Maternal death at Leratong Regional Hospital: a six-year retrospective review, South Africa.

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DECLARATION

I, Tumelo Ngaka Motau (student nr 916177) declare that this research report consists of my own work. It is being submitted for the Degree of Masters of Medicine in Obstetrics and Gynaecology at the University of Witwatersrand, Johannesburg. It has not been submitted before for any other degree or examination at this or any other University.

On this day 29 day of November 2021 in Johannesburg.

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ABSTRACT

Background

The aim of the study was to systematically examine the main causes of maternal deaths and contributing factors at Leratong Regional Hospital in order to recommend strategies that can assist in reducing maternal mortality at this level of healthcare.

Objectives

The objectives of the study were to: determine the institutional maternal mortality rate at Leratong Regional Hospital between 2012 to 2017, compare the trend (year on year) in the iMMR over the study period, describe the profile of women who died during the period under study, describe the clinical and surgical management of the women who died, and to determine the leading causes of maternal deaths, contributing factors and avoidable factors.

Methods

A hospital based retrospective study based on patient clinical records at Leratong hospital. it included all the maternal deaths that occurred at Leratong Regional Hospital during the six-year study period (2012-2017).

Results

There was a total of 78 maternal deaths with 32441 live births giving the MMR of 240 per 100 000 live births. However only 74 files could be analysed. The results showed that there was a rise in the maternal mortality rate over a six years period. The majority (70, 94.5%) of the women who died were African, aged between 20-35 years (56, 76%), multigravida (54, 73%) with a parity of three or more (23, 31%). Obstetric haemorrhage was the leading cause of maternal death particularly postpartum haemorrhage (11.14%) followed by non-pregnancy related infections, sepsis and eclampsia.

Conclusion

Maternal mortality has decreased according to recent confidential enquiry into maternal death in South Africa (2017-2019)[9] However our study did not demonstrate a decline but rather an increase in the maternal mortality rate at Leratong. It showed that most of the maternal deaths were avoidable and the need for urgent interventions in terms of education, improving access to health care facilities, intensifying health care worker skills training and better transport systems between health care facilities is important.

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ABBREVIATIONS

AA	Anaesthetic related death
AC	Acute collapse
AIDS	Acquired Immune Deficiency Syndrome
AF	Avoidable factors
APH	Antepartum haemorrhage
ARV	Antiretroviral drugs
BLDACD	Bleeding during or after caesarean delivery
CEMD	Confidential enquires into maternal deaths
CFR	Case Fatality Rate
CHC	Community Health Centre
CS	Caesarean Section
Decl.	Declined
DIC	Disseminated Intravascular Coagulation
DH	District Hospital
EC	Eastern Cape
Ec	Ectopic pregnancy
Em	Embolism
EMS	Emergency Medical Services
EOST	Emergency Obstetric Simulation Training
ESMOE	Essential Steps in Managing Obstetric Emergencies
FS	Free State
GP	Gauteng
HAART	Highly active antiretroviral therapy

HC	High Care
HCP	Health Care Professional
HG	Hyperemesis Gravidarum
HPT	Hypertension
ICU	Intensive Care Unit
iMMR	Institutional Maternal Mortality Ratio
KZN	Kwa-Zulu Natal
LP	Limpopo
LRH	Leratong Regional Hospital
MD	Maternal Disorders
MDG	Millennium Developmental Goals
Misc	Miscarriage
MP	Mpumalanga
MMR	Maternal Mortality Ratio
NC	Northern Cape
NCCEMD	National Committee for the Confidential Enquires into Maternal Death
Neg.	Negative
NPRI	Non Pregnancy related infections
NNDR	Neo Natal Death Rate
NW	North West
ObsH	Obstetric Haemorrhage
PCP	Pneumocystis carina pneumonia
PNMR	Perinatal Mortality Rate
Pos.	Positive
PPH	Postpartum Haemorrhage

PH	Provincial Hospital
PRS	Pregnancy Related Sepsis
RH	Regional Hospital
SMGL	Saving Mothers Giving Life
TH	Tertiary Hospital
TB	Tuberculosis
UN	United Nation
Unk.	Unknown
UHC	Universal Health Coverage
WC	Western Cape

PROTOCOL AND EXTENDED LITERATURE REVIEW

Introduction

Maternal mortality is an important indicator of the effectiveness of health care systems and the status of the women in society.[1] Deficiencies in the quality of maternal health services, in-patient transport, the provision of emergency obstetric care and the availability of intensive care units has led to poor maternal outcomes.[2]

Challenges associated with maternal death are multifactorial as many health care systems remain underfunded, especially in the public sector and therefore struggle to provide basic health services.[3] Maternal deaths is defined as the "death of a woman whilst pregnant or six weeks postpartum irrespective of the location or duration of the pregnancy, from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes".[4]

The Sustainable Developmental Goals committee aim to reduce the global maternal mortality rate to less than 70 per 100 000 live births by 2030, as well as to institute a national target that no country should have a maternal mortality rate more than 140 per 100 000 live births by 2030.[5] Although advances have been achieved in reducing maternal mortality (45% reduction globally), more still needs to be done to meet the SDG agenda.[5, 6]

Developing countries constituted approximately 99% of the global maternal deaths in 2015 with the sub-Saharan Africa alone comprising of an estimated 66% of the maternal deaths.[6] The lifetime risk of maternal death was approximately 1 in 36 in sub-Saharan Africa and roughly 1 in 4900 in developed countries[6]. India has the greatest number of maternal mortalities in the world and accounts for 22% of all maternal deaths.[7]

The seventh triennial report on Confidential Enquiry into Maternal Deaths in South Africa found that tertiary hospitals had the highest maternal deaths despite contributing only 8% to the total national deliveries.[8] According to this report, 25% of the mothers who died in tertiary hospitals were initially seen and managed at regional hospitals. There is therefore a need to review maternal deaths in regional hospitals in order to understand the causes, main drivers including contributing and avoidable factors.

South Africa has not escaped the burden of high maternal mortality rates and still faces the challenges related to lack of skilled health care personnel (general practitioners, nurses,

midwives and obstetricians in particular), lack of equipment and appropriate inter-facility referral systems. It was found that 62.4% of maternal deaths were potentially preventable, indicating inadequate quality of care during antenatal, delivery and post-delivery periods.[9] Leratong Hospital is a regional hospital (LRH) located in Gauteng province in South Africa. The hospital is a referral centre for 3 district hospitals, 17 clinics and 3 Maternity Outpatient Units. A comprehensive review of maternal deaths at LRH hospital has not been established as yet, therefore the aim of the study is to systematically assess the main causes of maternal deaths and identify the associated avoidable factors in order to recommend strategies that can assist in reducing maternal mortality at this level of healthcare.

Methods

The study was a hospital based retrospective cross-sectional study based on patient clinical records and it included all the maternal deaths that occurred at Leratong Regional Hospital during the six-year study period (2012-2017).

Leratong Regional Hospital is one of the regional hospitals affiliated with the University of Witwatersrand and is situated in the West Rand Johannesburg, South Africa. According to the West Rand District Municipality population estimates of 2016, the total population of West Rand was approximately 820 594. The department of obstetrics and gynaecology has a compliment of two consultants (one full time and one sessional consultant), thirteen medical officers, seven interns, twelve advanced midwives, three senior professional nurses and four professional nurses respectively. The department has 112 beds between obstetrics and gynaecology wards respectively and one outpatient's department. Maternity ward comprises of 28 beds and performs approximately 400 deliveries per month including both normal vaginal and caesarean section deliveries with the caesarean section rate of approximately 32%.

Data collection and analysis

Once a maternal death has taken place the case is discussed in the department within 48 hours of the death to identify avoidable factors and to remedy them appropriately. Further discussions regarding the death takes place at our next maternal mortality and morbidity meeting.

