Can skilled attendance at delivery reduce maternal mortality in developing countries ?

Wendy J Graham[1], Jacqueline S Bell[2] and Colin HW Bullough[3]

Summary

This paper explores the scientific justification for the key action message "ensure skilled attendance at delivery." Many governments and other provider agencies in poor countries will need to commit additional health resources in order to respond to this message, and opportunity costs will be incurred. Achieving targets will take time, and benefits in terms of maternal mortality may not be detected for several years. It is therefore crucial to review the basis for prioritising skilled attendance. This paper examines the historical and epidemiological evidence at both the individual and population levels of analysis.

The lack of a clear definition has been, and continues to be, the cause of much confusion over the role, and thus the potential, of skilled attendants. Recent initiatives to specify minimum and additional skills have improved understanding not only of training requirements but also of the wider environment which is required for skilled attendants to function effectively. This paper proposes that skilled attendance be conceived as encompassing 1) a partnership of skilled attendants (health professionals with the skills to provide care for normal and/or complicated deliveries), AND 2) an enabling environment of equipment, supplies, drugs and transport for referral.

At the individual level, there are sound clinical reasons for believing that the risk of maternal death can be reduced by skilled attendance, particularly as the causal pathways can be specified. However, this theory of how skilled attendance could work has not been rigorously tested, and the available empirical evidence – both historical and epidemiological, is flawed, either owing to weak study designs which fail to control for key confounding factors and/or inadequate power. Insights from modeling can be used to complement an empirical approach and in this paper a preliminary model is pre-

[1] Professor of Obstetric Epidemiology, Director,Dugald Baird Centre for Research on Women's Health, Department of Obstetrics and Gynaecology, Aberdeen Maternity Hospital, Cornhill Road, Aberdeen AB25 2ZL, Scotland. Email: w.graham@abdn.ac.uk (correspondence should be addressed to this author).

[2] Dugald Baird Centre for Research on Women's Health, Department of Obstetrics and Gynaecology, Aberdeen Maternity Hospital, Cornhill Road, Aberdeen AB25 2ZL, Scotland

[3] Dugald Baird Centre for Research on Women's Health, Department of Obstetrics and Gynaecology, Aberdeen Maternity Hospital, Cornhill Road, Aberdeen AB25 2ZL, Scotland

sented. This estimates that around 16% to 33% of all maternal deaths may be avoided through the primary or secondary prevention of four main complications (obstructed labour, eclampsia, puerperal sepsis and obstetric haemorrhage) by skilled attendance at delivery. The model highlights the importance of considering the potential of skilled attendance to impact not only on maternal mortality but also morbidity, and emphasises their primary prevention role through effective and appropriate management of normal labour and delivery.

At the population or aggregate level, correlational analysis has been the major stimulus for prioritising skilled attendance. The paper discusses two drawbacks to this – the intrinsic inability of this type of analysis to make causal connections, and the problems of the data – its varying reliability and the limitations of the independent and dependent variables correlated, such as the institutional delivery rate and the maternal mortality ratio. In particular, the reliance on the crude indicator "percentage of deliveries with health professionals" which groups together doctors, midwives and nurses, is challenged and an alternative independent variable – the Partnership Ratio – proposed. Correlational analysis highlights the inconsistencies in the postulated link between maternal mortality and skilled attendance, and emphasises the importance of timely access to quality maternity care. In particular, insights from the Partnership Ratio and the modeling approach suggest there is an optimal professional mix for skilled attendance to be effective in different country and service settings.

Introduction

"Having a health worker with midwifery skills present at childbirth, backed-up by transport in case emergency referral is required, is perhaps the most critical intervention for making motherhood safer."
(Starrs 1997)

This is arguably one of the most influential statements to emerge from the 1997 Technical Consultation on Safe Motherhood. Translated into the action message "ensure skilled attendance at delivery", it forms the basis of a key proxy indicator for monitoring global progress in reducing maternal mortality (AbouZahr & Wardlaw 2000). Regional and international advocacy meetings are now being held to encourage developing countries to prioritise skilled attendance (Safe Motherhood Inter-Agency Group/ SMIAG 2000a) and to meet the international development target of "80% of all births assisted by skilled attendants" by 2005 (United Nations 1999). The ease and speed with which skilled attendance has been promoted as a global priority is itself an indication of the urgent need to offer key decision-makers

an intervention perceived as feasible, comparatively discrete and intuitively effective. This need arises from the disappointment of earlier priorities – traditional birth attendant (TBA) training and antenatal 'at risk' scoring - regarding impact on maternal mortality, and the consequent threat to continuing donor support. The question is **can** skilled attendance at delivery do better?

This is clearly not just an academic question. Many governments and other provider agencies in poor countries will need to use scarce health resources to increase the proportion of deliveries with skilled attendance and opportunity costs will be incurred. Achieving targets will take time and benefits in terms of maternal mortality may not be detected for several years. It is therefore crucial to establish whether the evidence exists to justify this priori-

---

Box 1. Defining skilled attendant : joint WHO/UNFPA/UNICEF/World Bank statement (1999)

"The term '**skilled attendant**' refers exclusively to people with midwifery skills (for example, doctors, midwives, nurses) who have been trained to proficiency in the skills necessary to manage normal deliveries and diagnose, manage* or refer complications. Ideally, the skilled attendants live in, and are part of, the community they serve. They must be able to manage normal labour and delivery, recognise the onset of complications, perform essential interventions, start treatment, and supervise the referral of mother and baby for interventions that are beyond their competence or not possible in the particular setting."

Midwifery skills are a defined set of cognitive and practical skills that enable the individual to provide basic health care services throughout the period of the perinatal continuum and also to provide first aid for obstetric complications and emergencies, including life-saving measures when needed.

* "Manage" was added to this definition by the members of the Safe Motherhood Inter-Agency Group, which include WHO/UNFPA/ UNICEF/Word Bank, in recognition of the fact that skilled attendants include physicians and other medical personnel who may be able to manage complications.

---

tisation. "Evidence" is an increasingly emotive term, which clearly means different things to different people (Gray 1997). This paper will explore the fundamental question "can skilled attendance at delivery reduce maternal mortality in developing countries" recognising the different requirements on evidence. Firstly, the definition of skilled attendance will be considered. Secondly, the link between skilled attendance and maternal death at the individual level will be explored. Thirdly, the link at the population level will be examined – in other words, between the coverage of delivery care and the scale of maternal mortality. Recommendations for research to fill gaps in knowledge will be included throughout the paper.
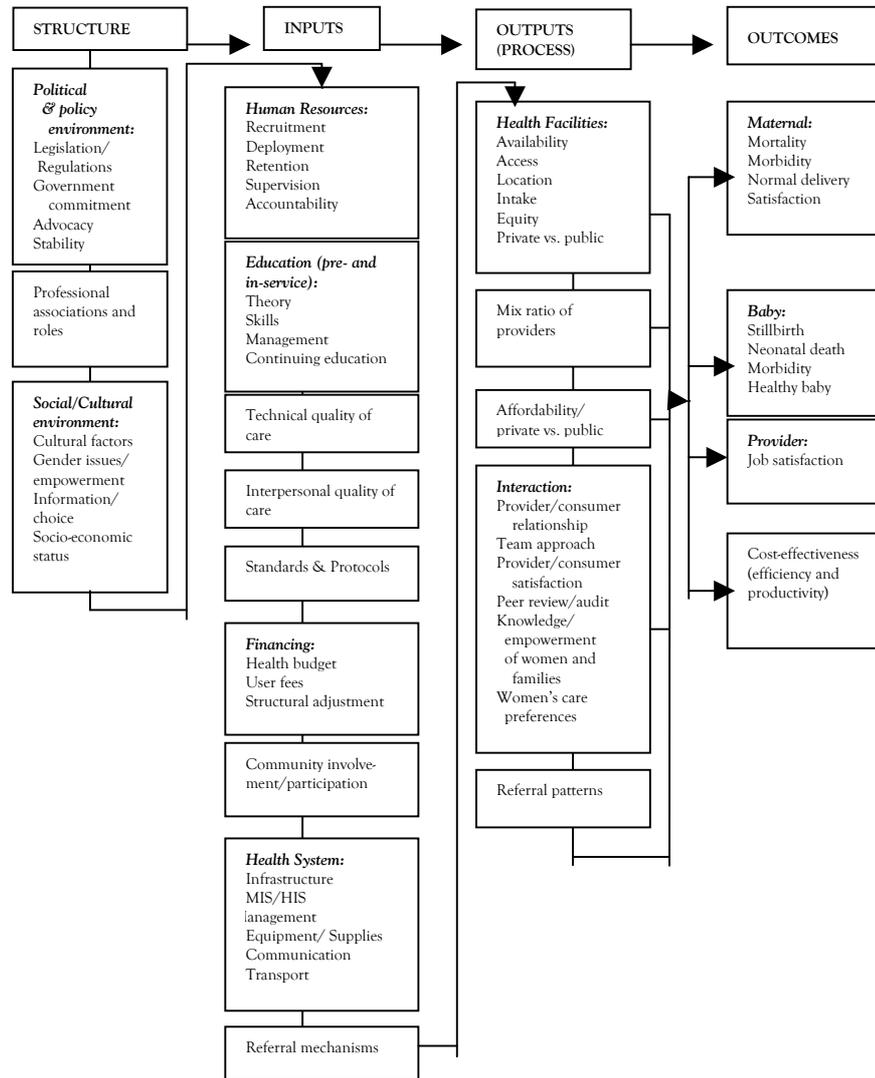
What is skilled attendance ?

