

# Cost-effectiveness analysis of alternative first-trimester pregnancy termination strategies in Mexico City

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**Objective** To assess the comparative health and economic outcomes associated with three alternative first-trimester abortion techniques in Mexico City and to examine the policy implications of increasing access to safe abortion modalities within a restrictive setting.

**Design** Cost-effectiveness analysis.

**Setting** Mexico City.

**Population** Reproductive-aged women with unintended pregnancy seeking first-trimester abortion.

**Methods** Synthesising the best available data, a computer-based model simulates induced abortion and its potential complications and is used to assess the cost-effectiveness of alternative safe modalities for first-trimester pregnancy termination: (1) hospital-based dilatation and curettage (D&C), (2) hospital-based manual vacuum aspiration (MVA), (3) clinic-based MVA and (4) medical abortion using vaginal misoprostol.

**Main outcome measures** Number of complications, lifetime costs, life expectancy, quality-adjusted life expectancy.

**Results** In comparison to the magnitude of health gains associated with all safe abortion modalities, the relative differences between strategies were more pronounced in terms of their economic costs. Assuming all options were equally available, clinic-based MVA was the least costly and most effective. Medical abortion with misoprostol provided comparable benefits to D&C, but cost substantially less. Enhanced access to safe abortion was always more influential than shifting between safe abortion modalities.

**Conclusions** This study demonstrates that the provision of safe abortion is cost-effective and will result in reduced complications, decreased mortality and substantial cost savings compared with unsafe abortion. In Mexico City, shifting from a practice of hospital-based D&C to clinic-based MVA and enhancing access to medical abortion will have the best chance to minimise abortion-related morbidity and mortality.

**Keywords** Abortion, cost-effectiveness analysis.

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## Introduction

Among the estimated three million pregnancies occurring annually in Mexico, more than one in ten end in induced abortion.<sup>1</sup> As a result of highly restrictive legal limitations on elective pregnancy termination, a proportion of these abortions are conducted under unsafe, clandestine conditions.<sup>2</sup> Unsafe abortion carries a risk of morbidity and mortality that is several hundred times higher than safe abortion.<sup>3</sup> Accordingly, in places where women have

restricted access to safe abortion, abortion leads among causes of maternal death and disability.<sup>4,5</sup> In Latin America and the Caribbean, abortion contributes to 12% of maternal deaths and is the 4th leading cause of maternal mortality.<sup>6</sup>

In April 2007, abortion up to 12 weeks gestation was legalised in Mexico City. Although abortion remains highly restricted in the rest of the country, elective, first-trimester abortion is available for free to Mexico City residents and for a nominal fee to nonresidents who present to public

hospitals in the Federal District.<sup>7</sup> Proponents of women's health and abortion rights carry high hopes that this shift in abortion policy may lead to further provision of affordable, safe abortion services in the private sector and motivate liberalisation of abortion laws in the other parts of Mexico and Latin America.

Abortion, when performed by a trained healthcare provider in a safe and legal environment, is one of the safest medical procedures, with mortality rates generally reported to be less than one per 100 000.<sup>8</sup> The three main methods used for safe, early pregnancy termination and management of incomplete miscarriage include dilatation and curettage (D&C), manual vacuum suction (MVA) and medical abortion (mostly with vaginal misoprostol alone).<sup>9</sup> While D&C is the most commonly performed procedure in Mexico City, MVA is associated with fewer complications and could offer logistical advantages in that it does not require electricity, general anaesthesia or operating room facilities and can therefore be provided within a clinic setting.<sup>5,9</sup> Similarly, medical abortion using a regimen of misoprostol has attributes that could enhance safe abortion access, including multiple means of distribution, low skill requirements and few health system demands, although it has a substantial rate of failure requiring secondary procedures.<sup>10</sup>

Policy recommendations intended to influence clinical practice ideally reflect an intervention's safety and effectiveness, acceptability, accessibility, affordability and cost-effectiveness. While provision of safe abortion has been shown to be cost-effective intervention for reducing maternal mortality in Mexico, there has not been a comparative analysis that formally incorporates the tradeoffs, health benefits and economic outcomes associated with specific modalities.<sup>11</sup> To guide discussions about the expansion of abortion services in Mexico City, we conducted a cost-effectiveness analysis of three methods for first-trimester pregnancy termination. To inform health sector investment decisions for other areas in Mexico and the Latin American and Caribbean region, these results were used to quantify the expected benefits and cost savings associated with policies that increase access to safe abortion.

## Methods

### Analytic overview

We synthesised the best available data and conducted a model-based comparative analysis of three methods for first-trimester pregnancy termination: dilatation and curettage (D&C), manual vacuum aspiration (MVA) and medical abortion using a regimen of vaginal misoprostol alone. Mifepristone is not registered in Mexico and vaginal misoprostol is a commonly used regimen for medical abortion there.<sup>12</sup> Model outcomes included intermediate outcomes, such as failed initial abortion, specific complica-

tions (e.g. uterine rupture, haemorrhage, infection) and long-term aggregate population measures, such as average per-woman lifetime costs (\$US 2005), life expectancy and quality-adjusted life expectancy. Strategies were ranked by increasing cost and incremental cost-effectiveness ratios (defined as the additional cost of a specific strategy divided by its additional clinical benefit compared with the next least expensive strategy) were calculated. Strategies that were more costly and less effective or more costly and less cost-effective, compared with the next best strategy, were considered strongly and weakly dominated respectively. One- and two-way sensitivity analyses were conducted to assess the effect of varying baseline estimates and assumptions on our results. Analyses were conducted from both a government payor and modified societal perspective and followed the recommendations for economic evaluation made in several published guidelines.<sup>13–16</sup>

### Model

We have previously described a maternal mortality policy model that simulates the natural history of pregnancy (both planned and unintended) and pregnancy-related complications in a cohorts of women followed over their lifetime.<sup>11</sup> The analytic tool developed for this analysis is a companion Markov model that simulates induced abortion and its potential complications, as well as alternative modalities for elective abortion. The target population is a representative cohort of 25-year-old Mexican women seeking pregnancy termination. A woman can have a safe or unsafe abortion, following which outcomes include a successful procedure, procedure failure without complications, major complications or death. An uncomplicated procedure failure is defined as the need for postprocedure surgical uterine re-evacuation with MVA as a result of incomplete miscarriage, prolonged bleeding or persistent severe discomfort. Major complications include uterine perforation, pelvic infection or haemorrhage requiring transfusion.<sup>17</sup> We assume all complications incur an additional cost and, with the exception of failed abortion, require hospitalisation for further management. All women are subject to age-specific all-cause mortality rates.

