Cost-effectiveness analysis of active management of third-stage labour in Vietnam

Vivien D Tsu,1* Carol Levin,1 Mai P T Tran,2 Minh V Hoang3 and Huong T T Luu4

Active management of the third stage of labour (AMTSL) using oxytocin substantially reduces postpartum haemorrhage (PPH), a leading cause of maternal mortality. An economic analysis of the use of AMTSL was conducted as part of an intervention study in Thanh Hoa Province, Vietnam. A spreadsheet was used to calculate various scenarios and estimate the costs and outcomes of the routine use of AMTSL with oxytocin in Uniject compared with oxytocin in ampoules, and AMTSL compared with no AMTSL. We estimated the health outcomes from probabilities that were generated from the effectiveness portion of the AMTSL intervention project. The study also estimates the costs of treating PPH and the net incremental costs of AMTSL (costs and savings); examines the impact of different scenarios of PPH rate and Uniject cost; and estimates the potential cost per PPH case and PPH death averted.

The additional net cost per woman of providing AMTSL with ampoules was just US$0.20 in the base case; using Uniject devices added only US$0.08 more per woman to the ampoule cost. Varying the rate of PPH had the biggest effect; if the underlying PPH rate were 8%, the incremental cost of AMTSL drops to just US$0.07 per woman with ampoules and the cost to avert a case of PPH is US$2.10 with ampoules and US$4.52 with Uniject. The low net incremental cost of AMTSL suggests that the introduction of AMTSL in primary-level facilities in Vietnam can reduce the incidence of PPH and benefit women’s health without adding much to national health care costs.

Keywords Postpartum haemorrhage, active management of third-stage labour, oxytocin, Uniject, cost-effectiveness

KEY MESSAGES

- Net incremental cost of active management of third-stage labour was low (US$0.20 in this study) and would be nearly cost-neutral where usual haemorrhage rates are at least 10%.

- Where postpartum haemorrhage (PPH) rates are at least 8%, the cost to prevent a case of PPH would be just over US$2.00, making active management a very cost-effective intervention.

Introduction

Although the average national maternal mortality ratio (MMR) has declined in Vietnam in recent years, it is still estimated to be about 165 per 100,000 live births (Ministry of Health of Vietnam 2003). As in the rest of the world, postpartum haemorrhage (PPH) is the major cause of these deaths.
Data from a seven-province study conducted by the Ministry of Health (MOH) with support from the World Health Organization (WHO) and Population Council suggest that 31.3% of all maternal deaths are due to haemorrhage (Tran et al. 2004). Preventing deaths due to postpartum bleeding is critical to government success in achieving the Millennium Development Goal of reducing maternal mortality by 75% by 2015.

Active management of the third stage of labour (AMTSL), a process that includes the use of a uterotonic drug (such as 10 international units [IU] of oxytocin), controlled cord traction, uterine massage after delivery, and (in some studies) prompt clamping of the umbilical cord, is now widely acknowledged to be an effective measure for preventing PPH when practiced by skilled birth attendants (WHO 2007). International bodies of midwives and obstetricians issued a joint statement in 2003 calling for global adoption of AMTSL (FIGO 2004). As of 2004, the MOH of Vietnam had not yet included AMTSL in its official national guidelines, but it had agreed to its pilot use at commune health centre (CHC) level in a few districts and listed it as a strategic solution to be considered in the Safe Motherhood Master Plan for 2003–2010 (Ministry of Health of Vietnam 2003).

Some midwives in the pilot districts had reported difficulties breaking open the ampoules and preparing a standard injection in the midst of other delivery activities, especially when they were practicing alone. The standard oxytocin available in Vietnam is imported in ampoules of 5IU and is administered with disposable syringes. There were concerns about risky recapping of needles, inappropriate breaking of glass ampoules, and waste disposal of used needles and syringes around health facilities. Making injections easier and safer for these midwives, who handle the majority of births in Vietnam, could increase the acceptance and effectiveness of AMTSL. The Uniject™ prefilled, single-use injection device (BD Pharmaceutical Systems, New Jersey, USA) offers a solution to some of these problems, since it guarantees a sterile, non-reusable device with an accurate dose. Earlier studies with midwives in Indonesia and Angola demonstrated that oxytocin in the Uniject device was acceptable and effective (Tsu et al. 2003; Strand et al. 2005).

