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Maternal and Neonatal outcomes following motor vehicle accidents during pregnancy; A systematic review

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Abstract

Background:

Trauma is the major reason for non-obstetric mortality and morbidity; major trauma during gestation is associated with adverse gestational outcomes. Motor vehicle crashes (MVCs) are the major reason of life-threatening trauma among pregnant subjects, and they are the most frequent reason for non-obstetric trauma linked with fetal mortality. Also, MVCs are responsible for several consequences for the survivors.

Aim:

To assess the maternal and neonatal outcomes that occurred after vehicle accidents during gestation by reviewing the prior studies related to this subject.

Methods:

Electronic databases were explored to obtain relevant articles and use various related terms. The eligible articles were written in English, were original articles published after 2010, and focused on the gestational outcomes following motor vehicle accidents.

Results:

Eight articles agreed with the criteria and were included with a total number of 239694 women. There were two studies that reported maternal outcomes only, whereas one study reported neonatal outcomes and five studies reported both maternal and neonatal outcomes.

Conclusion:

MVCs and accidents during pregnancy result in consequences for the mother and her fetus; the most frequent complications include preterm labor, placental abruption, stillbirth, and fetal mortality. The gestational outcomes following such accidents were influenced by various factors such as using seat belts, crash frequency, and gestational age.

Keywords: Maternal outcomes, Neonatal outcomes, Pregnancy, MVC.

Introduction:

Trauma is the major reason for non-obstetric mortality and morbidity that affects 0.13-7% of pregnant women **[1, 2]**. Major trauma during gestation is linked with placental abruption, miscarriage, and uterine rupture **[3, 4]**. On the other hand, minor trauma is linked with an elevated incidence of preterm labor and lower newborn weight **[2, 5-7]**.Motor vehicle crashes (MVCs) are the major reason of life-threatening trauma among pregnant women **[8]**. MVCs are the most frequent reason for non-obstetric trauma linked with fetal mortality, with an incidence of 2.3/100000 live births **[9]**.

Almost one-half of females in developed regions drive motor vehicles **[10],** and the outcomes of MVCs-related injuries involving pregnant females can be severe **[11]**. In the USA, almost 26% of injury hospitalizations during gestation resulted from MVCs **[12]**. Also, the incidence of maternal mortality following MVCs in pregnant women is 3.5/100000 women **[13]**. A previous analysis included 19 studies with 3222066 females, which revealed that the maternal death incidence was 3.6 per 1000 and fetal death or stillbirth was 6.6 per 1000 following MVCs **[14]**. The outcomes of MVC survivors are also concerning **[15]**.

The emergency care of pregnant women who are exposed to MVC can be challenging in some conditions due to the physiologic alterations of gestation that may mask the signs of acute blood loss and resuscitation and may complicate other management procedures such as performing radiography as it can be harmful to the fetus **[15]**.The physiology of gestation leads to increased plasma volume and cardiac output caused by elevated progesterone and estrogen production. Such alterations impact the clinical judgment of traumatic injury and the resuscitation procedure **[16]**. Radiographic imaging may

expose the fetus to radiation, and therefore, care must be taken with the avoidance of contrast where necessary. Also, a multidisciplinary team of obstetric and gynecological specialists, anesthetists, and neurosurgeons is necessary to save both lives **[17]**.

There is inadequate focus in the literature on the outcomes of mothers and their fetuses following MVCs during pregnancy. So, this review was carried out to assess the maternal and neonatal outcomes that occurred after vehicle accidents during gestation by reviewing the prior studies.

Method:

Search strategy:

The PRISMA checklist **[18]**was the guide for writing this review. The electronic databases were explored to obtain relevant articles; such databases included PubMed, Google Scholar, and Scopus. The exploration procedure was performed using various terms, including "Maternal, Neonatal, Outcomes, Adverse outcomes, Adverse effects, Gestation, Pregnancy, MVA, and Vehicle accidents." All the obtained articles were revised precisely to prevent missing potential studies.

