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Health Worker Familiarity with Maternal Mortality Cause Definitions in Kaduna State, Nigeria: A Cross-Sectional Study

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Abstract

Maternal mortality remains a critical public health challenge in Nigeria, with a ratio exceeding 1,000 per 100,000 live births. Beyond timely access to care, health worker knowledge of maternal mortality causes and their clinical definitions is vital for accurate diagnosis, management, and surveillance. This study assessed health worker familiarity with clinical definitions of maternal death causes in Kaduna State and explored system-level influences. A cross-sectional survey was conducted among 596 maternal healthcare providers across primary, secondary, and tertiary facilities, both public and private. Respondents included doctors, nurses/midwives, community health officers (CHOs), community health extension workers (CHEWs), and ancillary staff. Data were collected using a structured questionnaire capturing demographics, professional background, and self-reported familiarity with clinical definitions of maternal death causes. Analysis employed descriptive statistics, chi-square tests, and multivariable logistic regression to examine associations with gender, cadre, education, facility type, and experience. Overall, 96.1% of participants reported familiarity with maternal death definitions. Postpartum hemorrhage (32%) and eclampsia (11%) were most frequently cited, followed by medical mismanagement (12%). Bivariate analysis showed no significant associations between familiarity and age, education, experience, cadre, or facility type. However, multivariable analysis identified male gender (aOR = 4.49; 95% CI: 1.07–18.9; p = 0.041) and CHO cadre (aOR ≈ 31.5; p = 0.017) as significant predictors. All doctors reported familiarity. In conclusion, maternal death cause familiarity is high across cadres and facilities in Kaduna. However, gender and cadre disparities highlight the need for equitable training opportunities, continuous capacity building, adequate resources, and strengthened surveillance systems to effectively reduce maternal mortality.

Keywords: *Cause of Death, Cross-Sectional Study, Eclampsia, Health Worker Knowledge, Kaduna State, Maternal Mortality, Nigeria, Postpartum Hemorrhage.*

Introduction

Maternal mortality remains a critical global health challenge, with approximately 800 women dying every day from pregnancy-related causes [1]. Recent estimates show that 287,000 maternal deaths occurred worldwide in 2020, and 95% of these occurred in low- and middle-income countries (LMICs) [1]. Nigeria is a focal point of this crisis – it accounted for about 20–28% of global maternal deaths in recent years [1, 2]. In 2017, Nigeria's maternal mortality ratio (MMR) was estimated at 917 per 100,000 live births, rising to 1047 per 100,000 in 2020, one of the highest in the world [3]. This means a Nigerian woman has roughly a 1 in 22 lifetime risk of dying from pregnancy or

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childbirth complications, starkly contrasting with a 1 in 4900 risk in developed countries [2].

The leading causes of maternal death are well known. Globally, the most common direct causes include obstetric hemorrhage (especially postpartum hemorrhage), hypertensive disorders of pregnancy (pre-eclampsia/eclampsia), and sepsis/infections [1]. Together these account for about three-quarters of maternal deaths [1]. In Nigeria, similar patterns are observed: studies indicate that hemorrhage, hypertension, and sepsis are top contributors to maternal mortality [3]. For example, a recent hospital-based analysis found hypertensive disorders caused ~27% of maternal deaths, sepsis ~21%, and hemorrhage ~17% [3]. Many of these deaths are preventable with timely and appropriate care [3].

Addressing such high maternal mortality requires not only improving access to health facilities and resources but also ensuring health worker competency. Skilled health personnel at delivery and during emergencies are vital for preventing and managing complications. The World Health Organization emphasizes building a competent, well-trained maternal health workforce as a key strategy to reduce maternal deaths [1, 4]. This includes training providers in evidence-based practices and ensuring they understand the clinical definitions and management of major obstetric complications. In Nigeria, efforts like the national Maternal and Perinatal Death Surveillance and Response (MPDSR) system have been introduced to improve reporting and cause-of-death analysis, underscoring the importance of health worker knowledge in correctly identifying causes of maternal death [5]. If health workers are unfamiliar with standard definitions of maternal death causes (e.g. the clinical criteria for postpartum hemorrhage or eclampsia), they may misclassify or mismanage cases, undermining both patient care and the quality of maternal death audits.

System-level factors can influence health worker knowledge and performance. Education and training level can determine providers' familiarity with obstetric concepts – for instance, doctors and graduate-level clinicians might be expected to have deeper theoretical knowledge than auxiliary staff. The type of facility and its tier (primary, secondary, tertiary) may also play a role, as tertiary hospitals often have more specialized staff and training opportunities [4]. Similarly, differences in cadre (physicians, nurses/midwives, community health workers, etc.) and years of experience might lead to variability in knowledge. Even gender could be relevant; in many settings women comprise the majority of the frontline maternal health workforce (especially as midwives and nurses), yet male health workers may occupy more senior roles or have greater access to certain training, potentially creating knowledge or confidence gaps. Understanding these system-level determinants is important for designing targeted interventions – for example, if primary healthcare workers or certain cadres are less knowledgeable, training can be focused there.

In this study, we assessed health worker familiarity with the clinical definitions of maternal causes of death in Kaduna State, Nigeria, and analyzed how this familiarity relates to system-level factors. Kaduna State, in north-western Nigeria, has a mix of urban and rural communities and a high maternal mortality burden similar to national levels. We conducted a cross-sectional survey of health workers across multiple facilities and cadres in the state. Specifically, we examined: (1) the proportion of health workers who report being familiar with standard clinical definitions of causes of maternal death; (2) associations between familiarity and factors such as education, facility type (primary vs secondary vs tertiary care), gender, cadre, and years of experience; and (3) independent predictors of familiarity identified through logistic regression. By identifying gaps and

determinants of knowledge, this research can inform capacity-building efforts. Our findings are discussed in the context of other studies from Nigeria and similar low-resource settings, and we propose recommendations to strengthen health worker training and health system support for maternal health.

