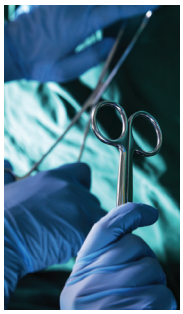

Chapter 5

Obstetric Surgery

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GLOBAL BURDEN OF SURGICALLY TREATABLE OBSTETRIC CONDITIONS

Surgically Preventable or Treatable Conditions

Pregnancy is not a disease but a condition undertaken by most women during their reproductive lives. Pregnancy, however, is a time when health can be threatened. Any pregnancy carries the risk for hemorrhage, obstructed labor, or the need for a cesarean delivery. The sheer volume of maternal morbidity and mortality worldwide indicates that *every* pregnant woman is at risk for surgically preventable obstetric complications that can lead to death or disability.

Maternal morbidity and mortality are significantly increased by conditions that can be prevented by access to safe obstetric surgery. Obstructed labor, which can lead to fistula formation, uterine perforation, hemorrhage, sepsis, or death, can be avoided by observing labor for deviations from normal and providing access to nearby safe cesarean delivery. Most low- and middle-income countries (LMICs) do not have birth attendants present at deliveries to monitor for abnormalities; most of these countries also lack the capacity to provide access to nearby hospitals, where safe and timely cesarean deliveries can be undertaken. Hemorrhage during pregnancy and the postpartum period can be catastrophic; the occurrence of hemorrhage remote from access to surgical services, such as uterine curettage or lifesaving hysterectomy, drives avoidable maternal mortality rates worldwide.

This chapter uses the World Health Organization's (WHO's) six geographical regions: African Region, Region of the Americas, South-East Asia Region, European Region, Eastern Mediterranean Region, and Western Pacific Region.

Burden of Maternal Mortality

In 2000, total maternal mortality was 421,010; by 2011, worldwide maternal mortality had decreased significantly to 279,000. The maternal mortality ratio (MMR)—maternal deaths per 100,000 live births—improved from 321 in 2000 to 207 in 2011. In high-income countries (HICs), a small increase was noted, from 12 to 14; LMICs saw a marked improvement, from 352 to 227 (WHO 2013). This risk is much higher in adolescent pregnancies, which account for an increasing proportion of maternal mortality in LMICs (Patton and others 2009).

In LMICs, a woman has a 1:150 lifetime risk, on average, of dying from complications of pregnancy and childbirth (WHO 2012). In some areas of Sub-Saharan Africa, this risk is as high as 1:16; a woman who survives until childbearing years has a 6.25 percent chance that her life will be ended prematurely from the complications of pregnancy. These burdens are even higher in the underdeveloped regions of countries with high maternal morbidity and mortality rates (Liang and others 2011).

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The reduction of maternal mortality during pregnancy and up to six weeks postpartum was established as Millennium Development Goal (MDG) 5 (UN 2013). Although the world has yet to approach the MDG 5 goal of a 75 percent reduction in the MMR, there are reasons for optimism (Hogan and others 2010). Worldwide efforts to meet this goal have yielded dramatic improvements. Overall success has been attributed to improvements in the total fertility rate, per capita income, maternal education level, and presence of skilled birth attendants. However, the HIV epidemic has significantly added to MMRs; areas that could have been expected to see a reduction in maternal mortality have instead not seen significant differences. The tremendous disparity in MMRs between HICs on the one hand and LMICs on the other indicates the potential to reduce maternal morbidity and mortality on a worldwide scale.

Disability Burden

Assessments of disability-adjusted life years (DALYs) have been made for major obstetric complications worldwide (table 5.1). A DALY is a metric of the number of years lost due to ill health, disability, or early death for one individual. When summed for a population, it can assess the burden of a disease in a way that mortality assessments may miss. The significance of such assessments is that efforts to drive down MMRs succeed in part by creating permanent disabilities in lieu of maternal death. The societal costs of these DALYs can be significant, and a full assessment of the burden of disease should include an evaluation of DALYs.

In 2010, the collective disability for all measured maternal disorders reached 16 million DALYs (Murray and others 2012). Of this number, 3.3 million DALYs were attributed to maternal hemorrhage, 1.8 million to complications of obstructed labor, and 1.3 million to maternal sepsis. These numbers are indicative of the tremendous morbidity associated with surgically preventable obstetric complications that can be targeted worldwide.

As table 5.1 demonstrates, dramatic improvements in reducing MMRs have been made in the past 20 years. However, obstructed labor has lagged behind the other major maternal disorders (Murray and others 2012). This lag is partly due to the challenges in the treatment of this condition. Simply having access to safe and timely cesarean delivery can prevent the sequelae of obstructed labor. This simple procedure has been more difficult to implement in LMICs than have the medical treatments that can reduce morbidity from hemorrhage or hypertensive diseases, in large part because of the associated up-front infrastructural and systems costs of developing the environments

Table 5.1 The Global Disability Burden of Obstetric Disease in Terms of Disability-Adjusted Life Years, 1990–2010

	All ages DALYs (thousands)			DALYs (per 100,000 total population)		
	1990	2010	Difference (%)	1990	2010	Difference (%)
Maternal disorders	21,582 (18,000–25,720)	16,104 (12,972–18,912)	–25.4	407 (340–485)	234 (188–274)	–42.6
Maternal hemorrhage	4,784 (3,923–5,713)	3,289 (2,619–3,860)	–31.2	90 (74–108)	48 (38–56)	–47.1
Maternal sepsis	2,043 (1,701–2,508)	1,309 (1,059–1,585)	–35.9	39 (32–47)	19 (15–23)	–50.7
Hypertensive disorders of pregnancy	4,108 (3,406–4,986)	2,797 (2,254–3,357)	–31.9	77 (64–94)	41 (33–49)	–47.6
Obstructed labor	1,891 (1,451–2,625)	1,792 (1,249–2,806)	–5.2	36 (27–50)	26 (18–41)	–27.1
Abortion	3,218 (2,668–3,945)	2,138 (1,731–2,592)	–33.6	61 (50–74)	31 (25–38)	–48.9
Other maternal disorders	5,538 (4,576–6,538)	4,778 (3,819–5,512)	–13.7	104 (86–123)	69 (55–80)	–33.6

Source: Adapted from Murray and others 2012.
Note: 95 percent confident interval in parentheses.

in which patients can be referred and safe cesarean delivery performed.

Societal Impact of Maternal Mortality

A valid assessment of the health burden of obstetric complications should not be limited to maternal morbidity and mortality, but should also consider the effect of the morbidity and mortality rates in LMICs. Such assessments have included the effects that a maternal death can have on societies as well as on families (Yamin and others 2013). Children who are orphaned as the result of a maternal death suffer from hindered access to health care, poorer nutrition, and worse education. Female orphans particularly suffer because they are often expected to perform the household chores that their mothers would have performed. Their educational and economic opportunities become limited, and high-risk sexual behavior or early marriage can result. These developments, in turn, can lead to early pregnancies, putting daughters at risk for the same complications that led to their mothers' deaths.

In addition to the negative impacts on orphan children, maternal deaths affect the entire family structure (Yamin and others 2013). Economically, the loss of a mother is a loss of help around the house, a loss of a potentially important secondary income, and the loss of a caregiver. In these environments with high maternal mortality, high societal mortality rates often lead to women having multiple children with different fathers. It is uncommon for surviving fathers to care for non-biological children, potentially abandoning orphaned children without living fathers. The loss of mothers frequently can lead to the dissolution and permanent fragmentation of families, with children going to different homes or family members. Support structures for families that have lost mothers are uncommon and not well developed in countries where maternal death rates are high.

In sum, the global health burden of obstetric disease is tremendous, with essentially all women of reproductive age at risk for obstetric complications. Some percentage of pregnancies require some form of operative delivery; an estimated 15 percent of all deliveries require cesarean delivery to optimize maternal and neonatal outcomes (Gibbons and others 2012). Worldwide, 50 percent of countries have cesarean delivery rates that are less than 15 percent; 25 percent of countries have cesarean delivery rates of less than 5 percent. The WHO estimates that in LMICs, the cesarean rate should be at least 5 percent to 10 percent of deliveries to optimize maternal and neonatal outcomes (Gibbons and others 2012).

OVERVIEW OF SURGICAL OBSTETRICAL PROCEDURES

The successful management of labor and delivery requires a balanced use of medical and surgical practices. Most pregnancies end with uncomplicated vaginal deliveries. Pregnant women in labor have the right to attendants who can manage obstetric complications as they arise and who can transfer patients to a higher level of care as needed.

The presence of skilled birth attendants at all deliveries facilitates normal deliveries and the identification and referral of complications, but their effectiveness is limited by available referral resources. Although birth attendants may be able to accommodate minor complications, the benefit of their ability to identify major morbidity is limited if patients lack timely access to higher levels of care.

A majority of obstetric complications that require surgical intervention occurs peridelivery. Obstructed labor from a number of causes, including malpresentation and large fetal size, can necessitate one of a number of procedures to facilitate fetal delivery. Following delivery, hemorrhage from a number of etiologies, including lacerations and uterine atony, can similarly require one of a number of lifesaving procedures to help stop ongoing bleeding.