When a maternal death occurs the provincial maternal and child health coordinator is informed who will allocate it a particular number. A Maternal Death Notification Form (MDNF) is completed and together with the photocopy of all clinical records is sent to the coordinator. The maternal death is then assessed by teams of independent provincial

assessors which include obstetricians, midwives, medical officers, and anaesthetists when indicated.

Causes and avoidable factors are identified by the assessor using a structured form. The data is then entered into an electronic data collection system the Maternal Morbidity and Mortality Audit System.

We reviewed cases of maternal deaths using patient's records from the hospital. Data of maternal mortality audit reports conducted at Leratong Regional Hospital during the study period was also used to supplement the information from patients' clinical files. Information of patients whose files were missing was sought from the death register or mortuary. Any outstanding laboratory results not in-patient records was accessed on the National Health Laboratory Services (NHLS) with permission from the hospital ethical committee.

Antenatal, intra-partum and postpartum information of maternal deaths identified was extracted from the patients' records using a structured questionnaire. Data was captured on Research Electronic Data Capture (REDCap®) and exported onto, and managed on Microsoft Excel 2010. Analysis was done with Stata®13.0 software. Descriptive statistics we collected and analysed using frequency.

Permission for the maternal mortality research review was obtained from the head of the department of Obstetrics and Gynaecology, the clinical manager and the Chief Executive officer at Leratong Regional Hospital. Ethics clearance was obtained from the Human Research Ethics Committee (HREC) of the University of the Witwatersrand (M200554 MED20-04-026)

Results

There was a total of 39870 deliveries, 32441 livebirths and 78 maternal deaths in the six-year study period. This translated into 13 maternal deaths §per annum and an institutional mortality of 240 per 100 000 livebirths. Overall institutional maternal mortality (iMMR) fluctuated over the six-year study period but did not demonstrate statistically linear trend for the study period (p =0.204).

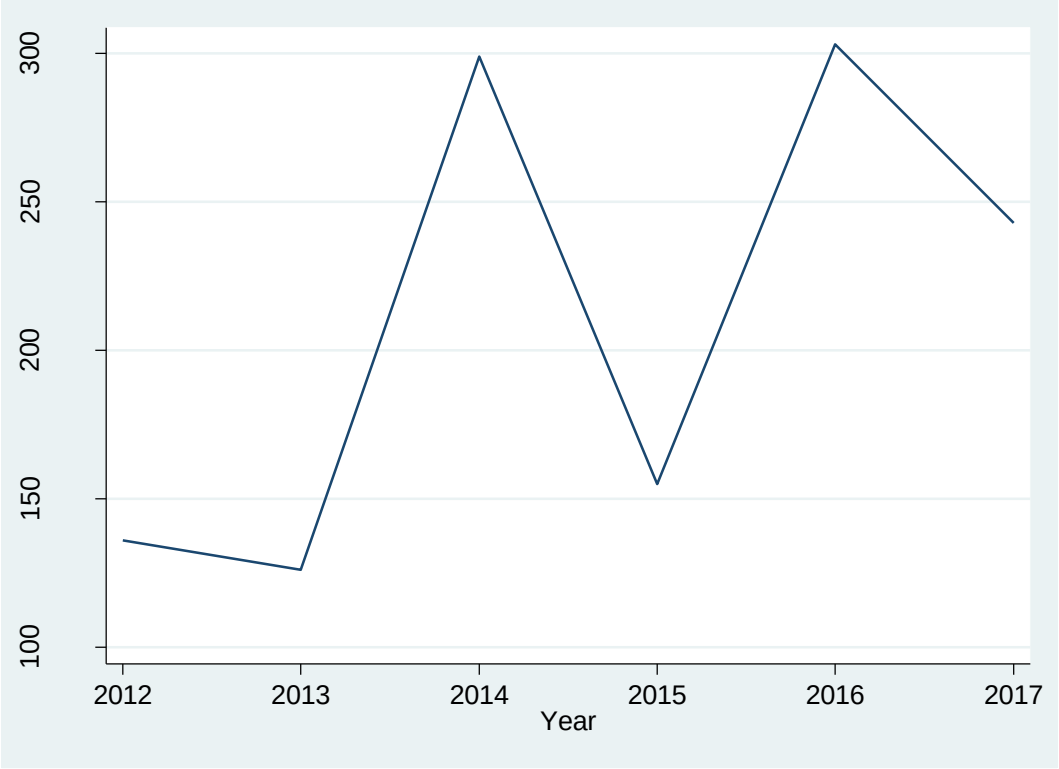

Figure 1: Institutional maternal mortality rate (iMMR) for the period 2012 – 2017 at Leratong Hospital.

As observed in **Table 1** the majority (70, 94.5%) of the women who died were African, aged between 20-35 years (56, 76%), multigravida (54, 73%) with a parity of three or more (23, 31%). In terms of social history most of the women did not consume alcohol (62, 84%), smoked (60, 81%), nor used drugs (62, 84%).

Table 1 Patients' maternal characteristics

Maternal characteristics	**Frequency**	
	N (74)	**%**
Age		
Less than 20 years	6	8.1
20 - 35 years	56	75.6
Greater than 35 years	12	16.2
Gravidity		
One	7	9.5
Two	0	0.0
Three	14	18.9
Four	24	32.4

Five	16	21.6
Six	7	9.5
Seven	4	5.4
Eight	2	2.7
Gravidity category		
Primigravida	7	9.5
Multigravida	54	73.0
Grand multigravida	13	17.5
Parity		
1	8	10.8
2	11	14.9
3	23	31.1
4	21	28.4
5	8	10.8
6	2	2.7
7	1	1.3
Race		
African	70	94.5
Coloured	3	4.1
Indian	1	1.4
White	0	0.0
Alcohol history		
Yes	0	0.0
No	62	83.8
Unknown	12	16.2
Smoking history		
Yes	2	2.7
No	60	81.1
Unknown	12	16.2
Drugs		
Unknown	12	16.2
Yes	0	0.0
No	62	83.8

The results presented in Table 2 indicate that the majority of the women had no previous pregnancy related complications (40, 54%), no medical history (30, 41%) and no previous surgical history (43, 58%).

Table 2 Medical and surgical history

Characteristics	N	%
Previous pregnancy complications		
Previous C/S x1	4	5.4
Previous C/S x1 and miscarriage	3	4.1
Ectopic pregnancy	2	2.7
Preterm labour	3	4.1
Nil	40	54.1
Previous C/S x2 and ectopic pregnancy	1	1.4
Previous C/S x2 and diabetes and mellitus	1	1.4
Hypertension	1	1.4
Miscarriage	2	2.7
Unknown	17	23.0
Medical history		
Hypertension	3	4.0
Diabetes mellitus	1	1.4
Nil	30	40.5
HIV	23	31.1
Thyroid disease	1	1.4
Unknown	16	21.6
Surgical history		
Previous C/S x1	7	9.46
Previous C/S x2	2	2.70
Previous laparotomy	1	1.35
Nil	43	58.11
Previous ectopic	3	4.05
Previous C/S x1 and previous laparotomy	1	1.35
Unknown	17	22.97

As seen in Table 3 the majority of the women were booked patients (49, 66%) and received antenatal care at local clinics (31, 42%). Just short of a third (24, 32%) of the women did not receive antenatal care. In a higher population of women (34, 46%) there was no indication of the gestational age at booking. Majority of the women (56, 71%) were tested for HIV and (29, 39%) were HIV positive however CD 4 count was not recorded in the majority of the cases (61, 82%). Only (19, 26%) were on ART and the rest were not on treatment and the information regarding their treatment was unknown. Most of the women's booking Hb (35, 48%) and Hb at 36 weeks (51, 69%) were unknown. A great number of the women did not

attend antenatal clinic (27, 37%). A significant number of the women (25, 34%) were attended to by midwives.