Methods

Study Design and Setting: We carried out a cross-sectional survey of health workers in Kaduna State, Nigeria. Kaduna state is one of the country's largest states with a mix of primary, secondary, and tertiary health facilities serving an ethnically diverse population. The survey was conducted in 2024/2025, targeting frontline maternal healthcare providers. We included multiple facility levels – primary health centers, secondary (general) hospitals, and tertiary hospitals – as well as both public and private health facilities, to capture a broad perspective. The study obtained necessary ethical approvals from appropriate institutional and state health authorities (as applicable).

Sampling and Participants: A total of 596 health workers participated in the survey.

Sample size selection: This was arrived at using the cochran formula [6]. Participants were selected using a multistage sampling approach. First, health facilities were stratified by level (primary, secondary, tertiary) and type (public/private), then randomly selected. Within facilities, we recruited available healthcare workers involved in maternal health services (antenatal, delivery, postpartum, or emergency obstetric care). The cadres represented included doctors, nurses and midwives, community health extension workers (CHEWs), community health officers (CHOs), environmental health officers (EHOs), laboratory scientists/technicians, hospital attendants, and health records officers. All respondents gave informed consent before participation.

Data Collection: Data were collected using a structured questionnaire administered in English (the official language for medical communication in Nigeria). The questionnaire captured demographic and professional information (age, gender, years of experience, highest educational qualification, cadre/professional role, and facility level). The key outcome measure was familiarity with clinical definitions of maternal causes of death. Specifically, participants were asked to identify a cause of maternal death (from a list of common causes or an open-ended option) and then asked whether they were *familiar with the clinical definition* of that cause of death (yes or no). For example, if a respondent selected "postpartum hemorrhage" as a cause, they were prompted to indicate if they know the clinical definition (criteria) of postpartum hemorrhage. "Clinical definition" was explained as the standard medical definition or diagnostic criteria (e.g., postpartum hemorrhage defined as blood loss ≥500 mL after vaginal birth or ≥1000 mL after cesarean, along with related signs [7]. We also collected information on whether the respondent had ever received formal training in maternal death review or emergency obstetric care, although those data are not the primary focus here (they were not included in the provided tables).

Data Analysis: We performed descriptive statistics to summarize the characteristics of the health workers and their familiarity with maternal death cause definitions. Categorical variables were described using frequencies and percentages. The distribution of responses for the cause of death identified by the health workers was compiled (Table 2). We then examined bivariate associations between the outcome (familiarity: yes vs no) and each predictor variable (age group, years of experience category, education level, cadre, facility level, facility type, etc.) using chi-square (χ^2) tests. The chi-square test results (with degrees of freedom, Cramer's V for effect size, and P-values) are presented in Table 3. A P-value < 0.05 was considered statistically significant. Finally, a multivariable logistic

regression analysis was conducted to identify independent predictors of familiarity (Table 4). All key covariates were entered into the model simultaneously: age, gender, years of experience, education level, cadre, facility level (classified as primary, secondary, tertiary), and facility ownership (public vs private). The outcome was binary (1 = "Yes, familiar with definition" vs 0 = "No, not familiar"). Adjusted odds ratios (aOR) with 95% confidence intervals and P-values were obtained for each predictor. In the regression, categorical variables were coded into indicator dummy variables; one category served as the reference group (for example, >45 years for age, female for gender, highest education for education, hospital attendant for cadre, tertiary facility for facility class, and private for facility type, based on how the data were structured). Goodness-of-fit and multicollinearity were checked to ensure model validity. All analyses were carried out using Excel 2010 and SPSS version 25 [8].

Results

Participant Characteristics: A total of 596 health workers were surveyed, spanning a range of professional and demographic groups (Table 1). The sample was predominantly female (81%), with males comprising 19% (Table 1). Participants were relatively young: the largest age bracket was 26–35 years old (39.6%), followed by 36–45 years (28.2%); only 15.4% were above 45 years (Table 1). Work experience reflected the age distribution – about 42% had 5–10 years of experience, and an additional 21% had 2–5 years, while fewer had over 15 years in service. In terms of education, the majority had mid-level health professional training: 41.6% held a health-related *certificate* (e.g., community health certificate), and 45.8% held a *diploma* (e.g., nursing or midwifery diploma). Only about 10.9% had a university *degree* and 1.7% a postgraduate qualification (Masters or above) (Table 1). The cadre mix of respondents was weighted toward frontline maternal care providers: Nurses and midwives were the largest group (38.4%), followed by Community Health Officers (24.0%) and Community Health Extension Workers (22.4%) (Table 1). Smaller proportions were medical doctors (4.4%), Environmental Health Officers (4.9%), hospital attendants (2.2%), health records officers (2.2%), and laboratory scientists/technicians (1.5%) (Table 1). These figures indicate that our sample primarily comprised midwives/nurses and community-level providers who are typically responsible for maternal and child health services at primary and secondary care levels, with fewer physicians and ancillary staff.

