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IMPACT OF SEAT BELT USE AND MOTOR VEHICLE CRASHES ON MATERNAL MORTALITY IN PREGNANT WOMEN: A SYSTEMATIC REVIEW

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Abstract

IMPACT OF SEAT BELT USE AND MOTOR VEHICLE CRASHES ON MATERNAL MORTALITY IN PREGNANT WOMEN: A SYSTEMATIC REVIEW

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BACKGROUND: Globally, an estimated 303,000 women died in 2015 during and following pregnancy and childbirth. The majority of maternal mortalities occurred in developing countries and accounted for about 99% of all deaths in 2015. Worldwide, the leading cause of maternal mortality (pregnancy-associated deaths) and traumatic fetal mortality are motor vehicle crashes (MVC). There is a knowledge gap as to the circumstances surrounding the occurrences of motor vehicle crashes and pregnant occupants.

OBJECTIVE: To evaluate the association between seat belt use and maternal mortality during motor vehicle crashes (pregnancy-associated death) in pregnant women.

METHODS: A systematic review following the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) was conducted to evaluate the association of seat belt use and maternal mortality during motor vehicle crashes (pregnancy-associated deaths) in pregnant women. The article search was performed using the terms "pregnancy" and "traffic accidents" along with listed mechanisms of mortality, in the PubMed database for studies published between December 1, 1990 and January 1, 2016. A descriptive analysis was conducted using frequencies and percentages, and odds ratio, 95% CI, and p values were calculated.

RESULTS: A total of 45 articles were screened using titles and abstracts. After reviewing for duplicates, full-text of articles were retrieved and read in their entirety, and re-evaluated with the inclusion and exclusion criteria. Fifteen articles met the criteria for inclusion. All the study designs were retrospective designs. Only five (33%) articles specified whether the pregnant women were belted (35% to 90%) or unbelted (10% to 90%). The fetal mortality percentage ranged from 0.7% to 35%. The key finding in this study was that there is no evidence supporting the association of the two variables: seat belt use and maternal mortality due to MVC.

CONCLUSION: The lack of evidence on the association between seat belt use and maternal mortality due to MVC may be because of the feasibility of conducting such research is complicated due to poor data linkage and accessibility, or sample size.

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CHAPTER I: INTRODUCTION

Over the last century, globally, maternal mortality has declined, particularly in developed nations (WHO, 2016b). According to the United Nations inter agencies, estimates of global maternal mortality ratio declined by 44% from 385 deaths per 100,000 live births in 1990 to 216 deaths per 100,000 live births in 2015 (World Bank Data, 2016), which was approximately 532,000 deaths in 1990 to an estimated 303,000 deaths in 2015 (WHO, 2016b). Yet, maternal mortality due to motor vehicle crashes is the leading cause of pregnancy-associated deaths around the world (Vladutiu & Weiss, 2012; Jamjute et al., 2005; Hogan, et al., 2010; Rueda-Clausen, Campbell, & Baker, 2011).

Maternal deaths due to traffic crashes are classified as coincidental and not pregnancy-related by the World Health Organization; however, others have argued that pregnancy is the root cause of such deaths, because pregnant women are more susceptible to crashes (McCall & Bhattacharya, 2014).

Pregnant occupants require an additional level of safety, particularly because of fetal protection, which during crashes might lead to varying degree of injury severity, and ultimately mortality for mothers and fetuses. For example, an area of concern might be the abdominal protrusion and distance between the steering wheel (Vladutiu et al., 2013a; Klinich et al., 2008; Acar & Weekes, 2004). Unfortunately, pregnant women and their safety remain an understudied population in motor vehicle safety research (Vladutiu et al., 2013b; Weiss & Strotmeyer, 2002).

Since seat belts are one of the safety features in a motor vehicle, research shows that the use of seat belts reduces the risk of adverse maternal outcomes, including death (Klinich et al. 2008). The proper use of seat belt is as a secondary safety precaution, which alleviates the risks of injury severity and mortality during collision, with effect on seating position. As motor vehicle occupants, pregnant women occupy varying seating positions, that is, in the front seat of the vehicle as a driver or passenger, and in the rear seat (Duma et al., 2006). As shown in several studies, pregnant women are considered vulnerable during motor vehicle crashes. As described above, their safety can be compromised due to body size and shape. Consequently, the American College of Obstetricians and Gynecologists recommended the proper use of seat belts throughout pregnancy.

As identified in several studies, classifying and understanding maternal mortality after motor vehicle incidents is a complicated issue (Say, 2014). To aid this knowledge gap, there is a need to identify the association between seat belt use and maternal mortality in pregnant women. Understanding this association would further clarify whether ineffective use of seat belts is one cause of pregnancy-associated deaths due to motor vehicle crashes, and the results of this thesis will identify efforts and recommendations to distinguish and alleviate pregnancy-associated deaths due to motor vehicle crashes.

Research Goal

It is the intent of this thesis to evaluate the association of maternal mortality with seat belt use and motor vehicle crashes in pregnant women.

> Former Director-General of the World Health Organization, Lee Jong-wook, April 2005: Mothers, newborn and children represent the well-being of a society and its potential for the future. Their health needs cannot be left unmet without harming the whole of society (World Health Report, 2005).
>
> Source: World Health Organization, 2005 (*World Health Report 2005)*

Definition of Terms

Four-point seat belt: is similar to a child safety seat or a racing vehicle seat belt but without the strap between the legs.

Lap-belt: is a two-point seat belt similar to the belt in an airplane that goes over the waist, and most commonly used in buses and coaches.

Maternal mortality: From the International Classification of Diseases ICD-10, the World Health Organization (WHO) defines maternal mortality as the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management, but not from accidental of incidental causes (WHO, 2015a). Maternal deaths are subdivided into two groups, direct (pregnancy-related) and indirect (pregnancy-associated) obstetrics death (WHO, 2015a).

Maternal mortality ratio: is the number of maternal deaths per 100,000 live births.

Millennium development goals (MDGs): are the eight international development goals that were established following the Millennium Summit of the United Nations in 2000, following the adoption of the United Nations Millennium Declaration.

Motor vehicle crash: The unintended collision of one motor vehicle or more with another, stationary object, or person, resulting in injuries, death and/or loss of property.

Moving violations: is any violation of vehicle laws that is committed by the driver of a vehicle, while the vehicle is moving.

Not-pregnancy-related death: The death of a woman while pregnant or within one year of termination of pregnancy due to a cause unrelated to pregnancy.

Pregnancy-associated death: The death of a woman while pregnant or within one year of termination of pregnancy, irrespective of cause.

Pregnancy-related death: The death of a woman which occurs during or within one year of the end of a pregnancy, from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes such as injury.

Primary seat belt enforcement laws: allow law enforcement officials to ticket a driver or passenger for not wearing a seat belt, without any other traffic offense present.

