

Maternal Mortality in the informal settlements of Nairobi city: What do we know?

Abdhalah Kasiira Ziraba ^{1§}, Nyovani Madise ², Samuel Mills ³, Catherine Kyobutungi ¹ and Alex Ezeh ¹

¹ African Population and Health Research Center, P.O. Box 10787, 00100, Nairobi Kenya

² University of Southampton, School of Social Sciences, University of Southampton, Southampton SO17 1BJ, United Kingdom

³ World Bank, The World Bank, MSN G7-701, 1818 H Street NW, Washington, DC 20433

§ Corresponding author

Email addresses:

AKZ: akziraba@yahoo.com

NM: N.J.Madise@soton.ac.uk

SM: smills@jhsph.edu

CK: ckyobutungi@aphrc.org

AE: aezeh@aphrc.org

Key words: Maternal mortality, slums, Kenya, urbanization, poverty, verbal autopsy, demographic surveillance system, HIV/AIDS, direct maternal deaths, indirect maternal deaths, skilled birth attendants, late maternal deaths, cause of death, health facility survey, emergency obstetric care, demographic surveillance system, abortion, delivery, obstetric complications

Abstract

Background

Current estimates for maternal mortality ratios in Kenya are as high as 560/100,000 live births. Given the pervasive poverty and lack of quality health services in slums, the maternal mortality situation in the slums can only be worse. With a functioning health care system, most maternal deaths are avoidable if complications are identified early. A major challenge in addressing the maternal mortality burden in developing countries is the lack of reliable data for planning. In this paper, we estimated the burden and identified causes of maternal mortality in two slums of Nairobi city.

Methods

We used data from verbal autopsies interviews conducted on all female deaths aged 12-49 years between January 2003 and December 2005 in the Nairobi Urban Health and Demographic Surveillance System (NUHDSS) and live births within the same period to estimate the maternal mortality ratio. In describing the distribution of maternal deaths by cause, we also categorized maternal deaths into early and late deaths. We also employed data from a survey of health facilities that serve majority of residents under surveillance. The survey was conducted in 2006 among other things to assess maternal death experiences in 2004-2005 as captured by the health information systems.

Results

The maternal mortality ratio for the two Nairobi slums, in the period from January 2003 to December 2005, was 703 maternal deaths per 100,000 live births. The major causes of maternal death were: abortion complications, hemorrhage, sepsis, eclampsia, and ruptured uterus. Only in 30% of the 29 maternal deaths did the delivery occur with assistance of a health professional. The verbal autopsy data seems to capture more abortion related deaths compared to health facility data. Additionally, there were 22 late maternal deaths (maternal deaths between 42 days and one year of pregnancy termination) most of which were due to complications of HIV/AIDS.

Conclusions

Maternal mortality ratio is high in the slum population. The leading causes of maternal death are; abortion complications, eclampsia, hemorrhage, sepsis and ruptured uterus. There is urgent need to address the burden of unwanted pregnancies and unsafe abortions among the urban poor. There is need to strengthen access to HIV services alongside maternal health services since HIV/AIDS is becoming a major indirect cause of maternal death.

Background

Maternal mortality, of all health indicators, exhibits the greatest disparity between the developed and developing world. Of the 536,000 deaths due to pregnancy or childbirth complications that occur each year worldwide, 96% are in Africa and Asia alone[1] . In sub-Saharan Africa where the burden is highest, the lifetime risk of dying from maternal causes is about 1 in 22 which contrasts sharply with a risk of 1 in 7,300 for women from the developed regions[1] . Over 70% of maternal deaths in the developing countries are due to direct maternal causes such as hemorrhage, sepsis, hypertensive disorders, unsafe abortion, and obstructed labor. Additionally, indirect causes such as HIV/AIDS, malaria, and anemia account for about 20% of maternal deaths [2]. Given that most obstetric emergencies are often unpredictable, and that life-threatening complications occur in roughly 15% of all pregnancies, potentially every pregnant woman is at risk of developing a complication. Initiatives aimed at improving maternal health such as the Safe Motherhood Initiative (Nairobi, 1987); and the UN International Conference on Population and Development [ICPD] (Cairo, 1994) have previously been launched, but there has been little progress in improving maternal health, particularly in Sub-Saharan Africa [3]. The fifth Millennium Development Goal of reducing maternal mortality ratio by 75% between 1990 and 2015, part of the UN development millennium declaration will not be realized in many African countries if steps are not taken to reduce the prevailing high maternal mortality [1, 4].