Table 1. Demographic and Professional Characteristics of Health Workers

Variables	Frequency	Percent	Valid Percent	Cumulative percent
Educational Level of Health Workers				
Certificate	248	41.6	41.6	41.6
Diploma	273	45.8	45.8	87.4
Degree	65	10.9	10.9	98.3
Masters and Above	10	1.7	1.7	100
Total	596	100	100	
Cadre of Health Care Workers				
Medical Doctor	26	4.4	4.4	4.9
Nurses/Midwives	229	38.4	38.4	43.3
CHEWS	134	22.4	22.4	65.7
CHOs	143	24	24	89.7
EHO	29	4.9	4.9	94.6

Lab Scientist/Technicians	9	1.5	1.5	96.1
Hospital Attendant	13	2.2	2.2	97.8
Health record officers	13	2.2	2.2	100
Total	596	100	100	
Age of Health Worker				
15- 20 yrs	22	3.7	3.7	3.7
21 - 25 yrs	78	13.1	13.1	16.8
26 - 35 yrs	236	39.6	39.6	56.4
36 - 45 yrs	168	28.2	28.2	84.6
> 45 yrs	92	15.4	15.4	100
Total	596	100	100	
Gender of Health Workers				
Male	113	19	19	19
Female	483	81	81	100
Total	596	100	100	
Years of Experience of Health Workers				
<1 yr	11	1.8	1.8	1.8
> 1 =< 2 yrs	34	5.7	5.7	7.5
>2 =< 5 yrs	125	21	21	28.5
5 - 10 yrs	252	42.3	42.3	70.8
11 - 15 yrs	87	14.6	14.6	85.4
16 - 20 yrs	44	7.4	7.4	92.8
> 20 yrs	43	7.2	7.2	100
Total	596	100	100	
Marital Status of Health Workers				
Married	474	79.5	79.5	79.5
Single	103	17.3	17.3	96.8
Widowed	19	3.2	3.2	100
Total	596	100	100	

Health Workers' Familiarity with Maternal Death Causes: Self-reported familiarity with clinical definitions of maternal death causes was very high among the respondents. Overall, 96.1% of health workers answered "Yes" – they are familiar with the clinical definition of the cause of death in question, while only 3.9% said "No" (Table 2). In other words, virtually all respondents claimed to know the standard medical definition of at least one cause of maternal death (and the vast majority knew the definitions of the causes they identified). When asked to identify a cause of maternal death they recognize, the most frequently identified cause was Postpartum Hemorrhage (PPH), cited by 191 respondents (about 32% of the sample) (Table 2). Eclampsia (a severe hypertensive disorder leading to seizures) was the next most common, identified by 66 respondents (~11.1%)(Table 2). Interestingly, the third most cited "cause" was "Medical mismanagement", chosen by 70 respondents (~11.7%)(Table 2). This category likely reflects perceptions that substandard care or errors contributed to maternal deaths – a notable finding that points to awareness of health system failings. Other notable causes named included *"Medical complications"* (6.5%), which may refer to indirect causes like underlying illnesses, and Obstructed labor (4.4%)(Table 2). Various

hypertensive disorders related to pregnancy were noted: aside from eclampsia, Pre-eclampsia and Pregnancy-Induced Hypertension (PIH) were each mentioned by 26 respondents (4.4% each) (Table 2). Antepartum hemorrhage (bleeding before birth, e.g. from placental abruption) was cited by ~3.2%, and Unsafe abortion was cited by ~3.4% [33]. Cases of sepsis were identified by a small fraction (~3.2% for generic "sepsis"; an additional 0.3% specifically noted puerperal sepsis) (Table 2) and anemia was mentioned by 3.4%. Rare responses (each <1%) included causes like ectopic pregnancy, ruptured uterus, complications of cesarean section, congestive heart failure, malaria, HIV ("retroviral sepsis"), sickle cell disease, etc., reflecting a wide range of direct and indirect causes but with very few respondents selecting each (Table 2). Figure 1 illustrates the distribution of the top causes identified by respondents (with PPH and eclampsia clearly dominating the profile). Crucially, nearly all respondents, regardless of which cause they named, reported being familiar with that cause's definition – underscoring the high self-assessed knowledge level.

Table 2. Causes of Death and Health Worker Familiarity with Clinical Definition

Variables	Frequency	Percent	Valid Percent	Cumulative percent
Cause of Death				
Unknown	17	2.9	2.9	2.9
Sepsis	19	3.2	3.2	6
Abortion	20	3.4	3.4	9.4
Anemia	20	3.4	3.4	12.8
Ante Partum Hemorrhage	19	3.2	3.2	15.9
Asthma	2	0.3	0.3	16.3
Cerebral Malaria	2	0.3	0.3	16.6
Complications of Caesarian Section	6	1.3	1.3	18
Congestive Cardiac Failure	17	2.9	2.9	20.8
Eclampsia	66	11.1	11.1	31.9
Ectopic Pregnancy	4	0.7	0.7	32.6
Hepatitis	3	0.5	0.5	33.1
Intra - Uterine Fetal death	4	0.7	0.7	33.7
Lack of Blood Transfusion	1	0.2	0.2	33.9
Medical complications	39	6.5	6.5	40.4
Medical Mismanagement	70	11.7	11.7	52.2
Obstructed Labor	26	4.4	4.4	56.5
Others	4	0.7	0.7	57.2
puerperal Sepsis	2	0.3	0.3	57.6
Placenta Retention	2	0.3	0.3	57.9
Post-Partum Hemorrhage	191	32	32	89.9
Pre-Eclampsia	26	4.4	4.4	94.3
Pregnancy Induced Hypertension	26	4.4	4.4	98.7
Retroviral Sepsis	2	0.3	0.3	99
Severe Malaria	1	0.2	0.2	99.2
Sickle Cell Anemia	2	0.3	0.3	99.5
Uterine Ruptured	3	0.5	0.5	100