Eligibility criteria:

The findings were then checked to preclude duplicate articles and those that reported adverse outcomes for mothers and neonates for irrelevant reasons. Articles focused on the prevalence, causes, or other elements related to motor vehicle accidents among pregnant women were excluded. Only articles that reported maternal and/or neonatal outcomes following motor vehicles were included. The eligible studies were those written in English, and the original articles provided original data. Therefore, reviews, case reports, and letters were precluded. The articles available for abstracts were excluded, and only full-text articles were eligible and included. Also, eligible articles were those published after 2010.The illustration of eligibility is displayed in figure 1.

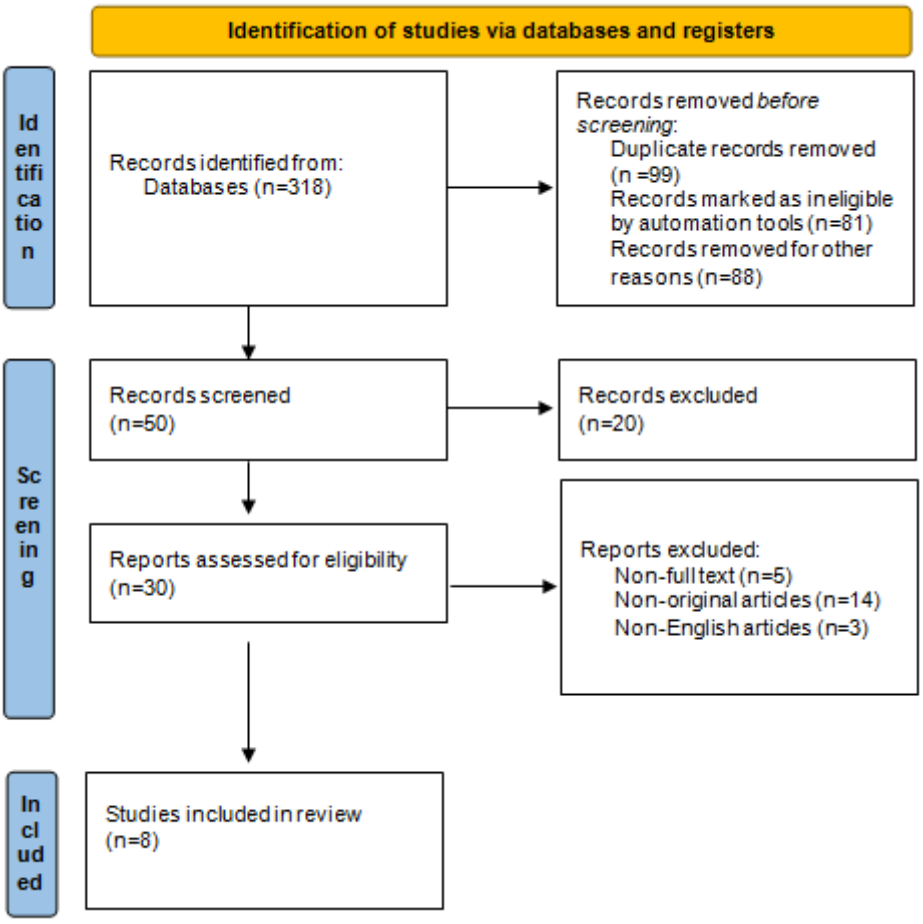
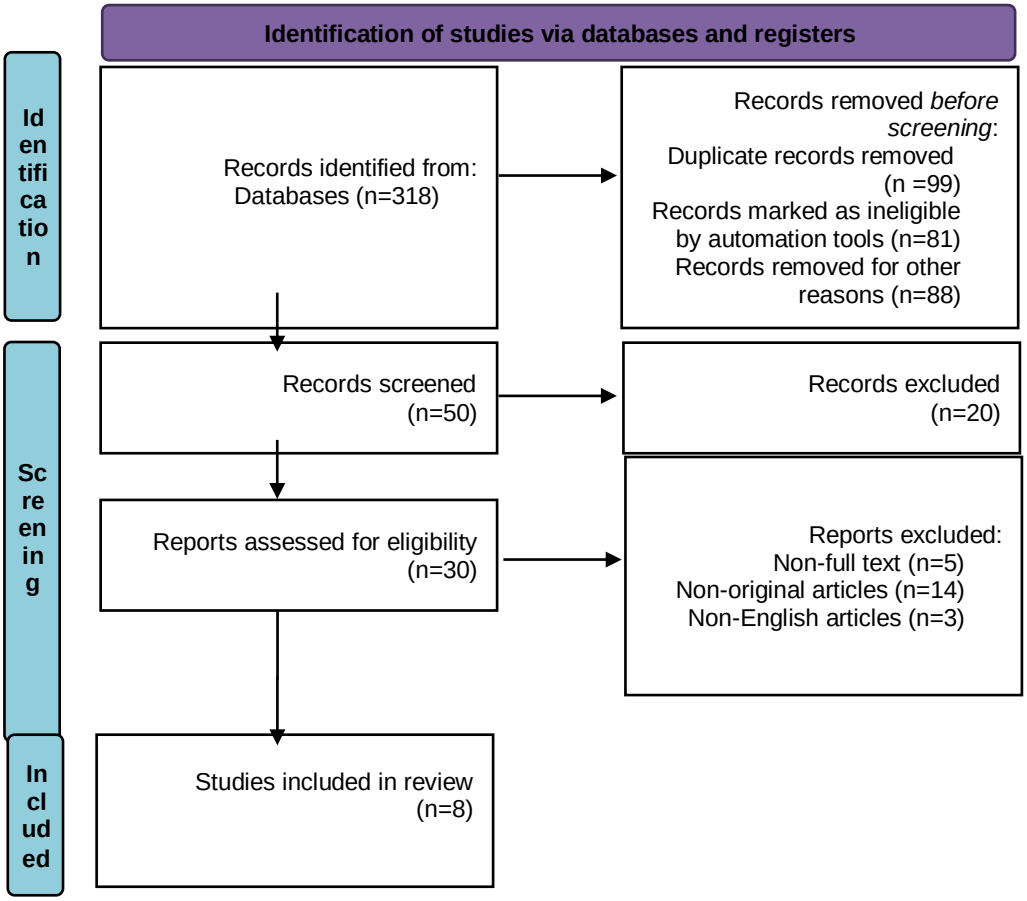


