, and other researchers may interpret and classify differently. In the majority of the content analysis studies researchers tried to minimize this bias by using multiple reviewers and calculating inter-rater reliability scores. However, it remains an important bias as it may be quite difficult to capture objective markers when collecting data via content analysis of social media platforms.

This systematic review focussed on studies of online populations, and the results of the reviewed studies only applied to people in a specific English social media platform(s) who publicly posted or responded, during the specific timeframe of the study. However several authors discussed the concept of generalizability of their results to the population in general. Although it has been reported that the digital divide between those who have access to the Internet and those who do not is decreasing (Schein et al., 2010), there is no evidence that any of the results from the reviewed studies could apply to the ‘offline’ population.

Notwithstanding the methodological limitations, this field of research has the potential to meaningfully contribute to public health knowledge and practice in ways not possible via traditional methodologies. Most importantly, social media platforms provide a venue to gather rich, real-time self-reported data from high-risk or stigmatized populations and from individuals previously unreachable via traditional methods. Public health professionals and researchers must acknowledge that social media are here to stay, thus it is imperative that research continues and evolves. In the future, these platforms may be the only or primary way to gather public health data. Research into social media and public health practice is still in its infancy, particularly in the study of health behaviours and attitudes. Future research should examine better mechanisms to study and change health behaviours, and determine how best to implement interventions online. In addition, there is a need for validation studies in terms of
translation to real-life behaviours, comparison studies to traditional methods for
generalizability, and evaluation of the significance and stability of the findings over time via
prospective cohort studies. Furthermore, as the internet and social media platforms continue to
be popular sources of health information, the influence of online social networks on individual
health behaviours needs to be further examined in order to identify how and where public
health can influence or intervene.

This systematic review is limited by only including English language articles and also by the use
of one single reviewer. Future reviews on the use of social media in the study of health
behaviours will be necessary as research in this field is increasing and rapidly evolving.

Acknowledgments

The author would like to acknowledge the support of the librarian services at Public Health
Ontario, the University of Toronto and the Public Health Agency of Canada.
References


Appendix 3- Online Survey (Unformatted English Version)

Parents, tell us what you think about vaccines!

Are you a Canadian parent with at least one child under 18 years of age?

Researchers at the Dalla Lana School of Public Health, University of Toronto, want to hear from you on important children's health issues. Complete this short (15 mins) survey and enter a draw where 1 out of every 90 parents who enter will win an iPad mini. Please read further information below to participate in the survey.

Dear Parent,
Researchers at the Dalla Lana School of Public Health, University of Toronto, would like to hear your thoughts on childhood vaccinations. This survey asks about your attitudes on vaccinations and how you decide whether or not to vaccinate your child. This study will help us understand how Canadian parents are thinking about childhood vaccines to help us improve immunization programs. If you complete the online survey, you can enter in a draw where 1 in 90 parents who enter will win an Apple iPad mini.

To participate in this study you must: Be over 18 years of age; Be a Canadian resident; and Have at least one child under the age of 18 years. Privacy policy: The survey is anonymous and will take approximately 15 minutes of your time. Your answers will remain confidential and no information provided can be linked back to you as an individual or your computer. Only the study researchers will have access to the collected data that will be kept in a secure file. You may stop the survey at any time or skip any questions you prefer not to answer. Your answers will not be included in the study if you choose to not complete the entire survey. This study has been approved by the University of Toronto’s Research Ethics Board (REB # 29309). If you have any questions regarding your rights as a research participant, please contact the Office of Research Ethics at ethics.review@utoronto.ca or 416-946-3273. If you have any questions specific to this research or any trouble with the survey, please feel free to contact Jordan Tustin PhD (candidate) at jordan.tustin@mail.utoronto.ca.

In addition, a summary of the research results or any resulting publications can be made available to you at your request. If you would like to participate in this survey now, please click the YES button below. You may print or save this form for your own reference.

○ Yes
○ No

182
Please indicate your sex
- Male
- Female

What is your age?