The lack of a clear definition has been, and continues to be, the cause of much confusion over the role and thus the potential of a skilled **attendant**. Whilst some feel that an internationally-accepted standard is impossible, it is crucial to acknowledge the implications of the various proposed definitions. Until the mid-1990s, the word "trained attendant" was used by many agencies, and national statistics on coverage tended to group both professionals and non-professionals (e.g. trained TBAs) together as long as they had received some "training". From 1996 onwards, however, the word "skilled" was employed, recognising that someone who has been trained is not necessarily skilled (Starrs 1997). Thus "trained" implies but does not guarantee the acquisition of knowledge and ability, whilst "skilled" implies the competent use of knowledge. In an effort to improve understanding, a joint WHO/UNFPA/UNICEF/ World Bank statement was issued in 1999, as indicated in Box 1.

"Skilled attendance" has only recently been defined explicitly as "the process by which a woman is provided with adequate care during labour, delivery and the early postpartum period" (SMIAG 2000b). This definition goes onto emphasise that the process requires a skilled attendant AND an enabling environment which includes adequate supplies, equipment and infrastructure as well as efficient and effective systems of communication and referral. The "environment" can, however, also be viewed more broadly to include the political and policy context in which skilled attendance must operate, the socio-cultural influences, as well more proximate factors such as pre- and in-service training, supervision and deployment and health sys-tems financing. This constellation of factors can be conceived as the conceptual framework

for skilled attendance, as illustrated in Figure 1.

Figure 1. Conceptual framework for skilled attendance at delivery

STRUCTURE → **INPUTS** → **OUTPUTS (PROCESS)** → **OUTCOMES**

Political & policy environment:
Legislation/ Regulations
Government commitment
Advocacy
Stability

Professional associations and roles

Social/Cultural environment:
Cultural factors
Gender issues/ empowerment
Information/ choice
Socio-economic status

Human Resources:
Recruitment
Deployment
Retention
Supervision
Accountability

Education (pre- and in-service):
Theory
Skills
Management
Continuing education

Technical quality of care

Interpersonal quality of care

Standards & Protocols

Financing:
Health budget
User fees
Structural adjustment

Community involvement/participation

Health System:
Infrastructure
MIS/HIS
Management
Equipment/ Supplies
Communication
Transport

Referral mechanisms

Health Facilities:
Availability
Access
Location
Intake
Equity
Private vs. public

Mix ratio of providers

Affordability/ private vs. public

Interaction:
Provider/consumer relationship
Team approach
Provider/consumer satisfaction
Peer review/audit
Knowledge/ empowerment of women and families
Women's care preferences

Referral patterns

Maternal:
Mortality
Morbidity
Normal delivery
Satisfaction

Baby:
Stillbirth
Neonatal death
Morbidity
Healthy baby

Provider:
Job satisfaction

Cost-effectiveness (efficiency and productivity)

*SOURCE : Graham and Bell 2000a

Box 2. Defining minimum and additional skills required of skilled attendants*

The skilled attendant *at delivery* will have the *minimum set of skills to:*

- Take a detailed history, asking relevant questions, demonstrate cultural sensitivity, and use good interpersonal skills.
- Provide antenatal care throughout pregnancy; provide continuity of care throughout the perinatal period.
- Perform a general examination, identify deviations from normal, and screen for conditions that are prevalent or endemic in the area.
- Take vital signs (temperature, pulse, respiration, blood pressure)
- Auscultate the foetal heart rate.
- Calculate the estimated date of delivery.
- Educate woman and family about danger signs during pregnancy, when and how to seek emergency care.
- Provide appropriate intervention (including referral) for
    infection
    intrauterine foetal death
    malpresentations and abnormal lies at term
    multiple gestation
    poor nutrition and anaemia
    pre-eclampsia and eclampsia
    rupture of membranes prior to term
    severe vaginal bleeding (suggesting abruptio placenta)
    other problems significantly affecting health (e.g. not limited to polyhydramnios, diabetes inadequate foetal growth, preterm labour)
- Perform an abdominal examination identifying abnormalities and factors that place the woman at increased risk.
- Prepare the woman and her family for the birth by providing information and support
- Time and assess the effectiveness of uterine contractions, monitoring the woman's response to pain and increasing pressure on the pelvic floor.
- Perform a vaginal examination, noting the vulva, status of the membranes and colour of amniotic fluid, cervical dilation, and presenting part.
- Provide support and psychological care for the woman and her family.
- Ensure hydration, nutrition, comfort, cleanliness, elimination, and mobility, appreciating and explaining the advantages of these approaches and the risks associated with their omission.
- Recognise delay in labour, prioritise care, take appropriate action, and evaluate the results of the intervention.
- Use the partograph or modified form
- Recognise the presence of meconium in amniotic fluid
- Make appropriate referrals in response to the level of indicated risk.

(Box 2 continued)
- Recognise foetal distress and take appropriate action
- Conduct vertex deliveries, using appropriate hand manoeuvres and aseptic precautions.
- Perform and repair episiotomy to save the life or protect the mother or baby from serious injury.
- Take appropriate care of the cord at birth.
- Manage a cord around the baby's neck at delivery.
- Clamp and cut the cord using aseptic technique.
- Perform physiologic OR active management of the third stage of labour
- Perform controlled cord traction
- Administer oxytocic agents
- Check the placenta and membranes for completeness
- Check that the uterus is well-contracted and estimate total
- Manage postpartum haemorrhage
- Administer oxytocic agents
- Perform aortic compression or internal bimanual compression, depending on country norms
- Perform life-saving skills in cases of
- convulsions
- obstructed airway
- serious infection
- shock
- unconsciousness
- vaginal bleeding (during pregnancy or postpartum)
- shoulder dystocia
- cord presentation and cord prolapse
- Provide a safe and warm environment for mother and infant
- Dry the infant.
- Ensure that respirations are established.
- Initiate newborn resuscitative measures when indicated.
- Encourage early and exclusive breastfeeding when health status of mother and baby are appropriate.
- Examine the newborn baby, noting risk factors from the pregnancy and labour history.
- Assess and monitor the infant in the immediate post-birth period for evidence of normal transition to newborn status; refer sick newborns to next level of care, where appropriate.
- Correlate all available information; record all relevant findings on maternal and newborn records; advise when to return for care.
- Perform immediate and periodic assessments of the woman during the postpartum period, assessing all parameters relevant to normal recovery from childbirth, and evidence of deviation from normal (including haematoma and infection).
- Educate woman and family regarding postpartum and newborn care (including care of the umbilical cord stump).
- Insert intravenous (IV) lines and administer IV fluids
- Prescribe and or administer, as appropriate:

(Box 2 continued)
- analgesics

- antibiotics
- anticonvulsants
- antimalarials
- antipyretics
- contraceptive drugs and devices
- immunisation agents
- iron supplements
- oxytocics (post-delivery or post-abortion)
- sedatives
- tetanus toxoid
- Make appropriate and timely referrals for additional and emergency care, arranging for transportation and care during transport.
- Identify breech and other malpresentations, and make timely referrals in early labour.
- Facilitate linkages between the community health facility, referral settings, and the traditional care providers in that community.
- Use appropriate interpersonal communication skills and counselling skills
- Employ critical thinking skills (includes self-assessment on and reflection of own practice)
- Respect diverse cultures and traditions
- Utilise management skills to organise the practice environment and to evaluate the effectiveness of service delivery.

The skilled attendant *at delivery* may have the *additional skills to:*
- Anticipate the need for forceps delivery or vacuum extraction; perform vacuum extraction
- Manage complications of late labour using appropriate interventions and hand manoeuvres.
- Identify and manage foetal distress.
- Identify and manage multiple births.
- Perform manual removal of retained placenta.
- Identify and repair cervical lacerations.

