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Research Article

Assessment of the Depth of Uterine Cavity Prior to *In-Vitro* Fertilization in Black African Women

Abayomi B Ajayi[1], Bamgboye M Afolabi[2,3]*, Victor D Ajayi[1], Ifeoluwa O Oyetunji[1], Arati Sohoni[1] and Usman Yakubu[1]

[1]*Nordica Fertility Center, Norman-Williams Street, South-west Ikoyi Lagos, Nigeria*

[2]*Nigerian Institute of Medical Research, Edmond Crescent, Yaba, Lagos, Nigeria*

[3]*Health, Environment and Development Foundation, Ogunfunmi Street, Surulere, Lagos Nigeria*

***Corresponding Author:** Bamgboye M Afolabi, Nigerian Institute of Medical Research, Edmond Crescent, Yaba and Health, Environment and Development Foundation, Ogunfunmi Street, Surulere, Lagos Nigeria.

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Abstract

Introduction: Uterine cavity provides suitable site and environment for the implantation of a fertilized ovum and development of the embryo. Uterine cavity abnormalities can be a contributing cause of sub-fertility and recurrent implantation failure due to distortion of the anatomy of the cavity.

Purpose of Study: The relevance, importance and influence of the depth of placement of embryos into the uterine cavity has been reported by several authors. Some have suggested placing the embryos 1 - 1.5 cm short of the uterine fundus. Others have suggested better implantation rates with mid-cavity placements as higher placements may increase risk of ectopic pregnancies. Knowing the depth of the uterine cavity (DOUC), which can also be influenced by uterine pathology is important in In-vitro fertilization (IVF) practice and embryo transfer for best outcome.

Materials and Methods: This was a retrospective study of 1122 patients who presented for Assisted Reproductive Technology (ART) at Nordica Fertility Center in Nigeria between 2003 and 2014. Only Black African women with complete records and who presented solely for fertility management were included. All patients had either sonohysterogram or hysteroscopy to determine uterine cavity depth and the state of uterine cavity. Analysis was conducted with NCSS21 statistical software. Study was approved by the Nigerian Institute of Medical Research Review Board (NIMR-IRB-18-006).

Results: When the mean DOUC (cm) of those ≤ 35 years was compared to that of women aged >35 years, there was no observable variation; but overall remarkable difference was observed when the mean DOUC (cm) was assessed by BMI in which those with BMI < 18.5 (n = 12, 1.1%) had mean DOUC of 8.6 cm (F-test = 11129.9, P-value << 0.001). Regardless of age, those who had uterine fibroid alone (in ≤ 35 years, n = 28; in > 35 years, n = 101) had remarkable variation (t-statistic = -2.38, P-value = 0.02; t-statistic = -3.07, P-value = 0.02) in mean DOUC (9.3 ± 2.4 cm; 8.7 ± 1.5 cm respectively) compared with those without any uterine pathology. Mean DOUC (8.7 ± 1.2 cm) of women aged > 35 years was notably longer (t-statistics= 2.54, P-value = 0.01) in those who had uterine polyps (n = 69) than the mean DOUC (8.2 ± 1.5 cm) of those with no uterine pathology (n = 316). Overweight (n = 56) and obese (n = 31) women with uterine fibroid alone were observed to have significantly longer (t-statistic = 2.36, P-value = 0.02; t-statistics = -2.41, P-value = 0.02 respectively) DOUC (8.9 ± 2.1 and 8.8 ± 1.2 cm respectively) than the DOUC of their counterpart with no uterine pathology. Uterine fibroid alone contributed a significant 2.0% (R2 = 0.020, F = 22.49, P-value < 0.001) and polyps alone also contributed a significant 0.5% (R2 = 0.005, F = 6.09, P-value = 0.014) to the variations observed in DOUC.

Conclusion: Knowledge of the details of uterine cavity depth and shape could make it easier to deposit the embryo at an optimum depth within the cavity, this may influence the chances of implantation during IVF treatment. From the comparative analysis of the Depth of uterine cavity in black African women, there is significant correlation between depth of uterine cavity and age. The mean depth of uterine cavity is significantly longer among women who had history of uterine fibroid, polyp and curettage compared to women with no history of uterine pathology or intervention. The age of the study subjects was significantly associated with the mean depth of uterine cavity more than their BMI.

Keywords: *Black African; Depth of Uterine Cavity; Uterine Pathology; Uterine Surgery*

Abbreviation

ANOVA: Analysis of Variance; ART: Assisted Reproductive Technology; BMI: Body Mass Index; CI: Confidence Interval; C/S: Caesarean Section; D and C: Dilatation and Curettage; DOUC: Depth of Uterine Cavity; ET: Embryo Transfer; FCT: Federal Capital Territory; Freq: Frequency; IUA: Intrauterine Adhesion; IUI: Intrauterine Insemination; IVF: In-Vitro Fertilization; Min./Max: Minimum/Maximum; Myom: Myomectomy; NIMR: Nigerian Institute of Medical Research; OR: Odds Ratio; PI: Primary Infertility; SI: Secondary Infertility

Introduction

Broadly speaking, infertility, defined as inability of a woman in reproductive age to conceive after 12 months of uninterrupted, unprotected heterosexual activity, is a common problem that affects up to 25 - 30% of couples in societies in various parts of the world [1-4] of which up to 10 - 15% remain unexplained [5]. Uterine cavity abnormalities are factors contributing to female sub-fertility and recurrent implantation failure in assisted reproductive technology. Abnormalities within the uterine cavity that are not diagnosed, such as intrauterine adhesion, endometrial polyps, diminutive sub-mucous fibroid, and congenital abnormalities could be regarded as obstructions to possibilities of conceiving either naturally or through IVF [6]. Anatomically, the uterine cavity, the space within the uterus, opens to the outside through the cervical canal and the vaginal opening, and to the inside through the right and left Fallopian tube canals. The uterus is a child bearing organ which provides suitable site and environment for the implantation of a fertilized ovum and development of the embryo, with the main function of nurturing and protecting the developing fetus. The optimal size of the uterine cavity is very important for continuation of the pregnancy till term and for proper development of the fetus. Proper assessment and measurement of the uterine depth are therefore necessary for suitable embryo transfer [7] specifically or in other cases of female infertility in general. Normal uterine measurements are length: 7.6 cm, breadth: 4.5 cm and thickness: 3.0 cm [8]. Depth of the uterine cavity is one of the most important measurements because it helps in the management of infertility. The importance of the uterine cavity lies in the fact that it is a space or an environment for sperm to navigate towards eggs in either, or in certain occasions, both Fallopian tubes. The uterine cavity is also vital for implantation of fertilized egg and its development. Absence of, or obstruction to, the uterine cavity may render reproduction impossible or may jeopardize any pregnancy. Adequate uterine depth ranges from 6 to 9 cm though the normal depth is 7.6 cm [9]. It is usually measured using mechanical instruments like sterile uterine sound, intrauterine insemination (IUI) or embryo transfer (ET) catheter. Visualization techniques like Transvaginal ultrasound scan, Contrast ultrasound using phase shifting medium, Sonohysterogram, Hysterosalpingogram, saline infusion 3D and 4D ultrasonography can also be used to measure the depth of the uterine cavity with variable accuracy [10-14]. Faivre., *et al* suggested that 3D transvaginal contrast hysterosonography may be most precise identifying and classifying congenital uterine anomalies, better than than office hysteroscopy and MRI and this instrumentation may conveniently become the only required step in the evaluation of the uterine cavity [14]. Colposonography is also a simple procedure that accurately measures the depth of the uterine cavity [15]. Uterine cavity abnormalities can be congenital, intrauterine adhesion, intracavitary fibroids and endometrial polyps. Depending on the population of study and geographical location, the prevalence of uterine anomalies in infertile population is somewhere around 5.5-38.3% [16-19]. However, data on the depth of uterine cavity in sub-Saharan Black African women in general, is scarce. This study is aimed at assessing the depth of uterine cavity among Black African women who previously had or did not have any uterine surgical procedure and among those who had or did not have any uterine pathology.

Methodology

Between 2003 and 2014, a total of 3176 women consulted mainly for management of infertility at Nordica Fertility Centers in Lagos, Abuja and Asaba, respectively lying in Southwest, Federal Capital Territory (FCT) and South-south geo-political zones of Nigeria. Of these number, hospital records, including anthropometry were completed for 3,044 (95.8%), while the remaining 132 (4.2%) were excluded from the study because of incomplete data. Of the 3044 patients, 1122 has complete sonohysterogram records for the evaluation of the uterine cavity. The study methodology has been reported elsewhere [19] but for the purpose of this particular study, it is briefly stated below.