In the baseline analysis, we first compared the cost-effectiveness of four options for safe, elective pregnancy termination. Strategies for elective abortion included (1) hospital-based D&C, (2) hospital-based MVA, (3) clinic-based MVA and (4) clinic-based medical abortion using a regimen of vaginal misoprostol alone. The baseline analysis assumed that each modality for safe abortion was equally available and acceptable to women and could be implemented to the full coverage of those desiring elective abortion. Although we recognise access to each modality is uneven in Mexico City, the intention of the baseline analysis was to provide information about the relative

cost-effectiveness of individual options for safe abortion to help define priorities for the enhancement of abortion services in Mexico City.

In a secondary analysis, we sought to stimulate a more realistic set of scenarios where the health and economic outcomes were compared for strategies comprised of combinations of abortion modalities (including unsafe abortion), reflecting their differential accessibility, preference and uptake.

## Data

Model inputs are provided in Table 1 and Data S1 (available online at Wiley Interscience). Clinical data used in the model were from the published and grey literature.<sup>2–4,10,17–38</sup> Direct medical costs associated with the specific abortion procedures and management of complications were based on primary data from a cost analysis of induced abortion and the treatment of incomplete miscarriage in four Mexico City health facilities (three public hospitals and one private clinic, see Data S1).<sup>28</sup> In this study, costs were estimated using an ingredients-based approach and included fixed and recurrent direct costs for personnel, drugs, disposable supplies, medical instruments and equipment (hospital, surgical and imaging) used in the hospital or clinic to induce an abortion, treat an incomplete miscarriage or manage abortion-related complications. In addition to direct medical costs, costs related to patient travel time, transportation costs and missed wage earnings were assessed for the three specific abortion procedures; these estimates were used for the analysis conducted from a modified societal perspective. Procedural costs relating to unsafe abortion and its long-term sequelae (i.e. infertility) were from the published literature.<sup>28,34,36</sup> All costs were expressed in 2005 US dollars. Future costs and benefits were discounted at an annual rate of 3%.

## Results

### Clinical and cost outcomes

Model-generated estimates for complications associated with the three abortion modalities differed although all provided substantial benefits over unsafe abortion (Figure 1, Upper Panel). Per 100 000 procedures, medical abortion using vaginal misoprostol resulted in the lowest rates of uterine perforation and infection, but the largest number of uncomplicated procedure failures. Excluding procedure failure without complications, among the three first-trimester abortion procedures, both MVA and vaginal misoprostol resulted in the fewest serious complications.

Model-projected direct medical costs associated with each of the strategies are shown in Figure 1, Lower Panel. For all strategies, the majority of costs related to the

procedure itself. Costs associated with complications ranged from 10 to 20% with surgical strategies, while almost 20% of the costs associated with vaginal misoprostol were attributable to failed abortion.

### Cost-effectiveness

All options for safe abortion provided life expectancy and quality-adjusted life expectancy gains and were associated with lower lifetime costs than unsafe abortion. The baseline analysis assumed that each modality for safe abortion was equally available and acceptable to women and could be implemented to full coverage of those desiring elective abortion. Given these assumptions, clinic-based MVA was the least costly and most effective. (Table 2) Hospital-based MVA was as effective as clinic-based MVA, but more costly. While D&C and medical abortion using vaginal misoprostol provided comparable benefits, costs associated with the latter were substantially lower. The general results were the same when time and personal costs were included, although average per-woman costs increased by 6 to 34%.

In comparison to the magnitude of health gains associated with all modalities for safe abortion (~26–27 years of life gained or 65–66 quality-adjusted years of life gained per 1000 women), the relative differences between strategies were more pronounced in terms of their comparative economic costs. Figure 2 shows the cost savings associated with two strategies, clinic-based MVA and medical abortion with vaginal misoprostol, relative to a baseline strategy of unsafe abortion (left, Figure 2) and relative to the current most common practice in Mexico City, D&C (right, Figure 2). Even assuming 100% access to D&C, shifting to clinic-based MVA would save nearly \$100 000 per 1000 women. Relative to unsafe abortion, these savings double in magnitude.

### Evaluating uncertainty

The magnitude of cost savings associated with all safe abortion modalities was influenced by assumptions about the procedural costs and overall complication rate associated with unsafe abortion. (Table 3) Absolute health gains associated with all safe abortion strategies were sensitive to assumptions about the mortality risk associated with unsafe abortion.

The rank-ordering of strategies (i.e., the status of competing strategies in terms of cost-effectiveness) was most sensitive to changes in the plausible range of values of the cost and efficacy of medical abortion and the cost of clinic-based MVA. In one-way sensitivity analyses, we identified two thresholds beyond which medical abortion with vaginal misoprostol became equally, or more, cost-effective than clinic-based MVA. First, when the cost of medical abortion was <\$37.25 (base case, \$69) and when the cost of clinic-based MVA exceeded \$84.75 (base case, \$53).

