Complications from first-trimester aspiration abortion:

A systematic review of the literature

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Abstract

Objective: We conducted a systematic review to examine the prevalence of minor and major complications following first-trimester aspiration abortion requiring medical or surgical intervention.

Study Design: We searched PubMed, CINHAL, Scopus, and the Cochrane Library for articles published between 1980 and April 2015 that reported on repeat aspiration, hemorrhage, infection, cervical/vaginal trauma, uterine perforation, abdominal surgery, hospitalization, anesthesia-related complications, and death. We limited our review to studies that included ≥100 abortions performed by physicians in North America, Western Europe, Scandinavia, and Australia/New Zealand. We compared the prevalence of complications that required additional interventions for abortions performed in office-based clinics and surgical center or hospital clinic settings.

Results: From 11,369 articles retrieved, 57 studies met our inclusion criteria. Evidence from 36 studies suggests ≤3.0% of procedures performed in any setting necessitate repeat aspiration. Hemorrhage not requiring transfusion occurred in 0-4.7% of office-based procedures and 0-4.1% of hospital-based procedures, but was ≤1.0% in 23 studies. Major complications requiring intervention, including hemorrhage requiring transfusion and uterine perforation needing repair, occurred in ≤0.1% of procedures, and hospitalization was necessary in ≤0.5% of cases in most studies. Anesthesia-related complications occurred in ≤0.2% of procedures in six office-based studies and ≤0.5% of procedures performed in surgical centers or hospital-based clinics. No abortion-related deaths were reported.

Conclusions: The percentage of first-trimester aspiration abortions that required interventions for minor and major complications was very low. Overall, the prevalence of major complications was similar across clinic contexts, indicating that this procedure can be safely performed in an office setting.

Implications: Laws requiring abortion providers to have hospital admitting privileges or facilities to meet ambulatory surgical center standards would be unlikely to improve the safety of first-trimester aspiration abortion in office settings.

Keywords: first-trimester surgical abortion; aspiration abortion; complications; systematic review

1. Introduction

Since 2011, there has been a marked increase in the number of abortion-related restrictions in the United States (US) enacted by state legislatures. Between 2011 and 2014, 231 state-level abortion regulations were passed, which was more than the total number passed by states in the preceding 10 years [1]. Many of these laws focus on regulating abortion providers by requiring physicians who perform abortions to have admitting privileges at area hospitals (often within 30 miles of the clinic where the procedure is performed) and requiring facilities that perform abortions to meet the standards for ambulatory surgical centers (ASCs) or hospitals [1]. At the time of this writing, admitting privileges requirements for abortion providers were in effect in five states; in the other seven states with these requirements, the laws were enjoined or temporarily not enforced due to legal challenges [2]. ASC and hospital standards are in effect in 21 of the 24 states that have passed these facility requirements [2].

Proponents of these laws argue that additional regulations on abortion are needed to ensure women's health and safety. For example, they claim that hospital admitting privileges will facilitate continuity of care for women who experience complications from the procedure [3]. Although ASC facility standards vary across states, these regulations typically include detailed physical plant and staffing requirements, such as the specific width of corridors, air flow and temperature regulations, piping for general anesthesia, and circulating nurses [4-6]. Such requirements are deemed necessary to accommodate emergency situations, including evacuating patients experiencing complications [7,8]. However, opponents of these regulations, including professional medical associations, assert that such requirements are medically unnecessary for abortion care, since the rate of complications requiring emergency treatment and hospitalization is low [9,10]. Moreover, abortion is less complex and, as practiced in the US, typically does not involve deep sedation, unlike other procedures (e.g., plastic surgery or colonoscopy) that are commonly performed in ASCs where such regulations are warranted [11,12].

We conducted a systematic review of the literature on the prevalence of complications that require additional medical or surgical interventions following first-trimester aspiration abortion and compared the need for interventions in office-based clinics and ASC or hospital clinic settings. We focused on first-trimester abortion because it accounts for more than 90% of abortions in the US [13]. These findings could inform policy decisions regarding regulations that affect the majority of US women seeking abortion care.

2. Materials and Methods

We used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to conduct this review [14]. Institutional Review Board approval was not required for this study.

2.1. Search strategy. We searched for studies published between January 1, 1980, and April 30, 2015, using databases for PubMed, the Cumulative Index to Nursing and Allied Health Literature (CINHAL), Scopus and the Cochrane Library. We combined the following search terms as Medical Subject Headings (MeSH) and text words: abortion, legal; abortion, induced; dilatation and curettage; vacuum curettage; vacuum aspiration; suction curettage; aspiration abortion, termination of pregnancy; first trimester; adverse events; complications; hemorrhage; infection; pelvic inflammatory disease; incomplete abortion; perforation; laceration; hospitalization; death; and mortality (Appendix). We also searched the reference lists of relevant publications for additional studies.

2.2. Study selection criteria. We included studies published from randomized controlled trials (RCTs), prospective cohort studies, and retrospective reviews of patient records for complications experienced by women undergoing aspiration abortion at ≤12 weeks' gestation; if study authors defined procedures ≤14 weeks' gestation as first-trimester abortions, we reviewed

the study for inclusion. We limited our review to studies of abortions performed by physicians in the US, Canada, Western Europe, Scandinavia, Australia and New Zealand because these countries have longer histories of legal abortion and academic research on abortion services. Studies also needed to report on at least one of the complications listed below to be included.

We excluded studies (or study arms) that had fewer than 100 abortions, used procedures considered out-of-date (e.g., amniotic instillation), provided concurrent surgical sterilization, or used methods unavailable in US settings (e.g. gemeprost for cervical priming). Studies published in a language other than English or Spanish were excluded, as were review articles, editorials, and commentaries in any language.

2.3. Outcomes. Our primary outcome was the percentage of first-trimester aspiration abortions that resulted in minor or major complications requiring additional interventions. Minor complications requiring intervention included: hemorrhage or excessive blood loss (defined by the study authors) that did not require transfusion; infection requiring outpatient treatment with antibiotics; minor trauma to the cervix or vagina requiring surgical repair (e.g., cervical laceration requiring sutures); and repeat aspiration. Major complications requiring intervention included: hemorrhage requiring transfusion; infection requiring intravenous (IV) administration of antibiotics; uterine perforation requiring hospitalization or surgical intervention; abdominal surgical procedures (e.g., hysterectomy, laparotomy); abortion-related hospitalization; and abortion-related death. We also assessed the percentage of first-trimester abortions with anesthesia-related complications.

2.4. Data abstraction. After initial title and abstract screening, two reviewers (KW and EC) independently evaluated full-text articles to determine whether they met the inclusion criteria. They extracted data on the study population and the number and type of interventions reported to treat each complication in eligible studies using a pre-designed form. For studies that had

multiple arms or cohorts meeting the inclusion criteria, they extracted data for each study arm separately. Differences were resolved through discussion. A third reviewer (DG) adjudicated unresolved differences.

We did not consider reaspirations for incomplete abortion identified at the time of the procedure as an intervention for minor complications. We also did not consider hospital transfers as hospitalizations unless authors reported that a woman was admitted to the hospital. If a transfer did not result from a major abortion-related complication, as defined above, we did not classify the event as a complication requiring intervention. When information on interventions for complications was unclear or incomplete, we attempted to contact study authors to obtain this information. If we did not receive a response after three attempts, we assumed minor intervention was necessary to treat the complication. For example, we assumed that all cases of failed abortion and retained products of conception required repeat aspiration and that hemorrhage or excessive bleeding and infections were treated on an outpatient basis.

Finally, we did not record complications that occurred more than six weeks following the abortion procedure because the majority of adverse events occur within this time period [15], and the proposed regulations would be most relevant to complications that take place around the time of the procedure. Accordingly, we excluded surveillance studies of abortion-related mortality since deaths within one year of the procedure are included in these reports [13,16,17], and it is not possible to ascertain more specific details on the timing of abortion-related deaths.

2.5. Data synthesis. We calculated the percentage of minor and major complications requiring intervention for each study (or study arm) and compared the percentages for abortions performed in office-based settings to those that took place in ASCs or hospital-based clinics; studies that combined reporting on abortions in both office- and hospital-based settings are

described separately. We did not conduct a meta-analysis given the heterogeneity between studies and instead summarize our primary outcomes in a narrative fashion.

