Risk Factors for Maternal Mortality: a Case-Control Study in Dakar Hospitals (Senegal)

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Abstract

This study was conducted in the three main hospitals of Dakar, the capital city of Senegal. Each case of 152 maternal deaths identified over a 12-month period was matched with two controls: a safe delivery in the same clinic, and a safe delivery in the same neighbourhood of residence. Controls were matched on age, birth order, place, and time of delivery. The leading causes of death were : puerperal sepsis and other infections (51 cases), haemorrhage (32 cases), eclampsia (29 cases), ruptured uterus (11 cases), and anaemia (7 cases). Results of the case-control study revealed the major risk factors associated with health system failures: medical equipment failure (odds ratio [OR] = 55.0), late referral (OR = 23.2), lack of antenatal visit (OR = 16.9), and lack of available personnel at time of admission (OR = 6.6). Various indicators of maternal status at time of admission (complications, blood pressure, temperature, oedema, haemoglobin level) and of health history prior to admission (previous complications, previous C-section, lack of treatment) were also strong predictors of survival. Lastly, socio-demographic factors also appeared as correlates of maternal mortality, in particular: first pregnancy (OR = 2.3), pregnancy of high birth order (OR = 1.9), rainy season (OR = 2.4), being unmarried (OR = 2.5), and low level of education (OR = 1.6). Implications for policy are discussed. (*Afr J Reprod Health* 1997;1(1):14–24)

Résumé

Facteurs de risque de la mortalité maternelle: une étude cas-témoins dans les hôpitaux de Dakar (Sénégal)

L'étude a été conduite dans les trois principaux hôpitaux de Dakar, la capitale du Sénégal. Chacun des 152 cas de décès maternels relevés au cours d'une période de 12 mois a été apparié avec deux témoins : un accouchement dans la même clinique et un accouchement dans le même quartier de résidence. Les témoins ont été appariés selon l'âge, le rang de naissance, le lieu et le jour d'accouchement. Les principales causes de décès étaient : les infections puerpérales et les autres infections (51 cas), les hémorragies (32 cas), les éclampsies (29 cas), les ruptures utérines (11 cas), et les anémies (7 cas). Les résultats de l'étude cas-témoin révèlent les principaux facteurs de risque associés avec les dysfonctionnements du système de santé : les défauts de l'équipement médical (RC = 55,0), l'évacuation tardive (RC = 23,2), l'absence de visite prénatale (RC = 16,9), et le manque de personnel au moment de l'admission (RC = 6,6). Divers indicateurs de l'état de la femme au moment de l'admission (complications, pression sanguine, température, oedèmes, niveau d'hémoglobine), et l'histoire obstétricale avant l'admission (complications antérieures, césarienne, absence de traitement), avaient aussi une forte valeur prédictive pour la survie. Enfin, les facteurs socio-démographiques étaient aussi corrélés à la mortalité maternelle, en particulier la première grossesse (RC = 2,3), les grossesses de rang élevé (RC = 1,9), la saison des pluies (RC = 2,4), être non mariée (RC = 2,5), et le faible niveau d'éducation (RC = 1,6). Les conséquences des résultats pour une politique de santé sont discutés. (*Afr J Reprod Health* 1997;1(1):14–24)

Key Words: *Maternal mortality, cause of death, risk factors, case-control study, health system, Senegal, Africa*

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Maternal mortality in developing countries has been described as a "multitude of quiet tragedies"[1] and a "disgrace to the modern world."[2] This is particularly true in sub-Saharan Africa, where large numbers of maternal deaths occur each year because of high maternal mortality ratios and high fertility rates. Awareness about this important public health problem increased after the Safe Motherhood Conference in Nairobi in 1987,[3] and since then various programs have been initiated by international agencies to addresss the problem.