Use managerial skills to improve service delivery

* *SOURCE* : SMIAG 2000b

The definitions of skilled attendance and attendants are clearly crucial to identifying the potential to impact on maternal mortality. Whilst at the simplest level, a skilled attendant is still often equated with "doctors, midwives and nurses", particularly in crude coverage statistics (WHO 1997), these professionals usually have very different scopes of work and skills, particularly with regard to surgical procedures. It will be argued later in the paper, that such aggregation is unhelpful and that if professional labels are to be used, these should be differentiated. Recently attempts have been made to refine the definitions in terms of essential or core competencies required for an attendant to be designated as "skilled" (ICM 1999, WHO 1999). These have now been synthesised into a proposed <u>minimum</u> set of skills required and a set of <u>additional</u> or optional skills (SMIAG 2000b), as indicated in Box 2.

Review of these skill sets suggests that "skilled attendant" appears to equate with midwives or nurses with midwifery skills and not to include doctors, since surgical skills are omitted whilst management of normal delivery and supportive nursing care is included. Thus the minimum and additional skills in Box 2 essentially relate to the provision of Basic (BEOC) but not Comprehensive Essential Obstetric Care (CEOC) (UNICEF 1999). This however contradicts the joint WHO/UNFPA/UNICEF/World Bank Statement (1999) referred to earlier which specifically includes doctors as skilled attendants. It may be helpful therefore to conceive of skilled attendance as encompassing a partnership of health professionals with the skills to provide care for normal and/or complicated deliveries, **AND** the enabling environment. This is consistent with the earlier definition of skilled attendance and is shown schematically in Figure 2. The important issue as regards the attendants is the emphasis on the word **skilled** since the professional title alone does not guarantee skills, and on the plural sense since women may need to be referred between different professionals, such as midwives and doctors.

Figure 2. Schematic representation of skilled attendance at delivery
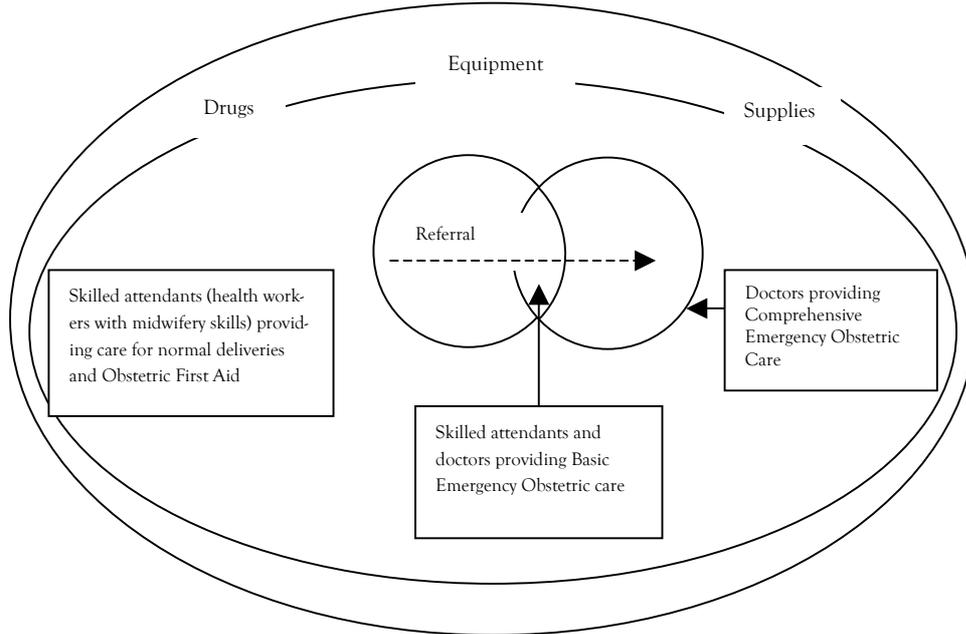
Boxes 1 and 2 also highlight the three other areas of uncertainty regarding skilled attendance:

- The place of attendance: recent documents refer to skilled attendants practising at "the primary or first referral level" (SMIAG 2000b), implying the former refers to domiciliary care and the latter health centres. This terminology is not however consistent with earlier documents, such as the WHO Mother–Baby Package (1994), which propose health centres as the primary tier and district hospitals as the first referral level. The extent to which skilled attendance does or does not include domiciliary care is crucial, since institutionalising all deliveries has profound resource and logistical implications for poor developing countries, as well as raising concerns over the risks of over-intervention and iatrogenicity.

- Time of attendance: the role of the skilled attendant outside the intrapartum and immediate postpartum period is unclear. One recent key document suggests that a skilled attendant serves as a "proxy for a health care professional who can also provide skilled antenatal, postnatal and

neonatal care" (SMIAG 2000b.). However, the extent to which they can impact upon early pregnancy complications, such as ectopic pregnancy or complicated induced abortion, or those occurring after the delivery, such as secondary postpartum haemorrhage, depends on the community's acceptance and recognition of this role and thus on contact with women outside labour and delivery.

▪ Extent of attendance: there is ambiguity in the degree of involvement during labour and delivery required to constitute "attendance". A health professional who only attends the final stages needs to be distinguished from one who is available throughout. Similarly, whether the attendant is physically present or just close-by can also be an important distinction in terms of preserving normality and detecting early warning signs.

Thus in order to identify the potential for skilled attendance to prevent the major causes of maternal death, assumptions must be made about the competency of the provider; the availability of essential drugs, equipment and supplies; the access to referral facilities; the location; and the time and duration of attendance. This assumption-based approach will now be used to consider the effectiveness of skilled attendance at two levels – the individual level, and the population level. The distinction here is crucial. At the former level, the association is considered between cases of maternal death and the type of attendant at delivery or, conversely between types of attendant at delivery and deaths among those they attend. At the population level, associations are considered in the aggregate, in other words between the maternal mortality ratio for the <u>entire</u> population and the proportion of deliveries in the <u>entire</u> population with or without skilled attendance.

How can skilled attendance work at the individual level ?

One of the major rationale often cited for prioritising skilled attendance at delivery is the concentration of maternal deaths around this time, with an estimated two-thirds occurring in late pregnancy through to 48 hours after delivery (AbouZahr 1998a). Assuming therefore that the primary involvement of the skilled attendant is from the onset of labour to the immediate puerperium (up to 48 hours), the four major direct causes of maternal death amenable to intervention are shown in Table 1, along with estimates of their incidence and case-fatality. If this involvement is extended to late pregnancy and the first week after delivery, then the proportion of eclamptic, antepartum haemorrhage and puerperal sepsis cases encountered by the skilled attendant is likely to be increased, but the other major causes - ectopic preg-

nancy and complicated abortion, would remain excluded.

Table 1. Major causes of maternal death close to the time of delivery, for developing countries ~1990

Complication	Incidence (Rate per 100,000 females 15-44)		Case-fatality rate[1] (%)	
	Highest estimate[2]	Lowest estimate[3]	Highest estimate[2]	Lowest estimate[3]
Obstructed labour	1422	354	9	0
Eclampsia	1185	442	17	2
Puerperal sepsis	2370	531	11	1
Obstetric haemorrhage	2370	885	17	4

*SOURCES: Data extracted from AbouZahr 1998b,c, AbouZahr and Guidotti 1998, AbouZahr et al. 1998.

[1] Derived from estimated number of deaths divided by estimated number of incident cases.
[2] Estimates for sub-Saharan Africa
[3] Estimates for China

The role of skilled attendance in averting deaths from the causes in Table 1 could be both through primary and secondary prevention. Figure 3 illustrates the main points for intervention along the causal pathway to death. Through appropriate case management (including referral), skilled attendance can prevent complications directly. The scope for primary prevention clearly varies according to the complication, although reliable data on the avoidable fraction is lacking. Table 2 provides first *guess-timates* of these proportions, emerging from a process comparing published incidence rates between developing and transitional countries, combined with expert clinical opinion, and assuming a basic level of health service infrastructure and limited access to care. Further confirmation of these figures can be regarded as a research need. These preliminary estimates give some broad indication of the potential of skilled attendance to impact not only on maternal deaths through primary prevention, but also on the number of women suffering with these complications – a number which is of course considerably greater than the number dying.