Patients

In about 60 - 65% of the cases, the first consultation excluded patients' male spouses until the second or third consultation, after being counseled, with reasons why, she should visit the clinic with her spouse. Initial lone consultation appeared to be more prevalent in Southwest than in other parts of the country.

Inclusion criteria

Only Black African women with complete records and who presented solely for fertility management were included. Data of all consenting patients with indications for use of any endoscopic equipment and who met patient selection criteria were selected. All the clients had either sonohysterogram or hysteroscopy to determine depth and the status of the uterine cavity.

Exclusion criteria

Those pregnant, those with history of acute pelvic inflammatory disease, pelvic cancer, and other conditions making patient unfit for laparoscopy or hysteroscopy, those who did not give consent and incomplete data were excluded from the study.

Procedure and equipment used

Ultrasound Machine Volusion E6 (General Electric, USA) was used as part of the routine clinical work-up for Sono-hysterographic investigation of the uterine cavity. In this procedure a small volume of normal saline was introduced into the uterine cavity for the purpose of making the endometrium to be clearly visible on an ultrasound scan, while the regularity of the endometrium was evaluated. At the same time, the uterine cavity was also assessed for any demonstrable abnormalities. This procedure was done during the first half of the menstrual cycle after the end of the menstrual flow. A detailed explanation of the procedure was given by the operating surgeon, and all women signed an informed consent before undergoing the procedure. A 3D-chip camera connected to the equipment that was used displayed real-time images of internal structures on a high resolution screen. A rigid 30° 5-mm hysteroscope was the instrument of choice for performing Hysteroscopy. This procedure is similar to what Alata., *et al* described [20].

Informed consent

Most patients gave informed consent by filling an agreement form including conformity to use data for the purpose of research and that her identity would be concealed. The advantages and benefits of using patients' data for teaching and research purposes were clearly explained to each patient by the attending gynecologist. The advantages and benefits of using patients' data for teaching and research purposes were clearly explained to each patient by the attending gynecologist. Attending gynecologists manually recorded stage-by-stage findings at laparoscopy or hysteroscopy in the hospital case file of each patient.

Statistical analysis

Data of patients were coded for anonymity, ease of reference, avoidance of bias and fed into a lap-top computer, cleaned and cross-checked for errors. Analysis was done using NCSS 21 (NCSS, Utah, USA) statistical software. Data were analyzed descriptively obtaining frequencies and percentages. Multivariate regression analysis was used to determine associations. Student's t-test was used to compare means of two categorical variables and Chi-square with Odds ratio and 95% Confidence Interval (CI), in this study refers to a range of values for specific variable constructed so that this range has a specified probability of including the true value of that variable) was used to test association. A P-value < 0.05 was regarded as statistically significant.Data were presented as Tables Figures and Graphs.

Consent and ethical approval

This study was approved by the Nigerian Institute of Medical Research Review Board (NIMR-IRB-18-006).

Definition

Uterine cavity space was measured as the axial length from the external os of the cervix to the fundal roof of the endometrial cavity. Body mass index was calculated as weight in kilograms divided by height squared in meters.

Results

Depth of uterine cavity (cm) was measured in 1357 patients who necessitated this procedure and of this number 1122 (82.7%) data were available for analysis.

Age, Body Mass Index and Gynecological profile of study subjects (Table 1 and Figure 1): Of the 1122 subjects in this study, 959 (85.5%) had undergone previous uterine surgery and only 163 (14.5%) had not, with a significant difference (t-test = 6.33, P-value = 0.00001) in the mean ages of the two groups but not in the mean BMI. In all, 873 (77.8%) were nulliparous, 249 (22.2%) had parity of 1 - 4, 379 (33.8%) presented with primary and 743 (66.2%) with secondary infertility. Parous women were significantly older (t-test = 4.35, P-value = 0.00002) and heavier (t-test = 4.54, P-value << 0.0001) than nulliparous women and those with secondary infertility were significantly older (t-test=7.61, P-value << = 0.0001) and also heavier (t-test = 2.57, P-value = 0.01) than those with primary infertility. The histogram and normal probability plot of patients' age is as illustrated in Figures 1a and 1b indicating that majority of the patients were aged between 30 and 50 years, about 10% were aged 30 years and below and approximately 7% were aged above 50 years. Figures 2a, b and c illustrate count by, histogram and normal probability plot of the depth of uterine cavity. A total of 80 (7.1%), 956 (85.2%) and 86 (7.7%) of the study subjects had DOUC of < 7 cm, 7 - 10 cm and > 10 cm respectively and pooled analysis shows distinct difference (Pearson's χ^2 = 10.85, P-value = 0.004) in the proportion of IUA relative to these categories of the DOUC.

Variable				All (n=1122)	Previous uterine surgery		Parity		Type of infertility	
					Yes (n=959, 85.5%)	No (n=163, 14.5%)	Nulliparous (n=873, 77.8%)	Parous (n=249, 22.2%)	Primary (n=379, 33.8%)	Secondary (n=743, 66.2%)
Age (years) Min/Max 24.0/58.0			Mean (±sd)	39.0 (6.2)	39.5 (6.0) !	36.1 (6.4)!	38.6 (6.3)	40.4 (5.6)	37.1 (6.1)	40.0 (6.0)
			26.0/58.0	24.0/53.0	24.0/58.0	27/53	24/55	24/58		
BMI (Kg/m²) Min/Max 16.3/53.4			Mean (±sd)	27.7 (4.8)	27.7 (4.7)^	27.5 (5.1)^	27.3 (4.5)	29.0 (5.4)	27.2 (5.1)	28.0 (4.6)
			16.3/53.4	16.9/45.0	16.3/53.4	17.7/47.0	16.9/53.4	16.3/47.0		
Depth of uterine cavity (cm)	All		Mean (±sd)	8.30 (1.5)	8.3 (1.5)	8.3 (1.5)	8.4 (1.5)	8.0 (1.4)	8.4 (1.5)	8.3 (1.5)
	<7	n (%)	Freq. (%)	80 (7.1)	74 (7.7)	6 (3.7)	52 (6.0)	28 (11.2)	12 (3.2)	68 (9.2)
		Fibroid		6 (7.5)	6 (8.1)	0 (0.0)	4 (7.7)	2 (7.1)	0 (0.0)	6 (8.8)
		Uterine polyp		4 (5.0)	4 (5.4)	0 (0.0)	1 (1.9)	3 (10.7)	0 (0.0)	4 (5.9)
		IUA		31 (38.8)	31 (41.9)	0 (0.0)	18 (34.6)	13 (46.4)	3 (25.0)	28 (41.2)
	7-10	n (%)		956 (85.2)	809 (84.4)	147 (90.2)	746 (85.5)	210 (84.3)	340 (89.7)	616 (82.9)
		Fibroid		152 (15.9)	127 (15.7)	25 (17.0)	126 (16.9)	26 (12.4)	51 (15.0)	101 (16.4)
		Uterine polyp		130 (13.6)	98 (12.1)	32 (21.8)	114 (15.3)	16 (7.6)	71 (20.9)	59 (9.6)
		IUA		280 (29.3)	263 (32.5)	17 (11.6)	215 (28.8)	65 (31.0)	62 (18.2)	218 (35.4)
	>10	n (%)		86 (7.7)	76 (7.9)	10 (6.1)	75 (8.6)	11 (4.4)	27 (7.1)	59 (7.9)
		Fibroid		22 (25.6)	16 (21.1)	6 (60.0)	19 (25.3)	3 (27.3)	12 (44.4)	10 (17.0)
		Uterine polyp		14 (16.3)	13 (17.1)	1 (10.0)	12 (16.0)	2 (18.2)	3 (11.1)	11 (18.6)
		IUA		31 (36.1)	28 (36.8)	3 (30.0)	29 (38.7)	2 (18.2)	7 (25.9)	24 (40.7)

