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Levels and causes of maternal mortality in Senegal

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Summary

OBJECTIVES To report the findings of a direct, community-based, assessment of maternal mortality and medical causes of death using verbal autopsy in three unique cohorts in rural Senegal.

METHODS Methods from ongoing demographic surveillance systems. We obtained records of all deaths and births in women of age 15–49 over a period of 14 years in Niakhar, 10 years in Bandafassi and 13 years in Mlomp. Relatives of all women who died were interviewed using a standard questionnaire. Causes of death were assigned by three physicians independently. Maternal deaths were defined according to the ninth and tenth revisions of the International Classification of Diseases.

RESULTS The maternal mortality ratio was similar in Mlomp [436 per 100 000 live births (95% confidence interval 209–802)] and Niakhar [516 per 100 000 (413–636)] but significantly higher in the more remote area of Bandafassi [852 (587–1196)] [relative risk compared with Niakhar 1.6 (1.0–2.4)]. Two-thirds of the maternal deaths were from direct obstetric causes, haemorrhage being the most common. Abortion was rare.

CONCLUSIONS Demographic surveillance systems are useful tools for the measurement of maternal mortality provided special studies are carried out to arrive at the levels and causes of maternal death. The estimates of maternal mortality reported here are lower than those published by the WHO and UNICEF but remain extremely high, particularly in the very remote areas with very limited health infrastructure, where as many as one in 19 women may be expected to die as a consequence of childbirth.

keywords maternal mortality, verbal autopsy, obstetric care, Senegal

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Introduction

Before major international initiatives such as the Safe Motherhood Initiative launched in 1987, maternal mortality data were essentially hospital-based (Graham 1991; Walsh *et al.* 1993). More recently, well-designed surveys to measure the level of maternal mortality at the community level have been undertaken, but few such surveys have been carried out in sub-Saharan Africa. Although it is generally claimed that the level of maternal mortality remained stable over the past decades, there are few data to support this claim (Liljestrand 1999; Weil & Fernandez 1999). Yet a good knowledge of the levels of, and, even more, the circumstances surrounding each maternal death, is often deemed essential to design interventions and to properly allocate resources (De Brouwere *et al.* 1998).

Maternal mortality is difficult to measure. The reasons for this are multiple, but mainly relate to measurement issues, including the under-reporting and misclassification of pregnancy as a cause of death and the relatively small numbers of maternal deaths involved (in statistical terms). Many pregnancy-related deaths still go unnoticed or unreported, and substantial errors in the estimates of maternal mortality persist, even in industrialized countries (Bouvier-Colle *et al.* 1991; Schuitemaker *et al.* 1997). Correctly measuring maternal mortality not only requires complete registration of deaths in women of reproductive age, which in many countries may be lacking, but also the recognition that the woman was

pregnant or recently delivered at the time of her death. Deaths during early pregnancy such as those because of abortion or ectopic pregnancy are often not recognized or reported as pregnancy-related, and death certificates often omit the notion of pregnancy. In settings where vital registration is weak, special studies are needed to correctly measure the levels and causes of maternal death.

In 1989, a national assessment by the Ministry of Health of Senegal yielded a maternal mortality ratio (MMRo) of 850 per 100 000 live births (report unpublished). The 1992–93 Demographic and Health Survey provided direct and indirect estimates of the MMRo, both based on sisters' survival, of 510 and 484 per 100 000 live births for 1972–92 and 1980, respectively (Sullivan *et al.* 1994). In 1996, WHO and UNICEF published revised estimates for the year 1990 which tended to be systematically higher than those previously reported (WHO & UNICEF 1996). For West Africa and Senegal, the MMRo were 1020 and 1200 per 100 000 live births, respectively, among the highest in the world.

In the rural West African context, where most deaths do not occur in hospitals with reliable medical records on hospitalized patients, retrospective confidential enquiries are not feasible and verbal autopsy is a useful retrospective method to find out about the medical causes of death (Chandramohan *et al.* 1994; Mungra *et al.* 1999). This method is based on an interview with people who are knowledgeable about the events leading to death, based on which physicians assign a cause of death. Verbal autopsies provide broad categories of the causes of maternal death as well as contributing factors (Campbell & Ronsmans 1995). A multicentre validation study of verbal autopsies for maternal deaths of direct cause in Tanzania, Ethiopia and Ghana showed good sensitivity (82%) and specificity (98%) when diagnoses were made by physicians (Chandramohan *et al.* 1998a,b).