In 2004, Vietnam’s MOH and PATH designed a study to generate local evidence regarding the effectiveness of AMTSL in reducing rates of PPH and the need for referral and complex treatment. This evidence was to enable policymakers to decide whether to recommend AMTSL for all births with skilled attendants. As part of this study, the MOH was interested in the acceptability, ease of use and costs of a prefilled injection device for including oxytocin as part of routine practice of AMTSL. The Uniject device, a plastic drug reservoir with an attached needle and plastic needle cap, comes packed in a foil packet and has a one-way valve that prevents refilling. Uniject devices have been used with a variety of other medicaments besides oxytocin, including injectable contraceptives in Brazil (Bahamondes et al. 1996), tetanus toxoid in Bolivia (Quiroga et al. 1998) and remote populations in Afghanistan and Mali (UNICEF 2003), and hepatitis B vaccine in Indonesia (Sutanto et al. 1999).

The objective of this paper is to present data on the costs and cost-effectiveness of introducing the routine use of AMTSL for the health system in Vietnam. The specific objectives of the analysis are to: (1) compare the costs of a normal delivery with and without AMTSL, with AMTSL conducted using either ampoules and syringes or Uniject prefilled devices; (2) estimate the costs of treating PPH and the net incremental costs of AMTSL (costs minus savings); (3) conduct a sensitivity analysis to examine the impact of different scenarios of PPH rate and Uniject cost; and (4) estimate the potential cost per PPH case and PPH death averted using AMTSL (versus no AMTSL) and comparing ampoules with Uniject.

Methods

An economic analysis of the use of AMTSL was conducted as part of the intervention study that evaluated the effectiveness and acceptability of AMTSL. A simple spreadsheet model using Excel (Microsoft, Redmond, WA) was used to estimate the total costs for each study arm (intervention plus any treatment costs for PPH complications) based on the probabilities of each outcome in the two facility types (commune centre and district hospital) and the associated facility- and outcome-specific costs. The routine use of AMTSL with oxytocin in the Uniject device was compared with oxytocin in ampoules, and AMTSL was compared with no AMTSL. Health outcomes were estimated from probabilities that were generated from the effectiveness results of AMTSL in the intervention study. Costs were estimated for each outcome and then combined proportionately (for hospital and CHC births) to estimate overall PPH-associated costs for each study arm.

Intervention study design

The intervention study was conducted in Thanh Hoa Province, where midwives in four districts participated in the effectiveness study (comparing AMTSL with no AMTSL), while midwives in two additional districts who were already performing AMTSL with ampoules switched to Uniject prefilled devices and provided additional data on acceptability. Altogether, more than 200 midwives and 4000 mothers participated in the 2004 study. All district hospital and CHC midwives in the intervention and comparison districts were included in the effectiveness study, and all consecutive women (18 years and older, whether at home or in a facility) completing the second stage of labour vaginally (and therefore suitable for AMTSL) while under the care of participating midwives during the study period were eligible for enrolment.

For this study, Uniject devices were filled with sufficient oxytocin to ensure a dose of 10 IU. The oxytocin available in ampoules in Vietnam comes in a 5 IU formulation, so two ampoules are needed to get the recommended 10IU dose.

Basic clinical information was collected on all cases of PPH, including treatments and final outcome. The primary outcomes regarding effectiveness of AMTSL either with standard ampoules and syringes or with Uniject devices included PPH rates, duration of third stage, the need for additional treatment, and final maternal condition. Bleeding was considered as normal if it was measured at <300 ml; mild if 300–499 ml (the Vietnamese threshold for PPH); moderate if 500–999 ml; and severe if 1000 ml or more. Outcomes adjusted for
confounding factors were calculated using a multiple logistic regression model. One model excluded women who had received oxytocin augmentation during the first stage of labour, as their outcomes were atypical and it was not possible to disentangle the effects of extra oxytocin and the prolonged labour which necessitated it. Further study details and results on the effectiveness of AMTSL are reported elsewhere (Tsu et al. 2006).