Total	596	100	100	
Health Worker Familiarity with Clinical Definition of Cause of Death				
No	23	3.9	3.9	3.9
Yes	573	96.1	96.1	100
Total	596	100	100	

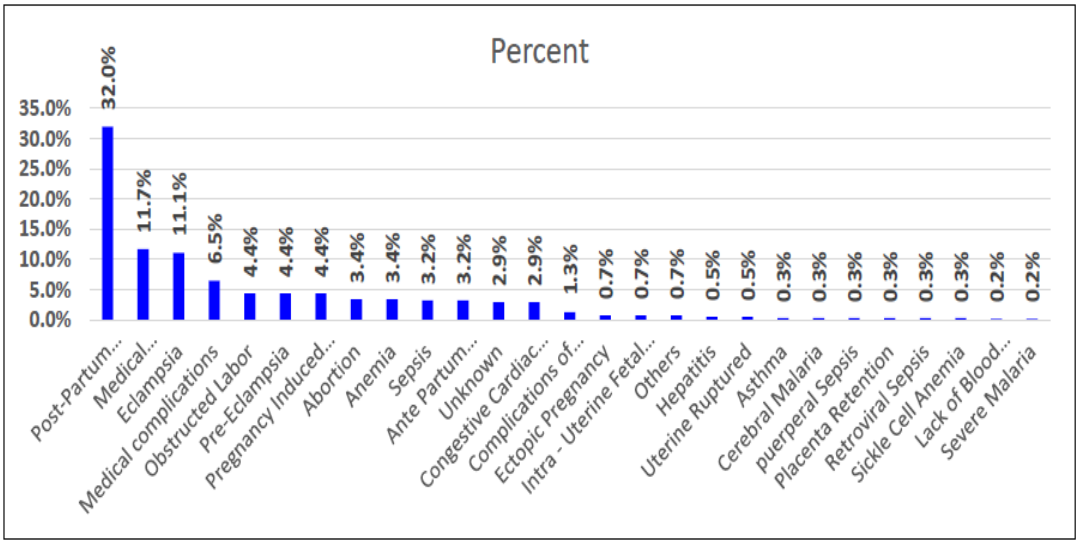

Figure 1. Distribution of maternal death causes identified by health workers (N=596)

Note: Postpartum hemorrhage was the most frequently cited cause (32%), followed by eclampsia (11%) and perceived medical mismanagement (12%). Hypertensive disorders (pre-eclampsia/PIH) and obstructed labor were also noted by some respondents. Many other causes were each cited by <5% of respondents. Nearly all participants (96%) reported familiarity with the clinical definition of the cause they identified.

Bivariate Associations: We examined whether certain groups of health workers were more or less likely to report familiarity with maternal death cause definitions. Given the very high overall familiarity rate (96%), differences were small, and chi-square tests found no statistically significant associations between familiarity (yes/no) and the various demographic or professional factors (Table 3). For instance, familiarity was >95% in every age category, and there was no trend of younger or older workers being significantly more knowledgeable (χ^2_ [5] = *5.875, P = 0.319)* (Table 3). *Years of work experience likewise showed no significant effect – even relatively new staff had high reported familiarity (χ^2* [7] = *4.966, P = 0.664)* (Table 3). *Educational level did not significantly influence knowledge either: whether a health worker had a basic certificate, diploma, or a higher degree, the vast majority in each group said they were familiar with maternal death causes (χ^2* [4] = *1.297, P = 0.862)* (Table 3). *Notably, even those with only certificate-level training were almost as likely to report familiarity as those with degrees, suggesting that basic obstetric knowledge is disseminated across training levels. We also found no significant association by cadre in the chi-square analysis (χ^2* [8]_ ≈ 10.85, P = 0.21) (Table 3). Nurses, midwives, CHEWs, CHOs, doctors, and others all had familiarity rates above 90%, with no cadre showing a statistically lower knowledge proportion. Similarly, there was no significant bivariate difference by facility level or type – staff at primary health centers were about as likely to report familiarity as those at tertiary hospitals, and staff in public vs. private facilities did not differ appreciably in familiarity (chi-square results for facility class and ownership yielded P > 0.3, not shown in Table 3 for brevity).

Table 3. Association of Variables with Health Worker Familiarity with Clinical Definition of Cause of Death

Variables	Pearson Chi-Square (□2)	df	Cramer's V	P-Value
Age of Health worker	5.875	5	0.099	0.319
Years of Experience of Health Worker	4.966	7	0.091	0.664
Educational Level of Health worker	1.297	4	0.047	0.862
Cader of Health Worker	10850	8	0.135	0.21

Multivariable Logistic Regression: Although bivariate analyses showed no significant group differences, the logistic regression (Table 4) provided additional insights by adjusting for all factors simultaneously. The model's outcome was whether a health worker is familiar with the cause-of-death definition (Yes=1). Gender emerged as a significant independent predictor: male health workers had higher odds of reporting familiarity than female health workers, with an adjusted odds ratio aOR = 4.49 (95% CI, approximately 1.07–18.9; P = 0.041) (Table 4). In practical terms, this suggests that male providers were about 4.5 times more likely to say they know the definitions compared to their female counterparts, after controlling for age, cadre, etc. Another significant predictor was cadre: being a Community Health Officer (CHO) was associated with much higher odds of familiarity (aOR ≈ 31.5, P = 0.017) relative to the reference category (which was hospital attendants) (Table 4). This indicates CHOs were extremely likely to report knowledge (virtually all CHOs did), especially compared to the lower-cadre hospital attendants (some of whom did not know the definitions). There was a trend for CHEWs (community health extension workers) to also have higher odds (aOR ~6.3) than hospital attendants, but this did not reach statistical significance (P = 0.098) (Table 4). Nurses/midwives and EHOs showed no significant difference from the reference group in the adjusted model, and laboratory personnel had an inconclusive lower OR (0.29, P = 0.47) suggesting their knowledge was not different after adjustment (Table 4).