In sub-Saharan Africa little is known about levels of maternal mortality in the community, although some efforts have been made to use Demographic and Health Surveys and indirect methods to estimate levels. Wherever studies have been conducted the levels appear to be quite high by international standards, up to 200 times the levels in western countries.[4–7] However, some significant improvements have been noted in several places, such as South Africa,[8,9] Burkina Faso,[10] and Senegal.[11]

Most available evidence on maternal deaths comes from hospital-based studies. Although they produce biased estimates of maternal mortality levels and of cause of death distribution compared to population-based studies, hospital-based studies may provide useful information on ways to avoid maternal deaths. Many such studies have been conducted in countries throughout Africa, such as Nigeria,[12–17] South Africa, [8,9,18,19] Ethiopia,[20] Tanzania,[21,22] Ghana,[23,24] Kenya,[25] Malawi,[26] Uganda,[27] Zambia,[28] Senegal,[29] Guinée,[30] and Niger.[31] In a review of 17 hospital-based studies from sub-Saharan Africa with at least 100 maternal deaths, the maternal mortality ratio (MMR) ranged from 190 to 1,239 per 100,000, with an average of 604 per 100,000. Observations of declining maternal mortality have been made in hospital data series over long periods of time, but because of the numerous biases involved no inference can readily be made at the level of the whole population.

Causes of maternal deaths are usually presented as direct, indirect, and unrelated, and in most hospital studies the proportion of undetermined causes of maternal deaths is negligible. According to previous studies, the leading direct causes of death are: puerperal sepsis, haemorrhage, hypertensive conditions (eclampsia, pre-eclampsia), ruptured uterus, post-abortum sepsis, ectopic pregnancy, embolism (pulmonary, amniotic fluid, air), and anaemia. To this list, iatrogenic causes should be added (anaesthesia and transfusion). The leading indirect causes of deaths are: infections (in particular hepatitis, malaria, bacterial meningitis, typhoid, tetanus, tuberculosis, AIDS), rheumatic heart disease, diabetes mellitus, cancers, and violence (homicide and suicide related to the pregnancy). Most of the unrelated causes are accidental (e.g., motor vehicle accidents). The wide variety of underlying causes of death and often the multiple causes (such as septicaemia after ruptured uterus, anaemia, and malaria, etc.) makes comparison very difficult, due to the small number of deaths in each case and to the lack of standardisation among studies.

Few of the hospital-based studies have provided quantitative evidence of risk factors specific to maternal mortality. A study conducted in Zimbabwe identified lack of antenatal care and lack of timely transport as major risk factors.[32] Another study conducted by the same team in the same country further identified diminished or absent social support (divorced, widowed, several wives, self-supporting), as well as age (> 35 years), high parity (> 6), and earlier experience of stillbirth or abortion as significant risk factors.[33] A study conducted in Uganda identified parameters of the health status at admission which were predictors of survival : low Apgar score, caesarean section or laparotomy, distance to the hospital, lack of antenatal visits, time of day of admission and delivery, and severe blood loss.[34] Lack of antenatal care was identified as a risk factor for eclampsia in South Africa,[35] and for all maternal deaths in Nigeria.[36] Many authors have noticed large differences between women who use preventive services

(booked) and those who do not (unbooked).[13]

This study was conducted to identify the most significant risk factors (institutional, behavioural, biological, and socio-demographic) of maternal deaths, and how the knowledge of those risk factors could be used to prevent maternal deaths.

Data and Methods

The study was designed as a case-control study for analysing the various risk factors of maternal deaths in Dakar, the capital city of Senegal. The cases (maternal deaths) were identified in the three main maternity wards of Dakar hospitals (Le Dantec, Principal, Abbas Ndao) over a 12-month period (March 1986 to February 1987). The selected cases included all deaths attributable to maternal causes according to the International Classification of Diseases (ICD-9) definition, with the exception of deaths following induced abortion and ectopic pregnancies, which were excluded for practical purposes. These three maternity wards receive most of the complicated cases for the whole city of Dakar, as well as some of the complicated cases from other towns and rural areas in the country. In addition, they receive large numbers of deliveries without complications, about one third of all deliveries in the city.