Table 3 Patients' current pregnancy characteristics

Column1	Frequency	
	N	%
ANC Booking Status		
Yes	49	66.2
No	23	31.1
Unknown	2	2.7
Level of care		
Local clinic	31	41.9
District hospital	1	1.4
Regional hospital	1	1.4
Regional and district hospitals	1	1.4
Community Health Centre	10	13.5
Community Health Centre and tertiary hospital	1	1.4
Private hospital	1	2.7
Nil	24	32.4
Unknown	3	4.1
Gestational age at booking		
< 14 weeks	12	16.2
14 -25 weeks 6 days	24	32.4
26 - 40 weeks	4	5.4
Unknown	34	46.0
HIV		
Reactive	29	39.2
Non-reactive	27	36.5
Unknown	18	24.3
CD4		
<250	10	13.5
251 – 500	1	1.4
>500	2	2.7
Unknown	61	82.4
ART		
Yes	19	25.7
No	30	40.5
Defaulted	1	1.4
Unknown	24	32.4
Booking Hb		

< 8 g/dl	3	4.1
8 - 10 g/dl	7	9.6
> 10	28	38.4
Unknown	35	48.0
Hb at 36 weeks		
< 8 g/dl	1	1.4
8 - 10 g/dl	6	8.1
> 10	16	21.6
Unknown	51	68.9
Number of ANC visits		
None	27	36.5
1 – 3	13	17.5
4 – 6	20	27.0
7 – 9	1	1.4
> 10	0	0.0
Unknown	13	17.6
Health care worker providing ANC		
Doctor	10	13.5
Professional nurse	8	10.8
Midwife	25	33.8
Specialist	3	4.1
Others	0	0.0
Nil	22	29.7
Unknown	6	8.1
ANC complications		
Hypertension	10	13.5
Others	9	12.2
Nil	26	35.1
Unknown	29	39.2

As seen on Table 4 most of the women (39, 52%) did not go into spontaneous labour. A partograph was not used in many of the women (57, 77%). The majority of the women who died were undelivered (26, 35.1%) at the time of their death, (22 ,29%) had a normal vaginal delivery and (24, 32%) were all delivered by emergency caesarean section.

A large proportion of the babies were born alive (31, 42%) with (10, 13%) stillbirths. There were (13, 17%) babies born weighing more than 2500g, babies born at less than 26 weeks were (15, 20%).

Table 4 Patients' delivery characteristics

	N	%
Did labour occur?		
Yes	33	44.6
No	39	52.7
Unknown	2	2.7
Partogram used		
Yes	12	16.2
No	57	77.0
Unknown	5	6.8
Type of delivery		
Undelivered	26	35.1
Vaginal	22	29.7
Vaginal assisted vacuum	1	1.4
C/S	24	32.4
Unknown	1	1.4
Birth weight		
500 - 999g	4	5.4
1000-1499g	7	9.45
1500 - 1999g	5	6.75
2000 - 2499g	7	9.45
2500 – 3499	13	17.56
3500 - 3999g	3	4.1
4000g or more	0	0.0
Nil	26	35.13
Unknown	9	12.16
Outcome		
Alive	31	41.8
Stillborn	10	13.5
Early neonatal death	1	1.4
Late neonatal death	0	0.0
Not applicable	15	20.3
Unknown	17	22.9

It is observed from Table 5 that the time of intervention in most of the deaths occurred in the postpartum period (39, 53%) followed by intervention at the antenatal period (15, 20%) and early in pregnancy (10, 13%). Most of the women who died received blood transfusion (21, 28%) whilst a number of them were admitted in ICU (8, 11%) and in other women who died there was no intervention at all (6, 8%). A large proportion the women (25, 34%) had general anaesthesia and only a few had spinal anaesthesia (5, 6.9%).

Delay in patients seeking help was found to be the commonest contributory factor to the women dying (45, 60%) with lack of expertise, training and education by the health care workers being the second commonest contributory factor (24, 32%). Both lack of communication between health care workers, inappropriate diagnosis and management contributing a quarter of the associated factors (18, 25%).

Majority of administrative associated factors (19, 25%) of the women that died were associated with delay in EMS and lack of transport between healthcare facilities. Lack of human resources was associated with a small number of maternal deaths (6, 8%)

Table 5 Management

	Frequency	
	N	**%**
Timing of intervention		
Early pregnancy	10	13.5
Antenatal	15	20.3
Intra-partum	5	6.8
Postpartum	39	52.7
Intra-partum and postpartum	2	2.7
Unknown	3	4.0
Types of intervention		
Evacuation	4	5.5
Evacuation, transfusion, invasive monitoring, ICU and ICU ventilation	1	1.4
Evacuation and hysterectomy	1	1.4
Evacuation, invasive monitoring and ICU	1	1.4
Evacuation and high care	2	2.7
Transfusion	21	28.8
Transfusion and instrumental delivery	1	1.4
Transfusion, symphysiotomy, ICU and other	1	1.4
Transfusion, hysterectomy and ICU	1	1.4
Transfusion and manual removal of placenta	1	1.4
Transfusion, invasive monitoring and ICU	1	1.4
Transfusion and ICU	1	1.4
Laparotomy	1	1.4
Hysterectomy, ICU and ICU ventilation	1	1.4

Invasive monitoring	2	1.4
Invasive monitoring and ICU ventilation	2	2.7
ICU	8	11.0
ICU and ICU ventilation	2	2.7
ICU and other	1	1.4
High care	1	1.4
ICU ventilation	2	2.7
Other	10	13.7
Nil	6	8.2
Unknown	1	1.4
Type of anaesthesia		
General anaesthesia	25	34.3
Spinal	5	6.9
Epidural	0	0.0
Local	0	0.0
None	42	57.5
Unknown	1	1.4
Patient associated factors		
Nil	19	25.7
Delay in woman seeking help	45	60.8
Declined treatment or admission	5	6.8
Delay in woman seeking help and declined treatment or admission	3	4.1
Other	1	1.4
Unknown	1	1.4
Health care worker associated factors		
Nil	20	27.4
Lack of expertise, training or education	24	32.9
Lack of expertise, training or education and lack of communication between health workers	7	9.5
Lack of expertise, training or education and inappropriate diagnosis and management	11	15.1
Lack of expertise, training or education, lack of communication between health worker and inappropriate diagnosis and management	5	6.9
Lack of communication between health workers	2	2.7
Inappropriate diagnosis and management	3	4.1
Unknown	1	1.4
Administrative associated factors		
Nil	31	41.9
Lack of human resources	6	8.1

Lack of human resources and lack of transport between healthcare facilities	1	1.4
Lack of human resources and lack of facilities, equipment or consumables	3	4.1
Delay in EMS	19	25.7
Delay in EMS and lack of transport between healthcare facilities	2	2.7
Delay in EMS and lack of facilities, equipment or consumables	2	2.7
Lack of transport between healthcare facilities	2	2.7
Lack of transport between healthcare facilities and lack of facilities, equipment or consumables	3	4.1
Lack of facilities, equipment or consumables	4	5.4
Unknown	1	1.4

As presented in Table 6 half of the women who died were referred (37, 50%), whilst the other half (37, 50%) had no source of referral suggesting that they were not seen by any healthcare provider prior to their admission to the hospital. District hospitals referred most the women (18, 24%) and the reason for referral was unknown in 50% of the deaths.

Most of the women who died (45, 60%) were in a critical condition on admission and a demised between 26-40 weeks gestation (45, 60%). Target organ damage was found in a large number of women (39, 52%) with the other women not having any identifiable target organ damage (32, 43%).

In terms of the attending health care workers at the time of the deaths, a significant number of them (70, 94%) were seen by a doctor.

The primary cause of death in a large percentage (11, 14%) of women was due to postpartum haemorrhage and the final cause of death in most of the women was due to cardiorespiratory failure (20, 27%).

Delays in patients seeking help was the most contributing factor (16, 21%) and a number of them were diagnosed with hypertension (14, 18%). Most of the women who died (62, 82%) had no autopsy done while only a small number (11, 14%) had autopsies done.

