Association between Social Determinants of Health and Adverse Pregnancy Outcomes in Adolescent Mothers

by

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Abstract

The association between adolescent childbearing and adverse pregnancy outcomes has been well documented in the literature. The association of social determinants of health (SDOH) and adverse adolescent pregnancy outcomes remains controversial. The overall aim of this thesis was to explore the role of SDOH in adverse adolescent pregnancy outcomes. A systematic review of the literature was conducted to summarize the current evidence on the association between SDOH and adverse maternal and birth outcomes in adolescent mothers. To investigate the combined impact of maternal area of residence and socioeconomic status (SES) on adverse adolescent pregnancy outcomes, a cross sectional study was conducted using population-based administrative health data from Alberta. Singleton live births to mothers aged 15-19 years (2010-2015) were extracted from the Alberta Perinatal Health Program registry. Maternal area of residence and neighborhood-level SES variables were determined using the Pampalon Material Deprivation Index Dataset. Data was analyzed using descriptive statistics and logistic regression models using urban, high-SES mothers as the reference category. Overall, rural mothers with low SES were found to have the highest rate of poor obstetric and neonatal outcomes. Compared to urban mothers with high SES, rural adolescents with low SES had increased odds of postpartum hemorrhage (Odds Ratio [OR]:1.57; 95% confidence interval [CI]: 1.41, 1.74); operative vaginal delivery (OR: 1.37; 95% CI: 1.18, 1.60), caesarean section (OR:1.39; 95% CI: 1.19, 1.62) and preterm birth (OR: 1.48; 95% CI:1.17, 1.87).This study enhances current understandings on the role of SDOH in adverse adolescent pregnancy outcomes and is a valuable addition to the existing literature on perinatal health inequalities in adolescent pregnancy outcomes. Based on study findings, suggestions are put forth for possible interventions aimed at reducing the gap in adverse adolescent pregnancy outcomes.

Preface

This thesis is an original work by Sana Amjad. The research project for this thesis received ethics approval from the University of Alberta Research Ethic Board (Study ID: Pro00074654; July 4, 2017). The overall aim of this thesis is to enhance current understanding on the role of social determinants of health on adolescent pregnancy outcomes and specifically investigate the association of maternal area of residence and socioeconomic status with adverse maternal and birth outcomes in adolescent mothers. This work is relevant to perinatal health researchers, policy makers, and general academia.

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CHAPTER 1: INTRODUCTION

1.1. Statement of the Problem

Adolescent pregnancy is the leading cause of death for women aged 15-19 years worldwide.[1] The association between adolescent childbearing and adverse pregnancy outcomes has been well documented in the literature.[1-4] Adolescent mothers have been found to have high rates of obstetric complications such as postpartum hemorrhage, eclampsia, sepsis, and long-term reproductive morbidities in comparison to adult mothers.[1-4] Adolescent mothers are also more likely to struggle with postpartum depression, and stress disorder.[5,6,7] Babies born to adolescent mothers are at risk of severe neonatal outcomes such as prematurity and low birth weight (LBW).[1-4] Adolescent motherhood is also associated with deleterious socioeconomic consequences for the young mothers, their children, and the society at large.[1,8-10] Adolescent mothers are likely to have poor economic prospects, discontinue education, and raise kids as single parents.[1,8,9] Economic evaluations conducted in the United States (U.S) have estimated the costs of health care, hospital admissions, and welfare services for adolescent mothers' amount to $9.1 billion dollars annually.[10]

Existing literature suggests a socioeconomic gradient in adverse adolescent pregnancy outcomes.[12-18] The most disadvantaged adolescent mothers have been observed to have the worst pregnancy outcomes.[12-18] A social determinants of health (SDOH) approach has been used to explain the influence of physical and social environment on adolescent mother's poor obstetric performance.[12] However, the contribution of the young mother's socioeconomic condition to adverse adolescent pregnancy outcomes is controversial.[19,20] Some studies suggest that the high rate of poor maternal and birth outcomes in teenage mothers is the result of biological immaturity of the young mother.[19,20,21] It is thought that adolescents are not physiologically

ready to meet the rigorous demands of pregnancy that puts them and their newborns at high health risk.[19-21] Studies have found that teenage mothers are at a higher risk of obstructed labor at term due to their developing pelvic skeleton compared to adult mothers.[22] A large epidemiological study found that after controlling for prenatal care, mothers under 17 years of age still had double the risk of having preterm and LBW babies compared to mothers aged 20-24 years.[20] On the other hand, a large body of evidence contests this view and implicates SDOH in adverse adolescent pregnancy outcomes.[12-18] A rigorous appraisal of the current literature on adolescent perinatal health is necessary to inform this controversy and to guide adolescent perinatal health policy and practice.

Current scientific evidence suggests that SDOH operate through interconnected mechanisms and exposure to multiple social disadvantages leads to an excess risk of adverse health outcomes.[23] Previous research suggests that rural residence and low socioeconomic status (SES) operate in a synergistic manner and their joint effect has a greater negative impact on pregnancy outcomes than either of these factors alone.[23,24,25] However, these associations have not been well-explored for adolescent mothers. So far, studies have mainly focussed on individual determinants and have not investigated the combined effect of SDOH on adolescent pregnancy outcomes. In order to reduce gaps in adolescent pregnancy outcomes, it is crucial to examine these combined effects and identify populations of adolescent mothers susceptible to worst maternal and birth outcomes.

The work presented in this thesis adds to the current literature on inequalities in adolescent perinatal health and aims to investigate the role of SDOH; in particular, maternal area of residence and SES on poor maternal and birth outcomes. It is hypothesized that SDOH influence maternal and birth outcomes in adolescents and that the risk of adverse maternal and birth

outcomes in adolescent mothers varies by their area of residence (rural/urban) and SES.

1.2. Research Objectives

The overall objective of this research was to explore the role of SDOH on poor maternal and birth outcomes in adolescent mothers. Specific objectives included:

1. To summarize and evaluate the current scientific evidence on the association between SDOH and adverse maternal and birth outcomes in adolescent pregnancy.
2. To explore the influence of maternal area of residence and SES on adverse pregnancy outcomes in adolescent mothers.

The methodological framework and conceptualization of this research was guided by the two study objectives. A systematic review was performed to evaluate the evidence in the scientific literature on the role of SDOH in adolescent pregnancy outcomes. To address the second objective, an analytical cross sectional study was conducted using population-based health data from Alberta, Canada.

1.3. Literature Review

1.3.1 Definition of adolescent pregnancy

Adolescence is considered a period of physical and psychological transition from childhood to adulthood.[26,27] It is a distinct phase of human development that starts with the onset of puberty and is characterized by marked physiological and cognitive growth.[26] There is no single universally accepted definition of adolescence.[27] In social and health research, adolescence refers to individuals under the age of 20 years.[27] Adolescents have also been characterized in the scientific literature as young adults under the age of 25 years.[26] The World Health Organization

(WHO) defines adolescence as the age group between 10 and 19 years of age.[28] Concurrently, various definitions exist in the literature for adolescent pregnancy. According to The United Nations Children's Fund (UNICEF), adolescent pregnancy refers to "*a teenage girl, usually within the ages of 13-19, becoming pregnant. The term in everyday speech usually refers to girls who have not reached legal adulthood, which varies across the world, who become pregnan*t".[29] This definition underscores that the chronologic definition of adolescent pregnancy may vary depending on the sociocultural context. The WHO defines adolescent pregnancy as "*pregnancy in a woman aged 10–19 years*".[1] Adolescent pregnancy is interchangeably used with teenage pregnancy or teen pregnancy in the literature.[1,8] Adolescent mothers are further defined in many health research studies as very young mothers (<15 years of age) and young mothers (15-19 years of age). Some researchers consider mothers under the age of 15 years to be different in terms of their biological and emotional growth than adolescent mothers aged 15-19 years.[1,12,20,21] The WHO definition of adolescent pregnancy was used as a starting point in this research.

1.3.2 Epidemiology of adolescent pregnancy

Teenage pregnancy and birth rates are important population health indictors as they are reflective of the country's overall health care performance and social development.[1] Adolescent pregnancy and birth rates are usually calculated for adolescents aged 15-19 years for cross-country and regional comparisons.[1,30] The WHO defines adolescent pregnancy rate as the total number of pregnancies which includes births as well as abortions, and fetal deaths per 1,000 women aged 15-19 years, while adolescent birth rate is defined as births per 1,000 women aged 15-19 years.[31]

Sub-Saharan Africa has the highest pregnancy rate in the world (143 per 1,000 women aged

15-19 years).[31] Among developed nations, the U.S has the highest adolescent pregnancy rate (57 per 1,000 adolescents aged 15-19 years), almost double that of its neighbouring country Canada (28 per 1,000 females aged 15-19 years).[32]

An important aspect to examine while looking at epidemiological estimates of adolescent pregnancy is the intention to get pregnant.[33,34] Research shows that adolescents intending to get pregnant are likely to be married, have better family support, and economic resources compared to adolescents with unplanned pregnancies.[1,33] The proportion of unintended pregnancies also highlights the magnitude of adolescent's unmet need for contraception.[1,33] However, the data on unintended adolescent pregnancy is limited.[33,34] WHO estimates show that about half of all adolescent pregnancies in the developing regions of the world are intended, which correlates with the high prevalence of early marriages in these countries.[1] On the other hand, it is estimated that 82% of all adolescent pregnancies in the U.S are unintended which maybe a reflection of high unmet need for contraception among these adolescents .[34] The rate of teenage abortion also varies significantly across regions.[32] In Canada, about 50% of all adolescent pregnancies end in abortion compared to 69% in Sweden.[32] Detailed epidemiological data on the incidence of spontaneous and medically-induced abortions among adolescent mothers is sparse.[1,30,31]

Due to the lack of reliable abortion data in many countries, adolescent birth rates are preferred for comparative purposes at the global and country level.[1,30,31] In 2018, the global adolescent birth rate was 44 births per 1,000 among women aged 15-19 years[34] with 17 million births to teenage women (15-19 year) worldwide.[1] As a result of concerted public health efforts, there has been a considerable decline in adolescent birth rates.[1] Between 1990 and 2015, the overall global adolescent birth rate decreased by 18%.[1] However, significant regional disparities remain across the world.[1,30] Country-specific adolescent birth rates per year range from 109

births per 1,000 among Nigerian teens aged 15-19 years compared to 10 births per 1,000 females aged 15-19 years in Canada.[30] It is important to note that in many administrative health databases, the age of the adolescent mother is determined at the time of birth so there is a potential of missing births to adolescent mothers who got pregnant at 19 years of age but delivered after their 20th birthday.[31]

1.3.3 Adverse adolescent pregnancy outcomes

The circumstances of adolescent childbearing have been widely scrutinized by academia and policy makers alike.[1-21] There is a general consensus in the literature that adolescent pregnancy is associated with dire health consequences for the young mother and the child.[2-5] Adverse adolescent pregnancy outcomes are a major public concern as they are associated with chronic health challenges for the young mother and the child and substantial health care costs incurred due to long-term hospital stays and provision of specialist care.[11]

Adverse maternal outcomes

Adverse maternal outcomes linked with adolescent pregnancy include a variety of obstetric diseases and intra-partum complications that have a long-lasting negative impact on the reproductive health and overall well-being of the young mothers.[1-4] Adolescent mothers have been found to have greater incidence of anemia, hypertensive disorders of pregnancy -namely preeclampsia and eclampsia-, and gestational diabetes mellitus.[1-4] The delivery complications of adolescent pregnancy described in the scientific literature include postpartum hemorrhage, episiotomy, obstructed labour, caesarean section, sepsis, and perinatal death.[1-4] In comparison to adult mothers, the rate of caesarean section has been found to be lower in adolescent mothers.[36] This may be due to the higher incidence of delivery of premature small babies to adolescent

mothers. Adolescent mothers also have twice the risk of postpartum depression compared to their adult conterparts.[6,7] It is speculated that adolescent mothers are more vulnerable to the emotional and physical stressors associated with motherhood. Young mothers are also more likely to face isolation during their pregnancy which can be detrimental to their psychological wellbeing.[6,7]

Adverse birth outcomes

The adverse birth outcomes consistently linked with adolescent pregnancy include LBW (birth weight <2500 grams), preterm birth (birth of the baby before 37 completed weeks of gestation), small for gestation age (birth weight <10th percentile for gestational age), and neonatal death (death of newborn within first 28 days after birth).[1-3] Prematurity and LBW are associated with developmental problems, long stays in neonatal intensive care unit (NICU), and life-long morbidities.[37,38,39]

Epidemiology of adverse adolescent pregnancy outcomes

The current scientific literature unanimously reports an increased incidence of adverse pregnancy outcomes among adolescent mothers compared to adult mothers.[1-5] About 30% of all adolescent pregnancies are complicated by life threatening obstetric conditions.[40] One study has linked 23% of the total burden of disease associated with childbirth in women of all age groups to adolescent pregnancy complications.[41] Every year about 70,000 adolescents die due to pregnancy related complications.[42] A recent study compiled adolescent maternal mortality data from 144 countries and reported an overall increased risk of mortality among adolescents aged 15-19 years (adolescent mortality ratio 260/100,000 live births) compared to adult mothers aged 20-24 years (adolescent mortality ratio 190/100,000 live births).[43] Studies have reported that very young mothers (<15 years) have about five times the risk of maternal mortality compared to adult mothers (20-24 years).[42] This maybe explained by the inverse relationship between

increasing age of the adolescent mother and the risk of obstetric complications such as pre-eclampsia, anemia, episiotomy, and operative vaginal delivery.[44] The rate of infant mortality rate is also significantly high in adolescent pregnancies.[42] In Sub-Saharan Africa about one in seven babies born to adolescent mothers die before their first birthday.[42] Adolescent mothers have been found to have significantly higher risk of having LBW and pre mature delivery compared to adult mothers.[44] In Canada, about 6.6% of total live births to adolescent mothers are LBW compared to 5.9% among women aged 20-34 years.[45]

Epidemiologic literature on adolescent pregnancy outcomes suggests SDOH differentials in adverse maternal and birth outcomes.[12-18] The highest incidence of adverse birth outcomes such as infant mortality, LBW and prematurity are seen in the most resource-depleted setting.[39] The rate of infant mortality ranges from 6 deaths per 1000 live births in the U.S to 114 deaths per 1000 live births in Malawi.[39] To highlight how socioeconomic environment may influence maternal and birth outcomes in teenage mothers, I now turn my attention to a discussion of SDOH and the conceptual frameworks used to guide this study.

1.3.4 Social determinants of health

Defining SDOH is a complex task. For the purpose of this research, the WHO's Conceptual Framework for Action on Tackling Social Determinants of Health Inequities was used to define SDOH.[46] The WHO defines SDOH as:

> "*The conditions in which people are born, grow, work, live, and age, and the wider set of forces and systems shaping the conditions of daily life. These forces and systems include economic policies and systems, development agendas, social norms, social policies and political systems*".[47]

The WHO framework uses a multilevel approach to explain the pathways to health inequalities.[46] It expands on the theory of social production of disease to describe how macro-level structural factors such as health policies, political will, and social position intersect with individual-level factors such as behavioral risk factors to produce health inequalities. The WHO framework defines health inequalities as "*health differences that are socially produced, systematic in their distribution across the population, and unfair"*.[46] This framework posits that political and structural mechanisms define social hierarchies and the resulting power imbalance and differential access to resources. It identifies race, ethnicity, gender, income, education, occupation, and social class as the bases of social hierarchies and the ensuing privileged and disadvantaged groups.[46] The *structural determinants* influence health outcomes through *intermediary determinants*.[46] Intermediary determinants of health include living conditions, physical environment, access to nutritious food and individual factors such as smoking, alcohol abuse, genetics, family support, and emotional stressors.[46] The structural determinants shape individuals' socioeconomic position which, in turn, controls the distribution of these intermediary factors and leads to systematic exclusion of disadvantaged groups.[46]

Another theoretical framework used in this thesis was the PROGRESS-PLUS framework recommended by the Campbell and Cochrane Equity Methods Group to conceptualize SDOH-focused systematic reviews.[48] This action-oriented framework was developed to provide a SDOH perspective to public health policy making and health research.[48] PROGRESS is an acronym for place of residence, race, occupation, gender/sex, religion, education, SES, and social capital. The Plus represents other relevant factors which can contribute to health disparities such as age, physical disabilities, and single-parent family.[48] These factors were included in the PROGRESS framework because of their well-established relationship with health outcomes.[48] The

PROGRESS-Plus framework emphasizes that health research should include SDOH and equity considerations in their knowledge generation and transfer practices.[48] This framework was used to select the SDOH included in the systematic review.