Each case was matched with two controls (safe delivery): type-1 controls (hospital controls) were women of the same age and parity who delivered safely in the same maternity at about the same time; type-2 controls (residential controls) were women of the same age and parity, resident in the same neighbourhood, who delivered safely at about the same time, whether in a maternity or at home. Type–2 controls were identified through special inquiries in the field. Since there were no obvious differences between type-1 and type-2 controls, these were pooled together for the final analysis. Since risks factors do not always apply to the whole sample, in particular for type-2 controls, missing values were excluded for the calculation of odds ratios.

Causes of death were identified after in-depth analysis of the hospital files. For complicated cases (14% of all deaths) an autopsy was performed.

For each case and each control a detailed questionnaire was completed, focusing on socio-demographic characteristics, antenatal screening, status at admission, complications and treatment, and circumstances of referral. Analysis of the hospital files and discussion with the practitioner provided clues for identifying failures of the health system. Furthermore, the physicians who reviewed the cases were asked to estimate whether the maternal death could have been prevented or not.

Risk factors were identified by comparing cases and controls and calculating odds ratios. Furthermore, for risk factors associated with the matching (age, parity, time of delivery), controls were taken in the general population from independent demographic sources (distribution of births by age, parity, month). Standard statistical analysis was performed for computing odds ratios (OR); 95

Table 1 **Distribution of cases and controls according to place of residence, Dakar 1986–1987**

Place of Residence	Cases	Control-1	Control-2	Total
Cap-Vert (Dakar city)	118	149	118	385
Other urban area	13	0	7	20
Rural area	16	1	11	28
Not stated	5	2	7	14
Total	152	152	143	447

Note: Type 1 controls were matched on age, parity, and place of delivery.
Type 2 controls were matched on age, parity, and place of residence.

Table 2 **Underlying causes of the 152 maternal deaths, Dakar 1986-1987**

Underlying Cause	Ante-partum	Intra-partum	Post-partum	Total
Sepsis	7	4	26	37
Other infection (see footnote)	4	1	9	14
Haemorrhage	4	3	25	32
Eclampsia, pre-eclampsia	3	4	22	29
Ruptured uterus	0	6	5	11
Anaemia	4	0	3	7
Post transfusion shock	1	0	3	4
Acute pulmonary oedema	0	0	4	4
Other pulmonary condition	1	0	2	3
Amniotic embolus	1	0	1	2
Choriocarcinoma	2	0	0	2
Acute kidney condition	1	0	1	2
Intestinal occlusion	0	0	2	2
Post anaesthesia shock	0	0	1	1
Ruptured aneurysm	0	0	1	1
Ovary tumor	1	0	0	1
Total	29	18	105	152

Note : Other infections include : viral hepatitis (5), cerebral malaria (5), meningitis (2), typhoid (1), and tetanus (1).

percent confidence intervals (CI), and Chi-square values were computed from Mantel-Haenszel formulae for case-control studies;[37] *p*-values for testing the degree of significance were computed with Excel-5.

Results

Over the 12 month period from March 1986 to February 1987, a total of 152 eligible maternal deaths were identified in the three maternity wards, 100 at Le Dantec, 29 at Principal and 23 at Abbas Ndao. Among the 152 cases, 118 (78%) were residents in Cap-Vert (Dakar city region), 13 (9%) came from other towns, 16 (11%) from rural areas, and in five cases the place of residence was missing (Table 1). The cases were matched with 152 local controls and 143 regional controls. In nine cases, the regional control could not be found, because the family of the deceased person could not be traced (inaccurate or missing address), or because the deceased person came from too far away.

Level of maternal mortality

Over the same period of time, 20,266 births were recorded in the same three hospitals (6,217 at Le Dantec, 4,754 at Principal, 9,295 at Abbas Ndao). The hospital maternal death rate (MDR) is therefore estimated at 750 per 100,000 live births, a value found in many other situations in Africa. There were considerable variations among the three hospitals, which reflect the screening for the most severe cases in the better equipped hospitals. Therefore, the data from the three centres were pooled for the final analysis.

The hospital death rate may be quite different from the MMR in the population. Among the 152 deaths, 118 occurred to women resident in Dakar.