Please input your current age in years

What is your date of birth (YYYY-MM-DD)?

Do you currently reside in Canada?
- Yes
- No

In what province or territory do you currently reside?
- Alberta
- British Columbia
- Manitoba
- New Brunswick
- Newfoundland and Labrador
- Northwest Territories
- Nova Scotia
- Nunavut
- Ontario
- Prince Edward Island
- Quebec
- Saskatchewan
- Yukon

In what country were you born?
- Afghanistan
- Albania
- Algeria
- Andorra
- Angola
- Antarctica
- Antigua and Barbuda
- Argentina
- Armenia
- Australia
... 171 additional choices hidden ...

- United States
- Uruguay
- Uzbekistan
- Vanuatu
- Venezuela
- Vietnam
- Yemen
- Zambia
- Zimbabwe
- Other

Are you a parent or guardian of someone under 18 years of age, who is living with you or somewhere else?
- Yes
- No

Do you have shared or primary responsibility for decisions regarding your children's healthcare?
- Yes
- No

How many children do you have under the age of 18 years?
- 0
- 1
- 2
- 3
- 4
- 5
- 6 or more

What is your youngest child's age?
- less than 1 month
- 1 month
- 2 months
- 3 months
- 4 months
- 5 months
- 6 months
- 7 months
- 8 months
- 9 months
- ... 10 additional choices hidden ...
- 10 years
○ 11 years
○ 12 years
○ 13 years
○ 14 years
○ 15 years
○ 16 years
○ 17 years
○ 18 years
○ Over 18 years

What is your youngest child's sex?
○ Male
○ Female

In what country was your youngest child born?
○ Afghanistan
○ Albania
○ Algeria
○ Andorra
○ Angola
○ Antarctica
○ Antigua and Barbuda
○ Argentina
○ Armenia
○ Australia
○ United States
○ Uruguay
○ Uzbekistan
○ Vanuatu
○ Venezuela
○ Vietnam
○ Yemen
○ Zambia
○ Zimbabwe
○ Other

... 171 additional choices hidden ...

What language do you speak most often at home?
○ English
○ French
○ Other, please specify... ______________________

Do you have a family doctor?
○ Yes
If you were looking for the most reliable and trustworthy information on vaccines, where would you look or who would you talk to? Please choose one or more (up to three) options in order of preference.

<table>
<thead>
<tr>
<th>1st choice</th>
<th>2nd choice</th>
<th>3rd choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physician</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Other health care worker (e.g. nurse)</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Local health authority</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Pharmacist</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Family member/friend</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Internet sites</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Medical book/journal</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>News/media (TV, newspaper, radio)</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Don’t know/Not sure</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Other</td>
<td>o</td>
<td>o</td>
</tr>
</tbody>
</table>

Have you ever looked for information about vaccines?
- Yes
- No

Where did you look or who did you talk to about vaccines? Please choose one or more (up to three) options in order of importance.

<table>
<thead>
<tr>
<th>Most important</th>
<th>2nd most important</th>
<th>3rd most important</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physician</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Other health care worker (e.g. nurse)</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Local health authority</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Pharmacist</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Family member/friend</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Internet sites</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Medical book/journal</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>News/media (TV, newspaper, radio)</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Don’t know/Not sure</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Other</td>
<td>o</td>
<td>o</td>
</tr>
</tbody>
</table>

If you answered Internet Sites as one of your top three choices for vaccine information in the previous question, where on the Internet would you typically go to look for vaccine information? Please choose one or more (up to three) options in order of frequency visited. Please continue to the next page if 'Internet' was not one of your choices in previous question.
<table>
<thead>
<tr>
<th>Source of Information</th>
<th>Visited</th>
<th>Visited</th>
<th>Visited</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical website or Smartphone/tablet applications (e.g. WebMD.com, MedicineNet.com, ETC)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Online chat rooms/forums/answers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Government websites</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Online medical peer-reviewed journals/search of journal database</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family parenting website (e.g. parents canada.com, todaysparent.com, ETC)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First websites that appear when browsing on a search engine (e.g. Google, Bing, Yahoo, ETC)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blogs on parenting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facebook posts or groups</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Twitter posts or threads</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Don't know/Not Sure</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If possible, please provide examples of the top three websites, blogs or microblogs you have visited for vaccine information:

[Blank]

What type of information on childhood vaccinations are you searching for? Please check all that apply.