Operative Vaginal Delivery

Operative vaginal delivery, such as delivery assisted with forceps or a vacuum, requires trained providers as well as available instruments (Hale and Dennen 2001); its use in LMICs is often limited to the hospital setting. Vacuums require a fundamental level of training before routine use, and forceps require potentially more training, in addition to provision of the actual devices. The WHO is developing variations on a vacuum to provide a low-cost and easy-to-use device that can be widely implemented by birth attendants to reduce morbidity and mortality (FIGO 2012). Some devices are reusable; after the initial investment in the device, the subsequent cost largely consists of training providers to effectively and safely use it. The use of operative vaginal delivery techniques in the appropriate clinical circumstance might prevent the need for an inaccessible but otherwise necessary cesarean delivery. Additionally, manual or digital rotation of the fetal head without the use of forceps can help to guide the head through the pelvis to facilitate vaginal delivery (Le Ray and others 2007), but it requires a similar level of training. In sum, the minimal costs associated with providing the devices, as well as training for

management of the second stage of labor, can help reduce morbidity and mortality without requiring the use of an operating theater.

Shoulder Dystocia

Shoulder dystocia and its association with poor fetal outcomes and brachial plexus injuries make it a feared obstetrical complication (Baskett, Calder, and Arulkumaran 2007; O'Grady and others 2008). Shoulder dystocia results from delivery of the fetal head, with a dystocia at the level of the shoulder that obstructs delivery. It is more common with large infants, particularly with relatively large shoulder widths born to mothers with diabetes. Attempts at delivery may cause permanent nerve injury, and delay in delivery may cause hypoxic injury or death.

Several maneuvers have been described for delivery. Most techniques involve rotation of the fetal shoulder from the anterior-posterior orientation to a more oblique position, where the more generous dimensions of the pelvis might permit shoulder delivery. Specific surgical instruments may be needed for operative management without successful resolution of the dystocia. Successful management of a shoulder dystocia depends primarily on the training of the attending providers.

Intentional pubic symphysiotomy, where the pubic bone is broken to facilitate fetal delivery, is controversial because it can cause significant maternal morbidity and chronic pain. Its implementation should be performed only by experienced providers when all other options have failed and cesarean delivery is not available. Significantly, it is only necessary without timely access to safe cesarean delivery.

Genital Tract Lacerations

Lacerations of the genital tract, which can occur spontaneously or result from an episiotomy, are the second most common cause of postpartum hemorrhage. They can occur at any level, including the perineum, sulci, cervix, or the broad ligament in the abdomen; without spontaneous hemostasis, they will require repair. The use of routine episiotomy in obstetrics has evolved, with studies demonstrating the cost-effectiveness of its selective rather than routine use (Borghi and others 2002). An attendant with available suture can repair a majority of perineal lacerations without referral, but severe lacerations can threaten or end a mother's life. Complicated lacerations can bleed profusely; ongoing bleeding can exhaust clotting factors, resulting in an inability to clot and death. Similarly, hematomas can occur; even without visible bleeding, large volumes of blood can accumulate in the pelvis following vaginal delivery. Depending on their location, prompt identification and treatment can be life saving.

Abnormal Fetal Presentation

Breech Presentation. In most pregnancies, the fetus moves into the safest position of head down at approximately 36 weeks. However, this movement does not occur in 4 percent of cases, resulting in breech presentation (Baskett, Calder, and Arulkumaran 2007), and its incidence rises dramatically with prematurity. Breech presentation is associated with inferior fetal outcomes, as a result of both the antenatal risk factors and the perinatal risk of birth injury at delivery.

Ideally, a breech presentation is identified before delivery so that consideration can be given to attempting the external turning of the fetus. This technique is optimally performed near 36 weeks, when the success rate is generally better than 50 percent. Although external version can effectively make a mother a candidate for vaginal delivery and decrease morbidity, it carries the risk of manually traumatizing the placenta or the fetus, necessitating immediate delivery. It should only take place when the fetal status can be confirmed, and intervention, including cesarean delivery, is immediately available. Unfortunately, in LMICs where antenatal care is scant, breech presentation may not be identified until labor, and delivery has to be facilitated either by emergent cesarean or by unanticipated vaginal breech delivery.

Large studies have demonstrated improved fetal outcomes in breech presentation with cesarean delivery (Hannah and others 2000; Hannah and others 2002); safe cesarean delivery is preferred, when available, unless practitioners are trained to manage breech labor and its complications. Birth attendants should be trained in the maneuvers to assist intact delivery in cases in which breech delivery is inevitable or advisable. Particularly in the absence of antenatal care, a possible clinical scenario is a vaginal breech delivery in progress, and fetal outcome will depend on a present provider who can safely deliver the fetus.

Other Presentation. Malpresentation, in which neither the fetal vertex nor the breech is the presenting part, as with a transverse presenting fetus (where the fetus is sideways), is a universal indication for cesarean delivery. Without a safe and timely cesarean delivery, the pregnancy can end with obstructed labor and its sequelae, or fetal demise.

Multiple Gestation

Delivery of more than one fetus is inherently more complicated (Baskett, Calder, and Arulkumaran 2007). Contraindications to vaginal delivery include three or more fetuses, an exceedingly uncommon event in the absence of assisted reproductive technology. Fortunately, the presenting fetus will usually be head down in the pelvis and can be managed essentially as a singleton labor. Following delivery of the first twin, and if the second twin does not present vertex, attempts can be made to externally rotate the fetus to vertex and proceed with vaginal delivery. Otherwise, breech extraction of the second twin can be considered. In multifetal deliveries, vaginal delivery has lower maternal morbidity than cesarean delivery, but a combined vaginal delivery and cesarean delivery is more morbid than either. If vaginal delivery of a second twin is doubtful, particularly in the absence of a provider comfortable with breech extraction, cesarean delivery may be considered primarily.

Postpartum Hemorrhage

Postpartum hemorrhage is a dreaded complication akin to the most severe surgical trauma. The average blood losses for a routine vaginal delivery and a cesarean delivery are commonly accepted to be 500 mls and 1,000 mls, respectively; blood loss in excess of these values is considered to be hemorrhage. The causes of postpartum hemorrhage are as follows, in the order of frequency, with optimal management based on underlying etiology (O'Grady and others 2008):

- Uterine atony
- Lacerations
- Retained placenta, including abnormal placentation
- Uterine rupture
- Uterine inversion
- Coagulopathy

Uterine Atony. Uterine atony accounts for approximately 80 percent of all postpartum hemorrhage (O'Grady and others 2008). Risk factors include uterine overdistension, prolonged labor, multiparity, infection, and use of uterine relaxants. Medical uterotonics, where available, can be administered to assist uterine tone, including pitocin, misoprostol, and ergots or prostaglandins. Consideration may also be given to draining the bladder, given that a distended bladder can contribute to uterine atony. Mechanically, bimanual massage can at least temporize uterine atony. Without medical or surgical interventions, effective bimanual massage can be life saving. Research has suggested that effective bimanual massage is optimized when two parties coordinate to help compress the atonic uterus and stop maternal hemorrhage (Andreatta, Perosky, and Johnson 2012). Active management of the delivery of the placenta itself can significantly help prevent atonic hemorrhage and limit the need for additional uterotonics (Stanton and others 2009).

If hemorrhage continues despite these maneuvers, surgical management should be considered. Surgical management can include blunt or sharp curettage of the uterus, particularly with a large curette to minimize the risk of perforating the fragile peripartum uterus and necessitating abdominal surgery. Otherwise, laparotomy can be used to access the uterus and perform maneuvers such as compression sutures, ligation of uterine vessels, or ultimately hysterectomy for definitive management. Delays in or the unavailability of surgical interventions can lead to uncontrolled hemorrhage, disseminated intravascular coagulopathy, and death. For persistent hemorrhage, the uterus can be packed to tamponade and temporize the bleeding. This procedure can be done either with packing or with a balloon catheter to help drain the uterine cavity while providing tamponade. Surgical management may still be fundamentally needed, but maternal survival may depend on the ability to transport to provide abdominal surgery.

Retained Placenta. Following delivery of the placenta, any remnant of the products of conception can contribute to uterine atony and ongoing vaginal bleeding. Retained products may be suspected with difficult extrusion of the placental membranes. In any scenario in which retained products of conception are suspected, consideration should be given to the possibility of placenta accreta because further placental bed manipulation could contribute to catastrophic hemorrhage and death. Surgical curettage may be needed to remove persistent retained products and arrest hemorrhage if placental abnormalities are not present.

Uterine Inversion. Inversion of the uterus can occur as a result of overzealous traction on a placenta or from fundal pressure in the third stage of labor. With inversion, on examination, the fundus may be noted to have descended or prolapsed into the vagina. A skilled attendant can use gentle manual replacement of the fundus back to its appropriate station, and effort may be needed to avoid relapse of the prolapse. Without successful manual replacement, other techniques may be urgently needed in the face of ongoing hemorrhage or maternal shock (Baskett, Calder, and Arulkumaran 2007). Nonsurgically, intravaginal pressure can be increased with infusion of intravenous fluids while the introitus

is blocked, which may reduce the inversion. Surgically, the abdomen can be entered with a Pfannenstiel incision or otherwise to gain exposure to the uterus. In the Huntington procedure, the round ligaments are elevated and followed medially, eventually restoring the inverted fundus. Alternatively, with the Haultian procedure, the inversion is incised vertically, permitting appropriate reapproximation of the fundus.