Table 1: *Anthropometric and gynecological profile of the study patients.*

**Fisher's exact; ! t-test (P-value)=6.33 (0.00001); ^ t-test (P-value)=0.47 (0.64); Pooled analysis shows no distinct difference (Pearson's χ^2=4.35, P-value=0.11; Pearson's χ^2=4.03, P-value=0.13) in the proportion of those with uterine fibroid or uterine polyp at DOUC of <7, 7-10 and >10 cm. But there was a significant difference (Pearson's χ^2=10.85, P-value=0.004) in the proportion of IUA at DOUC of <7, 7-10 and >10 cm.*

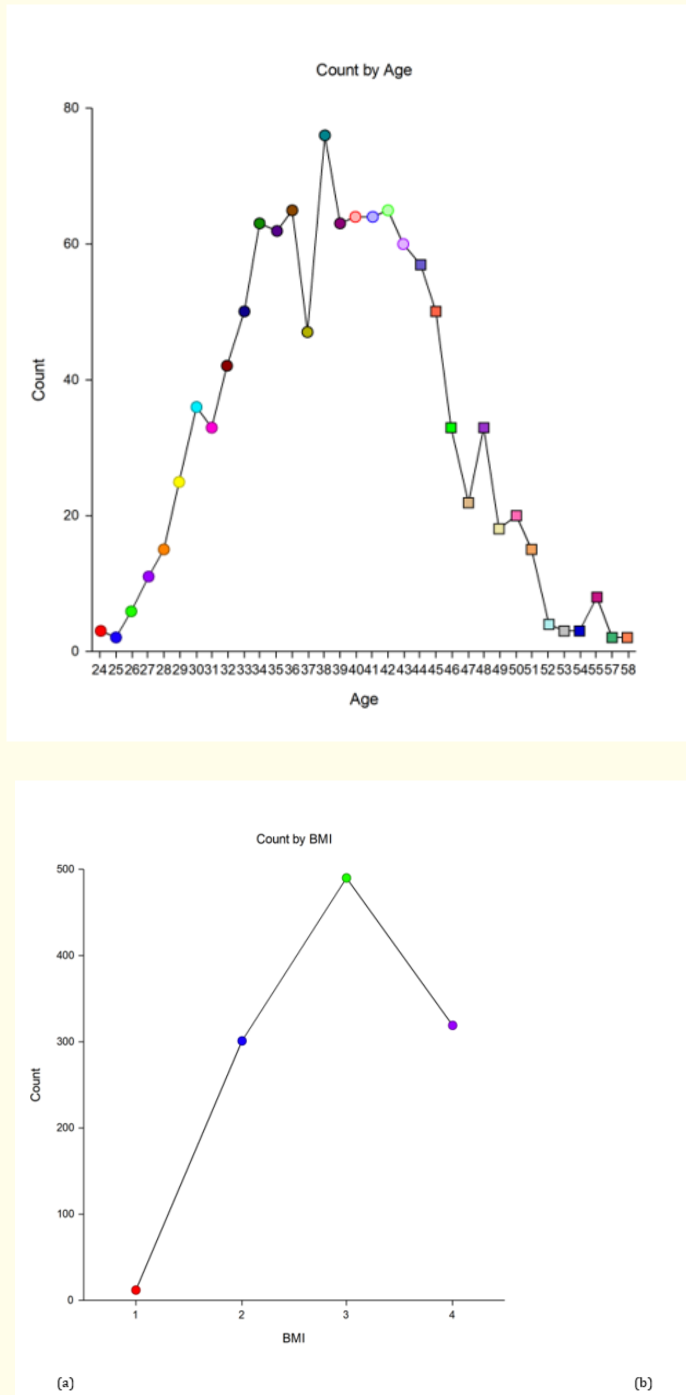


Figure 1: *Frequency distribution chart of (a) age in years and body mass index group in Kg/m2 of subjects in the study.*
BMI 1 = <18.5 kg/m2 (underweight); BMI 2 = 18.5-24.9 kg/m2 (normal weight); BMI 3 = 25.0-29.9 kg/m2 (overweight); BMI 4 = ≥30 kg/m2 (obese).

Depth of uterine cavity (DOUC) by biophysical characteristics relative to previous uterine surgery (Table 2 and Figures 2a, b, c)

Figures 2a, b and c, illustrate the DOUC by count,histogram and normal probability plot, indicating that approximately 350 study subjects had uterine cavity depth of 8 cm while approximately 5% had depth < 6 cm and about 3% had depth > 11 cm. The study subjects were then segregated into two age-groups ≤ 35 years and > 35 years and into four BMI groups - < 18.5 (underweight), 18.5 - 24.9 (normal), 25.0 - 29.9 (overweight) and ≥ 30 (obese) for comparative analysis of the DOUC among those who have had uterine surgery and those who had not. There was no significant difference in the DOUC relative to age group, regardless of whether a patient had had uterine surgery or not. However, overall remarkable variation was observed when the mean DOUC (cm) was assessed by BMI in which those with BMI < 18.5 (n = 12, 1.1%) had mean DOUC of 8.6 cm (F-test = 11129, P-value << 0.001) and by parity (F-test = 27962.5, P-value << 0.001) in which those with parity >2 had the longest mean DOUC of 8.5 cm. This level of significance was also observed among those who have had uterine surgery and those who had not.

Variable	Sub-variable	Depth of uterine cavity (cm)																	
		All (n=1122)					Have had uterine surgery (n=959, 85.5%)					Have never had uterine surgery (n=163, 14.5%)					T-test	P-value	CI
		Freq. (%)	%	Mean	±sd	Mode	Freq.	%	Mean	±sd	Mode	Freq.	%	Mean	±sd	Mode			
Age (y)	<35	286	25.5	8.3	1.4	8.0	213	22.2	8.3	1.2	8.0	73	44.8	8.4	1.9	8.0	-0.42	0.67	-0.57, 0.37
	≥35	836	74.5	8.3	1.5	8.0	746	77.8	8.3	1.6	8.0	90	55.2	8.3	1.2	8.0	0.00	1.00	-0.27, 0.27
T-test (P-value) (CI)		0.00 (1.00) (-0.19, 0.19)					0.00 (1.00) (-0.20, 0.20)					0.39 (0.70) (-0.41, 0.61)					-		
BMI Kg/m^2	<18.5	12	1.1	8.6	1.3	-	9	1.0	8.7	1.5	7.0	3	1.8	8.3	0.6	8.0	0.66	0.53	-0.97, 1.77
	18.5-24.5	301	26.8	8.2	1.3	8.0	256	26.7	8.2	1.4	8.0	45	27.6	8.1	1.2	8.0	0.50	0.62	-0.30, 0.50
	25.0-29.9	490	43.7	8.3	1.6	8.0	425	44.3	8.3	1.5	8.0	65	39.9	8.4	2.0	8.0	-0.39	0.70	-0.61, 0.41
	≥30	319	28.4	8.3	1.5	8.0	269	28.0	8.3	1.5	8.0	50	30.7	8.5	1.2	8.0	-1.04	0.30	-0.58, 0.18
F-test (P-value)		11129.9 (0.0000001)					9600.5 (0.0000001)					1526.2 (0.0000001)					-		
Parity	0	873	77.8	8.4	1.5	8.0	734	76.5	8.4	1.5	8.0	139	85.3	8.4	1.6	8.0	0.00	1.00	-0.29, 0.29
	1	199	17.7	8.0	1.5	8.0	183	19.1	8.0	1.5	8.0	16	9.8	8.5	1.6	10.0	-1.20	0.24	-1.37, 0.37
	2	38	3.4	8.2	1.3	8.0	31	3.2	8.3	1.4	8.0	7	4.3	7.8	0.7	8.0	1.37	0.19	-0.26, 1.26
	>2	12	1.9	8.5	1.0	8.0	11	1.2	8.6	1.1	8.0	1	0.6	8.0	0.0	8.0	0.00	0.0001	0.0, 0.0
F-test (P-value)		27962.5 (0.0000001)					23908.1 (0.0000001)					4041.5 (0.000000.1)					-		
Induced abortion	Yes	546	48.7	8.3	1.5	8.0	524	54.6	8.3	1.5	8.0	22	13.5	8.4	1.3	8.0	-0.35	0.73	-0.69, 0.49
	No	576	51.3	8.3	1.5	8.0	435	45.4	8.3	1.6	8.0	141	86.5	8.3	1.6	8.0	0.00	1.00	-0.31, 0.31
T-test (P-value)		0.00 (1.00) (-0.17, 0.17)					0.00 (1.00)					-0.32 (0.75) (-0.73, 0.53)							
Miscarriage	Yes	333	29.7	8.2	1.7	8.0	321	33.5	8.2	1.7	8.0	12	7.4	8.6	1.7	-	-0.80	0.42	-1.49, 0.69
	No	789	70.3	8.3	1.4	8.0	638	66.5	8.3	1.4	8.0	151	92.6	8.3	1.5	8.0	0.00	1.00	-0.26, 0.26
T-test (P-value) (CI)		-0.95 (0.34) (-0.31, 0.11)					-0.91 (0.36) (-0.32, 0.16)					-1.78 (0.10) (-2.00, 0.20)					-		