1.3.5 Operational definition of social determinants of health

The SDOH included in this study are defined operationally to highlight the various aspects of SDOH that may influence adverse adolescent pregnancy outcomes:

Place of residence

Place of residence encompasses the geographic location and the overall physical and social environment in which the person lives and the associated availability or lack of resources based on their geographic location.[23-25] Rural residents are likely to travel long distances to reach health care services.[25,43] Longer travel time to health care services is a well-known barrier to the uptake of maternal health services.[43] The relationship between urban/rural residence and adverse maternal and birth outcomes in adolescent mothers was framed using this definition.

Race/Ethnicity

For the purpose of this research, race was defined as a social and historical construction with the ability to impact health outcomes because of the shared social experiences of members of a racial group.[50-52] Historically, the concept of race has been embedded in differences in skin color and physical traits of humans.[50,52] A mounting body of scientific evidence rejects biological grounds of racial classification.[50-52] The WHO conceptual framework describes race as a social institution that perpetuates social stratification and differences in access to education and employment opportunities.[46] The race-based differences in adverse adolescent birth outcomes are well established in the United States.[51,52] It has been suggested that the shared experiences of

segregation, discrimination and social ostracization faced by African-American mothers in the U.S contribute to this divide.[54] Ethnicity, on the other hand, was defined as belonging to a distinct group based on shared culture, traditions and beliefs.[55] Ethnicity is an important variable to explore as it has been associated with the development of metabolic obstetric diseases e.g. gestational diabetes mellitus.[55]

Occupation

Occupation refers to employment or work that is the main source of livelihood of a person.[48,56] In the context of adolescent pregnancy, the occupation of the parents and partner/husband also needs attention as teenage mothers are likely to be financially dependent on their parents or partner for support. The definition of occupation was expanded to include the physical working environment, number of hours worked per week, minimum wage employment, and other aspects relevant to the occupational experience.[48]

Religion

Religion has been defined as a set of beliefs, and practices that govern every aspect of their devotees' life.[48] It is an important consideration in the context of adolescent pregnancy outcomes as teenage marriage and births are considered the norm in some religious groups and are encouraged by them. Consequently, some religious groups may have higher burden of adverse adolescent pregnancy outcomes.[1,34]

Education

For the purpose of this research education was defined as the formal training received by adolescent mothers in schools or other educational institutions.[48] Previous research has shown that teenage mothers with age-appropriate educational attainments are more likely to be employed and have access to antenatal health care services.[8,10]

Socioeconomic status

The term SES is sometimes interchangeably used with social standing or socioeconomic position.[40] Multiple individual-level and area-based definitions of SES have been used in the scientific literature on SES variations in maternal and birth outcomes.[19,18] SES was defined as "a *measure of one's combined economic and social status and tends to be positively associated with better health"*.[57] The SES was framed in this research as a multidimensional measure of adolescent mothers' social and financial condition and a proxy measure of their ability to access healthy food, health care services, and other relevant societal resources.

Social capital

Various definitions of social capital exist in the literature. Social capital refers to *"the sum of the actual and potential resources embedded within, available through, and derived from the network of relationships possessed by an individual or social unit"*.[58] The social capital perspective identifies social networks and relationships as commodities with productive benefits.[48] Social capital is an important consideration in the context of adolescent pregnancy outcomes as adolescents mothers on account of their young age are likely to rely on community networks for social and financial support. [1,12]

1.3.6 Social determinants of health and adverse adolescent pregnancy outcomes

Evidence suggests that adverse pregnancy outcomes experienced by adolescent mothers are the product of the material and social deprivation faced by the young mothers.[12] In the context of adolescent pregnancy, the concept of material deprivation encompasses adolescent mothers' limited access to communal resources such as economic structures, legal systems, education, employment opportunities, health care services, community networks, food, and water

resources.[46] On the other hand, social deprivation represents the experiences of social isolation and stigmatization faced by some adolescent mothers on account of their sociocultural background or low SES.[46,54] Studies have shown that low SES mothers receive poor-quality antenatal care than mothers with high SES.[24] Certain groups such as African-American and Indigenous mothers have reported higher rates of mistreatment by health care professionals which can lead to mental stress, poor uptake of antenatal care services and potentially impact their pregnancy outcomes.[54,59,60,61] Material and social deprivation can result in potential ostracization of populations of adolescent mothers that are denied basic health care resources, putting them at high risk of poor maternal and birth outcomes.

The recent literature conceptualizes SDOH as drivers and perpetuators of inequalities in adverse pregnancy outcomes.[46,62] It has been suggested that population-level exposures of socioeconomic disadvantage may have no direct impact on adolescent pregnancy outcomes but operate through individual-level health behaviors and biopsychosocial changes.[8,12,62] A review of the current literature identified that individual-level factors such as anthropometric measures (e.g., maternal stature, body mass index), substance use (e.g., smoking, alcohol, drugs), and exposure to psychological stress act as mediators in etiological pathways of disparities in adverse pregnancy outcomes.[62] The identification of these individual-level causal factors is crucial to reduce inequalities in adolescent pregnancy outcomes.

Existing evidence suggests that mothers experiencing deleterious population-level exposures are likely to accumulate a number of individual-level risk factors that can potentially impact their obstetric and birth outcomes.[24,25,63] A recent review found a robust association between multiple risk exposures and socioeconomic gradients in health outcomes.[62] Rural, low SES families have a greater risk of being exposed to poor housing conditions, and poor quality healthcare services

compared to their middle-income counterparts.[24,25] On the other hand, mothers living in high-income neighborhoods characterized by good housing conditions and proximity to healthcare services, and recreational resources are more likely to adopt healthier lifestyles, be in long-term supportive relationships, regularly attend antenatal care appointments and, consequently, have better maternal and birth outcomes compared to mothers living in low-income neighbourhoods.[18,24,25] These associations have not been explored for adolescent mothers and merit further investigation.

The significance of SDOH in adolescent pregnancy outcomes has also been recognized in the literature published by well-recognized public health and medical bodies.[64,65] The Canadian Paediatric and Adolescent Gynaecology and Obstetricians (CANPAGO) Committee identifies Indigenous status and rural residence as risk factors for poor adolescent pregnancy outcomes and recommends maternity care providers to be sensitive of the sociocultural context and the unique needs of high-risk subgroups of young mothers.[64] Similar guidelines have been issued by the Centers for Disease Control (CDC) and Prevention for African-American adolescent mothers in the United States.[65] These guidelines further recommend that research on adolescent maternal health should include broader social factors such as living conditions, neighbourhood areas, and SES to gain a comprehensive understanding of the factors underlying the observed disparities in adolescent pregnancy outcomes.[65]

1.4. Organization of the Thesis

This thesis follows a paper-based format. Chapter 1 introduces the background, study objectives, key concepts, and the theoretical paradigm driving the study methodology.

Chapter 2 of the thesis is a systematic review of the scientific literature that evaluates the

current evidence on the association between SDOH (i.e., place of residence, race, occupation, religion, education, SES and social capital) and poor adolescent pregnancy outcomes.

Chapter 3 of the thesis is an analytical cross sectional study that evaluates the combined effect of area of residence and SES on adverse maternal and birth outcomes in adolescent mothers.

Chapter 4 is a general discussion of the findings revealed in Chapters 2 and 3 and proposes potential practical implications of the study results and future research directions.

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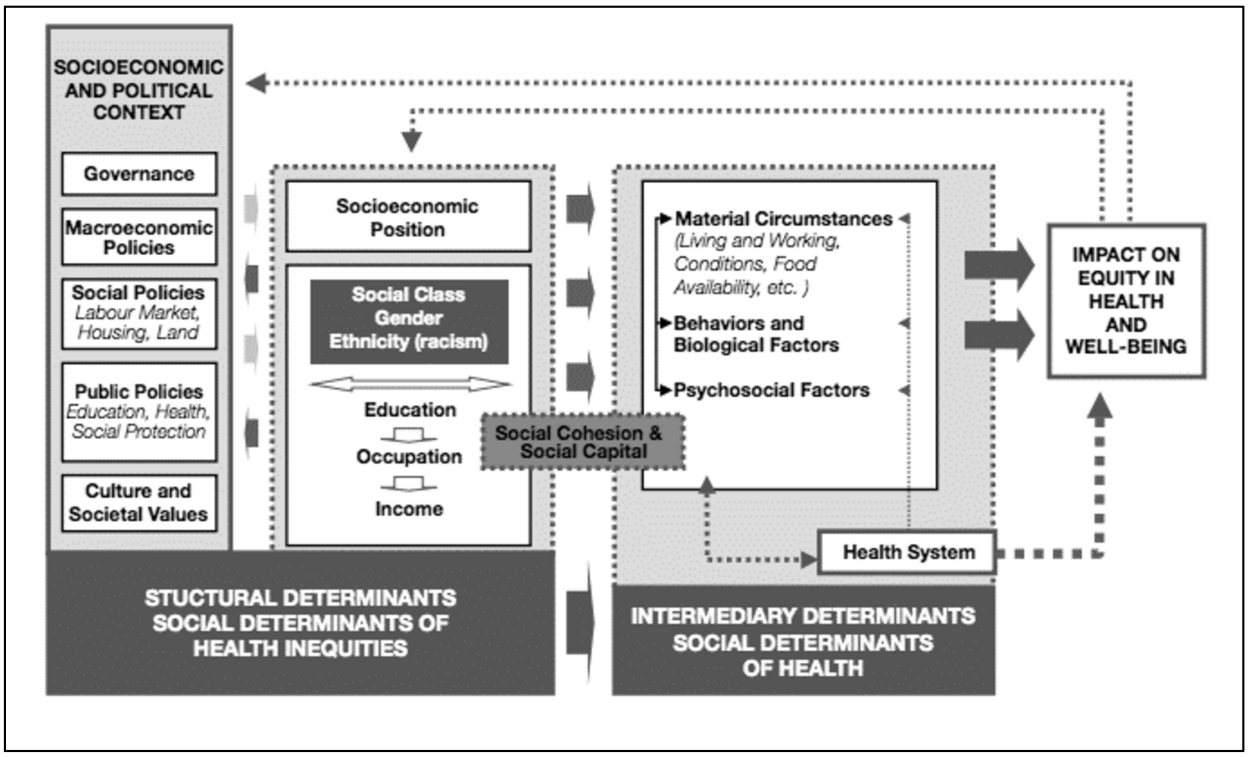
Figure 1.1 World Health Organization Conceptual Framework for Action on the Social Determinants of Health



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CHAPTER 2. SOCIAL DETERMINANTS OF HEALTH AND ADVERSE MATERNAL AND BIRTH OUTCOMES IN ADOLESCENT PREGNANCIES: A SYSTEMATIC REVIEW AND META-ANALYSIS[1]

2.1. Background

Maternal complications during pregnancy and delivery are the leading cause of death for women aged 15-19 years worldwide.[1] Despite concerted efforts and recent decline in adolescent pregnancy rates, adolescent pregnancy is still a significant public health issue in many industrialized and developing countries around the world.[1] Every year about 17 million teenagers give birth.[1]

The association between adolescent childbearing and adverse pregnancy outcomes has been well documented in the literature.[1,2] Adolescent pregnancies has been linked with an increased risk of maternal and neonatal mortality and life-threatening complications for both the mother and the child such as eclampsia, obstetric hemorrhage, placental abruption, preterm birth (PTB), and low birth weight (LBW).[1,2]

Poor outcomes in adolescent pregnancies have been traditionally attributed to the biological immaturity of the young mothers.[3,4] However, the role of young maternal age in adverse pregnancy outcomes is controversial.[2,5,6] A large body of evidence suggests that the observed association between adolescent pregnancy and poor perinatal outcomes is confounded by the

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social and economic conditions of poverty faced by the young mothers.[2,5,6] The social determinants of health (SDOH) perspective has been used extensively to frame adverse teenage pregnancy outcomes mediated by social inequalities.[1,2,6] The World Health Organization (WHO) defines SDOH as "*conditions in which people are born, grow, work, live, and age*."[7] The role of broad societal conditions on population health was first acknowledged in the Ottawa charter in 1986.[8] It recognized that complex interconnected societal resources such as education, employment opportunities, and community networks shape social hierarchies and the resulting health disparities.[8] Macro-level societal factors such as neighborhood poverty and socioeconomic disadvantage have been repeatedly linked with teenage pregnancy outcomes.[1,2,5,6] The conflicting evidence on the role of SDOH in adolescent pregnancy outcomes necessitates a critical examination of the existing literature on adolescent mothers to inform public health decision making. However, to date no systematic review has comprehensively evaluated the role of SDOH in adolescent pregnancy outcomes. The present systematic review aimed to inform this knowledge gap by summarizing and evaluating the evidence on the association between SDOH and maternal and birth outcomes in adolescent mothers.

For the purpose of this systematic review, the PROGRESS-Plus framework was selected as the conceptual model to guide the review process as recommended by the Campbell Collaboration and the Cochrane Equity Methods Group.[9] PROGRESS is an acronym for place of residence, race, occupation, gender/sex, religion, education, socioeconomic status (SES) and social capital.[9] These categories highlight the multidimensional factors that influence potentially avoidable health inequalities across communities.[9] The PROGRESS-Plus framework was used to select the SDOH included in this review. The model was used to frame place of residence (rural vs. urban), occupation, education, and SES as material indicators of adolescent mother's well-

being and proxy measures of their ability to maintain a healthy lifestyle.[9] Race was posited as a social institution that influences the young mother's access to societal resources and economic opportunities. Religion and social capital mediate these relationships.[9]

2.2. Methods

2.2.1 Searches

The systematic review was planned, conducted, and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)[10] and the guidelines proposed by the Cochrane Collaboration.[11] A protocol for the systematic review was registered in the International Prospective Register of Systematic Reviews database (PROSPERO # 42017068749).

Comprehensive electronic literature searches were conducted in the following bibliographic databases from database inception to May 2018: MEDLINE, EMBASE, CINAHL and Web of Science. The electronic search strategy was developed by a health sciences librarian at the University of Alberta John W. Scott Library and used selected subject headings, keywords, and Boolean operators adapted to each database. No search limits were applied on the basis of date, language or publication status. Grey literature searches included Google Scholar Web Search. Reference lists of reviews and retrieved articles were checked to identify further potentially relevant studies. The complete search strategy is outlined in Appendix 1.

2.2.2 Study selection

Two independent reviewers screened the titles and abstracts generated from the search strategy to identify potentially relevant studies. The full text of articles deemed relevant and

those whose abstracts and titles provided insufficient information were retrieved. Disagreements about study eligibility were resolved through discussion between reviewers until consensus was reached. In case of duplicate publications, only the most recent or complete report was included.

Studies were included if they were primary research (i.e., prospective and retrospective cohort studies, case-control studies, ecological studies, and cross-sectional studies), included a population of adolescent mothers, and evaluated the association between at least one SDOH and maternal and/or perinatal outcomes. Adolescent mothers were defined as mothers who gave birth before the age of 20 years.[1] Maternal outcomes of interest in the review included preeclampsia, eclampsia, placenta previa, abruptio placentae, gestational diabetes mellitus, premature rupture of membranes (PROM), postpartum hemorrhage, need of operative vaginal delivery (forceps or vacuum), caesarean section, and intra-hospital death. Adverse birth outcomes included LBW, PTB, small for gestational age (SGA) and perinatal death. These outcomes were selected based on their high clinical significance in regard to adolescent pregnancies.[1,2]

2.2.3 Assessment of methodological quality

Two independent reviewers evaluated the methodological quality of primary studies using the Newcastle-Ottawa Scale (NOS)[12] adapted by study design. This tool appraises the likelihood of bias in observational studies and comprises seven questions that assess bias in four realms: selection of study participants, comparability among study groups, ascertainment of exposure, and outcomes assessment.[12] Studies were classified as of good, fair, and poor quality based on their NOS score. Similar rating criteria have been used for assessing the quality of observational studies in systematic reviews.[13] Disagreements in quality assessment ratings were resolved by consensus.

2.2.4 Data extraction and synthesis

A pretested data extraction form was used to collect information from individual studies about study characteristics (year, country, duration, design, sample size); participants (age, comorbidities, pregnancy characteristics); SDOH (classified according to the PROGRESS-Plus framework); and outcomes (crude data, proportions and/or odds ratios [OR], risk ratios [RR] with 95% confidence intervals [CI], where possible). One reviewer extracted the data and a second reviewer independently verified the accuracy and completeness of the data extracted. Discrepancies were resolved by consensus.