3. Results

Of the 11,369 titles retrieved in our search, 57 studies met our inclusion criteria for the systematic review (Figure 1). Sixteen studies (n= 234,947 abortions) were conducted in office-based clinics (Table 1) [18-33]. Most of these were conducted in the US and Canada where abortions were typically performed using local anesthesia alone or in combination with moderate sedation. Of the 37 ASC or hospital-based studies, 29 (n=26,063 abortions) took place in Western European and Scandinavian countries [34-62], six (n=60,410 abortions) were conducted in the US [63-68], and two (n=16,040 abortions) in Australia/New Zealand [69,70]. Abortions were performed under general anesthesia in all or some cases in the majority (65%) of these studies. Three studies conducted in the United States [71-73] reported on 89,904 abortions performed in office- and hospital-based settings, and the clinic setting was not reported in one study of 20,251 abortions from Finland [74]. Overall, we included 21 prospective cohort studies, 17 RCTs, and 17 retrospective studies; one study combined prospective data collection with a retrospective review of charts for earlier years [69].

3.1 Risk of bias in included studies

Although the majority of studies reported on multiple interventions for minor and major complications, one study reported on every outcome considered in this review [20]; six studies only had information on treatment for infection [37,38,41,44,50,61] and two only reported on interventions for anesthesia-related complications [31,68]. The inclusion and exclusion criteria were clearly defined, but several studies reported excluding women who tested positive for a sexually transmitted infection or recently had been treated with antibiotics. In hospital-based studies, most authors noted that they only included healthy women with uncomplicated

pregnancies or excluded those with a history of or current medical conditions that may increase their risk of experiencing complications during the procedure.

3.2. Repeat aspiration

In 14 office-based studies, <0.1% [30] to 8.0% [22] of abortions required repeat aspiration, primarily for retained products of conception, although Thonneau et al. [24] did not explicitly report this intervention for the 14 women with retained tissue at follow-up (Table 2). Repeat aspiration ranged from 0% [57] to 5.0% [49] in 18 ASC and hospital-based studies, and we assumed reaspiration was needed for incomplete abortion in two of these studies [40,43]. Studies reporting ≥3.0% of abortions requiring repeat aspiration often included a large percentage of women at early gestational ages. For example, in the study with the highest percentage of repeat aspiration, all women were ≤6 weeks' gestation at the time of their office-based procedure [22]. In addition to 21 repeat aspirations performed for retained products of conception, 26 women (4.4%) in this study had continuing pregnancies at follow-up, and repeat aspiration was assumed for these cases. The authors note that clinicians with varying degrees of experience provided early abortion, and some may have been less skilled at performing the procedure and correctly identifying the presence of chorionic villi in the aspirate.

3.3. Minor interventions and transfusion for hemorrhage or excessive bleeding

The percentage of abortions where minor interventions were used to treat hemorrhage ranged from 0% [22,23,27] to 4.7% [26] in 13 office-based studies and 0% [34,57,60,65,70] to 4.1% [45] in 16 hospital-based studies (Table 3). Some authors specified that women experiencing heavy bleeding were treated by reaspirating the uterus or administering uterotonics (e.g., methergine, oxytocin). However, eight studies did not explicitly report treating women with hemorrhage or bleeding [24,29,35,40,52] or only noted that transfusion was not required [28,56,66].

185 The majority of studies in all settings reported that ≤1.0% of procedures required minor
186 interventions for bleeding, and studies in which the percentage was higher likely overestimated
187 the need for intervention. For example, Heisterberg and Kringlebach [45] reported that
188 'pathologic bleeding with or without recurettage' occurred in 4.1% of women having hospital-
189 based abortions in Denmark, but it was not possible to differentiate cases that did and did not
190 require recurettage. Jensen et al [26] reported that 8 of 172 women (4.7%) obtaining abortion
191 care in a US office-based clinic underwent reaspiration for retained products of conception and
192 'persistent bleeding,' but noted reaspiration in some instances may have been due to provider
193 treatment bias and women's low tolerance for expectant management.
194 None of the nine office-based studies, which included 180,465 total abortions, reported
195 incidents of hemorrhage or excessive bleeding requiring transfusion. Of the 12 ASC and
196 hospital-based studies that reported on this intervention, only two reported transfusion was
197 necessary, and each study cited only one case out of 6,093 total abortions [45,56]. A
198 transfusion was necessary in <0.1% of US office- and hospital-based abortions in the third
199 phase of the US-based Joint Program for the Study of Abortion (JPSA-III), [71] and Upadhyay et
200 al's [73] study using Medi-Cal claims, which included a total of 88,755 first-trimester procedures.
201
202 3.4. Administration of outpatient and IV antibiotics for infection
203 In 13 office-based studies, 0% [22,23] to 11.6% [26] of first-trimester aspiration abortions
204 involved infections that were treated with outpatient antibiotics, but in three studies reporting
205 cases of endometritis and pelvic inflammatory disease (PID), treatment was assumed [21,24,29]
206 (Table 4). All women received antibiotic prophylaxis in six office-based studies
207 [19,23,25,26,28,32], and all but one of these six studies reported that ≤2.0% of procedures
208 required outpatient treatment for infection, such as endometritis. In the other study, Jensen et
209 al. [26] noted that most women received a single dose of amoxicillin before or after their

procedure at a US office-based clinic, but 11.6% later reported uterine tenderness, with or without fever, and were presumptively treated for endometritis.

Infection requiring outpatient treatment was more common in hospital-based studies, many of which were conducted in Scandinavian countries in the 1980's. Fourteen of the 23 studies reported ≥5.0% of cases later developed infections requiring outpatient antibiotics, although seven studies did not explicitly report outpatient treatment for non-hospitalized cases of endometritis and PID [36,37,40-42,50,54]. Most studies in which ≥5.0% of women received outpatient treatment for infection noted that women were tested for Chlamydia prior to the procedure, and two provided antibiotic prophylaxis to those with positive results [39,46]. Information on treatment for Chlamydia-positive women was not available in the 1987 study by Heisterberg et al. [44], and only results for Chlamydia negative women, who did not receive prophylaxis, were included in four other studies [36,41,49,50]. Among women randomized to receive antibiotic prophylaxis in three RCTs [35,37,42], there was a lower incidence of PID at follow-up (4.8-5.5%) than for women assigned to the control group (8.6-10.9%). In two more recent ASC and hospital-based studies that provided universal prophylaxis [67] or only treated Chlamydia-positive women [61], infection requiring outpatient treatment was ≤0.4%.

The prevalence of infection requiring IV antibiotics ranged from 0% [19,23,25-28] to 0.4% [21] in 11 of 12 office-based studies (188,395 abortions). The type of infection was not specified in most studies, but one reported <0.1% of women developed pelvic sepsis; women in this study did not receive antibiotic prophylaxis prior to the procedure [20]. In the other office-based study, Bassi et al. [22] reported that 0.9% of women developed endometritis or salpingitis of 'moderate severity' and were hospitalized for treatment following abortion at ≤6 weeks; antibiotic prophylaxis was only provided to women who tested positive for Chlamydia. Infection requiring IV antibiotics, primarily PID, was more common in hospital-based studies (range: 0% [39] to 7.7% [46]), in which universal antibiotic prophylaxis was not routinely provided in older studies. In an RCT that randomized women to antibiotic prophylaxis, 1.0% of women were

treated with IV antibiotics for endometritis or salpingitis, and there was not a significant difference between women who received prophylaxis and those who did not [35]. Nielsen et al. [53] also did not find a significant difference between women randomized to 200mg ofloxacin prophylaxis or placebo, but a higher percentage of women in this study developed PID and received IV antibiotics following first-trimester abortion (1.9-4.7%).

3.5. Minor interventions for cervical or vaginal trauma and major interventions for uterine perforation

In all office-based studies reporting on cervical or vaginal trauma and in the majority of ASC or hospital-based studies, ≤0.1% of abortions required minor intervention for cervical or vaginal trauma (Table 5). In a large Canadian office-based study of 2,908 abortions, one cervical laceration was presumed to require repair [21]. Niinimäki et al. [74] reported 0.6% of abortions in the Finnish registry data had an ICD-10 code for injury, but their classification included cervical laceration as well as uterine perforations and other surgical interventions. In the JPSA-III, Cates et al. [71] reported cervical laceration occurred among 0.5% of teens ≤17 years undergoing first-trimester abortion in office- and hospital-based clinics, but the percentage was lower (0.2-0.3%) for adult women in the same study.