Other factors in the logistic regression were not statistically significant. Age did not show any clear pattern – none of the age brackets differed significantly from the >45 years reference (all P > 0.5) (Table 4). Years of experience similarly showed no significant adjusted effects (all P > 0.4), although point estimates fluctuated (for example, those with 5–10 years' experience had aOR ~5.2, P = 0.401, but the wide confidence interval included 1) (Table 4). Educational level had no meaningful impact in the model – certificate- or diploma-holders were just as likely as those with degrees to report familiarity (the odds ratios for having no certificate, a certificate, or diploma were essentially 0 with P ~0.999, indicating no difference vs. the reference of having a degree) (Table 4). Regarding facility level, we observed no significant difference between working at a primary health center vs. a tertiary hospital (aOR ~0.41, P = 0.587) or at a secondary hospital vs. tertiary (aOR ~4.90, P = 0.307), after adjusting for other factors (Table 4). The secondary vs. tertiary odds ratio was greater than 1, suggesting higher reported knowledge in secondary hospitals, but the effect was not significant, likely due to wide confidence intervals (possibly an artifact of almost universal familiarity across the board). Facility type (ownership) also was not significant – working in a public facility had an aOR ~0.99 compared to private (reference), P = 0.988 (Table 4), indicating no difference in knowledge between public-sector and private-sector health workers in this sample.

It is worth noting a few specifics: All medical doctors (n = 26) in the sample answered "Yes" (familiar), meaning none of the doctors reported a lack of knowledge. This perfect outcome for doctors resulted in an extremely large estimated OR in the regression (approaching infinity) with a non-significant *P* (due to quasi-separation) (Table 4). In practical terms, it confirms that the physicians were universally confident about definitions of causes of death. By contrast, the few health workers who said "No" were drawn from other categories – likely mostly among the lower-cadre or less-trained personnel, such as hospital attendants or certain junior staff. This explains why "hospital attendant" was used as the reference group and why CHOs and others showed high odds relative to it. In summary, the only statistically significant predictors of familiarity in our model were male gender and being in the CHO cadre, while factors like age, experience, education, facility level, and other cadres showed no significant independent association with knowledge of maternal death cause definitions.

Table 4. Predictors of Health Worker Familiarity with Clinical Definition of Cause of Death

Variables	aOR	P-Value
Age of Health Worker		
15 - 20yrs	1.01E+08	0.998
21 - 25yrs	0.69	0.858
26- 35yrs	0.347	0.583
36 - 45 yrs	0.586	0.778
> 45yrs	Ref	Ref
Gender of Health Worker		
Male	4.49	0.041
Female	Ref	Ref
Years of experience of Health worker		
< 1	1.34E+08	0.999
>1=< 2	5.12	0.473
>2=<5	2.784	0.607
5-10 yrs	5.187	0.401
11 - 15yrs	1.582	0.81
16-20 yrs	Ref	Ref
Marital Status		
Married	0	0.998
single	0	0.998
Divorced	Ref	Ref
Educational Level Health Worker		
No Certificate	0	0.999
Certificate	0	0.999
Diploma	0	0.999
Degree	Ref	Ref
Cader of Health Worker		

Medical Doctor	1.13E+08	0.998
Nurses/Midwife	2.651	0.39
CHEWs	6.294	0.098
CHOs	31.485	0.017
EHO	6.497	0.154
Lab. Scientist/Technician	0.287	0.47
Hospital Attendant	Ref	Ref
Health Facility Class		
Primary Health	0.411	0.587
Secondary	4.895	0.307
Tertiary	Ref	Ref
Type of Health Facility		
Public	0.991	0.988
Private	Ref	Ref

Discussion

In this cross-sectional survey of health providers in Kaduna State, Nigeria, we found that knowledge of clinical definitions for maternal mortality causes is nearly universal (96% self-reported familiarity) among respondents. This high level of knowledge is encouraging, as it suggests that most frontline health workers are aware of what the major causes of maternal death are and how they are defined. The most commonly recognized causes – postpartum hemorrhage and eclampsia – align with the well-documented leading causes of maternal mortality in Nigeria and globally [1, 3] . Postpartum hemorrhage (PPH) is the leading cause of maternal death worldwide [7, 9], and our finding that one in three health workers identified PPH as a key cause reflects this global priority. Similarly, hypertensive disorders (pre-eclampsia/eclampsia) are a top cause in Nigeria [3], and in our study a substantial proportion cited eclampsia or related hypertensive conditions. The concordance between health workers' perceptions and epidemiological reality is a positive sign; it means that training and experience have likely impressed upon them which complications are most deadly for mothers. A comparable study in south-western Nigeria found that 86.5% of midwives recognized hemorrhage and 80.9% recognized hypertensive disorders as major contributors to maternal deaths, demonstrating that Nigerian maternal health providers generally have good awareness of the principal causes of mortality [10]. Our data from Kaduna reinforce that frontline staff are not oblivious to what kills mothers – knowledge is widespread across different regions and cadres.