Maternal health indicators in Kenya have not improved significantly over the years. The 1998 and 2003 Kenya Demographic and Health Surveys (KDHS) indicated a national maternal mortality ratio of 590 and 414 maternal deaths per 100,000 live births respectively while the 2005 WHO/UNICEF/UNFPA/World Bank estimated it at 560 maternal death per 100,000 live births [1, 5, 6]. All these reports did not provide sub-national estimates which would have allowed monitoring of maternal mortality at provincial or district levels. Further, the proportion of births with skilled personnel in Kenya was reported to be only 42% in the 2003 KDHS. There were however wide disparities with 79% of deliveries with skilled personnel in Nairobi province as opposed to only 9% in the poorer North Eastern province [5]. Similarly, early childbearing remains a significant health and social problem in Kenya, leading to many clandestine abortions [7, 8]. Nearly a quarter of Kenyan women have started childbearing by the age of 20 and this proportion is double for women living in informal urban settlements [5, 9].

Like many other health indicators, the burden of maternal mortality is heaviest among the poor [10-12]. In the context of urban informal settlements (slums), our understanding of maternal mortality remains very limited although other indicators, such as low use of health services and increasing child mortality, suggest that the urban poor are a highly vulnerable and marginalized group [9, 13]. Rapid urbanization, fueled by high levels of rural-to-urban migration, has led to the growth of urban informal settlements in many African countries including Kenya. The slums are characterized by poor housing, lack of basic amenities such as water and sanitation, and low availability and utilization of formal health services including maternity care [14, 15].

A major challenge in trying to understand and address maternal mortality burden in the developing world is the lack of reliable data since registration of deaths is often non-existent or largely incomplete [10, 16]. The situation is even worse for marginalized populations such as slum residents who do not receive much attention in terms of research and/or service delivery. Verbal autopsy data from population-based demographic surveillance systems (DSS) may

therefore provide reasonably reliable and more detailed information in settings such as the Nairobi slums where such surveillance exists [17-19].

In this paper, we estimated the maternal mortality burden and identified the major causes of maternal deaths in two slums of Nairobi, Korogocho and Viwandani.

Methods

Study setting

The study was conducted in two slums in which the Nairobi Urban Health and Demographic Surveillance System (NUHDSS) has been running since 2002. The surveillance system monitors vital events such as births, movements and deaths on over 58,000 individuals in the two slums longitudinally. The two slums are located about 5-10 km from the city centre and occupy an area less than one square kilometer in size. The main means of transport is by commuter mini-buses which drop and pick passengers at the periphery of the slums but do not go inside the slum settlement as there are no paved roads. The informal nature of slums underscores their non-permanence, and implicitly justifies the lack of public infrastructure and social services. There are very few public health facilities serving the two slum communities, and these are located on the outskirts of the slums and are therefore inaccessible at night due to insecurity. The residents are from over 15 ethnic backgrounds with the majority being Kikuyu (28%), Luhya (24%), Kamba (21%) and Luo (15%). In Viwandani, the population is mainly comprised of labour migrants working in the neighboring industrial area, while the Korogocho population consists mainly of long-term settlers working in the informal sector.

We used data from verbal autopsies conducted on all female deaths aged 12-49 years between January 1, 2003 and December 31, 2005 in the NUHDSS. We also employed data from a health facility survey conducted in 2006 to assess maternal health experiences as captured by the health information system in health facilities during 2004-2005.