The majority of office- and hospital-based studies reported no cases of uterine perforation or noted that perforations which occurred were managed conservatively without the need for additional surgery or hospitalization. Of the three perforations that occurred among 2,908 abortions in an office-based clinic in Canada, Jacot et al. [21] reported that one woman was kept in the hospital overnight for observation only, and another had the abortion completed under laparoscopic observation but did not require sutures. The third woman had a laparotomy, but her perforation ultimately did not require repair. Uterine perforation in which additional interventions were necessary occurred in ≤0.1% [66,69] to 2.3% [46] of abortions in seven

hospital-based studies. However, only two studies reported >1.0% of cases with a perforation requiring surgical repair, and all six perforations occurred in the control groups (408 abortions) that did not receive laminaria for cervical dilation [46,49].

3.6. Abdominal surgery

Abdominal procedures to address abortion-related complications were required in ≤0.3% of first-trimester abortions in eight office-based studies (182,429 abortions), most of which used laparotomy or laparoscopy to diagnose and repair cases of actual or suspected uterine perforation (Table 6). None reported any woman who had a hysterectomy. In addition to eight cases requiring laparoscopy or laparotomy for uterine perforation, Hakim-Elahi et al [20] reported two ectopic pregnancies that ruptured at the time of the procedure and, in another study, Paul et al [27] mentioned one unrecognized ectopic pregnancy that later ruptured and required surgical intervention.

Two of the seven hospital-based studies reported that >1.0% of procedures in the control groups (408 abortions without laminaria for cervical dilation) required abdominal surgery; these studies also had the highest percentage of uterine perforations [46,49]. In the JPSA-III, Cates et al. [71] reported ≤0.1% of first-trimester abortions required abdominal surgery, and hysterectomy was used in some cases to treat abortion-related complications, such as uterine perforation and hemorrhage. Niinimäki et al. [74] combined ICD-10 codes for surgical interventions with those for cervical lacerations and any uterine perforation in Finnish registry data. The 0.6% of abortions requiring abdominal procedures in that study is likely an overestimate, since another claims-based study reported <0.1% of first-trimester aspiration abortions had a CPT code for an abdominal surgical procedure [73].

287 3.7. Hospitalization

288 Authors reported between 0% [25,26,28] and 2.4% [18] of women were hospitalized for
289 complications following aspiration abortion in 12 office-based studies, with the majority reporting
290 ≤0.5% of women requiring hospitalization (Table 7). Two office-based studies reporting >0.5%
291 of women were hospitalized for suspected retained products of conception provided few details
292 on the complications involved in these cases, making it difficult to determine whether hospital-
293 based care was necessary [18,30]. The majority of hospital-based studies reported ≥1.0% of
294 women hospitalized for complications, and many were conducted in Scandinavian countries in
295 the 1980's and early 1990's. Women in these studies were hospitalized primarily to treat PID or
296 for abdominal procedures; one study did not specify the reasons for hospitalization [54], and two
297 others noted that some women experiencing complications were hospitalized for 'social' or
298 'geographic' reasons, [36,45] suggesting that the percentages reported may not reflect the
299 severity of complications. Studies conducted in the mid 1990's and later reported a lower
300 percentage of women who were hospitalized, and Upadhyay et al's [73] study of 34,755 first-
301 trimester aspiration abortions performed in California between 2009-2010 found that only 0.1%
302 of procedures required hospitalization.

303

304 3.8. Anesthesia-related complications

305 Although most studies we reviewed used anesthesia, only 11 reported on the
306 occurrence of anesthesia-related complications (Table 8). Wilson et al. [31] reported three
307 cases of anesthesia-related complications among 1,249 first-trimester abortion patients (0.2%)
308 receiving local anesthesia with moderate sedation in a US office-based clinic. Seizure-like
309 activity occurred in two cases following administration of local anesthesia, and the oxygen
310 saturation level dropped in a third case; women became responsive soon after administration of
311 supplemental oxygen and reversal agents. No incidents of anesthesia-related complications

were identified in Wiebe et al's [33] review of 43,712 abortions performed with moderate sedation between 1998 and 2010 in office-based clinics in Canada.

Lichtenberg et al [65] reported only one anesthesia-related complication among 200 women randomized to methohexital for general anesthesia (0.5%) at a US-based ASC. The woman had a laryngospasm before a nasopharyngeal airway was inserted and received a respiratory stimulant prophylactically during the procedure. No complications occurred among the 200 women randomized to propofol. In a retrospective review of records from 2001 to 2008 at another US-based ASC, Dean et al. [68] did not identify any anesthesia-related complications among 51,086 first-trimester abortions performed using IV deep sedation. The authors note that women were screened prior to the procedure, and those who were not considered good candidates for deep sedation (e.g., body mass index >40kg/m^2, poorly controlled seizure disorder or asthma) or who did not follow fasting guidelines were referred to a hospital or had the procedure performed using local anesthesia.

3.9. Death

Four office-based studies (214,682 abortions) [20,26,28,33] and two hospital-based studies (8,466 abortions) [52,63] reported no deaths among women undergoing first-trimester aspiration abortion. Niinimäki et al. [74] identified four deaths in the Finnish registry data among 20,251 women who had first-trimester surgical abortions, but none of these deaths were attributable to complications from the procedure.

4. Discussion

From this review of 57 studies, we found that the percentage of first-trimester aspiration abortions that required interventions for minor complications was very low. With few exceptions, 1% or less of procedures resulted in cervical laceration needing sutures or hemorrhage that required medical management. Additionally, repeat aspiration was used in ≤3% of cases in

most studies. The percentage was higher in some older studies of abortion performed in early pregnancy when providers may have had less experience with protocols to verify successful completion of the procedure, and, in studies where experienced clinicians followed current protocols, a lower proportion of procedures required repeat aspiration.

There was wider variation across studies in the prevalence of infections that could be treated with oral antibiotics on an outpatient basis, but the majority of those that provided antibiotic prophylaxis noted that ≤2% of women developed infections following their procedure. The hospital-based studies conducted in Scandinavian countries are notable outliers, documenting considerably higher prevalence of infection than studies in other settings. Although the reasons for this are not clear, the difference may be due to variations in how infections were diagnosed and the fact that these older studies may have used less effective prophylactic regimens. There is now a large evidence base surrounding antibiotic prophylaxis, and its use is recommended for all women seeking first-trimester aspiration abortion by professional practice organizations [75,76]; this likely explains our finding that most studies published in the last 10 years noted that infections occurred following <1% of procedures.

As these studies indicate, when minor complications do occur, they often can be effectively managed in an office setting. For example, bleeding was treated with reaspiration of the uterus or administration of uterotonics, and hemorrhage requiring transfusion was very rare. Although few studies reported on anesthesia-related complications, such complications also were uncommon, and those that did occur were effectively managed with the use of reversal agents and supplemental oxygen at the source of care.

Major complications following first-trimester aspiration abortion were very rare. Unanticipated abdominal procedures and hemorrhage requiring transfusion occurred in ≤0.1% of abortions, and the proportion of patients requiring hospitalization to treat major complications was <0.5% in most studies reviewed. Those that had a higher percentage of women who were hospitalized reported more cases with PID and uterine perforation. Most procedures in these

studies were performed under general anesthesia, which has been associated with a higher incidence of uterine perforation compared to local anesthesia and is infrequently used for first-trimester aspiration abortion in US office-based clinics [11,77]. Furthermore, several of these studies hospitalized some women for reasons other than major complications or for complications that could have been treated in an outpatient setting.

Additionally, we found that the percentage of abortions that resulted in major complications necessitating intervention was not higher in office-based clinics compared to ASCs and hospital-based clinics, but rather was similar across settings. Therefore, legislation requiring facilities where abortions are performed to meet ASC standards is unlikely to lead to measurable improvement in complications from first-trimester aspiration abortion. In cases where a uterine perforation needs to be repaired or hemorrhage requires transfusion, a hospital transfer would be necessary for appropriate management and treatment as this level of care is typically not available in ASCs. It also is unlikely that requiring physicians performing abortions to have admitting privileges at local hospitals would make this procedure safer for women. In the rare event that a hospital transfer is needed, the clinician who is most qualified to treat a woman experiencing a major complication may not be the one who performed the abortion. Furthermore, since the percentage of women requiring hospitalization is very low, physicians will be admitting few (if any) patients, which may make it difficult for them to maintain hospital privileges.

Our review has several limitations. In an effort to include a diverse set of studies, we included some articles with limited information on interventions for complications; authors did not apply a standard definition for abortion-related complications (e.g., hemorrhage), and follow-up after the procedure varied across studies. We were not successful in obtaining clarification from authors in all cases, and therefore, we assumed intervention was required if it was not reported. However, this may mean that we overestimated the need for intervention.