- [ ] Vaccine schedule/timeline of vaccines
- [ ] Side effects/adverse events of vaccines
- [ ] Risk of autism
- [ ] Vaccine trials/research
- [ ] Vaccination legislation
- [ ] Individual experiences or opinions
- [ ] Other. Please specify: ______________________

In your opinion, on a scale from 1 (not at all safe) to 7 (extremely safe) how safe are childhood vaccinations in Canada?

- [ ] 1 - Not at all safe
- [ ] 2
- [ ] 3
- [ ] 4 - Moderately safe
- [ ] 5
- [ ] 6
- [ ] 7 - Extremely safe

To the best of your knowledge, how up-to-date is your youngest child on immunizations recommended for his/her age?
Please refer to the following links for information on the immunization schedules:


- Completely up-to-date
- Somewhat up-to-date
- Not at all up-to-date

Which vaccine or vaccines did your youngest child not receive? Check all that you think he/she did not (or has not yet) received.

Please refer to the following links for the immunization schedules: Provincial/Territorial immunization schedules for children under 6 years of age: [http://www.phac-aspc.gc.ca/im/iyc-vve/is-cv-eng.php](http://www.phac-aspc.gc.ca/im/iyc-vve/is-cv-eng.php)


- My youngest child is not yet due for vaccinations (under 2 months of age)
- My youngest child has not received any of the vaccines
- Measles/mumps/rubella (MMR) vaccine
- Tetanus/diphtheria/Hib/pertussis/polio vaccine
- The flu (influenza) vaccine (2013/2014 vaccine)
- The vaccine for chicken pox (Varicella)
- Hepatitis B
- Vaccine to prevent pneumococcal disease, including pneumonia, meningitis and bacteria in the blood
- Vaccine to prevent meningococcal disease including meningitis and bacteria in the blood
- HPV (Human Papillomavirus) vaccine
- Don't know/Not Sure

What are the main reasons for the last decision made to not vaccinate your youngest child against one or more vaccines? Please choose one or more (up to three) options in order of importance.

<table>
<thead>
<tr>
<th>Most important reason</th>
<th>2nd most important reason</th>
<th>3rd most important reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have not done it yet, but I’m planning to</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
Didn’t know how or where to access health care services | o | o | o
Did not remember/forgot | o | o | o
Don’t know the schedules of what vaccine is due | o | o | o
Don’t believe in them (e.g., philosophical or religious reasons) | o | o | o
Vaccines have many serious side effects | o | o | o
Some vaccines can cause autism or sudden infant death syndrome | o | o | o
Vaccines contain toxic ingredients like formaldehyde and mercury | o | o | o
Diseases prevented by vaccines do not exist in Canada anymore | o | o | o
Vaccines overload the immune system | o | o | o
Vaccines are not necessary (body takes care of itself) | o | o | o
Vaccines are not effective (they don't work) | o | o | o
Vaccines may cause the disease meant to be prevented | o | o | o
A doctor or health professional said that it was not safe to vaccinate | o | o | o
One or more of my children had an adverse reaction to a vaccine | o | o | o
Don’t know/Not sure | o | o | o
Other | o | o | o

If you answered 'Other' as one of your main reasons to not vaccinate your child, please provide further information on the reason(s).

Overall, have you found decisions relating to having your youngest child immunized very easy, easy, difficult or very difficult to make?