Table 6 Reason for referral and admission

	N	%
Patient referred		
Yes	37	50.0
No	37	50.0
Source of referral		
Local clinic	13	17.6
District hospital	18	24.3
Tertiary hospital	1	1.4
Community Health Centre	1	1.4
Private hospital	3	4.1
Others	1	1.4
Nil	37	50
Reason for referral		
Cerebral haemorrhage	1	1.4
Collapse	4	5.4
Ectopic pregnancy	2	2.7
Goitre	1	1.4
Hypertensive disorders	11	14.8
Hypokalaemia	1	1.4
Infections	2	2.7
Obstetric haemorrhage	7	9.5
Prolonged labour	2	2.7
Relook laparotomy	1	1.4
Respiratory disorders	3	4.1
Unknown	39	52.7
Clinical condition on admission		
Stable	28	37.8
Critical	45	60.8
Unknown	1	1.4
Target organ damage		
Yes	39	52.7
No	32	43.2
Unknown	3	4.1
Timing of death		
Antenatal	33	44.6
Intrapartum	1	1.4
Postpartum	40	54.1
Unknown	0	0.0
Gestational age at death		
< 14 weeks	3	4.1
14 - 25weeks 6 days	12	16.2

26 - 40 weeks	45	60.8
Unknown	14	18.9
Health worker at hospital		
Doctor	70	94.6
Others	1	1.4
Unknown	3	4.1
Primary cause of death		
Anaesthetic	1	1.4
Cardiomyopathy	1	1.4
Cardiomyopathy and pulmonary oedema	1	1.4
Cerebrovascular accident	2	2.7
Complicated malaria	1	1.4
Eclampsia	7	9.5
Ectopic pregnancy	4	5.4
Gastroenteritis	1	1.4
Liver failure and postpartum haemorrhage	1	1.4
Organophosphate poisoning	3	4.1
Pneumonia (Pneumocystis Jiroveci Pneumonia)	4	5.4
Pulmonary emboli	5	6.8
Pulmonary oedema	2	2.7
Pulmonary tuberculosis	4	5.4
Postpartum haemorrhage	11	14.9
Post-surgical complication	1	1.4
Renal failure	2	2.7
Sepsis	8	10.8
Severe PET	5	6.8
Haemorrhage	2	2.7
Ante partum haemorrhage	3	4.1
Mitral valve stenosis	1	1.4
Unknown	4	5.4
Final cause of death		
Acute respiratory failure	9	12.2
Cardio-respiratory failure	20	27.0
Cardio-respiratory failure and disseminated intravascular coagulopathy	2	2.7
Cardiac arrest	5	6.8
Hypovolemic shock	7	9.5
Intracranial haemorrhage	7	9.5
Multi organ failure	14	18.9
Multi organ failure and disseminated intravascular coagulopathy	2	2.7
Pulmonary oedema	1	1.4
Cerebrovascular accident	2	2.7
Unknown	5	6.8
Contributory factors		

Anaemia	2	2.7
Anaemia and hypertension	1	1.4
Anaemia and inappropriate diagnosis and management	1	1.4
Anaemia and prolonged labour	1	1.4
Delay in transferring patient	4	5.4
Delay in transferring patient and lack of skill and training	1	1.4
Delay in seeking help	16	21.6
Delay in seeking help and defaulted treatment	1	1.4
Delay in seeking help and inappropriate diagnosis and management	1	1.4
Delay in performing hysterectomy	1	1.4
Delay in blood transfusion	1	1.4
Defaulted treatment	2	2.7
Diabetes mellitus	1	1.4
Diabetic ketoacidosis	1	1.4
Hypertension	14	18.9
HIV	3	4.1
Lack of skill and training	1	1.4
Prolonged labour	4	5.4
Prolonged labour and no syntocinon available	1	1.4
Previous c/s	2	2.7
Post-surgical complication	1	1.4
Placenta praevia major	2	2.7
Parasuicide	1	1.4
Unknown	11	14.9
Autopsy		
Yes	11	14.9
No	63	85.1

Discussion

The institutional maternal mortality rate at Leratong regional hospital in this study done between 2012 to 2017 was 240/100000 live births which is very high compared to reports from other studies.[9] Thus although there has been a general decrease in maternal deaths over the past six years. Leratong regional hospital in this study has recorded an increasing trend in its institutional maternal mortality rate during 2012 to 2017 study period.

Most women who died (75%) were between the ages of 20-35 years out of the 74 deaths followed by women over the age of 35 years (16.2%) with the least number of deaths occurring at less than 20 years of age (8%). This is consistent with other reports that found that as age progresses the mortality risk increases. A study done in Central Gujarat, India (2019) reported similar results. The study showed that most maternal deaths (83.1%)

occurred between the ages of 20–34 years with the MMR rising significantly in women of 35 years old and above.[10]The reason for the decline in the numbers of women dying at less than 20 years of age might be due to increased use of contraceptives or termination of pregnancies according to that study. In South Africa the number of women of reproductive age who use .modern contraceptive methods to protect them from unplanned pregnancies has increased from 2002/2003 – 2013. The increasing numbers of terminations of pregnancy in women of reproductive age in South Africa implies that there is still a gap in accessing family planning services.[11]

In the present study out of the 74 deaths the majority of the women were multigravida (73%) followed by grand multiparous women (17.5%) and the least number of the deaths were primigravida (9.5%). Women with higher parity of three or more died (31.1%). Similar studies demonstrate that the more the number of pregnancies and the more the number of babies that reach viability the higher the risk of maternal death[5, 9]
Retrospective study by Fernandes observed that half of the women who died were multigravida followed by primigravida (47%) and grand multipara (2.5%).[12]

A large number of the women who died in this current study had no previous pregnancy complications (54.1%) while others had known previous pregnancy complications (23%) or had no known prior pregnancy complications (23%). As a result, the majority of the patients who died had no identifiable risk factors. Some studies have demonstrated that women who had complications during a previous pregnancy were at increased risk to develop severe morbidity in subsequent pregnancies.[13]
Most the women who died in the present study had no history of alcohol consumption, smoking or drug use (80%). High incidences of sexually transmitted infections and HIV infection together with conditions including but not limited to cardiac disease, antepartum haemorrhage, hypertension, fetuses with low weight and premature rupture of membranes were associated with substance abuse.[14, 15]

Antenatal care is known to be a contributing factor in improving pregnancy outcomes, with delayed booking being linked with increased maternal, fetal and infant mortality and

morbidity. In this present study the majority of the women who died were booked (66%) however only a few of the women who died attended antenatal clinic at least four to six times (27%). Reasons for lack of antenatal follow up visits are associated with lack of education, cultural and religious beliefs, having no partner, attitudes and knowledge regarding pregnancy. Other reasons include lack of access, affordability and availability of health care services.[16]

Most of the women who died were cared for at the local clinic (41%) and some of them at the community health centres (13.5%). Only a small number of women who died were cared for at private hospitals (2.7%) and others were seen at district hospitals (1.4%). According to Saving Mothers Report 2014-2016 reasons for the maternal deaths occurring at Tertiary Institutions was due to patients being referred from local clinics, community health centres, district hospitals and regional hospitals already in poor condition and having had poor quality of care.[8]

Most country guidelines recommend ANC visit within the first 16 weeks however some women in South Africa do not follow these guidelines and late booking remains common in many countries in sub-Saharan Africa.[17] The recommendation by the South African department of health is that pregnant women should have their first ANC visit before 20 weeks of pregnancy .[18]

HIV and complications associated with pregnancy remain the second leading causes of death for women of reproductive age globally.[19] Women living with HIV account for almost 18 million worldwide with greater than 90% of pregnant women living with HIV residing in sub-Saharan Africa.[20.21]

Most of the women who died in this study were HIV positive (39%) and a large number of them were not on treatment (40%). The reasons for not taking their treatment was not established from their records. HIV is regarded as one of the most devastating infections during pregnancy having both ethical and medical implications.[22, 23, 24]

In Sub-Saharan Africa low adherence to ART is associated with fear of stigma, HIV status disclosure, young age, lack partner involvement, quality and timing of HIV testing.[25]

Another study found out that the main reasons for non-adherence was due to patient dissatisfaction with health care services, issues regarding ART and alternative medication, insufficient patient support and education.[26]

Based on a systematic review done in sub-Saharan Africa, HIV-infected pregnant women or those in the post-partum period were measured to have almost eight times the risk of death than non-HIV-infected women.[27]

In the present study a number of the women who died had no booking HB (48%) and a number of them had an HB of less than 8g/dl (4.1%). Most (68.9%) of the deaths had no known HB at 36 weeks gestation (68.9%). Approximately fifty percent of all pregnant women in low-income and middle-income countries are diagnosed with anaemia which affects thirty two million pregnant women worldwide.[28, 29]These women are at increased risk of anaemia because of the higher frequency of dietary iron deficiency among other medical conditions.[28, 30] Increased prevalence haemorrhage has been associated with anaemia .[31] ANC complications in this study of the deaths were unknown (39%) .