Additionally, few studies reported on abortion-related death, and several articles we identified in our search were excluded because the follow-up period was longer than six weeks. Although it is possible that some deaths were not captured, recent estimates of deaths attributable to complications of abortion that occur within one year of the procedure are very low; the Centers for Disease Control and Prevention's most recent surveillance of abortion-related mortality in the US reported 0.7 deaths per 100,000 abortions – a figure that has remained relatively unchanged for the last two decades [13]. This is comparable to mortality rates due to several other outpatient medical procedures and common activities [78].

Our review indicates that first-trimester aspiration abortion is associated with very few complications requiring additional medical and surgical interventions and can be safely performed in office-based settings. The percentage of complications is comparable to other common office-based procedures, like vasectomy [79], and lower than that reported for procedures routinely performed in ASCs, such as colonoscopy [80]. To ensure that abortion remains safe, reproductive health policies should aim to reduce existing disparities in access to the service [81,82], rather than placing unnecessary restrictions on abortion providers and facilities.

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411

412 **Figure captions.**

413 Figure 1. Summary of study selection process

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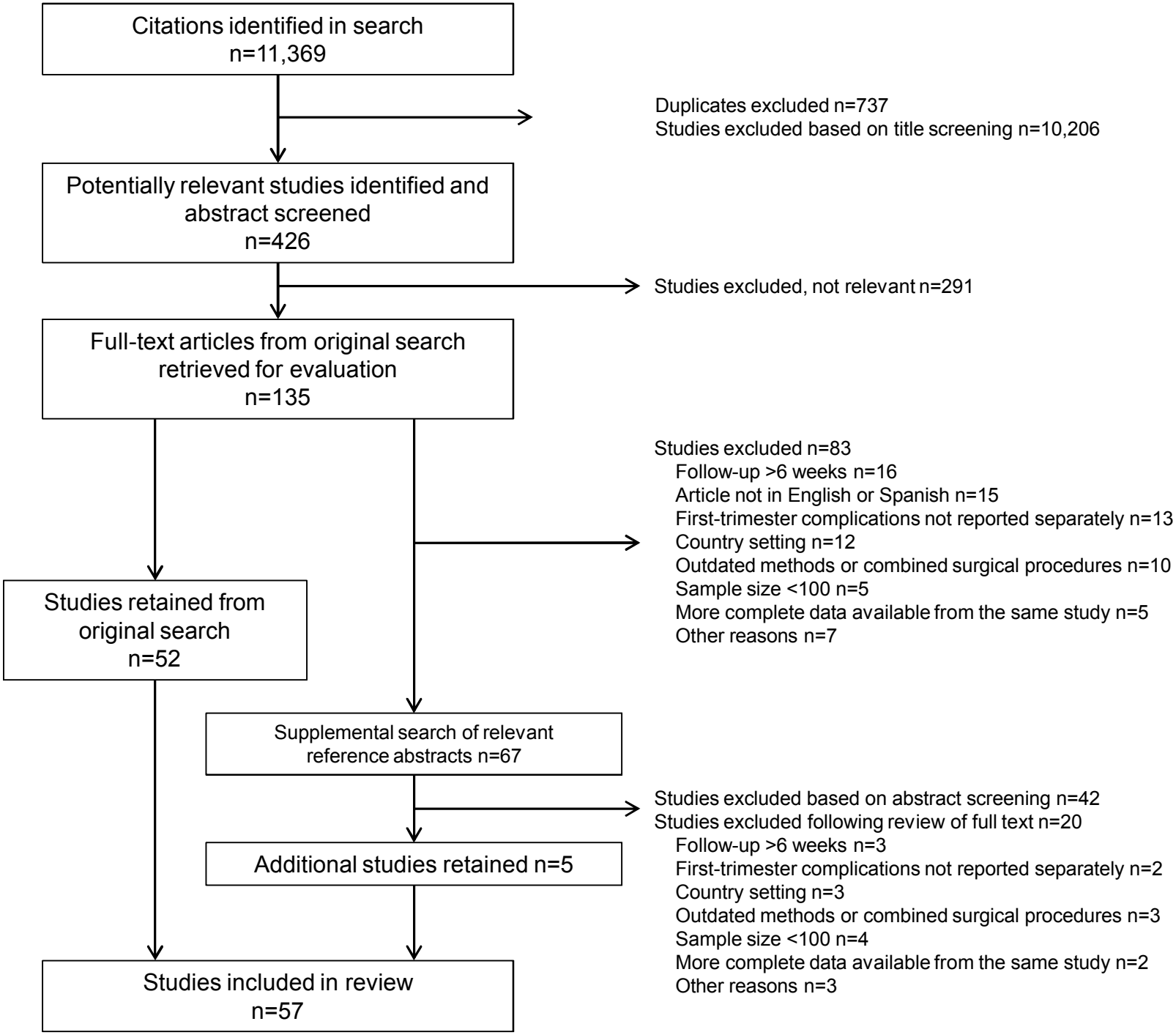
Citations identified in search
n=11,369
Duplicates excluded n=737
Studies excluded based on title screening n=10,206
Potentially relevant studies identified and abstract screened
n=426
Studies excluded, not relevant n=291
Full-text articles from original search retrieved for evaluation
n=135
Studies excluded n=83
Follow-up >6 weeks n=16
Article not in English or Spanish n=15
First-trimester complications not reported separately n=13
Country setting n=12
Outdated methods or combined surgical procedures n=10
Sample size <100 n=5
More complete data available from the same study n=5
Other reasons n=7
Studies retained from original search
n=52
Supplemental search of relevant reference abstracts n=67
Studies excluded based on abstract screening n=42
Studies excluded following review of full text n=20
Follow-up >6 weeks n=3
First-trimester complications not reported separately n=2
Country setting n=3
Outdated methods or combined surgical procedures n=3
Sample size <100 n=4
More complete data available from the same study n=2
Other reasons n=3
Additional studies retained n=5
Studies included in review
n=57

Table 1. Studies of complications from first-trimester aspiration abortion included in the systematic review

Author, year	Study design, location	Study population	Gestational age	Antibiotic prophylaxis	Level of sedation
Office-based clinics					
Marshall et al. [18], 1980	Retrospective cohort study, United States	543 women age not reported	≤8 weeks	If Chlamydia positive; regimen not specified	Local anesthesia
Meyer [19], 1983	Prospective cohort study, United States	454 women (age 12-43 yrs); 415 with follow up	≤9 weeks	All women; tetracycline (5 days), dosing regimen not specified	Local anesthesia
Hakim-Elahi et al. [20], 1990	Retrospective cohort study, United States	170,000 women age not reported	5-14 weeks	None	Local anesthesia, some also had general anesthesia
Jacot et al. [21], 1993	Retrospective cohort study, Canada	3,225 women (mean age 24.3 yrs); 2,908 with follow-up	≤14 weeks	If history of PID: 100mg doxycycline (twice a day, 3 days) before procedure; If Chlamydia or Gonorrhea positive: 100mg doxycycline (twice a day, 3-7 days) after the procedure	Local anesthesia and mild sedation
Bassi et al. [22], 1994	Prospective cohort study France	778 women (mean age 28.4 yrs), 584 with follow-up	≤6 weeks	If Chlamydia positive; regimen not specified	None
Edwards & Creinin [23], 1997	Prospective cohort study, United States	2,399 women, age not reported	<6 weeks	All women; 100mg doxycycline (twice a day, 7 days)	Local anesthesia and moderate sedation
Thonneau et al. [24], 1998	Prospective cohort study, France	858 women (mean age 28.4 yrs), 683 with follow-up	6-12 weeks	If Chlamydia positive; regimen not specified	Local anesthesia
Westfall et al. [25], 1998	Retrospective cohort study, United States	1,677 women (ages <15 and >39 yrs),	≤12 weeks	All women; doxycycline, dosing regimen not specified	Local anesthesia with moderate sedation