In this paper, we report the findings of a direct, community-based, assessment of maternal mortality and medical causes of deaths using verbal autopsy in three unique cohorts in rural Senegal.

Population and methods

Study sites

The three sites are located in different regions of Senegal. Table 1 summarizes the main demographic and reproductive health features.

Niakhar is located in the Department of Fatick, Region of Fatick (Sine-Saloum), 135 km south-east of Dakar. The Niakhar study zone comprises 30 villages with approximately 30 000 inhabitants who are mostly Sereer. Life expectancy at birth increased from 46 years in 1984–88 to 54 in 1989–93 and 1994–96. The total fertility rate (TFR) decreased from 7.9 to 7.7 and 7.1 over the same periods (Delaunay 1998). In the study area, there are three health posts associated with a maternity facility, each one staffed by a nurse. There is no qualified midwife within the study zone and deliveries in the health facility are assisted by traditional birth attendants. Obstetric emergencies are referred to the regional hospital of Diourbel or Kaolack via the health centre of Fatick (total 70 km), the nearest facilities providing comprehensive emergency obstetric care (EOC).

Bandafassi is located in the Department of Kedougou, Region of Tambacounda, 750 km south-east of Dakar. The study area comprises 42 villages with approximately 10 000 inhabitants, mostly Pulaar, Bedik and Malinke. Life expectancy at birth and fertility were lower than in Niakhar for the period 1986–97: 47 and 6.3, respectively (Pison *et al.* 1997). The health post of Bandafassi is staffed by a nurse but there is no qualified midwife. Most of the deliveries occur at home without assistance. When obstetric emergencies are referred, parturient women are transported, if roads are passable, to the health centre of Kedougou and to the regional hospital in Tambacounda, the nearest facility providing EOC, 250 km from the study area.

Mlomp is located in the Department of Oussouye, Region of Ziguinchor (Casamance), 500 km south of Dakar. The study area comprises 11 villages with approximately 8000 inhabitants, mostly Diola. Life expectancy at birth is higher than in the other areas

Table 1 Main demographic and reproductive health features of study sites in Senegal

Site	Region	Study period	Total population (01/01/99)	Population density (hab./km^2)	Number of villages	Life expectancy at birth (years)	Total fertility rate	Distance to nearest EOC* facility (km)
Niakhar	Fatick	84–97	30 042	131	30	51	7.7	70
Bandafassi	Tambacounda	88–97	9721	15	42	47	6.3	250
Mlomp	Ziguinchor	85–98	7888	63	11	61	5.0	50

*Comprehensive emergency obstetric care: availability of caesarean section and blood transfusion in addition to basic obstetric functions.

(61 years). Fertility (TFR), which is lower than in the other areas, has decreased from 5.3 children per woman during the period 1985–89 to 4.3 in 1990–94 and 3.6 in 1995–99 (Pison *et al.* 2001). The Catholic health post of the village, associated with a maternity facility, was staffed by a nurse, also a qualified midwife, from 1984 to 1991. Since 1991, it has been staffed by one nurse (Enel *et al.* 1993). Most women deliver in the maternity facility with the assistance of two traditional births attendants. Less frequently, they deliver at the health centre of Oussouye or the regional hospital of Ziguinchor, the nearest EOC facility where obstetric emergencies are referred (50 km, paved road).

Demographic surveillance system (DSS) and assignment of general causes of death

In Niakhar, censuses were organized on a yearly basis between 1983 and 1986 (Garenne & Koumans 1997). From 1987 to 1997, weekly follow-up visits and biannual censuses were carried out; and since March 1997, demographic follow-up has been conducted every quarter. Residents were interviewed for incident events as the preceding visit only, thus limiting the recall period and minimizing omissions. Households were visited by non-medical interviewers from the study zone who spoke the local language. In addition to births, migrations and deaths, pregnancies were recorded as soon as reported by the mother and followed until termination. A verbal autopsy was completed for each recorded death within 3 months using a standardized questionnaire which evolved slightly over time (Garenne & Fontaine 1986). Each verbal autopsy questionnaire was reviewed sequentially by two physicians. If the physicians disagreed, a panel of physicians involved in the research programmes in Niakhar discussed the case and reached an agreement on the diagnosis.