A partograph is one of the most valuable appropriate modalities used for monitoring of the progress of labour, maternal and fetal wellbeing. The partograph was initially named the Friedman's curve which was designed by Friedman in 1954 after a study on a significant number of patients in the USA .[32] Philpott and Castle improved the partograph by introducing the alert and action lines to assist with interventions during labour.[33] Obstructed and prolonged labour that lead to the majority of maternal deaths and complications could be prevented by the use of the partograph, which was found to be cost-effective and affordable.[34, 35] The partograph in the present study was not used in the majority of the women who were in labour (77%) and only a few of the women who were in labour were plotted on the partograph (16.2%).

Some of the women who died were undelivered (35.1%) while others delivered vaginally (29.7%), assisted delivery (1.4%) and emergency caesarean section (35.1%). There were (42.5%) live births (13.7%) stillbirths and (20.6%) of the births were non- viable. In one patient no record of the outcome was found.

In the present study most of the women died in the postpartum period (54%).These findings are in keeping with the results found in a study from a tertiary hospital of rural India wherein a large proportion of the women died in the postpartum period (48.85%).[36, 37]

Majority of the deaths (28.8%) required blood transfusion and some women needed ICU ventilation (11%) and evacuation of the uterus (5.5%) A large number of women who died (34.3%) had generalized anaesthesia and others had spinal anaesthesia (6.9%). In the present study deaths from an anaesthetic related cause were few (1.4%). General anaesthesia is associated with maternal mortality and morbidity. Some studies have suggested that the possible reasons associated with the increased risk of major haemorrhages was related to the lowered effect of anaesthetic agents on uterine contraction and platelet activity.[38, 39]
A larger number of women reaching facilities in poor clinical condition was attributed to their delay in seeking health care.[40-42] In the present study most of the deaths were associated with delay in patients seeking health care (60%) with some of the women of the women declining treatment (6.8%) or admission (6.8%). The challenges most related to health care-seeking behaviour may be attributed to women's autonomy, level of education, economic status, distance to the facility, attitudes about use of the health systems, recognition of disease its aetiology and the severity of symptoms.[43-46]

According to Saving Mothers report 2014-2016 cases dying due to bleeding at caesarean section was attributed to 33% due to lack of skilled doctors and 20% due lack of skilled nurses of cases post caesarean delivery. Lack of communication between health care workers, inappropriate diagnosis and management contributed 25% of the associated factors that led to the maternal deaths. In the present study lack of expertise, training and education was found to have contributed to the maternal deaths (32%). Appropriate referral systems and shortage of ambulances is of major concern.[47, 48] In South Africa medical and nursing staff shortages, backlogs in operating theatres and deficiencies in emergency transport services are a frequent challenge in the state-run health services.[49]

The Saving Mothers report 2017-2019 reported similar challenges with the national caesarean section delivery rate of 27.8% in South African and made recommendations to improve maternal outcomes related to bleeding during caesarean section including but not limited to a structured consultation on minimum standards for facilities to perform safe caesarean section, ESMOE training on post-partum haemorrhage and Surgical skills with availability of training videos on difficult caesarean sections. According this report the case fatality rate for South Africa was 145.7 deaths per 100,000 caesarean deliveries and for BLDACD it was 27.8. Despite these results the Maternal deaths from obstetrics haemorrhage decreased in part due to focused advocacy and training.[50]

Half of the women who died were referred from primary health centres (50%), community health centres, district hospitals and private hospital whilst the other half were not referred. Some of the deaths in the study were self-referrals (48%).
Most of the women who died were in critical condition on admission (60%) and majority of the deaths occurred in the postpartum period (54%). A large number of women (61%) died at gestational ages of between 26-40weeks with some women dying between 14-25 weeks gestation (16%) and others (4.2%) at less than 14 weeks gestation.

In this study the commonest direct cause of maternal death was obstetric haemorrhage (21.7%), postpartum haemorrhage accounting (14.9%), antepartum haemorrhage (4.1%). In South Africa hypertensive disorders and obstetric haemorrhage are major direct causes of maternal death and are the most preventable of all deaths.[51]

And in addition a large number of deaths were due to cardiorespiratory failure (27%) followed by multi organ failure (18.9%), acute respiratory failure (12.2%), hypovolaemic shock (9.5%), intracranial haemorrhage 9.5% and cardiac arrest 6.8%. Some reports have found that overall, 63% of maternal deaths were attributed to respiratory failure followed by immune system failure (62.8%) and septic shock (14.6%).[51]

The most common contributory factor of the deaths in this study was patient delay in seeking help (21.6%) followed by hypertension (18.9%), delay in transferring patients (5.4%), prolonged labour (5.4%) and HIV contributed (4.2%). Few women who died had anaemia (2.7%). Some studies found anaemia to be the major contributory factor leading to maternal death especially for non-pregnancy related infections, pregnancy related sepsis, obstetric haemorrhage and anaesthetic related deaths.[51]

In this study sepsis (10.8%) and non-pregnancy related infections (10.8%) were the second direct cause of maternal death particularly tuberculosis (5.4%) and pneumonia (5.4%). Eclampsia was the third cause of death (9.5%) with severe preeclampsia (6.8%) and pulmonary emboli (6.8%) being the fourth causes of death.

According to the trends in maternal deaths in South Africa Non pregnancy related deaths are still the most common cause of maternal mortality even though there has been a marked decline in the deaths due to the introduction of universal HIV testing and antiretroviral therapy for pregnant women together with TB screening.[52] Hypertensive disorders of pregnancy and Obstetric Haemorrhage were the second and third most common causes of maternal deaths according to Saving Mothers executive summary 2017-19.

Conclusion

Maternal mortality has decreased according to recent confidential enquiry into maternal death in South Africa however in contrast our findings in this study demonstrated a higher iMMR compared to the national average over the past six-year study period, therefore more still needs to be done to reach more desirable outcomes. This study highlighted the gaps that led to the maternal mortality at Leratong Regional hospital and demonstrated that most of the maternal deaths were avoidable necessitating the need for urgent interventions in terms of education, improving access to health care facilities to patients, intensifying health care worker skills training and better transport systems between health care facilities.

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APPENDIX 1: Approved Protocol

MATERNAL DEATH AT LERATONG REGIONAL HOSPITAL: A SIX YEAR RETROSPECTIVE REVIEW

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Department of Obstetrics and Gynaecology: Chris Hani Baragwanath Academic Hospital
Supervisor: Prof HL Chauke

1. INTRODUCTION

Maternal mortality is an important indicator of an effective health care system and the status of the women in society[1]. The death of a mother during pregnancy, childbirth or postpartum is one of the greatest tragedies that can occur within a family, and it has a wide range of consequences to the index child, other children, spouses, family members and the society at large. Deficiencies in the quality of maternal health services, most notably in patient transport, the availability of intensive care units and the provision of emergency obstetric care has led to poor maternal outcomes[2].