Table 2: *Depth of uterine cavity (DOUC) by biophysical characteristics relative to previous uterine surgery.*

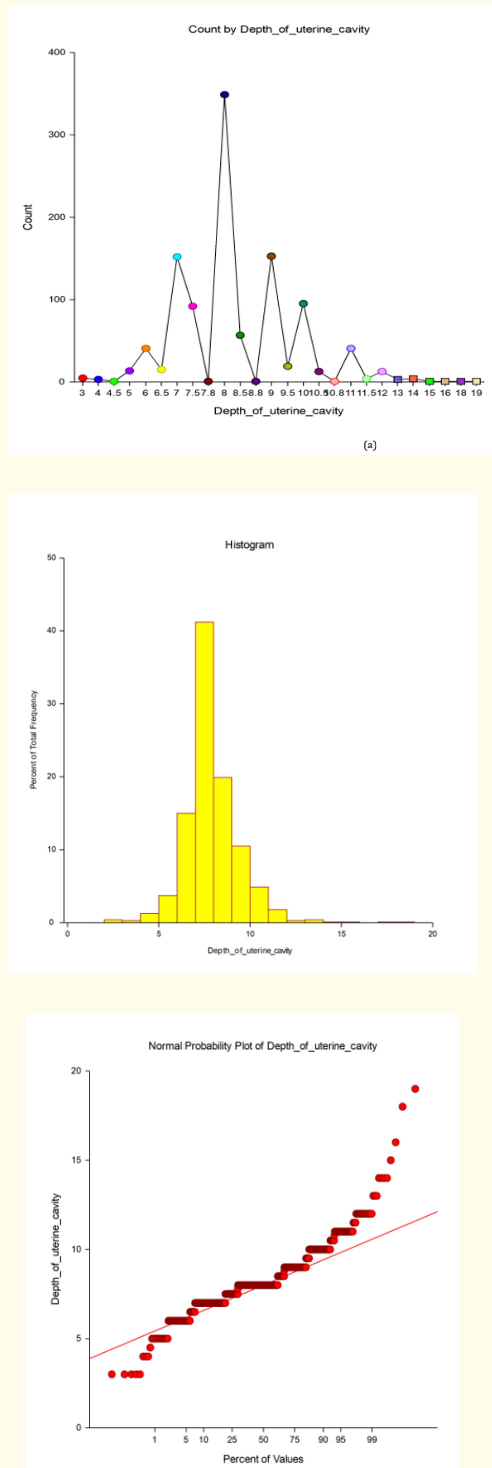


Figure 2a-2c: *Depth of uterine cavity (cm) by count (a), histogram (b) and (c) Normal Probability Plot among sub-fertile Black African women.*

Age, previous uterine surgery and depth of uterine cavity (Table 3)

There were 860 procedures done during the study period, of which frequency of single, double and triple procedures were 586 (68.1%), 274 (31.7%) and 1 (0.1%) respectively. Of these 860, 176 (20.5%) were done on age group < 35 years and 684 (79.4%) on those aged ≥ 35 years. Pooled analysis of frequency of procedure shows significant variation (Pearson's chi-square = 25.79 P-value << 0.0001). Those aged < 35 years were about 3 times more likely to have had single uterine surgical procedure than older women (χ^2 = 22.37, P-value << 0.0001), OR = 2.70, 95% CI = 1.77, 4.12) while those age ≥ 35 years were over 2½ times more likely to have undergone at least 2 uterine surgical procedures. The study then evaluated the mean DOUC according to type of previous uterine surgery in the two age groups and compared this with the mean DOUC of those who never had any uterine surgery. In the age group of < 35 years, the mean DOUC (9.1 ± 2.1 cm) of those who had myomectomy alone (n = 34, 11.9%) was significantly longer (t-test = 2.95, P-value = 0.005) than of those (n = 110) who had never had uterine surgery (8.0 ± 1.0 cm). Also, in the age group of ≥ 35 years (n = 146, 17.5%), the mean DOUC of those who had myomectomy alone (8.7 ± 1.5 cm) was notably longer (t-test = 2.97, P-value = 0.003) than that of their counterparts (n = 152) who never had uterine surgery (8.2 ± 1.4 cm). Overall, the DOUC was significantly longer (t-statistic = -4.17, P-value = 0.00004) in those who had previous myomectomy (n = 180, 8.8 ± 1.7) compared to those who never had any uterine surgery (n = 262, 8.2 ± 1.1).

Previous uterine surgery n		Age <35 y (n=286)						Age≥35 y (n=836)						T-statistic	P-value	CI n	All					
		Mean	±sd	Min.	Max.	Mode	n	Mean	±sd	Min.	Max.	Mode					Mean	±sd	Min.	Max.	Mode	
Single procedure	Myom.	34 (11.9)	9.1	2.1	6.0	19.0	8.0	146 (17.5)	8.7	1.5	6.0	14.0	8.0	1.05	0.30	-0.37, 1.17	180 (16.0)	8.8	1.7	6.0	19.0	8.0
	T-test (P-value)	2.95 (0.005)						2.97 (0.003)						-			4.17 (0.00004)					
	D and C	102 (35.7)	8.3	1.3	5.0	14.0	8.0	260 (31.1)	8.1	1.5	3.0	14.0	8.0	1.26	0.21	-0.11, 0.51	362 (32.3)	8.2	1.4	3.0	14.0	8.0
	T-test (P-value)	1.87 (0.06)						-0.68 (0.50)						-			0.00 (1.00)					
	C/S	10 (3.5)	8.5	1.0	7.0	10.0	8.0	34 (4.1)	8.2	1.9	3.0	11.0	8.0	0.66	0.51	-0.63, 1.23	44 (3.9)	8.3	1.7	3.0	11.0	8.0
	T-test (P-value)	1.51 (0.16)						0.00 (1.00)						-			0.38 (0.71)					
Freq. (%) proc.		146 (51.0%)						440 (52.6%)						-			586 (52.2)					
χ^2 (P-value), OR (95%CI)		22.37 (<<0.0001), 2.70 (1.77, 4.12)						22.37 (<<0.0001); 0.37 (0.24, 0.57)						-			-					
Double procedure	Myom. and C/S	3 (1.0)	9.2	1.3	8.0	10.5	-	6 (0.7)	8.0	1.3	7.0	10.0	7.0	1.31	0.26	-1.33, 3.73	9 (0.8)	8.4	1.3	7.0	10.5	7.0
	T-test (P-value)	1.58 (0.25)						-0.37 (0.73)						-			0.46 (0.66)					
	Myom. + D and C	15 (5.2)	8.5	1.2	6.0	10.0	9	189 (22.6)	8.4	1.7	3.0	18.0	8.0	0.30	0.77	-0.60, 0.80	204 (18.2)	8.4	1.7	3.0	18.0	8.0
	T-test (P-value)	1.54 (0.14)						1.19 (0.23)						-			1.46 (0.15)					
	D and C and CS	11 (3.8)	7.7	1.7	4.5	11.0	8.0	42 (5.0)	7.9	1.8	4.0	11.0	-	-0.34	0.74	-1.43, 1.03	53 (4.7)	7.9	1.7	4.0	11.0	-
	T-test (P-value)	0.58 (0.58)						1.00 (0.32)						-			-1.23 (0.22)					
Freq. (%) proc.		29 (10.1%)						237 (28.3%)						-			266 (23.7%)					
χ^2 (P-value), OR (95%CI)		21.64 (<<0.0001) 0.37 (0.24, 0.57)						20.97 (<<0.0001); 2.65 (1.73, 4.07)						-			-					
Triple procedure	Myom.+ D and C + C/S	1 (0.3)	8.0	0.0	8.0	8.0	8.0	7 (0.8)	8.3	1.3	6.5	10.0	-	0.00	0.00	0.00, 0.00	8 (0.7)	8.3	1.3	6.5	10.0	8.0
	T-test (P-value)	0.00 (0.00001)						0.20 (0.85)						-			0.22 (0.84)					
Freq. (%) proc.		1 (0.3%)						7 (0.8%)						-			8 (0.7%)					
χ^2 (P-value), OR (95%CI)		0.01 (0.90), 0.55 (0.07, 4.52)						0.01 (0.90); 1.81 (0.22, 14.80)						-			-					
No previous uterine surgery		110 (38.9)	8.0	1.0	5.0	12.0	8.0	152 (18.2)	8.2	1.4	3.0	14.0	8.0	-1.35	0.18	-0.49, 0.09	262 (23.4)	8.2	1.1	5.0	12.0	8.0

Table 3: *Mean depths of uterine cavity (DUC) by previous uterine surgery relative to age-group.*

Among those aged ≤35 years, the mean depth of uterine cavity in those who had myomectomy alone (n=48, 9.0±2.1cm) was significantly longer (t-test= 2.85, P-value=0.006) compared to those who had never done previous uterine surgery (n=127, 8.1±1.0 cm).