Measurement of cost

Costs of staff, equipment, supplies and infrastructure were identified for normal deliveries with and without AMTSL, with standard syringes and Uniject devices, and for PPH treatment for moderate and severe cases at CHC, district hospital and provincial hospital. The resource use data (type and quantity of drugs, supplies and equipment) were estimated through interviews with relevant staff who provide the services and were verified by reviewing sample records of specific cases of each type. Some unavailable costs of equipment were estimated using central prices. The analysis omits overhead or indirect costs for administrative support to facilities; therefore, costs may be underestimated, especially for the treatment of PPH. Data collection was done by researchers from Hanoi Medical University.

Labour costs were estimated using time allocation data obtained during interviews with health workers who were directly involved in each procedure to prevent or treat PPH. Total staff revenues data (salary plus all other allowances and bonuses—hereinafter called salary) were obtained from facility records. Salary levels varied slightly with the experience level of the particular personnel, so they were averaged within each of the two levels (CHC and district hospital).

Cost data were gathered retrospectively from two CHCs and the district hospital in each of four districts in December 2004, as well as in the Thanh Hoa Provincial Obstetric and Gynecology Hospital. Since costs at CHC level were relatively homogeneous, the two CHCs in each district were a convenience sample. All local costs were calculated in Vietnamese dong, but are presented here in US dollars. The exchange rate used throughout is (2004) US$1 = VND 15 900. Two 5-IU ampoules of oxytocin cost $0.37 and a disposable syringe cost $0.03. Uniject device cost was estimated at $0.50 since it was not yet commercially available; this estimate was based on another product (a vaccine) available internationally in Uniject with a comparable ingredient price.

Treatment costs for moderate PPH were estimated based on the extra drugs, supplies and time required, but excluding blood transfusion. The number of severe PPH cases was too few to calculate direct costs, so we estimated the costs from standard protocols for each level of severity. We assumed that treatment costs for severe PPH required all that was used for moderate PPH plus transfusion, but not surgery; treatment costs for very severe PPH required both transfusions and surgery. It was assumed that 10% of the severe PPH cases would require both transfusions and surgery. Patient out-of-pocket costs or indirect costs were not included, except transport for referral to district hospital, since this was sometimes paid by the CHC. The net incremental cost takes into account the cost of adding oxytocin and the savings that resulted from reduced PPH treatment costs or shorter third stage.

Estimation of outcomes

The effectiveness results, based on 3607 eligible women (1236 in the AMTSL intervention district and 2371 in the comparison districts), showed that AMTSL reduced the incidence of PPH, shortened the duration of the third stage, and significantly reduced the need for treatment despite a lower-than-expected rate of PPH overall (Tsu et al. 2006). Data were entered into Excel spreadsheets and were used to generate the cost per woman treated (from a health services perspective), based on the probabilities for normal delivery or mild, moderate and severe PPH, as seen in the effectiveness study (excluding those with oxytocin augmentation in the first stage of labour). The number of PPH cases that could be prevented was calculated for the base case using actual outcomes from the study.

Table 1 presents the clinical outcome assumptions used to estimate cost per woman treated for the base case model. The rates for normal deliveries, moderate PPH and CHC PPH that needed referral came from the intervention study; the division of severe PPH into severe and very severe came from the clinician interviews. Both outcomes and costs differed according to where deliveries occurred (CHC versus district hospital), so they were analysed separately and then combined at the end with weighting proportional to the actual distribution of births by facility in each study arm. Women without AMTSL had significantly higher rates of moderate and severe PPH, although the rates overall were lower than expected from national figures. The number of women needing various types of referral treatment was too small to use as a basis for the model, so estimates of proportions needing such treatment were derived from interviews with expert clinicians.