**Table 1.** Model parameters: baseline values and ranges used in sensitivity analyses

Variable	Base case	Plausible range	References
<b>Clinical Parameters (Risk per 1,000 procedures)</b>			
Dilatation and curettage (D&C)			
Procedure failure without complications*	24	18–24	17–19
Uterine perforation	7	2–33	17–20
Pelvic infection	14	14–29	17–21
Bleeding requiring transfusion	0.9	0.9–13	17–19
Deaths	0.018	0.001–0.06	3,22,23
Manual vacuum aspiration (MVA)			
Procedure failure without complications*	22	11–38	17,18,24,25
Uterine perforation	3	0.02–3	17–19,25,26
Pelvic infection	9.7	0.1–27	17–21,25–27
Bleeding requiring transfusion	0.5	0.5–15	17–19,25
Deaths	0.013	0.001–0.06	3,22,23
Misoprostol per vaginal route, 800 mcg x up to 2 doses			
Procedure failure without complications*	200	70–350	10,28
Pelvic infection	4.7	2.1–13	29–31
Bleeding requiring transfusion	3	3–12	10,32
Deaths	0.024	0.002–0.024	33
Unsafe abortion			
Procedure failure without complications*	160	0.5x–2.0x	2,4,34
Uterine perforation	18	0.5x–2.0x	2,4,34
Pelvic infection	77	0.5x–2.0x	2,4,34
Bleeding requiring transfusion	109	0.5x–2.0x	2,4,34
Infertility	20	0.5x–2.0x	2,4,5,34
Deaths	1	0.5x–2.0x	3,35
<b>Direct medical costs (2005 US\$)</b>			
Dilatation and curettage	143	103–192	28
Manual vacuum aspiration			
Clinic-based	53	31–106	28
Hospital-based	107	96–124	28
Misoprostol per vaginal route, 800 mcg x up to 2 doses	69	31–138	28
Unsafe abortion	90	0.5x–2.0x	28,34
Treatment of complications			
Procedure failure without complications*	93	53–192	28
Uterine perforation	1,408	907–2,271	28
Pelvic infection	601	293–912	28
Bleeding requiring transfusion	1,602	595–3,710	28
Infertility**	822	0.5x–2.0x	36
<b>Personal costs (2005 US\$)</b>			
Dilatation and curettage***	8.52	8.49–8.99	28
Manual vacuum aspiration***			
Clinic-based	22.27	11.14–44.54	28
Hospital-based	8.67	8.52–8.99	28
Misoprostol per vaginal route, 800 mcg x up to 2 doses***	29.70	17.00–29.70	28
Unsafe abortion****	8.67	8.52–8.99	28
Treatment of complications*****			
Procedure failure without complications*	8.72	4.36–13.08	28,37
Uterine perforation	30.52	17.44–43.60	28,37
Pelvic infection	10.90	8.72–13.08	28,37
Bleeding requiring transfusion	23.98	17.44–30.52	28,37
Infertility*****	34.68	0.5x–2.0x	28,37
<b>Quality of life parameters</b>			
	<b>Quality weight</b>	<b>Duration (days)</b>	
Procedure failure without complications*	0.90	2 (1–3)	28,38
Uterine perforation	0.65	7 (4–10)	28,38

Table 1. (Continued)

Quality of life parameters	Quality weight	Duration (days)	References
Pelvic infection	0.65	2.5 (2–3)	28,38
Bleeding requiring hospitalization	0.50	5.5 (4–7)	28,39
Infertility*****	0.82	To age 45 yrs	38

\*Defined as incomplete miscarriage, prolonged bleeding or excessive patient discomfort that requires surgical re-evacuation of the uterus using manual vacuum aspiration.

\*\*Applies to 25% of all women with infertility.

\*\*\*Includes costs associated with patient travel time, transportation and missed wage earnings.

\*\*\*\*Assumed to be the same as for hospital-based MVA and D&C.

\*\*\*\*\*Calculated by multiplying average minimum daily wages reported for Mexico by the duration of health decrement experienced for each specific complication.

\*\*\*\*\*Assumed to be four times the personal cost associated with hospital-based MVA and D&C.

\*\*\*\*\*Applies to the 75% of all women with infertility (i.e. those who do not receive an infertility evaluation).

To examine the impact of both the cost and uncomplicated procedure failure rate associated with medical abortion, (each found to be influential in one-way sensitivity analysis) on our results, we simultaneously varied these assumptions. Specifically, we varied the cost of medical abortion from \$7 to \$138 (base case, \$69) and the failure rate from 7 to 35% (base case, 20%). Figure 3 depicts the range of concurrent values for the procedural cost and rate of uncomplicated procedure failure associated with medical abortion, for which the strategy of medical abortion with vaginal misoprostol is cost-effective relative to clinic-based MVA.

### Real world implications

While the baseline analysis assumed that each modality for safe abortion was equally available, we simulated a more realistic set of scenarios in which combinations of abortion modalities were used, reflecting their differential accessibility, preference and uptake (Figure 4).

Several points are illustrated by Figure 4 in which the years of life gained per 1000 and cost savings per 1000 are shown for several strategies, in comparison with unsafe abortion. First, shifting from unsafe to safe abortion, regardless of modality, is the most influential factor on saving both lives and societal costs. For example, shifting 50% of women that would otherwise receive D&C to clinic-based MVA, without changing the percentage that pursue unsafe abortion, provides very small incremental benefits although does save substantial costs. Providing safe abortion for an additional 25% of women that would otherwise get an unsafe abortion has a much larger impact on years of life saved. If access to medical abortion provides a feasible and acceptable option, such that all women are assured access to safe abortion, years of life gained per 100 000 women approaches 2700 compared with unsafe

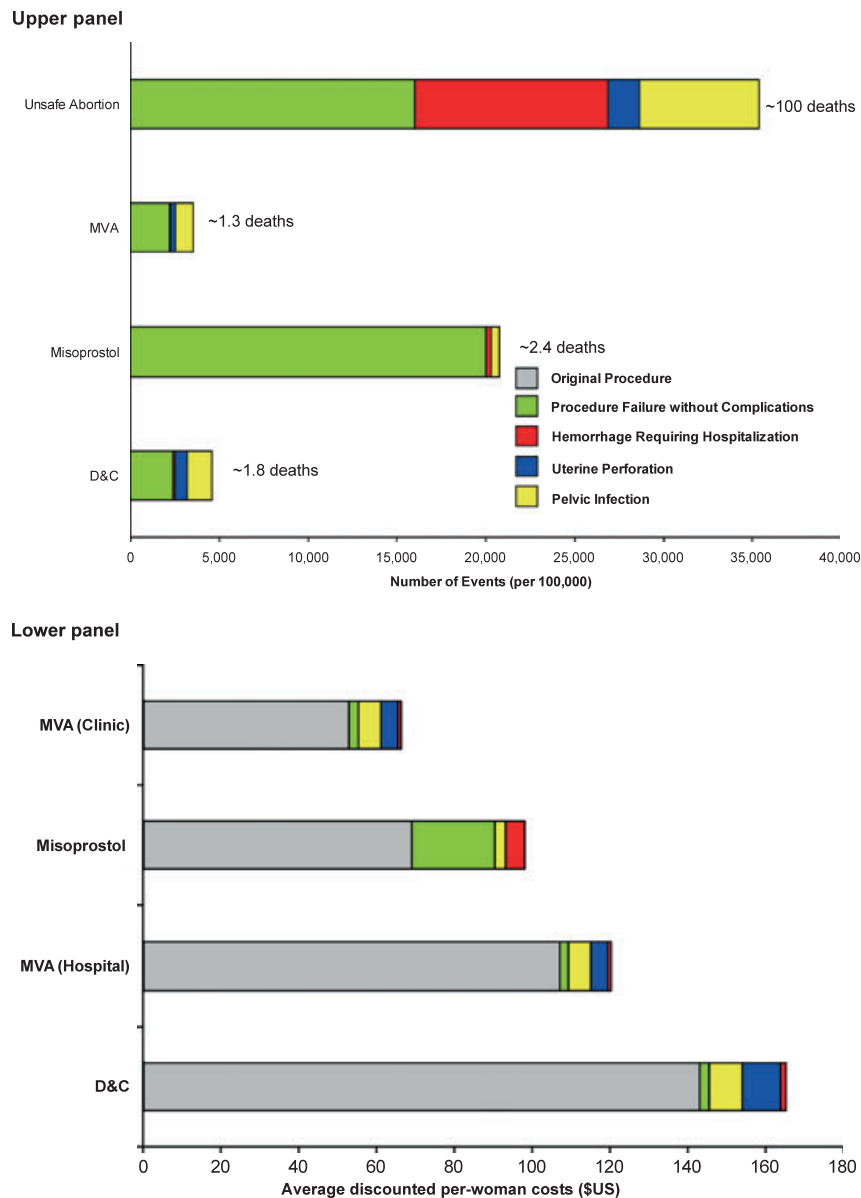
abortion. Major economic benefits are realised as clinic-based MVA and medical abortion replace D&C.