Verbal Autopsies

As part of the NUHDSS, verbal autopsy interviews are conducted using a questionnaire adapted from the validated verbal autopsy tool developed by World Health Organization [20]. All deaths in the two slum communities are captured through a death registration form by a field worker. A detailed verbal autopsy interview is then conducted by a trained field supervisor trained to conduct verbal autopsy interviews. All verbal autopsy interviewers must have a minimum of 12 years of formal education and are not residents of the slums but are familiar with slum setting. They are trained on the verbal autopsy procedures for at least one week and retrained at the beginning of each data collection round. Interviews are conducted after making an appointment with the bereaved household normally after the funeral but within approximately 6 weeks of registering the death. Respondents are typically members of the household who cared for the deceased prior to death or have good knowledge of the symptoms or events that led to death and must consent to have the interview. Three physicians independently review the verbal autopsy questionnaire and assign cause of death using the tenth revision of the International Classification of Diseases version (ICD-10) [21]. If two or more concur, the result is then accepted as the probable cause of death. Where agreement is not reached, the three physicians meet and discuss the case in order to reach a consensus. If consensus is not reached, the cause of death is coded as unknown. In this study, women who died between January 1, 2003 and

December 31, 2005 were identified from the DSS database. Three physicians (a medical epidemiologist and two obstetricians) independently reviewed the verbal autopsy records in order to ascertain the cause of death. The purpose of having the verbal autopsies reviewed again by a team involving two obstetricians was to ensure that any maternal deaths that could have been missed by the routine DSS coding were captured. The ICD-10 definition of maternal death, “*the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management but not from accidental or accidental causes*”, was employed. With the recognition that the 42 days cut off is arbitrary we also considered the late maternal death defined as “death of a woman from direct or indirect obstetric causes more than 42 days but less than one year after termination of pregnancy” [21]. We categorized maternal deaths into direct and indirect causes. Direct obstetric deaths are defined as maternal deaths resulting from obstetric complications or their interventions of the pregnant state (pregnancy, labor, and the puerperium) while indirect obstetric deaths are those resulting from previous existing disease or disease that developed during pregnancy and which was not due to obstetric causes, but was aggravated by physiologic effects of pregnancy [21].

Health Facility Survey

A health facility survey was conducted in 2006 and targeted facilities that are commonly used by pregnant women living in the two slum communities for obstetric care. A total of 25 health facilities where women delivered between 2003 and 2005 were identified. Selection of health facilities was based on information provided by women who had had a pregnancy outcome between 2003 and 2005 and had been interviewed in the household survey which was part of the larger maternal health project. Some of the health facilities assessed were located in the two slums while the rest were in other parts of Nairobi.

We sought ethical approval from the Kenya Medical Research Institute (KEMRI) Ethical Review Committee, which is one of the Institutional Review Boards authorized to give ethical approval for research in Kenya. We also obtained permission from the Ministry of Health and from the Medical Officer of Health in-charge of the Nairobi City before visiting the health facilities. Appointments were made with the respective health facilities to explain to the health facility personnel the details of the survey after which consent was sought to carry out the interview. Structured interviews were carried out by one clinical officer who underwent three-day training for this exercise. Data on causes of deaths for 2004 and 2005 were extracted from the medical records and examined. Descriptive statistics were used to describe the maternal mortality situation and causes of maternal death in the two slums.

Results

During the period 2003-2005, a total of 342 women aged 12-49 years died in the two slums and verbal autopsies were completed on 293 (86%). Out of the 293 female deaths aged 12-49 years, 29 (9.9%) were classified as maternal deaths. Additionally, 22 deaths occurred between six weeks and one year following the pregnancy termination, the ICD-10 definition of late maternal deaths. Table 1 shows the characteristics of maternal deaths and late maternal death. Nearly three-fifths of the maternal deaths occurred in women aged 20-29 years. About 18% of late maternal deaths occurred to women less than 20 years old. Over 90% of maternal deaths had at least primary level education. Of the diverse ethnic groups in the informal settlements, Luos accounted for 35% of the maternal deaths followed by the Kikuyus with 28%.

[Table 1 about here]

Table 2 presents the estimates for maternal mortality ratio using the verbal autopsy data. In computing maternal mortality ratio, cases with no data on cause of death were assumed to have a proportionate maternal mortality experience as those for which we had information on cause of death. Based on the 29 maternal deaths and adjusting for non-response, the expected number of maternal deaths was derived as shown in Table 2. Using the total live births of 4,806 recorded in the DSS during 2003-2005, the adjusted maternal mortality ratio for this population was estimated to be about 703 per 100,000 live births.