- Very easy. Why? Please specify: ______________________
- Easy. Why? Please specify: ______________________
- Difficult. Why? Please specify: ______________________
- Very difficult. Why? Please specify: ______________________

Have you ever changed your views on immunization?
Yes - Why/what happened? Please specify: ______________________
No - Why? Please specify: ______________________

To what extent do you agree or disagree with the following statements:

The Internet is giving parents access to good information to make informed decisions about vaccination
- 1 - Strongly Disagree
- 2
- 3
- 4 - Neither Disagree or Agree
- 5
- 6
- 7 - Strongly Agree

I am more concerned about the safety of vaccinations than I was five years ago
- 1 - Strongly Disagree
- 2
- 3
- 4 Neither Disagree or Agree
- 5
- 6
- 7 - Strongly Agree

There is a lot of misinformation about vaccines on the Internet
- 1 - Strongly Disagree
- 2
- 3
- 4 Neither Disagree or Agree
- 5
- 6
- 7 - Strongly Agree

I usually follow the advice of my child's doctor or nurse
- 1 - Strongly Disagree
- 2
- 3
- 4 Neither Disagree or Agree
- 5
- 6
- 7 - Strongly Agree

My health provider explains the risks and benefits of vaccines clearly
- 1 - Strongly Disagree
I think vaccines are safe
- 1- Strongly Disagree
- 2
- 3
- 4 Neither Disagree or Agree
- 5
- 6
- 7 - Strongly Agree

How often do you typically use Facebook?
- Every day
- Two or three times per week
- Once per week
- At least once per month
- Not often (less than once per month)
- Never

How often do you typically use Twitter?
- Every day
- Two or three times per week
- Once per week
- At least once per month
- Not often (less than once per month)
- Never

Would you use Facebook to find health information?
- Yes. Why? Please specify: ______________________
- No. Why? Please specify: ______________________
- Maybe. Why? Please specify: ______________________

Would you use Twitter to find health information?
- Yes. Why? Please specify: ______________________
- No. Why? Please specify: ______________________
- Maybe. Why? Please specify: ______________________

If a health professional was available online to discuss your health concerns (for example vaccinations) would you be interested in using this service?
If you were seeking out information on childhood vaccinations, how would you prefer to receive the information? Please choose one or more (up to three) options in order of preference.

<table>
<thead>
<tr>
<th></th>
<th>1st choice</th>
<th>2nd choice</th>
<th>3rd choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Email</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Facebook</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Twitter</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Text Message</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Online chatroom/forum</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Government website</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Other website</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Phone call</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Newsletter</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>In person</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

If you were seeking out information on vaccinations, from whom would you prefer to receive the information? Please choose one or more (up to three) options in order of preference.

<table>
<thead>
<tr>
<th></th>
<th>1st choice</th>
<th>2nd choice</th>
<th>3rd choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>A physician</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>My mother and/or father</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Another family member</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>A friend</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>A government public health representative</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>A pharmacist</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>A naturopath</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>A chiropractor</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>A mommy/daddy blogger</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>The media</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>A scientist</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

Please provide any further comments on how you would prefer to receive information on vaccinations


In your opinion, on a scale from 1 (not at all safe) to 7 (extremely safe), how safe are the following activities

<table>
<thead>
<tr>
<th></th>
<th>1 - Not at all safe</th>
<th>2</th>
<th>3</th>
<th>4 - Moderately safe</th>
<th>5</th>
<th>6</th>
<th>7 - Extremely safe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taking prescription drugs</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
Taking over the counter medicines
Using natural health products
Getting vaccinated
Consuming alcoholic beverages
Exposure to food preservatives
Taking oral contraceptives
Exposure to pesticides

How did you get directed to this survey?

○ Advertisement on Facebook newsfeed
○ Facebook friend who shared or liked the Facebook page
○ Facebook friend who posted or shared the link to the survey
○ Twitter post or share of the link to the survey
○ A friend told you about it or emailed link
○ Other. Please specify: ______________________

What is the highest level of education that you have completed?