Table 2. Guess-timates of the proportion of complications amenable to primary prevention by
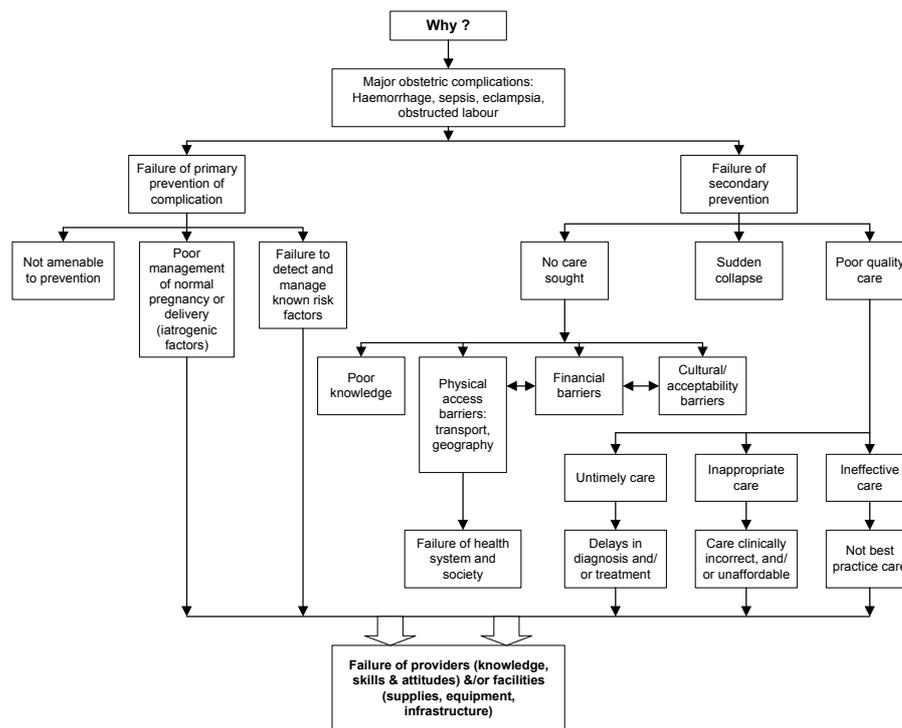
skilled attendance[1]

Complication	% complications preventable[2]		% change between highest developing country estimate and estimate for Former Soviet Union	% change between lowest developing country estimate and estimate for Former Soviet Union
	Optimistic estimate	Pessimistic estimate		
Obstructed labour	85	70	-80.1	-20
Eclampsia	40	20	-70.3	-21.4
Puerperal sepsis	70	50	-79.2	-7
Obstetric haemorrhage	50	30	-70.2	-20.2

SOURCES: Data extracted from AbouZahr 1998b,c, AbouZahr and Guidotti 1998, AbouZahr *et al.* 1998.

[1] Skilled attendance included skilled attendant (skilled health professional) AND enabling environment of drugs, equipment, supplies, and referral

[2] Estimated by reviewing incidence rates, combined with expert opinion, and assuming a basic level of health infrastructure and limited access to care.

Figure 3. Why do women in poor countries still die or suffer life-long disability owing to pregnancy or childbirth ?

A similar approach can be applied to assess the potential impact of skilled attendance through secondary prevention – namely effective, appropriate and timely essential obstetric care. Considering the competencies proposed earlier in Box 2, and assuming that the skilled attendant has access to an enabling environment for BEOC and CEOC, it is possible to model a set of management scenarios or algorithms for averting maternal deaths from the 4 main direct obstetric causes. The approach used here should be regarded as tentative, and research is needed to refine and validate the methodology by using, for example, the Delphi technique. Combining the derived figures with those estimated earlier for primary prevention, a crude indication can be gained of the overall impact on maternal mortality, as shown in Table 3.

Table 3. Estimates from preliminary model of maternal deaths averted by skilled attendance

1	2 CFR (%)	3 Range of estimates	4 % complications averted by primary prevention	5 Model 1 % deaths averted by secondary prevention		
Complication				OFA only	BEmOC only	CEmOC only
Obstructed labour (7.5%)	100	Optimistic	85	2	3	95
		Pessimistic	70	1.5	2	90
Eclampsia (12.6%)	50	Optimistic	40	2	20	45
		Pessimistic	20	0	15	40
Puerperal sepsis (15%)	50	Optimistic	70	20	40	49
		Pessimistic	50	10	30	45
Haemorrhage (25.1%)	50	Optimistic	50	10	20	46
		Pessimistic	30	5	10	42

	6 Model 1 Total % deaths averted with primary and secondary prevention			7 Model 2 % deaths averted by secondary prevention	8 Model 2 Total % deaths averted with primary and secondary prevention	9 % of all maternal deaths averted
Complication	OFA only	BEmOC only	CEmOC only			
Obstructed labour (7.5%)	85.3	85.45	99.25	97	99.55	7.47
	70.45	70.6	97	94	98.2	5.28
Eclampsia (12.6%)	21.2	32	47	48	48.8	6.15
	10	22	42	45	46	1.26
Puerperal sepsis (15%)	41	47	49.7	49	49.7	7.46
	30	40	47.5	45	47.5	4.50
Haemorrhage (25.1%)	30	35	48	48	49	12.30
	18.5	22	44.4	46	47.2	4.64

Notes:

[1] Major complications and % contribution to total maternal deaths

[2] Estimated case fatality rates in the absence of any intervention

[3] Upper and lower limits of estimates

[4] *Guess-timates* of % complications avoided by primary prevention through skilled attendance

[5] Model assuming that women present with the complication to a skilled attendant and receive one of three types of care, but with no referral between them: OFA Obstetric First Aid, BEmOC Basic Emergency Obstetric Care, CEmOC Comprehen-

sive Emergency Obstetric Care

[6] Estimates from column 5 combined with the proportion avoided by primary prevention

[7] Model 2 assumes women present with complication to a skilled attendant and receive OFA, followed by BEmOC, followed by CEmOC.

[8] Estimates from column 7 combined with the proportion avoided by primary prevention

[9] Use of highest (optimistic) and lowest (pessimistic) estimates of % averted multiplied by the % of all maternal deaths owing to that complication.

This type of sensitivity analysis is widely used in health economics (Briggs *et al.* 1994) and, as applied here, suggests that between about 16% and 33% of all maternal deaths could be avoided through skilled attendance, assuming certain competencies as well as the availability of essential, drugs, equipment and referral. The model focuses only on skilled attendance impacting only on the four main causes of maternal death close to delivery, and does not allow either for competing risks nor possible multiplicative effects of skilled attendance. The preliminary nature of these figures and the need for further developmental work must be emphasised. However, the optimistic proportion is comparable to the estimated figure of a third of maternal deaths avoidable by the provision of family planning (Winikoff & Sullivan 1997). To have this level of impact assumes that each woman has access to and utilises skilled attendance, which raises issues related to coverage at the population level, as discussed later.

Given this potential, the key question is what is the evidence that this can be achieved – in other words that the efficacy of skilled attendance can be translated into effectiveness – clinical and cost-effectiveness. The most rigorous approach to answering this question is a randomised-controlled trial (RCT) as it enables systematic bias between the intervention and non-intervention group to be eliminated. Whilst a large number of specific midwifery and obstetric practises have been evaluated using this gold-standard design, few have been conducted in developing countries and none have used maternal death as the primary outcome. In other words, there is no Grade 1 evidence (Gray 1997) to show that women delivering with skilled attendance have a lower risk of dying of maternal causes than women delivering without. However, given the proven effectiveness of specific practices, it would now be regarded as unethical to conduct a study in which the control group of women were specifically denied these procedures. It would on the other hand be possible to use a cluster randomised trial design (CRT) to

compare a complete package of skilled attendance (attendant and enabling environment) provided in intervention districts versus the existing maternity care in control districts. A natural opportunity to use this experimental design may arise where countries are committed to skilled attendance as defined above, but are unable to implement this across all districts at the same time. If districts can be randomised in terms of the order in which implementation occurs, then a CRT may be feasible (Graham & Bell 2000a).

In the absence of trial data, there are two main other types of "evidence" which can be used to explore the link between skilled attendance and the risk of maternal death at the individual level: historical and epidemiological. Neither of these can provide proof that there is a lower probability of dying of maternal causes with than without skilled attendance, owing to the difficulty of controlling for confounding factors, such as differences in women's risk at outset or place of delivery. The majority of historical evidence is in fact relevant to the link between skilled attendance and maternal mortality at the population level, which will be discussed in more detail later. However, the classic work by Loudon, Death in Childbirth (1992a), provides examples of data spanning an enormous period (1864 -1939) and across several continents, which show the risk of death by type of birth attendant. A selection of these figures is given in Table 4. Not surprisingly, there is no clear pattern and firm conclusions cannot be drawn, particularly as the crude maternal mortality ratios cannot be disaggregated according to, for example, intended place of delivery or booking status. But what perhaps these data do confirm is that the professional label alone is not a good proxy for skills or competencies and that we should not only consider reduced risk but also the elevated risk of maternal death in the presence of unskilled "professional" attendants. This concept of balancing benefit with harm is crucial in all areas of health care (Gray 1997), and in safe motherhood there are both historical and contemporary reviews of maternal deaths which attribute the fatal outcome to the professional attending the delivery (such as Bobadilla *et al.* 1996, Porges 1985, Egypt Ministry of Health 1994, United Kingdom HMSO 1998). It is of course hard to establish culpability in many situations, and the attendant finally involved in a case may be unfairly blamed when their involvement may have been too late and beyond their control. This sort of detail is lacking from most routine sources of information on coverage and helps to explain some of the patterns observed from correlational analysis which will be discussed later.