[Table 2 about here]

[Table 3 about here]

Table 3 provides use of healthcare variables and pregnancy outcome. Only 14% of maternal deaths and 9% of late maternal deaths delivered or had their pregnancy terminated in a health facility. About 21% of maternal deaths and 32% of late maternal death reported receiving skilled assistance in the process. Over 86% of maternal deaths and 96% late maternal deaths sought care at least once from a professional care worker prior to death. About 62% of maternal deaths occurred in a health facility compared to only 31% of late maternal deaths. The pregnancy outcome of more than two third of the pregnancies of maternal deaths was either a miscarriage or induced abortion which sharply contrasts with 14% among the late maternal deaths.

[Table 4 about here]

Table 4 shows a breakdown of the main causes of maternal deaths from the verbal autopsy data and from the medical records of health facilities. Direct maternal deaths accounted for 65.5% of all maternal deaths while 43.5% maternal deaths were due to indirect causes. The leading causes of direct maternal deaths were generally the same for the two data sources (abortion complications, antepartum and postpartum hemorrhage, postpartum sepsis, eclampsia, and ruptured uterus). The major difference was the order of magnitude of the burden that each cause contributed. From the verbal autopsy data, abortion complication was the leading cause of maternal death (31%), while eclampsia (23.7%) was the leading cause according to the medical records from the health facilities surveyed. For indirect causes, we also observe some differences. HIV/AIDS/tuberculosis and anemia are the major indirect causes of maternal deaths as per the verbal autopsy data. Overall HIV/AIDS and tuberculosis accounted for about 59% of all late maternal deaths. Conversely, anemia and malaria were the major indirect causes as per the medical records data.

Discussion

We estimated maternal mortality burden in two Nairobi slums and showed maternal mortality ratio (703/100,000) to be higher the national estimates (560/100,000). Using the two data sources we also identified the leading causes of maternal death as; abortion complications, eclampsia, postpartum sepsis, hemorrhage, and ruptured uterus. The order of magnitude each contributes

however differs for the two data sources. Abortion complications were the most important cause of maternal mortality in the population-based approach. It is not clear what could explain this observation. We speculate that it might be an issue of diagnosis ascertainment bias in the verbal autopsy data or incompleteness of health facility records. It is also important to note that the health facilities especially the bigger ones have a wider catchment area therefore it is possible that the distribution of causes of maternal death be slightly different from that of the slums. In spite of 47% of the health facility records being unavailable and thus excluded from this analysis, results from the health facilities records are consistent with other hospital based studies that have shown eclampsia and hemorrhage as the leading causes of maternal mortality. These differences notwithstanding, our results generally concur with what is generally known to be the major causes of maternal mortality in sub-Saharan Africa [22, 23].

Whereas current evidence suggests that maternal mortality in developing countries could be reduced if all pregnant women could have access to health professionals as well as quality emergency obstetric care services [24-26], many women still deliver without professional assistance. In this study most deliveries and abortions occurred outside of a health facility and without professional assistance. An earlier study from the same population reported that 70% of women interviewed delivered with professional assistance but on closer scrutiny of who actually attended to them at delivery, only 48% delivered with skilled birth attendants [27]. In this study only 21% of all maternal deaths delivered with help of a skilled attendant. This is an indication that indeed most maternal deaths are happening following mismanaged labor or abortion by non-skilled attendants. We also observed that all the abortion-related deaths in the verbal autopsy analysis were reported to have occurred outside of health facilities implying that they were unable to access health facilities after the abortion or deliberately avoided going to health facilities especially if the abortions were clandestine. It is likely that hospital-based studies using medical records miss out on abortions especially clandestine ones in countries such as Kenya where abortion is illegal [28]. Alternatively, given the legal restrictions on induced abortion, health facilities could be deliberately not recording abortion as a cause of death especially if the abortion was induced for unjustifiable reasons. There were also some differences in the order of magnitude of the indirect causes of maternal mortality. From the verbal autopsy data, HIV/AIDS and anemia were the major causes compared to anemia and malaria as per health facility records. The low number of deaths attributed to HIV/AIDS in the health facilities was surprising given the high AIDS-related mortality in this population [29]. HIV/AIDS is increasingly contributing to the burden of pregnancy related deaths [30, 31]. It is not clear whether the differences were due to measurement errors whereby the verbal autopsy tool over diagnosed HIV/AIDS and the health facility over diagnosed malaria. Most cases labeled as malaria in health facilities are not confirmed by laboratory investigations and thus diagnoses are mainly based on history and clinical examination. Given that Nairobi is low malaria transmission in area, it is likely that those labeled as malaria might have died from other febrile causes. On the other hand, verbal autopsy coders could also have over diagnosed HIV/AIDS especially for cases where vague signs and symptoms were reported. Further HIV/AIDS could have also have been over diagnosed by the verbal autopsy codes with the coder's bias being driven by their knowledge that HIV/AIDS is prevalent and a major cause of adult deaths in this population.

