1. Introduction

Maternal and perinatal mortality is a significant measure of a sufficient obstetric service. Since 1990, both maternal and perinatal mortality have decreased in all European countries, the United States, and Canada to approximately 0.5%–0.6% [1]. At present, maternal and perinatal mortality in Europe is the lowest worldwide, raising the question of which measures have been introduced in the maternal perinatal mortality in European countries, the United States, and Canada to approximately 0.5%–0.6% [1]. At present, maternal and perinatal mortality in Europe is the lowest worldwide, raising the question of which measures have been introduced in the maternal perinatal mortality in Europe is the lowest worldwide, raising the question of which measures have been introduced in the maternal perinatal mortality remain high in African countries [6]. Ways to improve the quality of care have been outlined by van den Broeck and Graham [8], and Dumont et al. [9].

In Nigeria, prenatal attendance is approximately 58%, only 35% of women deliver in health facilities, and most women deliver at home without a skilled attendant [10]. Up to 22% are delivered by traditional birth attendants, and only 42% receive postnatal checkup after delivery [10]. It is therefore not surprising that the National Demographic Health Service (NDHS) of Nigeria has recorded a maternal mortality ratio (MMR) of 545 per 100 000 live births [10], although this figure varies tremendously. The average MMR estimated by WHO, UNICEF, UNFPA, and the World Bank is 820, with a range of 460 to 1500. The NDHS also recorded an infant mortality rate of 75 per 1000 live births and an under-5-years mortality rate of 157 per 1000 live births. The quality of care provided by most maternity centers in Nigeria is poor; as a result, utilization of the services is still insufficient despite the provision of free maternity care in some states.

Against this background and as part of the Millennium Development Goals 4 and 5, Rotary International, supported by the German Federal Ministry of Economic Cooperation and Development in collaboration with the governments of Kano and Kaduna States, introduced a project of quality assurance in obstetric services in 10 hospitals located in northern Nigeria, where MMR is reported to be extremely high [10].
The basic principles of quality assurance in a hospital are based on 3 parameters: “quality of infrastructure,” “quality of process,” and “quality of outcome.” All 3 parameters are interdependent and closely related. Quality of infrastructure comprises the conditions of the hospital building, including water supply, power supply, hygiene conditions, number of staff, and equipment available. Quality of process is predominantly dependent on a sufficient infrastructure, but also on trained, skilled, and experienced health personnel. By contrast, quality of outcome is dependent on both the quality of infrastructure and the quality of process and can be evaluated by continuous data monitoring. The circle of quality is a continuous and interrelated process and has an inherent ability to lead to a spiral improvement of the system (Fig. 1).

The aim of the present study was to assess the 2-year results of an ongoing total quality assurance project in 10 Nigerian hospitals in a rural setting, and their impact on the MMR and fetal mortality ratio (FMR) in these hospitals from 2008 to 2009.

2. Materials and methods

Ten rural hospitals in the northern states of Kano and Kaduna (5 from each) were selected in agreement with, and on the proposals of, government officials for the present project of quality assurance. The hospitals participated under the supervision of the Aminu Kano Teaching Hospital (AKTH), Kano and Ahmadu Bello University Teaching Hospital (ABUTH), Zaria. To guarantee confidentiality, each hospital received a coded number by which they could identify themselves but not the other hospitals. This is an important instrument of benchmarking in order to improve the results and encourage honest criticism.

For uniform data collection, a maternity record book was developed and tested in 2007 and used by all hospitals. It records 16 obstetric values, such as age of patient, parity, gestational age, mode of delivery, complications at delivery and/or postpartum, birth weight, and Apgar score of baby. These data are routinely collected for all deliveries by midwives in the participating hospitals. For the quality assurance project, a monthly form was completed that summarized the obstetric data for the month, such as total prenatal clinic attendance, total deliveries, total cesarean deliveries, total cases of eclampsia, and total maternal and fetal deaths. The monthly summary forms were checked, monitored, and collected monthly by the chief midwife.