### Discussion

The most important principles implied by our findings include (1) provision of safe abortion is the single most influential factor on health and economic outcomes; (2) all else being equal, shifting services from D&C to clinic-based MVA will provide equivalent or greater benefits, result in fewer complications and cost less; (3) ensuring the availability of a nonsurgical option with vaginal misoprostol will optimise access for all women by providing choices; if even a small percentages of women who would have otherwise sought unsafe abortions avail themselves of a medical abortion option, overall population benefits increase and overall cost savings grow.

The WHO recommends vacuum aspiration (manual or electric) and medical abortion as the preferred methods for first-trimester abortion.<sup>5,8</sup> Our results generally support these recommendations and suggest clinic-based MVA is the most cost-effective option for safe, first-trimester induced abortion in Mexico City. Over a wide range of plausible assumptions, clinic-based MVA was the most effective and least costly strategy, provided it is available, accessible and acceptable to women seeking to terminate first trimester pregnancy. If clinic-based MVA is not available, the next best strategy is medical abortion using the vaginal misoprostol regimen.

While interventions that improve health at a cost should ideally be compared with other interventions that compete for the same resources, there is no universal criterion that defines a threshold cost-effectiveness ratio, below which an intervention would be considered cost-effective. A commonly cited rule of thumb is based on a report by the



**Figure 1.** (Upper Panel) Model-projected distribution of complications attributable to abortion. Model generated estimates for complications associated with the three abortion modalities all provided substantial benefits over unsafe abortion. Excluding procedure failures without complications, both MVA and medical abortion using a regimen of vaginal misoprostol resulted in the fewest serious complications. (Lower Panel) Model-projected Distribution of Costs. For all strategies, the majority of costs were attributable to the procedure itself. Complications were responsible for 10–20% of the total cost among the surgical strategies, while nearly 20% of the costs associated with medical abortion under a regimen of vaginal misoprostol were attributable to failed abortion alone.

Commission on Macroeconomics and Health, following which others suggested that interventions are ‘very cost-effective’ if they have cost-effectiveness ratios less than per capita Gross Domestic Product (GDP).<sup>40</sup> Given that nearly all strategies we found to be most effective were also associated with cost savings when compared to either current practice or unsafe abortion, investments in safe abortion services is likely to be one of the most cost-effective inter-

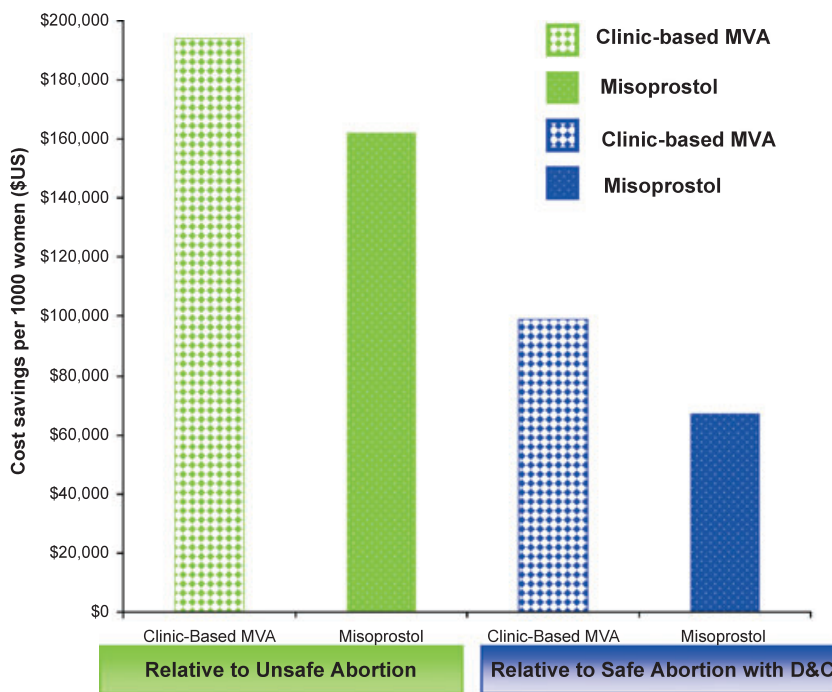
ventions that could be implemented in Mexico or any other country where unsafe abortion is prevalent.

The most influential variables affecting our results were those related to the cost and efficacy of medical abortion with misoprostol. Within the plausible range of values for the cost of medical abortion and clinic-based MVA, and assuming that both were equally available, we identified thresholds at which the strategy of medical abortion became

**Table 2.** Health and economic outcomes of three modalities in Mexico City to terminate first-trimester pregnancy\*

Strategy	Lifetime costs***, 2005 US\$ Government Payor Perspective	Lifetime costs***, 2005 US\$ Modified Societal Perspective	Years of life gained per 1000****	QALY gained per 1000****	ICER \$ per YLS	ICER \$ per QALY
Unsafe abortion	260	365	—	—	—	—
MVA, clinic-based	66	89	26.7	66.2	*****	*****
Misoprostol per vaginal route**	98	129	26.4	65.8	Dominated*****	Dominated*****
MVA, hospital-based	120	129	26.7	66.2	Dominated*****	Dominated*****
Dilatation and curettage	165	174	26.5	66.0	Dominated*****	Dominated*****

\*y, years; YLS, years of life saved; QALY, quality-adjusted life year; ICER, incremental cost-effectiveness ratio.  
 \*\*Misoprostol per vaginal route assumes 800 mcg, up to 2 doses.  
 \*\*\*Average per-woman discounted (3%) lifetime costs (2005 US\$); government payor perspective includes the direct medical costs of safe abortion and abortion-related complications (from safe and unsafe abortion); modified societal perspective further includes the cost of unsafe abortion as well as patient time and transportation costs.  
 \*\*\*\*Average discounted (3%) years of life and quality-adjusted life years gained per 1000 women, relative to unsafe abortion.  
 \*\*\*\*\*MVA is more effective and less costly than all other strategies.  
 \*\*\*\*\*This strategy is more expensive and less effective than MVA and is therefore strongly dominated.  
 \*\*\*\*\*Hospital-based MVA is equally effective but more costly than clinic-based MVA and is therefore dominated.