Despite the uniformly high knowledge, we did observe some interesting disparities. The logistic regression indicated that male health workers were significantly more likely to report familiarity than females. At first glance, this is surprising because women make up the majority of nurses and midwives who specialize in maternity care. One might expect female providers (who often have more hands-on obstetric experience in settings like Nigeria) to be at least as knowledgeable as their male counterparts. However, our sample's male subset likely included a higher proportion of physicians and senior clinicians, whereas the

female subset included many junior and mid-level cadres. It's possible that the male-female difference reflects a confounding of gender with professional role and training – for example, if most doctors were male and all doctors knew the definitions, this would drive up the male familiarity rate. In Nigeria, as in many countries, higher-level medical roles (surgeons, obstetricians) have historically had more male representation, while females dominate nursing and midwifery. If male health workers on average occupy higher cadres or receive more advanced training opportunities, they may indeed have greater confidence and knowledge of formal definitions. There could also be an element of confidence or response bias: male respondents might be more likely to assert they are knowledgeable, whereas female respondents (even if knowledgeable) might be slightly more cautious or modest in self-assessment. Without objective testing, we should be careful in interpretation. Nonetheless, this gender finding highlights the need to ensure equitable training and support for all health workers. Female providers form the backbone of maternal care; any gaps in their access to information or continuing education must be addressed. Prior research has not widely reported gender disparities in knowledge of maternal health, so our result may be context-specific. It underlines a potential area for further investigation: understanding whether female health workers have the same opportunities for professional development (e.g., workshops, seminars, mentorship) in maternal health as their male colleagues, and if not, making policy adjustments to bridge that gap.

Our analysis also showed that cadre differences were minimal in bivariate terms – virtually all types of providers reported high familiarity – but the regression singled out Community Health Officers (CHOs) as having especially high odds of knowledge (compared to the reference group of hospital attendants). CHOs in Nigeria are higher-level community health providers, often with additional training in public health and supervisory roles over frontline workers. The fact that CHOs almost unanimously knew the definitions (aOR ~31, $P = 0.017$) is reassuring: it suggests that those charged with overseeing primary health services are well-informed about maternal death causes and likely able to mentor others. The very low knowledge among the reference category (hospital attendants) is understandable – hospital attendants are support staff (orderlies) who may not have clinical training in obstetrics. In our sample, a few hospital attendants answered "No" (not familiar), which dragged their group's average down. This highlights that non-clinical support staff might lack even basic knowledge of obstetric concepts, which could matter if they are present during emergencies or needed to assist in some way. However, one could argue that it's not expected for hospital aides to know medical definitions; the key is that the trained clinical staff (doctors, nurses, midwives, CHOs, CHEWs) overwhelmingly did know them. Notably, nurses/midwives and CHEWs – who together comprised the majority of our respondents – had near-universal familiarity. This is important because these cadres conduct most maternity care, especially at primary and secondary levels. Our findings imply that training curricula for nurses, midwives, and community health workers in Nigeria are effectively imparting knowledge of major maternal mortality causes. Even those with only certificate-level training were as likely to know the definitions as those with degrees, suggesting a commendable penetration of basic maternal health knowledge into lower-tier health education programs.

It is instructive to compare our results with other studies on health worker knowledge and system factors, though direct parallels are few. One relevant area is knowledge of the maternal death surveillance and response (MDSR) process. In Tanzania, for instance, only 29.2% of health workers had adequate knowledge of

the MPDSR system (which includes understanding how to report and review maternal deaths) [4]. Predictors of better knowledge in that study were working at higher-level hospitals and having received training on MDSR [4, 11]. By contrast, in our study nearly all workers knew about causes of death, and neither facility level nor formal education level showed an effect. This disparity might be because knowing clinical definitions of causes is more basic and has been emphasized for a long time, whereas knowing procedural frameworks like MDSR (introduced more recently) requires specific training which many have not received [4]. In Nigeria, gaps in training and practice around maternal death audits have been documented. Studies on maternal death review in Nigerian hospitals noted that while awareness of the concept was fairly high, there were "significant gaps in training, experience, and institutional support" for conducting effective reviews [5, 12]. Many healthcare workers lacked confidence in how to systematically review a death or implement changes [5, 13]. Our finding of universally high self-reported knowledge should therefore be interpreted with caution – knowing the name or definition of a cause (e.g., PPH) is not the same as being able to manage it or to critically audit a case where it occurred. There may be an element of overestimation in self-report; health workers could be inclined to answer "yes, I know that" even if their understanding is superficial, due to social desirability bias. Future research could incorporate objective quizzes or case simulations to verify actual knowledge levels.

Importantly, the persistence of high maternal mortality in Nigeria despite health workers' awareness of causes points to the fact that knowledge alone is not enough. Nigeria's maternal mortality ratio remains extremely high (over 1000 per 100,000 in 2020) [3, 14], and has even risen in recent years despite global declines. This paradox can be explained by the well-known "Three Delays" model [1]: delays in seeking care, delays in reaching care, and delays in receiving quality care all contribute to maternal deaths. Health worker knowledge addresses just one component of quality care. Our study suggests that within the facility, providers are at least aware of what they should be treating. However, if the health system lacks essential supplies or adequate staffing, the outcome may not improve. For example, a midwife might know she is dealing with postpartum hemorrhage, but if the primary health center has no blood for transfusion, or no uterotonics in stock, that knowledge cannot save the woman's life. Systemic issues such as inadequate equipment, medication shortages, weak referral systems, and workforce shortages continue to plague maternal health services in Nigeria [1, 3]. Indeed, Nigeria faces a shortage of skilled health workers in rural and underserved areas [2, 10], meaning that many women deliver without any trained provider present. Our study focused on those who *are* in the system; we did not capture the knowledge (or lack) among unskilled birth attendants or community members, which is where further gaps likely exist. Additionally, the fact that ~12% of our respondents pointed to "medical mismanagement" as a cause of death is telling – it reflects that health workers themselves perceive failures in the system or clinical care (such as incorrect treatment, delayed interventions, or human error) as contributing to maternal loss. This aligns with findings from hospital-based maternal death audits in Nigeria, which frequently identify substandard care or provider mistakes in a significant fraction of maternal deaths [2, 15]. It takes more than knowledge to overcome such issues; it requires accountability, adequate training on practical skills (not just definitions), teamwork, and system support.