○ Public/elementary school or less (grade 1-8)
○ Some high school
○ Graduated from high school (grade 12-13)
○ Vocational/technical college or CEGEP
○ Trade certification
○ Some university
○ Bachelor’s degree
○ Professional certification
○ Graduate degree

In 2011, Statistics Canada reported the estimated median total household income for Canadian families as $72,240. Does your total household income (before taxes) for 2013 fall above or below the 2011 median?

○ Above (higher than the median)
○ Below (lower than the median)

What is your estimated gross total income (before taxes) for your household in 2013?

○ Under $30,000
○ From $30,000 to $39,999
○ From $40,000 to $49,999
○ From $50,000 to $59,999
○ From $60,000 to $69,999
From $70,000 to $79,999
From $80,000 to $89,999
From $90,000 to $99,999
From $100,000 to $119,999
$120,000 and over

Thank you very much for your time. Please click on the SUBMIT SURVEY tab at the bottom of your screen to complete the survey. Please provide your email address below if you would like to enter a draw to win an iPad mini (value of approximately $400) with 1 in 90 odds of winning. Your email address will be kept confidential and only used for the purposes of the draw. At the end of the draw, your email information will be destroyed.

Would you like to enter the draw to win an iPad mini?
- Yes. Please provide email address: ______________________
- No

Please visit the following websites for information on childhood immunizations in Canada:
- Public Health Agency of Canada, Immunization Fact and Fiction
- Public Health Agency of Canada, A Parent’s Guide to Immunization
- Immunization Schedules for all Provinces and Territories
Appendix 4 - Node Structure, Content Analysis, Aim2/Manuscript 1

<table>
<thead>
<tr>
<th>Hierarchical Name</th>
<th>Nickname</th>
<th>Aggregate</th>
<th>User Assigned Color</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Node</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nodes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nodes^|CONTEXTUAL INFLUENCES</td>
<td>Yes</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes^|CONTEXTUAL INFLUENCES|Communication and media environment</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes^|CONTEXTUAL INFLUENCES|Geographic barriers</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes^|CONTEXTUAL INFLUENCES|Historical influences</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes^|CONTEXTUAL INFLUENCES|Influential leaders, gatekeepers and anti- or pro-vaccination lobbies</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes^|CONTEXTUAL INFLUENCES|Pharmaceutical industry</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes^|CONTEXTUAL INFLUENCES|Politics, policies</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes^|CONTEXTUAL INFLUENCES|Religion, culture, gender, socio-economic</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes^|INDIVIDUAL AND GROUP INFLUENCES</td>
<td>Yes</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes^|INDIVIDUAL AND GROUP INFLUENCES|Beliefs, attitudes about health and prevention</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes^|INDIVIDUAL AND GROUP INFLUENCES|Experience with past vaccination</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes^|INDIVIDUAL AND GROUP INFLUENCES|Health system and providers trust and personal experience</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes^|INDIVIDUAL AND GROUP INFLUENCES|Immunization as a social norm vs not needed or harmful</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes^|INDIVIDUAL AND GROUP INFLUENCES|Knowledge, awareness</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes^|INDIVIDUAL AND GROUP INFLUENCES|Risk, benefit (perceived, heuristic)</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes^|VACCINE OR VACCINATION SPECIFIC ISSUES</td>
<td>Yes</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes^|VACCINE OR VACCINATION SPECIFIC ISSUES|Costs</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes^|VACCINE OR VACCINATION SPECIFIC ISSUES|Design of vaccination program or mode of delivery</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes^|VACCINE OR VACCINATION SPECIFIC ISSUES|Introduction of a new vaccine or new formulation</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes^|VACCINE OR VACCINATION SPECIFIC ISSUES|Mode of administration</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes^|VACCINE OR VACCINATION SPECIFIC ISSUES|Reliability and or source of vaccine supply</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes^|VACCINE OR VACCINATION SPECIFIC ISSUES|Risk benefit (scientific evidence)</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes^|VACCINE OR VACCINATION SPECIFIC ISSUES|Role of healthcare professionals</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes^|VACCINE OR VACCINATION SPECIFIC ISSUES|Vaccination schedule</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>
## Appendix 5- Node Structure, Content Analysis, Aim4/Manuscript 3