Table 3 **Risk factors associated with failure of the health system**

Risk Factor[a]	Odds Ratio	95% CI Min.	95% CI Max.	CHI²	*p*-value
Medical equipment failure (no failure)	54.97	30.39	99.44	175.51	<0.001
Late referral (24 hours or more) (less than 24 hours)	23.17	13.35	40.21	124.93	<0.001
No antenatal visit (at least one antenatal visit)	16.86	7.32	38.83	44.06	<0.001
No one available at time of admission (specialist or other available)	6.57	0.91	47.54	3.47	0.062
Prenatal visit to a specialised centre (prenatal visit to other centre)	0.94	0.59	1.49	0.08	0.777(NS)
Specialist performed the prenatal visit (non specialist)	0.80	0.41	1.57	0.41	0.524(NS)

[a] reference category in parentheses

These maternal deaths can be compared to the total number of births in the population, about 60,000 per year, for a population of about 1.2 million and a birth rate of about 50 per 1,000. This provides an estimate of the MMR in the population of about 200 per 100,000 live births. It should be noted that maternal deaths after induced abortion and ectopic pregnancies were not counted in this study, and that they may increase the figure by as much as 50 percent.

Causes of death

Among the maternal deaths, 69 percent occurred post-partum, 19 percent ante-partum, and 12 percent intra-partum (Table 2). Overall, the leading causes of death were infections (34% of all cases), either sepsis directly related to pregnancy and delivery (37 cases) or to other infections (indirect causes) which developed during pregnancy and after delivery (14 cases). In this last category there were five cases of viral hepatitis, five cases of cerebral malaria, two cases of meningitis, one case of typhoid, and one case of tetanus. The other important causes of death were: haemorrhage (21%), eclampsia and pre-eclampsia (19%), ruptured uterus/obstructed labor (7%), and anaemia (5%). Other causes displayed in Table 2 were rare (1 to 4 cases each). It should be noted that five cases could be considered iatrogenic, four cases of post-transfusion shock, and one case of post-anaesthesia shock. This distribution of maternal deaths by cause is roughly similar to that of other studies. Direct and indirect infections seemed to play a larger role in Dakar than reported elsewhere, although this might be due to the tendency of other studies to ignore indirect infections as a cause of maternal death. Furthermore, the distribution of causes of death in the hospital cannot be considered representative of causes of death in the population because of the many cultural and logistic selection biases associated with hospital recruitment. In particular, deaths that occur very quickly (e.g., haemorrhage) and causes poorly identified for cultural reasons (e.g., obstructed labor) are likely to be under-represented.

Risk factors

A first series of risk factors related to the functioning of the health system were identified (Table 3). The failure of the medical equipment had a very

Table 4 **Risk factors associated with the status at admission**

Risk Factor[a]	Odds Ratio	95% CI Min.	95% CI Max.	CHI²	*p*-value
Any complication at admission (no complication)	49.53	30.30	80.95	242.36	<0.001
— Haemorrhage	155.95	77.08	315.54	197.23	<0.001
— Infection	47.13	24.68	90.02	136.22	<0.001
— Eclampsia, pre-eclampsia	22.18	10.69	46.00	69.34	<0.001
— Ruptured uterus	28.07	11.34	69.51	51.96	<0.001
Low blood pressure at admission					
— Systolic < 95 mm (95–139)	Infinity	22.15	ND	60.31	<0.001
— Diastolic < 50 mm (50–89)	Infinity	5.40	ND	39.60	<0.001
High blood pressure at admission	3.08	1.56	6.06	10.59	0.001
— Systolic > 140 mm (95–139)					
— Diastolic > 90 mm (50–89)	2.28	1.16	4.47	5.76	0.016
Temperature at admission > 37.5 °C (≤ 37.5 °C)	7.37	3.92	13.87	38.36	<0.001
Generalized oedema (no oedema)	10.61	1.85	60.88	7.02	0.008
Localised oedema (no oedema)	1.41	0.86	2.33	1.86	0.173(NS)
Haemoglobin < 10 g / 100 ml (≥ 10 g / 100 ml)	7.48	1.88	29.86	8.13	0.004

[a] reference category in parentheses ND=not defined

high odds ratio (OR = 55.0), as well as the absence of qualified personnel at time of admission (OR = 6.6). Similarly, late referral (24 hours or more after onset of symptoms) appeared as a major risk factor (OR = 23.2). The role of antenatal visits also appeared clearly (OR = 16.9), and even a single visit made a difference. The level of qualification of the person conducting the antenatal visit (whether a gynaecologist, a physician, or simply a trained nurse), as well as the equipment of the centre (whether specialised in gynaecology or simply a general practice health centre) did not seem to matter.