Whereas most deliveries and abortions took place outside of a health facility, most deaths occurred at a health facility. This might be an indication of delays in recognizing a complication,

making a decision to go to a health facility, and reaching a health facility or receiving care while at a health facility. The lack of emergency ambulance services in the slums where infrastructure is non-existent and insecurity deters movement at night further complicates referral. On the other hand it might indicate that the quality of emergency obstetric services is poor, an observation also reflected in the high proportion of deaths due to puerperal sepsis. An earlier health facility assessment study showed that more than half of obstetric emergencies arrive at referral facilities either on foot or by public means and that emergency obstetric care facilities are lacking on staffing, skills, and equipment [32].

The verbal autopsy approach which takes advantage of the existing surveillance system circumvents the challenges of selection bias which hospital-based studies face since many of maternal deaths in this community occur at home. In such settings, the verbal autopsy approach can be used to identify both health facility and community-based maternal deaths [33, 34] to improve our understanding of the problem. Verbal autopsy interviews however suffer from the risk of recall bias and possible misclassification of the cause of death due to wrong recording and misinterpretation of signs and symptoms.

Limitations

The small numbers of maternal deaths from the verbal autopsy data presents a challenge in trusting the estimates. The maternal mortality estimates should be interpreted with caution, even though this is a common limitation with maternal mortality estimates [5, 16]. Up to 14% of all female deaths did not have a verbal autopsy and about 47% of the health facility medical records were not available. This could have potentially introduced bias in the estimates. The national estimate in KDHD 2003 was not disaggregated by province or rural-urban residence making comparison with the estimate found in the Nairobi slums difficult. Due to lack of proper catchment population and hence denominator, the health facility survey data could not be used to estimate maternal mortality ratio. These data were however used to establish the leading causes of maternal deaths.

Conclusions

Maternal mortality ratio is high in the slum population. The leading causes of maternal death are; abortion complications, eclampsia, hemorrhage, sepsis and ruptured uterus. There is urgent need to address the burden of unwanted pregnancies and unsafe abortions among the urban poor and there is also need to promote programs that facilitate access to contraceptives to mitigate the occurrence of unwanted pregnancies and unsafe abortions. Most maternal deaths deliver outside of health facility and with help of unskilled personnel. Efforts should be made to ensure that all deliveries occur with help of skilled personnel. HIV/AIDS is becoming a major indirect cause of maternal death therefore there is need to strengthen access to HIV services alongside maternal health services. In an environment with scarcity of reliable data, different research approaches and sources of data comes in handy to help fill the data gaps which are a challenge to major public health problems. We have demonstrated this by showing that indeed verbal autopsies seem to capture abortions better than facility based records and can be a very good additional source of data for establishing the burden of maternal mortality attributable to abortion complications.

Competing interests

There are no competing interests reported by any of the authors.

Author's contributions

AKZ took lead in preparing the manuscript. He participated in data collection, data cleaning, and conducted most of the analysis. NM conceptualized the idea of this paper; she supervised data collection and analysis and wrote sections of this paper. SM contributed to data analysis, manuscript preparation, and interpretation of findings. CK contributed to manuscript preparation and interpretation of findings. AE contributed to the conceptualization of the study, manuscript preparation, and interpretation of findings.

Acknowledgements

We acknowledge the financial support to the maternal health project provided by World Bank Grant, (Contract 7136587) and the financial support to NUHDSS from The Wellcome Trust Grant GR078530MA. We acknowledge the contribution of our field and data management staff at APHRC and we are also grateful to the dedicated physicians who carried out the coding of the verbal autopsies. We are also indebted to the participants, health facility management, and the office of the medical officer of health for allowing us to conduct the study.