Table 4. Selected historical estimates of maternal mortality by place and attendant at deliv-

ery *

Year	Country	Location	Attendant	Maternal mortality[1]	Source table
1864-73	England	Liverpool Lying-in Hospital	Midwives and doctors	1591	12.2
1876-80	England	Birmingham Lying-in Charity (Domiciliary care)	Midwives and General Practitioners	145	12.3
1873	Scotland	Glasgow Maternity (Lying-in) hospital	Midwives and doctors	2500	12.2
1879-81	Scotland	Glasgow Maternity Hospital (Domiciliary care)	Midwives and General Practitioners	875	12.3
1880-84	England	Queen Charlotte's Hospital	Midwives and doctors	1050	12.5
1885-89	England	Queen Charlotte's Hospital	Midwives and doctors	420	12.5
1909-14	England	Provincial Lying-in hospital	Midwives and doctors	5680	13.5
1909-14	England	Provincial Hospital (Domiciliary care)	Midwives and General Practitioners	2960	13.5
1929	Canada	Institutional deliveries	Midwives and doctors	1310	6.2
1929	Canada	Non-institutional deliveries	Midwives and General Practitioners	370	6.2
1931	United States (Ohio)	Maternity hospitals	Midwives and doctors	590	174
1931	United States (Ohio)	Domiciliary	Midwives	5142	17.4
1931	United States (Ohio)	Domiciliary	General practitioners	1090	17.4
1931	United States (Ohio)	Maternity hospitals	Obstetricians	734	17.4
1935-39	United States (Michigan)	Home deliveries	Midwives and General Practitioners	130	21.3
1935-39	United States (Michigan)	Hospital deliveries	Obstetricians	1340	21.3

*SOURCE : Loudon 1992

[1] No information is available to disaggregate these maternal mortality ratios according to intended place of delivery or booking status.

In terms of epidemiological evidence, this broadly falls into two categories - quasi-experimental and descriptive. In the former case, control groups are used to assess the effects of specific interventions. Perhaps the most famous – and contested – relevant example of this design is the Maternity Care Program in Matlab, Bangladesh, involving both historical (before-and-after comparison) and contemporary (non-intervention) controls. The intervention comprised increasing the number of skilled attendants (government-trained community midwives), together with the creation of the enabling environment of a referral chain and access to a health centre able to provide

BEOC (Maine *et al.* 1996). Although this data set has the potential and the power to examine the complex link at the individual level between maternal death and the delivery attendant, and indeed to unravel the sequence of care-givers prior to death, these results do not appear to be available. Instead, aggregate analysis is used to show that a statistically significant decline in the level of maternal mortality occurred in the intervention area from 1984-86 to 1987-89 but not in the control area (Fauveau *et al.* 1991). However, subsequent analysis of maternal mortality in a third area – the Comparison Area – found evidence of a fall comparable to that in the intervention area even though it did not receive the Maternity Care Program; this third area did however have access to a district hospital providing CEOC. This suggests that the control area was perhaps not comparable from the outset to the intervention area, and re-emphasises the difficulty of interpreting findings from non-randomly selected groups (Ronsmans *et al.* 1997).

Descriptive study designs consider patterns of maternal mortality relative to other variables, such as place of delivery and type of attendant, but again cannot prove causal connections owing to their inability to control for confounding factors. One of the most well cited examples relevant to skilled attendance is that reported by Kaunitz and colleagues (1984). Here maternal death among the Faith Assembly religious group of Indiana was compared with that for the remainder of the state population. A tenet of the sect is that members should not receive medical care, and thus all women give birth without professional obstetric assistance. The pregnant women in this religious group are widely regarded as "low-risk" with regard to demographic and health characteristics. For the period 1975-1982, the maternal mortality ratio among the Faith Assembly women was 872 per 100,000 live births, compared with 9 among the remainder of the Indiana population (Loudon 1992a). In other words, the risk in the former group delivering without skilled attendance was 92 times (95% CI 19-280) greater than that for the latter who had access to (though not necessarily used) modern maternity care services. Although it is hard to identify potential confounding factors that might explain this huge difference, neither can this study be regarded as providing rigorous evidence of the effectiveness of skilled attendance, particularly in view of the small number of deaths considered.

A more recent and developing country example of a descriptive study is provided by de Bernis and colleagues (2000) as part of the MOMA survey (Bouvier-Colle *et al.* 1997). Within this cohort study of pregnant women, the component conducted in two different areas of Senegal found that among

those delivering in health facilities, there were higher risks of maternal death for those conducted by non-professionals compared to women delivering with health professionals. However, again the number of deaths is extremely small and thus the confidence intervals very wide. Moreover, as for all descriptive studies there is uncertainty about the comparability of the populations in the two areas, since maternal characteristics appeared to differ significantly in a number of respects. Interestingly, for maternal morbidity the reverse pattern was observed – with higher rates recorded in the area where more women delivering in health facilities had professional attendance. Such a finding may be attributed to improved diagnostic techniques among the professionals or to greater iatrogenicity. Further analysis to examine the proportion of women admitted in normal labour and developing complications versus those admitted with complications could help to throw some light on this.

The lack of rigorous data on the effectiveness of skilled attendance in terms of reducing maternal mortality obviously also explains the lack of knowledge on cost-effectiveness. The most frequently used information is that derived from a costing exercise undertaken by WHO in support of the Mother-Baby Package (WHO 1994). This estimated that the maternal component of the package would cost $2 per capita to deliver in low-income countries, with a cost of $230 per mother or infant life saved. These figures are suggested to be "lower than or similar to the cost of many other programmes, such as measles immunisation" (Starrs 1997), but do not enable a judgement to be made about the cost-effectiveness of the skilled attendance component versus other elements of the package.

Normal delivery and essential obstetric care are, however, estimated to account for about 44% of the total costs of the Mother-Baby package (Jowett 2000).

There are sound clinical reasons for believing that the risk of maternal death can be reduced by skilled attendance, particularly as the causal pathways can be elucidated. However, the theory of how skilled attendance can work has not been rigorously tested, and the information available is flawed either owing to weak study designs or inadequate power. The former reflects in part the complexities of mounting controlled trials and thus the resort to quasi-experimental and descriptive approaches which cannot allow adequately for the differences between women receiving or not receiving skilled attendance. Case-control studies, for example, have faced huge difficulties in identifying appropriate controls (Abdulghani 1993). Moreover, the data are

often limited to studying the effect of just one type of attendant rather than including all those involved and the timing of their involvement; clearly the risk of maternal mortality can appear higher among doctors simply because they attend the most serious complications. Further explorations of existing data sets may help to establish patterns of attendance involving more than one professional. In summary, we know that skilled attendance <u>could</u> work to reduce maternal mortality at the individual level; we do not know reliably if it <u>can</u> or <u>has</u>.

How can skilled attendance work at the population level ?

A key rationale cited for prioritising skilled attendance is the findings from correlational analysis of historical and contemporary data. There are, however, two drawbacks to this approach which should be acknowledged from the outset: firstly, the intrinsic inability to make causal connections using aggregated data, and secondly, the problems of the data – its reliability as well as the choice of independent and dependent variables. Whilst awareness of the former drawback needs to be raised among those using the findings to advocate skilled attendance, there is no way to overcome it completely, although - as will be shown later - multi-variate analysis can at least offer some control over known confounders. The drawbacks to the data, on the other hand, are not insoluble, and methodological research could help refine the most commonly-used independent variable – "proportion of deliveries with health professionals" (Graham and Bell 2000a).

As for the previous section, it is helpful to distinguish between two types of evidence on the link between maternal mortality and skilled attendance at the population level: historical and epidemiological. There is a comparative wealth of information on the historical trends in maternal mortality in modern day industrialised countries, such as Sweden and the United States, and transitional countries, such as Malaysia and China (De Brouwere *et al.* 1998, Koblinsky *et al.* 1999, Loudon 1992b). Most of these historical series seek to identify the contributory factors in the downward trend and all conclude that no single factor can be held responsible. Having acknowledged the multi-factorial nature of the decline, the concern has been to establish the relative importance of various factors, and skilled attendance – as reflected in a variety of measures, has emerged as of central importance. Beyond this, there has been an attempt to disentangle the elements of skilled attendance, primarily in terms of place of delivery and type of attendant (doctor or midwife). A justification for this is the perceived relevance of the lessons to con-

temporary developing countries. Relevance is however hard to assess, since the historical declines occurred when many other demographic, economic, political, cultural and scientific developments were happening in the countries concerned. Some of these factors can be quantified and allowed for in the interpretation, if not the analysis itself, and so, for example, there are authors who argue that maternal mortality was not reduced by broader socio-economic development (Loudon 1992b). The relevance of the historical lessons is also affected by the complexity of the situation today in developing countries, and particularly the limited availability (rather than technological state) of health resources, the new disease challenge of HIV/AIDS, and the declines in fertility – all of which affect maternal mortality.