Local standards for infrastructure status (IS) and hygiene status (HS) were not available. Most of the hospitals were in a dreadful condition that was hard to evaluate. As a result, the quality of the infrastructure of the 10 hospitals was evaluated via a structured questionnaire (Table 1). For each hospital, score criteria for the “general status of the infrastructure/equipment” and score criteria for “hygiene conditions” were used. Each of 5 areas (units)—operating theater, delivery room, neonatal unit, delivery ward/prenatal clinic, and general conditions of the hospital—was scored by 2 investigators by evaluating different criteria within each area from 1 (excellent, best result) to 6 (very poor, worst result).

For the operating theater unit, 12 criteria were evaluated for both IS and HS; for the delivery room unit, 8 criteria were evaluated for both IS and HS; for the neonatal unit unit, 3 criteria were evaluated for both IS and HS; for the delivery ward and prenatal clinic unit, 7 criteria were evaluated for both IS and HS; and, for the general hospital condition unit, 7 criteria were evaluated for both IS and HS. This provided a simple method for defining the impression of the facility in numbers.

According to the points given for each unit, the total score for general infrastructure/equipment ranged from a minimum of 5 points to a maximum of 30 points, for hygiene conditions from 5 to 30 points, and in total from 10 (best result) to 60 (worst result) points. The

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![Fig. 1. Circle of quality assurance, demonstrating a cycle of continuous improvement via the introduction of standards, collection of data, and discussion of results.](image-url)
scores were used to obtain a comprehensive impression of each hospital and to identify the relationship between maternal mortality as the worst outcome of infrastructure and the score for each hospital.

The quality of process was improved by training healthcare workers from the 10 hospitals on emergency obstetric care—in particular, the use of magnesium sulfate for managing eclampsia, and the treatment of postpartum hemorrhage (PPH), including use of an anti-shock garment. However, evaluation of this is based on only the improvement post-test because there were no pre-training data available for comparison.

All data collected from the summary forms were collated and analyzed via Excel (Microsoft, Redmond, WA, USA). A statistician was trained at AKTH under the supervision of a senior consultant at the Department of Obstetrics and Gynaecology. The aim was to establish an “Institute of Quality Assurance” at AKTH, which would oversee the data collection and analysis of all hospitals, and feed back the results to the participating hospitals in a blind way. The hospitals would then have the opportunity to compare their own results with those of the other hospitals. This flow of data from the hospitals to the institute and back to the hospitals is an essential step in the quality assurance circle (Fig. 2).

Review meetings were held with the aim of inducing competition among the hospitals. The outcome parameter was MMR, and FMR was also a strong parameter. The quality circle (Fig. 1) starts with observation of a practice or identification of problems, sets standards to reduce maternal mortality as the ultimate outcome, compares practice with these standards, and then analyzes the effect of the practice on outcome (maternal mortality). Regular review meetings with representatives (usually a lead doctor and midwife) of each hospital were carried out at half-yearly intervals in a benchmarking process to discuss the anonymous data that had been collected and evaluated. At these meetings, major problems observed from the data collection and at hospital visits were addressed.

3. Results

A total of 29833 deliveries were analyzed in the 2 study years of 2008 and 2009. The total number of deliveries varied among the study hospitals: 250 was the lowest number of deliveries in a hospital, and 1500 was the highest in a half-year (6-month) period (Fig. 3A).

Table 2 shows the incidence of MMR, FMR, cesarean delivery, eclampsia, and PPH in the 10 hospitals in 2008 and 2009. A maternal death was considered as a death of the mother after admission in pregnancy, labor, or after delivery, but before discharge from the hospital. There was a significant reduction in the average MMR from 1790 per 100 000 births in the first half of 2008 to 940 per 100 000 births in the second half of 2009 (Fig. 3B). Hospital MMR also decreased steadily over the study period, ranging from 100 to 6000 per 100 000 births in the first half of 2008, but from 100 to 1500 per 100 000 births in the second half of 2009. However, MMR showed a wide variation over the period of observation. Hospital MMR was strongly related to and dependent on the number of deliveries in the hospitals (Fig. 4). Hospitals with high delivery rates had a lower MMR than hospitals with low delivery rates.

The FMR also showed marked variation among the hospitals. It ranged from 4% to more than 20%. It is evident that FMR is also associated with the number of deliveries in a hospital; for example, hospitals with low delivery rates had the highest FMR (Fig. 5). Overall, there was a close relationship between maternal mortality and fetal mortality, with FMR increasing with MMR. However, there was a wide variance among the hospitals, where high FMR was not associated with high MMR.