Characteristics of included studies and results of the methodological quality assessment were described using proportions and/or percentages as appropriate. Individual study results were summarized by SDOH in a narrative way according to the guidelines suggested by Popay et al.[14] Meta-analyses of the association between SDOH and adverse birth outcomes were planned for sufficiently homogenous studies (i.e., similar study design, same SDOH and outcome). Unadjusted OR were pooled in a Mantel-Haenszel random-effects model meta-analysis. Heterogeneity across studies was tested using the I^2 statistic with I^2 values of 25, 50, and 75% representing low, moderate, and high heterogeneity, respectively.[15] Sources of heterogeneity across individual studies were explored qualitatively and subgroup analyses were conducted based on study design.

Assessment of publication bias using funnel plots was planned where sufficient studies (<5) were included in the analyses. Statistical analyses were performed using Review Manager (RevMan) software version 5.3 (Copenhagen: The Nordic Cochrane Centre: The Cochrane Collaboration; 2014). Study selection, methodological quality assessment, and data extraction were managed with Microsoft Excel™ (Microsoft Corporation, USA).

2.3. Results

2.3.1 Search results

The search strategy (including electronic and grey literature sources) identified a total of 3,151 citations. After removal of 1,191 duplicates, 1,958 titles and abstracts were screened. At this stage, 62 articles were judged to be potentially relevant and retained for full-text review. Of these, a total of 31 individual studies were included in the review. Detailed review process is outlined in Figure 2.1. The complete list of excluded studies and reasons for exclusion is available on request.

2.3.2 Characteristics of included studies

Thirty-one studies published from 11 countries and involving 249,142 adolescent mothers (age range:10-19 years) were included in the review.[16-46] The majority of studies were published in the United States (U.S) (n=18)[16,18-28,30,32,34,35,41,42] followed by Australia (n=2)[17,33] and Nigeria (n=2).[36,40] The most frequently evaluated SDOH in the individual studies was race[16-19,23-30,32,35,37,39-42] while the most commonly reported maternal and birth outcomes were caesarean section[16,17,23,28,31,33,34,37-40] and PTB,[16,17,19,20,22-26,28,29,31,34,35,43] respectively.

The primary studies included 16 retrospective cohort studies,[16-31] seven cross-sectional studies,[38-44] six prospective cohort studies,[32-37] one ecological,[45] and one case-control study.[46] Study populations differed in regard to age (<16-years of age[26,37] vs. >16-year of age[36]), type of pregnancy (single[16-25,27-46] vs. multiple gestation[26]) and parity (first birth[16-23,25-46] vs. second birth[24]). The studies used different criteria to define urban-rural status,[30,31,33] maternal SES, education, and occupation.[21,24,42,44,45]

Detailed characteristics of the individual studies are summarized in Table 2.1.

2.3.3 Methodological quality of included studies

Overall, the methodological quality of included studies was fair. Based on their NOS score, seven studies were classified as good,[16,18,24,30,31,33,34], nine as fair,[17,19,20,22,25,26,32,39,42] and 15[21,23,27,28,29,35-38,40,41,43-46] were poor-quality studies. Sixteen out of 31 studies did not account for confounding in the design or analysis phase.[17,19-21,23,28,29,32,33,35-38,40,45,46] Detailed performance of studies in individual NOS domains is summarized in Figure 2.2.

2.3.4 Association between SDOH and maternal and birth outcomes

Overall, the included studies were methodologically diverse, defined SDOH differently and/or not enough studies (<2) reported the same outcome. A meta-analysis for the association between race and birth outcomes was conducted as sufficiently homogenous studies were available on this association that allowed pooling of data. It was not possible to conduct meta-analyses for other SDOH due to the high heterogeneity across studies. Key review findings are summarized in Figure 2.3.

Race

Nineteen primary studies (retrospective cohort [n=12],[16-19,23-30] cross-sectional [n=4],[39-42] and prospective cohort [n=3][32,35,37]) evaluated maternal race as a determinant of maternal and birth outcomes in adolescent mothers. The included studies used the terms White or Caucasians, Black or African American alternatively to define the different racial groups and used teen mother's self-reported racial identity to assess the association of maternal race and pregnancy outcomes.[16,18,19,23,25]

Meta-analyses of the five U.S-based retrospective cohort studies (Figure 2.4) showed that compared to White adolescents, African-American adolescent mothers had 67% (OR 1.67; 95%

CI 1.59, 1.75; $I^2 = 0\%$)[16,19,23,25] and 53% (OR 1.53; 95% CI 1.45, 1.62; $I^2 = 0\%$)[16,18,23,25] increased odds of having a baby with PTB and LBW, respectively. Twins born to Black mothers were also found to have an elevated risk of LBW than White twins.[26] Black adolescents also had a high rate of PROM compared to Caucasian and Hispanic adolescent mothers.[35] This racial gap in adolescent pregnancy outcomes persisted after controlling for potential confounders such as smoking, gestational age, and area of residence.[24,42]

The role of Indigenous status of the adolescent mother on birth outcomes was investigated in only one Australian study.[17] Indigenous teens were found to be at an increased risk of adverse birth outcomes such as neonatal death, PTB, LBW, and SGA than their non-Indigenous counterparts.[17]

Socioeconomic status

The role of SES on adverse maternal and birth outcomes was analyzed in nine epidemiological studies (retrospective cohort [n=3],[20,21,24] cross-sectional [n=4],[38,39,42,44] prospective cohort [n=1],[36] and ecological study [n=1][45]).

Studies used different criteria to define maternal SES depending on country-specific cultural contexts. Three studies used husband or supporting parents' education status and occupation as surrogate measures of the SES status of adolescent mothers,[20,36,39] while six studies measured SES more comprehensively using census data on household income, education, number of dependents, and other relevant socioeconomic predictors.[21,24,38,42,44,45]

Adolescent mothers in the lowest income quintiles had a higher incidence of obstetric complications,[36] and maternal deaths.[21] The rate of caesarean section were higher among adolescents from high SES in contrast to low SES mothers.[39] Five studies reported that low SES adolescents are at an increased risk of LBW.[24,38,42,44,45] The association between low SES and

LBW persisted after adjustment for prenatal care, race, and smoking.[24,42]

Area of residence

Area of residence was reported in eight observational studies (retrospective cohort [n=4],[22,25,30,31] cross-sectional [n=2], [38,43] case-control [n=1],[46] and prospective cohort [n=1][33]).

Rural maternal residence was consistently associated with a high risk of PTB.[25,30,31] The association between rural residence and PTB remained significant after controlling for behavioral risk factors and obstetric chaarcteristics.[25,31] Evidence of an association between rural residence and LBW was inconclusive;[30,33,46] however, rural non-White adolescents had a higher risk of LBW than their urban non-White counterparts.[30] Infants of rural teen mothers were also found to be at a high risk of death [30] and SGA.[31] Adolescents living in the most marginalized communities were reported to have high rates of caesarean section.[38]

Education

The association between education and adverse maternal and birth outcomes was evaluated in six observational studies (cross-sectional [n=3],[39,40,43] retrospective cohort [n=2],[21,24,] and case-control [n=1][46]).

Age-appropriate education of the adolescent mother was found to confer a protective effect against pregnancy complications.[21,24,46] Maternal illiteracy was identified as a significant predicator for maternal mortality.[21,40] Teen mothers with adequate level of education for age were reported to have high rates of caesarean births.[39] After adjustment for potential confounders such as maternal age, inter-pregnancy interval, and prenatal care utilization, second births to adolescents with less than 12 years of completed education were at an increased risk of PTB and LBW compared to adolescent mothers with more than 12 years of completed education.[24]

Occupation

Maternal occupation was evaluated in five studies (retrospective cohort [n=1],[17] cross-sectional [n=3],[39,42,44] and prospective cohort [n=1][34]).

Occupational status of the mother was analyzed as a predictor of social marginalization.[17,39,42,44] Unemployed adolescent mothers were reported to be at an increased risk of caesarean section than employed adolescents.[39] A significant association was found between minimum wage employment and the risk of LBW.[44] Adolescent mothers working for more than 15 hours per week during pregnancy had about 4 times higher risk of having a SGA infant compared to non-employed teen mothers after adjusting for potential confounders such as maternal height, weight gain, and smoking.[34]

Social capital

The role of social capital on adverse adolescent pregnancy outcomes was analyzed in five studies (retrospective cohort [n=3],[18,20,29] and cross-sectional [n=1][41,43]).

Social support was found to decrease the risk of LBW in adolescent mothers[18,20,29,41] especially for Black teens.[18] Partner support remained significantly associated with a lower risk of adverse birth outcomes after adjusting for education, income, and level of prenatal care.[41]

Religion

The association between religion and adverse maternal and birth outcomes was evaluated in two studies (retrospective cohort [n=1],[27] and cross sectional [n=1][40]).

The studies provided inconclusive evidence regarding the role of religion in adverse adolescent pregnancy outcomes.[27,40]

2.4. Discussion

The present systematic review has comprehensively evaluated the role of SDOH in

adolescent pregnancy outcomes. The review has revealed that SDOH influence adverse adolescent pregnancy outcomes.[16-46]

African-American teens were found to be at a high risk for PTB and LBW.[16,18,19,23,25] Evidence suggests that early-life experiences of racism and marginalization negatively impact the reproductive health of African-American women and increase their likelihood of having premature, low weight infants.[47] Further research is needed in this area to better understand the social etiology of racial disparities in birth outcomes and highlight potential areas of intervention and improvement. Rural residence and lack of social support was found to compound the risk of adverse birth outcomes associated with non-White race.[18,30] These interactions suggest that SDOH operate through interconnected mechanisms and particular sub-populations may be at a greater risk of poor pregnancy outcomes than others. Recognition of these interactions is important to design effective targeted solutions for the high-risk groups.

Low SES was consistently linked with LBW in adolescent pregnancy despite the variability in the definition of SES.[24,28,35,41,44] Findings of the study are in line with the existing literature on socioeconomic disparities in birth outcomes.[48] Low SES teens have been reported to be at a greater risk of under nutrition before, during, and after pregnancy which may explain the high rate of LBW in this group.[48] Currently, there are no guidelines regarding the best approach to measure SES of teenagers.[49] Future reviews should focus on identifying the most suitable way to measure SES of adolescent mothers to facilitate future research in this area.

There is evidence that rural teens have higher rates of PTB compared to urban teenagers.[25,30,31,46] The high frequency of PTB among rural teens has been correlated with high rates of smoking in this population.[31] Smoking cessation services should be incorporated in existing adolescent prenatal programs, particularly in rural areas, to reduce the risk of PTB

among rural adolescents. Evidence for the association between LBW and rural residence was inconclusive, which may be explained by differences in study settings and the definitions of rural/urban used in the individual studies.[30,33,46]

Low literacy skills were found to be a risk factor for maternal mortality[21,30] and PTB,[24] which may reflect differences in social status and access to health care services among educated and uneducated adolescents. Interestingly, a strong positive association was reported between employment and school enrollment status of the adolescent mother.[34] Employment may provide the teenage mothers financial independence which can help them continue their education.[1] However, this finding is based on a single study[34] and therefore, it is an aspect that merits further investigation. Long-term comparative data is lacking on the role of education, occupation, religion, and social capital on adolescent pregnancy outcomes. Well-designed observational studies are needed in this area to accurately estimate the risk associated with under-studied SDOH and adolescent pregnancy outcomes.

Evidence from included studies also suggest regional differences in the reporting of SDOH. Future research on adolescent mothers should aim to highlight country-specific concerns; particularly for countries with highest adolescent maternal mortality rates in order to identify effective solutions and decrease global inequalities in adolescent pregnancy outcomes.

2.5. Strengths and Limitations of the Systematic Review

We followed the Cochrane Collaboration's guidelines for conducting a comprehensive systematic review of observational studies. Publication bias assessment using funnel plots was planned but could not be performed due to the small number of studies (<5) comparing similar outcomes; however, the comprehensive search strategy is likely to have identified most of the

available literature on the role of SDOH in adolescent pregnancy outcomes. Dual independent screening of retrieved articles; data extraction, and methodological quality assessment was performed to minimize potential assessor biases. The review methodology and analytical plan were pre-specified, and the review protocol was registered before conducting literature searches to enhance the transparency of the review methods.

However, findings from the systematic review should be applied with caution as they are potentially limited by the methodological diversity and moderate quality of the included studies. The majority of the studies included only teenage mothers who had received prenatal care or had a hospital-based delivery.[19,20,22,23,29,32,33,34,36,39,40,44,46] This can result in missing the most socioeconomically disadvantaged teens and dilute the true magnitude of the association between SDOH and pregnancy outcomes. The majority of the studies did not adjust for confounding and presented crude estimates.

All of the studies included in the meta-analyses were conducted in the U.S and may reflect country-specific disparities. Previous studies have found disparate poor birth outcome rates between foreign born and US-born African-American mothers.[50] Hence, results from the meta analyses may be more pertinent to U.S-born adolescents.

2.6. Conclusion

Current scientific literature suggests that African-American race, rural residence, inadequate education, low SES, unemployment, and lack of social support are associated with poor pregnancy outcomes in adolescent mothers. Adolescent perinatal health programs should incorporate SDOH considerations in their policies and practice to improve perinatal outcomes for this group. Future studies should focus on the least understood SDOH such as education,

occupation, religion, and social capital and highlight solutions to reduce disparities in perinatal outcomes for adolescent mothers and their infants.

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Table 2.1. Characteristics of Included Studies

First Author	Year	Country	Study Design	Study Population	Sample Size	SDOH Reported
Anderson[30]	2000	U.S	Retrospective cohort	*Pregnant adolescents *Age range: <20 years *Enrolled in Missouri rural adolescent pregnancy project	54,092	Area of residence, Race
Blankson[19]	1993	U.S	Retrospective cohort	*Pregnant adolescents *Age range: <20 years *Having second singleton pregnancy	737	Race
Brewin[18]	2007	U.S	Retrospective cohort	*National sample of teenage mothers *Age range: <20 years	1,870	Race, Social capital
Coley[42]	2016	U.S	Cross-Sectional	*Adolescent mothers *Age range: <20 years of age *Born in the U.S and residing in North Carolina	8,302	Occupation, Race, Socioeconomic status
Felice[35]	1986	U.S	Prospective cohort	*Pregnant adolescents *Age range: 11-19 years of age *Living in the San Diego Area	212	Race
Gaff-Smith[33]	2005	Australia	Prospective cohort	*Pregnant adolescents *Age range: <20 years of age	122	Area of residence

First Author	Year	Country	Study Design	Study Population	Sample Size	SDOH Reported
				*Living in rural New South Wales		
Gama[39]	2014	Brazil	Cross-sectional	*Post-partum adolescents *Age range: <20 years of age	23,940	Education, Occupation, Race, Socioeconomic status
Hardoff[27]	1996	Israel	Retrospective cohort	*Pregnant adolescents *Age: 15-19 years of age	195	Religion
Holling[32]	1976	U.S	Prospective cohort	*Pregnant adolescents *Age: 12-18 years' old *Enrolled in University of Kentucky's Young Mother's Program	417	Race
Khalid[29]	2013	Malaysia	Retrospective cohort	*Pregnant adolescents *Age: < 20 years of age *Received care at Ampang hospital	752	Social capital
Koshar[28]	1998	U.S	Retrospective cohort	*Pregnant Hispanic adolescents *Age: 15-19 years of age	781	Race
LaGuardia[22]	1989	USA	Retrospective cohort	*Pregnant adolescents *Age: < 19 years of age	225	Area of residence

First Author	Year	Country	Study Design	Study Population	Sample Size	SDOH Reported
				*Living in New York		
Laureano[38]	2016	Mexico	Cross-sectional	*Adolescent females *Age: 10-19 years of age *Living in Jalisco, Mexico	28,178	Area of residence, Socioeconomic status
Leland[25]	1995	U.S	Retrospective cohort	*Adolescent mothers *Age: 12-14 years of age	38,551	Race
Magadi[43]	2006	U.K	Cross-sectional	*Pregnant adolescents *Age: 12-19 years of age *Living in South Nyanza, Kenya	1,247	Area of residence, Education, Social capital
Morris[16]	1992	U.S	Retrospective cohort	*Adolescent mothers *Age: <17 years of age *Treated at University of Texas	1,080	Race
Ndaiye[46]	2001	Senegal	Case-Control	*Live births to adolescent mothers	455	Area of residence
Nebot[45]	1989	Spain	Ecological	*Health districts and Neighborhoods in Barcelona	48	Socioeconomic status
Obed[36]	1997	Nigeria	Prospective cohort	*Pregnant adolescents *Age: 12-14 years	1,352	Socioeconomic status
Partington[24]	2009	U.S	Retrospective cohort	*Adolescent mothers *Age: <20 years	18,050	Race, Education,