The number of deaths averted was estimated from national maternal mortality figures, estimates as to the proportion of maternal mortality due to PPH, and the protective effect from the logistic regression model. The formula for estimating the

<table>
<thead>
<tr>
<th>Table 1 Clinical outcome assumptions for base cost model</th>
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<tbody>
<tr>
<td><strong>Factor</strong></td>
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<td>---------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Commune health centre</strong></td>
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<tr>
<td>Normal delivery</td>
</tr>
<tr>
<td>Moderate PPH</td>
</tr>
<tr>
<td>Severe PPH</td>
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<tr>
<td>PPH with referral to DH</td>
</tr>
<tr>
<td>Very severe PPH</td>
</tr>
<tr>
<td><strong>District hospital</strong></td>
</tr>
<tr>
<td>Normal delivery</td>
</tr>
<tr>
<td>Moderate PPH</td>
</tr>
<tr>
<td>Severe PPH</td>
</tr>
<tr>
<td>Very severe PPH</td>
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<tr>
<td>Proportion CHC vs. DH deliveries</td>
</tr>
</tbody>
</table>

PPH = postpartum haemorrhage.
DH = district hospital.
CHC = commune health centre.
years of life lost is based on Fox-Rushby and Hanson (2001), where the discount rate is assumed to be 3%.

Estimation of cost-effectiveness
Incremental cost-effectiveness ratios were defined as the cost per averted case of PPH, the cost per PPH death averted, and the cost per life-year gained from averted PPH.

Sensitivity analysis
A univariate sensitivity analysis was conducted to test the effect of the different Unject device prices ($0.40, $0.75) and of different overall PPH rates (5%, 8%, 10%) since these are the main drivers of incremental costs. The Unject prices were based on the low end of known prices with another inexpensive medicament and a 50% higher cost than the base case price. The range of PPH rates represents rates commonly noted in the literature and in national Vietnamese reports (Prendiville 2000; Ministry of Health of Viet Nam 2004; Derman 2006). PPH cases prevented for higher levels of PPH in the sensitivity analysis were based on the protective effect estimated by the logistic regression model (OR = 0.60, or PPH reduction of 40%), since this rate has been reported in a wide variety of studies, and on the relative proportions of moderate and severe PPH from the base case. A series of one-way sensitivity analyses was conducted.

Ethical review
The study protocol was approved by the Scientific Committee of the MOH in Vietnam, the Columbia University Institutional Review Board, and PATH’s Human Subjects Protection Committee.

Results
Costs
The basic costs for normal deliveries with and without AMTSL, the cost of treating PPH at different facility types, and the net incremental cost per woman of AMTSL are shown in Table 2. As expected, the use of oxytocin and corollary supplies added to the cost of a normal delivery by between $0.49 and $0.65 depending on the place of delivery. The difference between a CHC and a hospital normal delivery was slight ($0.16 with no AMTSL and $0.25–0.32 with AMTSL), since the procedures followed were similar (including the staffing and use of supplies). The cost of treatment once PPH occurred was, however, much higher at the district hospital than the CHC (by an additional $6.19 to $53 depending on PPH severity), and slightly higher still at the provincial hospital (by $59). Costs for normal deliveries were quite low, primarily because salaries are low, facilities are quite basic, and delivery care is non-interventionist. The additional net cost per woman of providing AMTSL with ampoules (after subtracting the savings due to reduced need for treatment and quicker third stage of labour) was just $0.20; using Unject devices added only $0.08 more per woman to the ampoule cost.

Cost-effectiveness analysis
From this estimate, the number of deliveries treated with AMTSL to prevent one case of PPH and the costs associated with that were calculated (Table 3). At the low rates of haemorrhage seen in the base case, it would take provision of AMTSL to 77 women to prevent one case of PPH, with a resulting cost of $15.70 to $21.68 per case of PPH averted with ampoules and Unject devices, respectively.

With approximately 130 maternal deaths per 100,000 live births in Vietnam (WHO et al. 2003), of which perhaps 31.3% are due to PPH (Tran et al. 2004), AMTSL might be expected to prevent 40% of those PPH deaths, or 16.3 deaths per 100,000 live births. If each woman received AMTSL with ampoules, it would cost an additional $20 400 for 100 000 deliveries and cost just over $1251 per life saved. It was not possible to calculate disability adjusted life years with this data set, but assuming that the average age of women with haemorrhage was 25 years (80% were in the 20–34 year group) and that their life expectancy was 60 years [life expectancy of Vietnamese women born in 1980 was 58.1 years at birth (United Nations 2007) and these women had already survived infancy], the average number of years lost for each death would be 32 with discounting. Even without accounting for disability, the cost per year of life saved would be just $39 if MMR were 130.