Secondary seat belt enforcement laws: allow law enforcement officials to issue a ticket for not wearing a seat belt only when there is another traffic offense cited.

Site of pregnancy: includes delivery, ectopic pregnancy, miscarriage or termination.

Sustainable development goals (SDGs): otherwise known as the Global Goals, build on the Millennium Development Goals (MDGs) and are eight anti-poverty targets that the world committed to achieving by 2015. The new SDGs, post-2015 agenda, and the broader sustainability agenda, go much further than the MDGs, addressing the root causes of poverty and the universal need for development that works for all people.

Three-point seat belt: this is a unitized lap and sash belts in a Y-shaped arrangement. It is the standard seat belt in most vehicles. The three-point lap and diagonal seat-belt is the safest and most commonly used in cars, vans, minibuses, trucks and the driver's seat of buses and coaches.

Verbal autopsy: is a method used to ascertain the cause of a death based on an interview with next of kin or other caregivers.

CHAPTER II: REVIEW OF THE LITERATURE

This literature review describes the global burden of maternal mortality, maternal mortality and motor vehicle crashes in developed and developing countries, and risk factors of maternal mortalities from motor vehicle crashes (MVC). This literature review also presents, as related to maternal mortality, the global traffic report, seat belt use, policy impact of seat belt use, along with compliance with use of seat belts, especially among pregnant women. Finally, this chapter discusses the conclusion and overall significance of pregnancy-associated deaths due to MVC. It is worthy to indicate that there will be some back and forth regarding available data used in this review from the US, other developed countries, and developing countries as deemed relevant concerning maternal mortality and MVC.

Global Burden of Maternal Mortality

Globally, an estimated 303,000 maternal deaths occurred in 2015, most of which were in low-income and middle-income countries (developing countries), and were preventable (WHO, 2016a). Decreasing maternal mortality has long been a global health priority and, between 2000-2015, was a target in the United Nations (UN) Millennium Development Goals (MDGs) framework (UN, 2013). The goal of MDG 5 (Target 5.A) was to improve maternal health, with a target to reduce maternal mortality ratio by 75%. To achieve a 75% decrease by the end of 2015, only 23 countries were on track (WHO, 2016a). However, in some countries, annual declines in maternal mortality, between the years 2000-2010, were above 5.5%, which was the rate needed to achieve MDG 5 globally (WHO, 2016a). Between 2015 to 2030, decreasing maternal mortality continues to be a target for the Sustainable Development Goals (SDGs). Under the SDGs, Target 3.1 is to reduce the global maternal mortality ratio to less than 70 deaths per 100,000 live births by 2030, in comparison to the estimated 210 deaths per 100,000 live births observed in 2013 (UN, 2015). In 2015, since maternal mortality continues to be a global concern, the Global Strategy for Women's, Children's and Adolescent's Health at the UN General Assembly for 2016-2030 was established (WHO, 2015b).

Maternal Mortality and Motor Vehicle Crashes in Developing and Developed Countries

There are disparities in maternal mortality between and within developing and developed countries. The maternal mortality ratio in 2015 was 239 deaths per 100,000 live births in developing countries versus 12 deaths per 100,000 live births in developed countries. In addition, the World Health Organization observed that there are not only large disparities between countries, but also within countries, (WHO, 2016b). For example, in addition to the inequalities between and within countries, disparities also occur among women with high and low income, and among women living in rural versus urban areas in developing and developed countries (WHO, 2016c).

Over the last few decades, the leading cause of pregnancy-associated maternal mortality and traumatic fetal mortality in both developed and developing countries was motor vehicle crashes during pregnancy (pregnancy-associated deaths) (Weiss & Strotmeyer, 2002). Changes in maternal mortality and morbidity patterns have led to the awareness that motor vehicle related injuries are the leading cause of death during pregnancy in developed countries, including the United States (Weiss, 2001a). For example, in the United States, approximately 92,500 pregnant women are injured from motor vehicle crashes each year (Vladutiu et al., 2012), and 6,130 women die due to motor vehicle crashes (CDC, 2011). Overall, pregnant women continue to be an understudied population with regard to motor vehicle crashes, and this problem is overshadowed by other health concerns, such as infant and child mortality.

To identify and lessen pregnancy-associated deaths due to motor vehicle crashes, it is important to examine existing sources of information in developing and developed countries. In developing and developed countries, each country has a vital records system (Vital Statistics System) that serves as the first source of data to determine the magnitude of maternal mortality in any specific population. Developed countries readily have the availability of data sources to report and monitor occurrences related to maternal mortality, but in developing countries, these type of data sources are limited, thereby emphasizing the disparities that do exist between developing and developed countries. Two examples of data sources in developed countries include the Mothers and Babies: Reducing Risk through Audits and Confidential Enquiries for the UK (MBRRACE-UK) and The National Highway Traffic Safety Administration for the US.

The Mothers and Babies: Reducing Risk through Audits and Confidential Enquiries across the UK (MBRRACE-UK), is part of the European Detailed Mortality Database. This is a surveillance data collection system, aimed at providing robust data to support the delivery of safe, unbiased, high quality, dedicated maternal, newborn and infant health services (NPEU, 2016). These include the notifications of maternal deaths (i.e., all deaths of pregnant women, and women up to one year following the end of pregnancy; regardless of the place and circumstances of the death). The MBRRACE-UK system applies to England, Wales and Scotland, and Northern Ireland though reformed arrangements are in place for Northern Ireland.

The National Highway Traffic Safety Administration (NHTSA) is a data source for information on maternal mortality due to motor vehicle crashes in the United States. In the Fatality Analysis Reporting System (FARS) datasets from 1990 to 2014, produced by NHTSA, there was no information specifically on pregnant women as a subject or group that was available to the public. Similarly, in the National Automotive Sampling System Crashworthiness Data System, also produced by NHTSA there was no information specifically on pregnant women as a subject or group that was available to the public.

Other data sources for developed countries include:

- England, Wales, Scotland and Northern Ireland - MBRRACE-UK (described above)
- Sweden - Swedish National Medical Birth Register (Birth Register) and Swedish National Traffic Accident Register (Accident Register)
- Israel - National Trauma Registry
- United States - National Center for Health Statistics, Pregnancy Mortality Surveillance System, Pregnancy Risk Assessment Monitoring System (PRAMS Surveillance). *Note, these four sources are more specific to pregnancy-related mortalities, and not pregnancy-associated mortalities. However, they still provide valuable data useful in evaluating pregnancy-associated deaths.*

Risk Factors of Pregnancy-Associated Deaths due to Motor Vehicle Crashes

One risk factor related to pregnancy-associated deaths from motor vehicle crashes may include bad weather and poor road infrastructure (Saha et al., 2016). Research shows that bad weather continues to be an indicator for many motor vehicle crashes and mortality. Inclement weather can drastically increase the number of crashes, and higher rates occur in the winter months (Perrels et al., 2015). In addition to weather worldwide, road infrastructure has a great impact on adverse outcomes of pregnancy-associated deaths. For example, quality of road, availability of speed bumps, lack of rumble strips, poorly lighted roads, and the location of the road structures (rural, urban, or tribal) are all factors of road infrastructure with effect on maternal mortality due to motor vehicle crashes. Lastly, it is important to note that both weather and road infrastructure mortality occurrences vary by geographic location (Saha et al., 2016).