Jensen et al. [26], 1999	Prospective cohort study,[a] United States	199 women (mean age 26.2 yrs), 172 with follow up	≤9 weeks	Most women; amoxicillin (single dose)	Moderate/ deep sedation
Paul et al. [27], 2002	Prospective cohort study, United States	1,132 women (mean age 27.0 yrs), 750 with follow up	<6 weeks	NR	Local, with or without moderate sedation
Goldman et al. [28], 2004	Prospective cohort study,[b] United States	798 women (age ≤20 & ≥45 yrs)	≤12 weeks	All women; 100mg doxycycline (twice a day, 7 days)	Local
Charonis & Larsson [29], 2006	Prospective cohort study, Sweden	324 women, age not reported	<13 weeks	If Chlamydia positive: 1g azithromycin If bacterial vaginosis: clindamycin cream or metronidazole tablets (regimen not specified)	NR
Goodyear-Smith et al. [30], 2006	Retrospective cohort study,[c] New Zealand	2,921 women, (age 11->40 yrs)	≤12 weeks	Administration of prophylaxis varied across providers; regimen not specified	Local anesthesia in most cases
Wilson et al. [31], 2009	Retrospective cohort study,[d] United States	1,249 women (mean age 23.5 yrs);	≤12 weeks	NR	Local anesthesia and moderate sedation
Weitz et al. [32], 2013	Prospective cohort study,[e] United States	5,812 women (mean age 25.7 yrs);	≤14 weeks	All women; regimen not specified	Local anesthesia and moderate sedation
Wiebe et al. [33], 2013	Retrospective cohort study,[f] Canada	43,712 women (mean age 26.5 yrs)	≤12 weeks	NR	Local anesthesia and moderate sedation
		ASC and Hospital-based clinics			
Dalaker et al. [34], 1981	Prospective cohort study, Norway	381 primigravidae women (age ≤16 & ≥25 yrs)	<10 weeks	None	General anesthesia
Krohn [35], 1981	RCT, Sweden	210 women (age 14-43 yrs);	≤12 weeks	Intervention arm: 2g tinidazole	Local or general anesthesia

		Intervention (n=104): tinidazole; Control (n=106): placebo			
Meirik et al. [36], 1981	RCT,[g] Sweden	291 women (mean age 27.4 yrs)	≤12 weeks	None	NR
Sonne-Holm et al. [37], 1981	RCT, Denmark	493 women (age 14-45 yrs), Intervention (n=254): penicillin; Control (n=239): placebo	≤12 weeks	Intervention arm: 2 million IU penicillin (intramuscular) before and 350mg pivampicillin (3 times a day, 4 days) after the procedure	NR
Weström et al. [38], 1981	RCT, Sweden	212 women (ages 15->39 yrs), Intervention (n=102): tinidazole; Control (n=110): placebo	6-12 weeks	Intervention arm: 2g tinidazole (single dose)	General anesthesia
Marshall et al. [63],1982	Retrospective cohort study, United States	260 women (mean age 25 yrs)	≤12 weeks	Administration of prophylaxis (tetracycline or ampicillin, 4 days) varied across providers; dosing regimen not specified	Local anesthesia with or without moderate sedation
Westergaard et al. [39], 1982	Prospective cohort study, Denmark	333 women (age 15-46 yrs), 270 with follow-up	6-12 weeks	If Chlamydia positive: ampicillin; dosing regimen not specified	General anesthesia
Jonasson et al. [40], 1984	RCT,[h] Sweden	102 primigravidae women (age 13-33 yrs)	gestational age range not specified	NR	NR
Heisterberg et al. [41], 1985	RCT, Denmark	532 women, Intervention (n=269): lymecycline; Control	≤12 weeks	Intervention arm: 300mg lymecycline (twice a day, 7 days)	General anesthesia

		(n=263): placebo			
Krohn [42], 1986	RCT, Sweden	285 women, (age 15-44 yrs); Intervention (n=145): sulbactam/ ampicillin; Control (n=140): placebo	gestational age range not specified	Intervention arm: 0.5g sulbactam/ 1g ampicillin	Local or general anesthesia
Duthie et al. [43], 1987	Prospective cohort study, England	167 women, age not reported	gestational age range not specified	None	General anesthesia
Heisterberg et al. [44], 1987	Prospective cohort study, Denmark	129 women (age 18-34 yrs)	≤12 weeks	NR	General anesthesia
Heisterberg & Kringelbach [45], 1987	Retrospective cohort study, Denmark	5,851 women (age ≤19 & ≥45 yrs)	≤12 weeks	NR	General anesthesia
Bryman et al. [46], 1988	RCT Sweden	245 women (age 15-30 yrs) Intervention (n=115): laminaria tents; Control (n=130): manual dilation	7-12 weeks	If Chlamydia positive: doxycycline (10 days); dosing regimen not specified	General anesthesia
Skjeldestad & Dalen [47], 1988	Prospective cohort study, Norway	769 women (age ≤19 and >30)	Gestational age range not specified	NR	General anesthesia
Bokström & Wiqvist [48], 1989	RCT,[i] Sweden	375 women (mean age 22.7-23.8 yrs) Intervention 1 (n=200): 4mm Dilapan, 3-4 hrs; Intervention 2 (n=175): 3mm Dilapan, 16-20 hrs	10-12 weeks	If Chlamydia positive; doxycycline (10 days), dosing regimen not specified	General anesthesia
Jonasson et al. [49], 1989	RCT,	519 women	5-12 weeks	NR	General

	Sweden	(age ≤20 and >40 yrs); Intervention (n=241): laminaria tent for cervical dilation; Control (n=278): manual dilation			anesthesia
Kaali et al. [64], 1989	Prospective cohort study,[j] United States	6,408 women (mean age 21 yrs)	gestational age range not specified	NR	Local anesthesia (11%), General anesthesia (89%)
Osser & Persson [50], 1989	Prospective matched cohort study,[k] Sweden	138 women (age 15-42 yrs)	<14 weeks	None	General anesthesia
Hill & Mackenzie [51], 1990	Retrospective cohort study,[l] England	265 women (mean age 27.2 yrs)	4-8 weeks	NR	Local anesthesia
Osborn et al. [52], 1990	Retrospective cohort study,[m] Italy	8,206 women age not reported	<11 weeks	NR	Local anesthesia (72%); General anesthesia (28%)
Nielsen et al. [53], 1993	Stratified RCT Denmark	1,073 women (age >18 yrs), low PID risk intervention (n=376): ofloxacin; high PID risk intervention (n=149): ofloxacin; low PID risk control (n=389): no antibiotics; high PID risk control (n=159): no antibiotics	gestational age range not specified	Intervention arms: 200mg ofloxacin (single dose)	General anesthesia
Henriques et al. [54], 1994	Stratified RCT, Denmark	786 women (mean age 23.9-	≤12 weeks	Intervention arm (low & high PID risk): 1g	Not specified

		26.0 yrs), low PID risk intervention (n=275): ceftriaxone injection; high PID risk intervention (n=108): ceftriaxone injection; low PID risk control (n=274): no antibiotics; high PID risk control (n=129): ampicillin/ metronidazole		ceftriaxone injection Control arm (high PID risk): 1g ampicillin + 500mg metronidazole (intravenous) before and 500mg metronidazole + 500mg pivampicillin (three times a day, 4 days) after the procedure	
Mikkelsen & Felding [55], 1994	Prospective cohort study, Denmark	117 women (age 18-48 yrs)	7-12 weeks	NR	General anesthesia
Pridmore & Chambers [69], 1999	Retrospective (1992-1996) and prospective (1996-1998) cohort studies,[n] Australia	12,040 women age not reported	≤12 weeks	NR	Local and general anesthesia
Ashok et al. [56], 2002	Partially-randomized patient-preference trial,[o] Scotland	242 women (mean age 24.8, 26.0 yrs) Preference surgical (n=62); Randomized surgical (n=180)	10-13 weeks	If Chlamydia positive: regimen not specified	General anesthesia
Lichtenberg et al. [65], 2003	RCT, United States	400 women (mean age 25.8, 26.7, yrs); Intervention 1 (n=200): methohexital; Intervention 2 (n=200): propofol	4-14 weeks	NR	General anesthesia