Sensitivity analysis
After the base case was constructed, sensitivity analyses were carried out using different costs for Unject, different PPH rates and different maternal mortality ratios (Table 3). At the lower

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Base model of delivery and PPH treatment costs per delivery (in 2004 US$)</th>
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<tbody>
<tr>
<td><strong>Cost of normal delivery</strong></td>
<td></td>
</tr>
<tr>
<td>At CHC, without AMTSL</td>
<td>1.17</td>
</tr>
<tr>
<td>At CHC, with AMTSL, ampoule</td>
<td>1.66</td>
</tr>
<tr>
<td>At CHC, with AMTSL, Unject</td>
<td>1.75</td>
</tr>
<tr>
<td>At DH, without AMTSL</td>
<td>1.33</td>
</tr>
<tr>
<td>At DH, with AMTSL, ampoule</td>
<td>1.91</td>
</tr>
<tr>
<td>At DH, with AMTSL, Unject</td>
<td>1.98</td>
</tr>
<tr>
<td><strong>Cost of treating PPH</strong></td>
<td></td>
</tr>
<tr>
<td>At CHC, moderate, without referral</td>
<td>3.56</td>
</tr>
<tr>
<td>At CHC, severe, without referral</td>
<td>10.27</td>
</tr>
<tr>
<td>At CHC, severe, with referral</td>
<td>10.94</td>
</tr>
<tr>
<td>At DH, if delivered there, moderate</td>
<td>10.47</td>
</tr>
<tr>
<td>At DH, if delivered there, severe</td>
<td>36.60</td>
</tr>
<tr>
<td>At DH, if delivered there, severe+</td>
<td>64.07</td>
</tr>
<tr>
<td>At DH, if referred in, moderate</td>
<td>11.67</td>
</tr>
<tr>
<td>At DH, if referred in, severe</td>
<td>36.48</td>
</tr>
<tr>
<td>At DH, if referred in, severe+</td>
<td>64.60</td>
</tr>
<tr>
<td>At provincial hospital, if referred in, severe+</td>
<td>69.94</td>
</tr>
<tr>
<td><strong>Net incremental cost per woman receiving AMTSL</strong></td>
<td></td>
</tr>
<tr>
<td>Net incremental cost of adding AMTSL, ampoule</td>
<td>0.204</td>
</tr>
<tr>
<td>Net incremental cost of adding AMTSL, Unject</td>
<td>0.282</td>
</tr>
</tbody>
</table>

*Assumes $1 = VND 15 900.
PPH = postpartum haemorrhage.
CHC = commune health centre.
DH = district hospital.
cost of Uniject, AMTSL using the Uniject device would actually be very slightly less expensive than ampoules ($0.002); at the higher cost, use of Uniject devices would be $0.33 higher per woman than ampoules. Varying the rate of PPH had the biggest effect, as might be expected. If the underlying PPH rate were 8%—as in other settings in Vietnam and elsewhere—and assuming the 40% reduction in treatment that occurred in the study (adjusted for other factors), the incremental cost of AMTSL drops to just $0.07 per woman with ampoules. With a PPH rate of 10%, as suggested by Geller et al. (2006), AMTSL becomes essentially cost neutral ($0.002) with ampoules and is just $0.08 per woman with Unijects that cost $0.50. With a PPH rate of 10%, one case would be prevented for every 25 women treated, and the cost per PPH case averted would drop from $15.70 to just $0.05 with ampoules, and from $21.68 to just $2.01 with oxytocin in Uniject devices.