Fig1: Eligibility of selection

Review and analysis of data:

The eligible articles were explored to determine the data of interest; then the full-text article was reviewed precisely to extract the data of interest using a specially designed Excel sheet. The extracted data was then revised and transferred to a table for data summarization.



*Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers).
**If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools.
From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

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Results:
This review enrolled eight articles that fulfilled criteria **[19-26] (Table 1).**The enrolled studies were published between 2013 and 2024; five studies were published after 2020 **[19-23]**, and only two studies were published before 2015 **[25, 26]**. One study didn't report its design **[20]**, and most of the studies were based on retrospective design, data registry, or databases **[19, 21, 23, 24, 25, 26]**.
The total number of women was 239694; only one study reported the number of neonates, and it was 95292 neonates **[22]**. There were four studies that categorized women into two groups**[19, 22, 25, 26]**. One study categorized women into 23559 pregnant who encountered accidents and 94236 non-pregnant women who encountered accidents **[19]**. Another study categorized mothers as those who didn't experience accidents, with a total number of 75345 women who gave birth to 76015 neonates and 19218 pregnant women who experienced accidents and gave birth to 19277 neonates **[22]**. One study categorized women based on the number of crashes they experienced in a single pregnancy into 24399 women who were drivers in one crash and 769 who experienced two or more crashes **[25]**. The fourth study categorized women into those who were restrained or unrestrained **[26]**.

Regarding the outcomes, two studies reported maternal outcomes only **[19, 21]**, whereas one study reported neonatal outcomes **[22],** and five studies reported both maternal and neonatal outcomes **[20, 23, 24, 25, 26]**.

The findings of the studies were heterogeneous and included reporting comparing outcomes of pregnant and non-pregnant, maternal outcomes, rates of emergency CS among this population of women, neonatal outcomes, outcomes based on a number of crashes, and being restrained or not.

One study reported that pregnant females had a considerably higher risk of mild (aOR 8.63) and severe (aOR 1.79) injuries after accidents, especially those riding scooters had a higher risk of severe injury (aOR 4.25). Pregnant women, even without injuries, are more prone to visit the clinic compared to non-pregnant ones **[19]**.