Blood Transfusion. The WHO considers access to safe blood transfusion be a key lifesaving intervention (WHO 2008). The availability of blood transfusions at the time of obstetric emergency can be life saving. Accordingly, blood transfusion services should be considered part of emergency obstetric management capacity. Blood transfusion availability is severely limited in LICs and LMICs, and efforts to make it available locally can save lives.

Cesarean Delivery

Prolonged labor can lead to uterine rupture, which can lead to rapid fetal or maternal exsanguination. In settings of prolonged and obstructed labor, eventual cesarean section has a significantly increased risk of maternal morbidity or potentially death, compared with timely cesarean delivery.

Indications. The indications for cesarean delivery are numerous, and its potential to reduce associated morbidity is significant. The decision to proceed is influenced by a number of factors, including the training of the operator, the operative and clinical resources, and the variables of the clinical presentation. The caveat is that cesarean delivery is a more morbid procedure: blood loss is increased, recovery time is lengthened, and potentially inferior fetal outcomes can occur. In certain scenarios, however, a cesarean is necessary and inevitable to save a life or lives. Efforts to develop evidence-based best practices for cesarean delivery are ongoing (Berghella, Baxter, and Chauhan 2005; Dahlke and others 2013).

Preoperative Preparation. Once the decision is made to proceed, the patient is moved to the operating theater, and the appropriate anesthesia, whether regional or general, is administered. The abdomen is prepared in a sterile manner. A Foley catheter may be placed to help minimize the presence of the bladder in the operative field and to provide an accurate assessment of urine output. A single dose of antibiotic prophylaxis within 30 minutes before incision is associated with decreased risk of infection. The risk of venous thromboembolism during routine cesarean delivery is low in the absence of other risk factors, and routine medical thrombolytic prophylaxis is not recommended (Dahlke and others 2013).

Incision. The Pfannenstiel incision, transversely in the lower abdomen, has classically been described for cesarean delivery. A midline vertical incision may be considered for better exposure. Alternatives to the Pfannenstiel or midline vertical incisions include the Joel-Cohen technique and the Misgav-Ladach method in which blunt dissection is used and may decrease blood loss and operative time, although studies have not shown significant decreases in morbidity or mortality (CORONIS 2013).

The uterus is incised in the lower nonmuscular portion to facilitate fetal delivery. Occasionally, a contraction ring or "Bandl's ring" can be seen in prolonged obstructed labor at the time of cesarean delivery. Its treatment requires perpendicular incision, through the ring and muscle of the uterus, to relax the tension and permit delivery, with significant future morbidity associated with the incision. Notably, any uterine incision that extends up into the thick muscle significantly compromises the uterus and increases the risk of uterine rupture in a future pregnancy. It is considered a contraindication to a future trial of labor, sentencing the patient to indicated cesarean deliveries for all future pregnancies.

Delivery. The fetus is delivered through the uterine incision, with morbidity associated with cesarean delivery increasing if the fetal head has engaged in the pelvis and labor has taken longer, as with obstructed labor. Techniques to facilitate a challenging cesarean delivery may include breech extraction, use of the vacuum extractor, or use of one or two forceps blades to facilitate delivery through the hysterotomy. Morbidity includes hemorrhage, infection, or uterine excision extension into the nearby anatomy of either the major vasculature or the urinary tract.

If the placenta does not easily separate, occult placenta accreta may be considered. If accreta is suspected, manual removal should be avoided; if spontaneous delivery does not occur, then hysterectomy should be considered. The uterus may be exteriorized to facilitate exposure for closure, although this may increase patient discomfort and nausea, as well as risk of avulsion of adhesions to the uterus, if present.

Uterine closure then takes place quickly in the face of bleeding from the hysterotomy edges and from the uterus. Atony should be addressed while surgery continues with bimanual massage used as needed. If the

patient desires an intrauterine device for contraception, it can be placed at this time directly at the level of the fundus, with the strings trimmed and introduced near or through the cervix.

Obstetric Hemorrhage at Time of Cesarean Delivery. Hemorrhage following cesarean differs from that following vaginal delivery in that there is already access to the abdominal cavity, improving the odds of successful definitive management. Conservative measures can also be taken, including medicines and bimanual massage. Without quick resolution, a stitch can be placed bilaterally around the large uterine vessels to decrease active hemorrhage from the uterus. Hypogastric artery ligation can similarly decrease the blood flow and rate of blood loss, although its dissection is technically challenging and should only be undertaken by an operator sufficiently trained in and comfortable with the procedure. Tamponade and packing can be performed and left in place to arrest bleeding as well.

If atony is the underlying issue and the outlined steps have not stopped the bleeding, compression sutures may be helpful in the scenario in which bimanual massage is effective, but as soon as the hands are removed uterine tone is lost.

When ongoing hemorrhage is significant and not easily abated, definitive management with hysterectomy should be strongly considered because delay will only increase morbidity. The B-Lynch suture is described as passing a stitch on a large needle across the hysterotomy about halfway toward the side (El-Hamamy, Wright, and Lynch 2009). The stitch is then taken to the posterior of the uterus, where it is passed transversely at approximately the level of the anterior low uterine segment hysterotomy. It is brought back anterior, where it is thrown vertically across the hysterotomy on the other side. The two ends of the suture are tied down while an assistant has maximally compressed and folded the uterus on itself, so that when the stitch is tied down, the uterus is as compressed as possible because any relaxation will contribute to bleeding from atony. Other types of compression sutures are described as passing anterior to posterior in the body of the uterus to tamponade sequential pockets throughout the cavity. If compression sutures are performed, care should be taken not to obstruct cavity outflow given that hematometra or pyometra can result.

Abnormal Placentation and Cesarean Hysterectomy

When the placenta grows into tissue beyond its normal boundaries, it can embed in that tissue and cause catastrophic hemorrhage with attempted removal. The term *placenta accreta* encompasses *placenta increta* (where placenta grows into the uterine wall) and *percreta* (where placenta grows into nearby tissue including bowel and bladder). Risk factors include previous uterine scarring from surgical procedures, including previous cesarean section.

Antenatal diagnosis can be achieved with ultrasound imaging in combination with clinical history. With antenatal diagnosis, preparations should be made at the onset of labor to plan for delivery in a scheduled setting, ready for the probability of cesarean hysterectomy and the need for blood products, if available. Even in settings with full obstetric resources, placenta accreta can lead to poor maternal outcomes. The aggressive hemorrhage associated with incomplete placental separation can quickly lead to disseminated coagulopathy and require massive blood transfusions to maintain maternal life.

Suspicion of placenta percreta before delivery calls for the coordination of a team of surgeons in a facility with resources to maximize the likelihood of safe delivery. Cesarean delivery should be undertaken, with consideration for a midline vertical incision to facilitate a potential hysterectomy. Following exposure of the gravid uterus, a uterine incision may be made to avoid disruption of the placental bed if its location is known. In cases of diagnostic certainty, cesarean hysterectomy can be accomplished without attempting placental delivery, decreasing the risk of morbidity associated with hemorrhage. In cases in which accreta is not identified until the time of delivery, a balloon catheter can be used to tamponade the uterine cavity, potentially avoiding further surgical morbidity.

Following delivery, the hysterectomy is performed; in these cases, the caliber of the vasculature is significantly generous and the anatomy can be distorted. Care must be taken to skeletonize the engorged uterine vessels while ensuring safe distance from the ureters to prevent their injury.

There is no definitive answer for when to deliver suspected placenta accreta, although it is frequently done between 34 weeks and 36 weeks to balance neonatal survival against risk of onset of labor and emergent delivery in the setting of acute hemorrhage (ACOG 2013).

EFFECTIVENESS AND COST-EFFECTIVENESS OF OBSTETRIC SURGERY

The need to prove the cost-effectiveness of operative obstetrics to decrease the tragedy of preventable maternal mortality or morbidity may be offensive to some.

Regardless, the provision of safe cesarean delivery to prevent obstructed labor in LMICs has been demonstrated to be cost-effective, with a positive net economic return to those societies.

Safe Cesarean Delivery

Numerous studies have demonstrated the significant cost-effective benefits of providing access to safe cesarean delivery in countries where it is not currently available (table 5.2) (Grimes and others 2014). Separate analysis finds that the provision of cesarean for obstructed labor, malpresentation, or fetal distress in these countries would cost US$73 for each DALY averted in Sub-Saharan Africa, and US$2,638 in South-East Asia (Adam and others 2005).

A study in Guinea finds that the provision of cesarean delivery for obstructed labor was very cost-effective at US$18 per year of life saved (Jha, Bangoura, and Ranson 1998). A study in the Democratic Republic of Congo reinforces the challenges and the importance of providing emergency obstetric services during humanitarian crises; it further demonstrates that financial investments can significantly improve maternal and neonatal mortality (Deboutte and others 2013).