Challenges associated with maternal death are multifactorial as many health systems remain underfunded especially in the public sector and therefore struggle to provide basic health services[3]. Maternal death is defined as the "death of a women whilst pregnant or six weeks postpartum irrespective of the location or duration of the pregnancy, from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes"[4].

Developing countries accounted for approximately 99% of the global maternal deaths in 2015 with the sub-Saharan Africa alone accounting for an estimated 66% of the maternal deaths[5]. The life time risk of maternal mortality was estimated at 1 in 36 in sub-Saharan Africa and

approximately 1 in 4900 in developed countries[5]. India has the largest number of maternal deaths in the world and accounts for 22% of all maternal deaths[6].

The seventh triennial report on Confidential Enquiry into Maternal Deaths in South Africa found that tertiary hospitals had the highest maternal deaths despite contributing only 8% to the total national deliveries[7]. According to this report, 25% of the mothers who died in tertiary hospitals, were initially seen and managed at regional hospitals. There is therefore a need to review maternal deaths in regional hospitals in order to understand the causes, main drivers including contributing and avoidable factors.

Such knowledge could inform policy makers, managers, clinicians and other stakeholders as to which steps need to be taken to reduce this human tragedy. Leratong Hospital is a regional hospital located in Southern Africa in Gauteng province and it caters for 3 District hospitals, 17 clinics and 3 Maternity Outpatient Units.

Furthermore, LRT refers to 4 Tertiary hospitals, which are located in Gauteng. A comprehensive review of maternal deaths at LRT hospital has not been established as yet, therefore this study aims to fill this gap in response to the national findings of the high number of women who die in tertiary hospitals after being managed at regional hospitals.

Globally, the routine and complete information regarding maternal deaths has been a challenge as a result of insufficient data collection and absence of crucial registration systems[8]. Where such systems do exist, under-reporting continues to pose a major challenge to data accuracy[5, 8]. Understanding these causes and circumstances surrounding maternal deaths in regional hospitals will enhance the current efforts aimed at addressing this problem.

In the year 2000 the Millennium Development Goals were established, wherein eight international development goals for the year 2015 were established. Improvement in maternal health was the fifth MDG in which a global commitment was made to achieve a 75% reduction in the maternal mortality ratio by 2015[5, 9-11]. Overall, the global MMR declined by

2.6% per year between 1990 and 2013. Although there have been significant advancements in some of the MDGs, the progress has been slow[9].

As a result, the Sustainable Developmental Goals committee aimed to reduce the global maternal mortality rate to less than 70 per 100 000 live births by 2030 as well as to institute a supplementary national target that no country should have a maternal mortality rate greater than 140 per 100 000 live births by 2030[12]. Although progress has been made in reducing maternal mortality (45% reduction globally), more still needs to be done to meet the SDG agenda[5, 12].

A significant number of sub-Saharan African countries have reduced their maternal deaths by half. Asia, North Africa, Rwanda, Nepal, Eritrea, Cambodia and Equatorial Guinea have achieved more than 75 percent reduction in maternal mortality since 1990[13,14] . Uganda and Zambia on the other hand used the Saving Mother Giving Life model approach that resulted in a 35% reduction in the population-based maternal mortality ratio in one year (from 534 to 345 and from 310 to 202 per 100000 live births, respectively)[15].

South Africa has not escaped the burden of high maternal mortality rates and still faces the challenges related to lack of skilled health care personnel (doctors, nurses, midwives and obstetricians in particular), lack of equipment, appropriate inter-facility referral systems and the likes. It was found that 61% of maternal deaths were potentially preventable indicating inadequate quality of care during antenatal, delivery and post-delivery episodes[16].

Deaths due to Non-Pregnancy Related Infections have shown a steady decline including obstetric haemorrhage whilst maternal deaths from hypertensive disorders have increased[7, 16]. Therefore indicating that maternal deaths related to hypertensive disorders still need to be addressed.

2. PROBLEM STATEMENT

There is a mutual relationship between the functioning of a healthcare system and the status of women in society in relation to its maternal mortality rate [1]. Majority of the maternal deaths (61%) were found to be avoidable despite the availability of guidelines and protocols put in place to prevent and manage obstetric complications[7]. Over 300000 maternal deaths were reported in 2015 worldwide and the majority of these deaths occurred in sub-Saharan Africa[12].

In South Africa 4452 maternal deaths were recorded and the majority of these deaths were from regional hospitals[15]. Leratong is one of the regional hospitals situated in Gauteng province. As such it is not immune to the burden of maternal deaths experienced both locally and internationally. There has not been a comprehensive review of maternal deaths at LRH to date.

Therefore, there is a need to review maternal deaths in this regional hospital in order to understand the causes, main drivers, including contributing and avoidable factors. Such knowledge could inform policy makers, managers, clinicians and other stakeholders as to which steps need to be taken to reduce this human tragedy.

3. JUSTIFICATION

The high number of women who die in tertiary hospitals after being managed at regional hospitals is unacceptable[16]. Understanding the causes and circumstances surrounding maternal deaths in regional hospital will enhance the current efforts aimed at addressing this problem.

4. AIMS AND OBJECTIVES

The aim of the study is to systematically examine the main causes of maternal deaths and contributing factors at Leratong Regional Hospital in order to recommend strategies that can assist in reducing maternal mortality at this level of healthcare.

Specific Objectives:

4.1.1 To determine the institutional maternal mortality rate for LRH for 6 year period.

4.1.2 To compare the trend (year on year) in the iMMR in LRH over the 6 year study period.

4.1.3 To describe the profile of women who died in LRH during the period under study

4.1.4 To describe the clinical management of the women who died.

4.1.5 To describe the surgical management of the women who died.

4.1.6 To determine the leading causes of maternal deaths, contributing factors, and avoidable factors.

5. METHODS

5.1 Study design

This will be a hospital based retrospective cross sectional study based on patient clinical records.

5.2 Study Setting

The study will be carried out at LRH. This is one of the regional hospitals affiliated with the University of Witwatersrand and is situated in the West Rand Johannesburg, South Africa. According to the West Rand District Municipality population estimates of 2016, the total population of West Rand was approximately 820 594. The department of obstetrics and gynaecology has a compliment of two consultants (one sessional consultant), thirteen medical officers, seven interns, twelve advanced midwives, three senior professional nurses and four professional nurses respectively. The department has 112 beds between obstetrics and gynaecology wards respectively and one outpatients department. Maternity ward comprises of 28 beds and performs approximately 400 deliveries per month including both normal vaginal and caesarean section deliveries with the caesarean section rate of approximately 32%.

5.3 Study population

All maternal deaths that occurred at LRH during the six year study period

5.3.1 Inclusion and Exclusion Criteria

a. Inclusion

a.1 Maternal death is defined as death of a woman while pregnant or within 42 days postpartum irrespective of the gestational age or location of the pregnancy but not due to incidental or accidental causes[1].

a.2 Women who fulfil the above definition who were certified dead at LRH.

5.4 Sample size

All the maternal deaths that took place between 01 January 2012 to 31 December 2017.

6. DATA COLLECTION AND ANALYSIS

Once a maternal death occurs the clinical manager of the hospital and the next of kin is informed about the incident as soon as possible. Clinical discussions regarding the sequence of events leading to the maternal death is undertaken within three days in the department. The provincial maternal death coordinator and the provincial office is informed about the maternal death within three weeks of the incident. Maternal death notification form is completed and copies of all the relevant notes from medical, nursing and anaesthesiologist personnel are made. Maternal mortality and morbidity discussions are held within six weeks of the incident in the department of obstetrics and gynaecology at LRH. The maternal records are then archived for safe keeping.