Celentano et al. [57], 2004	Prospective cohort study,[p] Italy	662 nulliparous women, age not reported	<13 weeks	NR	General anesthesia
Goldberg et al. [66], 2004	Retrospective cohort study, United States	1,726 women (mean age 26 yrs); Intervention 1 (n=1,002) manual vacuum aspiration; Intervention 2 (n=724) electric vacuum aspiration	≤10 weeks	All women; doxycycline, regimen not specified	Local anesthesia and moderate sedation
Lichtenberg & Shott [67], 2004	RCT, United States	530 women (mean age 26.6 yrs); Intervention (n=273): 3-day doxycycline; Control (n=257): 7-day doxycycline	≤13 weeks	Intervention arm: 100mg doxycycline (twice a day, 3 days) Control arm: 100mg doxycycline (twice a day, 7 days)	Local or general anesthesia
Oppegaard et al. [58], 2004	RCT, Norway	551 women (mean age 26.4, 26.5 yrs); Intervention 1 (n=276): 400mcg oral misoprostol for cervical dilation; Intervention 2 (n=275): 200mcg oral misoprostol for cervical dilation	7-12 weeks	NR	NR
Chambers et al. [70], 2009	Retrospective cohort study, Australia	4,000 women, Cohort 1 (n=1,000): no misoprostol for cervical dilation; Cohort 2 (n=1,000): 200mcg oral misoprostol for	≤11 weeks	None	Local anesthesia, with or without deep sedation

		cervical dilation; Cohort 3 (n=1,000): 200mcg sublingual misoprostol for cervical dilation; Cohort 4 (n=1,000): 200mcg oral + 200mcg vaginal misoprostol for cervical dilation			
Díaz Blanco [59], 2009	Prospective cohort study, Spain	1,600 women, age not reported	Gestational age range not specified	All women; 100mg doxycycline (twice a day, 4 days)	Local anesthesia
Dean et al. [68], 2011	Retrospective cohort study,[q] United States	51,086 women (age 12-56 yrs)	≤12 weeks	NR	Deep sedation
Nygaard et al. [60], 2011	RCT, Norway	309 women (median age 27.2, 28.1 yrs), Intervention (n=164): oxytocin prior to procedure; Control (n=145): no oxytocin	≤12 weeks	NR	General anesthesia
Lavoué et al. [61], 2012	Retrospective cohort study, France	978 women, (mean age 26.6 yrs)	Gestational age range not specified	If Chlamydia positive; 1g azithromycin (single dose)	NR
Pillai et al. [62], 2015	Prospective cohort study,[r] England	305 women (age 15-45 yrs)	<13 weeks	NR	Local anesthesia
		Office- and Hospital-based clinics			
Cates et al. [71], 1983	Prospective cohort study,[s] United States	54,000 women	≤12 weeks	Administration of prophylaxis varied across institutions; regimen not specified	Local anesthesia, with some women also undergoing general anesthesia

Niinimäki et al. [74], 2009	Retrospective cohort study,[t] Finland	20,251 women (mean age 26.0 yrs),	≤9 weeks	NR	NR
Bennett et al. [72], 2010	Prospective cohort study United States	1,149 women (age 15-30+ yrs),	≤12 weeks	All women; 200mg doxycycline (twice a day, 3 days)	Local anesthesia
Upadhyay et al. [73], 2015	Retrospective cohort study,[u] United States	34,755 abortions (mean age 25.1 yrs)	≤14 weeks	NR	NR

ASC: ambulatory surgical center; RCT: randomized controlled trial; PID: pelvic inflammatory disease; NR: not reported; IU: international units

a. Excludes women obtaining medical abortion (n=178).
b. Excludes women who had an abortion performed by physician assistants (n=546) or who were ≥13 weeks' gestation (n=19).
c. Excludes women obtaining medical abortion (n=380).
d. Excludes women ≥13 weeks' gestational age (n=178) or who were missing information on gestation age (n=6).
e. Excludes women who had an abortion performed by advanced practice clinicians (n=5,675).
f. Excludes women ≥12 weeks' gestational age (n=3,714).
g. Excludes women who received antibacterial vaginal jelly (n=199).
h. Excludes women randomized to the control (no cervical priming; n=96).
i. Excludes women who received 4mm Dilapan tent at home for 16-20 hours (n=50) or who received 3mm Dilapan tent at the hospital for 3-4 hours (n=25).
j. Excludes women who had concurrent laparoscopic sterilization (n=706).
k. Excludes chlamydia positive women (n=69) who were age-matched to the chlamydia negative women.
l. Excludes women who had prostaglandin instillation (n=820).
m. Excludes women ≥11 weeks' gestation (n=1,485) since no upper gestational age limit was reported in the study.
n. Excludes women ≥13 weeks' gestational age (n=1,925).
o. Excludes women who expressed a preference for medical abortion (n=15) or were randomized to medical abortion (n=188).
p. Excludes women who received intravaginal gemeprost (n=84).
q. Excludes women ≥13 weeks' gestational age (n=11,039).
r. Excludes medical abortions (n=680) and women who did not undergo manual vacuum aspiration (n=899)
s. Excludes abortions performed between 1971-1975 since complications were defined differently in that study period.
t. Excludes women obtaining medical abortion (n=22,368).
u. Excludes medical abortions (n=11,319) and second-trimester or later procedures (n=8,837).

Table 2. Studies reporting repeat aspiration for minor complications following first-trimester aspiration abortion

Office-based clinics		ASC and Hospital-based clinics		Office- and Hospital-based clinics	
Study	%	Study	%	Study	%
Marshall et al. [18], 1980	3.9	Krohn [35], 1981 (tinidazole)	0	Niinimaki et al. [74], 2009	1.8
Meyer [19], 1983	0.2	Krohn [35], 1981 (no prophylaxis)	0.9	Bennett et al. [72], 2010	2.2
Hakim-Elahi et al. [20], 1990	0.4	Marshall et al. [63], 1982	3.5	Upadhyay et al. [73], 2015	0.8
Jacot et al. [21], 1993	0.9	Westergaard et al. [39], 1982	3.7		
Bassi et al. [22], 1994	8.0	Jonasson et al. [40], 1984	1.0		
Edwards & Creinin [23], 1997	0.2	Duthie et al. [43], 1987	1.8		
Thonneau et al. [24], 1998	0.6	Heisterberg & Kringelbach [45], 1987	2.9		
Westfall et al. [25], 1998	0.5	Skjeldestad & Dalen [47], 1988	3.2		
Jensen et al. [26], 1999	4.7	Jonasson et al. [49], 1989 (laminaria)	1.7		
Paul et al. [27], 2002	3.1	Jonasson et al. [49], 1989 (no laminaria)	5.0		
Goldman et al. [28], 2004	0.2	Hill & MacKenzie [51], 1990	1.5		
Charonis & Larsson [29], 2006	1.9	Mikkelsen & Felding [55], 1994	4.3		
Goodyear-Smith et al. [30], 2006	<0.1	Ashok et al. [56], 2002*	2.1		
Weitz et al. [32], 2013	0.2	Celentano et al. [57], 2004	0		
		Goldberg et al. [66], 2004 (MVA)	2.2		
		Goldberg et al. [66], 2004 (EVA)	1.7		

Lichtenberg & Shott [67], 2004 (3-day doxycycline)	1.8
Lichtenberg & Shott [67], 2004 (7-day doxycycline)	2.3
Oppegaard et al. [58], 2004 (400mcg misoprostol)	0
Oppegaard et al. [58], 2004 (200mcg misoprostol)	0.4
Chambers et al. [70], 2009 (no misoprostol)	0.5
Chambers et al. [70], 2009 (oral misoprostol)	0.4
Chambers et al. [70], 2009 (sublingual misoprostol)	0.2
Chambers et al. [70], 2009 (oral & vaginal misoprostol)	0.2
Díaz Blanco [59], 2009	<0.1
Pillai et al. [62], 2015	0.3

ASC: ambulatory surgical center; MVA: manual vacuum aspiration; EVA: electric vacuum aspiration

* Only interventions for complications that occurred ≤2 weeks following aspiration abortion are reported here.