One of the major sequelae of not having access to safe cesarean delivery is obstetric fistula resulting from obstructed labor (see chapter 6). An estimated 3 million women suffer from obstetric fistula worldwide. Obstetric fistula can result in societal marginalization, in addition to significant medical morbidities that are frequently permanent (Wall 2006). One analysis that examines only the impact of obstructed labor sequelae finds that the provision of safe cesarean delivery where not available would avert 16,800 maternal deaths in one year (Alkire and others 2012). This study, which analyzes countries where the number of cesarean deliveries provided is inadequate to meet demand, finds that approximately 1 million DALYs would be saved by providing accessible cesarean delivery to 90 percent of the pregnancies complicated by obstructed labor

Table 5.2 Overview of Studies Evaluating the Cost-Effectiveness of Cesarean Delivery

Study	Country or region	Details of intervention analyzed	Cost-effectiveness	Measurement
Alkire and others 2012	49 countries with unmet demand for cesarean delivery	Evaluation of the unmet need for cesarean delivery indicated for obstructed labor	Median US$304 Range $251–$3,462	Cost per DALY averted
Adam and others 2005	High-risk areas of Sub-Saharan Africa and South-East Asia	Evaluation of the unmet need for cesarean delivery indicated for a composite of obstructed labor, malpresentation, and nonreassuring fetal status	Sub-Saharan Africa: US$1,576 South-East Asia: US$1,449	Cost per DALY averted
Jha, Bangoura, and Ranson 1998	Guinea	Evaluation of the unmet need for multiple surgical services, including cesarean delivery indicated for obstructed labor	US$18	Cost per YLS
Hu and others 2007	Mexico	Upgrading current obstetric practice to meet the WHO mother-baby standard of care package	US$550 US$390	Cost per YLS Cost per DALY
Erim, Resch, and Goldie 2012	Nigeria	Stepwise improvement in family planning; safe abortion provision; and intrapartum care, including cesarean delivery	US$3,930–US$4,481	Cost per maternal death averted
Goldie and others 2010	India	Stepwise improvement in family planning; safe abortion provision; and intrapartum care, including cesarean delivery	US$300 in rural India US$350 in urban India	Cost per YLS
Carvalho, Salehi, and Goldie 2013	Afghanistan	Stepwise improvement in family planning; safe abortion provision; and intrapartum care, including cesarean delivery	US$178	Cost per YLS
Deboutte and others 2013	Congo, Dem. Rep.	Investment in an NGO hospital in the postconflict environment to provide emergency obstetric care	US$9.2	Cost per health-adjusted YLS

Source: Adapted from Grimes and others 2014.
Note: NGO = nongovernmental organization; WHO = World Health Organization; YLS = year of life saved.

(Alkire and others 2012). The cost-effectiveness associated with providing cesarean delivery services at this level varies widely by country, from US$251 for each DALY averted in countries with higher maternal morbidity risks to US$3,462 per DALY averted in other countries analyzed.

Free or Subsidized Surgical Care

The provision of safe cesarean delivery services implies inherent costs to individuals without subsidized cesarean delivery that prevent implementation of indicated cesarean deliveries. This provision of free intrapartum services that include cesarean delivery is associated with increased rates of supervised labor and increased utilization of needed cesarean delivery (Lawn and others 2009). This scenario has been evaluated in Senegal, where the provision of free cesarean delivery helped to increase the rate to greater than 5 percent (Witter and Diadhiou 2008; Witter and others 2010). The US$461 cost associated with each additional cesarean delivery was judged to be beneficial, given that it represents a cesarean delivery that would otherwise not be provided. Similarly, in Ghana, a policy removing patient responsibility for costs at birth and postpartum was associated with an increase in attended births and institutional delivery (Lawn and others 2009; Witter and others 2007).

In India, Janani Suraksha Yojana, a cash incentive program to promote attended obstetric delivery, encouraged the practice, but it also raised concerns regarding the targeting of funding to the poorest in the population (Lim and others 2010). Subsidizing and encouraging safe obstetric delivery and free cesarean delivery in areas where the infrastructure exists to provide the services risks exacerbating disparities between areas where access to safe and timely cesarean delivery is available and areas where it is not available regardless of cost (Witter and others 2010).

In addition, care must be taken in auditing cesarean delivery rates in areas where costs are subsidized to ensure that the system does not develop a supratherapeutic cesarean rate. Overall, however, the evidence clearly indicates that the provision of financial incentives, or the removal of disincentives, can help improve access to emergency obstetric care (Briand and others 2012).

Synergy of Providing Obstetric Care with Family Planning Services

An analysis demonstrates that in Mexico, coupling effective family planning with emergency obstetric services saves costs of US$900,000 per 100,000 women compared with the current practice (Hu and others 2007).

The cost-effectiveness of safe cesarean delivery and emergency obstetric care can be significantly enhanced by effective family planning programs involving contraception and safe abortion (see chapter 7). An analysis in India suggests that combining the cost savings of effective family planning with the cost savings of providing emergency obstetric care could amount to savings of US$1.5 billion dollars per year and would help to reduce maternal mortality by as much as 75 percent (Goldie and others 2010). A similar analysis in Afghanistan finds that providing access to effective family planning services results in significant cost savings and reductions in maternal mortality (Carvalho, Salehi, and Goldie 2013). Additional reductions in maternal mortality depend on access to safe cesarean delivery and emergency obstetric care; in combination with family planning services, such access could help reduce maternal mortality by as much as 80 percent. In Nigeria, a similar analysis using a stepwise improvement package of family planning, abortion services, and emergency obstetric care demonstrates cost-effective improvements in public health (Erim, Resch, and Goldie 2012).

It is clear from these and other studies that the cost-effectiveness of cesarean delivery has synergy with other public health interventions involving family planning and abortion care (Souza and others 2013). The combination of these interventions will be far more effective than any single intervention in achieving the goals of substantial improvements in maternal mortality, as in MDG 5 (UN 2013).

An overview of studies evaluating the cost-effectiveness of obstetric interventions in different countries or areas is limited by the ability of the results from one setting to be generalized to another. The countries and areas in table 5.2 are widely variable, limiting this generalizability. A consistent theme, however, is that the provision of these fundamental obstetric packages is profoundly cost-effective or cost saving. The concept of areas where interventions can save a year of maternal life for less than US$20 or save the life of a reproductive-age woman for less than US$5,000 argues for the implementation of such programs to help save lives.

Other Obstetric Surgical Procedures

Little research has been conducted to justify the cost-effectiveness of other obstetric surgical procedures, in part because safe childbirth and prevention of unnecessary maternal and neonatal death may be considered goals without the need for cost justification.

Additional shared costs are involved when considering use of the techniques discussed in addition to cesarean delivery. Cost-effectiveness analysis of other operative obstetric techniques—including operative vaginal delivery and surgical treatment of postpartum hemorrhage—is limited in part by the difficulty of associating the costs and benefits of a single intervention. Although procedures may employ reusable equipment or sutures, these costs are relatively minor when compared with the cost of provider training to perform these procedures. Given the significant costs of developing a surgical center with providers trained to perform safe cesarean delivery, these same providers at these facilities—or elsewhere in the field—can be readily trained to perform the other obstetric surgical procedures.

Although the WHO estimates that the cesarean rate should be at least 5 percent to 10 percent of deliveries in LMICs to optimize maternal and neonatal outcomes, studies suggest that cesarean delivery rates higher than 15 percent to 20 percent in these countries may have greater associated maternal and neonatal surgical morbidity rates, compared with those for vaginal delivery, without providing significant health benefits (Gibbons and others 2012). The cost of excess cesarean rates in HICs has been estimated to be well over US$2 billion annually, suggesting the cost-saving utility of operative vaginal delivery to reduce the rate of unnecessary cesarean delivery in HICs (Gibbons and others 2012). The costs of both supplies and obstetric training must be considered in evaluating operative vaginal techniques, but both are likely to be cost saving compared with a cesarean delivery. This modeling has limitations when safe alternatives to vaginal delivery, including safe cesarean delivery, are not available.

Task-Shifting to Increase Skilled Providers

As countries attempt to meet the goal of providing safe cesarean delivery, expanding the pool of those who provide surgical services to providers other than obstetricians becomes an option. Mullan and Frehywot (2007) in an assessment of Sub-Saharan countries find that more than 50 percent use nonphysician clinicians in lieu of medical doctors to provide health care for communities. Task-shifting has been evaluated with non-obstetrician physicians, or even clinical officers, trained to perform cesarean deliveries.

In Tanzania, nonphysician clinicians have been an important asset in helping overcome the unmet need, which exceeds 70 percent, of emergency obstetric care (Nyamtema and others 2011). These nonphysician clinicians were given an effective three-month training curriculum; upon completion, they have provided a majority of the emergency obstetric care in the area (Pereira and others 2011). The evaluation found no significant differences in the obstetric outcomes between the nonphysician clinicians and the physician providers (McCord and others 2009). Despite the implementation of these nonphysician clinician teams, most emergency obstetrical care needs remain unmet. Further gains appear to depend on access to hospital care centers rather than additional qualified obstetric providers.

The cost-effectiveness of using different providers has been evaluated in Burkina Faso (Hounton and others 2009). Clinical officers are trained nurses who undergo two additional years of surgical training; general practitioners in rural areas are trained in basic surgical techniques, including cesarean delivery. Obstetricians and general practitioners had significantly better maternal and neonatal outcomes compared with clinical officers. Obstetricians overall had moderately better neonatal outcomes than the general practitioners, but at significantly higher costs; the cost per cesarean delivery was twice as high with obstetricians compared with task-shifted providers. The benefit of using the trained general practitioners rather than clinical officers was associated with a cost of US$200 for each neonatal life saved.