The study will therefore review cases of maternal deaths using patient's records from the hospital. Data of maternal mortality audit reports conducted at LRH during the study period will also be used to supplement the information from patients' clinical files. Information of patients whose files are missing will be sought from the death register or mortuary. Any outstanding laboratory results not in-patient records will be accessed on the National Health Laboratory Services (NHLS) with permission from the hospital ethical committee. Antenatal, intra-partum and postpartum information of maternal deaths identified will be extracted from the patients' records using a structured questionnaire. Data will be captured on Research Electronic Data Capture (REDCap®) and exported onto, and managed on Microsoft Excel 2010. Analysis will be done with Stata®13.0 software. Descriptive statistics will be collected and analysed using frequency, range and mean, and presented in tables and graphs. Appendix A illustrates the type of information that will be collected from the patients records.

7. ETHICAL CONSIDERATIONS

Permission for the maternal mortality research review will be obtained from the head of the department of Obstetrics and Gynaecology, the clinical manager and the Chief Executive officer at LRH.

Ethical approval for the study will be sought from the University of the Witwatersrand's Human Research and Ethics Committee.

8. FUNDING

No specific study funding will need to be obtained as the researcher will bear all costs involved in conducting the research.

9. BUDGET

ITEM	COST
Protocol print out	**R 300**
Data collection sheet	**R 300**
Data analysis by Statistician	**R 3000**
TOTAL	**R3600**

10. TIMELINE

Task	**Jan-Feb 2019**	**Mar-Oct 2019**	**Oct-Nov 2019**	**Dec 2019 - Feb 2020**	**Mar – Apr 2020**	**May 2020**	**June-July 2020**
Postgraduate Protocol Review Committee	**X**						
Ethics application			**X**				
Institutional permission		**X**					
Data Collection				**X**			
Data analysis and article and thesis write-up					**X**		
Submission for examination						**X**	
Submission for publication							**X**

11. DISSEMINATION OF STUDY FINDINGS

Results will be shared with the department of obstetrics and gynaecology, hospital management at LRH and other interested parties within the department of health. When opportunities arise, the result of the study will be presented at local and international meetings.

12. LIMITATIONS OF THE STUDY

This is a retrospective review of patients' clinical records and therefore some of the files might be missing. Furthermore, there is a risk of missing/incomplete information on clinical records

APPENDIX 2: Data Collection Sheet

A. DEMOGRAPHIC INFORMATION
Age:____ **Gravidity:_____** **Parity:_____** **Race:** AF = African; CO = Coloured; In = Indian; WH = White; T=Other_____ (***please circle applicable choice)*** **Previous pregnancies and complications** 1._____ 2._____ 3._____ 4._____

Medical history

1._____

2._____

3._____

4._____

Surgical History

1._____

2._____

3._____

4._____

Social history (***please circle applicable choice)***

Alcohol Y/N

Smoking Y/N

Drugs Y/N

INDEX PREGNANCY(***please circle applicable choice)***

Booked: Y/N

Level of Care where booked(***please write applicable choice)***

Local Clinic/DH/RH/TH/CH/PrvH/_____

Other(specify)_____

Gestational age at booking:_____

Rh status:_____

HIV(***please circle applicable choice)***

Reactive/Non-reactive/Unknown

If Reactive, CD4 Count:_____

On ART? (***please circle applicable choice)*** Y/N/Unknown

If Yes, latest VL:_____

Booking HB:_____

HB at 36 weeks:_____

Level of health worker who provided antenatal care: Doctor/ Professional Nurse/Midwife (***please write applicable choice)*** _____

Other(specify)_____

Total number of ANC visits:_____

Antenatal complications:

1._____

2._____

3._____

4._____

MATERNAL DEATH

Level of care where the death occurred(***please write applicable choice)***

Local Clinic/DH/RH/TH/CH/PrvH:_____

Gestational Age at death:_____

Was the patient alive on admission? (***please circle applicable choice)*** Y/N

Was the patient referred? (***please circle applicable choice)*** Y/N

If referred from which level of Care? (***please write applicable choice)***

Local Clinic/DH/RH/TH/PrvH/Other(specify)_____

Reason for referral:_____

Diagnosis on admission:_____

Clinical Condition of admission(***please circle applicable choice)***:
Stable/Critical

Any target organ damage? (***please circle applicable choice)*** Y/N

Please provide details: _____

Timing of maternal death (***please circle applicable choice)***:
Antenatal/Intrapartum/Postpartum

Level of health worker who provided antenatal care: Doctor/ Professional Nurse/Midwife

(***please write applicable choice)*** _____

CAUSE OF DEATH

(*Note AIDS is NOT a primary cause of death – if the woman has AIDS please give the specific cause of death e.g. TB, pneumonia, meningitis, malaria, abortion, puerperal sepsis etc.)*

Primary (underlying) cause of death *(Please specify)*:_____

Final cause of death *(Please specify)*:_____

Contributory (or antecedent) factors*(Please specify)*:_____

Autopsy(***please circle applicable choice)*** Y/N

DELIVERY, PUERPERIUM AND NEONATAL INFORMATION

Did Labour occur? (***please circle applicable choice)*** Y/ N/Unknown

If "Y", was a partogram used? (***please circle applicable choice)*** Y/N

Type of Delivery(***please circle applicable choice)***

Undelivered/Vaginal/ Caesarean Section

Undelivered(***please circle applicable choice)*** Y/ N

Vaginal delivery(***please circle applicable choice)*** assisted/ unassisted

If assisted(***please circle applicable choice)*** Vacuum/forceps

Caesarean section(***please circle applicable choice)*** Y/ N

If "Y" was it an Emergency Caesarean Section/Elective Section
(***please circle applicable choice)***

If "Y" was the baby Alive/Stillborn(***please circle applicable choice)***

Baby Birthweight(g)_____

5 min Apgar_____

Outcome_____

Neonatal death_____

Comments on labour delivery and puerperium_____
_____
_____

INTERVENTIONS (Tick appropriate box)

Timing: Early pregnancy ☐ Antenatal ☐ Intrapartum ☐ Postpartum ☐

Other ☐ ***(please specify)_____***

Type of intervention: Evacuation ☐ Transfusion ☐ Instrumental delivery ☐

Anaesthesia – GA ☐
– Spinal ☐
– Epidural ☐
– Local ☐

Laparotomy ☐ Symphysiotomy ☐ Hysterectomy ☐

Manual removal of placenta ☐ Invasive monitoring ☐ ICU ☐ HC ☐

ICU ventilation***(please specify)_____***

Other***(please specify)_____***

IN YOUR OPINION DID ANY OF THE FOLLOWING FACTORS CONTRIBUTE TO THE DEATH OF THIS PATIENT?

Patient associated factors (***please circle applicable choice)*** Y/ N
(If "Y" please tick appropriate box)

Family Delay in woman seeking help ☐
Declined treatment or admission ☐

Other***(please specify)***_____

Health worker associated factors (***please circle applicable choice)*** Y/ N
(If "Y" please tick appropriate box)

Lack of expertise, training or education ☐
Lack of communication between health workers ☐
Inappropriate diagnosis and management ☐
Lack of transport from home to health care ☐

Other***(please specify)***_____

Administration associated factors(***please circle applicable choice)*** Y/ N
(If "Y" please tick appropriate box)

Lack of human resources ☐
Delay in EMS response ☐
Lack of transport between health care facilities ☐
Lack of facilities, equipment or consumables (drugs,beds,blood,fluids etc.) ☐

Other***(please specify)***_____

APPENDIX 3: Ethics Clearance Certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R49 Dr TN Motau

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M200554

NAME: (Principal Investigator)	Dr TN Motau
DEPARTMENT:	School of Clinical Medicine Department of Obststrics and Gynaecology Medical School University
PROJECT TITLE:	*Maternal death review at Leratong Regional Hospital: a six year retrospective study*
DATE CONSIDERED:	2020/05/29
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Professor L Chauke
APPROVED BY:	CB Penny Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	2021/07/08

This Clearance Certificate is valid for 5 years from the date of approval. An extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office secretariat on the 3rd floor, Phillip Tobias Building, Parktown, University of the Witwatersrand, Johannesburg.