The historical series all tend to use the maternal mortality ratio as the dependent variable, and to obtain this from vital registration systems. The reliability of these figures cannot be assumed, although they are likely to compare favourably in terms of accuracy with model-based estimates, which is all that is available for many developing countries. As for the independent variable, time is the one most often used, with the occurrence of particular historic events, such as the English Midwives Act of 1902, indicated on the graph. The other independent variables used are place of delivery, often comparing percentage of deliveries at home with those in different types of health institutions, or the type of attendant, usually differentiating between specialists, general physicians, professional midwives, and "others" (lay persons). The correlation observed, both over time and cross-sectionally, emphasises the crucial importance of quality of care, reflecting both the skills of the provider and the environment in which they practised – including the scientific knowledge and availability of drugs. Thus, for example, Högberg and Wall (1986) shows for Sweden a correlation between falling maternal mortality and increased deliveries by professional midwives between 1861 and 1894, but for deaths excluding puerperal sepsis since the "enabling environment" before 1880 did not include knowledge of asepsis. Loudon (1992a) provides many examples of higher historical rates of maternal mortality in Europe and the United States among institutional rather than home deliveries and among general practitioner rather than midwife deliveries, in periods before the use of asepsis and the availability of antibiotics and before abuse of anaesthesia and instrumental deliveries was addressed (see Table 4). The correlation between the pace and timing of the fall in maternal mortality with the professionalisation and promotion of midwifery care in different industrialised countries is a further indication of the importance of the ena-

bling environment for these skilled attendants (De Brouwere *et al*.1998).

Turning to the analysis of time trends for more recent periods, Koblinsky and colleagues (1999) identify 4 organisational models for delivery care that they correlate with levels of maternal mortality. In all 4 scenarios, functioning essential obstetric care is assumed to be "available". Their findings support the conclusions of other studies, namely that in populations where the majority of deliveries are at home with non-professional attendants, the level of maternal mortality appears not to be reducible to below 100 per 100,000 live births, even with BEOC and/or CEOC available. Of course in the sort of population in which such a model prevails, there may be other factors intervening to keep maternal mortality high, such as poor maternal health status and barrier to access to care, but this type of correlational analysis cannot untangle such influences. In a population in which all women deliver in CEOC facilities with a health professional, Koblinksy and colleagues also found that maternal mortality may remain above 100 per 100,000 live births. Although they say that iatrogenic factors are assumed not to operate in any of the 4 models considered, this may in fact be part of the explanation for the level of mortality where all deliveries are in CEOC institutions. Further research is needed to try to gauge the iatrogenic fraction. The two models which correlated with maternal mortality of less than 50 per 100,000 live births both involved professionals (mostly midwives) attending deliveries, in one case at home (model 2) and the other in BEOC facilities (model 3). Interestingly, Koblinsky *et al* (1999) note that all countries in which a model 2 prevailed in the past have now made the transition to model 3, for example Malaysia and Sri Lanka. However they also note that there is insufficient data available to determine which configuration of professional attendance is most cost-effective, and what the constraints are with respect to the enabling environment.

The contemporary epidemiological evidence for the link between maternal mortality and skilled attendance has perhaps been over-interpreted and the constraints of this form of correlational analysis been under-estimated (Graham and Bell 2000a). Figure 4 shows a graphical representation of this link – showing the regression of national estimates of the maternal mortality ratio for developing countries against national coverage statistics, mostly from DHS surveys, on the percentage of deliveries reported by women to have been attended by "doctors, nurses or midwives". Depending on the countries included, the coefficients for this regression – and thus the strength of the relationship - vary, but its negative nature holds up – coun-

tries with high proportions of deliveries with these professionals tend to have low levels of maternal mortality. Nevertheless, it is important to note that the relationship is considerably weaker if the values for industrialised countries, which all cluster around very low maternal mortality and very high professional attendance, are omitted.

Although this type of exploratory analysis can be helpful in suggesting other relationships to examine, its simplicity also encourages over-interpretation – to infer that increasing the proportion of deliveries with health professionals will itself reduce maternal mortality. There are two inter-related issues here to consider – one to do with the indicators used, and the other the nature of the association between maternal mortality and deliveries with professionals. Whilst it is unlikely that inaccuracies in the dependent and independent variable can totally "explain" the observed pattern, it is important to acknowledge the crudity of the measures used. Maternal mortality ratios for many of the poorest developing countries are derived from modelling methods, which use the percentage of deliveries with health professionals (PDHP) to predict the level. By removing those countries with modelled estimates from the regression, a relationship remains but the explanatory power is not surprisingly reduced; for mortality data for 1990, the adjusted coefficient of variation falls from 65% to 51%. The PDHP has the benefit of being widely available from national surveys, but the extent to which women can and do report reliably on who attended their births has not been established.

Major uncertainty surrounds the effects of only recording the most qualified person, the definition of "attended" (e.g. the person who "caught the baby" or the person attending most of the time), and the confusion over who is a professional in some facility settings. The focus, for example, on recording attendance at delivery only for a woman's live births, as in the Demographic and Health Surveys, means that stillbirths are omitted. Moreover, the crude PDHP can disguise many other important differentials between and within countries besides socio-economic status – between regions, urban and rural localities, institutional vs. home settings, private and public facilities, doctors and midwives/nurses, as well as maternal characteristics such as age, parity, education, and birth outcomes.
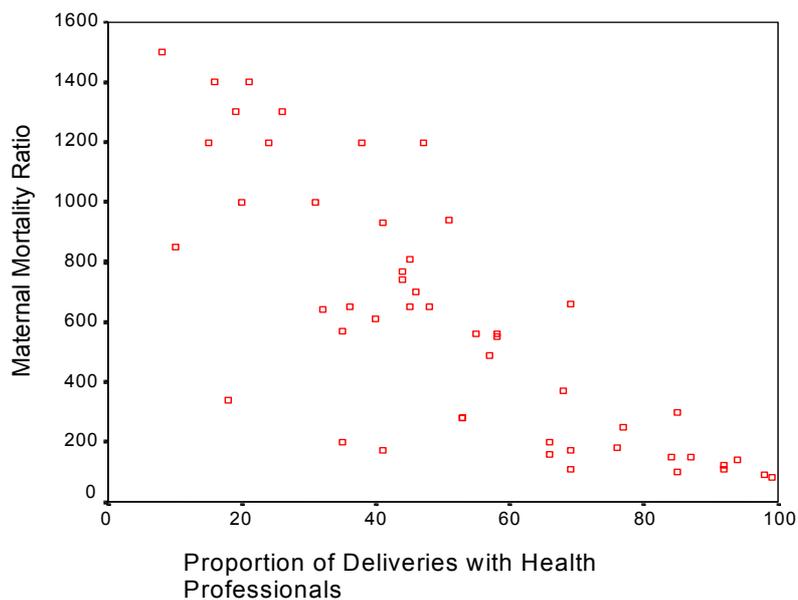
At the recent five-year review of the programme of action for the International Conference on Population and Development (United Nations 1999), international development targets were set for this indicator, with those for countries with "high" levels of maternal mortality being 40% of deliveries with skilled attendants by 2005 and 60% by 2015. Figure 5 shows the levels of this indicator, as reflected in the proportion of deliveries with health professionals, for selected world regions in 1996, and highlights the targets. The selection of this so-called benchmark indicator was made owing partly to the acknowledged difficulty of measuring maternal mortality, partly the ready availability of data on PDHP, and partly the inferred causal link. Figure 5 itself challenges the link, since several world regions have already achieved or are close to achieving the targets and yet their estimated levels of maternal mortality remain high.

Figure 5. Deliveries with health professionals in 1996, for selected world regions
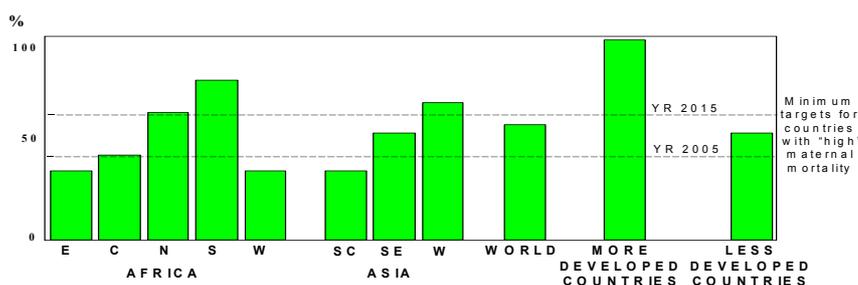
The crude relationship can be examined further with bi-variate and multivariate analysis, revealing some intriguing findings with important policy and programme implications. We have disaggregated the data for 50 developing countries according to whether the most qualified person present at delivery was a doctor or midwife, as reported by women. Although some countries with modelled estimates of maternal mortality are included, as mentioned earlier, their removal has little impact on this disaggregated analysis. As the proportion of deliveries attended by doctors increases, the level of maternal mortality appears to exponentially decrease (Figure 6). Looking at countries with less than 15% of deliveries with doctors, there is an enormous range from less than 200 maternal deaths per 100,000 live births to about 1500. Alternatively, looking at countries with maternal mortality ratios of less than 200, the proportion of doctors attending deliveries also varies hugely - from 15-90%. For deliveries with midwives, any pattern is less obvious (Figure 7).