A review in Ethiopia finds that more than 63 percent of obstetric procedures and cesarean deliveries are performed by nonphysician clinicians (Gessessew and others 2011). The study finds similar postoperative outcomes in the two groups. The review suggests that the nonphysician clinicians were more likely to remain in rural areas, providing a potential solution to the migration of more trained providers.

Unfortunately, the analysis of these clinical officers who perform emergency obstetric procedures in Malawi, Mozambique, and Tanzania finds that these officers are apt to leave their positions after training (McAuliffe and others 2013). Specifically, negative predictors of retention include an absence of oversight or supervision of the clinical providers in their roles, suggesting that formal supervision is correlated with job satisfaction and, in effect, with provider retention. Given the significant costs of training these individuals, attention to maintaining cohorts of trainees is important to maximize their benefit.

Diminishing returns were observed on investments in training providers to provide cesarean delivery in Burkina Faso (Hounton and others 2009) and Tanzania (Nyamtema and others 2011). Although these types of studies are difficult to perform and have limitations related to data collection, it is clearly more cost-effective

to train lower-level providers to provide cesarean deliveries than fully trained obstetricians. In Sub-Saharan Africa, a small minority of countries (Ethiopia, Ghana, Malawi, Mozambique, and Tanzania) allow nonphysician providers to perform emergency obstetric surgery (Pereira and others 2011). In other areas, these nonphysician clinicians provide obstetric care but not cesarean delivery, limiting their utility.

Overall, clinical outcomes may be improved when a trained obstetrician performs the cesarean deliveries, but with significant cost. It is worth considering that trained obstetricians have the ability to train those around them and elevate the skills of other members of the team (Anderson and others 2014). Having supervisory forces for the nonphysician teams may assist in the retention of trained providers. Because of their lower up-front cost, however, task-shifted providers may solve short-term workforce problems.

When training a workforce, consideration needs to be given to training obstetric providers rather than medical practitioners to provide cesarean deliveries, depending on the resources and short- and long-term goals. It would be unreasonable in an HIC with an adequate supply of trained obstetric providers to fully revert to nonobstetricians to provide cesarean services and emergency obstetric care, because doing so would exacerbate negative maternal and neonatal outcomes. In LMICs attempting to establish fundamental obstetric care, task-shifting provides a short-term solution to unbearable circumstances (Hounton and others 2009). Given the tremendous burden of unmet need, however, implementation of task-shifting appears to be a reasonable step while infrastructure is developed (McCord and others 2009).

Challenges in Assessing the True Costs and Benefits of Obstetric Surgery

Cost analysis becomes difficult because of the wide number of variables across nations. In the long term, the common goal of reducing morbidity and mortality will be accomplished by establishing universally accessible first-level hospitals with mechanisms to refer to second- and third-level hospitals with fully trained providers to optimize maternal and neonatal outcomes. However, in the short term, in areas with limited resources for training an obstetric force, training task-shifted individuals can help mitigate maternal and neonatal morbidity and mortality rates.

Similar to the difficulty of assessing the cost-effectiveness of a single intervention, the difficulties of assessing the true costs associated with maternal morbidity or mortality hinder valid assessment. As with obstetric fistula, obstetric morbidity has frequently been associated with social ostracism, the cost of which is difficult to measure (Wall 2006). The loss of a maternal life has far-reaching effects, including the impact on her family structure and downstream effects on that family and on society as a whole (Yamin and others 2013). This reality suggests that most assessments involving the cost of maternal deaths are likely to underestimate those costs. The cost of basic obstetric interventions widely used in HICs that can significantly reduce maternal morbidity in LMICs can be difficult to measure. Given the significant benefits to health that they offer, their potential implementation cost would have to be dramatic if they were to be not cost-effective in their lifesaving employment. Although cost-effectiveness data are lacking for some of these interventions, such as vaginal laceration repair to prevent hemorrhage, implementation costs are so minimal and health benefits are so significant that these data may not ever be produced.

The analyses examining the benefits of cesarean delivery focus on maternal morbidity and mortality, although neonatal morbidity and mortality are also directly related. The provision of cesarean delivery for obstructed labor, malpresentation, or intrauterine fetal distress often means the difference between neonatal intact survival, on the one hand, and fetal demise or permanent and significant injury, neurologic or otherwise, on the other hand (Hofmeyr and others 2009). The provision of neonatal resuscitation by birth attendants has been demonstrated to be cost-effective, at US$208 per neonatal life year saved and US$5 per neonatal DALY averted (Wall and others 2010). Full implementation of trained birth attendants to provide immediate neonatal care would avert 100 million DALYs at a cost of US$1.8 billion (Lawn and others 2009). In this analysis, the additional provision of emergency obstetric care to cover 90 percent of perceived need would cost US$2.8 billion and avert 150 million DALYs. Synergy was noted by bundling birth attendance, emergency obstetric care including cesarean delivery, and neonatal resuscitation, with resulting improved costs and cost-effectiveness of all the interventions. Overall, the universal provision of emergency obstetric services to 90 percent of women in need could avert approximately 500,000 neonatal deaths annually (Lawn and others 2009).

Beyond the provision of cesarean delivery, little evidence is available to guide cost-effective techniques, but common sense suggests that the provision of fundamental obstetrical services is a reproductive right. The fact that adolescent women in LMICs can have a higher

risk of dying from pregnancy than other factors is not something that should be tolerated. The cost of birth attendants can vary, but their provision is accepted as fundamental to the amelioration of the status of women's health worldwide.

OBSTETRIC SURGICAL IMPLEMENTATION IN LOW- AND MIDDLE-INCOME COUNTRIES

Challenges to Provision of Safe Cesarean Delivery

Although access to safe and timely cesarean delivery should be a fundamental right guaranteed to all pregnant women, cesarean rates vary widely. The general consensus is that cesarean rates of less than 10 percent are low and inadequate to meet the obstetric needs of the population (Gibbons and others 2012). Cesarean rates of less than 5 percent, as throughout much of Sub-Saharan Africa, are considered extremely low. In these settings, most cesarean deliveries are undertaken intrapartum, frequently following failed labor.

A different problem has developed in countries with widely accessible cesarean delivery. Although many countries have rates well in excess of 20 percent, these higher rates are not associated with improvements in maternal or fetal outcomes (Gibbons and others 2012). Moreover, higher rates of cesarean delivery are associated with higher incidence of placenta accreta and surgical morbidity. Many factors influence increased cesarean delivery rates, including societal factors; some countries in South America have rates as high as 45 percent. Active discouragement of such high rates of cesarean delivery has not been successful. As further data are produced regarding the long-term morbidity and societal burden from these supratherapeutic cesarean rates, it is likely that the populations will start to respond.

Fundamental to the provision of safe cesarean delivery is an adequate triage system. In countries with the lowest rates of cesarean delivery, the many challenges faced in implementing skilled obstetric care include the following:

- The pervasive lack of trained obstetric providers—midwives, obstetricians, and anesthetists—especially in rural areas (Darmstadt and others 2009; Mavalankar and others 2009)
- The ineffective distribution of the available skilled providers, as well as difficulty retaining those who are dispersed
- The lack of support staff, infrastructure, equipment, and supplies (Koblinsky and others 2006).

Even when other factors are not an issue, transportation of patients can be limited because of poor roads and other impediments (Mehtsun and others 2012). These factors illustrate how a focus on relatively simple efforts in rural areas can have significant impacts on public health (You and others 2012).

Approaches to Improving Access to Surgical Care

More Widespread Technology. More widespread distribution of technology to access remote areas and link them to centers for emergency obstetric care will facilitate significant improvements to maternal health. The increasing availability of cell phones has the potential to improve women's health services networks while overcoming traditional obstacles to establishing effective health care systems (Fiander and Vanneste 2012). Low-cost cellular technology can connect birth attendants with regional obstetric officers, helping to guide management of intrapartum complications remotely, outside of health care centers, averting potential morbidity, and to coordinate access to emergency services. New methods of transferring funds using cell phones have been used to finance transport for patients to regional centers for advanced levels of care (Fiander and Vanneste 2012).

Improved Infrastructure. Infrastructural shortcomings and lack of provider motivation can prevent the full implementation of available obstetric resources to benefit maternal and child health in LMICs (Koblinsky and others 2006), as can societal reluctance to access available obstetric resources. Factors influencing this reluctance include financial costs and an unwelcome environment resulting from discriminatory or culturally insensitive practices. Any hesitation can delay presentation to permit the timely diagnosis and treatment of potential complications. Fundamentally, the establishment or development of first-level hospitals that can support safe cesarean delivery and obstetric care will be necessary to employ the trained providers and receive referred patients who require emergency obstetric care.

Increased Supply of Trained Providers. The education and training of obstetric providers need to be expanded to meet the needs of the populations in LMICs (Evans and others 2009; Hofmeyr and others 2009). Efforts to train large numbers of providers, which have been challenging without an established training infrastructure, must persist. An essential complement to initiatives to increase the numbers of skilled obstetric providers is

the provision and maintenance of first-level hospitals or centers where the providers can perform cesarean deliveries and administer anesthesia (Anderson and others 2007).