First Author	Year	Country	Study Design	Study Population	Sample Size	SDOH Reported
				*Resident of Milwaukee Area and gave birth the second time		Socioeconomic status
Restrepo[44]	2005	Colombia	Cross-sectional	*Pregnant adolescents *Age: 10-19 years of age	659	Occupation, Socioeconomic status
Rickert[34]	1998	U.S	Prospective cohort	*Adolescent Mothers *Age: <18 years of age *Gave birth at University of Texas Hospital	384	Occupation
Robson[31]	2006	Australia	Retrospective cohort	*Adolescent mothers *Age: <20 years of age *Residing in New South Wales	21,880	Area of residence
Roop[37]	1975	Trinidad	Prospective cohort	*Teenage mothers *Age: <16 years of age	455	Race
Gale[20]	1989	U.S	Retrospective cohort	*Adolescent mothers *Age:15-19 years of age	421	Social capital Socioeconomic status
Salihu[26]	2005	U.S	Retrospective cohort	*Adolescent mothers *Age: 15-19 years of age *Had twin delivery	29,307	Race
Shah[41]	2014	U.S	Cross-	*National sample of teenage	5,609	Social capital

First Author	Year	Country	Study Design	Study Population	Sample Size	SDOH Reported
			sectional	mothers *Age: 15-19 years		
Taylor[23]	1995	U.S	Retrospective cohort	*Adolescent mothers *Age: <20 years of age *Residing in North Carolina	183	Race
Ujah[40]	2005	Nigeria	Cross-sectional	*Adolescent women *Age: 10-19 years	4,564	Education, Religion
Verguet[21]	2016	Nigeria	Retrospective cohort	*Adolescent females *Age: <20 years of age *Born in India and Nigeria	59,421,00	Socioeconomic status
Westenberg[17]	2002	Australia	Retrospective cohort	*Adolescent mothers *Age: <20 years of age *Living in South Australia	5,074	Occupation, Race

Figure 2.1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Flow Diagram

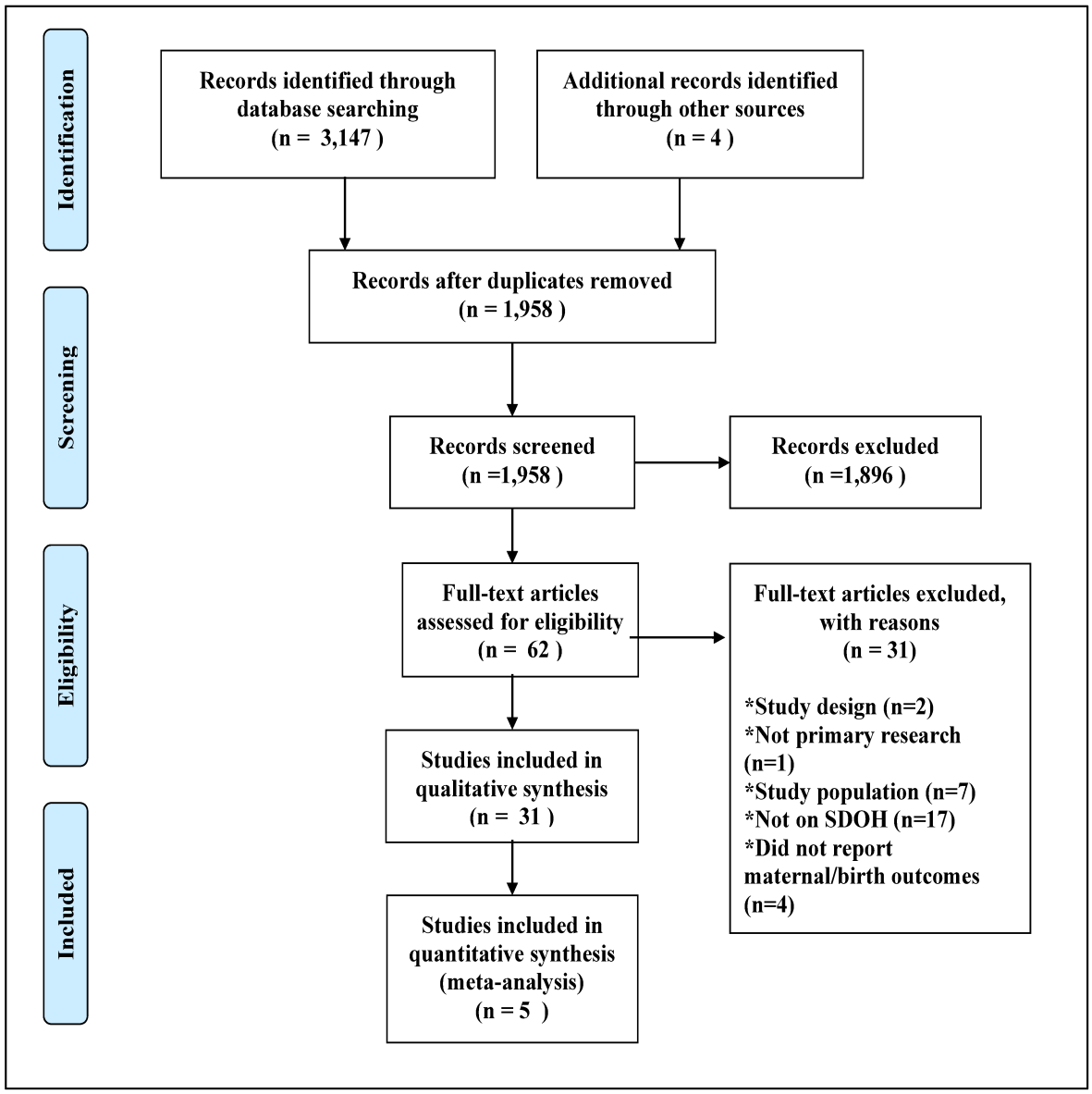
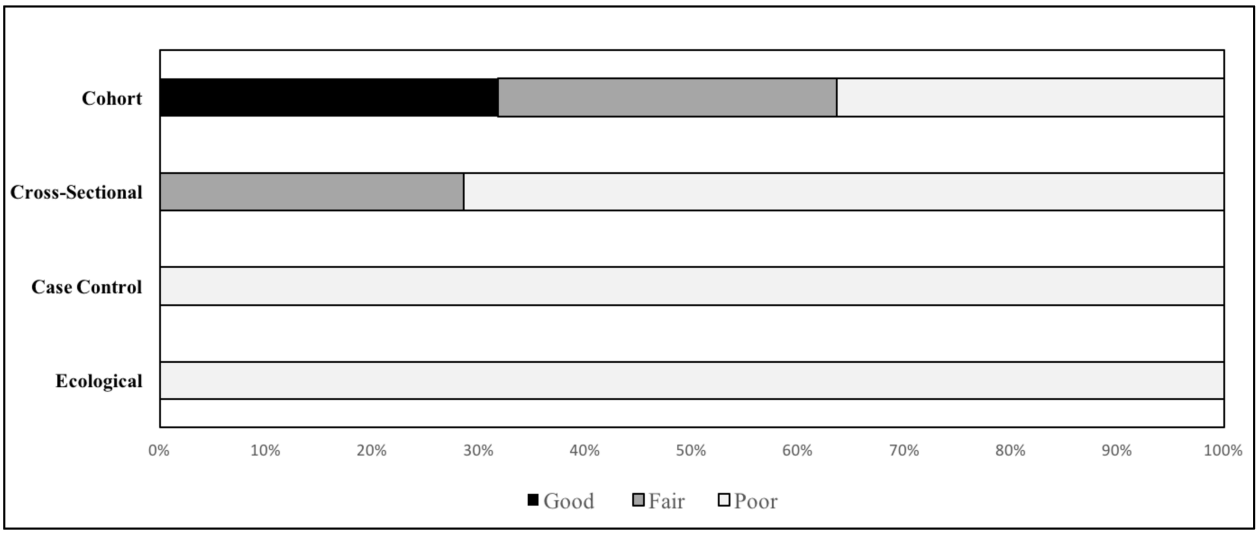


Figure 2.2. Summary of Methodological Quality of Included Studies Across Study Designs*

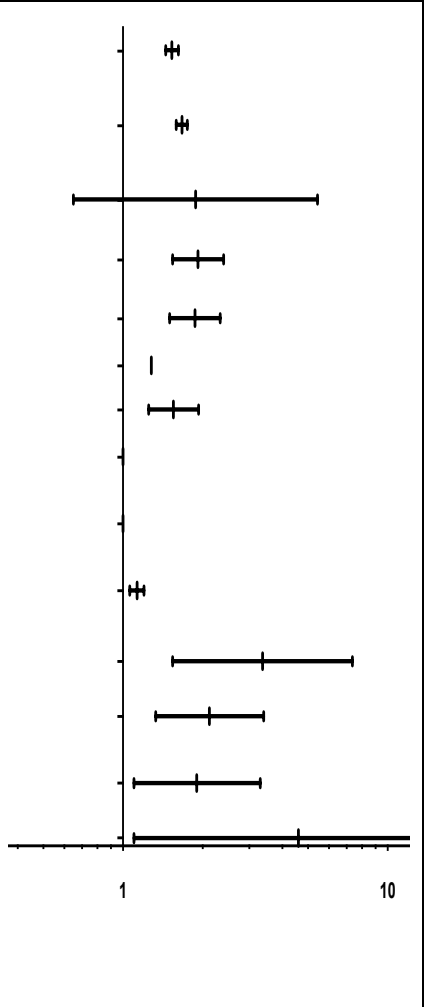


*Studies were classified according to the Agency for Healthcare Research and Quality (AHRQ) standard designations into good, fair, and poor quality based on their New-Castle Ottawa score. The following rating criterion were used adapted for each study design:

1) Cohort Studies: good quality 7-9, fair quality 6, poor quality <5
2) Cross Sectional Studies: good quality 6-7, fair quality 5, poor quality <4
3) Ecological Study: good quality 5, fair quality 4, poor quality <3
4) Case Control Study: good quality 7-9, moderate quality 6, poor quality <5

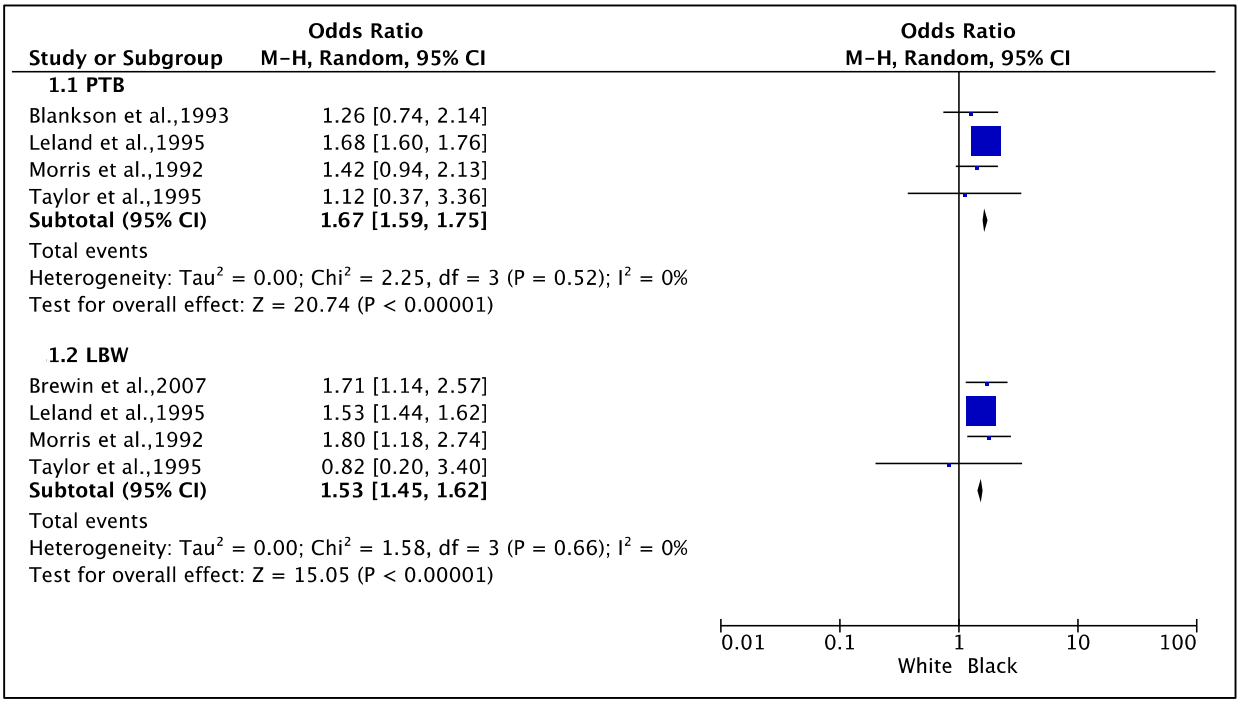
Figure 2.3. Summary of Main Review Findings

SDOH (Risk Factors)	Outcome	Sample Size (Number of Studies)*	Point Estimate (95 % Confidence Interval)*
African American race	LBW	40,774 (4)[16,18,23,25]	pOR 1.53 (1.45, 1.62)[16,18,23,25]
	PTB	40,297 (4)[16,19,23,25]	pOR 1.67 (1.59, 1.75)[16,19,23,25]
Indigenous status	Neonatal mortality	5,074 (1)[17]	1.88 (0.65, 5.43)[17]
	LBW		1.92 (1.54, 2.40)[17]
	PTB		1.87 (1.50, 2.33)[17]
Low socioeconomic status	LBW	55,237 (5)[24,38,42,44,45]	a1.28[24]
			1.55 (1.25, 1.93)[42]
	Maternal mortality	5,942,100 (1)[21]	NR
Poor educational attainment	Maternal mortality	5,946,664 (2)[21,40]	NR
Rural residence	PTB	114,532 (3)[25,30,31]	1.13 (1.06, 1.20)[25]
			3.37 (1.54, 7.36)[31]
	SGA	21,880 (1)[31]	2.12 (1.33, 3.40)[31]
Low social capital	LBW	8,112 (4)[18,20,29,41]	1.90 (1.10, 3.30)[18]
Occupation (working for more than 15 hours per week)	SGA	384 (1)[34]	4.60 (1.10, 19.30)[34]



LBW = Low Birth Weight; pOR=Pooled odds ratio; PTB = Preterm birth; SDOH = social determinants of health; SGA = Small for gestational age

Figure 2.4. Meta-Analysis of the Association between Maternal Race and Preterm Birth and Low Birth Weight



Low Birth Weight=LBW, Pre-term Birth=PTB

CHAPTER 3. AREA OF RESIDENCE, SOCIOECONOMIC STATUS AND THE RISK OF ADVERSE MATERNAL AND BIRTH OUTCOMES IN ADOLESCENT PREGNANCIES[2]

3.1. Background

Adolescent pregnancy is defined as pregnancy among women under the age of 20 years.[1] Pregnancy during teenage years poses a myriad of health risks and long-term social and economic challenges for the young mothers and their children.[2,3] Adolescent mothers have been reported to have increased risk of pregnancy induced hypertension, obstructed labour, surgical deliveries, PTB, LBW and SGA.[1,2,3] Adolescent pregnancy is an important public health concern in Canada.[4,5] About 40,000 Canadian teens become pregnant every year, for a national teen pregnancy rate of 28 per 1,000 females (aged 15-19 years).[4,5] Despite an overall reduction of adolescent pregnancy rates in Canada, regional variations persist.[5] According to the Sex Information and Education Council of Canada (SIECCAN), estimates of adolescent pregnancy rate in Alberta (34.8 per 1,000 females aged 15-19 years) are 39% higher compared to those in Ontario (21.2 per 1,000 females (aged 15-19 years) highlighting unequal advancements in adolescent perinatal health.[5]

A well-established body of evidence suggests an important role of social determinants of health (SDOH) in adolescent pregnancy outcomes.[6,7] SDOH -defined as the "*conditions in which people are born, grow, live, work and age*[8]"- have been extensively explored in the context of disparities in adolescent pregnancy outcomes.[3,4] SDOH such as rural/urban residence have been shown to have a profound effect on the obstetric performance of adolescent mothers.[9-13] Previous

[2] This chapter has been prepared for submission to the Canadian Medical Association Journal (CMAJ). Reference: Amjad S, Osornio-Vargas A, Chandra S, Voaklander D, Ospina MB. Area of residence, socioeconomic status and the risk of adverse maternal and birth outcomes in adolescent pregnancies [Manuscript in preparation].

studies have observed high rates of severe maternal morbidity, preterm birth (PTB), and neonatal death among rural adolescent mothers.[9,10] Research has identified longer travel time to reach health care services and lack of specialist care as one of the main causes of rural/urban disparities in poor pregnancy outcomes.[14,15,16] Moreover, the high rate of chronic medical conditions such as diabetes mellitus and cardiovascular disease among rural populations and behavioral risk factors such as smoking may also contribute to the higher prevalence of adverse pregnancy outcomes among rural residents compared to their urban counterparts.[17]

Another SDOH which has been consistently associated with adolescent pregnancy outcomes is maternal socioeconomic status (SES).[11-13] Adolescent mothers with high SES have been reported to have better pregnancy outcomes than low SES adolescents.[11,12] A large cohort study based on census data from the United States (U.S) found a 55% increased risk of low birth weight (LBW) in adolescent mothers from low-income neighborhoods.[13] Investigators have suggested that the observed socioeconomic gradient in pregnancy outcomes may reflect population-level differences in accessibility and affordability of nutritious food, health care, and other societal resources.[18,19]

Previous research has demonstrated that the combined effect of multiple SDOH compounds the risk of poor health outcomes associated with these factors.[19,20] Rural residence and low SES seem to have a negative joint effect on health outcomes. Existing evidence suggests that rural mothers with low SES are at increased risk of adverse health outcomes, which is attributed to chronic exposure to food insecurity, socioeconomic deprivation and poor-quality antenatal care services.[19,20] The joint effect of maternal area of residence and SES on adolescent pregnancy outcomes has not been explored. It is important to investigate these associations to identify subgroups of adolescent mothers at increased risk of life-threatening maternal and birth

outcomes and to reduce inequalities affecting adolescent pregnancy health.