References

1. AbouZahr C, Wardlaw T: **Maternal Mortality in 2000: Estimates Developed by WHO, UNICEF AND UNFPA**. Geneva: World Health Organization; 2003.
2. Khan KS, Wojdyla D, Say L, Gulmezoglu AM, Van Look PF: **WHO analysis of causes of maternal death: a systematic review**. *Lancet* 2006, **367**:1066-1074.
3. AbouZahr C, Wardlaw T: **Maternal mortality at the end of a decade: signs of progress?** *Bull World Health Organ* 2001, **79**:561-568.
4. UN: **United Nations Millennium Declaration. Fifty-fifth Session of the United Nations General Assembly**. New York: United Nations Millennium Declaration; 2000.
5. Central Bureau of Statistics MoH, and ORC Macro **Kenya Demographic and Health Survey 2003**. Calverton, Maryland: Central Bureau of Statistics (CBS) [Kenya], Ministry of Health (MOH), [Kenya] and ORC Macro; 2004.
6. National Council for Population and Development CBS, and Macro International Inc: **Kenya Health and Demographic Survey 1998**. Calverton, Maryland: National Council for Population and Development (NCPD), Central Bureau of Statistics (CBC) (Office of the Vice President and Ministry of Planning and National Development) [Kenya], and Macro International Inc (MI); 1999.
7. Gebreselassie H, Gallo MF, Monyo A, Johnson BR: **The magnitude of abortion complications in Kenya**. *Bjog* 2005, **112**:1229-1235.
8. Osiemo R: **Unsafe abortion in Kenya**. *Trop Doct* 2005, **35**:159-160.
9. APHRC: **Population and Health Dynamics in Nairobi's Informal Settlements**. Nairobi (Kenya): African Population and Health Research Center; 2002.
10. AbouZahr C: **Global burden of maternal death and disability**. *Br Med Bull* 2003, **67**:1-11.
11. Ronsmans C, Graham WJ: **Maternal mortality: who, when, where, and why**. *Lancet* 2006, **368**:1189-1200.
12. Magadi M, Diamond I, Madise N: **Analysis of factors associated with maternal mortality in Kenyan hospitals**. *J Biosoc Sci* 2001, **33**:375-389.
13. Magadi MA, Zulu EM, Brockerhoff M: **The inequality of maternal health care in urban sub-Saharan Africa in the 1990s**. *Popul Stud (Camb)* 2003, **57**:347-366.
14. Undie Chi-Chi, Johannes John-Langba, Kimani E: **"The place of cool waters": Women and water in the slums of Nairobi, Kenya**. *Wagadu: A Journal of Transnational Women's and Gender Studies* 2006, **3**.

15. United Nations Human Settlements Programme: **The challenge of slums: Global Report on Human Settlement 2003**. UN-HABITAT; 2003.
16. Hill K, El Arifeen S, Koenig M, Al-Sabir A, Jamil K, Raggars H: **How should we measure maternal mortality in the developing world? A comparison of household deaths and sibling history approaches**. *Bull World Health Organ* 2006, **84**:173-180.
17. Chandramohan D, Maude GH, Rodrigues LC, Hayes RJ: **Verbal autopsies for adult deaths: their development and validation in a multicentre study**. *Trop Med Int Health* 1998, **3**:436-446.
18. Chandramohan D, Rodrigues LC, Maude GH, Hayes RJ: **The validity of verbal autopsies for assessing the causes of institutional maternal death**. *Stud Fam Plann* 1998, **29**:414-422.
19. Hoj L, Stensballe J, Aaby P: **Maternal mortality in Guinea-Bissau: the use of verbal autopsy in a multi-ethnic population**. *Int J Epidemiol* 1999, **28**:70-76.
20. **WHO Verbal autopsy standards: ascertaining and attributing cause of death** [<http://www.who.int/whosis/mort/verbalautopsystandards/en/index.html>]
21. *International Statistical Classification of Diseases and Related Health Problems. Tenth Revision. Instruction Manual* 2nd edn. Geneva: World Health Organisation; 2004.
22. Begum S, Aziz un N, Begum I: **Analysis of maternal mortality in a tertiary care hospital to determine causes and preventable factors**. *J Ayub Med Coll Abbottabad* 2003, **15**:49-52.
23. Thonneau PF, Matsudai T, Alihonou E, De Souza J, Faye O, Moreau JC, Djanhan Y, Wellfens-Ekra C, Goyaux N: **Distribution of causes of maternal mortality during delivery and post-partum: results of an African multicentre hospital-based study**. *Eur J Obstet Gynecol Reprod Biol* 2004, **114**:150-154.
24. Paxton A, Maine D, Freedman L, Fry D, Lobis S: **The evidence for emergency obstetric care**. *Int J Gynaecol Obstet* 2005, **88**:181-193.
25. Campbell OM, Graham WJ: **Strategies for reducing maternal mortality: getting on with what works**. *Lancet* 2006, **368**:1284-1299.
26. Kayongo M, Butera J, Mboninyibuka D, Nyiransabimana B, Ntezimana A, Mukangamuje V: **Improving availability of EmOC services in Rwanda--CARE's experiences and lessons learned at Kabgayi Referral Hospital**. *Int J Gynaecol Obstet* 2006, **92**:291-298.
27. Fotso JC, Ezeh A, Madise N, Ziraba A, Ogollah R: **What does Access to Maternal Care Mean Among the Urban Poor? Factors Associated with Use of Appropriate Maternal Health Services in the Slum Settlements of Nairobi, Kenya**. *Matern Child Health J* 2008.