In Bandafassi, after the initial census which was organized at different dates according to ethnicity (in 1970 for Mandinka villages, in 1975 for Fula villages and in 1980 for Bedik villages), a multiround surveillance survey was performed annually. Once a year, key informants in all villages or hamlets were visited to record events since the last visit (Pison *et al.* 1997). Information on causes of death was collected using the same verbal autopsy questionnaire as in Niakhar for child deaths (<15 years) and more simple questions for adult deaths. The likely cause of death was attributed by one physician.

In Mlomp, the first census was carried out in 1984–85 (Pison *et al.* 1993). Demographic events are recorded by annual household visits made by female interviewers from the village. Verbal autopsy, completed with information from the deaths register maintained by the health post, is carried out for all deaths using the same questionnaire as in Niakhar. The likely cause of death is attributed by one physician.

Identification of maternal deaths and their causes

A list of all deaths of women aged 15–49 years over the past study periods (Niakhar: 1984–97; Bandafassi: 1988–97; Mlomp: 1985–98) was compiled from the database maintained for each site. The relatives of all deceased women were interviewed by the Principal Investigator (B.K.) with the aim of reconstructing the sequence of the events which led to death, and in particular to ascertain whether the woman was pregnant prior to or at the time of death. These interviews took place in 1996–97 in Niakhar, in 1998 in Bandafassi and in 1999 in Mlomp. The same standardized questionnaire with closed and open questions was used for all three sites. When a deceased woman had attended or had died at a health facility, pertinent information was retrieved from the registers. The study protocol was approved by the Ministry of Health in 1996, before field investigations.

Information from the two data sources on the circumstances preceding the death (the general verbal autopsy from the DSS conducted shortly after the death – except Bandafassi – and the special interviews of female deaths conducted later) was summarized in a report that was then read by two obstetricians independently (L.D.B., M.B.). The obstetricians were asked to classify deaths as maternal or not, to subsequently categorize maternal deaths as direct (i.e. from complications directly attributable to the pregnancy) or indirect (i.e. from previous existing disease, or disease that developed during pregnancy and which was not because of direct obstetric causes but which was aggravated by physiological effects of pregnancy) obstetric deaths and to assign the underlying cause of the direct obstetric deaths. Discordant cases were reviewed by a third physician (C.R.). A death was classified as maternal if at least two reviewers agreed. Both the definition of maternal death from the ninth revision of the International Classification of Diseases (ICD) (death of a woman while pregnant or within 42 days of termination of pregnancy, from any cause except accidents and incidental causes) and the definition of late maternal deaths as suggested in the tenth ICD (up to 1 year after delivery) were used (WHO 1977, 1993). Causes of maternal death were classified using the list of causes suggested by the World Health Organization (Campbell & Ronsmans 1995).

Statistical analysis

Demographic databases provided the number of live births and the TFR for the study periods. MMRo are expressed per 100 000 live births and confidence intervals computed assuming a Poisson distribution. In order to be compared, the ratios were interpreted as incidence rates using the exact method implemented in Stata v.6 (Greenland & Rothman 1998). The lifetime risk of dying from a maternal cause ($R_{15–49\ years}$) was computed as: $R_{15–49\ years} = 1 - (1 - \text{MMRo})^{\text{TFR}}$ (Graham 1991). It assumes a constant MMRo over the 35 years of reproductive life. Maternal mortality rates per 10 000 person-years (MMRe) were calculated based on the number of women-years lived (extracted from the database) in Niakhar, and using the estimate of the lifetime risk for Bandafassi and Mlomp (adapted from Kleinbaum *et al.* 1982):

$$\text{Risk}_{(t0,t)} = 1 - \exp\{-\text{rate} \cdot \Delta t\}$$

where

$$\text{Risk}_{(t0,t)} = R_{15-49\text{years}}, \text{rate} = \text{MMRe and } \Delta t = 35 \text{ years}$$

$$\text{MMRe} = -\ln(1 - R_{15-49\text{years}})/35$$

Results

Maternal mortality

A total of 317, 110 and 44 deaths of women in reproductive age were identified from the databases in Niakhar, Bandafassi and Mlomp, respectively (Table 2). After review by the panel of experts, 87, 33 and 10 deaths, respectively, were classified as maternal (ICD-9), accounting for between 22.7 and 27.4% of the total female deaths, depending upon site.