The objective of the present study was to address current gaps in the existing literature about the combined effects of area of residence and SES on maternal and birth outcomes in adolescent pregnancy. The specific objectives were: 1) to describe the sociodemographic characteristics and obstetric and pregnancy outcomes of adolescent mothers in Alberta, and 2) to investigate the joint effect of area of residence and SES on adverse adolescent pregnancy outcomes.

3.2. Methods

3.2.1 Study design

A population-based analytical cross sectional study was conducted to address the study objectives. The study is reported as per the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.[21] Ethics approval for the study was obtained from the University of Alberta's Health Research Ethics Board (HREB).

3.2.2 Data sources

De-identified individual-level data by fiscal year (April 1st of a given year to March 31st of the subsequent year) was obtained from the Alberta Perinatal Health Program (APHP). The APHP is a clinical perinatal database that contains demographic, delivery, and pregnancy outcomes for all hospital-based and midwife attended births in Alberta.[22] The APHP collects all electronic and paper delivery records directly from the birthing facility.[22] The delivery records are stored as a two part documents within the APHP: part one outlines pre-pregnancy conditions, and obstetric history; while part two deals with the complications and details of the current birth. Data collection is conducted by trained personnel. APHP data collection, usage and

disclosure is guided by the provincial health information privacy laws.[22]

The *Pampalon Material Deprivation Index Dataset* (PMDID) is a new database within Alberta Health Services (AHS) related to the SES of the Albertan population aged 15 and over, excluding First Nations. The Pampalon material deprivation index is a small area–based composite SES index that uses 2011 census data for income, education and employment at the dissemination area level to describe SES disparities among the population.[23] Based on their postal code of residence at the time of delivery, study participants were assigned to a neighborhood deprivation category based of Q1 (least deprived) to Q5 (most deprived) corresponding to highest to lowest neighborhood SES, respectively. This index has been used extensively in previous Canadian studies on health disparities for measurement of area-level SES.[23] The index file includes a composite measure of rural/urban status calculated based on population density and travel time to health care services at the local geography area level. The local geographic areas are provincial administrative subdivisions used by AHS to facilitate community-level health service planning and delivery.[24]

3.2.3 Study population

The study population comprised all singleton live births (≥ 23weeks of gestation) in Alberta between April 1, 2010 and March 31, 2015 among women aged 15-19 years. Adolescent mothers younger than 15 years were excluded due to lack of SES information in the PMDID. Adolescents who gave births multiple times during the study period were included in the analyses and each birth was treated as a separate event. Inclusion in the study was restricted to pregnancies of ≥23 weeks of gestation as the focus of this study were the perinatal (starts after 22 completed weeks of gestation)[25] outcomes of young mothers.

3.2.4 Classification of the study population

Adolescent mothers were assigned an urban/rural status based on their allocated area of residence category (*metro/urban/rural*) in the PMDI dataset. The area of residence category is a composite measure based on neighborhood-level characteristics (i.e., population density and travel time to healthcare) which have a well-established relationship with pregnancy outcomes.[14,15] Subcategories of *urban* and *metro* were defined as urban because of their higher population density and likely proximity to health care facilities. Adolescent mothers assigned to the subcategory *rural* in the PMDID were considered to have rural residence. Adolescent mothers were allotted a SES quintile by linking their postal code of residence to the corresponding dissemination area.[16] Groups of high SES (Q1-3) and low SES (Q4,5) were created to facilitate comparison.

The study population was classified into four groups based on their area of residence (rural/urban) and SES (high/low) i.e. rural adolescents with high SES (rural/high SES); rural adolescents with low SES (rural/low SES); urban adolescents with high SES (urban/high SES); and urban adolescents with low SES (urban/low SES). The study flow process is summarized in Figure 3.1.

3.2.5 Outcome measures and covariates

The **s**tudy outcomes included adverse perinatal maternal and birth outcomes as recorded in the APHP delivery records.[22] Adverse maternal outcomes included pregnancy-induced hypertension, gestational diabetes mellitus, postpartum hemorrhage (>500 ml bleeding for vaginal delivery or >1000 ml bleeding for caesarean section), operative vaginal delivery (forceps or vacuum), caesarean section, and intra-hospital maternal death. Adverse birth outcomes

included small for gestational age (SGA; birth weight <10th percentile for gestational age as defined by Canadian sex-specific, population-based reference standards)[26], large for gestational age (LGA; birth weight >90th percentile for gestational age)[18], LBW (birth weight <2500 grams), spontaneous and medically indicated PTB (live birth with gestation period <37 weeks) and neonatal death (within 28 days of birth).

The covariates included maternal demographic and obstetric characteristics such as maternal age at delivery, parity, pre-pregnancy medical conditions (i.e., diabetes mellitus, hypertension, heart disease), smoking status, drug dependency, alcohol use during pregnancy, poor weight gain during pregnancy (<0.5kg/week or weight loss in 26-36 weeks of gestation), high antepartum risk score (calculated based on medical and obstetric history; score >6 is considered high risk)[22], antenatal provider, and delivery provider expertise.

3.2.6 Statistical analysis

Maternal sociodemographic and obstetric characteristics, and study outcomes were described using frequencies and percentages for categorical data and mean and standard deviation (SD) or median and interquartile ranges (IQR) for continuous variables. Subgroup comparisons of the maternal risk factors and adverse pregnancy outcomes was performed by area of residence and SES. An initial exploratory analysis was conducted to determine the correlation between categorical independent variables using the chi-square test and the Cramer's V coefficient. For variables with a high Cramer's V coefficient (>0.9), the most clinically significant variables were selected. Multiple logistic regression analysis as per Hosmer & Lemeshow was conducted to investigate the association between maternal area of residence/SES dyads and pregnancy outcomes.[27]

Multiple logistic regression models were built using statistically (Wald' statistic $P<0.05$) and clinically significant predictors and the following potential confounders: smoking, drug dependency, alcohol use, parity, poor weight gain, pre-pregnancy medical conditions, health care provider expertise and the antepartum risk score. Model diagnostics were conducted using the Hosmer-Lemeshow goodness-of-fit test.[27] Adjusted odds ratios (OR) with 95% confidence intervals (CI) were calculated to compare the odds of poor pregnancy outcomes among area of residence-SES groups. The urban/high SES group was used as the reference category in all the models. All statistical analyses were conducted using STATA Data Analysis and Statistical Software (Version 12, StataCorp LLC, Texas, USA).

3.3. Results

We identified 9,606 singleton live births to adolescent mothers aged 15-19 years during the study period. Of these, 362 births (3%) were excluded from the regression analysis as they had out of province residence. Mean age of adolescents at delivery was 18 years (SD:1.1). The majority of adolescent mothers in the study cohort had urban residence (57%, n = 5,301) while 43% (n = 3,943) lived in rural areas. Overall, 64% (n = 5,882) had a low SES while 36% (n = 3,662) were of high SES, 41% (n = 3,948) smoked, 6% (n = 526) had drug dependency while 8% (n = 745) used alcohol at some point during pregnancy. Detailed sociodemographic and obstetric characteristics of the study population are presented in Table 3.1.

Thirty percent (n = 2,767) of the mothers were in the urban/high SES group; 27% (n = 2,534) were in the urban/low SES group; 7% (n = 595) were in the rural/high SES group and 36% (n = 3,348) had rural residence and low SES. Overall, rural adolescents with low SES were more likely to be under 17 years of age at time of delivery, multiparas, smokers, had drug

dependency, and used alcohol during pregnancy. Rural/low SES mothers were also most likely to have poor weight gain during pregnancy, high antepartum risk scores, and chronic medical conditions. Irrespective of their SES status, the majority of adolescent mothers living in rural settings received antenatal and delivery care services from a family physician while the majority of mothers living in urban centers received delivery services from an obstetrician. Detailed distribution of maternal and obstetric risk factors by area of residence/SES are described in Table 3.2.

3.3.1 Association between maternal area of residence-SES and study outcomes

Overall, rural/low SES adolescents had the highest proportion of adverse maternal outcomes i.e. gestational diabetes mellitus (37%), pregnancy induced hypertension (38%), operative vaginal delivery (40%), cesarean section (40%), and excessive blood loss (35%). Cases of maternal death were not identified in the study cohorts. Mothers in the rural/low SES group also had the highest rate of PTB (40%) and SGA (33%). The rates of LBW babies were identical among adolescents of low SES (34%), irrespective of their urban/rural status. The rate of neonatal death (42%) was the highest among urban/low SES mothers. Table 3.3 presents the results of the multiple logistic regression analyses by area of residence/SES groups adjusted for confounding factors.

Rural adolescent mothers with low SES

Compared to the urban/high SES group, rural adolescent mothers with low SES had increased odds of postpartum hemorrhage (OR:1.57; 95% CI: 1.41, 1.74); operative vaginal delivery (OR: 1.37; 95% CI: 1.18, 1.60) and caesarean section (OR:1.39; 95% CI: 1.19, 1.62). Rural residence/low SES was also associated with 48% increased odds of PTB (OR: 1.48; 95%

CI:1.17, 1.87), 39% increased odds of LGA (OR:1.39; 95% CI:1.16, 1.66), and 18% decreased odds of SGA (OR:0.82; 95% CI: 0.69, 0.97).

Rural adolescent mothers with high SES

Similar to their low SES/rural counterparts, there was increased odds of operative vaginal deliveries (OR: 1.37; 95% CI:1.06, 1.77), and LGA babies (OR:1.46, 95% CI:1.08, 1.96) in the rural high SES group. Rural/high SES adolescents have decreased odds of postpartum hemorrhage (OR:0.95, 95% CI:0.79, 1.15), PTB (OR:0.86, 95% CI:0.52, 1.39), SGA (OR:0.73, 95% CI:0.53, 1.01), and LBW (OR:0.66, 95% CI:0.37, 1.99).

Urban adolescent mothers with low SES

In contrast to urban residents with high SES, urban/low SES adolescent mothers had 20% (OR:1.20, 95% CI:1.02, 1.41) and 49% (OR: 1.49, 95% CI: 1.33, 1.66) increased odds of operative vaginal delivery and postpartum hemorrhage, respectively. There was a positive association between urban residence/low SES and neonatal death (OR:2.62; 95% CI: 1.01, 6.81).

3.4. Discussion

This is one of the first studies in Canada that evaluate the combined effect of area of residence and SES in the occurrence of adverse pregnancy outcomes among adolescent mothers. Using a clinical perinatal database from Alberta, the study results suggest that the risk of adverse pregnancy outcomes in adolescent mothers varies by residence/SES hinting at a joint effect of these determinants. The combination of rural residence and low SES was associated with a multitude of adverse pregnancy outcomes in adolescent mothers.

The results suggest a 1.5-fold increased risk of PTB among adolescent mothers of low SES living in rural areas. The high rate of PTB among rural mothers has been linked previously to

high smoking rates in this group.[9] The high proportion of smokers in this study cohort is in agreement to the current smoking statistics for pregnant adolescents in Alberta.[28] Smoking is a known perinatal health problem among young mothers in Alberta.[28] The prevalence of smoking among pregnant Albertan adolescents is three times higher than the overall provincial rate of smoking for all pregnant women.[28] These estimates reflect a need for tailored smoking cessation programs for adolescent mothers. The results indicate that rural adolescents are likely to receive antenatal services from a family physician. Antenatal smoking interventions are well documented to increase long-term smoking reduction and improve pregnancy outcomes.[28,29] Family physicians, especially those working in rural areas should be sensitive of the social context of smoking and trained in equity-informed smoking cessation practices. Although not explored, the high prevalence of urinary tract and sexually-transmitted infections in rural settings may also have contributed to the excess risk of PTB in this group.[30]

The study found an increased risk of postpartum hemorrhage among low SES adolescent mothers irrespective of their rural/urban residency status. The high risk of postpartum hemorrhage in low SES adolescents is alarming as it is a well-established risk factor for significant maternal morbidity and mortality.[31] Health care providers working with low SES adolescent mothers should be vigilant for risk factors associated with excessive bleeding during labour such as anemia, multiple births, past history of postpartum hemorrhage, and employ necessary clinical measures to reduce the incidence and health risks associated with postpartum hemorrhage.[31]

The study found a high risk of caesarean section among mothers of low SES living in rural areas. Similar findings were reported by a hospital-based Canadian study which found a higher rate of surgical deliveries among women residing in low-income neighborhoods compared to

women living in high-income areas.[32] The study did not explore the differences between the rate of elective and medically-indicated caesarean section in the analysis. Future studies should highlight the SES differences in preferred mode of delivery of adolescent mothers. The risk of operative vaginal delivery was high across all the area of residence/SES groups of adolescent mothers.

In line with existing literature, there was an increased risk of LBW in low SES mothers from both urban and rural areas of residence.[7,11,13] A growing body of evidence shows that rural residence is associated with a decreased likelihood of SGA and an increased likelihood of LGA.[15,33] The study presented here found similar results for adolescent mothers. The association between SGA, LGA and rural residence did not differ by maternal SES. This result may be explained by the higher prevalence of obesity among rural Canadian youth, which is a well-established risk factor for LGA.[34] About 10% of the LGA babies in the study cohort were also PTB. Infants born before 37 weeks of gestation are likely to be diagnosed LGA at lower birth weights which can potentially result in inaccurate diagnosis.[35,36]

3.5. Strengths and Limitations of the Study

An overall strength of this study is the use of a large population-based clinical perinatal database which captures the majority of births (~94%) in Alberta.[22] The cross sectional design with linkage of individual and area-level data involved a large number of adolescent mothers. The use of a single composite measure of area of residence and SES allowed us to include information from both these related determinants in the regression models while avoiding the issue of multicollinearity. The analytical methods were robust, as estimates were adjusted for potential confounders. It is within reason to expect that results of this study can allow inferences

that can be applied to populations of adolescent mothers in other Canadian provinces.

This study has several limitations, which need consideration. The associations observed in this study maybe more representative of population-level effects and should be interpreted as such. Particularly, caution should be taken when applying area-level characteristics onto individual outcomes. The use of a composite measure to determine the joint effect of area of residence and SES allowed us to highlight the at-risk sub groups of adolescent mothers. However, this approach does not provide information about the respective attribution of maternal area of residence and SES to the observed outcomes.

Other limitations of this study involve the ascertainment of the area of residence and SES. There is no widely acceptable definition of rural/urban residence in Canada.[33] The study employed a definition of rural/urban status based on population density and distance to health care services at the local geographic area level. Population density is a major determinant of the availability of health care resources in a community while time to health care services is a known predictor of pregnancy outcomes so this definition of rural/urban status was appropriate to explore the impact of geographic location and associated characteristics on adolescent pregnancy outcomes.[14,15] However, the local geographic areas are used for health planning and administrative purposes and may not represent micro-level geographic variations in adverse pregnancy outcomes. The Pampalon SES index was used to measure SES at the dissemination area level.[23] Dissemination areas are the smallest census units with an average population size of 400-700 individuals[23] and are likely to be homogenous in terms of their material environment; however, previous research shows that area-level SES may not be in agreement with individual-level SES, which can result in misclassification of the exposure and non-differential bias affecting the association between SES and health outcomes.[37,38]

Findings from the study should be applied with caution as they are potentially limited by the quality and accuracy of the datasets used. The APHP has validation and audit processes in place to ensure high quality of the data; however, potential misclassification and errors cannot be disregarded. The role of variables such as body mass index, pre-pregnancy body weight, intention to get pregnant, Indigenous and immigrant status, and ethnicity were not considered in the analysis as this information was lacking in the administrative datasets used which can potentially result in residual confounding. Finally, the results may not apply to very young mothers as adolescent mothers under 15 years of age were excluded due to the lack of SES information for this group.