If the MMR were 165 (Ministry of Health of Vietnam 2003) instead of 130, the number of deaths prevented (assuming the base rate of 40% reduction) would be about 20.7/100 000, and the cost per death prevented would drop to about $986. The cost per year of life saved would be just $31 if MMR were 165. Since we do not have data to show whether the proportion of deaths prevented would be parallel to the proportion of PPH cases averted, we varied the proportion of deaths by 50% in each direction. In addition to the base proportion of 40% (as with PPH incidence), we also considered the possibility that AMTSL would prevent only 20% of maternal PPH deaths (e.g. that AMTSL mostly prevented the less serious PPH cases) or that it might prevent 60% of maternal PPH deaths (e.g. that AMTSL prevents a high proportion of the most serious PPH cases and/or moderates their impact). Under the most favourable assumptions (high underlying rate of PPH, high maternal mortality ratio, and strongly protective effect of AMTSL), the best-case cost per PPH death averted would be just $7 with ampoules and $260 with Unijects.

Discussion

The actual net incremental cost of routine use of AMTSL per woman is very small and would be almost cost neutral in districts with more typical rates of PPH than those found in this study. The underlying rate of PPH in this population was relatively low (4.2%) compared with studies in the United Kingdom (16.5%) and in Ghana (17.4%) (Rogers et al. 1998; Geelhoed et al. 2002). In addition to all the illness and treatment costs avoided by preventing PPH, the cost per death averted is considerably lower than other maternal and perinatal health intervention packages (Graham et al. 2006). With a health expenditure of $30 per capita in 2004, the use of oxytocin in ampoules at $0.05 per case of postpartum haemorrhage averted is both affordable and good value for the investment. Even at approximately $2.00 per case averted, the use of oxytocin in Uniject is an affordable life-saving intervention.

These cost estimates do not include the indirect costs associated with maintaining emergency transportation, blood transfusion capacity or surgical services, which would also be

Table 3

<table>
<thead>
<tr>
<th>PPHb</th>
<th>Probability averted</th>
<th>No. averted/100 treatedc</th>
<th>No. needed to treatd</th>
<th>Net incremental cost per deliverye</th>
<th>Cost per PPH averted ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ampoule</td>
<td>Uniject</td>
</tr>
<tr>
<td>4.2%</td>
<td>0.4</td>
<td>1.3</td>
<td>76.9</td>
<td>0.204</td>
<td>0.282</td>
</tr>
<tr>
<td>5%</td>
<td>0.4</td>
<td>2.0</td>
<td>50.0</td>
<td>0.166</td>
<td>0.244</td>
</tr>
<tr>
<td>8%</td>
<td>0.4</td>
<td>3.2</td>
<td>31.3</td>
<td>0.067</td>
<td>0.145</td>
</tr>
<tr>
<td>10%</td>
<td>0.4</td>
<td>4.0</td>
<td>25.0</td>
<td>0.002</td>
<td>0.080</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PPH deathf</th>
<th>No. averted/100 000 treated</th>
<th>Cost per PPH death averted ($)</th>
</tr>
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<tbody>
<tr>
<td>40.7g</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>51.6h</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>0.4</td>
<td>0.2</td>
<td>20.7</td>
</tr>
<tr>
<td>0.6</td>
<td>0.2</td>
<td>31.0</td>
</tr>
<tr>
<td>Best case</td>
<td>0.2</td>
<td>31.0</td>
</tr>
</tbody>
</table>

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*aPPH rate varied from base case of 4.2% to 10%.
bPPH = postpartum haemorrhage rate.
c(PPH rate) × (% averted) × 100.
d100/(number averted).
eNet incremental cost, compared to delivery without AMTSL.
fPPH death = maternal death due to PPH per 100 000 live births.
gAssumes 31.3% of MMR at 130 due to PPH (Tran et al. 2004).
hAssumes 31.3% of MMR at 165 due to PPH (Tran et al. 2004).
reduced by AMTSL. Nor do they capture the impact on women or their families of extra costs related to travel, reduced productivity related to post-PPH anaemia, or family care provision for convalescent mothers. The current study was not able to estimate the potential benefit that could be expected if the Uniject device also contributed to more widespread implementation of AMTSL (higher coverage) and more timely use for greater effectiveness.