Another risk factor related to pregnancy associated deaths from motor vehicle crashes may be due to vehicle design. Duma et al. (2006) investigated pregnant occupant crash exposure, and accounted for seating positions and crash directions. The frontal seating position had the highest impact at 53.0%, followed by the far side at 13.5%, then the middle at 13.2% and the rear crash impact was last at 8.3%. Further, the existing performance standards for vehicle safety designs are based on the physique of the average male drivers. As stated by Acar, Weekes and Van Lopik (2009), motor vehicle designs are specific to male drivers and accommodations are made for the measurement of larger men as well. However, these vehicle designs for larger male drivers are not applicable to pregnant women (Acar and Weekes, 2004). Certain vehicle devices, such as seat belts and steering wheels may bring about discomfort to pregnant women as regards to the location and adjustments of these devices to fit a pregnant occupant (Acar and Weekes, 2004). Specifically, one vulnerability depends on depending on the rate of protrusion of their abdomen (Weiss et al., 2002). For example, Auriault et al. (2016), in a study of 234 pregnant women, found that significant differences depended on the stage of pregnancy, the driving position during pregnancy, the distance measured between the abdomen and steering wheel of the vehicle that continues to get shorter by the months with the progression of pregnancy, injury and death. Vladutiu et al. (2012) indicated that these actions (the location and adjustments of these devices) put pregnant women and their fetuses at risk of injury since the vehicle design was not built to accommodate pregnant women. Therefore, policy implementations should require automobile manufacturers to consider pregnant women when designing and testing vehicles (Vladutiu, 2012; Acar, Weekes, & Van Lopik, 2009). Further, a vehicle's safety devices should better accommodate pregnant occupants.

A third risk factor related to pregnancy associated deaths from motor vehicle crashes may be due to how country-specific differences in moving violations affects country-specific maternal mortality. This particularly applies to pregnant occupants since studies show that they are vulnerable in motor vehicle crashes, regardless of moving violations. For instance, over speeding and driving-distraction (use of mobile/cell phones) both have significant impact on the outcomes of motor vehicle crashes but differ in legislative consequences by country. The expected speed limit within urban areas is 50km/h (31m/h); only 29 countries have such existing laws (WHO, 2015c). With the increased influx of technology, driving-distractions are on the rise (Lee et al., 2008). A big culprit in driving-distractions is the use of mobile phones in vehicles while driving.

The use of mobile phones in vehicles while driving is a harmful issue in road safety (Lee et al., 2014). Consequently, in some countries around the world, including the UK, Brazil, Israel, Australia, and Nigeria, the use of mobile phones is prohibited while driving. However, the use of mobile phones is yet to be considered a moving violation in the US. This is despite evidence by NHTSA (2016) that 90% of motor vehicle crashes are through driver errors, and it is likely that the use of mobile phone is one key instance of driving-distraction.

Lastly, demographic charateristics and different cultural norms may affect pregnancy associated deaths from motor vehicle crashes**.** Vladutiu et al. (2012) reported that race or ethnicity plays a role in crash risks among pregnant women. For example, similar to other studies (Hyde et al., 2003; Schiff et al., 2005), Vladutiu et al. (2012) found that the risk factors for crash risk were particularly higher among young, black, high-school educated, or single pregnant women. Gender norms can affect the seating position in motor vehicles for pregnant women and this may be a factor as to the outcome of a motor vehicle crash of pregnant women (WHO, 2015c). The mode of transportation, that is, personal vehicle, or public or commercial vehicle fleets, as well as the family size also contribute to the outcome of MVC in pregnant women particularly in developing countries (WHO, 2015c).

Global Traffic Report

While the *Global status report* (*Decade of Action*) is not specific to pregnant women, its goal is to alleviate and decrease road traffic fatalities worldwide, which aligns with preventing maternal mortality from motor vehicle crashes (Vladutiu et al., 2012;

Weiss & Strotmeyer, 2002). As a part of the *Decade of Action*, the pillars of a road safety plan provides the roadmap towards the goal to alleviate the worsening situation of road traffic fatalities, which contributes significantly to maternal mortality. The plan promotes proven solutions to lessen the road traffic mortalities and make roads safer. Some solutions include: (a) road safety management – develop a national road safety strategy, establish lead agency, strengthen institutional capacity; (b) safer roads and mobility – assess regularly safety of roads, explore various forms of transport and safe infrastructure; (c) safer road users – sustain or increase enforcement, adopt model road safety legislations.; and (d) safer vehicles – harmonize global standards, promote use of crash avoidance technologies, equip all new cars with minimum safety features, including seat belts. Over the past years, countries continue to associate their traffic laws with best road safety practices as stated in the report. Examples of associating traffic laws with these best road safety practices include speed limits, legislation against drunk-driving, and seat belt use, among others.

Seat Belt Use

Although the existing performance standards for vehicle safety designs are not based on pregnant women, as described previously, the use of seat belts as a safety precaution is highly recommended for pregnant occupants throughout their pregnancy, irrespective of the seating position. The main purpose of seat belts is to prevent vehicle occupants from sudden ejections, collision with the interior structures of the vehicle, and to reduce the impact of collision (Schoenfeld et al, 1987). According to the World Health Organization, the use of seat belt reduces the fatality risk among front-seat passengers by

40–50% and for rear-seat passengers by between 25–75% (WHO, 2016c). Research shows that the proper use of seat belts reduces the risk of death and injury following a motor vehicle collision by more than 50% (McGwin et al., 2003). Seat belt use reduces the risks of fatality for the women and their fetuses in motor vehicle crashes (NHTSA, 2016). These results are generalizable (Hyde et al., 2003; Schiff et al., 2005; Haapaniemi, 1996; Klinich et al., 2008; Wolf et al., 1993). However, there may be limited data to evaluate the association between seat belt use and maternal mortality due to MVC.

Many countries have specific recommendations for pregnant women and seat belt use. For example, the American Congress of Obstetricians and Gynecologists and the Japan Society of Obstetrics and Gynecology, and the Japan Association of Obstetricians and Gynecologists. The American Congress of Obstetricians and Gynecologists (ACOG) recommends for pregnant women to sit 10 inches away from the steering wheel and wear the seat belt properly (ACOG, 2016). For proper seat belt use pregnant occupants should *"buckle the lap belt below your belly so that it fits snugly across your hips and pelvic bone, and place the shoulder belt across your chest (between your breasts) and over the mid-portion of your collar bone (away from your neck)"* (ACOG, 2016). ACOG warned that pregnant women should never place the shoulder belt under the arm or behind the back and to ensure to pull any slack (looseness) out of the belt.