28. Brookman-Amissah E, Moyo JB: **Abortion law reform in sub-Saharan Africa: no turning back.** *Reprod Health Matters* 2004, **12**:227-234.
29. Kyobutungi C, Ziraba AK, Ezeh A, Ye Y: **The burden of disease profile of residents of Nairobi's slums: Results from a Demographic Surveillance System.** *Popul Health Metr* 2008, **6**:1.
30. Khan M, Pillay T, Moodley JM, Connolly CA: **Maternal mortality associated with tuberculosis-HIV-1 co-infection in Durban, South Africa.** *Aids* 2001, **15**:1857-1863.
31. Le Coeur S, Khlat M, Halembokaka G, Augereau-Vacher C, Batala-M'Pondo G, Baty G, Ronsmans C: **HIV and the magnitude of pregnancy-related mortality in Pointe Noire, Congo.** *Aids* 2005, **19**:69-75.
32. Ziraba AK, Mills S, Madise NJ, Saliku T, Fotso JC: **The state of emergency obstetric care services in Nairobi informal settlements and environs: Results from a maternity health facility survey.** *BMC Health Serv Res* 2009, **9**:46.
33. Setel PW, Whiting DR, Hemed Y, Chandramohan D, Wolfson LJ, Alberti KG, Lopez AD: **Validity of verbal autopsy procedures for determining cause of death in Tanzania.** *Trop Med Int Health* 2006, **11**:681-696.
34. Setel PW, Sankoh O, Rao C, Velkoff VA, Mathers C, Gonghuan Y, Hemed Y, Jha P, Lopez AD: **Sample registration of vital events with verbal autopsy: a renewed commitment to measuring and monitoring vital statistics.** *Bull World Health Organ* 2005, **83**:611-617.

Tables:

Table 1: Percentage distribution of maternal and late maternal deaths of women aged 12-49 years by socio-demographic characteristics: Nairobi Urban Health and Demographic Surveillance System, Korogocho and Viwandani, 2003-2005

| Characteristic | Maternal deaths | Late maternal deaths | Total |
|----------------|-----------------|----------------------|-------|
| | N=29 | N=22 | N=51 |
| < 20 yrs | 6.9 | 18.2 | 11.8 |
| 20-29 yrs | 58.6 | 50.0 | 54.9 |
| 30-39 yrs | 34.5 | 22.7 | 29.4 |
| 40-49 yrs | 0.0 | 9.1 | 3.9 |
| Residence | | | |
| Korogocho | 69.0 | 40.9 | 56.9 |
| Viwandani | 31.0 | 59.1 | 43.1 |
| Ethnicity | | | |
| Kikuyu | 27.6 | 31.8 | 29.4 |
| Luo | 34.5 | 22.7 | 29.4 |
| Kamba | 17.2 | 22.7 | 19.6 |
| Luhya | 13.8 | 22.7 | 17.7 |
| Others | 6.9 | 0.0 | 3.9 |
| Education | | | |
| No education | 6.9 | 4.6 | 5.9 |
| Primary | 82.8 | 81.8 | 82.3 |
| Secondary | 10.3 | 13.6 | 11.8 |