Improved Patient Transport and Local Facilities. In HICs, the time to prepare to perform an indicated cesarean providing obstetric surgery is expected to be 30 minutes to optimize outcomes (ACOG 2009; Soltanifar and Russell 2012). This standard is ambitious for LMICs, but a realistic and reliable expectation of timely transport to such facilities would substantially reduce the burden of disease from obstructed labor (Spangler 2012).

The development of these locally accessible first-level hospitals would effectively make a network of these hospitals that would be universally accessible where cesarean deliveries could be performed. Such first-level obstetric institutions would require the availability of obstetric providers to perform the surgery and the capacity to administer anesthesia safely. Contributing to these structures would be the local network of skilled birth attendants at the bedside with mothers in labor—attendants with the ability to manage minor complications and successfully transfer patients in a timely manner when major complications arise or cesarean delivery is needed.

In developing these units, providing fully trained anesthesiologists and obstetricians for all deliveries will be a challenge (Evans and others 2009; Mavalankar and others 2009). Countries have examined the implementation of teams of nonspecialists trained to provide emergency obstetric care. Studies in Tanzania examining such nonphysician clinicians show good results (Nyamtema and others 2011; Pereira and others 2011). Despite the availability of trained nonspecialists, too many significant obstetric complications, particularly those requiring cesarean delivery, remained untreated.

CONCLUSION: FUTURE DIRECTIONS

Future efforts to reduce the global disease burden of obstetric complications requiring surgery will depend on interventions that have demonstrated equal effectiveness on small scales, and will implement those interventions on a universal scale.

Numbers of Skilled Birth Attendants

Significant progress has been seen with the provision of birth attendants; the next step is the universal provision of emergency obstetric providers who can perform safe cesarean delivery. These emergency obstetric providers will require additional training to acquire a more sophisticated skill set than that possessed by birth attendants. Societal and economic investments in successful outcomes will be critical, both in training and in retaining these providers. The effective retention of trained providers will require satisfactory facilities and resources to utilize their training. The provision of the resources for emergency obstetric care at local levels will dramatically improve worldwide maternal health in the coming decades.

Quality Care and Improvement Initiatives

Achieving the goal of universal provision of evidence-based obstetric care will take time and resources. Programs have examined established practice improvement techniques using educational outreach and morbidity and mortality reviews, as in the QUARITE (QUAlity of care, RIsk management and TEchnology in obstetrics) trial taking place in Senegal and Mali. The establishment of infrastructure to monitor outcomes will help improve care at local levels by focusing on unsatisfactory outcomes that can be improved in those areas (Dumont and others 2013; Pirkle and others 2013). Practice-based learning and morbidity and mortality reviews are established methods of improving care and maternal outcomes, and their application to nations working to establish or build up obstetric services will be significant (Choo and others 2013). Partnerships between programs in LMICs and HICs will help the former to develop the training infrastructure to cultivate and maintain an obstetric workforce (Klufio and others 2003).

Lessons from Ghana

Ghana has been a model for improvement in women's reproductive health. In 1989, a grant from the Carnegie Foundation established university-based training programs to help train obstetric providers; its goal was to maintain trained obstetricians in practice after they completed their training (Anderson and others 2014). Before this program, Ghana had significant difficulty retaining trained providers (Clinton, Anderson, and Kwawukume 2010); the retention rate of trained obstetric providers had been 10 percent. Since establishment of the program in 1989, over 95 percent of the trained obstetric providers have remained in country to practice (Anderson and others 2014).

With the exponential increase in obstetric providers in the country, the ability to train later generations of providers each year has increased; the country had 20 certified practicing obstetricians in 2000 and 85 in 2010.

With the increase in providers, some individuals have located to different periurban and more rural first-level hospitals, expanding the areas where safe emergency obstetric services are available. Although this program did not produce dedicated birth attendants, it produced certified obstetrical and gynecological providers who have the skills to manage a wide variety of women's health issues. Their wide variety of expertise encompasses contraception and obstetric care, including definitive delivery and management of obstetric complications. The influence of this program is difficult to assess because of the implementation of other programs to improve obstetric care. At one rural institution, however, the implementation of certified obstetrical and gynecological capacity reduced maternal mortality by 74 percent (Anderson and others 2014).

The establishment of this training program resulted from a concerted effort by the American College of Obstetrics and Gynecology and the Royal College of Obstetrics and Gynecology, in combination with the obstetrics and gynecology departments at The Johns Hopkins University and the University of Michigan (Anderson and others 2014). With the assistance of these institutions, Ghana was able to design the five-year program that has produced so many trained providers. The ongoing relationship between the university-based training programs in Ghana and the University of Michigan has caused the evolution of evidence-based obstetric training within the country. Practice-based learning and maternal mortality and morbidity reviews have guided improvements in obstetric training and management that have spread across the country as providers complete their training (Choo and others 2013). The provision of funding to establish this type of academic partnership, and the establishment of in-country training programs, will contribute significantly to the goal of providing universal access to emergency obstetric care services and cesarean delivery.

Future Goals of Global Operative Obstetrics

Future efforts to improve maternal mortality and morbidity will expand successful programs to areas where they have yet to be implemented, will scale up established programs to provide health care to a wider population, and will develop new methods to improve access to care and standards of care in LMICs. Self-reflection and evidence-based medicine will help identify programs that work and those that need to improve.

The numbers of skilled birth attendants, who constitute the front line in the ability to provide safe childbirth care, will continue to increase. Technological advances will help coordinate that front line with first-level hospitals that have essential emergency care capabilities, including cesarean delivery. Once cesarean delivery is available at the regional level, a wide variety of surgical interventions will be available to improve public health, using synergistic capabilities and therapies. These quantum units of referral and emergency care centers will become more widespread, making safe cesarean delivery a universally accessible reproductive right, available to women throughout all HICs and LMICs alike.

Regional and academic centers will assist in training and retaining the necessary workforces to provide care in these nations, and they will serve as referral centers for complicated cases beyond the first-level hospitals to second- and third-level hospitals where appropriate.

The common goal will be the prevention of unnecessary pregnancy-related morbidity and death through the provision of universal access to standard and emergency obstetric care that is safe and effective—with benefits to the mothers, their families, and their societies as a whole.

Consideration of Essential Obstetric Interventions to Improve Obstetric Outcomes

Surgical obstetric interventions—including operative vaginal delivery, cesarean delivery, and emergency obstetric care—are clearly effective at reducing morbidity and death. Sufficient evidence demonstrates that access to these services can improve the health of societies. As with any intervention, the costs must be weighed against the potential benefits. Whether these costs warrant investment is not easily answered with scientific study. We reviewed a number of studies that have evaluated a broad range of obstetric surgical interventions to improve the health of societies. These interventions appear universally cost-effective, albeit to different degrees, across different LMICs. We implore interested parties to consider the relatively small cost per individual of these interventions to save maternal and neonatal lives. We recommend consideration of the following goals to improve the health of reproductive-age women and their children worldwide.

Birth Attendants. Universal access to birth attendants who can help address obstetric emergencies that require emergent attention should be a goal. Training will ultimately include the management of postpartum hemorrhage, operative vaginal delivery, and facilitated emergency vaginal breech delivery. Most important, training will facilitate the identification of obstetric complications that require transfers to higher levels of care.

Hospital Units. Approximately 10 percent to 15 percent of deliveries need operative interventions that require access to a nearby hospital or center to provide these surgical services, including cesarean delivery. In the long term, transport to such centers within two hours for any woman in labor is desirable. In the short term, access to such centers within six hours would be a significant improvement.

These centers require the ability to perform safe cesarean delivery. An operating theater with anesthetic availability should be part of that center. Blood transfusion services could help improve maternal outcomes. These centers require staffing by individuals trained in cesarean delivery and management of obstetric emergencies, with the ability to transfer to higher levels of care, if needed.

Trained Obstetric Providers. Effectively trained obstetric providers could help train other providers, as well as the birth attendants present at time of delivery who may be in the best position to timely manage obstetric emergencies. Obstetric training partnerships, as in Ghana, can successfully train providers who can rapidly grow a nation's obstetric workforce to staff local centers for the management of obstetric emergencies and cesarean delivery. In the short term, nonphysician clinicians can participate in obstetric care to help quickly meet improvement goals. Involving these clinicians in all aspects of emergency obstetric care can help meet immediate health needs, depending on the population. Partnerships to train obstetric providers, along with financial support, will grow, as the obstetric workforce in Ghana has grown, thereby improving the worldwide supply of obstetric providers in local settings. These trainees can then help train other physician and nonphysician providers and provide ongoing supervision to help retention efforts. The training of these obstetric providers will affect all levels of obstetric care and improve overall reproductive health care in their individual nations.

Valuation of Maternal Health and Reproductive Rights

> *"When women thrive, all of society benefits, and succeeding generations are given a better start in life."*
>
> –Kofi Annan

Death or morbidity in childbirth is a preventable tragedy. As societies develop and improve maternal health, all levels of society will benefit. Future obstetric interventions will fully consider the value of these maternal lives and the societal costs of failing to provide these fundamental surgical services. Societal expectations will include the provision of obstetric care as a fundamental reproductive and human right. With this effective valuation of maternal health and consideration of obstetric and reproductive rights, maternal outcomes in particular and societal outcomes in general will improve.