Regarding CS, one study reported a rate of 36.84% **[20]**, another study reported emergency CS with a rate of 8% **[21]**, and 12.5% were perimortem CS, as reported in the third study **[24]**. Emergency CS had higher rates of injuries in the lung ($P<0.001$), spleen ($P<0.001$), elevated shock index ($P<0.001$), higher rates of complication ($P<0.001$), and death ($P= 0.012$). The risk factors of emergency CS included severe head injury (OR 2.65), abdominal injury (OR 2.07), and elevated shock index (OR 2.17) **[21]**.

The rate of overall adverse outcomes was 37.47% **[20]**, and minor injuries were 11%, whereas 89% had severe adverse materno-fetal gestational outcomes **[24]**.

The reported adverse outcomes included 23.68% preterm labor**[20]**, (3.2%) **[23]**, (40%) **[24]**, 15.78% placental abruption **[20]**, (5.3%) **[23]**, (58.8%) **[24]**, 18.42% PROM, 28.94% preterm PROM, 7.89% chorioamnionitis/sepsis, 5.26% admission to high dependency unit **[20]**, maternal death (1.1%) **[23]**, (13.7%) **[24]**, high hospitalization rate with increased gestational age **[23]** and uterine rupture (1.6%) **[24]**.

The adverse fetal outcomes included intrauterine death 7.89%, stillbirth 7.89%, asphyxia at birth 5.26%, ICU stay of more than 10 days 18.42% **[20]**, fetal loss (3.2%) **[23]**, higher risk of birth defects (aOR 1.21), especially during the first (aOR 1.31) and second (aOR 1.32) trimesters and with mild (aOR 1.31) and sever (aOR 2.43) injuries **[22]** and fetal death (10.7%) **[24]**.

However, one study revealed that successful delivery of neonates in the adverse condition of maternal women was 60.53% **[20]**, and 81% of fetuses survived **[24]**.

Regarding the impact of crash frequency, a single crash slightly elevated preterm birth (aRR 1.23),placental abruption (aRR1.34), and PROM (aRR1.32). On the other hand, more crashes highly increased preterm birth (aRR1.54), stillbirth (aRR 4.82), placental abruption (aRR 2.97), and PROM (aRR 1.95) **[25]**.

Regarding the impact of being restrained, one study reported no significant variations between restrained and unrestrained pregnant women regarding maternal abdominal trauma, abdominal pain, maternal surgery, placental abruption, gestational age at delivery, and delivery mode. However, being unrestrained was significantly associated with intrauterine fetal death ($P=0.01$) **[26]**. Another study revealed that the rates of stillbirth were higher among unbelted mothers (aRR 2.77) **[25]**. One study discovered that only 21% of women who experienced accidents were using seat belts **[24]**.

Table 1: The summarized data

Author and Publication year	Study design	Population characteristics	Outcomes	Results and main findings
Chang et al. 2024 [19]	Data registry	-N=117795 women *23559 pregnant encountered MVCs *94236 non-pregnant victims	Maternal	*Pregnant subjects had a considerable risk of severe (aOR 1.79) and mild injuries (aOR 8.63) following MVCs. *Riding scoter pregnant women had a high risk of severe injury (aOR 4.25). *Pregnant women without injury were more prone to visit a clinic than non-pregnant.
Dineshan&Varkey 2024 [20]	-----	-N=38 pregnant women with RTA head injuries	Maternal & neonatal	*The outcomes included 23.68% preterm labor, 18.42% PROM, 28.94% Preterm PROM, 15.78% placental abruption, 7.89% experienced chorioamnionitis/sepsis, 5.26% cases were admitted to high dependency unit. *The rate of CS was 36.84%. *The total adverse outcomes were 39.47%; the remaining newborns were normal. *The adverse fetal outcomes, included intrauterine death 7.89%, still birth 7.89%, asphyxia at birth 5.26%, and ICU stay more than 10 days 18.42%. *The successful labor of newborns with the adverse status of maternal head injuries was in 60.53%.
Hough et al. 2024 [21]	Database	-N=1183 pregnant trauma patients after MVCs	Maternal	*8 % of subjects underwent emergency CS. *The emergency CS cases had higher injury rates of lung (P<0.001), spleen (P<0.001), and elevated shock index (P<0.001). *Emergency CS patients had higher rates of complication (P<0.001) and death (P= 0.012). *Independently associated risk factors for emergency CS included severe head injury (OR 2.65, P= 0.023), abdominal injury (OR 2.07, P= 0.028) injuries, and elevated shock index (OR 2.17, P= 0.006).
Chang et al. 2023 [22]	Cohort	-N=94563 mothers *Mother without MVC=75345 *Mothers with MCV=19218 -N=95292 neonates *without MCV=76015 *With MCV=19277	Neonatal	*Offspring exposed to maternal MVCs during gestation had a greater risk of birth defects (aOR 1.21). *The positive association was sustained with exposure to an MVC during the first (aOR1.31) or second trimester (aOR 1.32). *A correlation (P=0.002) was noted between the level of injury severity and the risk of birth defects, and birth defect risk increased with mild injury (aOR 1.31) and severe injury (aOR 2.43).
Soysal et al 2021 [23]	Retrospective	-N=95 pregnant women	Maternal & neonatal	*Preterm labor occurred for 3.2%, while 3.2% had a fetal loss and 5.3% had a placental abruption. *One mother was lost (1.1%) due to multiple traumas in MVCs.