The MMRo was similar in Niakhar and Mlomp [516 and 436 per 100 000 live births, respectively, RR = 1.2 (0.6–2.5)] but much higher in Bandafassi (852 per 100 000). The difference between Bandafassi and Niakhar was significant [RR = 1.6 (1.0–2.4)] but only reached statistical significance between Bandafassi and Mlomp because of smaller samples size [RR = 1.9 (0.9–4.4)]. The lifetime risk of dying from a maternal cause was extremely high for all sites. In Bandafassi, the accumulation of both high levels of maternal mortality and fertility result in a lifetime risk of dying of one in 19. Even in Mlomp, where the combined effects of lower levels of fertility and substantially lower levels of maternal mortality reduce the lifetime risk of maternal death, one in 46 women is still expected to die as a consequence of childbirth.

In Niakhar, 18.4% of the deaths occurred before the beginning of the labour while this proportion reached 43.7% in Bandafassi. Including late maternal deaths (ICD-10 definition) yielded slightly higher estimates of maternal mortality for Bandafassi and Niakhar where 10 and three additional deaths between 43 days and 1 years after delivery were deemed to be related to the pregnancy. In Mlomp no late maternal death was identified.

After grouping years by 5-year periods, no difference in MMRo between periods and no trend could be observed in either site (data not shown).

In Niakhar, two-thirds of maternal deaths (55/87) occurred between the ages of 20 and 39 years when the MMRo was lowest (406 per 100 000 live births). Women who were over 40 when they gave birth had a risk of dying from maternal causes of nearly 2% (1709 per 100 000 live births), four times higher than their younger peers [RR = 4.2 (2.4–7.1)].

Comparison between DSS and special investigation of maternal mortality in Niakhar

Over the restricted period 1984–95 during which the DSS only ascertained maternal deaths, 84 maternal deaths were diagnosed by the special maternal mortality study. Among these deaths, 64 were previously identified by the DSS, giving a sensitivity of 76.2% for the DDS diagnosis. The

Table 2 Maternal mortality indicators by study site and ICD definition, Senegal, 1984–98

Site	No. of deaths*	Live births	Maternal deaths (%)		MMRo† (95% CI)		$R_{15–49}$‡		MMRe§	
			ICD-9	ICD-10	ICD-9	ICD-10	ICD-9	ICD-10	ICD-9	ICD-10
Niakhar	317	16 866	87 (27.4)	97 (30.6)	516 [413–636]	575 [466–702]	1/25	1/23	12.0	13.3
Bandafassi	110	3873	33 (30.0)	36 (32.7)	852 [587–1196]	930 [651–1287]	1/19	1/17	14.9	17.3
Mlomp	44	2292	10 (22.7)	10 (22.7)	436 [209–802]	436 [209–802]	1/46	1/46	6.3	6.3

* Deaths of women 15–49 years.
† Maternal mortality ratio (per 100 000 live births).
‡ Lifetime risk of dying from maternal cause.
§ Maternal mortality rate (per 10 000 person-years).

specificity was 98.9% (189/191), two deaths being falsely diagnosed as maternal death of undetermined origin by the DSS. One was a 40-year-old woman who died 2 years after her last delivery. The second was a 31-year-old with an history of a very short febrile illness 5 months after a stillbirth.

Causes of deaths

Nearly two-thirds of the maternal deaths were classified as direct obstetric deaths in each site. The reviewers were unable to determine the obstetric origin of the deaths in a substantial proportion, between 21.8% and 30.3% (Table 3). Among direct obstetric deaths, haemorrhage was by far the most common cause in all sites and early pregnancy death (abortion) the least common cause in Niakhar and Bandafassi. The exclusion of the few late maternal deaths did not change this rank.

Discussion

The results of this population-based cohort study suggest that maternal mortality in rural Senegal ranges from 436 to 826 deaths per 100 000 live births, with haemorrhage being the leading cause of death. Considering the persistently high levels of fertility, the number of women that can be expected to die in their lifetime as a consequence of childbirth may be as high as 1 in 19, particularly in the most remote areas.