Pregnant occupants use the three-point and four-point seat belts as well as the lap-belt (Duma et al., 2006). The three-point seat belt is the standard seat belt in most motor vehicles (Schiff et al., 2010). Generally, the use of a three-point seat belt locks into position, thereby preventing ejection in the occurrence of collision from a motor vehicle crash (Duma et al., 2006). However, as stated by Klinich et al. (2008), there was a higher risk of getting injured in a vehicle with airbags if the occupant was not restrained properly with the seat belt. It was also observed that the four-point seat belt generates a marginally improved capability in reducing adverse fetal and maternal outcomes relative to the three-point seat belt (Duma et al., 2006). Although seat belt use decreases adverse maternal outcomes, studies have shown that lap restraints can be associated with uterine, placental, and fetal injuries (Schoenfeld et al, 1987; Crosby et al., 1972; Astarita & Feldman, 1997). Despite these adverse outcomes of lap restraints, pregnant occupants are recommended to use any seat belts, including lap restraints. Particularly, there are recommendations for pregnant occupants to appropriately use the standard three-point seat belt present in most motor vehicles.

Policy Impact of Seat Belt Use

Globally, the compliance rate of seat belt use and the trend in road traffic fatalities varies substantially between different regions of the world, especially between developing and developed countries. The World Report on Road Traffic Injury Prevention recommends that all countries adhere to the road traffic safety good practices, which include the implementation and enforcement of seat belt use for every motor vehicle occupant, regardless of the country's income level (WHO, 2015c). The WHO recommended that all countries have mandatory policies and laws for motor vehicle manufacturers to provide seat belts in all automobile. The WHO also recommended the use of seat belts by all drivers especially in the developing countries. Nevertheless, this is yet to be achieved, and motor vehicle crashes continues to be one of the leading causes of pregnancy-associated deaths around the world (Vladutiu & Weiss, 2012; Jamjute et al., 2005; Hogan, et al., 2010; Rueda-Clausen, Campbell, & Baker, 2011). More than 95% of fatalities due to motor vehicle crashes take place in developing countries of Africa, Asia, Latin America, the Caribbean and Eastern Europe (WHO, 2015c), which are attributable to lack of seat belt use. The implementation of legislations in developed countries has brought about the decrease in fatality rates and increase in compliance rates compared to developing countries. Unfortunately, without enforced compliance, increased number of crashes should be anticipated with the increase in the level of motorization in developing countries (WHO, 2015c). For example, in India, the number of four-wheel vehicles increased by 23% (4.5 million) between 1990 and 1993, with a projected increase to 267 million by 2050 (Suri & Parr, 2004).

Seat belt legislation and enforcement approaches have proven to increase seat belt use, which are critical to alleviating maternal mortality due to motor vehicle crashes. Several developed nations, including the United States, have legislation that requires seat belt use, with no exemptions for pregnant women. In the UK, the mandatory enforcement of seat belt use was established in 1983 for front seat occupants and established in 1991 for rear seat occupants (Johnson & Pring, 2000). In contrast, China, Iran, Japan, and Thailand are a few of countries that allow seat belt exemption based on position in vehicle (Weiss et al., 2006). Further, Japan and few other countries (Spain, Italy, Greece, and Poland) allow specific seat belt exemptions for pregnant women (Weiss et al., 2006). Currently, the Japan Society of Obstetrics and Gynecology recommends that pregnant women should use seat belts, and worn appropriately to protect mother and fetus (The Japan Times, 2008). However, even after the introduction of the seat belt legislation in

Japan in 2008, a substantial number of pregnant women in Japan may still not use seat belt (Morikawa et al., 2016).

In developed countries, enforced seat belt legislation may have contributed to reduced fatalities (Table 1). In 2013, the United Kingdom had a 90% seat belt use rate and 0.6 fatality rate per 100 million persons; Switzerland at 92% and 0.7 fatality rate per 100 million persons; Netherlands at 97% and 0.7 fatality rate per 100 million persons; Germany at 97% and 0.8 fatality rate per 100 million persons; Israel at 97% and 0.8 fatality rate per 100 million persons; Japan at 99% and 1.3 fatality rate per 100 million persons; Italy at 64% and 1.1 fatality rate per 100 million persons.

Table 1: Percentage of Seat Belt Use and Fatality Rates in some Developed Countries in 2013

Country	Percentage of seat belt use	Fatality rate per 100 million persons
United Kingdom	90	0.6
Switzerland	92	0.7
Netherlands	97	0.7
Germany	97	0.8
Israel	97	0.8
Japan	99	1.3
Italy	64	1.1

Source: U.S. Department of Transportation (National Highway Traffic Safety Administration, 2017)

In developing countries, policies impact the several means of road transportation (domestic and commercial) and the use of seat belts in pregnant women. In developing countries, the majority of pregnant occupants are predominantly passengers in commercial vehicles (e.g. minibuses, lorries, two and four-wheel motor vehicles) (Furjouh, 2003). As a result, it is important to note that the use of seat belt may not be mandated by law because a substantial number of the commercial vehicles may not have functioning seat belts (Furjouh, 2003). Additionally, as stated by Weiss et al. (2006), high rates of seat belt use cannot be guaranteed by simply implementing a national law with minimal exemption. From a global perspective, it is crucial to also understand and consider the differences in cultural and socioeconomic contexts between countries when planning and implementing interventions for pregnant occupants (Weiss et al, 2006).

Compliance with Use of Seat Belts, Especially among Pregnant Women

There are several reasons for compliance with seat belt use, especially among pregnant women. A study in the United States suggested that seating positions correlates with seat belt use. Duma et al., 2006 reported that for seating positions in a motor vehicle among pregnant women, 75.2% were drivers, 21.7% were passengers, and 2.7% were in the rear seat, indicating that pregnant occupants are usually drivers. It was also observed that rear seat occupants are less likely to use seat belts relative to front seat occupants, thereby making them prone to injury during a collision, and possibly affecting other passengers as well (Bhat et al., 2015; Bose et al., 2013). Other studies have shown that low seat belt use compliance is affected by age (i.e. younger pregnant women), lower education level, seating position, as well as lower socioeconomic status (Weiss et al, 2002). Importantly, Ichikawa (2003) stated that discomfort stands out as a major concern for pregnant occupants regarding the use of seat belts. The discomfort experienced by pregnant women makes them come up with unsafe decisions and actions such as seat belt use noncompliance and altering seat belts (Acar & Weekes, 2004). Therefore, accommodating the physical changes in body and size of pregnant women is more of a safety issue rather than a comfort issue (Acar & Esat, 2012).

