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Evaluation of the Competence of Sonographers in 3D/4D Ultrasound Imaging: The Case of Nairobi County

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Abstract:
Background: There is variable utilization and in some cases non-utilization of 3D/4D ultrasound imaging, even when the application is available in equipment. The reasons of non-utilization of 3D ultrasound given the high amounts of money invested in purchase of equipment with such technology in Kenya remain largely unknown.
Objectives: The aim of this study was to evaluate the competence of sonographers in 3D/4D ultrasound imaging in Nairobi County in Kenya. The main outcome measures were knowledge, skills, and attitudes of sonographers in the use of 3D/4D ultrasound imaging.
Methodology: This was a cross-sectional descriptive survey in which self-administered questionnaires were utilized to gather data regarding utilization of 3D/4D ultrasound imaging among practicing sonographers in both public and private imaging facilities within Nairobi County.
Results: The majority, 60% of the respondents worked in private healthcare facilities. In terms of gender distribution, 52% of the respondents were male. The professional inclination of the majority of the respondents, 60% had a radiography background. None of the participants had a radiology inclination while one respondent (4%) had an obstetrics inclination. However, it is noted that 24 %(n=6) of the respondents did not respond to the question on their professional inclination and it is probable that those respondents were uncomfortable with the question. The majority, 76 % (n=19) of the respondents had an experience of between zero and four years in sonography. The highest professional qualification of the majority of the respondents was diploma level while only 8% (n=2) of the respondents had a bachelor's degree and above. A significant number of the respondents, 68 %(n=17) did not have formal training in 3D/4D ultrasound imaging. The majority, 68 % of the respondents did not practice 3D/4D ultrasound imaging. The majority of the respondents, 52% had regular access to 3D/4D equipment. The majority of the respondents, 64% did not undergo continuing education in 3D/4D. Most respondents, 80% believe that 3D/4D ultrasound imaging is clinically useful in obstetrics. The majority, 48 % of the respondents thought that performing 3D/4D examinations was cumbersome The majority, 68% of the respondents thought that 3D/4D ultrasound imaging was good for patient entertainment and as a commercial gimmick. The majority of the respondents, 64 % had never recommended 3D/4D ultrasound imaging to a clinician. The majority, 92 % held that 3D/4D added information in medical diagnosis. This correlates well with the participants' majority opinion that 3D/4D was useful. The majority, 96 % of respondents was of the opinion that showing 3D/ 4D images to patients was re-assuring and it enhanced patient's confidence in the sonographer. Some respondents also opined that 3D/4D gives detailed images, as one is able to project images in several dimensions.
Conclusion: There is a generally low level of knowledge and utilization of 3D/4D ultrasound imaging among sonographers in Nairobi County and much equipment with 3D/4D functionalities remain under-utilized despite the fact that use of 3D/4D options adds value in ultrasound imaging. A number of respondents thought that 3D/4D ultrasound imaging was for patient entertainment or simply a commercial gimmick.

This suggests precedence of the push factors that vendors use to achieve a sale of new equipment while neglecting the clinical supremacy of the clinical application.
Recommendation: Purchase of ultrasound equipment should be strategic rather than passive so that equipment are not purchased expensively with in-built state of art technology like 3D/4D that is left to lie idle while other priorities are denied funding. In case there is purchase of ultrasound equipment with 3D/4D capability, there should be regular continuing medical education workshops or seminars by the dealers on user application training in order to achieve optimal utilization of the functionalities. The curriculum for training of sonographers should incorporate aspects of 3D/4D imaging to harness the benefits of using this technology as an adjunct to the routine 2D ultrasound imaging.

***Keywords**: 3D/4D ultrasound imaging, competence of sonographers, utilization of 3D ultrasound*

CHAPTER 1

1. Introduction and Background Information

Ultrasonography is a medical imaging technique that uses high frequency sound waves and their echoes to visualize and produce images of the internal body organs. Medical ultrasound utilizes multiple scanning display modes that include A-mode, B-mode, and M-mode. In **A**-mode scanning, the amplitudes of the returning echo signals from tissue interfaces display as a series of amplitude deflections along horizontal axis, as on an oscilloscope. In B-mode scanning (brightness mode), reflected ultrasound pulses are displayed on the monitors as spots of varying brightness in proportion to their intensity. The transmission of sound waves into the tissue in a parallel scan or a fan-shaped beam, results in reflection of echoes back to the transducer that then assembles them line by line according to their arrival time. Approximately 120 image lines are assembled to make a two dimensional (2D) sectional image via conversion of various echo intensities by electronic processing into image spots of varying density or shades of gray (gray scale display, brightness modulation). M-mode scanning (time motion) generates a time-motion trace of acoustic reflectors such as heart valves and myocardial walls over time (Woo, 1998-2001; Schmidt, 2007).