				*Hospitalization was highly indicated with elevated gestational age, but other parameters had no impact on hospitalization.
Chibber et al. 2015 [24]	Retrospective chart	-N=728 pregnant women	Maternal & neonatal	*11% sustained minor injuries/sprains. *89% had severe adverse materno-fetal gestational outcomes. *Adverse outcomes, included placental abruption 58.8%; preterm labor 40%; and uterine rupture 1.6%. *There were 13.7% maternal and 10.7% fetal deaths. *There were 12.5% perimortem CS, and 81% of fetuses survived. *Only 21% were using seat belts during the accident.
Vladutiu et al 2013 [25]	Retrospective cohort	-N=25168 pregnant women *Drivers in one crash=24399 pregnant women *Drivers in two or more crashes=769 pregnant women	Maternal & neonatal	*After a single crash, pregnant drivers had slightly increased rates of preterm birth (aRR 1.23), placental abruption (aRR1.34), and PROM (aRR1.32). *After a second or subsequent crash, pregnant drivers had more highly elevated rates of preterm birth (aRR1.54), stillbirth (aRR 4.82), placental abruption (aRR 2.97), and PROM (aRR 1.95). *Stillbirth rates were elevated following crashes involving unbelted pregnant drivers (aRR 2.77) compared to belted pregnant drivers.
Luley et al 2013 [26]	Registry & medical records	-N=124 pregnant women *Restrained=111 *Unrestrained=13	Maternal & neonatal	*No considerable variations between both groups regarding maternal abdominal trauma (p=0.4), abdominal pain (P=0.2), maternal surgery (P=0.07), placental abruption (P=0.5), gestational age at delivery (P=0.5) and mode of delivery (P=0.08). *There were significant variations between both groups regarding intrauterine fetal death (P=0.01); unrestrained women were more prone to experience fetal death.

MVCs; Motor vehicle crashes, RTA; Road traffic accidents, PROM; Premature rupture of membranes, CS; Cesarean section, ICU; Intensive care unit.

Discussion:

The majority of studies investigating the outcomes of MVCs during pregnancy are very earlier **[27]**. Also, there was an inadequate review of maternal and neonatal outcomes following MVCs during gestation**[14]**. Therefore, this review was established to identify the maternal and neonatal outcomes after MVCs during gestation by reviewing previous related studies that were published more recently as much as possible.

It was reported that pregnant subjects who experience MVCs complain of less severe injuries compared to non-pregnant ones involved in MVCs **[28, 29]**. However, in our review, one study reported an elevated risk of mild and severe injuries by more than eightfold and more than onefold for pregnant women compared to non-pregnant ones following MCVs. Furthermore, riding score increased the risk of severe injury by more than fourfold, indicating that the scoter may represent a higher risk for severe injuries compared to vehicles **[19]**.