Conclusion

In conclusion, motor vehicle crashes are one of the leading causes of death in the United States and globally (CDC, 2013; WHO, 2016c), and the leading causes of pregnancy-associated deaths (Weiss, 2001a). Based on numerous studies, pregnant women are vulnerable when it comes to riding in a motor vehicle. As described, seat belt use may decrease mortality in pregnant women from motor vehicle crashes. Yet, there is a knowledge gap regarding the circumstances surrounding the occurrences of MVC and pregnant women/occupants. Thus, the purpose of this study is to conduct a systematic review evaluating the association between seat belt use and motor vehicle crashes on maternal mortality among pregnant women.

Significance

Motor vehicle crashes during pregnancy (pregnancy-associated deaths) are the leading cause of maternal mortality and traumatic fetal mortality largely all over the world. Studies have explored the biomechanics of pregnant occupants and driving patterns during pregnancy (Duma et al., 2006), as well as the association of MVC and adverse fetal outcomes (Kvarnstrand et al., 2008; Hyde et al., 2003; Schiff et al., 2010; Wolf et al., 1993; Schiff et al., 2005; Duma et al., 2004). Several studies also indicate that the leading cause of fetal mortality in motor vehicle crashes was maternal mortality, and the use of seat belt significantly reduced the adverse outcome (Weiss et al, 2001b; Wolf et al., 1993; Schiff et al, 2010; Crosby et al., 1972; Schiff et al., 2005). Yet, there is still much unknown regarding seat belt use, maternal mortality, and fetal mortality (Vladutiu et al., 2012; Weiss et al., 2001a). Additionally, research shows that pregnancy stage has little to no effect on the risk factors of a collision, seating position or seat belt use (Weiss & Strotmeyer, 2002). Combined, there is a knowledge gap as to the circumstances surrounding the occurrences of motor vehicle crashes and pregnant occupants, and the characteristics that may increase the susceptibility of pregnant women to motor vehicle crashes. Consequently, this study will shed light on one of the leading causes of pregnancy-associated deaths due to MVC, and its association to seat belt use, thereby, aiding in the reduction of maternal deaths due to MVC.

CHAPTER III: METHODOLOGY: DATA COLLECTION AND ANALYSIS

Study Purpose

The purpose of this research was to evaluate, through a systematic review, among pregnant women globally, the association between seat belt use and maternal mortality during motor vehicle crashes.

IRB and Confidentiality

The study was exempted from the Emory Institutional Review Board (IRB). The determination was that no IRB review was required because the study did not meet the definition of human subjects research as stated in Emory policies and procedures, and federal rules.

Data Source and Search Terms for Systematic Review

This systematic review followed the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The author conducted the article search between May 2016 and July 2016 using PubMed to retrieve original relevant scientific articles. The author searched PubMed for articles published between December 1, 1990 and January 1, 2016. The primary exposure of interest was seat belt use while the primary outcome of interest was the occurrence of maternal mortality after motor vehicle crashes. The articles search was done using search and MeSH terms of key words "pregnancy" and "traffic crashes" in combination with "death OR mortality", "fatal" "hospitalization", and "risk", "rate" along with "baby", "babies", "infants", "fetal" and "fetus", and English, and "humans"[MeSH Terms] NOT Case Reports AND ("1990/12/01"[Date - Publication]: "2016"[Date - Publication]). For the selected articles, language limit was used in the search, and only English-language abstracts were reviewed (Figure 1).

Data Extraction

The author created a MyNCBI library in PubMed. From the MyNCBI library, articles were reviewed using title and abstract only. If the title and abstract met the inclusion and exclusion criteria (Table 2), the full-text article was retrieved and read in its entirety, and re-evaluated with the inclusion and exclusion criteria. Articles that met the inclusion and exclusion criteria (Table 2) were abstracted into a customized database. For the customized database, an Excel (Microsoft Excel for Mac, version 15.30; Seattle, U.S.A.) spreadsheet was created. From the full articles reviewed, data was extracted from each of the studies (such as descriptive data) and entered into the Excel spreadsheet. The data extracted from the retrieved articles included: author, year of study publication, geography/location and state, sample size of pregnant women, age range, age mean where provided, study design, seat belt use (belted and unbelted), motor vehicle crashes, maternal injury, maternal mortality, fetal mortality, relationship between seat belt use and maternal mortality.

The statistical methods used in the articles varied considerably. Since there were no measures of association specific to the relationship between the variables, seat belt use and maternal mortality, none was retrieved from the eligible articles. Instead, descriptive and quantitative analyses were conducted. Descriptive analysis included frequencies and percentages. Quantitative analysis included, for Table 6, odds ratios, 95% confidence interval and *p*-values from abstracted stratified data available from four applicable articles regarding the exposure and outcome (seat belt use and maternal mortality) of this review, using an online calculator (http://vassarstats.net/odds2x2.html).

Table 2: Inclusion/Exclusion Criteria

Inclusion/include	**Exclusion/exclude**
Abstracts that included one or more of the key search terms, and were restricted to only English language	Article included mention of trauma only but no motor vehicle crashes (MVC), injury only, or airbags and did not include seat belt.
Stated that pregnant women were involved in traffic crashes/motor vehicle crashes (MVC)	Article only includes non-pregnant women, simulations, monitoring elements or surveillance, non-traffic crashes.
Mentioned sample size (>4) of pregnant women	Article was a case report
	Article only described fetal mortality and injury but not maternal mortality

CHAPTER IV: RESULTS

Summary of Searches and Study Selection Process

Using the search string (see Methods), the author identified a total of 45 articles using titles and abstracts of which there were no duplicates (Figure 1). After screening, using only title and abstracts, 30 articles out of the 45 were excluded for the following reasons: article described only trauma or injury; articles described no motor vehicle crashes, airbags only or no seat belt; articles described only non-pregnant women, or computer simulations (computational models of pregnant women), monitoring elements, surveillance, or non-traffic crashes; article was a case report.