3.6. Conclusion

Adverse maternal and birth outcomes in adolescent pregnancies are influenced by maternal area of residence and SES. Study results suggest that the combination of rural residence and low SES defines a subgroup of adolescent mothers at high risk of having adverse maternal and birth outcomes. SDOH principles should be integrated into current adolescent perinatal health programs and clinical practice to address the needs of most deprived adolescent mothers. Future research should focus on highlighting modifiable causes of disparities in adolescent pregnancy outcomes to reduce the socioeconomic gradient in adolescent maternal and perinatal health.

3.6. References

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Table 3.1. Sociodemographic and Obstetric Characteristics of Adolescent Mothers (n = 9,606) in Alberta, 2010-2015

Characteristics	**Number (%)**
Multi-parity	1,663 (17%)
Poor weight gain during pregnancy	166 (2%)
Smoking during pregnancy	3,948 (41%)
Drug dependency	526 (6%)
Alcohol use during pregnancy	745 (8%)
High antepartum risk score	507 (5%)
Pre pregnancy diabetes mellitus	44 (0.5%)
Pre pregnancy hypertension	45 (0.5%)
Rural residence	3,943 (43%)
Low socioeconomic status	6,244 (65%)
Antenatal provider expertise	
Obstetrician	2,963 (38%)
Family physician	4,528 (58%)
Midwife/Other	344 (4%)
Delivery provider expertise	
Obstetrician	4,327 (45%)
Family physician	5,055 (53%)
Midwife/Other	166 (2%)

Table 3.2. Distribution of Maternal and Obstetric Risk Factors by Area of Residence and Socioeconomic Status (SES) of Adolescent Mothers (n = 9,606) in Alberta, 2010-2015.

Risk factor	Urban Number (%)		Rural Number (%)		p-Value
	High SES	Low SES	High SES	Low SES	
Maternal age <17 years	272 (26%)	310 (30%)	57 (5%)	408 (39%)	<0.01
Multi parity	364 (23%)	440 (28%)	110 (7%)	680 (43%)	<0.01
Smoking during pregnancy	1,080 (29%)	1,058 (28%)	248 (7%)	1,391 (37%)	0.06
Drug dependency	151 (30%)	117 (23%)	29 (6%)	213 (42%)	0.02
Alcohol use	222 (31%)	172 (24%)	40 (6%)	283 (40%)	0.06
Poor weight gain during pregnancy	49 (30%)	30 (18%)	15 (9%)	71 (43%)	0.02
Pre-pregnancy diabetes mellitus	11 (25%)	19 (43%)	0 (0%)	14 (32%)	0.06
Pre-pregnancy hypertension	10 (23%)	10 (23%)	6 (14%)	18 (41%)	0.16
Pre-pregnancy heart disease	15 (44%)	12 (35%)	0 (0%)	7 (21%)	0.06
High antepartum risk score	137 (28%)	135 (28%)	26 (5%)	189 (39%)	0.41

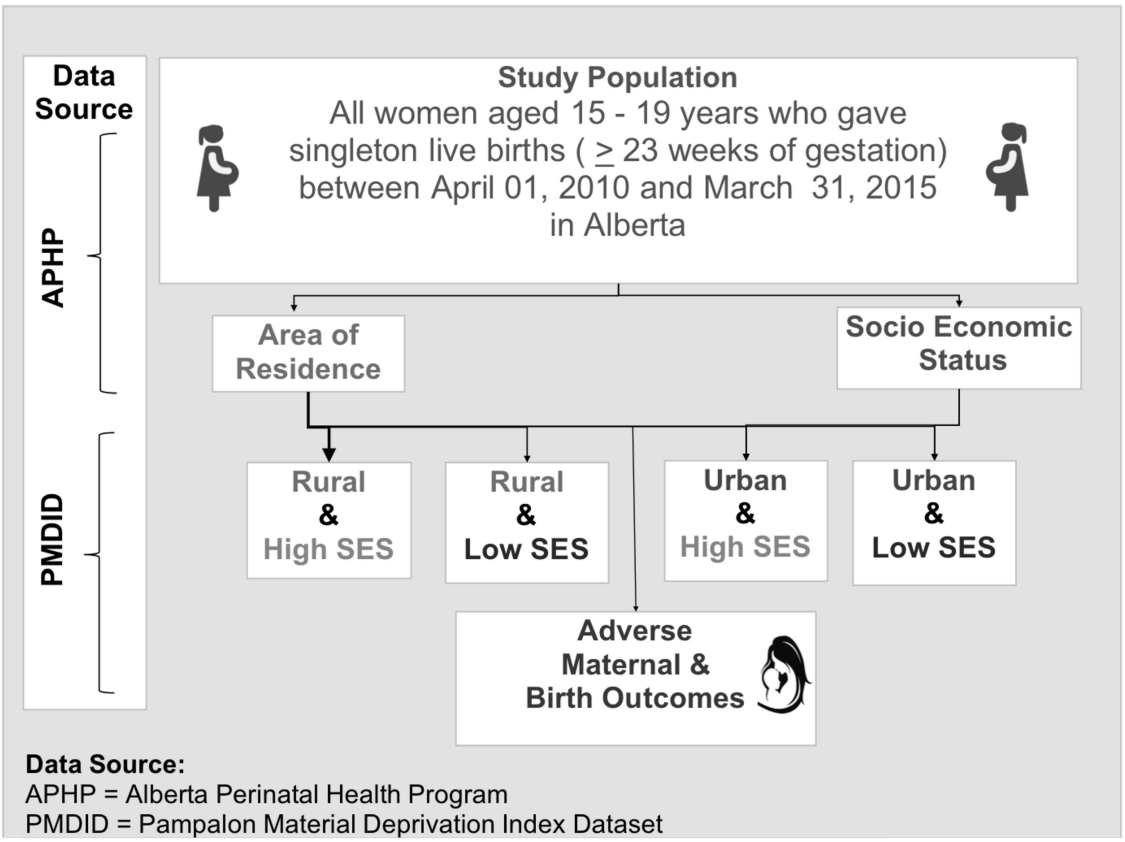
Risk factor	**Urban Number (%)**		**Rural Number (%)**		**p-Value**
	High SES	**Low SES**	**High SES**	**Low SES**	
Antenatal provider expertise					
Obstetrician	857 (30%)	1,088 (39%)	62 (2%)	819 (19%)	<0.01
Family practice	981 (23%)	793 (18%)	451 (10%)	2,117 (49%)	
Midwife	35 (40%)	13 (15%)	1 (1%)	40 (45%)	
Delivery provider expertise					
Obstetrician	1,382 (30%)	1,563 (37%)	126 (3%)	1,110 (27%)	<0.01
Family practice	1,317 (27%)	930 (19%)	453 (9%)	2,117 (44%)	
Midwife	39 (39%)	20 (20%)	7 (7%)	33 (33%)	

Table 3.3. Odds ratio (OR) for the Association between Area of Residence/Socioeconomic Status (SES) and Adverse Maternal and Birth outcomes

Adverse maternal and birth outcomes	OR (95% CI)†		
	Urban and Low SES	Rural and High SES	Rural and Low SES
Operative vaginal delivery	1.20 (1.02, 1.41)*	1.37(1.06, 1.77)*	1.37(1.18, 1.60)*
Caesarean section	1.03(0.87, 1.23)	1.29(0.99, 1.68)	1.39(1.19, 1.62)*
Postpartum hemorrhage	1.49(1.33, 1.66)*	0.95(0.79, 1.15)	1.57(1.41, 1.74)*
Gestational diabetes mellitus	1.17(0.78, 1.76)	0.63(0.27, 1.49)	1.07(0.72, 1.57)
Pregnancy induced hypertension	0.97(0.74, 1.28)	1.12(0.72, 1.73)	1.16(0.90, 1.48)
Preterm birth	1.02(0.78, 1.32)	0.86(0.52, 1.39)	1.48(1.17, 1.87)*
Small for gestational age	1.03(0.87, 1.23)	0.73(0.53, 1.01)	0.82(0.69, 0.97)*
Large for gestational age	1.02(0.84, 1.25)	1.46(1.08, 1.96)*	1.39(1.16, 1.66)*
Low birth weight	1.12(0.84, 1.49)	0.66(0.37, 1.99)	1.11(1.07, 1.65)*
Neonatal death	2.62(1.01, 6.81)*	1.87(0.37, 9.57)	1.77(0.52, 3.53)

†Reference category: urban adolescents with high SES
†Adjusted for smoking, drug dependency, alcohol use, multiparity, poor weight gain, pre-pregnancy medical conditions, care provider expertise, high antepartum risk score,
CI= confidence interval, OR=odds ratio; *=statistically significant association

Figure 3.1. Data Sources and Study Flow Process



CHAPTER 4. DISCUSSION AND RECOMMENDATIONS

The overall aim of this thesis was to investigate associations between SDOH and adverse maternal and birth outcomes in adolescent mothers, and to examine the combined effect of area of residence and SES on their perinatal outcomes. To address the study objectives, a systematic review of the scientific literature was conducted to synthesize the current evidence on the role of SDOH in poor adolescent pregnancy outcomes. This was followed by an analytical cross sectional study documenting the sociodemographic characteristics of adolescent mothers in Alberta and analyzed the relationship between maternal area of residence, SES and adverse maternal and birth outcomes in adolescent pregnancies. Key findings from the systematic review and cross sectional study will be discussed in the subsequent section.

4.1. Systematic Review and Meta-Analysis

A systematic review of observational studies evaluated the relationship between SDOH and adverse maternal and birth outcomes in adolescent pregnancies. A total of 31 primary studies were included that evaluated adverse pregnancy outcomes in adolescent mothers according to SDOH categories. The studies used different criteria to estimate SDOH which made direct comparison and pooling of data difficult. The majority of included studies analyzed birth outcomes which suggests a predilection of fetal-centric approach in the current adolescent perinatal health research.[1-31]

4.1.1 Conclusions from the systematic review and meta-analysis

A narrative exploration of individual study results and meta-analysis of included studies

suggest that biology alone does not explain the high incidence of adverse perinatal outcomes in adolescent mothers. A common theme that emerged from the included studies was the association of certain SDOH such as low SES, rural residence, unemployment, and low literacy skills with an increased risk of adverse maternal and birth outcomes in adolescent mothers. The included studies consistently reported a higher prevalence of poor pregnancy outcomes among socioeconomically deprived adolescents compared to their well-off counterparts, which suggests that certain subgroups of adolescent mothers may be at a high risk of poor pregnancy outcomes and require special attention.[1-31]

4.1.2 SDOH define a subgroup of high-risk adolescent mothers

African American adolescents and risk of adverse birth outcomes

Results from a meta-analysis revealed a higher risk of LBW and PTB among African-American mothers compared to White adolescent mothers. Previous research has identified that African-American mothers have poor obstetric outcomes due to the physical and social barriers they face in accessing health care services, quality food, education and economic opportunities.[32-35] A recent review reported that racial disparities in birth outcomes persisted even after adjusting for individual-level risk factors and suggested that psychosocial stress associated with coping with racism may also play an important role in the development of racial inequality gaps in birth outcomes.[35] This emphasizes the importance of social setting and cultural environment as predictors of maternal and neonatal wellbeing. Adolescent perinatal health researchers particularly in the US and those working with disadvantaged populations should adopt relevant social and racial considerations in their research to enhance the current understanding of the influence of racism and discrimination on pregnancy outcomes of teenage

mothers.

Low SES and the risk of low birth weight

The systematic review showed that low SES defines a subgroup of adolescent mothers with an increased risk of having LBW babies. Previous research on adult mothers has also implicated low SES in the etiology of LBW variations.[36,37,38] It is hypothesized that socioeconomic inequalities in birth weight are mediated by multidimensional factors such as access to nutritious food, maternal weight gain during pregnancy, awareness of obstetric risk factors, knowledge of prenatal care services, and paternal involvement during pregnancy.[36,37,38] Studies included in the review used household income, husband or supporting parent's education status and occupation, and other proxy measures of SES. Multilevel SES studies on adolescents have been useful in differentiating the role of neighbourhood- and family-level variables in health outcomes and pinpointing areas of interventions.[39] However, none of the included studies explained the SES variation in LBW by neighbourhood- and family-level variables.

Rural residence and the risk of pre-term birth

The systematic review found evidence of rural residence as a risk factor for PTB. There is a growing body of evidence on the association of rural/remote residence on pregnancy outcomes.[40-42] Existing research shows that rural residents are likely to have high rates of potentially preventable risk factors of PTB (i.e., smoking, drug use, barriers to access health care services, diabetes mellitus, untreated sexually transmitted and urinary tract infections[40-44]). It is crucial to identify these contributory factors to guide targeted solutions to reduce the rate of PTB among rural adolescent mothers.

Maternal illiteracy and the risk of maternal mortality

The systematic review found evidence that low literacy skills are a risk factor for adolescent

maternal mortality.[6,25] The results are supported by previous evidence of a negative dose-response relationship between the number of years of education and the risk of maternal death.[45,46] The effectiveness of female education programs in reducing maternal mortality rates has been consistently demonstrated in large well-designed studies.[6,47] It is suggested that educated mothers are likely to have planned pregnancies, adopt healthier lifestyles and utilize antenatal care services.[47] Targeted educational programs can be crucial in reducing the rate of adolescent maternal mortality in the most affected areas.

Evidence regarding the association of occupation, religion and social capital and poor maternal and birth outcomes in adolescent pregnancies was insufficient and needs further consideration in future studies.

4.1.3 Adolescent mothers with multiple social disadvantages

The systematic review revealed that adolescent mothers with multiple SDOH are at an increased risk of adverse maternal and birth outcomes.[1-31] As drivers of social and material deprivation, SDOH operate through intertwined complex mechanisms which coalesce and lead to health inequalities.[48,49] The cumulative effect of multiple SDOH seems to increase the risk of adverse pregnancy outcomes associated with these determinants alone. Evidence from the included studies highlighted that, compared to African-American mothers with no partner support, African-American adolescents in supportive relationships have decreased odds of LBW.[26] Rural residence also compounded the risk of adverse birth outcomes associated with non-White race.[16] It is suggested that, compared to their urban counterparts, rural non-White adolescent mothers face additional challenges in accessing maternity care services which can negatively impact their pregnancy outcomes.[16] Adolescent mothers with poor social capital are

likely to be of low SES and have a greater risk of adverse maternal and birth outcomes.[26] These associations emphasize that *one-size-fits-all* approach to reduce disparities in adolescent perinatal health may not be effective and subgroups of adolescent mothers with multitude of SDOH may need unique and customized solutions. Future studies should focus on elucidating the casual aspects of SDOH that perpetuate disparities in adolescent pregnancy outcomes to inform targeted interventions for high risk mothers.

4.2. Analytical Cross Sectional Study

None of the studies included in the systematic review evaluated the joint effect of maternal area of residence and SES on adolescent pregnancies. This gap in the scientific literature warranted further examination and guided the conception of the cross sectional study.

4.2.1 Sociodemographic and obstetric characteristics of adolescent mothers in Alberta

Overall, 43% of the adolescent mothers had rural residence while 65% were of low SES. These results are in line with current literature on rural/urban estimates of adolescent pregnancy rates in Alberta.[50] About 17% of the total Albertan population resides in rural areas; however, rural areas face a disproportionately high burden of adolescent pregnancies.[50] Rural exposures that influence adolescent pregnancy rate in Alberta merit further attention.