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated from the research protocol as approved, I/we undertake to submit details to the Committee. **I agree to submit a yearly progress report**. When a funder requires annual re-certification, the application date will be one year after the date when the study was initially reviewed. In this case, the study was initially reviewed in **May** and therefore reports and re-certification will be due in the month of **May** each year. Unreported changes to the study may invalidate the clearance given by the HREC (Medical).

Signature of Principal Investigator — Date: 26/07/2021

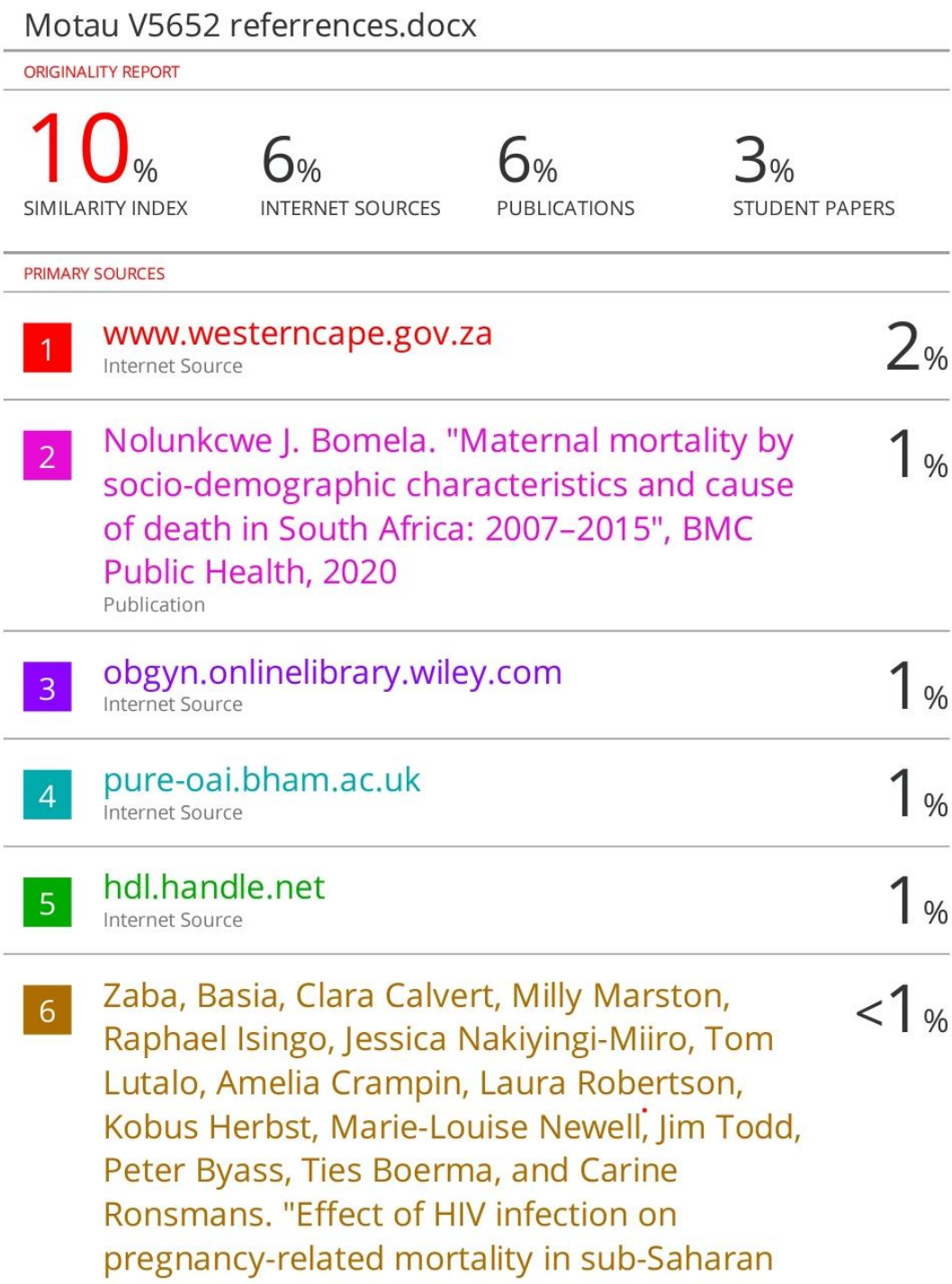
APPENDIX 4: Author Guidelines from PLOS ONE Journal

Manuscript files can be in the following formats: DOC, DOCX, or RTF. Microsoft Word documents should not be locked or protected. LaTeX manuscripts must be submitted as PDFs. Read the LaTeX guidelines.
Manuscripts can be any length. There are no restrictions on word count, number of figures, or amount of supporting information. We encourage you to present and discuss your findings concisely.
Use a standard font size and any standard font, except for the font named "Symbol". To add symbols to the manuscript, use the Insert → Symbol function in your word processor or paste in the appropriate Unicode character.
Limit manuscript sections and sub-sections to 3 heading levels. Make sure heading levels are clearly indicated in the manuscript text.
Manuscript text should be double-spaced. Do not format text in multiple columns.
Include page numbers and line numbers in the manuscript file. Use continuous line numbers (do not restart the numbering on each page).
Footnotes are not permitted. If your manuscript contains footnotes, move the information into the main text or the reference list, depending on the content.
Manuscripts must be submitted in English. You may submit translations of the manuscript or abstract as supporting information. Read the supporting information guidelines.
Define abbreviations upon first appearance in the text. Do not use non-standard abbreviations unless they appear at least three times in the text. Keep abbreviations to a minimum.
PLOS uses "Vancouver" style, as outlined in the ICMJE sample references. See reference formatting examples and additional instructions below.
We recommend using MathType for display and inline equations, as it will provide the most reliable outcome. If this is not possible, Equation Editor or Microsoft's Insert→Equation function is acceptable. Avoid using MathType, Equation Editor, or the Insert→Equation function to insert single variables (e.g., "$a^2 + b^2 = c^2$"), Greek or other symbols (e.g., β, Δ, or ′ [prime]), or mathematical operators (e.g., x, ≥, or ±) in running text. Wherever possible, insert single symbols as normal text with the correct Unicode (hex) values. Do not use MathType, Equation Editor, or the Insert→Equation function for only a portion of an equation. Rather, ensure that the entire equation is included. Equations should not contain a mix of different equation tools. Avoid "hybrid" inline or display equations, in which part is text and part is MathType, or part is MathType and part is Equation Editor.

Use correct and established nomenclature wherever possible.

Units of measurement	Use SI units. If you do not use these exclusively, provide the SI value in parentheses after each value. Read more about SI units.
Drugs	Provide the Recommended International Non-Proprietary Name (rINN).
Species names	Write in italics (e.g., *Homo sapiens*). Write out in full the genus and species, both in the title of the manuscript and at the first mention of an organism in a paper. After first mention, the first letter of the genus name followed by the full species name may be used (e.g., *H. sapiens*).
Genes, mutations, genotypes, and alleles	Write in italics. Use the recommended name by consulting the appropriate genetic nomenclature database (e.g., HGNC for human genes; we strongly recommend using this tool to check against previously approved names). It is sometimes advisable to indicate the synonyms for the gene the first time it appears in the text. Gene prefixes such as those used for oncogenes or cellular localization should be shown in roman typeface (e.g., v-fes, c-MYC).
Allergens	The systematic allergen nomenclature of the World Health Organization/International Union of Immunological Societies (WHO/IUIS) Allergen Nomenclature Sub-committee should be used for manuscripts that include the description or use of allergenic proteins. For manuscripts describing new allergens, the systematic name of the allergen should be approved by the WHO/IUIS Allergen Nomenclature Sub-Committee prior to manuscript publication. Examples of the systematic allergen nomenclature can be found at the WHO/IUIS Allergen Nomenclature site.

APPENDIX 5: Turnitin Originality Report



Motau V5652 referrences.docx

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