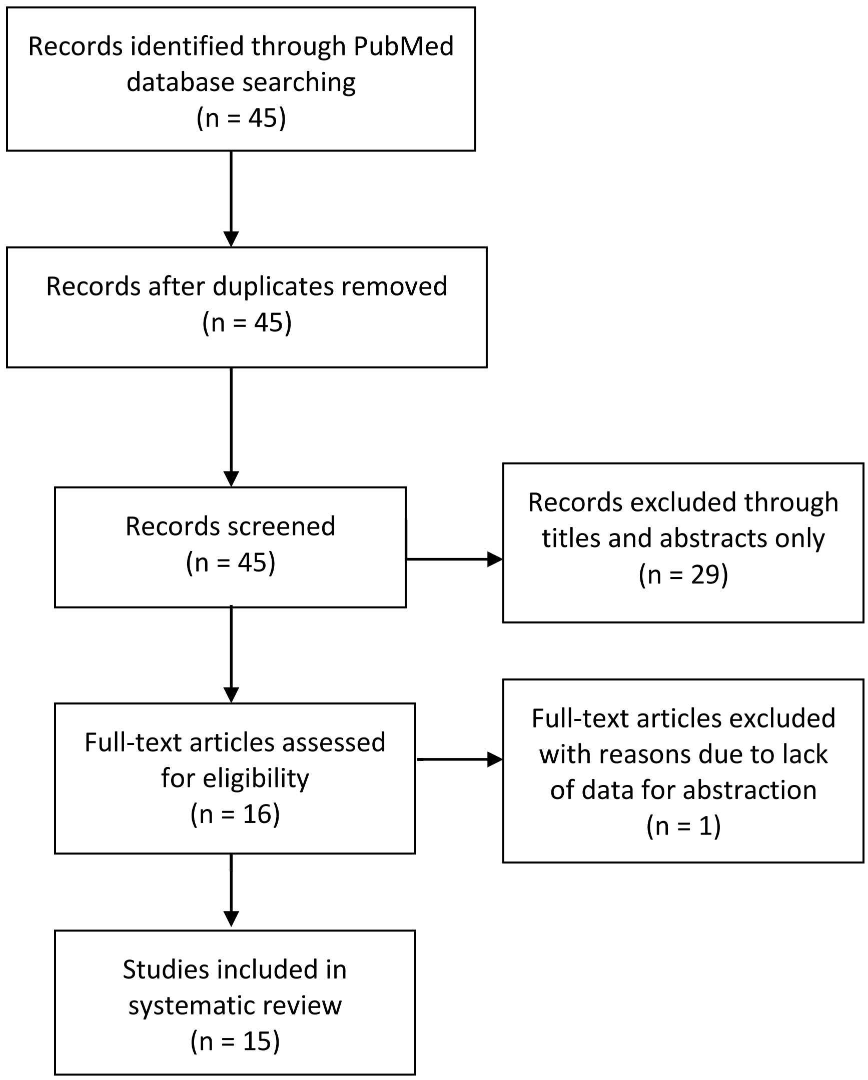

Figure 1: Flow of information through the different phases of a systematic review. This systematic review followed the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Figure 1).

Table 3: Article Description

Variables	Values
Number of articles	15
Year of publication	1991 – 2015
Age range of pregnant women	14 - 45
Studies location (by continents)	Africa, Asia, Australia, Europe and North America
Sample size range	35 – 880,000
Study design	Retrospective analysis (case-control, cohort)

The author extracted characteristics such as year of publication, age range of pregnant women stated in articles, location of study, sample size range, and study design from all 15 articles (Table 3). The 15 articles were published from the years 1991 to 2015 (24 year period). In these articles, the age range of the pregnant women was from 14 to 45 years old. The studies were conducted in the following continents; Africa, Asia, Australia, Europe and North America. In addition, the 15 articles had studies with sample size ranging from 35 to 880,000, and all followed a retrospective design (Table 3).

Table 4: Distribution of Studies by Location and Design

Study by country	Study design	Number of studies
Australia	Retrospective cohort	1
Finland	Retrospective cohort	1
Iran	Retrospective cohort	1
Nigeria	Retrospective cohort	1
Sweden	Retrospective case-control	1
United States*	Retrospective case-control and cohort	10

* Number of articles from each state in the U.S.: Maryland - 1, New Mexico - 1, North Carolina - 2, Utah - 1, Washington - 3, Multiple states – 2

To examine the distribution of studies by geographical location, the author quantified the number of articles per location, and matched them with their corresponding study design. Based on the eligible articles in this review, the United States had the majority of the articles, ten in total and all other countries had one each. There were two retrospective study designs in this review, case-control and cohort. Australia, Finland, Iran, and Nigeria used cohort study designs, Sweden used a case-control study design, and the United States used both study designs (cohort and case-control).

Table 5: Frequency and Percentage of Maternal Mortality and Seat Belt Use

Variables	**Values (frequency & percentage)**
Maternal mortality collected and reported in articles	13 (87%)
Seat belt use data collected and reported	9 (60%)
Seat belt use and maternal mortality both collected in article	9 (60%)
Belted (Restrained pregnant women reported in article) *	86 (5, 35% – 90%)
Unbelted (Unrestrained pregnant women reported in article) *	14 (5, 10% – 65%)

* Median (number of articles, range) – the median and range were calculated by the author from article data.

To identify the percentage and relationships of the variables (seat belt use and maternal mortality) that is, exposure and outcome, the author re-reviewed the 15 articles to ascertain the frequency and percentage of these variables. Seat belt use was later broken down into two categories, belted and unbelted. Of the 15 articles, 13 (87%) collected and reported data on maternal mortality, and nine (60%) collected data on seat belt use and maternal mortality. Only five (33%) articles specified whether the pregnant women were belted or unbelted. Among these articles, the percentage of pregnant women ranged from 35% to 90% among the belted group, and 10% to 90% among the unbelted group (Table 5). Of the nine articles that collected data on seat belt use and maternal mortality, only two articles investigated whether there was an association between seat belt use and maternal mortality. Of these two articles, neither reported the result of this investigation likely because there was no maternal death (Wolf, 1993) or because only dead, without live pregnant women were considered (Schiff, 1997). Since Schiff (1997) had only one maternal death as sample size without live pregnant women, who were involved in MVC, it would be difficult to conduct a rigorous statistical analysis for strong conclusive evidence. However, it was not clear if the other articles also examined the association between the two variables and if they did, they did not report. Overall, there was no evidence supporting a relationship between seat belt use and maternal mortality and this relationship was not explored conclusively in the reviewed articles.

Table 6: Comparison of Maternal Mortality among Belted & Unbelted Pregnant Women

Articles	**Maternal Mortality & Seat Belt Use (Belted)**	**Maternal Mortality & No Seat Belt Use (Unbelted)**	**Estimated OR, 95% CI***	***p*-value***
Esposito, 1991	0/15	1/28	0.9 (0.03, 28.44)	0.60
Wolf, 1993	0/1243	0/1349	Not determined	NA
Aitokallio-Tallberg, 1997	0/28	1/4	0.07 (0.002, 2.49)	0.25
Luley, 2013	0/112	0/13	Not determined	NA

*Author calculated OR, 95% CI, and p value (see Methods) from extracted data from articles. OR and 95% CI could not be calculated from 2 articles with no maternal mortality in both belted and unbelted groups (Wolf, 1993 and Luley, 2013). In articles with mortality in unbelted groups (Esposito, 1991 and Aitokallio-Tallberg, 1997), because ORs cannot be calculated with 0 cells, to obtain an approximate OR, 0 cells from belted group were replaced with a value of 0.5 (Tian, 2009).