Obviously, women experiencing complications during pregnancy and at time of delivery were more likely to die than women who had no complications (Table 4). Virtually all the complications investigated were highly significant, with the exception of localised oedema, but risks associated with some complications were much higher than for others. Among the largest predictors were any complication of the pregnancy: haemorrhage (OR = 156.0), infection (OR = 47.1), eclampsia and pre-eclampsia (OR = 22.2), and obstructed labor (OR = 28.1). Low blood pressure at admission was always of lethal prognosis, and high blood

Table 5 **Risk factors associated with the health history prior to admission**

Risk Factor[a]	Odds Ratio	95% CI Min.	95% CI Max.	CHI²	*p*-value
Any complication during pregnancy (no complication)	160.48	74.88	343.93	170.50	<0.001
—Infection	304.50	119.00	779.16	142.32	<0.001
—Obstetric condition & hypertension	177.63	78.68	401.02	155.42	<0.001
Previous C-section (no C-section previously)	3.99	1.75	9.13	10.76	0.001
Never treated previously (was treated previously)	2.29	1.45	3.60	12.77	<0.001
Previously hospitalised (never hospitalised)	3.57	1.35	9.46	6.55	0.010

[a] reference category in parentheses

pressure was a significant risk factor (OR = 3.1 and 2.3). Temperature (OR = 7.4), generalised oedema (OR = 10.6), and low levels of haemoglobin (OR = 7.5) were also significant.

Health history prior to admission was also a strong predictor of survival. In particular, any complication during this pregnancy (prior to the terminal episode) was a risk factor : any infection (OR = 304.5), any obstetric complication, and hypertension (OR = 177.6). An history of earlier C-section (previous pregnancy) had an odds ratio of 4.0. Women who had been previously hospitalised had an odds ratio of 3.6. However, women who escaped the health system, that is, who had never been treated for a pregnancy-related condition, were also at higher risk (OR = 2.3) (Table 5).

A series of socio-demographic factors were also investigated (Table 6). Birth order was a predictor of survival of the mother : the first pregnancy had a higher risk (OR = 2.3), as well as pregnancies of high order, that is, seven or more (OR = 1.9). The peak rainy season, that is, the three months from August to October, was a high risk period, as is the case for virtually all causes of death in Senegal (OR =2.4). Being unmarried (OR = 2.5) and having a low level of education, that is, less than seven years of schooling (OR = 1.6) were also significant. However, age and employment status were not significant.

Discussion

This study was designed to analyse risk factors of maternal death in Dakar, and is certainly not representative of the whole of Senegal. Dakar is the best equipped city in the country, and has the largest number of physicians and gynaecologists per capita. Furthermore, distances are quite small within the city and even the most remote areas are less than 40 km away from the hospitals. Most people live less than 30 minutes by taxi from the nearest hospital. This certainly does not reflect the situation of other regions, where access to health services is much more limited.