Age, uterine pathology and depth of uterine cavity (Table 4)

In all, 602 uterine pathology, 535 singles, 66 double and only 1 triple, necessitating surgical intervention, were observed. There were 109 (38.1%) pathology recorded in those aged < 35 years and 493 (59.7%). Younger women were slightly more likely to present with double pathology (χ^2 = 0.13, P-value = 0.72, OR = 1.12, 95% CI = 0.59, 2.14). In age-group of < 35 years, the mean DOUC (9.5 ± 2.7 cm) of those with uterine fibroid alone (n = 19) was significantly longer (t-statistics = 2.08, P-value = 0.05) than that (8.2 ± 1.2 cm) of those with no fibroid, no IUA and no polyps (n = 110). In the older age group of ≥ 35 years, means of DOUC (8.7 ± 1.4; 8.7 ± 1.3; and 8.7 ± 1.2 cm respectively) were significantly longer (t-statistics = 3.84, P-value = 0.0002; t-statistics = 3.54, P-value = 0.0006; and t-statistics = 3.41, P-value = 0.02 respectively) in those who had uterine fibroid alone (n = 110), uterine polyps alone (n = 76) and co-morbidity of uterine fibroid and intrauterine adhesion (n = 26) than the mean DOUC (8.1 ± 1.5 cm) of those with no fibroid, no IUA and no polyps (n = 343). In all patients, mean DOUC (cm) was significantly longer (t-statistics = 3.71, P-value = 0.0003; t-statistics = 3.10, P-value = 0.002; and t-statistics = 2.38, P-value = 0.02) among those who had uterine fibroid alone (n = 129), uterine polyps alone (n = 112), and those who had uterine fibroid and IUA (n = 31) compared to the mean DOUC (8.2 ± 1.4 cm) of those who did not have any uterine pathology (n = 520).

Uterine pathology n (%)		Age<35 (n=286)						Age ≥35 (n=836)						T-test	P-value	95% CI n	All (n=1122)					
		Mean	±sd	Min.	Max.	Mode	n (%)	Mean	±sd	Min.	Max.	Mode					Mean	±sd	Min.	Max.	Mode	
Single pathology	Uterine fibroid	19 (6.6)	9.5	2.7	7.0	19.0	-	110 (13.2)	8.7	1.4	6.0	14.0	8.0	1.95	0.22	-0.52, 2.12	129 (11.5)	8.8	1.7	6.0	19.0	8.0
		T-test (P-value) (CI)	2.08 (0.05) (-0.01, 2.61)					3.84 (0.0002) (0.29, 0.91)						-			3.71 (0.0003) (0.28, 0.92)					
	IUA	40 (14.0)	8.1	1.5	4.5	12.0	8.0	254 (30.4)	8.2	1.7	3.0	18.0	8.0	-0.38	0.70	-0.62, 0.42	294 (26.2)	8.1	1.6	3.0	18.0	8.0
		T-statistics (P-value) (CI)	-0.39 (0.70) (-0.61, 0.40)					0.75 (0.46) (-0.16, 0.36)						-			-0.90 (0.37) (-0.32, 0.12)					
	Polyps	36 (12.6)	8.3	0.8	6.5	10.0	8.0	76 (9.1)	8.7	1.3	6.0	14.0	8.0	-2.00	0.04	-0.80, -0.00	112 (10.0)	8.6	1.2	6.0	14.0	8.0
		T-test (P-value) (CI)	0.62 (0.53) (-0.22, 0.42)					3.54 (0.0006) (0.26, 0.94)						-			3.10 (0.002) (0.15, 0.65)					
	Total number of patients (%)		95 (32.5%)					440 (52.6%)						-			535 (47.7%)					
	χ^2 (P-value), OR (95%CI)		0.40 (0.53); 0.82 (0.44, 1.53)					0.40 (0.53); 1.22 (0.65, 2.30)						-			-					
Double pathology	Uterine fibroid + IUA	5 (1.7)	9.9	3.0	7.5	15.0	-	26 (3.0)	8.7	1.2	6.5	11.0	8.0	0.88	0.42	-2.50, 4.90	31 (2.8)	8.9	1.6	6.5	15.0	8.0
		T-test (P-value) (CI)	1.26 (0.27) (-2.02, 5.42)					2.41 (0.02) (0.09, 1.11)						-			2.38 (0.02) (0.10, 1.30)					
	Uterine fibroid + Polyps	5 (1.7)	8.4	0.4	8.0	9.0	-	14 (1.7)	8.8	1.7	7.0	12.0	8.0	-0.82	0.42	-1.43, 0.63	19 (1.7)	8.7	1.5	7.0	12.0	8.0
		T-test (P-value) (CI)	1.00 (0.36) (-0.28, 0.68)					1.52 (0.15) (-0.29, 1.69)						-			1.43 (0.17) (-0.23, 1.23)					
	IUA + Polyps	3 (1.0)	8.8	1.4	8.0	10.5	8.0	13 (1.6)	8.6	2.1	3.0	12.0	-	0.20	0.85	-2.47, 2.87	16 (1.4)	8.6	1.9	3.0	12.0	8.0
		T-test (P-value) (CI)	0.74 (0.54) (-2.82, 4.02)					0.85 (0.41) (-0.78, 1.78)						-			0.84 (0.42) (- 0.62, 1.42)					
	Total number of patients (%)		13 (4.5%)					53 (6.3%)						-			66 (5.9%)					
	χ^2 (P-value), OR (95%CI)		0.13 (0.72) 1.12 (0.59, 2.14)					0.12 (0.72) 0.89 (0.47, 1.70)						-			-					
Triple pathology	Uterine fibroid + IUA + Polyps	1 (0.3)	8.0	0.0	8.0	8.0	8.0	0 (0.0)	0	0	0	0	0	-	-	-	1 (0.09)	8.0	0.0	8.0	8.0	8.0
		T-test (P-value) (CI)	0.00 (0.00001) (0.0, 0.0)					-						-			0.0 (0.00001) (0.0, 0.0)					
	Total number of patients (%)		1 (0.3%)					0 (0.0%)									1 (0.09%)					
	χ^2 (P-value), OR (95%CI)		0.69 (0.41) (undefined)					0.69 (0.41), (undefined)									-					
No uterine pathology		177 (61.9)	8.2	1.2	5.0	14.0	8.0	343 (41.0)	8.1	1.5	3.0	16.0	8.0	0.82	0.41	-0.14, 0.34	520 (46.3)	8.2	1.4	3.0	16.0	8.0

Table 4: *Mean depths of uterine cavity in patients with and without uterine fibroid, intrauterine adhesion and uterine polyps relative to age group.*

Body mass index, previous uterine surgical procedure and depth of uterine cavity (Table 5)

Analysis of variance shows that there was no noteworthy variation (F-statistic = 0.80, P-value = 0.50) in the mean depth of uterine cavity (cm) among sub-fertile women who were underweight (n = 12, 8.6 ± 1.3), normal weight (n = 301, 8.2 ± 1.3) overweight (n = 490, 8.3 ± 1.6) or obese (n = 319, 8.3 ± 1.5). However, considering normal weight sub-fertile women, mean depth of uterine cavity (8.8±1.3 cm) was significantly longer (t-test = -3.29, P-value = 0.001) among those who had myomectomy (n = 61) compared to those who did not have any uterine surgical procedure done (n = 82, 8.1 ± 1.2). This significance was also observed among overweight sub-fertile women who had myomectomy (n = 69, t-test = 3.08, P-value = 0.003) and those who had experienced dilatation and curettage as well as Caesarean section (n = 21, t-test = -2.96, P-value = 0.007).