The prevalence of smoking in the study population (41%) was more than double than the national smoking rate (17.5%) for Canadian women older than 11 years.[51] High smoking prevalence among pregnant Albertan adolescents is a critical public health concern[52] as smoking is a risk factor for a multitude of adverse pregnancy outcomes, chronic morbidities, and reduced life expectancy.[52]

The study cohort also had a high rate of multiparas (17%) which raises concerns about the effectiveness of adolescent pregnancy prevention programs in the province. The majority of adolescent mothers in the study cohort received antenatal (58%) and delivery care (53%) from a family physician. Previous research has shown no significant differences in the delivery outcomes of mothers treated by family physicians compared to those treated by obstetricians; however, evidence on the role of delivery provider expertise in adolescent pregnancy outcomes is limited.[53]

Among all area of residence-SES groups, rural adolescent mothers with low SES had the highest proportion of smoking, drug dependency, and alcohol use. A recent report published by the Canadian Centre on Substance Abuse found similar epidemiological estimates of alcohol and drug use among rural Canadian teens.[54] Among urban adolescent mothers, the rate of smoking was similar between high and low SES groups, while the rates of drug dependency and alcohol use during pregnancy were slightly high in the urban, high SES group. This is supported by existing research on substance abuse among high, SES urban youth.[55]

4.2.2 Maternal area of residence-SES and the risk of adverse maternal and birth outcomes

Rural mothers with low SES had the highest risk of multiple adverse maternal and birth outcomes among all area of residence-SES groups of adolescent mothers. These findings suggest that rural poverty is a marker of potentially *at-risk* adolescent pregnancies. The excess risk of poor perinatal outcomes among rural, low SES mothers may be attributed to the higher prevalence of obstetric risk factors such as pre-existing chronic medical conditions, multi parity, smoking, and substance use in this group. The results show that, compared to urban-high SES mothers, adolescent mothers living in rural areas with low SES are 1.5-fold times more likely to

have PTB. Socioeconomic disparities in PTB have been well established in the literature; however, the reason of these disparities is not completely understood.[56] Researchers have implicated cigarette smoking, high prevalence of sexually transmitted infections, and psychological stressors associated with socioeconomic disadvantage as contributors to the socioeconomic gradient in PTB.[56] The psychosocial stressors need particular attention in the context of adolescent mothers as studies have shown that pregnant adolescents are vulnerable to stigmatization and social isolation.[26,57]

Our findings suggest that compared to urban/low SES adolescent mothers, rural adolescents with high SES were likely to have generally favorable pregnancy outcomes with decreased odds of postpartum hemorrhage, PTB, SGA and LBW babies. High SES seems to rescind the health challenges linked with rural residence such as longer travel time to health care services. Existing evidence also supports these findings.[40,42,58,59] Rural residents with high SES are likely to have better access to health care services, a greater sense of community belonging, and decreased risk of mental health issues. [40,42,58,59] Future research should highlight the specific aspects of rurality that lead to rural/urban variations in adolescent pregnancy outcomes.

Rural adolescent mothers had a high risk of caesarean section irrespective of their SES. According to the Canadian Institute of Health Information (CIHI), about 25% of all caesarean sections among rural Canadian women are performed by a family physician.[40] The rate of caesarean sections performed by family physicians (33%) in the study cohort was quite high compared to the CIHI estimates. These results highlight the role of rural family physicians in Alberta in providing delivery care to adolescent mothers. It will be interesting to compare the immediate- and long-term obstetric outcomes of rural adolescent mothers attended by family physicians to those of adolescent mothers who received specialized obstetrical care. The risk of

LGA was also found to be high among rural adolescents, a result that is line with the current Canadian literature on the prevalence of LGA and linked with a higher prevalence of obesity and diabetes mellitus in rural areas.[60]

4.3. Strengths and Limitations of this Study

The overall objective of this study was to explore the association of SDOH with adverse adolescent pregnancy outcomes. The study followed a coherent methodological structure as guided by the study objectives. The systematic review followed the Cochrane guidelines and a prospectively registered protocol guided the different stages of the review process. The literature searches were comprehensive and involved both peer-reviewed and grey literature. The methods for study screening, data extraction, and risk of bias assessment minimized potential biases. The implications of the systematic review were limited by the methodological diversity and fair quality of the included studies. The majority of studies in the review presented crude estimates and focused on country-specific disparities that precluded direct comparisons and statistical pooling of the results.[1-31]

Gaps identified in the systematic review helped shape the theoretical background of the cross sectional study. A large clinical perinatal database that capture the majority of births in Alberta was used to identify the study cohort. A pre-specified data analysis plan was drafted to guide the study methods. Potential maternal and obstetric confounders were adjusted in the analysis. However, the results of this analysis have a number of limitations that should be considered when interpreting the results. The associations observed in the cross sectional study are likely to represent population-level effects. Inferences from this study are thus applicable only at the population level. A composite measure was used to determine the joint effect of area

of residence and SES which does not give information about the respective attribution of the individual factors (maternal area of residence and SES) to the observed outcomes-an issue inherent to the use of composite measure.

Defining urban/rural status has been proven to be notoriously difficult in the Canadian setting.[60] Adolescent mothers were assigned an urban/rural status based on population density and distance to health care services at the provincial local geography boundaries level. The local geography boundaries are used by Alberta Health Services to monitor, plan, and deliver health care services at the neighborhood level.[61] Population density determines the availability of health care, social, and economic resources in an area.[61] Generally, areas with high-population densities have greater resource allocation. On the other hand, distance to health care services is a known predictor of pregnancy outcomes.[62] These two measures of rural/urban status were used to obtain a comprehensive definition of area of residence that aligns with the objectives of this research. However, the use of local geographic area level rural/urban status may have resulted in masking the impact of micro-level geographic variations on adolescent pregnancy outcomes.

Another important consideration is the use of area-level SES measures in the study. Based on 2011 census data on income, education, and employment, adolescent mothers were assigned into SES categories at the dissemination area level.[63] Dissemination area is the smallest census unit and is likely to have minimal variations in its social and material environment.[63] However, researchers have cautioned against the use of area-level SES measures in health research as they may not be an accurate representation of individuals' perceived SES, which can result in misclassification and over/under estimation of the true association between SES and health outcomes.[64,65]

The findings from this study may not be applicable to very young mothers (<15 years) as

they were excluded due to the lack of SES information in the administrative databases. Data on some important maternal characteristics for example pre-pregnancy body weight, sexually transmitted infections, Indigenous status, migration status, marital/relationship status, and intention to get pregnant was not available in the databases and hence were not considered in this analysis. Future research should consider relevant contextual factors in their analysis and provide a more detailed insight into the association between area of residence-SES and adverse adolescent pregnancy outcomes.

4.4. Practical Implications and Future Research Directions

Adverse adolescent pregnancy outcomes are associated with substantial risk of long-term morbidities for the young mother and their newborns. Findings of this study emphasize the need of adopting a SDOH perspective in adolescent perinatal health research and practice to reduce the rate of adverse maternal and birth outcomes. Based on the study results, recommendations and future research implications are put forth:

4.4.1 Policy recommendations

Adapting SDOH approach in adolescent perinatal health care

The impact of social environment on perinatal health is supported by a large body of evidence.[1-31] However, a survey of Canadian health region websites found that only 25% of the interventions proposed by the 89 Canadian health regions tackle health disparities in their agenda.[66] This highlights a gap between knowledge and current practices. Policy makers and other relevant stakeholders should be sensitive of context-specific SDOH considerations and barriers that influence perinatal health inequalities. Health and non-health sectors should

collaborate to devise integrated adolescent perinatal health programs that provide health care services, social support, and meet the education needs of young mothers. A multi-sectorial approach to adolescent perinatal health has been shown to improve the perinatal and long-term wellbeing of adolescent mothers and their children.[15]

Targeted interventions for high-risk adolescent mothers

This study has revealed that SDOH drive health inequalities in adolescent pregnancies. The most deprived adolescents are those at the highest risk of adverse maternal and birth outcomes. Directed health care services and community support systems are needed for high-risk groups of adolescent mothers (i.e., rural mothers with low SES) to reduce the gap in perinatal health. Adolescent maternal health interventions should also focus on assisting the young mothers' transition to motherhood and future parenting needs.

Smoking cessation interventions for adolescent mothers

Our results have highlighted that cigarette smoking is a major concern among adolescent mothers in Alberta, especially in rural low SES pregnant women. The antenatal period provides a window of opportunity for smoking cessation interventions.[52] Previous research has shown that pregnant women are more receptive to health education and are likely to uptake healthier lifestyles during their pregnancy.[52] The association between cigarette smoking and SES has been well-established in the literature.[52] Equity-informed smoking cessation programs are needed in Alberta and other Canadian provinces with high adolescent pregnancy rates to enhance the health literacy of adolescent mothers about cigarette smoking and other substance use and assist them to make healthier choices.

Role of family physicians

Results of this study indicate that Albertan adolescent mothers are likely to receive antenatal

and delivery care from a family physician. Family medicine educational programs should include training sessions on SDOH in their curriculum. Family physicians, especially those working in rural areas, should be trained in identifying social predictors of adolescent perinatal health and integrate these concepts in their routine clinical practice.

4.4.2 Future research directions

Identifying context-specific SDOH

The relevance of specific SDOH varies across regions depending on the historical background and sociocultural environment. Future studies in countries with high mortality rates among adolescent mothers should aim to identify relevant determinants that need consideration in adolescent perinatal health and maternal mortality prevention programs.

Understudied SDOH

There is limited evidence about the role of maternal education, occupation, religion, and social capital in adverse adolescent pregnancy outcomes. Future studies should enhance the current knowledge base on the role of these understudied SDOH on adolescent pregnancy outcomes.

Deprivation and pyschosocial stress

The impact of socioeconomic deprivation and the associated psychological stress on adolescent pregnancy outcomes need further investigation. Mixed methods or qualitative studies can help understand how the experience of social discrimination, racism and socioeconomic deprivation affect the perinatal and psychological health of pregnant adolescents.

Joint effects of SDOH

The joint effects of SDOH on adolescent maternal and perinatal health have not been well-

explored in the scientific literature. Future studies should examine the combined effect of SDOH such as Indigenous status and SES on adolescent pregnancies and perinatal outcomes. These interactions are important to recognize and understand as they can help identify the most vulnerable subgroups of adolescent mothers.

Interventions to reduce disparities in adolescent pregnancy outcomes

Future studies should focus on identifying macro- and micro-level interventions aimed at reducing disparities in adolescent pregnancy outcomes. Understanding the specific casual factors that lead to disadvantage in adolescent maternal and birth outcomes should be a priority for future adolescent perinatal researchers. Adolescent mothers, especially from socioeconomically deprived backgrounds, should be engaged in this discourse to highlight their specific concerns and perspectives on what changes should be made in the health care system and other resources to better address the needs of the most vulnerable group of adolescent mothers.

4.5. Conclusion

This study suggests that the socioeconomic conditions of the young mothers influence their maternal and birth outcomes. Synthesis of the current evidence shows that rural residence, low SES, African-American race, low literacy, and poor social capital are risk factors for adverse adolescent pregnancy outcomes. Investigation of the joint effect of maternal area of residence and SES revealed that the risk of adverse pregnancy outcomes is influenced by maternal area of residence and SES with rural, low SES mothers having the greatest disadvantage. Future studies should focus on highlighting *how* SDOH operate and impact adolescent pregnancy outcomes. In order to reduce the gap in adolescent perinatal health, etiological factors that mediate disparities in pregnancy outcomes should be explored and areas of intervention should be identified.

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APPENDICES

Appendix 1: Complete Search Strategy

1. MEDLINE In-Process & Other Non-Indexed Citations and Ovid MEDLINE(R) & MEDLINE Epub Ahead of Print

1**.** pregnancy complications/ or abortion, spontaneous/ or diabetes, gestational/ or hypertension, pregnancy-induced/ or maternal death/ or abruptio placentae/ or fetal membranes, premature rupture/ or obstetric labor, premature/ or placenta previa/ or postpartum hemorrhage/ or perinatal death/

2. Cesarean Section/

3. exp infant, low birth weight/ or infant, premature/

4. exp Perinatal Death/

5. fetal death/ or stillbirth/

6. Maternal Mortality/

7. exp hypertension, pregnancy-induced/

8. (spontaneous abortion or stillbirth or still birth or stillborn or still born).mp.

9. ((birth or pregnan* or prenatal or perinatal or pre natal or peri natal or maternal) adj complication*).mp.

10. gestational diabet*.mp.

11. (pre-eclampsia or preeclampsia).mp.

12. ((pregnan* or maternal or fetal or prenatal or pre natal) adj2 (death or mortality)).mp.

13. placental abruption.mp.

14. (premature rupture adj3 membranes).mp.

15. PROM.mp.

16. ((prematur* or preterm or pre matur* or pre term) adj (labour or labor or deliver*)).mp.

17. placenta pr?evia.mp.

18. (postpartum h?emorrhage or post partum h?emorrhage or postpartum bleeding or post partum bleeding).mp.

19. (c-section or c?esarean section).mp.

20. (low birth weight or lbw).mp.

21. or/1-20

22. exp Socioeconomic Factors/ or exp "Social Determinants of Health"/

23. exp Religion/

24. exp Educational Status/

25. Income/

26. social capital/ or social isolation/ or vulnerable populations/ or working poor/

27. Poverty/

28. (religion or religious or poverty or income or social capital).mp.

29. (socio-economic* or socioeconomic* or social determinant* or insurance status or standard* of living or lower income or under-insured or social class* or resource poor or social condition* or disadvantage* or social status or household income or family income or income level*).mp.

30. ((education* adj (status or attainment or achievement*)) or (illiteracy or literacy)).mp.

31. (high school adj3 (graduat* or complet* or degree* or drop-out*)).mp.

32. gender/ or (gender or soc* cultur*).mp.

33. Language/ or "emigrants and immigrants"/ or refugees/ or (language* or non-english speak*).mp.

34. Rural/ or Rural Health Services/ or Rural Health/ or rural population/ or suburban population/

or urban population/

35. (rural or urban* or (remote adj2 (area* or region* or population*))).mp.

36. (slum? or shanty town* or favela* or gecekondu or skid row or barrio? or ghetto*).mp.

37. or/22-36

38. 21 and 37

39. ((adolescen* or teen* or young* people or young* person* or young* wom?n or youth or high school* or minor*) adj3 (mother* or maternal or pregnan* or birth)).mp.

40. (young* mother* or young maternal).mp.

41. Pregnancy in Adolescence/

42. or/39-42

43. 38 and 42

44. remove duplicates from 43

2. Embase

1. pregnancy complication/ or pregnancy disorder/ or stillbirth/ or spontaneous abortion/ or pregnancy diabetes mellitus/ or maternal hypertension/ or exp "eclampsia and preeclampsia"/ or maternal death/ or maternal mortality/ or solutio placentae/ or premature fetus membrane rupture/ or exp "immature and premature labor"/ or placenta previa/ or postpartum hemorrhage/ or fetus death/ or perinatal death/ or perinatal mortality/ or cesarean section/ or exp low birth weight/

2. (spontaneous abortion or stillbirth or still birth or stillborn or still born).mp.

3. ((birth or pregnan* or prenatal or perinatal or pre natal or peri natal or maternal) adj complication*).mp.

4. gestational diabet*.mp.

5. (pre-eclampsia or preeclampsia).mp.

6. ((pregnan* or maternal or fetal or prenatal or pre natal) adj2 (death or mortality)).mp.

7. placental abruption.mp.

8. (premature rupture adj3 membranes).mp.

9. PROM.mp.

10. ((prematur* or preterm or pre matur* or pre term) adj (labour or labor or deliver*)).mp.

11. placenta pr?evia.mp.

12. (postpartum h?emorrhage or post partum h?emorrhage or postpartum bleeding or post partum bleeding).mp.

13. (c-section or c?esarean section).mp.

14. (low birth weight or lbw).mp.

15. or/1-14

16. exp socioeconomics/ or "Social Determinants of Health"/

17. exp Religion/

18. social capital/ or exp social status/ or household income/ or family income/ or personal income/ or lowest income group/ or working poor/ or vulnerable population/

19. (religion or religious or poverty or income or social capital).mp.

20. (socio-economic* or socioeconomic* or social determinant* or insurance status or standard* of living or lower income or under-insured or social class* or resource poor or social condition* or disadvantage* or social status or household income or family income or income level*).mp.

21. ((education* adj (status or attainment or achievement*)) or (illiteracy or literacy)).mp.

22. (high school adj3 (graduat* or complet* or degree* or drop-out*)).mp.

23. or/16-22

24. 15 and 23

25. ((adolescen* or teen* or young people or young person* or young wom?n or youth or high school* or minor*) adj3 (mother* or maternal or pregnan* or birth)).mp.

26. (young mother* or young maternal).mp.

27. adolescent pregnancy/

28. gender/ or "gender and sex"/ or gender bias/ or (gender or soc* cultur*).mp.

29. language ability/ or english as a second language/ or refugee/ or migrant/ or asylum seeker/ or exp immigrant/ or (language* or non-english speak*).mp.

30. rural area/ or rural health care/ or rural population/ or urban rural difference/ or (rural or urban* or (remote adj2 (area* or region* or population*))).mp. or (slum? or shanty town* or favela* or gecekondu or skid row or barrio? or ghetto*).mp.