Table 2: Estimation of maternal mortality ratio, women aged 12–49 years: Nairobi Urban Health and Demographic Surveillance System, Korogocho and Viwandani, 2003-2005

| Characteristic/Variable | Year | | | |
|---|------|------|------|-----------|
| | 2003 | 2004 | 2005 | 2003-2005 |
| Maternal deaths identified in verbal autopsies | 8 | 10 | 11 | 29 |
| Female deaths covered in verbal autopsies | 117 | 102 | 74 | 293 |
| Total female deaths | 139 | 114 | 89 | 342 |
| Total live births | 1779 | 1830 | 1197 | 4806 |
| Maternal deaths (adjusted for non-response) ¹ | 9.5 | 11.2 | 13.2 | 33.8 |
| Unadjusted Maternal mortality ratio (per 100,000 live births) | 450 | 552 | 919 | 603 |
| Adjusted Maternal mortality ratio (per 100,000 live births) | 534 | 612 | 1103 | 703 |

¹ Adjusted maternal deaths were computed as follows: (Maternal deaths/Female deaths 15-49 yrs with a VA)*All female deaths (15-49 yrs)

Table 3: Percentage distribution of all maternal and late maternal deaths among women aged 12–49 years, by selected variables: Nairobi Urban Health and Demographic Surveillance System, Korogocho and Viwandani, 2003-2005

| Characteristic | Maternal deaths | Late maternal deaths | Total |
|----------------------------------|-----------------|----------------------|-------|
| | N=29 | N=22 | |
| Delivered by health professional | | | |
| Non-professional | 79.3 | 68.2 | 74.5 |
| Professional | 20.7 | 31.8 | 25.5 |
| Place of delivery | | | |
| Outside of Health facility | 86.2 | 90.9 | 88.2 |
| Health facility | 13.8 | 9.1 | 11.8 |
| Outcome of pregnancy | | | |
| Abortion/still birth | 69.0 | 13.6 | 45.1 |
| Live birth | 31.0 | 86.4 | 54.9 |
| Place of death | | | |
| Outside Health Facility | 37.9 | 68.2 | 51.0 |
| Health Facility | 62.1 | 31.8 | 49.0 |
| Sought care before death | | | |
| No | 13.8 | 4.6 | 9.8 |
| Yes | 86.2 | 95.5 | 90.2 |

Table 4: Major causes of maternal mortality using data from two different sources: Nairobi Urban Health Demographic Surveillance System, (2003-05) and Health Facility survey, 2006

| Causes of maternal deaths from verbal autopsies in the surveillance area, 2003-2005 | | | Causes of maternal deaths that occurred between 2004 and 2005. Health Facility Survey 2006, | | |
|---|---------------|-----------------------|---|---------------|-----------------------|
| <i>Direct maternal causes</i> | <i>Number</i> | <i>Percentage (%)</i> | <i>Direct maternal causes</i> | <i>Number</i> | <i>Percentage (%)</i> |
| Abortion related | 9 | 31.0 | Abortion cause | 23 | 7.3 |
| Ante/post partum hemorrhage | 4 | 13.8 | Ante/postpartum Hemorrhage | 33 | 10.4 |
| Postpartum sepsis | 3 | 10.3 | Postpartum sepsis | 43 | 13.6 |
| Eclampsia | 2 | 6.9 | Eclampsia | 75 | 23.7 |
| Ruptured uterus | 1 | 3.5 | Ruptured uterus | 13 | 4.1 |
| | | | Retained placenta | 10 | 3.2 |
| | | | Prolonged labor | 5 | 1.6 |
| | | | Ectopic pregnancy | 3 | 0.9 |
| | | | Other direct | 4 | 1.3 |
| <i>Indirect maternal causes</i> | | | <i>Indirect maternal causes</i> | | |
| HIV/AIDS/TB | 4 | 13.8 | TB/HIV/AIDS | 9 | 2.8 |
| Anemia | 2 | 6.9 | Anemia | 39 | 12.3 |
| Other indirect maternal causes | 4 | 13.8 | Other maternal indirect | 32 | 10.1 |
| | | | Malaria | 27 | 8.5 |
| Total | 29 | 100.0 | Total | 316 | 100.0 |