Previous uterine surgery		Depth of uterine cavity (cm)																									
	BMI<18.5						BMI 18.5-24.5						BMI 25.0-29.9						BMI≥30								
	n	Mean	±sd	Min.	Max.	Mode	n	Mean	±sd	Min.	Max.	Mode	n	Mean	±sd	Min.	Max.	Mode	n	Mean	±sd	Min.	Max.	Mode	F-ratio	P-value	
All		12	8.6	1.3	7.0	11.0	-	301	8.2	1.3	3.0	16.0	8.0	490	8.3	1.6	3.0	19.0	8.0	319	8.3	1.5	3.0	14.0	8.0	0.80	0.50
Single procedure	Myomec-tomy	1 (8.3)	7.0	0.0	7.0	7.0	7.0	61 (20.3)	8.8	1.3	6.0	11.0	8.0	69 (14.1)	9.0	2.0	7.0	19.0	8.0	49 (15.4)	8.6	1.6	7.0	14.0	7.0	0.22	0.88
	T-test (P-value)	0.00 (0.00001) (0.0, 0.0)						-3.29 (0.001) (-1.12, 0.28)						3.08 (0.003) (0.28,, 1.32)						1.49 (0.14) (-0.13, 0.93)						-	
	C/S	0 (0.0)	0	0	0	0	-	6 (2.0)	7.8	1.5	5.0	9.0	-	20 (4.1)	8.7	1.1	7.0	11.0	8.0	18 (5.6)	8.1	2.3	3.0	11.0	8.0	1.68	0.20
	T-test (P-value)	-						-						0.00 (1.00) (-1.20, 1.20)						0.00 (0.00) (0,0)						-	
	D and C alone	3 (25.0)	9.5	1.3	8.5	11.0	-	91 (30.2)	7.9	1.2	3.0	11.0	8.0	163 (33.3)	8.2	1.5	5.0	14.0	8.0	105 (32.9)	8.2	1.4	5.0	14.0	8.0	2.63	0.07
	T-test (P-value)	-1.76 (0.17) (-4.14, 1.14)						1.09 (0.27) (-0.16, 0.56)						0.00 (1.00) (-0.28, 0.28)						0.00 (1.00) (-0.39, 0.39)						-	
Total number of procedures		4 (33.3%)						158 (42.5%)						252 (51.4%)						172 (53.9%)							
Double procedure	Myo. and C/S	0 (0.0)	0	0	0	0	-	3 (1.0)	8.0	1.0	7.0	9.0	-	4 (0.8)	8.1	1.7	7	10.5	7.0	2 (0.6)	9.5	0.7	9.0	10.0	-	1.59	0.29
	T-test (P-value)	-						0.17 (0.88) (-2.22, 2.42)						-0.17 (0.91) (-2.78, 2.58)						2.53 (0.21) (-3.37, 5.97)						-	
	Myo. and D and C	4 (33.3)	9.0	1.5	7	10.5	-	50 (16.6)	8.3	1.5	6.0	16.0	8.0	102 (20.8)	8.5	1.8	3.0	18.0	8.0	48 (15.0)	8.4	1.6	3.0	12.0	8.0	0.43	0.73
	T-test (P-value)	-1.18 (0.30) (-3.25, 1.25)						-0.80 (0.43) (-0.70, 0.30)						0.96 (0.34) (-0.21, 0.61)						0.74 (0.46) (-0.34, 0.74)						-	
	D and C and CS	0 (0.0)	0	0	0	0	-	8 (2.7)	7.8	1.9	4.5	10.0	-	21 (4.3)	7.0	1.8	4.0	11.0	11.0	24 (7.5)	8.7	1.3	6.5	11.0	8.0	5.50	0.01
	T-test (P-value)	-						0.42 (0.69) (-1.38, 1.98)						-2.96 (0.007) (-2.03, -0.336)						1.66 (0.10) (-0.11, 1.11)						-	
Total number of procedures		4 (33.3)						53 (17.6)						101 (20.6)													
Triple procedure	Myo, C/S and DandC	0 (0.0)	0	0	0	0	-	0 (0.0)	0	0	0	0	0	7 (1.4)	8.2	1.3	6.5	10.0	8.0	1 (0.3)	8.5	0.0	8.5	8.5	8.5	0.00	1.00
	T-test (P-value)	-						0.48 (0.65) (-1.27, 1.87)						1.89 (0.07) (-0.04, 1.04)						-0.18 (0.86) (-1.27, 1.07)						-	
Nil done		4 (33.3)	8.0	0.8	7.0	9.0	8.0	82 (27.2)	8.1	1.2	6.0	12.0	8.0	104 (21.2)	8.2	1.0	6.0	11.0	8.0	72 (22.6)	8.2	1.2	5.0	12.0	8.0	0.04	0.99

Table 5*: Mean depths of uterine cavity (DUC) in patients who had undergone uterine surgery (C/S, Myomectomy and D&C and those who had not relative to Body Mass Index (Kg/m^2).*

Body mass index, uterine pathology and depth of uterine cavity (Table 6)

Analysis of variance shows a significant variation (F-statistic = 4.25, P-value = 0.03) in the mean depth of uterine cavity (cm) of underweight (n = 3, 10.3 ± 0.8), normal weight (n = 39, 8.5 ± 1.2), overweight (n = 56, 8.9 ± 2.1)) and obese (n = 31, 8.8 ± 1.2) women who had uterine fibroid alone. Compared to those who had no uterine pathology, the depth of uterine cavity (cm) was significantly longer (t-statistic = 2.36, P-value = 0.02; t-statistics = -2.41, P-value = 0.02 respectively) among overweight (n = 56, 8.9 ± 2.1) and obese (n = 31, 8.8 ± 1.2) sub-fertile women respectively. This was also observed among overweight women who had polyps alone (t-statistic = -2.58, P-value = 0.01). Incidentally, the mean DOUC (10.3 ± 0.8 cm) in underweight women (n = 3) with uterine fibroid was much longer than but not significantly different (t-test = -2.11, P-value = 0.22) from that (8.0 ± 1.4 cm) of their counterparts (n = 2) who had no uterine pathology.