From a programme perspective, one possible conclusion from this might be that countries should seek to increase access to doctors for deliveries rather than midwives. Another conclusion might be to dismiss the findings as an artefact – reflecting the intrinsic problems of correlational analysis, of confounding, and of the reliability of the data. But our multivariate analysis shows that an association remains between doctors and maternal mortality after controlling for various factors, including GNP, female literacy, antenatal care, and fertility.

Figure 6. Proportion of deliveries with doctors and the maternal mortality ratio for 50 devleoping countries, ˜ 1990
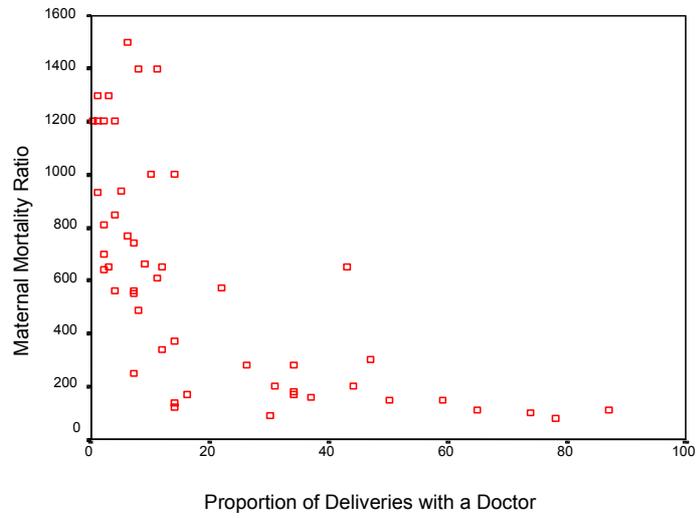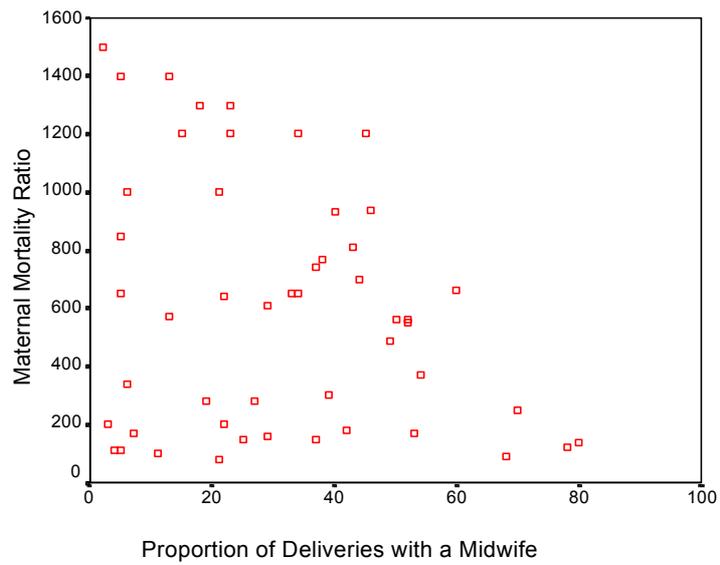

Figure 7. Proportion of deliveries with midwives and the maternal mortality ratio for 50 developing countries, ˜ 1990

There is however a further interpretation of Figure 7. The lack of an obvious link between maternal mortality and the proportion of deliveries with midwives hints at the wide variability in the skills of those with this professional label as well as the constraints under which they practice, including inability to refer complicated cases. Merely having a bigger pool of delivery attendants will not work unless they are appropriately skilled, can refer to other professionals as the need arises and have access to an enabling environment. The crucial issue is that a health professional is not necessarily a skilled attendant, and a skilled attendant is not the same as skilled attendance which encompasses both the providers and the environment appropriate to normal as well as complicated cases.

Our analysis also suggests, however, that the mix ratio between medical and midwifery professionals is a powerful correlate of maternal mortality, thus emphasising the importance of partnerships between providers. Figure 8 plots the proportion of deliveries with midwives against those with doctors, and indicates the level of maternal mortality for each country represented. We have called this new indicator the "*Partnership Ratio*" (Graham & Bell 2000b). It is expressed as two mutually exclusive figures: the proportion of deliveries with a doctor and those with a midwife, such as *PR (10, 55)*, with the sum indicating the total proportion of deliveries with professional attendance. The *PR* can also be analysed for key differentials such as region, private/public sector, parity, or maternal education, and so reveal important inequities in access and uptake of delivery care. We acknowledge the need both to avoid overly simple interpretation of this measure and for further developmental work, including case studies of countries with different *PRs*. The *Partnership Ratio* does however have the strong advantages of being easily derived from existing data, so giving countries a tool to use now, and of providing insights on effective mix ratios of medical and midwifery staff.

If the goal of 100% of deliveries with health professionals is accepted, along with the need for doctors to attend at least 15% of deliveries (this being the usual estimate of the proportion of cases with life-threatening complications), an "optimum" point can be plotted – at *PR (15, 85)*. The two countries which come closest to this point on Figure 8 are Sri Lanka and Jamaica – countries frequently cited as "success stories" in the reduction of maternal mortality. All countries shown in Figure 8 with very high levels of maternal mortality (>1000 deaths per 100,000 live births) have *Partnership Ratios* lower (for both proportions) than *PR (15, 50)*, and some of these - such as Nepal, have ratios as low as *PR (6, 2)*. It can also be seen that many devel-

oping countries with relatively low maternal mortality have more than a third of deliveries with doctors, and in the case of three Central American countries more than two-thirds. This is not however a realistic or affordable option for the majority of poor countries with high maternal mortality where the *Partnership Ratio* between midwives and doctors needs to be established on a cost minimisation basis. In these countries, some of which already have fairly high proportions of deliveries with midwives, such as Senegal, progress in reducing maternal mortality is more likely to lie in improving the enabling environment, and increasing access to doctors for those women needing emergency obstetric care. The next step in this form of analysis is to look in more detail at those countries which are out-liers in terms of the *Partnership Ratio*, and to identify the obstacles and facilitators of their higher or lower than predicted levels of maternal mortality.

Although correlational analysis cannot provide the definitive answer to the question "can skilled attendance reduce maternal mortality", it does suggest possible mechanisms when combined with our understanding of how skilled attendance may work at the individual level. The earlier diagrams on the *Partnership Ratio* seems to suggest a threshold effect such that ensuring <u>all</u> deliveries in a population take place with a health professional may not by itself be the most effective nor cost-effective route to lower maternal mortality in the immediate term. This argument does not necessarily extend however to maternal morbidity, since the estimates produced earlier (Table 2 and 3) perhaps suggest that the primary prevention role of skilled professionals may be very significant.

There are some populations in which more than a quarter of their deliveries occur without health professionals but the level of maternal mortality is below 250 per 100,000 live births, such as Peru, Tunisia, Egypt and Namibia. Conversely, there are other countries with nearly half of their deliveries with health professionals but maternal mortality remains high – above 500 per 100,000 live births, such as Malawi, Ghana, Bolivia, and Zambia. The key words here are access and quality. Thus those countries with lower than expected maternal mortality may have achieved this not by ensuring that all deliveries occur with skilled attendance but rather that those who need emergency care receive it. Conversely, those countries with higher than expected mortality may have health professionals without a functioning enabling environment and/or professionals who are not in fact skilled.