Our analysis did not find facility-level differences in knowledge, which is somewhat surprising. We anticipated that staff at tertiary hospitals (which typically have specialists and are sites for advanced training) might have

higher familiarity, or conversely that primary health center staff (often with lower qualifications) might have gaps. The lack of difference could indicate that even primary-level workers have been exposed to the key maternal health concepts, perhaps through Nigeria's training programs for lower cadres. For instance, the Midwives Service Scheme and various in-service trainings in Nigeria have aimed to update skills of primary healthcare workers in maternal care [16]. It could also be that our question was too basic to capture subtle knowledge differences – knowing what "postpartum hemorrhage" means is common knowledge for any trained birth attendant, but more detailed clinical knowledge (e.g., proper active management of third stage of labor, or criteria for sepsis) might differ by facility level. Some studies mentioned, working at a hospital (higher level) was associated with better MDSR knowledge [4, 17]; by analogy, one might expect tertiary hospital staff in Nigeria to better understand formal protocols. However, our result suggests that knowledge dissemination has been relatively uniform, or that those who lacked knowledge were so few that statistical power to see facility differences was low.

In comparing cadres, aside from CHOs vs. attendants, we didn't see strong differences between, say, nurses and doctors. This could be partly due to the near-ceiling effect (everyone knows the basics). It's worth noting, however, that all doctors reported full familiarity, which is good but also expected given their training. The challenge is ensuring *every* birth is attended by someone who knows what to do. Unfortunately, in Nigeria a large fraction of births – especially in rural areas – still occur at home or in under-resourced settings without skilled providers [8, 18]. That context is outside the scope of our survey (which covered those within the health facilities), but it reminds us that knowledge within the health system must be paired with community outreach and improved service utilization. Even the most knowledgeable health worker cannot save a mother they never see because she delivers at home without care. Interventions to reduce maternal mortality must be multi-pronged: improve community awareness (so families seek care promptly), improve access (so women can reach facilities in time), and improve quality of care at facilities (where our study fits in) [3, 17].

One notable finding we should discuss is the implication of "medical mismanagement" being frequently cited by respondents as a cause of maternal death. This reflects a level of insight and candor among health workers – they acknowledge that beyond medical conditions like hemorrhage or eclampsia, the way care is delivered can itself be life-saving or lethal. Issues such as delay in treatment, incorrect clinical decisions, lack of adherence to protocols, or communication failures are encapsulated in "mismanagement." This resonates with literature on avoidable factors in maternal deaths. A significant proportion of maternal deaths in hospitals have been attributed to suboptimal care ("third delay") in studies from Nigeria [2, 19] and other LMICs [1]. Our respondents' awareness of this suggests that they recognize the need for improving clinical management and health system functioning. It also underscores why continued training and quality improvement are critical. Knowledge of definitions is only the first step; health workers must also be trained in the correct *actions* to manage hemorrhage (like uterotonic use, uterine massage, IV fluids, blood transfusion) or eclampsia (magnesium sulfate, blood pressure control, timely delivery), and in team communication and referral procedures. Regular emergency drills and updates (e.g., on pre-eclampsia management protocols) could help translate knowledge into practice. The WHO and other partners have developed numerous training guidelines for obstetric emergencies that should be utilized [2]. Indeed, WHO advocates not just for training but also for establishing systems of accountability and review – for example,

conducting maternal death audits and *feedback loops* so that mismanagement issues are identified and corrected in each facility [20]. A previous study in Nigeria highlighted that instituting mandatory maternal death reviews in all hospitals and providing continuous training on quality obstetric care were key recommendations to prevent future deaths [5]. Our findings reinforce that health workers are receptive to this; they know when things go wrong, and with proper support, they could be changing agents in improving care.

Strengths and Limitations: This study benefited from a large sample covering diverse health facilities and worker cadres in Kaduna State, which improves the generalizability of the findings to similar settings in Nigeria. By focusing on familiarity with standard definitions, we shed light on a foundational aspect of provider knowledge that is less frequently assessed in research (most studies focus on clinical skills or service coverage rather than definition knowledge). However, there are notable limitations. The measure of "familiarity" was self-reported and not validated by an objective test – it is possible some respondents overestimated their knowledge. We did not probe the depth of their understanding; for instance, a respondent might say they know what "sepsis" means but might not accurately list its diagnostic criteria. Moreover, the high proportion of "yes" answers led to limited variability, making it hard to statistically detect differences – a classic ceiling effect. This could have masked some true differences in knowledge quality. Another limitation is the cross-sectional nature: we captured knowledge at one point in time and cannot ascertain causality or changes over time. It would be insightful to know if training programs in recent years have improved knowledge compared to earlier cohorts, but our data can't address that. Finally, our study did not directly measure how this knowledge (or lack thereof) impacted actual maternal outcomes. We assume that better knowledge is beneficial for care, but it would require linkage of provider knowledge to patient results to confirm that, which was beyond our scope.