**Figure 2.** Cost savings of MVA and misoprostol relative to unsafe abortion and safe abortion with D&C (Government Payor Perspective). Relative to a baseline strategy of unsafe abortion, a strategy of 100% clinic-based MVA or 100% medical abortion with vaginal misoprostol alone would save over \$190 000 or \$160 000 per 1000 women respectively. Relative to most commonly practiced first-trimester abortion method of D&C, shifting to clinic-based MVA would save nearly \$100 000 per 1000 women.

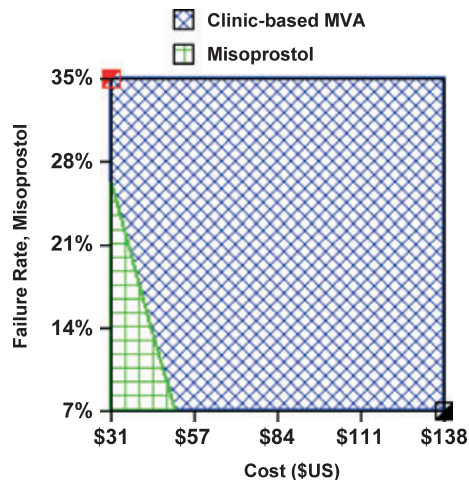
an equally attractive option. Importantly, the relative value of medical abortion with misoprostol is substantially influenced by its uncomplicated procedure failure rate, as the

additional procedure required to re-evacuate the uterus incurs an additional cost. Additionally, the cost of misoprostol itself has some influence; for example, in Mexico City,

**Table 3.** Impact of varying unsafe abortion assumptions on health and economic outcomes (modified societal perspective)\*

Strategy	Base case				Unsafe abortion parameters		
	Lifetime costs***, 2005 US\$	Cost savings per 1000****, 2005 US\$	Quality-adjusted life expectancy, years	QALY gained per 1000****, years	Mortality 50% lower	Complications***** 50% lower	Cost***** 50% lower
					QALY gained per 1000****, years	Cost savings per 1000****, 2005 US\$	Cost savings per 1000****, 2005 US\$
Unsafe abortion	365	—	26.0772	—	—	—	—
MVA, clinic-based	89	275 690	26.1434	66.22	53.15	144 782	230 690
Misoprostol per vaginal route**	129	235 101	26.1431	65.85	52.78	104 194	190 101
MVA, hospital-based	129	235 600	26.1434	66.21	53.15	104 692	190 600
Dilatation and curettage	174	190 103	26.1433	66.05	52.98	59 196	145 103

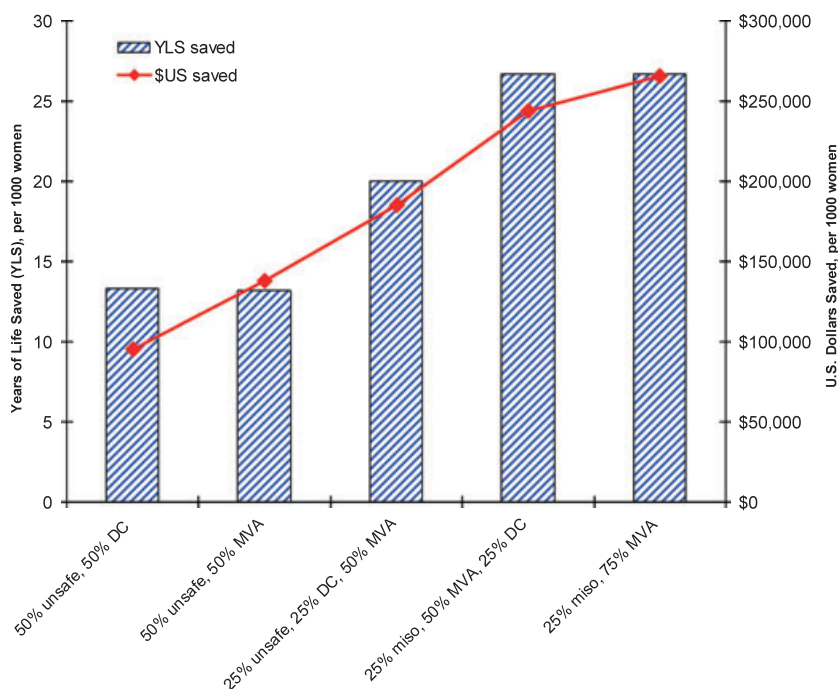
\*QALY, quality-adjusted life year; ICER, incremental cost-effectiveness ratio.  
 \*\*Misoprostol per vaginal route assumes 800 mcg, up to 2 doses.  
 \*\*\*Average per-woman discounted (3%) lifetime costs (2005 US\$); modified societal perspective includes patient time and transportation costs.  
 \*\*\*\*Average discounted (3%) costs saved per 1000 women, relative to unsafe abortion.  
 \*\*\*\*\*Average discounted (3%) quality-adjusted life years gained per 1000 women, relative to unsafe abortion.  
 \*\*\*\*\*Refers to unsafe abortion-associated risk of procedure failure without complications, haemorrhage, pelvic infection and uterine perforation.  
 \*\*\*\*\*Refers to procedural cost of safe abortion (baseline, \$90).



**Figure 3.** The impact of varying the uncomplicated procedure failure rate and cost of medical abortion on the optimal strategy. Two-way sensitivity analysis showing the impact of varying the cost of medical abortion with vaginal misoprostol and its failure rate on the strategies of clinic-based MVA and medical abortion with vaginal misoprostol. The area shaded in blue represents the region where the strategy of clinic-based MVA is the optimal strategy and strongly dominates the competing alternatives. The green line depicts the simultaneous values for which the cost of the two strategies is equal. Medical abortion is cost-effective in the area shown in green and is less costly than clinic-based MVA.

the current cost of misoprostol is approximately \$3 per 200 mcg tablet or over \$23 for the full misoprostol regimen per vaginal route (8 tablets), which is over five times the minimum daily wage in Mexico.<sup>28,37</sup> As the drug becomes more widely used for medical abortion, the large-scale purchase of this drug may result in substantial price reductions. In the USA, the cost per 200 mcg dose of misoprostol <\$1.<sup>41</sup> With only modest improvements in efficacy and reductions in the drug’s price, the cost-effectiveness of medical abortion will be comparable to clinic-based MVA.