Figure 8. Proportion of deliveries with midwives and the proportion with doctors for 50 developing countries, ~ 1990
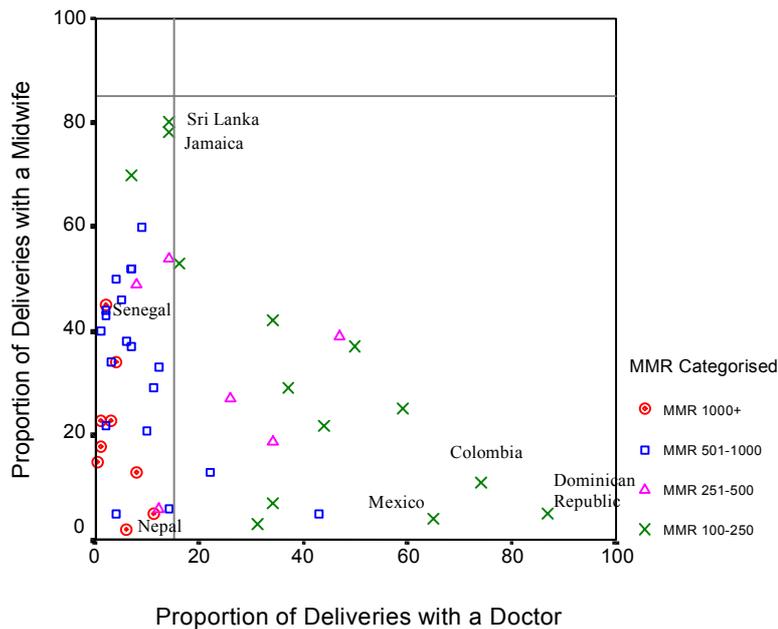
This is not to suggest that skilled attendance for all deliveries should not be a goal, but it does raise questions about the most effective and efficient intermediate steps to reaching it. Childbirth is undeniably a normal physiological process as well as the cause of some tragedies. Many women in poor developing countries will continue to deliver without skilled attendance for the foreseeable future. An impact on maternal mortality may however be possible with improved mechanisms for referral. Those settings in which skilled attendance is not negatively correlated with maternal mortality raise major questions about the quality of care, and bring us back to the question of the definitions. Skilled attendance implies competent attendants AND an enabling environment. The partnership between these attendants is crucial – and particularly between midwives and doctors, so that their different skills can be used appropriately to meet the different needs of women at the time of delivery. A lack of such partnership was historically an obstacle to progress in developed countries (Loudon 1992a) and elements of this competition indeed remain today. This lesson is highly relevant to those countries that continue to face the challenge of maternal mortality.

References

Abdulghani N (1993). Risk Factors for Maternal Mortality among Women using Hospitals in North Yemen. Doctoral dissertation. London School of Hygiene and Tropical Medicine.

AbouZahr C (1998a). Maternal mortality overview. *In: Murray CJL, Lopez, AD. Health Dimensions of Sex and Reproduction. Global Burden of Disease and Injury Series.Volume III*. Geneva: World Health Organization. pp.111-164.

AbouZahr C (1998b). Antepartum and postpartum haemorrhage. *In: Murray CJL, Lopez, AD. Health Dimensions of Sex and Reproduction. Global Burden of Disease and Injury Series.Volume III*. Geneva: World Health Organization. pp.165-190.

AbouZahr C (1998c). Prolonged and obstructed labour. *In: Murray CJL, Lopez, AD. Health Dimensions of Sex and Reproduction. Global Burden of Disease and Injury Series.Volume III*. Geneva: World Health Organization. pp.243-266.

AbouZahr C, Guidotti R (1998). Hypertensive disorders of pregnancy. *In: Murray CJL, Lopez, AD. Health Dimensions of Sex and Reproduction. Global Burden of Disease and Injury Series.Volume III*. Geneva: World Health Organization. pp.219-242.

AbouZahr C, Ahman E, Guidotti R (1998). Puerperal sepsis and other puerperal infections. *In: Murray CJL, Lopez, AD. Health Dimensions of Sex and Reproduction. Global Burden of Disease and Injury Series.Volume III*. Geneva: World Health Organization. pp.191-218.

AbouZahr C, Wardlaw T (2000). Maternal mortality at the end of the decade: what signs of progress. *Bulletin of the World Health Organization* (Forthcoming).

de Bernis L, Dumont A, Bouillin D, Gueye A, Dompnier JP, Bouvier-Colle MH. (2000). Maternal morbidity and mortality in two different population of Senegal: A prospective study. (MOMA survey). *British Journal of Obstetrics and Gynaecology* **107**(1), 68-74.

De Brouwere V, Tonglet R, Van Lerberghe W (1998). Strategies for reducing maternal mortality in developing countries: what can we learn from the history of the industrialised West? *Tropical Medicine and International Health* **3**(10),771-782.

Bobadilla JL, Reyes Frausto S, Karchmer S (1996). The magnitude and causes of maternal mortality in the Federal District (1988-1989). *Gaceta Médica de México* **132(1),**5-18.

Bouvier-Colle MH, Prual A, de Bernis L et al. (1997). *Maternal morbidity in western Africa: results of a ppopulation-based study in Abidjan, Bamako, Niamey, Nouakchott, Ouagadougou, Saint Louis and Kaolack*. Ministère français de la coopération. INSERM-U 149, Paris.

Briggs A, Sculpher M, Buxton M (1994). Uncertainty in the economic evaluation of health care technologies: the role of sensitivity analysis. *Health Economics* **3,**95-104.

Egypt Ministry of Health (1994). *National Maternal Mortality Study: Findings and conclusions*. Cairo: Child Survival Project. Ministry of Health.

Fauveau V, Stewart K, Khan SA, Chakraborty J (1991). Effect of mortality of community-based maternity care programme in rural Bangladesh. *Lancet* **338**(8781),1183-1186.

Graham W, Bell J (2000a). Monitoring and evaluating skilled attendance at delivery: trials and tribulations. *Bulletin of the World Health Organization* (Submitted).

Graham W, Bell J (2000b). Maternal mortality and skilled attendance at delivery. *American Journal of Public Health* (Submitted).

Gray JAM (1997). *Evidence-based Healthcare*. London: Churchill Livingstone.

Högberg U, Wall S (1986). Secular trends in maternal mortality in Sweden from 1750 to 1980. *Bulletin of the World Health Organization* **64,**79-84.

International Confederation of Midwives (1999). Provisional essential competencies for basic midwifery practice. Draft document. ICM.

Jowett M (2000). Cost-effective safe motherhood interventions in low-income countries: a review. Discussion paper 181. York: Centre for Health Economics. University of York.

Kaunitz AM, Spense C, Danielson TS, Rochat RW, Grimes DA (1984). Perinatal and maternal mortality in a religious group avoiding obstetric care. *American Journal of Obstetrics and Gynaecology* **150**(7),826-831.

Koblinsky M, Campbell O, Heichelheim J. Organising delivery care: what works for safe motherhood? *Bulletin of the World Health Organization* **77**(5),399-406.

Koblinsky M (2000). The MotherCare Experience. Presentation at Technical Consultation "Ensure skilled attendance at delivery. Geneva: 25-27 April 2000. New York: SMIAG/FCI.

Loudon I (1992a). *Death in Childbirth An international study of maternal care and maternal mortality 1800-1950*. Clarendon Press, Oxford..

Loudon I (1992b). The transformation of maternal mortality. *British Medical Journal* **305**,1557-1560.

Porges RF (1985). The response of the New York Obstetrical Society to the report by the New York Academy of Medicine on maternal mortality, 1933-1934. *American Journal of Obstetrics and Gynaecology* **152**,642-649.

Maine D, Akalin MZ, Chakraborty, J, De Francisco A, Strong M (1996). Why did maternal mortality decline in Matlab? *Studies in Family Planning* **27**(4),179-187.

Ronsmans C, Vanneste AM, Chakraborty J, van Ginneken J (1997). Decline in maternal mortality in Matlab, Bangladesh: A cautionary tale. *Lancet* **350**,1810-1814.

Safe Motherhood Inter-Agency Group (2000a). Technical Consultation "Ensure skilled attendance at delivery. Geneva: 25-27 April 2000. New York: SMIAG/FCI.

Safe Motherhood Inter-Agency Group (2000b). Skilled Attendance at Delivery: A Review of the Evidence (draft). New York: Family Care International.

Starrs A (1997). *The Safe Motherhood Action Agenda: Priorities for the Next Decade.* New York: Inter-Agency Group for Safe Motherhood and Family Care International.

United Kingdom HMSO. Department of Health (1998). *Why Mothers Die. Report on the Confidential Enquiries into Maternal Deaths in the United Kingdom 1994-1996.* London: HMSO.

United Nations (1999) *Key actions for the further implementation of the Programme of Action for the International Conference on Population and Development.* New York: United Nations. Para 64.

World Health Organization (1994). *Mother-Baby Package: Implementing safe motherhood in countries.* WHO/FHE/MSM/94.11. Geneva: WHO.

World Health Organization (1996). *Revised 1990 Estimates of Maternal Mortality. A New Approach by WHO and UNICEF.* World Health Organization. WHO/FRH/MSM/96.11. Geneva: WHO.

World Health Organization (1997). *Coverage of Maternity Care. A listing of available information.* 4th edition. WHO/RHT/MSM/96.28. Geneva: WHO.

WHO/UNFPA/UNICEF/World Bank Statement (1999). *Reduction of maternal mortality: a joint statement.* Geneva: WHO.

World Health Organization (1999). Essential Care Practice Guidelines. Draft chart booklets.. Geneva: WHO.

Winikoff B, Sullivan M (1997). Assessing the role of family planning in reducing maternal mortality. *Studies in Family Planning* **18**,128-143.