Table 3. Studies reporting hemorrhage requiring minor interventions and transfusion following first-trimester aspiration abortion

Office-based clinics			ASC and Hospital-based clinics			Office- and Hospital-based clinics		
Study	Minor (%)	Trans-fusion (%)	Study	Minor (%)	Trans-fusion (%)	Study	Minor (%)	Trans-fusion (%)
Marshall et al. [18], 1980	0.5	NR	Dalaker et al. [34], 1981	0	0	Cates et al. [71], 1983[†]	0.2-0.3	<0.1
Meyer [19], 1983	0.2	0	Krohn [35], 1981 (tinidazole)	1.9	NR	Niinimäki et al. [74], 2009	2.1	NR
Hakim-Elahi et al. [20], 1990	<0.1	0	Krohn [35], 1981 (no prophylaxis)	0.9	NR	Bennett et al. [72], 2010	0.4	0
Jacot et al. [21], 1993	0.3	NR	Meirik et al. [36], 1981	NR	0	Upadhyay et al. [73], 2015	0.1	<0.1
Bassi et al. [22], 1994	0	0	Marshall et al. [63], 1982	3.8	NR			
Edwards & Creinin [23], 1997	0	NR	Westergaard et al. [39], 1982	3.7	0			
Thonneau et al. [24], 1998	0.7	0	Jonasson et al. [40], 1984	2.0	NR			
Westfall et al. [25], 1998	2.0	0	Heisterberg & Kringelbach [45], 1987	4.1	<0.1			
Jensen et al. [26], 1999	4.7	0	Hill & MacKenzie [51], 1990	1.1	0			
Paul et al. [27], 2002	0	NR	Osborn et al. [52], 1990	0.2	0			
Goldman et al. [28], 2004	0.1	0	Ashok et al. [56], 2002[*]	0.4	0.4			
Charonis & Larsson [29], 2006	0.3	0	Lichtenberg et al. [65], 2003 (methohexital)	0	0			
Weitz et al. [32], 2013	<0.1	0	Lichtenberg et al. [65], 2003 (propofol)	0	0			
			Celentano et al. [57], 2004	0	0			
			Goldberg et al. [66], 2004 (MVA)	0.7	0			

Goldberg et al. [66], 2004 (EVA)	1.0	0
Chambers et al. [70], 2009 (no misoprostol)	0	0
Chambers et al. [70], 2009 (oral misoprostol)	0	0
Chambers et al. [70], 2009 (sublingual misoprostol)	0	0
Chambers et al. [70], 2009 (oral & vaginal misoprostol)	0	0
Nygaard et al. [60], 2011 (oxytocin)	0	0
Nygaard et al. [60], 2011 (no oxytocin)	0	0
Pillai et al. [62], 2015	0.3	NR

Minor interventions include administration of uterotonics, reaspiration, balloon tamponade.

ASC: ambulatory surgical center; MVA: manual vacuum aspiration; EVA: electric vacuum aspiration; NR: not reported

* Only interventions for complications that occurred ≤2 weeks following aspiration abortion are reported here.
† Authors reported complications separately by age group. The minimum and maximum percentages reported are presented here.

Table 4. Studies reporting infections requiring outpatient and intravenous (IV) administration of antibiotics following first-trimester aspiration abortion

Office-based clinics			ASC and Hospital-based clinics			Office- and Hospital-based clinics		
Study	Out-patient (%)	IV (%)	Study	Out-patient (%)	IV (%)	Study	Out-patient (%)	IV (%)
Marshall et al. [18], 1980	1.8	0.2	Krohn [35], 1981 (tinidazole)	4.8	1.0	Niinimäki et al. [74], 2009	1.7	<0.1
Meyer [19], 1983	1.3	0	Krohn [35], 1981 (no prophylaxis)	9.4	1.0	Bennett et al. [72], 2010	0.1	NR
Hakim-Elahi et al. [20], 1990	0.5	<0.1	Meirik et al. [36], 1981	5.8	6.9	Upadhyay et al. [73], 2015	0.2	<0.1
Jacot et al. [21], 1993	3.0	0.4	Sonne-Holm et al. [37], 1981 (penicillin/pivampicillin)	5.5	NR			
Bassi et al. [22], 1994	0	0.9	Sonne-Holm et al. [37], 1981 (no prophylaxis)	10.9	NR			
Edwards & Creinin [23], 1997	0	0	Weström et al. [38], 1981 (tinidazole)	9.8	NR			
Thonneau et al. [24], 1998	0.6	NR	Weström et al. [38], 1981 (no prophylaxis)	15.4	NR			
Westfall et al. [25], 1998	0.7	0	Marshall et al. [63], 1982	1.9	NR			
Jensen et al. [26], 1999	11.6	0	Westergaard et al. [39], 1982	11.8	0			
Paul et al. [27], 2002	0.5	0	Jonasson et al. [40], 1984	10.8	NR			
Goldman et al. [28], 2004	2.0	0	Heisterberg et al. [41], 1985 (lymecycline)	9.3	NR			
Charonis & Larsson [29], 2006	4.9	NR	Heisterberg et al. [41], 1985 (no prophylaxis)	9.5	NR			
Goodyear-Smith et al. [30], 2006	NR	0.1	Krohn [42], 1986 (sulbactam/ampicillin)	4.8	NR			
Weitz et al. [32], 2013	0.1	<0.1	Krohn [42], 1986 (no prophylaxis)	8.6	NR			
			Duthie et al. [43],	4.2	NR			

1987		
Heisterberg et al. [44], 1987	10.9	NR
Heisterberg & Kringelbach [45], 1987	3.2	NR
Bryman et al. [46], 1988 (laminaria)	1.7	0
Bryman et al. [46], 1988 (no laminaria)	5.4	7.7
Skjeldestad & Dalen [47], 1988	NR	1.4
Jonasson et al. [49], 1989 (laminaria)	1.2	1.7
Jonasson et al. [49], 1989 (no laminaria)	5.8	6.5
Osser & Persson [50], 1989	6.5	NR
Hill & MacKenzie [51], 1990	0	2.3
Nielsen et al. [53], 1993 (no PID history, ofloxacin)	6.6	2.7
Nielsen et al. [53], 1993 (PID history, ofloxacin)	8.7	4.7
Nielsen et al. [53], 1993 (no PID history, no prophylaxis)	8.7	3.1
Nielsen et al. [53], 1993 (PID history, no prophylaxis)	15.1	1.9
Henriques et al. [54], 1994 (low PID risk, ceftriaxone)	2.5	NR
Henriques et al [54], 1994 (high PID risk, ceftriaxone)	4.6	NR
Henriques et al. [54], 1994 (low PID risk, no prophylaxis)	4.0	NR
Henriques et al. [54], 1994	5.4	NR

(high PID risk, ampicillin/metronidazole)		
Mikkelsen & Felding [55], 1994	0	NR
Lichtenberg & Shott [67], 2004 (3-day doxycycline)	0	NR
Lichtenberg & Shott [67], 2004 (7-day doxycycline)	0.4	NR
Chambers et al. [70], 2009 (no misoprostol)	0.2	NR
Chambers et al. [70], 2009 (oral misoprostol)	0.1	NR
Chambers et al. [70], 2009 (sublingual misoprostol)	0.1	NR
Chambers et al. [70], 2009 (oral & vaginal misoprostol)	0.0	NR
Lavoué et al. [61], 2012	0.4	NR
Pillai et al. [62], 2015	0.3	NR

ASC: ambulatory surgical center; MVA: manual vacuum aspiration; EVA: electric vacuum aspiration; PID: pelvic inflammatory disease; NR: not reported

Table 5. Studies reporting minor interventions for cervical/vaginal trauma and major interventions for uterine perforation following first-trimester aspiration abortion

Office-based clinics			ASC and Hospital-based clinics			Office- and Hospital-based clinics		
Study	Minor (%)	Major (%)	Study	Minor (%)	Major (%)	Study	Minor (%)	Major (%)
Marshall et al. [18], 1980	NR	0	Dalaker et al. [34], 1981	0	0	Cates et al. [71], 1983†	0.2-0.5	<0.1-0.2
Meyer et al. [19], 1983	NR	0.2	Meirik et al. [36], 1981	0	0	Niinimäki et al. [74], 2009	0.6	0.6
Hakim-Elahi et al. [20], 1990	<0.1	<0.1	Marshall et al. [63], 1982	0	0	Bennett et al. [72], 2010	0	0
Jacot et al. [21], 1993	<0.1	0.1	Westergaard et al. [39], 1982	NR	0	Upadhyay et al. [73], 2015	NR	<0.1
Bassi et al. [22], 1994	0	0	Jonasson et al. [40], 1984	NR	0			
Edwards & Creinin [23], 1997	0	0	Heisterberg & Kringelbach [45], 1987	0.1	0.4			
Thonneau et al. [24], 1998	NR	0	Bryman et al. [46], 1988 (laminaria)	NR	0			
Westfall et al. [25], 1998	0	0	Bryman et al. [46], 1988 (no laminaria)	NR	2.3			
Paul et al. [27], 2002	0	0	Skjeldestad & Dalen [47], 1988	NR	0			
Goldman et al. [28], 2004	0	0	Bokström et al. [48], 1989 (Dilapan at hospital)	0	0			
Goodyear-Smith et al. [30], 2006	NR	<0.1	Bokström et al. [48], 1989 (Dilapan at home)	0	0			
Weitz et al. [32], 2013	<0.1	<0.1	Jonasson et al. [49], 1989 (laminaria)	0	0			
			Jonasson et al. [49], 1989 (no laminaria)	0.4	1.1			
			Kaali et al. [64], 1989	NR	0			
			Hill & MacKenzie [51], 1990	0	0.7			

Pridmore & Chambers [69], 1999	NR	<0.1
Celentano et al. [57], 2004	0	0
Goldberg et al. [66], 2004 (MVA)	0	0‡
Goldberg et al. [66], 2004 (EVA)	0	0.1‡
Oppegaard et al. [58], 2004 (400mcg misoprostol)	0.4	0
Oppegaard et al. [58], 2004 (200mcg misoprostol)	0.4	0
Chambers et al. [70], 2009 (no misoprostol)	0	0
Chambers et al. [70], 2009 (oral misoprostol)	0	0
Chambers et al. [70], 2009 (sublingual misoprostol)	0	0
Chambers et al. [70], 2009 (oral & vaginal misoprostol)	0	0
Nygaard et al. [60], 2011 (oxytocin)	NR	0
Nygaard et al. [60], 2011 (no oxytocin)	NR	0
Díaz Blanco [59], 2009	0	0
Pillai et al. [62], 2015	NR	0.3

Minor interventions for cervical/vaginal trauma include sutures for lacerations. Major interventions for uterine perforation include hospitalization or surgical repair.