To further investigate the association between seat belt use and maternal mortality, the author abstracted the available stratified data from four applicable articles regarding the exposure and outcome (seat belt use and maternal mortality) of this review. The four articles were reassessed and data on seat belt use (belted and unbelted) and maternal mortality (yes and no) were extracted to construct a two by two table. From the two by two table, the odds ratio, 95% confidence interval and *p* value were calculated. The results (Table 6) indicated two articles that could not assess the relationship between seat belt use and maternal mortality because there was no maternal death (Wolf, 1993 and Luley, 2013) in both belted and unbelted groups. The other two articles with available data suggest that the relationship between the exposure and outcome was not significant (Esposito, 1991 and Aitokallio-Tallberg, 1997). This not significant result could be because there was only one maternal death in their unbelted groups and overall small sample sizes. In conclusion, there was no significant evidence on the relationship between seat belt use and maternal mortality or that it was explored conclusively.

Table 7: **Notes on Maternal Mortality from Articles (Excerpts)**

Author, year	Notes on seat belt use and maternal mortality
Esposito, 1991*	*…There were eight maternal deaths (10%) (Table 1). Pg. 1074 …Information with regard to seat belt use was available for 43 (74%) of the 58 motor vehicle occupants (Table 5). Fifteen patients (35%) were wearing restraints. Of all occupants in their first trimester, 40% were belted, of those in their second trimester, 23% were belted, and 46% of patients in their third trimester were wearing restraints. Mean ISS (Injury Severity Score) was essentially the same for both groups.* ***The one death that occurred was in an unrestraint patient.*** *Four (31%) of 13 known pregnancy outcomes were unsuccessful in the belted occupants, and five (26%) of the 19 outcomes were unsuccessful in the unbelted occupants. This difference was not statistically significant. Pg. 1075*
Aitokallio-Tallberg, 1997*	*…**Four of the five patients were restrained, and the one unrestrained woman died**. At the autopsy the reason for her death was rupture of the cervical spinal canal. Pg. 314*
Schiff, 1997*	*…Motor vehicle crashes accounted for 33 (70%) of the 47 injury-related deaths. The majority of deaths were among women passengers on rural highways throughout New Mexico.* ***The majority of decedents (77%) were not wearing seat belts at the time of the crash.*** *A woman killed in a crash in a rural area was significantly less likely to be wearing a seat belt compared with a woman killed in an urban area (P < 0.003) (data not shown). Most of the crashes (79%) occurred during the evening or nighttime hours, and 45% of the crashes involved alcohol. Pg. 20*
Hyde, 2003	*…In only one case, involving a belted woman, did a fetal death link to a maternal death in the crash file. Pg. 282*

*Bolded sentences are excerpts suggesting a relationship between the two variables (seat belt use and maternal mortality)

Since maternal mortality and seat belt use is the focus for this review, and to complement the quantitative analysis in Table 6, articles were re-reviewed to determine any description of a textual association between seat belt use and maternal mortality due to motor vehicle crashes (Table 7). To establish if there were any suggestions of a relationship between seat belt use and maternal mortality in any of the articles, the author focused on all articles that had keywords, seat belt and maternal mortality, limiting the review to the results and discussion sections of each article. The textual excerpts from these qualifying articles were collected based on chunks of text abstracted from paragraphs and by sentences that best fit. Out of the nine (60%) articles that stated both seat belt use and maternal mortality in the article (Table 5), four (27%) articles had textual excerpts describing both seat belt use and maternal mortality. Of these four articles, there is a suggestion that there might be a relationship between the two variables (seat belt use and maternal mortality). The textual excerpts from the first three articles (Esposito, 1991, Aitokallio-Tallberg, 1997 and Schiff, 1997) (Table 7) indicated data on their belted and unbelted pregnant women. There was a higher number of deaths for the unbelted group compared to the belted group. The last article (Hyde, 2003) (Table 7) had insufficient data for a comparison. In conclusion, there is suggestive evidence that depicts an association between seat belt use and maternal mortality due to motor vehicle crashes. However, this was not a rigorous statistical analysis or strong evidence.

Table 8: Frequency and Percentage of Fetal Mortality indicated in Articles

Articles (First Author), year	**Number of Fetal Deaths**	**Fetal Mortality (%)**
Manoogian, 2015*	Not stated	Not stated
Schiff, 2005*	Not stated	Not stated
Wolf, 1993	9	0.7
Schiff, 2010	14	0.8
Hyde, 2003	40	1.5
Zangene, 2014	2	2.0
Orji, 2002	3	3.6
Luley, 2013	6	6.1
Aitokallio-Tallberg, 1997	5	14
Vivian Taylor, 2010	34	31
Esposito, 1991	18	34
Kvarnstrand, 2008	14	35

* These articles are part of the 12 articles that collected data on fetal mortality but had no data reported

The author observed that a substantial number of the eligible articles mentioned fetal mortality. Although this was not the purpose of this review, to examine the percentage of fetal mortality, the author re-reviewed the fifteen articles to establish the frequency and percentage of this outcome per article. Out of the 15 articles, 12 articles collected data on fetal mortality, and the year of publication ranged from 1991 to 2015 (Table 3). Overall, in the reviewed articles, the fetal mortality percentage of motor vehicle crashes ranged from 0.7% to 35% (Table 8).

CHAPTER V: DISCUSSION

Motor vehicle crashes are the leading cause of pregnancy-associated deaths and traumatic fetal mortality (Schiff et al., 1997; Weiss & Strotmeyer, 2002), globally. The objective of this systematic review was to evaluate the association of maternal mortality with seat belt use and motor vehicle crashes in pregnant women. The systematic review suggested three findings. First, in the systematic review, all studies were retrospective and there were no prospective study designs. Second, in the reviewed articles, four (27%) articles (Table 7) had textual excerpts describing both seat belt use and maternal mortality. Lastly, unfortunately, the objective of this study was not achieved. Despite the repeated and rigorous searches using a wide set of screening parameters with the search terms related to maternal mortality and MVC, there was no evidence supporting the association between seat belt use and maternal mortality due to MVC.

The first finding was that all the studies identified were retrospective with varying outcomes. Some studies examined fetal outcomes, injury and trauma outcomes, while some considered adverse maternal outcomes. Articles investigating adverse outcomes of motor vehicle crashes usually use a retrospective design, and this finding was supported by other literature (Vladitiu, 2012; Weiss et al, 2002; Sirin et al., 2007; Vladitiu et al., 2013a). The research studies in the systematic review may be restricted to retrospective designs due to the challenges of executing prospective studies, including their expense, their length of time, that they are prone to high dropout rates (Levin, 2003), and require larger sample size (Collins, 2004). For example, to design a prospective study on maternal mortality and MVC, the study would have to identify and follow a sufficient number of pregnant women during the period of their pregnancy that were involved in

MVC and died. The feasibility of capturing a large sample size of pregnant women that would have been involved in MVC, and died during that period of time is limited. For instance, a study was conducted in Sweden using data linkage from 1991 to 2001 (retrospective study design), which accounted for pregnant women in MVC. There were 2,270 pregnant women involved in MVC of which there were 15 maternal mortalities and 40 fetal deaths (Kvarnstrand et al., 2008). This emphasizes the difficulty and complexity of capturing a large sample size. Thus, securing the required sample size for a powered prospective study examining the relationship between seat belt use and maternal mortality from MVC would be expensive and logistically difficult.