NOTE

The World Bank classifies countries according to four income groupings. Income is measured using gross national income (GNI) per capita, in U.S. dollars, converted from local currency using the *World Bank Atlas* method. Classifications as of July 2014 are as follows:

- Low-income countries (LICs) = US$1,045 or less in 2013
- Middle-income countries (MICs) are subdivided:
  - Lower-middle-income = US$1,046 to US$4,125
  - Upper-middle-income (UMICs) = US$4,126 to US$12,745
- High-income countries (HICs) = US$12,746 or more

REFERENCES

ACOG (American Congress of Obstetricians and Gynecologists). 2009. "Optimal Goals for Anesthesia Care in Obstetrics." Committee Opinion No. 433, Committee on Obstetric Practice. *Obstetrics and Gynecology* 113: 1197–99.

———. 2013. "Medically Indicated Late-Preterm and Early-Term Deliveries." Committee Opinion No. 560, Committee on Obstetric Practice. *Obstetrics and Gynecology* 121 (4): 908–10.

Adam, T., S. S. Lim, S. Mehta, Z. A. Bhutta, H. Fogstad, and others. 2005. "Cost Effectiveness Analysis of Strategies for Maternal and Neonatal Health in Developing Countries." *British Medical Journal* 331 (7525): 1107.

Alkire, B. C., J. R. Vincent, C. T. Burns, I. S. Metzler, P. E. Farmer, and others. 2012. "Obstructed Labor and Caesarean Delivery: The Cost and Benefit of Surgical Intervention." *PloS One* 7 (4): e34595.

Anderson, F. W., I. Mutchnick, E. Y. Kwawukume, K. A. Danso, C. A. Klufio, and others. 2007. "Who Will Be There When Women Deliver? Assuring Retention of Obstetric Providers." *Obstetrics and Gynecology* 110 (5): 1012–16.

Anderson, F. W., S. A. Obed, E. L. Boothman, and H. Opare-Ado. 2014. "The Public Health Impact of Training Physicians to Become Obstetricians and Gynecologists in Ghana." *American Journal of Public Health* 104 (Suppl 1): S159–65.

Andreatta, P., J. Perosky, and T. R. Johnson. 2012. "Two-Provider Technique for Bimanual Uterine Compression to Control Postpartum Hemorrhage." *Journal of Midwifery and Women's Health* 57 (4): 371–75.

Baskett, T. F., A. A. Calder, and S. Arulkumaran. 2007. *Munro Kerr's Operative Obstetrics*. 11th ed. Philadelphia, PA: Saunders Elsevier.

Berghella, V., J. K. Baxter, and S. P. Chauhan. 2005. "Evidence-Based Surgery for Cesarean Delivery." *American Journal of Obstetrics and Gynecology* 193 (5): 1607–17.

Borghi, J., J. Fox-Rushby, E. Bergel, E. Abalos, G. Hutton, and others. 2002. "The Cost-Effectiveness of Routine versus Restrictive Episiotomy in Argentina." *American Journal of Obstetrics and Gynecology* 186 (2): 221–28.

Briand, V., A. Dumont, M. Abrahamowicz, M. Traore, L. Watier, and others. 2012. "Individual and Institutional Determinants of Caesarean Section in Referral Hospitals in Senegal and Mali: A Cross-Sectional Epidemiological Survey." *BMC Pregnancy and Childbirth* 12: 114. doi:10.1186/1471-2393-12-114.

Carvalho, N., A. S. Salehi, and S. J. Goldie. 2013. "National and Sub-national Analysis of the Health Benefits and Cost-Effectiveness of Strategies to Reduce Maternal Mortality in Afghanistan." *Health Policy and Planning* 28 (1): 62–74.

Choo, S., D. Papandria, S. D. Goldstein, H. Perry, A. A. Hesse, and others. 2013. "Quality Improvement Activities for Surgical Services at District Hospitals in Developing Countries and Perceived Barriers to Quality Improvement: Findings from Ghana and the Scientific Literature." *World Journal of Surgery* 37 (11): 2512–29.

Clinton, Y., F. W. Anderson, and E. Y. Kwawukume. 2010. "Factors Related to Retention of Postgraduate Trainees in Obstetrics-Gynecology at the Korle-Bu Teaching Hospital in Ghana." *Academic Medicine: Journal of the Association of American Medical Colleges* 85 (10): 1564–70.

CORONIS Collaborative Group, E. Abalos, V. Addo, P. Brocklehurst, M. E. Sheikh, and others. 2013. "Caesarean Section Surgical Techniques (CORONIS): A Fractional, Factorial, Unmasked, Randomised Controlled Trial." *The Lancet* 382 (9888): 234–48.

Dahlke, J. D., H. Mendez-Figueroa, D. J. Rouse, V. Berghella, J. K. Baxter, and others. 2013. "Evidence-Based Surgery for Cesarean Delivery: An Updated Systematic Review." *American Journal of Obstetrics and Gynecology* 209 (4): 294–306.

Darmstadt, G. L., A. C. Lee, S. Cousens, L. Sibley, Z. A. Bhutta, and others. 2009. "60 Million Non-facility Births: Who Can Deliver in Community Settings to Reduce Intrapartum-Related Deaths?" *International Journal of Gynaecology and Obstetrics* 107 (Suppl 1): S89–112.

Deboutte, D., T. O'Dempsey, G. Mann, and B. Faragher. 2013. "Cost-Effectiveness of Caesarean Sections in a Post-conflict Environment: A Case Study of Bunia, Democratic Republic of the Congo." *Disasters* 37 (Suppl 1): S105–20.

Dumont, A., P. Fournier, M. Abrahamowicz, M. Traore, S. Haddad, and others. 2013. "Quality of Care, Risk Management, and Technology in Obstetrics to Reduce Hospital-Based Maternal Mortality in Senegal and Mali (QUARITE): A Cluster-Randomised Trial." *The Lancet* 382 (9887): 146–57.

El-Hamamy, E., A. Wright, and C. B. Lynch. 2009. "The B-Lynch Suture Technique for Postpartum Haemorrhage: A Decade of Experience and Outcome." *Journal of the Institute of Obstetrics and Gynaecology* 29 (4): 278–83.

Erim, D. O., S. C. Resch, and S. J. Goldie. 2012. "Assessing Health and Economic Outcomes of Interventions to Reduce Pregnancy-Related Mortality in Nigeria." *BMC Public Health* 12 (786): 1–11.

Evans, C. L., D. Maine, L. McCloskey, F. G. Feeley, and H. Sanghvi. 2009. "Where There Is No Obstetrician: Increasing Capacity for Emergency Obstetric Care in Rural India: An Evaluation of a Pilot Program to Train General Doctors." *International Journal of Gynaecology and Obstetrics* 107 (3): 277–82.

Fiander, A. N., and T. Vanneste. 2012. "TransportMYpatient: An Initiative to Overcome the Barrier of Transport Costs for Patients Accessing Treatment for Obstetric Fistulae and Cleft Lip in Tanzania." *Tropical Doctor* 42 (2): 77–79.

FIGO (International Federation of Gynecology and Obstetrics). 2012. "Management of the Second Stage of Labor." Safe Motherhood and Newborn Health (SMNH) Committee. *International Journal of Gynaecology and Obstetrics* 119 (2): 111–16.

Gessessew, A., G. A. Barnabas, N. Prata, and K. Weidert. 2011. "Task Shifting and Sharing in Tigray, Ethiopia, to Achieve Comprehensive Emergency Obstetric Care." *International Journal of Gynaecology and Obstetrics* 113 (1): 28–31.

Gibbons, L., J. M. Belizan, J. A. Lauer, A. P. Betran, M. Merialdi, and others. 2012. "Inequities in the Use of Cesarean Section Deliveries in the World." *American Journal of Obstetrics and Gynecology* 206 (4): 331.e1, 331.19.

Goldie, S. J., S. Sweet, N. Carvalho, U. C. Natchu, and D. Hu. 2010. "Alternative Strategies to Reduce Maternal Mortality in India: A Cost-Effectiveness Analysis." *PLoS Medicine* 7 (4): e1000264.

Grimes, C. E., J. A. Henry, J. Maraka, N. C. Mkandawire, and C. Cotton. 2014. "Cost-Effectiveness of Surgery in Low- and Middle-Income Countries: A Systematic Review." *World Journal of Surgery* 38 (1): 252–63.

Hale, R. W., and E. H. Dennen. 2001. *Dennen's Forceps Deliveries*. 4th ed. Washington, DC: American College of Obstetricians and Gynecologists.

Hannah, M. E., W. J. Hannah, S. A. Hewson, E. D. Hodnett, S. Saigal, and others. 2000. "Planned Caesarean Section versus Planned Vaginal Birth for Breech Presentation at Term: A Randomised Multicentre Trial: Term Breech Trial Collaborative Group." *The Lancet* 356 (9239): 1375–83.

Hannah, M. E., W. J. Hannah, E. D. Hodnett, B. Chalmers, R. Kung, and others. 2002. "Outcomes at 3 Months after Planned Cesarean vs Planned Vaginal Delivery for Breech Presentation at Term: The International Randomized Term Breech Trial." *Journal of the American Medical Association* 287 (14): 1822–31.

Hofmeyr, G. J., R. A. Haws, S. Bergstrom, A. C. Lee, P. Okong, and others. 2009. "Obstetric Care in Low-Resource Settings: What, Who, and How to Overcome Challenges to Scale Up?" *International Journal of Gynaecology and Obstetrics* 107 (Suppl 1): S21, 44, 44–45.