Controls were selected to analyse risk factors associated with hospital deaths occurring in Dakar. This sample included deaths of women who were living in Dakar and women coming from outside the city. The controls were selected based on place of delivery and on place of residence. Therefore, the results do not only reflect the situation of maternal deaths of women living in Dakar, but include some of the risk factors to women living further away. This procedure may have biased some of the estimates if compared to a fully representa-

Table 6 **Risk factors associated with the socio-demographic situation**

Risk Factor[a]	Odds Ratio	95% CI Min.	95% CI Max.	CHI²	*p*-value
First pregnancy (birth order 2–6; see footnote)	2.26	1.33	3.84	9.11	0.003
7th + pregnancy (birth order 2–6; see footnote)	1.94	1.20	3.12	7.36	0.007
Age < 20 years (age 20–34 years; see footnote)	1.23	0.70	2.17	0.51	0.476
Age 35+ years (age 20–34 years; see footnote)	1.35	0.82	2.21	1.39	0.238
Rainy season (August – October) (November–July; see footnote)	2.43	1.61	3.66	18.00	<0.001
Not married (married)	2.47	1.29	4.71	7.48	0.006
Less than 7 years of schooling (7 years or more)	1.55	0.98	2.45	3.48	0.062
Not employed (employed)	1.22	0.73	2.05	0.58	0.448

[a] reference category in parentheses

Note : Since controls were matched on age, birth order, and season of admission, controls for these three categories were taken in the general population.

tive sample of the Dakar population (which was not available). For instance, women referred from further away were more likely to have had severe complications and to arrive late, and this may have inflated the odds ratios associated with complications, with distance from the hospital, and with late referral. This type of bias is unfortunately always built into hospital studies, and only a full scale prospective study in the population could avoid such biases.

The estimated level of maternal mortality in the city (lower bound) is high by international standards, but matches other estimates in sub-Saharan Africa. Including the maternal deaths which were excluded from the study (induced abortion and ectopic pregnancy) may increase it by some 50 percent. In any case, maternal mortality in Dakar is clearly a significant public health problem.

The causes of deaths were varied, as usually found in other studies, but the role of infections appeared larger than in other studies. In addition to sepsis, which indicates that many deliveries were not done in proper hygienic conditions, two infections seem to play a dramatic role: hepatitis and malaria. The role of hepatitis has been noted already in many African countries, such as Ethiopia,[38] Sudan,[39] and Nigeria.[40] The major role of malaria has been noted in Mozambique.[41] Both hepatitis and malaria can be easily prevented: vaccination against hepatitis-B exists and was available in Senegal at the time, and chloroquine is widely used for children, but unfortunately less so for pregnant women. Tetanus, also a known cause of maternal death, although rare in this sample (1 case), can also be easily prevented, and in fact major efforts have been made since 1986 to vaccinate pregnant women.[42]

The physicians who reviewed the cases esti-

mated that a majority (65%) could have been "easily prevented," and that an additional 26% could have been "probably prevented." Only 13 cases were considered "difficult to prevent." This gives an order of magnitude of what could be gained by improving the preventive and curative health systems, which could bring the level of maternal mortality close to that of a developed country. The reviewers did not specify in writing how each death could have been prevented, and this information could not be retrieved.

According to the empirical findings, a lot could be gained by simple prevention, in particular regular antenatal visits, vaccinations, and quick referral in case of complications. Many simple actions are at stake here, such as warning the women about clean delivery, warning about the critical symptoms requiring quick referral, prevention and treatment of anaemia, and monitoring of hypertension. It should be remembered that there was no obvious need for qualified gynaecologists (who are in short supply in most sub-Saharan African countries) in the antenatal visits, and that simple screening by a trained nurse (who are widely available) could help prevent many deaths.

Better care of emergencies in the hospital could also save many lives. In this study, it was striking to note that the quality of the equipment and the presence of qualified personnel at the time of admission were strong predictors of survival. This is often related to the time of day of admission, as already noted in Uganda.[34] Availability and quality of intensive care can be improved at reasonable cost with better management, and when needed, with alternative financing of the health system. Some developing countries, such as China, have shown that this is possible even with a low level of income per capita.

Some deaths could also be prevented by identifying biological risks factors, in particular any previous obstetric complication such as C-section. Although maternal complications and deaths often occur to women without previous problems, and obviously to women in their first pregnancy, empirical evidence shows that special care of these women could significantly contribute to the reduction of maternal risks.

Some maternal deaths could also be prevented by tackling demographic risk factors. In particular, women who already had many live births and were older could have prevented their pregnancies. Family planning services have developed significantly in Dakar over the past 15 years, but are still far from providing all the necessary services for the whole population.