ASC: ambulatory surgical center; MVA: manual vacuum aspiration; EVA: electric vacuum aspiration; NR: not reported

† Authors reported complications separately by age group. The minimum and maximum percentages reported are presented here.

‡ Authors reported one additional uterine perforation that required diagnostic laparoscopy but did not need to be repaired. This patient was excluded from the overall sample because she underwent manual and later electric vacuum aspiration.

Table 6. Studies reporting abdominal surgery following first-trimester aspiration abortion

Office-based clinics		ASC and Hospital-based clinics		Office- and Hospital-based clinics	
Study	%	Study	%	Study	%
Marshall et al. [18], 1980	0	Bryman et al. [46], 1988 (laminaria)	0	Cates et al. [71], 1983†	≤0.1
Meyer et al. [19], 1983	0.2	Bryman et al. [46], 1988 (no laminaria)	2.3	Niinimäki et al. [74], 2009	0.6
Hakim-Elahi et al. [20], 1990	<0.1	Jonasson et al. [49], 1989 (laminaria)	0	Upadhyay et al. [73], 2015	<0.1
Jacot et al. [21], 1993	0.1	Jonasson et a.l [49], 1989 (no laminaria)	1.1		
Westfall et al. [25], 1998	0	Kaali et al. [64], 1989	0		
Paul et al. [27], 2002	0.1	Hill & MacKenzie [51], 1990	0.7		
Charonis & Larsson [29], 2006	0.3	Pridmore & Chambers [69], 1999	<0.1		
Weitz et al. [32], 2013	0	Goldberg et al. [66], 2004 (MVA)	0‡		
		Goldberg et al. [66], 2004 (EVA)	0.1‡		
		Pillai et al. [62], 2015	0.3		

ASC: ambulatory surgical center; MVA: manual vacuum aspiration; EVA: electric vacuum aspiration

† Authors reported complications separately by age group. The minimum and maximum percentages reported are presented here.
‡ Authors reported one additional uterine perforation that required diagnostic laparoscopy but did not need to be repaired. This patient was excluded from the overall sample because she underwent manual and later electric vacuum aspiration.

Table 7. Studies reporting hospitalization following first-trimester aspiration abortion

Office-based clinics		ASC and Hospital-based clinics		Office- and Hospital-based clinics	
Study	**%**	**Study**	**%**	**Study**	**%**
Marshall et al. [18], 1980	2.4	Krohn [35], 1981 (tinidazole)	1.0	Bennett et al. [72], 2010	0
Meyer et al. [19], 1983	0.2	Krohn [35], 1981 (no prophylaxis)	1.0	Upadhyay et al. [73], 2015	0.1
Hakim-Elahi et al. [20], 1990	0.1	Meirik et al. [36], 1981	6.9		
Jacot et al. [21], 1993	0.5	Heisterberg & Kringelbach [45], 1987	6.1		
Bassi et al. [22], 1994	0.9	Bryman et al. [46], 1988 (laminaria)	0		
Westfall et al. [25], 1998	0	Bryman et al. [46], 1988 (no laminaria)	7.7		
Jensen et al. [26], 1999	0	Skjeldestad & Dalen [47], 1988	4.8		
Paul et al. [27], 2002	0.1	Jonasson et al. [49], 1989 (laminaria)	1.7		
Goldman et al. [28], 2004	0	Jonasson et al. [49], 1989 (no laminaria)	7.5		
Charonis & Larsson [29], 2006	0.3	Hill & MacKenzie [51], 1990	3.0		
Goodyear-Smith et al. [30], 2006	0.6	Nielsen et al. [53], 1993 (no PID history, ofloxacin)	2.7		
Weitz et al. [32], 2013	0.1	Nielsen et al. [53], 1993 (PID history, ofloxacin)	4.7		
		Nielsen et al. [53], 1993 (no PID history, no prophylaxis)	3.1		
		Nielsen et al. [53], 1993 (PID history, no prophylaxis)	1.9		
		Henriques et al. [54], 1994 (low PID risk, ceftriaxone)	4.0		
		Henriques et al. [54], 1994 (high PID risk, ceftriaxone)	8.3		

Henriques et al. [54], 1994 (low PID risk, no prophylaxis)	4.4
Henriques et al. [54], 1994 (high PID risk, ampicillin/metronidazole)	7.7
Pridmore & Chambers [69], 1999	<0.1
Ashok et al. [56], 2002*	0.4
Celentano et al. [57], 2004	0
Goldberg et al. [66], 2004 (MVA)	0
Goldberg et al. [66], 2004 (EVA)	0.1

ASC: ambulatory surgical center; MVA: manual vacuum aspiration; EVA: electric vacuum aspiration; PID: pelvic inflammatory disease

* Only interventions for complications that occurred ≤2 weeks following aspiration abortion are reported here.

Table 8. Studies of first-trimester aspiration abortion reporting anesthesia-related complications

Office-based clinics		ASC and Hospital-based clinics		Office- and Hospital-based clinics	
Study	%	Study	%	Study	%
Hakim-Elahi et al. [20], 1990	<0.1	Westergaard et al. [39], 1982	0	Upadhyay et al. [73], 2015	<0.1
Westfall et al. [25], 1998	0	Lichtenberg et al. [65], 2003 (methohexital)	0.5		
Goldman et al. [28], 2004	0	Lichtenberg et al. [65], 2003 (propofol)	0		
Wilson et al. [31], 2009	0.2	Dean et al. [68], 2011	0		
Weitz et al. [32], 2013	<0.1	Pillai et al. [62], 2015	0		
Wiebe et al. [33], 2013	0				

ASC: ambulatory surgical center

Appendix. PubMed search strategies for studies on complications following first-trimester aspiration abortion

#1	“abortion, legal”[mesh] or “abortion, induced”[mesh] or “Dilatation and Curettage”[mesh] or “dilation and curettage”[Text Word] or “Vacuum Curettage”[mesh] or "vacuum curettage"[Text Word] or “vacuum aspiration”[Text Word] or "aspiration abortion"[Text Word] or "suction curettage"[Text Word] or abort* or terminat*
#2	complication*[Text Word] or "adverse event*"[Text Word] or "adverse effect*"[Text Word] or "Uterine hemorrhage"[mesh:NoExp] or hemorrhag*[Text Word] or Infection[mesh:NoExp] or infection*[Text Word] or "Pelvic Inflammatory Disease"[mesh:NoExp] or "pelvic inflammatory disease"[Text Word] OR "PID"[Text Word] or endometritis[Text Word] or salpingitis[Text Word] or parametritis[Text Word] or incomplete[Text Word] or “retained products of conception” [Text Word] or "Uterine perforation"[mesh:NoExp] or perforation[Text Word] OR laceration[Text Word] or hospitalization[mesh:NoExp] or hospitaliz*[Text Word] or death*[Text Word] OR died[Text Word] OR mortality[Text Word]
#3	("Pregnancy"[Mesh:NoExp] or pregnan*[Text Word]) and "first trimester"[Text Word] OR "first-trimester"[Text Word] OR week*[Text Word]) or Pregnancy Trimester, First[mesh] or “gestational age”[Text Word]
#4	#1 AND #2 AND #3
#5	#4 AND (("1980/01/01"[PDAT] : "2015/04/30"[PDAT]) AND "humans"[MeSH Terms])