Hogan, M. C., K. J. Foreman, M. Naghavi, S. Y. Ahn, M. Wang, and others. 2010. "Maternal Mortality for 181 Countries, 1980–2008: A Systematic Analysis of Progress towards Millennium Development Goal 5." *The Lancet* 375 (9726): 1609–23.

Hounton, S. H., D. Newlands, N. Meda, and V. De Brouwere. 2009. "A Cost-Effectiveness Study of Caesarean-Section Deliveries by Clinical Officers, General Practitioners and Obstetricians in Burkina Faso." *Human Resources for Health* 7 (34): 1–12.

Hu, D., S. M. Bertozzi, E. Gakidou, S. Sweet, and S. J. Goldie. 2007. "The Costs, Benefits, and Cost-Effectiveness of Interventions to Reduce Maternal Morbidity and Mortality in Mexico." *PloS One* 2 (8): e750.

Jha, P., O. Bangoura, and K. Ranson. 1998. "The Cost-Effectiveness of Forty Health Interventions in Guinea." *Health Policy and Planning* 13 (3): 249–62.

Klufio, C. A., E. Y. Kwawukume, K. A. Danso, J. J. Sciarra, and T. Johnson. 2003. "Ghana Postgraduate Obstetrics/Gynecology Collaborative Residency Training Program: Success Story and Model for Africa." *American Journal of Obstetrics and Gynecology* 189 (3): 692–96.

Koblinsky, M., Z. Matthews, J. Hussein, D. Mavalankar, M. K. Mridha, and others. 2006. "Going to Scale with Professional Skilled Care." *The Lancet* 368 (9544): 1377–86.

Lawn, J. E., M. Kinney, A. C. Lee, M. Chopra, F. Donnay, and others. 2009. "Reducing Intrapartum-Related Deaths and Disability: Can the Health System Deliver?" *International Journal of Gynaecology and Obstetrics* 107 (Suppl 1): S123–40, S140–42.

Le Ray, C., P. Serres, T. Schmitz, D. Cabrol, and F. Goffinet. 2007. "Manual Rotation in Occiput Posterior or Transverse Positions: Risk Factors and Consequences on the Cesarean Delivery Rate." *Obstetrics and Gynecology* 110 (4): 873–79.

Liang, J., L. Dai, J. Zhu, X. Li, W. Zeng, and others. 2011. "Preventable Maternal Mortality: Geographic/Rural-Urban Differences and Associated Factors from the Population-Based Maternal Mortality Surveillance System in China." *BMC Public Health* 11 (243): 1–9.

Lim, S. S., L. Dandona, J. A. Hoisington, S. L. James, M. C. Hogan, and others. 2010. "India's Janani Suraksha Yojana, a Conditional Cash Transfer Programme to Increase Births in Health Facilities: An Impact Evaluation." *The Lancet* 375 (9730): 2009–23.

Mavalankar, D., K. Callahan, V. Sriram, P. Singh, and A. Desai. 2009. "Where There Is No Anesthetist: Increasing Capacity for Emergency Obstetric Care in Rural India: An Evaluation of a Pilot Program to Train General Doctors." *International Journal of Gynaecology and Obstetrics* 107 (3): 283–88.

McAuliffe, E., M. Daly, F. Kamwendo, H. Masanja, M. Sidat, and others. 2013. "The Critical Role of Supervision in Retaining Staff in Obstetric Services: A Three Country Study." *PloS One* 8 (3): e58415.

McCord, C., G. Mbaruku, C. Pereira, C. Nzabuhakwa, and S. Bergstrom. 2009. "The Quality of Emergency Obstetrical Surgery by Assistant Medical Officers in Tanzanian District Hospitals." *Health Affairs* 28 (5): w876–85.

Mehtsun, W. T., K. Weatherspoon, L. McElrath, A. Chima, V. E. Torsu, and others. 2012. "Assessing the Surgical and Obstetrics-Gynecology Workload of Medical Officers: Findings from 10 District Hospitals in Ghana." *Archives of Surgery* 147 (6): 542–48.

Mullan, F., and S. Frehywot. 2007. "Non-physician Clinicians in 47 Sub-Saharan African Countries." *The Lancet* 370 (9605): 2158–63.

Murray, C. J., T. Vos, R. Lozano, M. Naghavi, A. D. Flaxman, and others. 2012. "Disability-Adjusted Life Years (DALYs) for 291 Diseases and Injuries in 21 Regions, 1990–2010: A Systematic Analysis for the Global Burden of Disease Study 2010." *The Lancet* 380 (9859): 2197–223.

Nyamtema, A. S., S. K. Pemba, G. Mbaruku, F. D. Rutasha, and J. van Roosmalen. 2011. "Tanzanian Lessons in Using Non-physician Clinicians to Scale Up Comprehensive Emergency Obstetric Care in Remote and Rural Areas." *Human Resources for Health* 9 (28): 1–8.

O'Grady, J. P., M. L. Gimovsky, L. A. Bayer-Zwirello, and K. Giordano. 2008. *Operative Obstetrics*. Baltimore: Williams & Wilkins.

Patton, G. C., C. Coffey, S. M. Sawyer, R. M. Viner, D. M. Haller, and others. 2009. "Global Patterns of Mortality in Young People: A Systematic Analysis of Population Health Data." *The Lancet* 374: 881–92.

Pereira, C., G. Mbaruku, C. Nzabuhakwa, S. Bergstrom, and C. McCord. 2011. "Emergency Obstetric Surgery by Non-physician Clinicians in Tanzania." *International Journal of Gynaecology and Obstetrics* 114 (2): 180–83.

Pirkle, C. M., A. Dumont, M. Traore, and M. V. Zunzunegui. 2013. "Effect of a Facility-Based Multifaceted Intervention on the Quality of Obstetrical Care: A Cluster Randomized Controlled Trial in Mali and Senegal." *BMC Pregnancy and Childbirth* 13 (24): 1–13.

Soltanifar, S., and R. Russell. 2012. "The National Institute for Health and Clinical Excellence (NICE) Guidelines for Caesarean Section, 2011 Update: Implications for the Anaesthetist." *International Journal of Obstetric Anesthesia* 21 (3): 264–72.

Souza, J. P., A. M. Gulmezoglu, J. Vogel, G. Carroli, P. Lumbiganon, and others. 2013. "Moving beyond Essential Interventions for Reduction of Maternal Mortality (The WHO Multicountry Survey on Maternal and Newborn Health): A Cross-Sectional Study." *The Lancet* 381 (9879): 1747–55.

Spangler, S. A. 2012. "Assessing Skilled Birth Attendants and Emergency Obstetric Care in Rural Tanzania: The Inadequacy of Using Global Standards and Indicators to Measure Local Realities." *Reproductive Health Matters* 20 (39): 133–41.

Stanton, C., D. Armbruster, R. Knight, I. Ariawan, S. Gbangbade, and others. 2009. "Use of Active Management of the Third Stage of Labour in Seven Developing Countries." *Bulletin of the World Health Organization* 87 (3): 207–15.

UN (United Nations). 2013. *The Millennium Development Goals Report 2013*. New York: United Nations.

Wall, L. L. 2006. "Obstetric Vesicovaginal Fistula as an International Public-Health Problem." *The Lancet* 368 (9542): 1201–19.

Wall, S. N., A. C. Lee, W. Carlo, R. Goldenberg, S. Niermeyer, and others. 2010. "Reducing Intrapartum-Related Neonatal Deaths in Low- and Middle-Income Countries: What Works?" *Seminars in Perinatology* 34 (6): 395–407.

WHO (World Health Organization). 2008. "Universal Access to Safe Blood Transfusion." WHO, Geneva.

———. 2012. *Trends in Maternal Mortality: 1990–2010—Estimates Developed by WHO, UNICEF, UNFPA, and the World Bank*. Geneva: WHO.

———. 2013. "Global Health Estimates for Deaths by Cause, Age, and Sex for Years 2000–2011." WHO, Geneva. http://www.who.int/healthinfo/global_health_estimates/en/.

Witter, S., D. K. Arhinful, A. Kusi, and S. Zakariah-Akoto. 2007. "The Experience of Ghana in Implementing a User Fee Exemption Policy to Provide Free Delivery Care." *Reproductive Health Matters* (30): 61–71.

Witter, S., and M. Diadhiou. 2008. "Key Informant Views of a Free Delivery and Caesarean Policy in Senegal." *African Journal of Reproductive Health* 12 (3): 93–111.

Witter, S., T. Dieng, D. Mbengue, I. Moreira, and V. De Brouwere. 2010. "The National Free Delivery and Caesarean Policy in Senegal: Evaluating Process and Outcomes." *Health Policy and Planning* 25 (5): 384–92.

Yamin, A. E., V. M. Boulanger, K. L. Falb, J. Shuma, and J. Leaning. 2013. "Costs of Inaction on Maternal Mortality: Qualitative Evidence of the Impacts of Maternal Deaths on Living Children in Tanzania." *PloS One* 8 (8): e71674.

You, F., K. Huo, R. Wang, D. Xu, J. Deng, and others. 2012. "Maternal Mortality in Henan Province, China: Changes between 1996 and 2009." *PLoS One* 7 (10): e47153.