Conclusion

This study highlights that in Kaduna State, Nigeria, frontline health workers largely recognize and understand the major causes of maternal mortality, which is a positive foundation for tackling the maternal health crisis. The vast majority (over 96%) of surveyed doctors, midwives, nurses, and community health workers reported being familiar with the clinical definitions of key maternal death causes such as hemorrhage and eclampsia. Knowledge was consistently high across different levels of the health system, suggesting that even lower-tier facilities and mid-level cadres have been reached with basic maternal health education. However, subtle gaps exist: female health workers and the lowest-cadre staff were slightly more likely to lack familiarity, indicating a need to ensure no group is left behind in training efforts. Moreover, knowing the cause of death is only the first step – the health system must empower workers with the skills, resources, and support to prevent and manage those causes effectively.

Based on our findings and the broader literature, we recommend the following actions to strengthen maternal health outcomes in Nigeria and similar contexts:

Continuous Training and Education: Implement regular in-service training programs for all maternal healthcare providers, with updated evidence-based protocols. Simulation drills for managing obstetric emergencies (postpartum hemorrhage, eclampsia, etc.) should be held to reinforce practical skills. Ongoing continuing medical education and refresher courses will ensure that knowledge of definitions translates into correct actions [1]. Training should also target areas of identified weakness, such as proper use of the Maternal Death Surveillance and Response (MDSR) system, where knowledge gaps persist [4, 5].

Promote Gender Equity in Capacity Building: Recognize and address any gender disparities in training opportunities and professional development. Female health workers (who form the bulk of the maternal health workforce) should have equal access to advanced training, leadership roles, and decision-making forums. Encouraging mentorship programs and supportive supervision can build confidence among all providers regardless of gender. Ensuring that both men and women in healthcare receive support will maximize the entire team's competency and morale.

Strengthen Lower-Tier Facilities: Prioritize investments in primary and secondary healthcare facilities so that knowledge can be effectively utilized. This means equipping these facilities with essential medications (uterotonics, anticonvulsants, antibiotics), blood transfusion capabilities, and basic emergency obstetric equipment (IV fluids, surgical supplies) [9, 21]. Many maternal deaths occur in or near communities where the first point of care is a primary health center; thus, these centers must be empowered to handle common complications or stabilize and refer promptly. A robust referral system is critical – e.g., provision of ambulances and communication networks to ensure patients can be transferred to higher-level care without delay [19]. Strengthening rural and peripheral facilities will reduce the burden on tertiary hospitals and bring life-saving care closer to where women live.

Accountability through Maternal Death Reviews: Institutionalize and enforce the practice of Maternal and Perinatal Death Surveillance and Response (MPDSR) in all health facilities. Every maternal death should trigger a no-blame, in-depth review by a committee of doctors, midwives, and administrators to identify causes (medical and systemic) and develop action plans. Our findings show health workers are aware of problems like "medical mismanagement"; MPDSR meetings can channel this awareness into concrete solutions. The government should support this by formal policy (as recommended by experts [5, 16], by training health workers in audit techniques, and by ensuring that recommendations from audits (e.g., need for blood bank, training gaps) are followed up and funded. Such reviews not only help learn from mistakes but also foster a culture of continuous improvement and accountability.

Broader Health System Improvements: Finally, reducing maternal mortality requires a comprehensive approach. Alongside improving health worker knowledge and facility readiness, efforts must address community factors. We echo calls for increased public awareness so that pregnant women and their families recognize danger signs and seek care early [3, 21]. Removing financial and transportation barriers is also crucial – policies like emergency transport schemes or subsidized maternal care can mitigate the first two delays. At the health system level, increasing the number of skilled health workers in underserved areas is imperative [3]. This could involve expanding midwifery and obstetric training programs, incentive schemes to deploy staff to rural clinics, and improving working conditions so that trained providers remain in the system.

In conclusion, health workers in Kaduna State demonstrate strong knowledge of maternal death causes, providing a necessary underpinning for quality maternal healthcare. The challenge ahead lies in converting this knowledge into effective action – through ongoing training, equitable support, and system reforms that empower providers to deliver timely, lifesaving interventions. By investing in health worker capacity and the infrastructure they operate in, Nigeria can make meaningful progress toward curbing its unacceptably high maternal mortality rate. Every maternal death is a tragedy, but it is often also a learning opportunity; with a knowledgeable workforce and responsive health system, those lessons can be applied to prevent the next tragedy.

Achieving the Sustainable Development Goal of maternal mortality reduction will require sustained commitment to both human resource development and health system strengthening, ensuring that no woman dies from causes that we have long known how to prevent or treat [1, 3]. The findings from this study affirm that we have a knowledgeable foundation of providers – now we must support them with the necessary tools, environment, and policies to translate knowledge into safe motherhood for all.

Declarations

Ethics Approval and Consent to Participate

The study was done according to Helsinki's declaration and National Code of Health Research Ethics (2006) [21, 22] Federal Ministry of Health, Nigeria, with approval given by Kaduna state ministry of Health ethical committee with approval number NHREC/17/03/2018/ MOH/ADM/744/VOL1/111021 dated December 12, 2023.

Consent for Publication

Not applicable.

Availability of Data and Materials

Data are available from the corresponding author upon reasonable request.

Competing Interests

The authors declare that they have no competing interests.

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Authors' Contributions

SB contributed to study design, data collection, and manuscript drafting. SGI conducted data analysis, interpretation, and manuscript finalization. Both authors read and approved the final manuscript.

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