Beyond economic considerations, MVA and medical abortion possess additional qualities, which could conceivably enhance access and feasibility in resource-constrained settings. For example, in contrast to D&C, MVA has low health system requirements and can be performed in different clinical settings (e.g. health centre, private clinic, hospital outpatient or inpatient clinic) and by a number of different health providers (e.g. physician, midwife, nurse practitioner).<sup>5</sup> In fact, a recent randomised equivalence trial in South Africa and Vietnam demonstrated that MVA performed by mid-level providers are as safe and efficacious as those conducted by physicians.<sup>27</sup> Furthermore, MVA is a highly versatile procedure and can be applied to a number of clinical indications including first- and second-trimester abortion, menstrual regulation, treatment of incomplete



**Figure 4.** Alternative Mixed Modalities for First Trimester Abortion: Health and Economic Outcomes. The years of life gained (blue striped columns) and costs savings (red line) increase as access to D&C increases and unsafe abortion is minimised (three left columns). Regardless of modality mix, the years of life and costs saved from reducing unsafe abortion far outweigh all differences between strategies. Cost savings increases as the modality mix shifts towards increasing access to MVA.

miscarriage and endometrial biopsy. The WHO Technical Working Group identifies MVA as an essential service at the first-referral level.<sup>42</sup>

Similarly, medical abortion using a regimen of misoprostol alone has advantages that enhance its potential for achieving high coverage, as it is easy to store (i.e. does not require refrigeration), potentially inexpensive, widely available in Latin America because of its multiple health applications and has the potential for self-administration at home.<sup>43</sup> However, it should be noted that, while technically simpler, medical abortion may be logistically more difficult than MVA.<sup>44</sup> In Mexico City in 2005, at the time the costing study used in the analysis presented here was performed, medical abortion using vaginal misoprostol required four clinic visits: an initial screening and counselling visit, a visit to provide the medications and two follow-up visits. However, this protocol can likely be streamlined to two or three clinic visits, which would greatly reduce the personal and direct medical cost of medical abortion, without impacting patient safety.<sup>43,44</sup> In addition, as the abortive process commonly occurs outside of the clinical setting, the onus of recognising complications and accessing medical care falls on the patient. These factors can work to increase the personal cost of medical abortion and to reduce its overall safety, especially if post-abortion services are not readily available.<sup>44,45</sup>

Nevertheless, in areas where access to surgical abortion facilities is limited, the provision of medical abortion could make the difference between receiving a safe and unsafe abortion.<sup>46</sup> This has particular relevance to other parts of Mexico and to the broader context of countries in the Latin American and Caribbean region and beyond.<sup>43</sup> According to a recent model-based study, a 26% reduction in unsafe abortion-related maternal deaths can be expected from a 40% shift to misoprostol-induced abortion from unsafe abortion.<sup>46</sup> This analysis supports equally compelling potential health gains, but also finds there to be fairly substantial economic benefits. For example, if access to medical abortion provides a feasible and acceptable option for even 25% of women, such that all women desiring elective abortion are assured access to safe abortion, the cost savings per 100 000 women exceeds \$20 million dollars.

Dilatation and curettage continues to be the most commonly used method for early pregnancy termination and treatment of incomplete miscarriage in many lower and middle income countries, including Mexico.<sup>9,47–50</sup> Our results support a shift from D&C to MVA as the preferred surgical modality, enhanced access to medical abortion with misoprostol (if mifepristone is not available) for those who prefer this modality and for those who would otherwise not have access to safe abortion services. Future research should focus on improving the efficacy of the

misoprostol alone medical abortion regimen and lowering its costs, as well as improving access to more effective regimens involving mifepristone.

Our study has several formidable limitations. First, the limitations of our primary data sources are our study's limitations as well. Because of the illegal status of elective abortion in this region, Mexico- and Latin America-specific data relating to safe and unsafe abortion were scarce. In addition, because safe abortion-related mortality and morbidity are infrequent events, most published studies lack the power to estimate these risks reliably. Moreover, randomised clinical trials tend to underestimate true mortality and morbidity risks from safe abortion as these studies are conducted in tertiary health centres by experienced physicians and do not represent the outcomes of general, clinical practice. We endeavoured to overcome these obstacles by: (1) using estimates from national or regional databases (which tend to reflect outcomes from a range of clinical settings) or from large, prospective studies; (2) electing to use surgical abortion data from the 1970s, a period shortly after abortion laws were relaxed throughout the USA, which mirrors the current situation in Mexico City and (3) establishing wide plausible ranges for our estimates in sensitivity analyses.

Second, Mexico- and region-specific data for the cost of safe and unsafe abortion procedures and their complications are extremely limited. For safe abortion procedures and complications, we capitalised on the availability of primary data from four representative health facilities in Mexico City.<sup>28</sup> We acknowledge there may be considerable variation in the cost of these procedures among the different Mexican states and especially between urban and rural areas. That being said, our cost estimates are consistent with the general trend reported in other developing countries for the relative cost of medical abortion, MVA and D&C.<sup>5,34,51,52</sup> For example, in Vietnam, the cost of providing D&C is higher than MVA<sup>52</sup> and in India, the cost of providing medical abortion is higher than clinic-based MVA.<sup>51</sup>

Third, estimates of quality-of-life decrements associated with abortion complications were not available and we adopted utilities assigned to sexually transmitted infections, their sequelae and other similar health conditions as a proxy. We varied the weights used to reflect an impact on the quality of life of a woman with complications from abortion widely in sensitivity analyses and our results were robust. Fourth, we did not include other types of abortion-related morbidity, such as cervical injury and anaesthesia-associated complications. Reliable cost estimates associated with these risks were not available in the literature. Inclusion of these risks would improve the economic attractiveness of medical abortion, although the overall impact on the main results would be minimal as the events are relatively infrequent. Fifth, we did not include the

broader societal costs associated with a maternal death, although their inclusion would only make our results more robust. Although a maternal death undoubtedly has a significant impact on the health and well-being of the children and larger household, data are not available to accurately monetize these costs for inclusion in a cost-effectiveness analysis. We emphasise although, that as our main goal was to conduct a comparative assessment of modalities for safe abortion, the incremental costs and benefits *between modalities* would be similar with and without inclusion of these broader societal costs; in contrast, the total economic gains associated with saving lives with any of the modalities would certainly be much greater. For this reason, these data are a priority for future research. Sixth, we did not consider alternative medical abortion regimens utilising the combination of mifepristone and misoprostol, which is more efficacious but more costly than misoprostol alone. Currently mifepristone is unavailable in most of Latin America and the cost associated with using this drug for medical abortion in Mexico is unknown.<sup>12</sup> However, the advantage of the model-based approach used here is that as more data become available, the model may be adapted to a broad range of settings and used to expediently conduct additional analyses.