The frequency of cesarean delivery decreased during the 2 study years, and ranged from 2.8% to 12.3% in 2009. There was, however, a big variation in cesarean rates over the 2 study years, and also among the hospitals during this time. Contrary to expectations, FMR increased with the number of cesarean deliveries (Fig. 6). This may be because cesareans are performed mainly to save the life of the mother.

The incidence of eclampsia did not change over the study period, ranging from 7.04% to 10.12%. There was, however, a tendency toward
a higher incidence in hospitals with a lower number of deliveries. Similar observations were made for PPH. Although PPH did not show a close association with MMR, it showed a higher incidence in hospitals with a lower delivery rate.

By using the score criteria for assessing the quality of hospital structure in terms of infrastructure/equipment conditions and hygiene conditions of the theater, delivery room, neonatal unit, and prenatal clinic, hospitals with the lowest score of 20–40 had the lowest MMR of approximately 500 maternal deaths per 100 000 births, and hospitals with the highest score of about 45–50 had the highest MMR of 2000 maternal deaths per 100 000 births in the year 2009 (Fig. 7). This clearly illustrates that the hospitals with better quality of infrastructure had a better MMR and those with poor quality of structure had a poorer MMR.

An assessment of the clinical data was feasible by comparing the statistical evaluation of the data to the total data pool among the hospitals participating in the study (Table 3). Although it is interesting to look at different variables, such as the number of twin deliveries, breech deliveries, cesarean deliveries, vacuum extractions, and severe diseases such as eclampsia/pre-eclampsia and PPH, of chief importance is the benchmarking of maternal and fetal mortality and their relation to the other parameters (Table 3).

In the ongoing quality assurance project, the hospital with the lowest MMR is considered to be the “leading hospital,” and is used as the reference hospital. It has the highest number of prenatal clinic visits and follow-ups, a high number of deliveries, a medium number of cesarean deliveries, and a lower number of PPH incidents.

**Table 2**

<table>
<thead>
<tr>
<th>No. of deliveries</th>
<th>Cesarean</th>
<th>MMR No. (per 100,000 deliveries)</th>
<th>FMR</th>
<th>Eclampsia</th>
<th>PPH</th>
</tr>
</thead>
<tbody>
<tr>
<td>January–June 2008</td>
<td>6878</td>
<td>494 (7.2)</td>
<td>123 (1.790)</td>
<td>584 (8.5)</td>
<td>484 (7.0)</td>
</tr>
<tr>
<td>July–December 2008</td>
<td>7369</td>
<td>451 (6.1)</td>
<td>120 (1.630)</td>
<td>653 (8.9)</td>
<td>490 (6.7)</td>
</tr>
<tr>
<td>January–June 2009</td>
<td>7695</td>
<td>457 (5.9)</td>
<td>106 (1.380)</td>
<td>750 (9.8)</td>
<td>779 (10.1)</td>
</tr>
<tr>
<td>July–December 2009</td>
<td>7891</td>
<td>369 (4.7)</td>
<td>74 (9.40)</td>
<td>659 (8.4)</td>
<td>776 (9.8)</td>
</tr>
<tr>
<td>Total 2008 and 2009</td>
<td>29833</td>
<td>1771 (5.9)</td>
<td>423 (1.240)</td>
<td>2646 (8.9)</td>
<td>2529 (8.8)</td>
</tr>
</tbody>
</table>

Abbreviations: FMR, fetal mortality ratio; MMR, maternal mortality ratio; PPH, postpartum hemorrhage.

* Values are given as number (percentage) unless otherwise indicated.
of cesarean deliveries, and only a few cases of eclampsia and PPH. The FMR is also low. From this comparison of the median and range values, conclusions can be drawn with regard to obstetric management in that hospital and the other hospitals. It should be noted that the data collected were cumulative data rather than individual data analyses; such analyses remain a challenge in most of the participating hospitals at present.