It was noteworthy that, with higher rates of PPH, AMTSL with oxytocin in ampoules becomes almost cost neutral. The low rate of PPH in the study area may be a reflection of the high quality of midwife attendance (about half have at least 10 years of experience), the relatively low parity of women, and the low level of medical intervention in the delivery process. In other provinces where such favourable conditions are not present and PPH rates are higher, the expected benefit of AMTSL should be higher. In a study of costs using data from Guatemala and Zambia and assuming a 10% underlying PPH rate and a 5% rate when AMTSL is practiced, AMTSL would have saved about $18 000 per 100 000 deliveries in Guatemala and over $145 000 per 100 000 deliveries in Zambia (Fogarty et al. 2004).

Using the Uniject device instead of ampoules would add only a small incremental cost and would enable midwives in difficult settings to benefit from its greater ease of use. Governments could not only satisfy the preferences midwives have expressed for the Uniject device (Tsu et al. 2003; Strand et al. 2005; Tsu et al. 2008), but also increase the likelihood that AMTSL will be practiced more consistently. At a slightly lower cost for the Uniject device (as has already been achieved with hepatitis B vaccine), AMTSL with Uniject devices would also be cost neutral or even slightly cost saving when savings from averted PPH cases are considered. While oxytocin in Uniject has not previously been commercially available, a company in Argentina began production and received regulatory approval in 2008. A company in India is also beginning preparations for production.

In this study, the rates of referral (like the rates of PPH) were lower than expected, with many women with PPH being successfully treated at the CHC level, perhaps because of the highly experienced midwives. In districts that did not have such expertise available at the CHC level, referrals would have been higher and cost savings associated with averted PPH episodes would have been even greater. Care at district hospitals was generally more expensive, in part due to more senior staff and more complex infrastructure, so avoiding the need for referral would help reduce costs.

The costs used in this study were drawn specifically from the districts in Thanh Hoa Province, which is densely populated and has better than average infrastructure. They did not involve start-up costs like training or indirect costs like facilities and other infrastructure. Data that were more representative of national average costs might have given a slightly different picture of the cost-effectiveness of these alternative strategies for managing third-stage labour. If midwives at the primary level were less able to deal with haemorrhage and referral costs were higher in other settings, the cost of PPH treatment would be higher and the benefits of prevention would be greater.

Other limitations of the study were the inability to measure mortality reduction or actual years of life lost due to PPH. The uncertain cost of Uniject and of PPH rates in other districts in Vietnam make it difficult to ascertain how much these results apply to the rest of the country. However, the conservative nature of the estimated PPH reductions suggests that the benefits seen here are likely to be the minimum benefits. It would be helpful if similar studies were done to weigh the costs of using misoprostol prophylactically (taking into account the trade-offs associated with its slightly lower efficacy and higher price, and its potential for wider coverage and freedom from cold chain support), since that is being recommended by some researchers as the primary alternative (Derman et al. 2006; Prata et al. 2006; Zachariah et al. 2006).

Conclusions

The low net incremental cost of AMTSL suggests that the introduction of AMTSL in primary-level facilities in Vietnam can reduce the incidence of PPH and benefit women's health without adding much to national health care costs. In countries with scarce health care resources, where levels of PPH are generally much higher, AMTSL by either ampoule or Uniject device would likely be cost neutral, if not cost saving. This is the first study to estimate the cost and affordability of AMTSL used in primary-level facilities in a low-resource country. As countries with scarce health care resources consider the global recommendations to adopt AMTSL wherever a skilled provider attends a delivery, it is important that decision-makers have relevant data as to the likely costs and savings they can expect. Midwives can easily learn AMTSL in a relatively short time, but putting it into practice using ampoules and standard syringes may be difficult in primary care facilities like CHCs where midwives often practice without any assistance. Use of Uniject devices overcomes many of the barriers cited by midwives with regard to the use of oxytocin in ampoules and will be less expensive than ampoules if prices at the lower end of the likely range become available. The low net incremental cost of AMTSL is very encouraging. If the eventual commercial price of oxytocin in Uniject is similar to the price used in this model, it will be quite feasible for governments to satisfy the preferences midwives have expressed for the Uniject device.

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