Although not entirely new, these findings are more comprehensive than other risk factor studies. They have allowed the quantification of the magnitude of the problems and the risk factors, and have provided solid arguments for the various policy implications, especially hospital care and antenatal visits.[5] Odds ratios associated with antenatal care, with risks associated with previous obstetric history, and with intensive care of complications were very high, in the range of 10 to 100 or more. This readily provides an estimate of what can be gained by tackling these issues. It was by providing quality accessible care and by identifying high risk pregnancies that most of the gains in preventing maternal deaths were obtained in developed countries over the past 30 to 40 years; such is needed in Dakar.

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References

1. Kwast B. A multitude of quiet tragedies. *People* 1987;14(3):14–6.
2. Holness D. A disgrace to the modern world. *Populi* 1989;16(4):52–8.
3. Cohen SA. The safe motherhood conference. *Int Fam Plann Perspect* 1987;13(2):68–70.
4. World Health Organization. Maternal mortality ratios and rates: a tabulation of available information. Geneva: World Health Organization, Revised edition, 1991; WHO/MCH/MSM/91.6.
5. Royston A, Armstrong S. Preventing maternal deaths. Geneva: World Health Organization, 1989.
6. Boerma JT. The magnitude of the maternal mortality problem in sub-Saharan Africa. *Soc Sci Med* 1987;24(6):551–8.
7. Paul BK. Maternal mortality in Africa: 1980–87. *Soc Sci Med* 1993;37(6):745–52.
8. Van Coeverden de Groot HA. Trends in maternal mortality in Cape Town, 1953–1977. *S Afr Med J* 1980;57(7):224–5.
9. Van Coeverden de Groot HA. Maternal mortality in Cape Town, 1978–1983. *S Afr Med J* 1986;69 (13):797–802.
10. Garenne M, Sauerborn R, Nougtara A, Borchert M, Benzler J, Diesfeld J. Direct and indirect estimates of maternal mortality in a rural area of Burkina Faso (Nouna). *Stud Fam Plann* 1997 (in press).
11. Garenne M, Fontaine O, Leroy O, Beau JP, Cantrelle P. Maternal mortality in a rural area of Senegal: 1963–1989 (unpublished observations).
12. Adetoro OO. Maternal mortality—a twelve-year survey at the University of Ilorin Teaching Hospital (U.I.T.H.), Ilorin, Nigeria. *Int J Gynaecol Obstet* 1987;25(2):93–8.
13. Briggs ND. Maternal deaths in booked and unbooked patients: University of Port Harcourt Teaching Hospital experience. *Trop J Obstet Gynaecol* 1988;1(1):26–9
14. Chukudebelu WO, Ozumba BC. Maternal mortality in Anambra State of Nigeria. *Int J Gynaecol Obstet* 1988;27(3):365–70.
15. Harrison KA. Maternal mortality: a sharper focus on a major issue of our time. *Trop J Obstet Gynaecol* 1988;1(1):9–13.
16. Okosior AT. Maternal mortality in the Lagos University Teaching Hospital: a 5-year survey 1970–1974. *Niger Med J* 1978;8(4):349–54.
17. Unuigbe JA, Oronsaye AU, Orhue AA. Preventable factors in abortion-related maternal mortality in Africa: focus on abortion deaths in Benin City, Nigeria. *Trop J Obstet Gynaecol* 1988;1(1):36–9.
18. Boes EG. Maternal mortality in southern Africa, 1980–1982. Part I: pregnancy can be lethal. *S Afr Med J* 1987;71(3):160–1.
19. Boes EG. Maternal mortality in southern Africa, 1980–1982. Part II: causes of maternal deaths. *S Afr Med J* 1987;71(3):158–60.
20. Yoseph S, Kifle G. A six-year review of maternal mortality in a teaching hospital in Addis Ababa. *Ethiop Med J* 1988;26(3):115–20.
21. Mtimavalye LAR, Lisasi D, Ntuyabaliwe WK. Maternal mortality in Dar es Salaam, Tanzania, 1974–1977. *East Afr Med J* 1980;57:111–8.
22. Justesen A. An analysis of maternal mortality in Muhimbili Medical Center, Dar es Salaam, July 1983–June 1984. *J Obstet Gynaecol E Centr Afr* 1985;4:5–8.
23. Ampofo DA. Causes of maternal death and comments, Maternity Hospital, Accra 1963–1967. *West Afr Med J* 1969;18(3);75–81.
24. Adadevoh SW. Maternal mortality in Ghana: is there a place for traditional birth attendants (TBAs) as reporters of maternal mortality-related data? *Trop J Obstet Gynaecol* 1988;(1):40–4.
25. Ruminjo JK. Socio-demographic and gynaecological variables of maternal mortality in a Kenyan subdistrict: January 1981–September 1988. *East Afr Med J* 1990;67(2):118–25.
26. Wiebenga JE. Maternal mortality at Queen Elizabeth Central Hospital, 1989–1990. *Malawi Med J* 1992;8(1):19–23.
27. Grech ES, Galea J, Trussell RR. Maternal mortality in Uganda. *Int J Gynaecol Obstet* 1969;7(6):263–78.
28. Grech ES. Obstetric deaths in Lusaka. *Med J Zambia* 1978;12(2):45–53.