The major reason for increase in use of 3D ultrasound emanates from the limitations of 2D viewing of 3D anatomy, using conventional ultrasound. According to Fenster et al (2001), interpretation of 2D images yields variable results, as the diagnostician has to integrate multiple images in his mind given that conventional images are 2D yet the anatomy is 3D. Furthermore, later reproducibility of 2D ultrasound image is rather difficult by the same or different operators as there is no standard reference frame. Three Dimensional (3D) imaging involves acquisition of several two-dimensional images by moving the probes across the body surface or rotating inserted probes followed by computerized combination of the two-dimensional scans to form 3D images. Three-dimensional ultrasound is an improvement to the traditional 2D imaging and 4D refers to 3D in real time. In 4D, the final image is the same as 3D and the only difference is time factor. Thus, 4D is merely an enhancement of 3D rendering, and for the purposes of this study, 3D and 4D refers to same thing. Sonologists and Sonographers around the world have always conjured three-dimensional images of anatomy and pathology in their minds while doing their 2D scans (Dahiya, 2010). According to Hagen-Ansett, (2011), the state of the art of ultrasound demands a high degree of manual dexterity, hand-eye coordination, and conceptualization of two-dimensional information into a three-dimensional format. Using 3D and 4D imaging in ultrasonography in obstetric scanning it is possible to demonstrate medical conditions such as cleft lips, spina bifida and anencephaly among other fetal abnormalities with amazing clarity. Above all, 3D/4D provides pregnant mothers with a sneak preview of the facial appearance of the unborn baby and assure normalcy.

Following the introduction of medical ultrasound in Kenya in the early 1980s, the application has gained universal usage with many radiologists and radiographers attaining competence in the modality. Modern ultrasound machines have in-built configuration that enables advanced imaging possibilities among them three-dimensional (3D) imaging.

1.1. Research Problem

3D/4D ultrasound has significant clinical benefits when applied skillfully in specific ultrasound investigations, especially in obstetrics. Literature evidence suggests that clinical outcomes improve through utilization of multiplanar and volume rendered ultrasound imaging in the diagnosis of conditions such as cleft lip, spina bifida and anencephaly, among others. In spite of the previously mentioned, there is under utilization and in some cases non-utilization of 3D/4D ultrasound imaging, even when the application is available in equipment. The reasons of non-utilization of 3D ultrasound given the high amounts of money invested in purchase of equipment with such technology in Kenya remain largely unknown.

Utilization of advanced ultrasound technology improves imaging techniques and enhances clinical outcomes. Evaluation of the competence of sonographers in optimal utilization of advanced medical imaging tools like 3D/4D ultrasound could add information that is critical for managers of healthcare. Managers and policy makers require evaluation of the utilization of such technologies to enable informed decisions in health resource prioritization, procurement, and allocation.

1.2. Aims and Objectives

The aim of this study was to evaluate the competence of sonographers in 3D/4D ultrasound imaging in Nairobi County. The main outcome measures were knowledge, skills and attitudes of sonographers in the use of 3D/4D.

1.2.1. Research Question

What is the level of competence of sonographers in 3D/4D ultrasound imaging in Nairobi County?

1.2.2. Specific Objectives

The following were the specific objectives of the research:

- To determine the level of knowledge on 3D/4D ultrasound imaging among Sonographers
- To determine the level of utilization of 3D/4D ultrasound imaging among Sonographers
- To determine the constraints that hamper the use of 3D/4D imaging by Sonographers and come up with recommendations to improve/increase its utility

1.3 Justification

Ultrasound researchers have continually undertaken to develop new methods of imaging. Health system scientists have in recent years sought to narrow the gap between knowledge and action. Equipment manufacturers place emphasis on less dependence on human skills by configuring imaging equipment to fill the skill gaps through evidence-based solutions.

Sonographers ought to keep up with the technological trends in order to contribute to improved clinical results. Once new technology has translated from research to commercial phase, it needs matching with user training in order to provide value to end consumer of imaging service. Low utilization of the 3D/4D functions in-built in an ultrasound is tantamount to wasted investment. Above all, it leads to misdiagnosis if not utilized in certain situations.

The study sought to find out the level of competency of sonographers in the utilization of 3D/4D that shall be useful for ultrasound curriculum developers as well as policy makers in strategic procurement of ultrasound machines.