Uterine pathology		Depth of uterine cavity (cm)																									
		BMI<18.5 (n=12)						BMI 18.5-24.5 (n=301)						BMI 25.0-29.9 (n=490)						BMI≥30 (n=319)						F-ratio	P-value
	n (%)	Mean	±sd	Min.	Max.	Mode	n	Mean	±sd	Min.	Max.	Mode	n	Mean	±sd	Min.	Max.	Mode	n	Mean	±sd	Min.	Max.	Mode			
Single pathology	Uterine fibroid	3 (25.0)	10.3	0.8	9.5	11	-	39 (13.0)	8.5	1.2	6.0	12.0	8.0	56 (11.4)	8.9	2.1	6.0	19.0	8.0	31 (9.7)	8.8	1.2	7.0	11.0	8.0	4.25	0.03
	T-test (P-value)	-2.11 (0.22)						-1.86 (0.67)						-2.36 (0.02)						-2.41 (0.02)						-	
	IUA	5 (41.7)	8.1	1.0	7.0	9.0	-	61 (20.3)	8.2	1.6	4.5	11.5	-	142 (29.0)	8.1	1.8	3.0	18.0	8.0	86 (27.0)	8.2	1.5	3.0	12.0	8.0	0.09	0.96
	T-test (P-value)	-0.09 (0.94)						-0.44 (0.66)						0.56 (0.58)						0.0 (1.00)						-	
	Polyps	2 (16.7)	8.0	0.0	8.0	8.0	8.0	34 (11.3)	8.5	1.1	7.0	12.0	8.0	35 (7.1)	8.7	1.0	7.0	11.0	8.0	41 (12.9)	8.5	1.5	6.0	14.0	8.0	0.55	0.67
	T-test (P-value)	0.0 (1.0)						-1.88 (0.08)						-2.58 (0.01)						-1.13 (0.26)						-	
Total number of pathology		12 (100.0%)						134 (44.5%)						233 (47.6%)						158 (49.5%)						-	
Double pathology	Uterine fibroid + IUA	0 (0.0)	0	0	0	0	-	4 (1.3)	9.5	1.3	8.0	11.0	-	21 (4.3)	8.9	1.9	6.5	15.0	-	6 (1.9)	8.4	0.6	7.5	9.0	-	1.34	0.31
	Test (P-value)	-						-2.13 (0.12)						-1.65 (0.11)						-0.73 (0.49)						-	
	Uterine fibroid + Polyps	0 (0.0)	0	0	0	0	-	8 (2.7)	8.6	1.1	8.0	11.0	8.0	9 (1.8)	9.0	1.9	7.0	12.0	-	2 (0.6)	7.8	1.1	7.0	8.5	-	0.63	0.59
	T-test (P-value)	-						-1.25 (0.25)						-1.25 (0.25)						0.51 (0.70)						-	
	IUA + Polyps	0 (0.0)	0	0	0	0	-	4 (1.3)	7.0	2.7	3.0	9.0	8.0	6 (1.2)	9.1	1.0	8.0	10.5	8.5	6 (1.9)	9.3	1.7	7.5	12.0	-	1.00	0.42
	T-test(P-value)	-						081 (0.48)						-2.15 (0.08)						-1.56 (0.18)						--	
Total number of pathology		0 (0.0%)						16 (5.3%)						36 (7.3%)						14 (4.4%)						-	
Triple pathology	Uterine fibroid + IUA + Polyps	0 (0.0)	0	0	0	0	-	0	0	0	0	0	0	1 (0.2)	8.0	0.0	8.0	8.0	8.0	0 (0.0)	0	0	0	0	-	-	-
	T-test (P-value)	-						-						0.00 (0.00)						-						-	
Total number of pathology		0						0						1 (0.2%)						0						-	
No uterine pathology		2 (16.7)	8.0	1.4	7.0	9.0	-	151 (50.2)	8.1	1.2	6.0	16.0	8.0	220 (44.9)	8.2	1.4	5.0	14.0	8.0	147 (46.1)	8.2	1.5	3.0	14.0	8.0	0.25	0.86

Table 6: *Mean depths of uterine cavity in patients with and without uterine fibroid, intrauterine adhesion and uterine polyps relative to BMI.*

Multivariate regression analysis (Table 7)

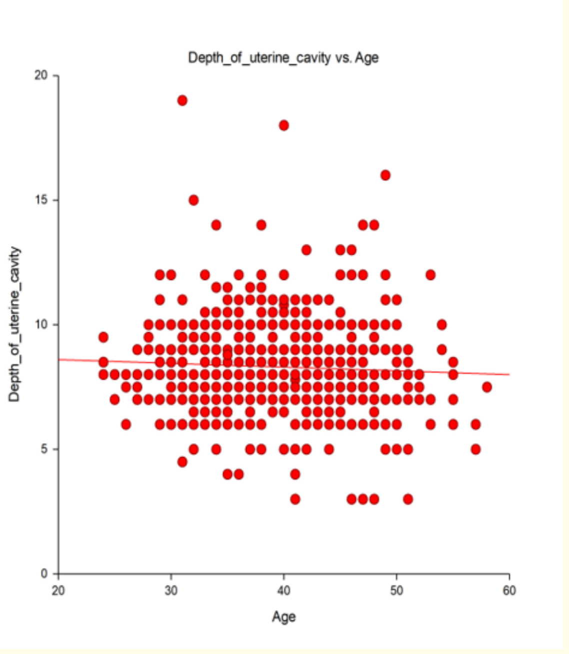
When combined, age (years) and BMI (Kg/m^2) had a significant 7% contribution to changes observed in the depth of uterine cavity (R^2 = 0.007, F = 4.10, P-value = 0.017) and they are notably associated with the DOUC. However, age alone has a significant 4% contribution to the alteration observed in DOUC (R^2 = 0.004, F = 4.52, P-value = 0.034) while BMI alone has not such contribution to DOUC. Likewise, when combined, Dilatation and curettage, Myomectomy and Caesarean section had a significant 2.5% contribution to the changes observed in the DOUC (R^2 = 0.025, F = 9.34, P-value < 0.001) but individually, myomectomy alone has a significant 21.1% contribution (R^2 = 0.211, F = 4.52, P-value = 0.034) and to a smaller extent, Dilatation and curettage has significant 4% contribution (R^2 = 0.004, F = 4.02, P-value = 0.045) to the alterations seen in DOUC. Uterine fibroid alone was observed to contribute a significant 2.0% (R^2 = 0.020, F = 22.49, P-value < 0.001) and polyps alone was observed to contribute a significant 0.5% (R^2 = 0.005, F = 6.09, P-value = 0.014) to the variation observed in DOUC.

Type of analysis	Independent Variable	Regression Coefficient	SE	T-value	P-value	Confidence Interval	R^2	F	P-value
Combined	Age	-0.017	0.007	-2.38	0.017	-0.03, -0.00	0.007	4.10	0.017
	BMI	0.018	0.009	1.91	0.056	-0.00, 0.04			
	Intercept	8.484	0.361	23.53	0.000001	7.78, 9.19			
Individual	Age alone	-0.015	0.007	-2.13	0.034	-0.03, -0.00	0.004	4.52	0.034
	Constant	8.906	0.286	31.16	0.0000001	8.34, 9.47			
	BMI alone	0.015	0.009	1.59	0.113	-0.00, 0.03	0.002	2.52	0.113
	Constant	7.894	0.262	30.05	0.000001	7.38, 8.41			
Combined	Dilatation and curettage	-0.163	0.089	-1.82	0.069	-0.34, 0.12	0.025	9.34	0.000001
	Myomectomy	0.435	0.093	4.66	0.000001	0.25, 0.62			
	Caesarean section	-0.118	0.148	-0.80	0.425	-0.41, 0.17			
	Constant	8.253	0.078	105.39	0.000001	8.10, 8.41			
Individual	Dilatation and curettage	-0.180	0.090	-2.01	0.045	-0.36, -0.00	0.004	4.02	0.045
	Myomectomy	0.454	0.092	4.91	0.000001	0.027, 0.64	0.211	24.10	0.0000001
	Caesarean section	0.215	0.148	-1.45	0.147	-0.51, 0.08	0.0019	2.10	0.147
Combined	Uterine fibroid	0.580	0.122	4.78	0.000001	0.34, 0.82	0.026	9.82	0.000001
	Intrauterine adhesion	-0.006	0.098	-0.06	0.952	-0.20, 0.19			
	Polyps	-0.341	0.133	-2.57	0.010	-0.60, -0.08			
	Constant	8.851	0.249	35.60	0.000001	8.36, 9.34			
Individual	Uterine fibroid alone	0.573	0.121	4.74	0.000001	0.34, 0.81	0.020	22.49	0.000001
	IUA alone	-0.102	0.097	-1.05	0.294	-0.29, 0.09	0.001	1.10	0.294
	Polyps alone	-0.326	0.132	-2.47	0.014	-0.58, -0.07	0.005	6.09	0.014

Table 7: *Multivariate regression analysis with depth of uterine cavity as dependent variable and Age, BMI, D and C, Myomectomy, C/S, uterine fibroid, IUA and Polyps as individual or as combined independent variables.*

The linear regression and correlation analysis figures 3a (age) and figure 3b (BMI)

These illustrate Linear Regression and correlation analysis between DUOC and Age (a) and between DUOC and Body Mass Index (b). Firstly, the equation of the straight line relating DUOC and Age estimated as: DUOC = (8.91) + (- 0.02) Age. The y-intercept, the estimated value of DOUC when Age is zero, is 8.9 (SE = 0.29). The slope, the estimated change in DOUC per unit change in Age, is -0.02 (SE = 0.01). There was a significant correlation between DOUC and Age (r = -0.06, t-value of - 2.13, P-value = 0.03). Secondly, the equation of the straight line relating DOUC and BMI estimated as: DUOC = (7.89) + (0.02) BMI. The y-intercept, the estimated value of DUOC when BMI is zero, is 7.90 (SE = 0.26). The slope, the estimated change in DUC per unit change in BMI is 0.01 (SE = 0.01). The value of R^2, the proportion of the variation in DUC that can be accounted for by variation in BMI is 0.0022 (F-statistic = 2.52, P-value = 0.11). The correlation between DUC and BMI (r = 0.05) was not significant (t-value = 1.59, P-value = 0.11).