<table>
<thead>
<tr>
<th>Hierarchical Name</th>
<th>Nickname</th>
<th>Aggregate</th>
<th>User Assigned Color</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Node</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Nodes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nodes[CLAIMS MADE IN POST]</td>
<td>Yes</td>
<td>Red</td>
<td></td>
</tr>
<tr>
<td>Nodes[CLAIMS MADE IN POST],Comments on survey</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes[CLAIMS MADE IN POST],CONTEXTUAL,Pharmaceutical industry</td>
<td>Yes</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes[CLAIMS MADE IN POST],CONTEXTUAL,Pharmaceutical industry,Mistrust in pharma</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes[CLAIMS MADE IN POST],CONTEXTUAL,religion culture gender sex</td>
<td>Yes</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes[CLAIMS MADE IN POST],CONTEXTUAL,religion culture gender sex,Religious views</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes[CLAIMS MADE IN POST],INDIVIDUAL AND GROUP INFLUENCES</td>
<td>Yes</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes[CLAIMS MADE IN POST],INDIVIDUAL AND GROUP INFLUENCES,Beliefs, attitudes about health and prevention</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes[CLAIMS MADE IN POST],INDIVIDUAL AND GROUP INFLUENCES,Beliefs, attitudes about health and prevention,Natural immunity</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes[CLAIMS MADE IN POST],INDIVIDUAL AND GROUP INFLUENCES,Beliefs, attitudes about health and prevention,Vaccines do not work</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes[CLAIMS MADE IN POST],INDIVIDUAL AND GROUP INFLUENCES,Experience with past vaccination</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes[CLAIMS MADE IN POST],INDIVIDUAL AND GROUP INFLUENCES,Experience with past vaccination,Experience with adverse event past vaccination</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes[CLAIMS MADE IN POST],INDIVIDUAL AND GROUP INFLUENCES,Health system and providers-trust and personal experience</td>
<td>Yes</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes[CLAIMS MADE IN POST],INDIVIDUAL AND GROUP INFLUENCES,Health system and providers-trust and personal experience,Mistrust in government</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes[CLAIMS MADE IN POST],INDIVIDUAL AND GROUP INFLUENCES,Health system and providers-trust and personal experience,Mistrust in HOW</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes[CLAIMS MADE IN POST],INDIVIDUAL AND GROUP INFLUENCES,Knowledge or awareness</td>
<td>Yes</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes[CLAIMS MADE IN POST],INDIVIDUAL AND GROUP INFLUENCES,Knowledge or awareness,inaccurate knowledge or misperception</td>
<td>Yes</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes[CLAIMS MADE IN POST],INDIVIDUAL AND GROUP INFLUENCES,Knowledge or awareness,inaccurate knowledge or misperception,Children not a threat to yours</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes[CLAIMS MADE IN POST],INDIVIDUAL AND GROUP INFLUENCES,Knowledge or awareness,inaccurate knowledge or misperception,Vaccinated people spread disease too. Not 100%</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes[CLAIMS MADE IN POST],INDIVIDUAL AND GROUP INFLUENCES,Knowledge or awareness,inaccurate knowledge or misperception,Parents knowledgeable on vaccines, science</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes[CLAIMS MADE IN POST],INDIVIDUAL AND GROUP INFLUENCES,Risk Benefit</td>
<td>Yes</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes[CLAIMS MADE IN POST],INDIVIDUAL AND GROUP INFLUENCES,Risk Benefit,Not all vaccines are necessary or work</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes[CLAIMS MADE IN POST],INDIVIDUAL AND GROUP INFLUENCES,Risk Benefit,Risk of disease or death unlikely</td>
<td>No</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Nodes[CLAIMS MADE IN POST],INDIVIDUAL AND GROUP INFLUENCES,Risk Benefit,Vaccines are not safe, adverse events</td>
<td>Yes</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>