Pregnant subjects who experience MVCs may encounter serious maternal adverse outcomes, and fetuses are at a significant risk of injury **[30]**. In our analysis, we found that the overall rate of adverse outcomes represented a significant proportion **[20]**, with more occurrences of severe adverse outcomes compared to minor ones **[24]**.The reported outcomes were various and heterogeneous; the most frequent maternal outcomes included preterm labor, placental abruption, and PROM. The fetal outcomes were more heterogeneous, and they includedstillbirth, birth defects, fetal loss, and fetal death.

An association between MVCs and maternal mortality was reported **[31]**. However, in our analysis, we found that maternal death rates were relatively low and ranged between 1.1% and 13.7%. It was reported that maternal mortality is rare, whereas fetal mortality is as high as 73% following penetrating injury **[32]**. Nonetheless, the rates of fetal death, including stillbirth, fetal loss, and fetal death, didn't exceed 11%, whereas maternal death reached 13.7% in one study **[24]**. Furthermore, the mortality rate among injured pregnant subjects is varied due to the heterogeneity of methods and mechanisms of injury **[33]**.

It was stated that there is scarce information regarding the impacts of crashes on fetal outcomes **[27]**. This may be due to the varied mechanism of crashes, variation in the trimester when the crashes occur, and other factors. In our analysis, the fetal outcomes were affected by trimester and the severity of injury **[22]**.

Not only MVCs during gestation are associated with perinatal mortalities **[34]**, but also other injuries and consequences such as abdominal injuries, placental abruption, preterm birth, and CS **[14]**. Placental abruption and preterm labor were two major consequences reported in the included studies in this review. Additionally, CS was performed at a significant rate of 36.84%, whereas perimortem CS was in the second rank (12.5%), followed by emergency CS, which represented 8%. However, the major data was reported regarding the emergency CS, and it was carried out due to severe head injury and abdominal injury that increased the risk of emergency CS by more than twofold.

The severity of outcomes following MCV for pregnant women is dependent on several factors such as gestational age at time of injury, seat belt usage, and crash severity **[35, 36]**. We found that the risk of birth defects was increased in the first and second trimesters **[22]**, revealing the considerable impact of gestational age on gestational outcomes. Additionally, the severity of injuries affected the risk of birth defects **[22]**. Furthermore, we found that the frequency of crashes during a single pregnancy was also a determinant factor affecting the gestational outcomes. Two or more crashes per single pregnancy increased the risk of preterm birth, stillbirth, PROM, and placental abruption **[25]**.

The data regarding seat belts in our analysis supported the importance of using seat belts; one study reported no variation between restrained and unrestrained women regarding several maternal outcomes; however, being unrestrained was associated with intrauterine fetal death **[26]**. Another study revealed that the risk of stillbirth exceeded twofold among unbelted women **[25]**, and only 21% of those who experienced accidents were using the belt **[24]**. In a previous early study, it was revealed that 77% of mortality cases among women weren't wearing seat belts at the time of crash **[36]**.

There is inadequate safety guidance on traveling during pregnancy **[37-39]**. The focus on this tends to be on questions around the usage of seat belts and the activation of airbags in the car **[39]**.

Similar to our findings in a previous analysis, it was demonstrated that pregnant females who experienced MVC were at high risk of maternal complications compared to those who didn't experience MVC, and such increased complications included placental abruption with increased risk by 1.43 fold and maternal death with an odd of 202.27. The other reported complications included labor induction, preterm delivery, and CS **[14]**.

Conclusion:

MVCs during pregnancy result in significant consequences for the mother and her fetus; the most frequent complications include preterm labor, placental abruption, PROM, CS, stillbirth, and fetal

mortality. However, the exact rates can't be determined due to the heterogeneity of the studies and the presence of determinant factors that affected the gestational outcomes, such as using seat belts, crash frequency, and gestational age.

Limitations, strengths and recommendations:

The limitations of this review are the inclusion of few and some early studies with high heterogeneity in findings due to the lack of studies focusing on this subject. However, the strength of this review is that it tried to fill the gap of the lack of systematic analysis regarding the present subject. Therefore, further studies investigating this topic are very recommended and necessary, and it is recommended to report the full outcomes of both the mothers and their fetuses.

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