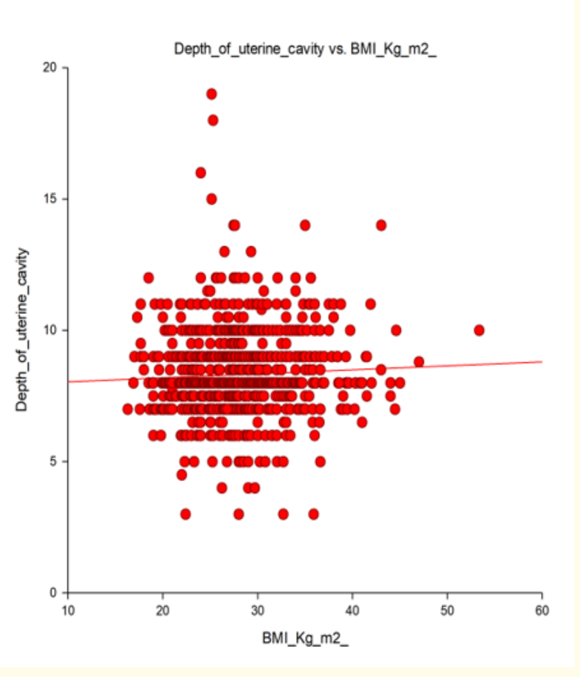


Figure 3: *Linear regression and correlation analysis between Depth of uterine cavity by (a)Age and by (b) Body Mass Index.*

Discussion

Abnormal uterine structure or pathological findings within the uterine cavity contribute to unfavorable reproductive outcome by preventing or obstructing proper implantation of the embryo resulting in placenta praevia or spontaneous miscarriage. The uterus has nurturing and protective functions for the developing fetus. Therefore, uterine cavity appraisal can facilitate prediction and management of various intrauterine events such as cause(s) of infertility, prospects and characteristics of implantation, gestation and risks of spontaneous or therapeutic abortion as well as status of the endometrium surrounding the cavity. Prior to deposition of fertilized ova, total uterine cavity length and endometrial shape are routinely evaluated to identify the most appropriate and most conducive location for the fertilized ovum to successfully develop and achieve an uneventful pregnancy. Precise measurement of the depth of uterine cavity is therefore important for improving and ameliorating many intrauterine procedures such as embryo placement in In-vitro fertilization, endometrial ablation, even in the management of different types of abortion [21-23].

This was a facility-based retrospective study involving data of 1122 women who presented for ART at a private fertility facility in Nigeria, from 2003 to 2014. The mean age of the patients recorded as 39.0 ± 6.2 years was higher than the 28.0 ± 3.6 years reported by Abd-Ellah in Egypt [24] or the 32.90 ± 5.40 years reported by Mishra., *et al* in India [25] Age is a major variable in fertility management because of ovarian and endometrial factors which may be age-dependent. The mean BMI 27.7 ± 4.8 Kg/m^2 reported here for study subjects was higher than the 24.92 reported by Ryley., *et al* [26] and in the study of Aghajhanova., *et al* [27], the 2.8% underweight and 69.1% normal weight were higher that the 1.1% underweight and 26.8% normal weight reported in this study, while the 18.7% overweight and 9.4% obese were much lesser than the 43.7% overweight and 28.4% obese also reported in this study. Underweight and overweight possibly have negative effects on IVF parameters and outcome leading to decreased chances of pregnancy [27]. The 33.8% prevalence of primary infertility reported here is lower that the 51.4% reported in an European study [29] The mean depth of uterine cavity among study subjects was (8.30 ± 1.5 cm), slightly lesser than the 9 cm reported in a case study [30]. Underweight sub-fertile women had significantly longer depth of uterine cavity than their counterparts with normal weight, overweight or obese. Although these may be novel findings, the very few number of those who were underweight in this study makes it technically impossible to draw any valid conclusion but requires further investigations and explanations. When the depth of the uterine cavity was divided into < 7 cm, 7 - 10 cm and >10 cm, pooled analysis shows that there was a distinct variation in the proportion of intrauterine adhesion (IUA) and not fibroid or polyps, in each of these divisions. Another key finding is that the proportion of older women who had single or double uterine procedure was higher that that of younger women aged < 35 years and while older women were approximately thrice as likely to have double (multiple uterine surgical procedures, younger women were about 2 times as likely to have single uterine surgical procedure. This may likely mean that as women grow older, they tend to have many gynecological or obstetric conditions that require intervention. Furthermore, a significant difference in the mean depth of uterine cavity, which was not noted in those who had dilatation and curettage or Caesarean section, was observed among those who have had myomectomy, a phenomenon that needs further investigation. This study speculates that after myomectomy, the uterus probably overcompensates by getting either bigger, longer or both, thus resulting in deeper uterine cavity. The myometrium may have played an vague yet unraveled role in this hypothesized overcompensation theory. The precise mechanism by which the depth of uterine cavity is longer in those with uterine fibroid or those who had undergone myomectomy is not fully elucidated. The most common single pathology was intrauterine adhesion, in higher proportion among older women aged ≥ 35 years than in younger women and in all categories of body mass index. Intrauterine adhesion was still more prominent when it occurred as a co-morbidity with uterine fibroid in overweight sub-fertile women or as comorbidity with either uterine fibroid or uterine polyps in obese women. The 26.2% prevalence of IUA observed in this study is greater than the 10.2% reported in Egypt [24], the 6.9% in India [25] or the 0% by Kasius., *et al* in Europe [29]. Finally, this study shows that individually, age, uterine fibroid and myomectomy are significantly associated with the depth of uterine cavity. These variables should be considered cogently by gynecologists in sub-Saharan Africa when dealing with cases of female sub-fertility

Conclusion

Knowledge of the details of uterine cavity depth and shape could make it easier to deposit the embryo at an optimum depth within the cavity, this may influence the chances of implantation during IVF treatment. From the comparative analysis of the depth of uterine cavity in Black African women, there is significant correlation between depth of uterine cavity and Body Mass Index (BMI). The mean depth of uterine cavity is significantly longer among women who had history of uterine fibroid, polyp and curettage compared to women with no history of intervention and among those who have had myomectomy compared to those who had not had any previous uterine surgery or surgical procedure. There is however no significant impact of body mass index on the mean depth of uterine cavity. Intrauterine adhesion was the most prevalent pathology observed within the uterine cavity in this study. Abnormalities within the uterine cavity can be a contributing cause of female sub-fertility, probably by shifting the most appropriate locus for the embryo to attach to the uterus or by altering the shape of the uterus and distorting its cavity. In view of the possibility that uterine abnormalities can contribute to sub-fertility and recurrent implantation failure, uterine cavity assessment has been suggested as a routine investigation in the evaluation of sub-fertile women. Detailed information on uterine cavity depth and shape could make it easier to deposit the embryo at an optimum depth within the cavity, this may influence the chances of implantation during IVF treatment. Measuring uterine cavity is clinically useful to ascertain the depth beyond which catheter insertion should not occur during an IVF [31]. Findings in this study call for a a more intense research on the mechanism by which intrauterine cavity is longer among sub-fertile women with uterine fibroid and those who had myomectomy.

Study Limitation

This study has some limitations that need to be discussed. In the first instance, the sample was a convenience sample of sub-fertile women who presented for ART and who signed that their data could be used for studies in infertility. Therefore the results may not be quite representative of all sub-fertile Black women in sub-Saharan Africa. We did not include the data of subjects who did not sign an agreement to use their data for research, though these were few. Additionally, the study design was retrospective for ten years and may have been possible errors in reporting finding. However, this would have been very minimal as operating surgeons always met post-surgery to discuss findings. Most of the subjects in this study were from a moderate socio-economic status living in cities thus, data of sub-fertile women in low socio-economic status living in villages were not available. Further, the study did not distinguish between ethnic groups, residence or marital status, though there may be differences in intra-uterine abnormalities relative to these variables. Furthermore, fibroid was not distinguished as sub-serosal, intra-mural or sub-mucous, and intrauterine adhesion was not categorized by severity. Other uterine abnormalities that occurred in very low frequency such as unicornuate or transcervical septum were not included in the study.

Disclosure

All authors declare no conflict of interest.

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