1.4. Conceptual Framework

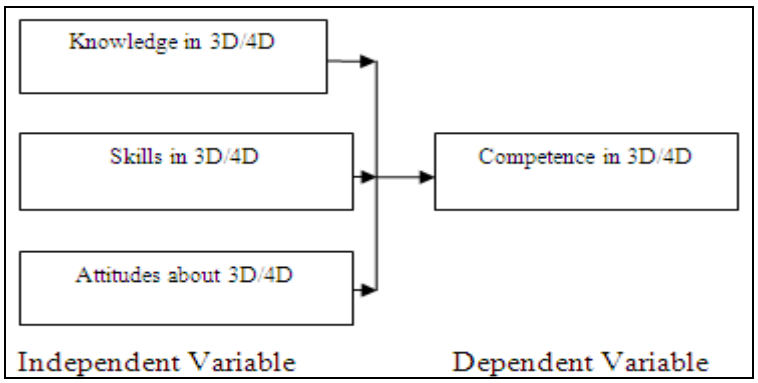

Figure 1: Conceptual Framework

1.5 Operationalization of variables influencing 3D/4D utility

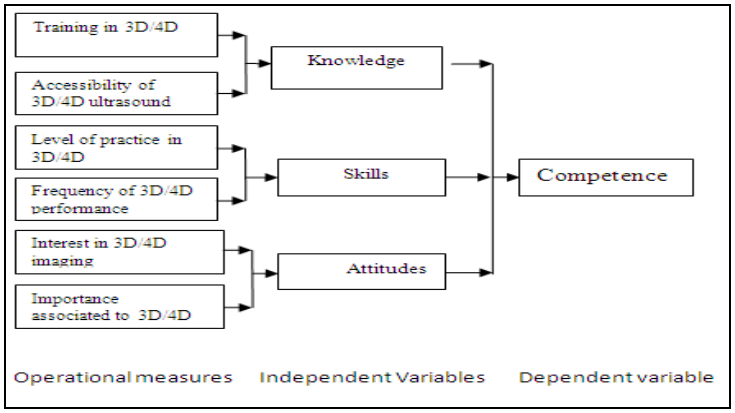

Figure 2: operational Framework

CHAPTER 2

2. Literature Review

2.1. Importance of Three Dimensional Imaging

The utility of 3D ultrasound imaging has greatly improved uterine morphological assessment especially with regard to congenital abnormalities. The 3D ultrasound is also useful in the diagnosis of multiple abnormalities of the fetal face like cleft lip/palate, micrognathia, dysplastic ear and midface hypoplasia. The 3D ultrasound imaging further improves understanding of fetal anatomy by families and promotes maternal fetal bonding (Chudleigh and Thilaganathan (2004: pg 82), Tarsa, Pretorius&Agostini (2006: pg 328), Tarsa *et al*, 2006: pg 321).

2.2. Knowledge, Skills and Attitudes in 3D/4D Imaging

Tarsa *et al* (2006: pg 328) states that the learning capacity of individuals for 3D/4D is variable and the adoption process of this technology is dependent on multiple factors.

According to Fenster et *al* (2000), the 3D ultrasound application tools are generally difficult to use as they require complicated user interface.

Dahiya (2010,GE Brochure), states that what cannot be seen in 2D cannot be seen in 3D which means that the limitations of 2D are inherent in 3D/4D. Despite the fact that 3D ultrasound may provide vivid images of the first trimester fetus, Hobbins (2008) states that the tool is underutilized. Thus, 3D imaging is a useful adjunct when used with 2D according to Curry et al (2004).

2.3. Research Gaps

From available literature, there was no documented evaluation of the level of utilization or competence of sonographers regarding 3D/4 D ultrasound in Kenya and Nairobi County in particular. This research will add to the body of knowledge in ultrasound imaging on this most important modern imaging method as it evaluates the knowledge, skills and attitudes of sonographers in 3D/4D ultrasound imaging.

CHAPTER 3

3. Research Design and Methodology

3.1. Research Design

The study is a cross-sectional descriptive type of research design. The design provided a cost effective method of collecting data and its analysis.

3.2. Research site and scope

This study utilized questionnaires to gather data among practicing sonographers in both public and private imaging facilities within Nairobi County. The Nairobi County is the most progressive county in medical imaging in Kenya since it is home to the nation's capital city. The Nairobi County has most of the major hospitals. These include The Nairobi Hospital, Aga Khan University Hospital, Mater Hospital, Karen Hospital, M.P. Shah Hospital, Kenyatta National Hospital, Forces Memorial Hospital and Mbagathi District Hospital. Others are St Mary's Hospital, Langata, Kayole Hospital (Mama Lucy Kibaki Hospital), Guru Nanak Hospital, Avenue Hospital, Nairobi Women's Hospital, Nairobi West Hospital, Coptic Hospital, Melchizedek Hospital, Menelik Hospital, St James Hospital, KasaraniNeema Hospital and St Francis, Kasarani Hospital, among others. Standard sampling methods were used to obtain data in the above facilities using a questionnaire.