4. Discussion

Maternal mortality and child mortality in Nigeria are among the highest worldwide. According to national statistics, the MMR was 800 per 100,000 deliveries in 2005 [11], although a more recent NDHS survey in 2008 [10] has shown a decrease to 545 per 100,000 live births. MMR is much higher in the northern states of Nigeria [11,12]; the northeast zone has the highest MMR of 1549 per 100,000 live births as compared with 165 per 100,000 live births in the southwest zone [13].

According to the latest systematic review by Hogan et al. [14], many interventions to reduce MMR have failed. Family planning methods have not shown the expected effect, and the treatment of isolated, singular complications during pregnancy and labor has not been successful. As a result, a new approach is needed to tackle the high MMR, as proposed by numerous research groups [14–17].

According to experience in European countries [4], high MMR and FMR are, in general, the result of problems in (1) awareness, (2) organization of healthcare, (3) infrastructure of hospitals, and (4) quality of process in healthcare systems (i.e. hospitals should be staffed with skilled medical personnel and should be based on a good infrastructure) [3,4,18–20]. In previous studies, tackling the causes of maternal mortality has focused mainly on describing the causes, rather than on sustainable intervention, of the problem. The present study describes a successful intervention targeting the third problem—infrastructure of the hospitals—and has addressed the issue of how to reduce maternal mortality in 10 hospitals in Kano and Kaduna States in northern Nigeria by comparative quality assurance (benchmarking) and systematic improvements in quality.

In 2000, a WHO report showed that the MMR of a country is closely correlated to the quality of healthcare in that country [21]. “Quality of healthcare” is used here in its holistic sense, not just as a measure of the best that the country can provide in its large teaching hospitals but also of how effectively good-quality healthcare reaches the country’s poorest people in rural areas. Therefore, it was not surprising that introducing quality assurance in the 10 study hospitals led to a marked decrease in MMR, with the average MMR falling from 1750 per 100,000 deliveries in the first half of 2008 to 940 per 100,000 deliveries in the last half of 2009. Individual hospitals also demonstrated a marked decrease in MMR (Fig. 3B).

The present project improved the quality of obstetric service by improving the quality of process, for example, by introducing protocols for management of obstetric complications. These protocols included use of magnesium sulfate for management of eclampsia, active management of the third stage of labor for preventing PPH, and use of the partograph for managing labor. These procedures are in line with the recommendations of a South African confidential inquiry into maternal death, which emphasized the pivotal role of health services in reducing MMR [22].

The present project also demonstrated that hospitals with a high number of deliveries have a lower MMR and vice versa. This is because utilization of maternity services is related to the quality of care provided in a health facility, as shown in Zimbabwe [23]. The pattern of utilization of maternity services by rural women has been shown to be based on rational decision-making, which takes into account not only the distance to a service but also whether the care provided is considered to be of good quality [24]. Hence, the low quality of care offered in maternity clinics contributes to the low utilization of the service. The FMR was also lower in hospitals with a high number of deliveries (Fig. 5); however, the FMR was shown to rise with increasing frequency of cesarean section. A possible explanation for this unusual finding might be that cesarean is often done after the fetus is dead in order to save the life of the mother.

The present project demonstrates that without improvements in the quality of the infrastructure of health facilities, such as hygiene and equipment; all maternal health interventions will have a minimal impact on maternal health statistics (Fig. 7). Hospitals with low scores and better quality of infrastructure have a lower MMR. The half-yearly review meetings, in which the collated and analyzed data of the 10 hospitals (coded) are discussed, have been extremely useful in improving the quality of healthcare services provided in the hospitals. Continuous improvement of obstetric practice will be achieved by this circle of activities [24], which also provides an avenue for useful criticism and opportunity for an individual hospital to assess itself among other hospitals. This also encourages competition by benchmarking. When fully established, the Institute of Quality Assurance will continue to oversee the continuous collection and analysis of obstetric care data.

Securing women’s health is a comprehensive issue and has remained a constant challenge since described by Fathalla in 1994 [25]. Those of us who are trying to reduce maternal mortality from a medical perspective will be unable to achieve fundamental change without a massive improvement in the quality of healthcare services that we provide in our health facilities. In this context, governments play a key role in rural areas by providing the necessary skilled staff and equipment, and thereby improving the quality of care in the health facilities. The present study has shown that applying quality assurance measures in rural hospitals can improve maternal health.

Conflict of interest

The authors have no conflicts of interest.

References