31. or/25-30

32. 24 and 31

33. remove duplicates from 32

3. CINAHL

S1	(MH "Abortion, Spontaneous+") OR (MH "Diabetes Mellitus, Gestational") OR (MH "Pregnancy-Induced Hypertension+") OR (MH "Perinatal Death") OR (MH "Maternal Mortality") OR (MH "Abruptio Placentae") OR (MH "Fetal Membranes, Premature Rupture+") OR (MH "Labor, Premature") OR (MH "Childbirth, Premature") OR (MH "Placenta Praevia") OR (MH "Postpartum Hemorrhage") OR (MH "Cesarean Section+") OR (MH "Infant, Low Birth Weight+")
S2	"spontaneous abortion" or stillbirth or "still birth" or stillborn or "still born"

S3	"birth complication*" OR "pregnan* complication*" OR "pre natal complication*" OR "prenatal complication*" OR "perinatal complication*" OR "peri natal complication*" OR "maternal complication*"
S4	"gestational diabet*" OR preeclampsia or “pre-eclampsia”
S5	pregnan* N2 death OR pregnan* N2 mortality OR maternal N2 death OR maternal N2 mortality OR fetal N2 death OR fetal N2 mortality OR prenatal N2 death OR prenatal N2 mortality OR pre-natalN2 death OR pre-natal N2 mortality
S6	placental abruption OR "prematue rupture" N3 membranes OR PROM
S7	"prematur* labour" OR "prematur* labor" OR "prematur* deliver*" OR "preterm labour" OR "preterm labor" OR "preterm deliver*" OR "pre matur* labour" OR "pre matur* labor" OR "pre matur* deliver*" OR "pre term labor" OR "pre term labour" OR "pre term deliver*"
S8	("placenta previa" OR "placenta praevia") OR ("postpartum hemorrhage" OR "postpartum haemorrhage") OR ("post-partum hemorrhage" OR "post-partum haemorrhage") OR ("postpartum bleeding" OR "post-partum bleeding") OR (c-section or cesarean section or caesarean section) OR ("low birth weight" or lbw)
S9	S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7 OR S8
S10	(MH "Socioeconomic Factors+") OR (MH "Health Status Disparities") OR (MH "Social Determinants of Health") OR (MH "Religion and Religions+") OR (MH "Educational

	Status") OR (MH "Social Capital") OR (MH "Social Isolation+") OR (MH "Special Populations")
S11	(religion or religious or poverty or income or "social capital") OR ("socio-economic*" or socioeconomic* or social determinant* or insurance status or standard* of living or lower income or under-insured or "social class*" or "resource poor" or "social condition*" or disadvantage* or "social status" or "household income" or "family income" or "income level*") OR ("education* status" OR "education* attainment" OR "educational achievement*") OR (illiteracy OR literacy) OR "high school" N2 completion OR "high school" N2 graduation OR "high school" N2 degree OR "high school" N2 drop-out*
S12	(MH "Gender Bias") OR (MH "Gender Role+") OR (MH "Gender Specific Care") OR (MH "Gender Identity+")
S13	gender or "soc* cultur*"
S14	(MH "Language+") OR (MH "Refugees") OR (MH "Immigrants+")
S15	language* or "non-english speak*"
S16	(MH "Rural Health Centers") OR (MH "Hospitals, Rural") OR (MH "Rural Population") OR (MH "Rural Health Services") OR (MH "Rural Areas") OR (MH "Rural Health")

S17	(MH "Urban Population") OR (MH "Hospitals, Urban") OR (MH "Urban Health Services") OR (MH "Urban Areas") OR (MH "Urban Health")
S18	rural OR urban OR (remote N2 (area* or region* or population*))
S19	slum or "shanty town" or favela* or gecekondu or "skid row" or barrio or ghetto*
S20	S10 OR S11 OR S12 OR S13 OR S14 OR S15 OR S16 OR S17 OR S18 OR S19
S21	(MH "Pregnancy in Adolescence+")
S22	(adolescen* N3 (mother* or maternal or pregnan* or birth*)) OR (teen* N3 (mother* or maternal or pregnan* or birth*)) OR ("young* people" N3 (mother* or maternal or pregnan* or birth*)) OR ("young* person*" N3 (mother* or maternal or pregnan* or birth*)) OR ("young* women" N3 (mother* or maternal or pregnan* or birth*)) OR ("young woman" N3 (mother* or maternal or pregnan* or birth*)) OR (youth N3 (mother* or maternal or pregnan* or birth*)) OR ("high school*" N3 (mother* or mater ...
S23	"young mother*" OR "young maternal"
S24	S21 OR S22 OR S23
S25	S9 AND S20 AND S24

4. Web of Science

1. TS=("spontaneous abortion" OR stillbirth OR "still birth" OR stillborn OR "still born" OR "birth complication*" OR "pregnan* complication*" OR "pre natal complication*" OR "prenatal complication*" OR "perinatal complication*" OR "peri natal complication*" OR "maternal complication*")
2. TS=("gestational diabet*" OR preeclampsia OR pre-eclampsia)
3. TS=(pregnan* NEAR/2 death) OR TS=(pregnan* NEAR/2 mortality) OR TS=(maternal NEAR/2 death) OR TS=(maternal NEAR/2 mortality) OR TS=(fetal NEAR/2 death) OR TS=(fetal NEAR/2 mortality) OR TS=(prenatal NEAR/2 death) OR TS=(prenatal NEAR/2 mortality) OR TS=(pre-natal NEAR/2 death) OR TS=(pre-natal NEAR/2 mortality)
4. TS=(placental abruption OR "prematue rupture" N3 membranes OR PROM)
5. TS=("prematur* labour" OR "prematur* labor" OR "prematur* deliver*" OR "preterm labour" OR "preterm labor" OR "preterm deliver*" OR "pre matur* labour" OR "pre matur* labor" OR "pre matur* deliver*" OR "pre term labor" OR "pre term labour" OR "pre term deliver*")
6. TS=("placenta previa" OR "placenta praevia" OR "postpartum hemorrhage" OR "postpartum haemorrhage" OR "post-partum hemorrhage" OR "post-partum haemorrhage" OR "postpartum bleeding" OR "post-partum bleeding" OR c-section or cesarean section or caesarean section OR "low birth weight" or lbw)
7. #6 OR #5 OR #4 OR #3 OR #2 OR #1
8. TS=(religion OR religious OR poverty OR income OR "social capital" OR "socio-economic*" OR socioeconomic* OR social determinant* OR insurance status OR standard* of living OR "lower income" OR under-insured OR "social class*" OR "resource poor" OR "social condition*" OR disadvantage* OR "social status" OR "household income" OR

"family income" OR "income level*" OR "education* status" OR "education* attainment" OR "educational achievement*" OR illiteracy OR literacy)

9. TS=(school NEAR/2 completion) OR TS=(school NEAR/2 graduation) OR TS=(school NEAR/2 degree) OR TS=(school NEAR/2 drop-out*)
10. TS=(slum or slums or shanty town* or favela* or gecekondu or skid row or barrio* or ghetto*) OR TS=(rural OR urban*) OR TS=(remote NEAR/2 area*) OR TS=(remote NEAR/2 region*) OR TS=(remote NEAR/2 population*) OR TS=(language* OR "non english speak*" OR immigrant* OR refugee* OR migrant*) OR TS=(gender OR "soc* cultur*")
11. #8 OR #9 OR #10
12. #11 AND #7
13. TS= (adolescen* NEAR/3 mother*) OR TS= (adolescen* NEAR/3 maternal) OR TS= (adolescen* NEAR/3 pregnan*) OR TS= (adolescen* NEAR/3 birth*)
14. TS= (teen* NEAR/3 mother*) OR TS= (teen* NEAR/3 maternal) OR TS= (teen* NEAR/3 pregnan*) OR TS= (teen* NEAR/3 birth*)
15. TS= (youth* NEAR/3 mother*) OR TS= (youth* NEAR/3 maternal) OR TS= (youth NEAR/3 pregnan*) OR TS= (youth NEAR/3 birth*)
16. #15 OR #14 OR #13
17. #12 AND #16

Appendix 2: Title and Abstract Screening Form

For title and abstract screening, the exclusion criteria will be kept relatively broad to exclude those articles that are obviously irrelevant to the research question. For each article go through the topic and abstract. To be excluded the article needs to fulfill at least one exclusion criterion. Stop at the first "yes" and exclude the study. If the article does not meet any of the exclusion criterion or it is unclear if the article meets the exclusion criteria, include it for retrieval.

Reference ID #:	Author(s):	Reviewer ID #:	Year of Publication:		
Exclusion Criteria					
1. Population					
Mothers >20 years of age			Yes ☐	No ☐	Maybe ☐
2. Study Design					
Editorial/Review Articles/Case report/Case Series/Letter			Yes ☐	No ☐	Maybe ☐
3. Exposure					
Clearly not on Social determinants of health (SDOH) The main topic of the article/abstract does not include SDOH or at least one of the following related terms: ☐ Place of residence ☐ Race/ethnicity ☐ Occupation ☐ Religion ☐ Education ☐ Socioeconomic Status ☐ Social Capital			Yes ☐	No ☐	Maybe ☐

4. Outcomes			
The study does not report on at least one of the following maternal/birth outcomes: ☐ Maternal outcomes: caesarean section, impending preeclampsia/eclampsia, placenta previa, abruptio placentae, gestational diabetes mellitus, preterm premature rupture of membranes, postpartum, need of operative vaginal delivery, total antepartum risk score and intra-hospital death. ☐ Birth outcomes: small for gestational age, low birth weight, preterm birth and perinatal death	Yes ☐	No ☐	Maybe ☐

FINAL DECISION

Include for retrieval Exclude

Appendix 3: Inclusion Exclusion Form

Instructions:

- For inclusion/exclusion screening, go through the full text of the article. Identify the study design, study population, exposure studied, and outcome reported. To be included the article needs to meet all from 1,2,4 and 3a or 3b. Otherwise, exclude the article and record the reason(s) for exclusion.
- Flag useful background information in the article.

Reference ID #:	Author(s):	Reviewer ID #:	Year of Publication:		
1. Study Design					
a) Primary research			Yes ☐	No ☐	Unclear ☐
b) Does study design satisfy one of the following? • Prospective cohort study • Retrospective cohort study • Case control study • Cross sectional study			Yes ☐	No ☐	Unclear ☐
2. Topic/Exposure					
a) Primary Research evaluating the impact of social determinants of health (SDOH) on maternal and birth outcomes			Yes ☐	No ☐	Unclear ☐
b) Includes at least one of the following social determinants of health (SDOH) • Place of residence • Race/ethnicity/culture/language • Occupation • Religion • Education			Yes ☐	No ☐	Unclear ☐

• Socioeconomic Status • Social Capital			
3) Study Participants			
a) Does the study population include?: • Pregnant adolescent (adolescents who became pregnant before the age of 20 years) • Adolescent mothers (adolescents who gave singleton or multiple births before the age of 20 years)	Yes ☐	No ☐	Unclear ☐
4. Outcomes			
a) The study reports on maternal/birth outcomes in the perinatal period	Yes ☐	No ☐	Unclear ☐
b) The study reports on at least one of the following maternal/birth outcomes: • Maternal outcomes: impending preeclampsia/eclampsia, placenta previa, abruptio placentae, gestational diabetes mellitus, postpartum hemorrhage, need of operative vaginal delivery, cesarean section, total antepartum risk score and intra-hospital death. • Birth outcomes: small for gestational age, low birth weight, pre-term birth and perinatal death	Yes ☐	No ☐	Unclear ☐

FINAL DECISION

Include if Yes to 1a, 1b, 2a, 2b, 3a or 3b, 4a and 4b

Include Exclude

Appendix 4: Data Extraction Template

Country: Indicates the country of publication.

Funding: Is the study funded?

Source of Funding: Please specify the source of funding if applicable.

Aim of Study: This refers to the purpose of the study.

Duration of Study: This refers to the length of period or number of months or years taken to complete the research study

Study Design: Please select only one of the following:

- **Prospective cohort study:** A type of analytical observational study where a group of subjects with a specific characteristic or exposure are followed over a period of time to assess outcomes. Comparisons are made with a concurrent control group. No interventions are normally applied to the participants. It is important to note that: 1) They are longitudinal and go forward over time, 2) Compare exposed vs. unexposed persons, 3) Start with a defined group of people (defined by exposure). 4) Participants are followed through time for occurrence of disease/outcome of interest.
- **Retrospective cohort study:** A type of observational investigation in which medical/other records of groups of individuals who are alike in many ways but differ by a certain characteristic are compared for a particular outcome.
- **Case-control study:** A case-control study is an observational investigation in which people with a condition ("cases") are identified, suitable comparison subjects ("controls") are identified, and the two groups are compared with respect to prior exposure to certain factors. Thus, subjects are sampled by disease status. It is important to note that: 1) They are generally retrospective. 2) Start with disease of interest (cases), 3) Compare people

with a condition to people without the condition, 4) Compare frequency of the exposure of interest between cases and controls.

- **Cross-sectional study:** A study where a group of individuals defined by a certain characteristic of interest are evaluated at a single point in time cross-sectionally. Sometimes they are compared with a control group without that characteristic on certain characteristics/outcomes of interest.

Study population: Population that was recruited for the study. Provide a description of the participants in terms of the type of population.

Study has controls/unexposed: Please specify if the study has unexposed/control

Definition of Control/Unexposed group: Has the study clearly defined controls/unexposed group.

Eligibility Criteria: Criteria for inclusion of participants into study**.** Use NR (Not Reported) or Unclear if required.

Data Source: Refers to data sources used in the study.

Study Setting: Refers to the location of data collection.

Sample Size: The sample size refers to the total of participants who entered the study.

Sample Size Justification: Explanation of how the sample size was arrived at (rationale for sample size was given in the study yes/no/unclear.

Participants included in the study: Number of participants actually included in the study.

Number of Cases/Exposed: Number of cases/exposed included in the study (if applicable).

Number of Controls/Unexposed: Number of controls/unexposed included in the study. (if applicable).

Social determinant of Health (SDOH) reported: Please select SDOH reported in the study. (There can be more than one)

SDOH clearly defined: Is the SDOH under study clearly defined?

Outcome reported: Please select the outcome/s reported in the study**.** (There can be more than one)

Outcome Clearly defined: Is the outcome understudy clearly defined? (Yes/No/Unclear)

Method of Analysis: Statistical methods used to examine groups, sub-groups, association, interactions e.g. descriptive statistics, regression analysis etc.

Confounding: Does the study control for confounding? (Yes/No/Unclear)

Methods for control of confounding: Please select the method used for controlling confounding where applicable**.**

Summary Measure/s reported: State the principal summary measures (such as odds ratio, risk ratio, difference in means, frequency measures). There maybe more than one.

Unadjusted Estimate/s:

Unadjusted estimates with precision [95% confidence interval (C.I)] There maybe more than one.

Adjusted Estimate/s:

Estimates adjusted for confounders with precision [95% confidence interval (C.I)]. There maybe more than one.

Appendix 5: Supplementary Figures

Figure 1. Performance of Included Studies in Individual New Castle Ottawa domains

Study Author	Selection	Comparability	Outcome
Anderson et al.	☺	☺	?
Blankson et al.	☺	☹	?
Brewin,D.	☺	☺	?
Coley et al.	?	☺	?
Felice et al.	?	☹	?
Gaff-Smith,M.	☺	☹	☺
Gale et al.	☺	☹	?
Gama et al.	☺	☺	☺
Hardoff et al.	☹	☹	?
Hollingsworth et al.	☺	☹	?
Khalid et al.	?	☹	?
Koshar et al.	?	☹	?
LaGuardia et al.	☹	☺	?
Laureano et al.	?	☹	?
Leland et al.	☺	☺	?
Magadi, M.	?	☹	☹
Morris et al.	☺	☺	?
Ndiaye et al.	?	☹	☹
Nebot et al.	?	☹	?
Obed et al.	☺	?	☺
Partington et al.	☹	☺	?
Restrepo et al.	☹	?	☺
Rickert et al.	?	☺	☺
Robson et al.	☺	☺	?
Roopnarinesingh,S.	☹	☹	?
Salihu et al.	☹	☺	?
Shah et al.	☹	☺	☹
Taylor et al.	☺	☹	?
Ujah et al.	?	☹	☺
Verguet et al.	☺	☹	?
Westenberg et al.	☺	☹	?

☺=Good Performance in the NOS domain.

?=Fair Performance in the NOS domains.

☹= Poor performance in the NOS domains