29. Correa P, Diadhio F, Lauroy J, Bah MD, Adanlete FA. Mortalité maternelle au cours de la parturition à la clinique gynécologique et obstétricale de Dakar: aspects épidémiologiques. *Bull Soc Med Afr Noire Langue Fr* 1978;23(3):262–9.

30. Thonneau P, Goyaux N, Toure B, et al. Mortalité maternelle en Guinée: mesure et perspectives. *J Gynaecol Obstet Biol Reprod* (Paris) 1994;23(6):721–6.

31. Vangeenderhuysen C, Banos JP, Mahaman T. Mortalité maternelle évitable en milieu urbain à Niamey (Niger). *Cah Sante* 1995;5(5):49–54.

32. Mbizvo MT, Fawcus S, Lindmark G, Nystrom L. Operational factors of maternal mortality in Zimbabwe. *Health Policy Plan* 1993;8(4):369–78.

33. Mbizvo MT, Fawcus S, Lindmark G, Nystrom L. Maternal mortality in rural and urban Zimbabwe: social and reproductive factors in an incident case-referent study. *Soc Science Med* 1993;36(9):1197–205.

34. Kampikaho A, Irwig LM. Risk factors for maternal mortality in five Kampala hospitals, 1980–1986. *Int J Epidemiol* 1990;19(4):1116–8.

35. Moodley J, Daya P. Eclampsia: a continuing problem in developing countries. *Int J Gynaecol Obstet* 1994;44(1):9–14.

36. Ekwempu C. The influence of antenatal care on pregnancy outcome. *Trop J Obstet Gynaecol* 1988;1(1):67–71.

37. Kleinbaum DG, Kupper LL, Morgenstern H. Epidemiologic research. Belmont, California: Lifetime Learning Publications, 1982.

38. Kwast BE, Stevens JA. Viral hepatitis as a major cause of maternal mortality in Addis Ababa, Ethiopia. *Int J Gynaecol Obstet* 1987;25(2):99–106.

39. Mirghani OA, Saeed OK, Basama FM. Viral hepatitis in pregnancy. *East Afr Med J* 1992;69(8):445–9.

40. Ojo OA, Savage VY. A ten-year review of maternal mortality rates in the University College Hospital, Ibadan, Nigeria. *Am J Obstet Gynecol* 1974;118 (4):517–52.

41. Elling D. Geburtshilfliche Daten von 11874 Entbindungen unter den Bedingungen einer Universitatsklinik in einem Nationalstaat. *Zentralbl Gynakol* 1990;112(6):369–75.

42. Fauveau V, Mamdani M, Steinglass R, Koblinsky M. Maternal tetanus: magnitude, epidemiology and potential control measures. *Int J Gynaecol Obstet* 1993;40(1):3–12.