A second finding was that out of the nine (60%) articles that stated both seat belt use and maternal mortality in the article (Table 5), four (27%) articles had textual excerpts describing both seat belt use and maternal mortality. Of these four articles, there is a weak suggestion that there might be a relationship between the two variables (seat belt use and maternal mortality). The textual excerpts from the first three articles (Esposito, 1991, Aitokallio-Tallberg, 1997 and Schiff, 1997) (Table 7) indicated a higher number of deaths for the unbelted group compared to the belted group. The last article (Hyde, 2003) (Table 7) had insufficient data for a comparison. Although, there is a weak suggestion of association between the two variables, this was not a rigorous statistical analysis. In conclusion, there was weak suggestive evidence that depicts an association between seat belt use and maternal mortality due to motor vehicle crashes which somewhat indicates a relationship between the two variables but it is weak.

One important finding from this systematic review was that there was no evidence supporting the association between seat belt use and maternal mortality due to MVC.

Although, two of the eligible articles planned to examine the association between the two variables, neither reported the result of this investigation (Wolf et al., 1993; Schiff et al., 2005). This could be because there was no maternal death (Wolf, 1993) or because only dead, without live pregnant women were considered (Schiff, 1997). The lack of significant ($p > 0.2$) odds ratios for the two articles, calculated by the author (Esposito, 1991 and Aitokallio-Tallberg, 1997) (Table 6) indicated there was no significant evidence between seat belt use and maternal mortality. Based on these quantitative data, there was no evidence supporting the association between seat belt use and maternal mortality due to MVC.

This lack of evidence supporting the association between seat belt use and maternal mortality due to MVC could be because of the limited research on pregnancy-associated deaths and MVC. Yet, several studies found MVC to be one of the leading causes of pregnancy-associated deaths, injuries, as well as traumatic fetal mortality (Vladutiu et al., 2013a; Weiss & Strotmeyer, 2002; Vladutiu et al., 2012; Schiff et al., 2005; Sirin et al., 2007; Brown et al., 2015; Jamjute et al., 2005; Manoogian et al., 2015) and thus an important public health issue. A second reason may be that the feasibility of conducting such research might be difficult due to complex data accessibility, poor data linkage and complicated causality. Data on pregnant occupants are not readily accessible through the National Highway Traffic Safety Administration (NHTSA) or National Automotive Sampling System/Crashworthiness Data System (NASS/CDS), and the author thinks this might be similar for other developed countries. Researchers may be able to access these data, but the process seems complex. Also, poor data linkage creates a major issue in effectively conducting research on pregnancy-associated deaths due to

MVC. For example, there are limited pregnancy-associated studies that indicated the use of data linkage in the U.S.; however, for the few, the data linkage was probabilistic for MVC and pregnant women (Vladutiu et al., 2013b). A third reason may be that the sample size was very small which was evident in the odds ratios (Table 6) since there was no significant association between the exposure and outcome (seat belt use and maternal mortality).

Though there were no articles that thoroughly examined the association between seat belt use and maternal mortality, this systematic review identified five articles (population-based studies) that evaluated the association of motor vehicle crashes and fetal outcomes. While this was not the objective of this study, these results are worth mentioning. The results from these five articles suggested that pregnant women are at increased risk of being exposed to adverse fetal outcomes after MVC. In fact, Hyde et al. (2003) stated that in one case involving a belted woman, the fetal death was linked to maternal death. As shown in Table 8, the fetal mortality rate ranged from 0.7% to 35%, and as indicated by these five studies, there is a possible association between adverse maternal and fetal outcomes. Although only a few studies have specifically examined the association of fetal mortality and motor vehicle crash, several research studies have been conducted on adverse fetal outcome and motor vehicle crash (Kvarnstrand et al., 2008; Hyde et al., 2003; Schiff et al., 2010; Wolf et al., 1993; Schiff et al., 2005). This is beneficial because, with increased research, more evidence is available, thereby creating avenues for needed prevention strategies. Generally, there are limited studies on pregnancy-associated deaths, as well as on the association between seat belt use and adverse fetal outcomes related to MVC. Yet, evidence indicates the possible association between the two outcomes (Wolf et al., 1993; Schiff et al., 1997) because the safety of pregnant women and fetuses is somewhat interdependent in MVC.

This study has limitations that should be noted. The process of creating a search string or inclusion/exclusion criteria, and finding the appropriate keywords to comprehensively capture all relevant articles was a challenge. In principle, a minimum of two persons or reviewers conduct a systematic review. However, in this study, the review of the selected articles, data extraction, and the re-review during multiple times to reduce the chance of missing information, was conducted mainly by the author. Consequently, there is the possibility of missing information, selective reporting or misinterpretation by the author which may have occurred unintentional. The use of English language alone also narrowed the expanse of relevant articles for the review analysis. Importantly, the findings from this review should be interpreted with caution due to the limited sample size of the analysis. Some strengths of the study were that a standard procedure (PRISMA) was followed to conduct this systematic review. Quantitative data and textual excerpts were extracted from articles and analyzed to further strengthen and confirm the results of the study. To the knowledge of the author, this is the first study of this kind, and hopefully it will create the need for more research to be conducted to clarify the association between seat belt use and motor vehicle crashes.

Recommendations and Conclusion

For the safety of pregnant occupants and their fetuses, the American College of Obstetrics and Gynecologists (ACOG) recommends the use of seat belts throughout pregnancy to alleviate the adverse outcomes of MVC. Based on this systematic review, there are no known studies that thoroughly evaluated the association between seat belt use and maternal mortality due to MVC. Although there are some research studies that have examined the association between motor vehicle crashes and fetal outcomes, they are limited (Kvarnstrand et al., 2008; Hyde et al., 2003; Schiff et al., 2010; Wolf et al., 1993; Schiff et al., 2005). Therefore, research on the association between seat belt use and maternal mortality due to MVC is essential to better understand the association between seat belt use and maternal mortality due to MVC. This will also clarify if the association between this exposure and outcome is the area of focus, or if there are other underlying factors, that is, if some other risk factors need to be examined. Importantly, the findings from this review should be interpreted with caution due to the limited sample size of the analysis.

There is a also a need for increased attention shift to pregnancy-associated deaths, particularly due to MVC since motor vehicle crashes are the leading cause of maternal mortality. The attention shift can create possible solutions to the complex causality of pregnancy-associated deaths.

In conclusion, the impact of this study indicates the need for evidence-based research on the association between seat belt use and maternal mortality due to MVC. Consequently, these future studies can provide clarity and understanding on the association between seat belt use and pregnancy-associated deaths due to MVC, which can inevitably alleviate the rate of maternal and fetal mortality due to motor vehicle crashes.

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