## Conclusion

This study demonstrates that the provision of safe abortion will result in reduced complications, decreased mortality and substantial cost savings compared to unsafe abortion. The most effective and cost-effective strategy for safe, first trimester abortion is clinic-based manual vacuum aspiration. The availability of medical abortion for women desiring this modality and, in particular, for those who would otherwise pursue an unsafe abortion, will provide additional health and economic gains. In Mexico City, a three-pronged approach that includes shifting from a practice of D&C to MVA, making MVA available in a broad range of nonhospital clinical settings and enhancing access to medical abortion, will have the best chance to minimise abortion-related morbidity and mortality.

## Disclosure of interest

D.H., D.G., C.L., K.B. and S.J.G. have no conflicts of interest to disclose.

## Contribution to authorship

D.H., D.G. and S.J.G. designed the study, supervised the analysis and interpreted the results. C.L. and K.B. contributed to the analysis and interpretation of results. D.H. drafted the article and others commented. All authors have approved the final version.

## Details of ethics approval

None was sought, as this study is an economic evaluation for which no patient data were collected.

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## Supporting information

Additional Supporting Information may be found in the online version of this article:

### Data S1. Additional Materials and Methods

Please note: Wiley-Blackwell are not responsible for the content or functionality of any supporting materials supplied by the authors. Any queries (other than missing material) should be directed to the corresponding author for the article. ■

## References

- Henshaw SK, Singh S, Haas T. The incidence of abortion worldwide. *Int Fam Plann Persp* 1999;25:S30–8.
- Sedgh G, Henshaw S, Singh S, Ahman E, Shah IH. Induced abortion: estimated rates and trends worldwide. *Lancet* 2007;370:1338–45.
- World Health Organization. *Unsafe Abortion: Global and Regional Estimates of Incidence of Unsafe Abortion and Associated Mortality in 2003*. Geneva, Switzerland: World Health Organization, 2007.
- Singh S. Hospital admissions resulting from unsafe abortion: estimates from 13 developing countries. *Lancet* 2006;368:1887–92.
- Grimes DA, Benson J, Singh S, Romero M, Ganatra B, Okonofua FE, et al. Unsafe abortion: the preventable pandemic. *Lancet* 2006;368:1908–19.
- Khan KS, Wojdyla D, Say L, Gülmezoglu AM, Van Look PF. WHO analysis of causes of maternal death: a systematic review. *Lancet* 2006;367:1066–74.
- Mexico City bill that legalizes abortion during first three months' gestation published into law. . Kaiser Daily Women's Health Report 2008, 2008 [http://www.kaisernetwork.org/daily\_reports/rep\_index.cfm?DR\_ID=44545]. Accessed 29 July 2008.
- World Health Organization. *Safe Abortion: Technical and Policy Guidance for Health Systems*. Geneva, Switzerland: World Health Organization, 2003.
- García S, Lara D, Goldman L. Conocimientos, actitudes y prácticas de los médicos mexicanos sobre el aborto: Resultados de una encuesta nacional. *Gac Med Mex* 2003;139:91–102.
- Faúndes A, Fiala C, Tang OS, Velasco A. Misoprostol for the termination of pregnancy up to 12 completed weeks of pregnancy. *Int J Gynaecol Obstet* 2007;99:S172–7.
- Hu D, Bertozzi SM, Gakidou E, Sweet S, Goldie SJ. The costs, benefits, and cost-effectiveness of interventions to reduce maternal morbidity and mortality in Mexico. *PLoS ONE* 2007;2:e750.
- Lafaurie MM, Grossman D, Troncoso E, Billings DL, Chávez S. Women's perspectives on medical abortion in Mexico, Colombia, Ecuador and Peru: a qualitative study. *Reprod Health Matters* 2005;13:75–83.
- Gold MR, Siegel JE, Russell LB, Weinstein MC, editors. *Cost-Effectiveness in Health and Medicine*. New York, NY: Oxford University Press, 1996.
- Cost-effectiveness analysis. In: Jamison DT, Breman JG, Measham AR, editors. *Priorities in Health*. Washington, DC: The World Bank; 2006. pp. 39–59.
- Drummond MF, Schulpher MJ, Torrance GW, O'Brien BJ, Stoddart GL. *Methods for the Economic Evaluation of Health Care Programmes*. New York, NY: Oxford University Press, 2005.
- Baltussen R, Adams T, Toress TT, Hutubessy R, Acharya A, Evans DB, Murray CJL, editors. *Making Choices in Health: WHO Guide to Cost-Effectiveness Analysis*. Geneva, Switzerland: World Health Organization, 2003.
- Tietze C, Levit S. Legal abortions: early medical complications. An interim report of the Joint Program for the Study of Abortion. *Fam Plann Perspect* 1971;3:6–14.
- Edelman DA, Brenner WE, Berger GS. The effectiveness and complications of abortion by dilatation and vacuum aspiration versus dilatation and rigid metal curettage. *Am J Obstet Gynecol* 1974;119:473–80.
- Tietze C. *Induced Abortion*. New York, NY: Population Council c1979, 1979.
- Lean TH, Vengadasalam D, Pachauri S, Miller ER. A comparison of D & C and vacuum aspiration for performing first trimester abortion. *Int J Gynaecol Obstet* 1976;14:481–6.
- Vladov E. The vacuum aspiration method for interruption of early pregnancy. *Am J Obstet Gynecol* 1967;99:202–7.
- Institute of Medicine. *Legalized Abortion and the Public Health: Report of a Study by a Committee of the Institute of Medicine*. Washington, DC: National Academy of Sciences, 1975.
- Koonin LM, Smith JC, Ramick M. Abortion surveillance—United States, 1990. *MMWR CDC Surveill Summ* 1993;42:29–57.
- Goldberg AB, Dean G, Kang MS, Youssof S, Darney PD. Manual versus electric vacuum aspiration for early first-trimester abortion: a controlled study of complication rates. *Obstet Gynecol* 2004;103:101–7.
- Laufe LE. The menstrual regulation procedure. *Stud Fam Plann* 1977;8:253–6.
- Hodgson JE, Portmann KC. Complications of 10,453 consecutive first-trimester abortions: a prospective study. *Am J Obstet Gynecol* 1974;120:802–7.
- Warriner IK, Meirik O, Hoffman M, Morroni C, Harries J, My Huong NT, et al. Rates of complication in first-trimester manual vacuum aspiration abortion done by doctors and mid-level providers in South Africa and Vietnam: a randomised controlled equivalence trial. *Lancet* 2006;368:1965–72.
- Levin C, Grossman D, Berdichevsky K, Diaz C, Aracena B, Garcia S, Goodyear L. Exploring the costs and economic consequences of unsafe abortion in Mexico City before legislation. *Reprod Health Matters* 2009;16:1–13.
- Spitz IM, Bardin CW, Benton L, Robbins A. Early pregnancy termination with mifepristone and misoprostol in the United States. *N Engl J Med* 1998;338:1241–7.
- Carbonell JL, Varela L, Velazco A, Cabezas E, Fernández C, Sánchez C. Oral methotrexate and vaginal misoprostol for early abortion. *Contraception* 1998;57:83–88.
- Shannon C, Brothers LP, Philip NM, Winikoff B. Infection after medical abortion: a review of the literature. *Contraception* 2004;70:183–90.
- Esteve JL, Varela L, Velazco A, Tanda R, Cabezas E, Sánchez C. Early abortion with 800 micrograms of misoprostol by the vaginal route. *Contraception* 1999;59:219–25.