Validity

We may have underestimated the levels of maternal mortality either because death reporting was incomplete or because pregnancy was underreported as a cause of death. The three sites studied here benefit from extensive prospective demographic surveillance systems using local villagers to report on deaths and it is unlikely that adult deaths have been missed. Families, however, may not have acknowledged a current or recent pregnancy because they were unaware of it, or because they preferred not to report it, and we may have underestimated pregnancy-related mortality. The extent of this underestimation is likely to be small in Niakhar and Mlomp, as Niakhar has prospective surveillance of pregnancies and all pregnant women from Mlomp receive regular antenatal follow-up in the local maternity unit (Enel *et al.* 1993). In Bandafassi, on the other hand, no such pregnancy surveillance exists and some pregnancy-related deaths may have been misclassified as nonmaternal. Circumstances of the interview could also interfere. For example, in Mlomp, the questions related to pregnancy, delivery and postpartum must be put to Diolas by female interviewers. By contrast, in Niakhar, all interviewers were male and well-accepted.

Level of maternal mortality

Our estimates of maternal mortality are much lower than those reported by WHO and UNICEF (WHO & UNICEF 1996). The latter estimates for Senegal (1200 per 100 000 live births) are between 1.4 and 3 times higher than those observed here. Although we may have missed some deaths, particularly those because of abortion, the conformity of our findings with those from other rural areas in West Africa, particularly the low levels of early pregnancy deaths (Cantrelle *et al.* 1992; Hoj *et al.* 1999; Walraven *et al.* 2000), and the special efforts made to ascertain pregnancy-related mortality in this study make the huge underestimation of maternal mortality suggested by the WHO–UNICEF models unlikely. In addition, national estimates include urban populations, some of which may have lower maternal mortality (De Bernis *et al.* 2000). Hence, the levels shown here for rural populations probably represent an upper bound estimate for Senegal as a whole.

The routine demographic surveillance system missed a quarter of all maternal deaths, a finding similar to that observed in Bangladesh (Ronsmans *et al.* 1998). The deaths that were falsely reported as nonpregnancy related were because of indirect or unknown causes, suggesting that deaths tend to be interpreted as maternal only when

Table 3 Obstetric origin and underlying causes of maternal deaths (ICD-9 definition) by study sites, Senegal, 1984–98

	Obstetric origin (%)			Causes of direct obstetric deaths					
Site	Direct	Indirect	Undetermined	Haemorrhage	Eclampsia	Dystocia	Sepsis	Early pregnancy death	ND*
Niakhar	59 (67.8)	9 (10.3)	19 (21.8)	24	11	9	6	4	5
Bandafassi	20 (60.6)	3 (9.1)	10 (30.3)	5	3	2	4	0	6
Mlomp	6 (60)	1 (10)	3 (30.0)	1	1	1	1	2	0

*Not determined.

they are directly attributable to the pregnancy. To avoid this problem, verbal autopsy questionnaires for adult female deaths should include an explicit question on pregnancy, regardless of the circumstances leading to death (Ronsmans *et al.* 2002).

Not surprisingly, the levels of maternal mortality were substantially higher in Bandafassi than in the two other rural areas. In this remote area with very poor medical infrastructure, women have to travel about 250 km – part of which are impracticable in the rainy season – to reach a facility where a major intervention can save their lives (Pison *et al.* 2000). The inequitable distribution of health facilities in Senegal is well known (Bouillin *et al.* 1994; Pison *et al.* 1995) and the first and foremost priority is clearly to make life-saving EOC more accessible to all women.

The very high levels of maternal mortality, even in the so-called low risk age groups, also confirm the limited role of family planning on the reduction of the MMRo (Fortney 1987).

Causes of deaths

Verbal autopsies are useful but imperfect tools to ascertain causes of maternal deaths. Although their validity has been reported to be high, at least for direct obstetric deaths in hospitalized women, cause-specific mortality data drawn from verbal autopsies should be interpreted with caution (Chandramohan *et al.* 1998a,b). In Niakhar, comparison of the written accounts of the circumstances leading to death obtained immediately after death with those obtained many years later suggests that the memory of events remains intact (data not shown). However, up to 21.8% of causes in Niakhar and 30.3% in Bandafassi could not be determined, not even at the crude level of distinguishing direct from indirect obstetric causes. The same proportion was observed in Guinea-Bissau (Hoj *et al.* 1999). The latter is important, as it has been suggested that measures of direct obstetric mortality may better inform safe motherhood strategies than indicators including all maternal deaths (Fauveau *et al.* 1991). Verbal autopsies, however, may lack the accuracy to do so, at least in predominantly illiterate populations such as those studied here.

Conclusion

Sustained reductions in maternal mortality will only be possible if modern high-quality obstetric care is made available to all women through a system of professional midwifery and referral hospital care in a context of political commitment and accountability of health providers.

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