- 33 Grimes DA. Risks of mifepristone abortion in context. *Contraception* 2005;71:161.
- 34 Henshaw SK, Adewole I, Singh S, Bankole A, Oye-Adeniran B, Hussain R. Severity and cost of unsafe abortion complications treated in Nigerian hospitals. *Int Fam Plan Perspect* 2008;34:40–50.
- 35 World Health Organization. *Unsafe Abortion. Global and Regional Estimates of the Incidence of Unsafe Abortion and Associated Mortality in 2000*. Geneva, Switzerland: World Health Organization, 2004.
- 36 Ojha K, Philips Z, Darne FJ. Diagnosing infertility in a district general hospital: a case-note and cost analysis. *Hum Fertil* 2003;6:169–73.
- 37 U.S. Department of State. *Mexico. Country report on human rights—2005*. Washington, DC: U.S. Department of State. [<http://www.state.gov/g/drl/rls/hrrpt/2005/62736.htm>]. Accessed 30 July 2008.
- 38 Appendix 2: Chlamydia. In: Stratton KR, Durch JS, Lawrence RS, editors. *Vaccines for the 21st Century: A Tool for Decisionmaking*. Washington, DC: National Acad Pr; 2000. pp. 149–58.
- 39 Tengs TO, Wallace A. One thousand health-related quality-of-life estimates. *Med Care* 2000;38:583–637.
- 40 World Health Organization. *Macroeconomics and Health: Investing in Health for Economic Development—Report of the Commission on Macroeconomics and Health*. Geneva, Switzerland: World Health Organization, 2001.
- 41 Jain JK, Mishell DR Jr. A comparison of intravaginal misoprostol with prostaglandin E2 for termination of second-trimester pregnancy. *N Engl J Med* 1994;331:290–3.
- 42 World Health Organization. *Essential Elements of Obstetric Care at First Referral Level*. Geneva, Switzerland: World Health Organization, 1991.
- 43 Clark WH, Gold M, Grossman D, Winikoff B. Can mifepristone medical abortion be simplified? A review of the evidence and questions for future research. *Contraception* 2007;75:245–50.
- 44 Grimes DA. Medical abortion in early pregnancy: a review of the evidence. *Obstet Gynecol* 1997;89:790–6.
- 45 Grimes DA, Creinin MD. Induced abortion: an overview for inter-nists. *Ann Intern Med* 2004;140:620–6.
- 46 Harper CC, Blanchard K, Grossman D, Henderson JT, Darney PD. Reducing maternal mortality due to elective abortion: potential impact of misoprostol in low-resource settings. *Int J Gynaecol Obstet* 2007;98:66–9.
- 47 Etuk SJ, Ebong IF, Okonofua FE. Knowledge, attitude and practice of private medical practitioners in Calabar towards post-abortion care. *Afr J Reprod Health* 2003;7:55–64.
- 48 Kulier R, Fekih A, Hofmeyr GJ, Campana A. Surgical methods for first trimester termination of pregnancy. *Cochrane Database Syst Rev* 2001;2:CD002900.
- 49 Johnson BR, Benson J, Bradley J, Rabago Ordonez A, Zambrano C, Okoko L, et al. *Costs of alternative treatments for incomplete abortion*. Washington DC: The World Bank, 1993 [[http://www-wds.worldbank.org/external/default/WDSContentServer/IW3P/IB/1993/01/01/000009265\\_3961004040704/Rendered/PDF/multi0page.pdf](http://www-wds.worldbank.org/external/default/WDSContentServer/IW3P/IB/1993/01/01/000009265_3961004040704/Rendered/PDF/multi0page.pdf)]. Accessed 30 July 2008.
- 50 Rehan N, Inayatullah A, Chaudhary I. Characteristics of Pakistani women seeking abortion and a profile of abortion clinics. *J Womens Health Gen Based Med* 2001;10:805–10.
- 51 Ipas. *Medical abortion: making a difference in rural India and around the globe*. Chapel Hill, NC: Ipas, 2008 [[http://www.ipas.org/Library/News/News\\_Items/Medical\\_abortion\\_making\\_a\\_difference\\_in\\_rural\\_India\\_around\\_the\\_globe.aspx](http://www.ipas.org/Library/News/News_Items/Medical_abortion_making_a_difference_in_rural_India_around_the_globe.aspx)]. Accessed 18 July 2008.
- 52 Program for Appropriate Technology in Health. *Examining the cost of providing medical abortion in Vietnam. Hanoi, Vietnam*. Seattle, WA: Program for Appropriate Technology in Health, 2006 [[http://www.path.org/files/CP\\_vietnam\\_med\\_abt\\_cost\\_study\\_rpt.pdf](http://www.path.org/files/CP_vietnam_med_abt_cost_study_rpt.pdf)]. Accessed 19 July 2008.