3.3. Study Population

The study population constituted all sonographers in Nairobi County. They were located in public, private, and medical training facilities.

3.4. Sampling method

Sampling is the process of studying only a small portion representative of the whole population and then generalizing the results to the whole. According to Lucey (1996: pg72), it involves drawing inference about the population based on the sample studied.

A list of imaging facilities in Nairobi County was computed from the records of the Kenyan Ministry of Health. A list of all radiology facilities in Nairobi County was obtained from the Kenyan Radiation Protection Board offices. Various heads of radiology were contacted to provide the number of radiographers in their facility. A list was then made of the sonographers and a simple random sampling done to obtain the target sample size.

3.5. Inclusion/exclusion criteria
Respondents were selected from existing government records of health facilities with ultrasound at the time of conducting this study. Facilities not yet identified by the Ministry of Health were excluded. Such exclusion was unlikely to affect the study, since Ministry of Health records are a primary source of information related to health services.

3.6. Data Collection
The researcher supplied the respondents with the self-administered questionnaires with guiding instructions on how to fill the same. The respondents were to fill the questionnaire within three days after which the same could be collected for analysis. The duration was appropriate since it ensured the respondents did not forget nor lose the questionnaires.

3.7. Data Analysis and Presentation
Data collected was analyzed using Microsoft Excel. Analyzed data was presented in frequency and percentage tables, graphs and charts.

3.8. Ethical Considerations
Data collected was treated with utmost confidentiality. Necessary approvals were obtained for the study from the Ministry of Education via the Director of Kenya Medical Training College and the right of respondents to participate or decline was assured and respected.

3.9. Data Collection Method
A transmittal letter accompanied the questionnaires explaining how to fill it and assuring respondents of their rights and privacy. A total of 75 questionnaires were distributed. Difficulties were encountered in locating the sonographers due to their work and schedules as well as geographical distribution. Twenty five (25) questionnaires were filled and returned. Some sonographers declined to respond to the questionnaires while others gave appointments that they did not honour.

CHAPTER 4

4. Introduction to study findings
The findings of analyzed data from the 25 questionnaires filled up by respondents were analyzed and organized as follows:

- General findings about Sonographers
- Training of Sonographers in 3D/4D
- Skills of Sonographers in 3D/4D
- Attitudes towards 3D/4D

4.1. Data Presentation
Data obtained was presented in tables and charts as follows:

Description of Facility	Frequency (f)	Percentage (%)
Public Healthcare Facilities	8	32
Private Healthcare Facilities	15	60
Health Training Institutions	1	4
Others	1	4
Total (n=25)	25	100

Table 1: nature of healthcare facility
The majority, 15 (60%) were working in private healthcare facilities

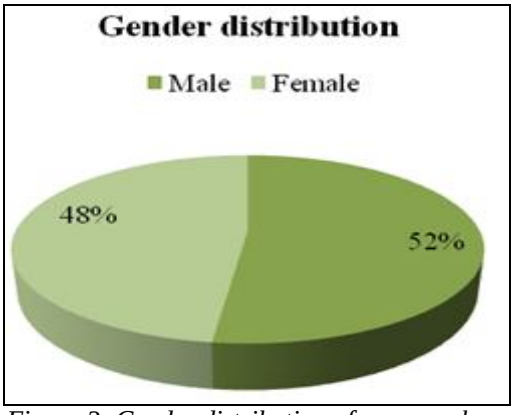

Figure 3: Gender distribution of sonographers
Majority, (52%) were male.

Professional Inclination	Frequency (f)	Percentage (%)
Radiography/Imaging	15	60
Radiology	0	0
Obstetrics	1	4
Others	1	4
No response	8	32
Total (n=25)	25	100

Table 2: Professional inclination of sonographers
The majority of respondents (60%) had a radiography/imaging inclination.

Years of Experience	Frequency (f)	Percentage (%)
0-4	19	76
5-9	4	16
10-14	0	0
15-19	0	0
20-24	1	4
25-29	1	4
Total	25	100

Table 3: Experience of respondents in sonography
The majority, 19 (76%) had an experience of between zero and 4 years.
Only 2 (8%) had an experience of over 10 years in sonography.

Highest Professional Qualification	Frequency (f)	Percentage (%)
Diploma	6	24
Higher Diploma	17	68
Bachelor's Degree	1	4
Master's Degree	1	4
PHD	0	0
Others	0	0
Total (n=25)	25	100

Table 4: Highest professional qualification
Only 8% (n=2) had a bachelor's degree and above

Training on 3D/4D		
Answer	**Frequency (f)**	**Percentage (%)**
YES	8	32
NO	17	68
Total (n=25)	25	100

Table 5: Whether trained in 3D/4D
Majority, 68% (n=17) were not trained in 3D/4D ultrasound imaging.

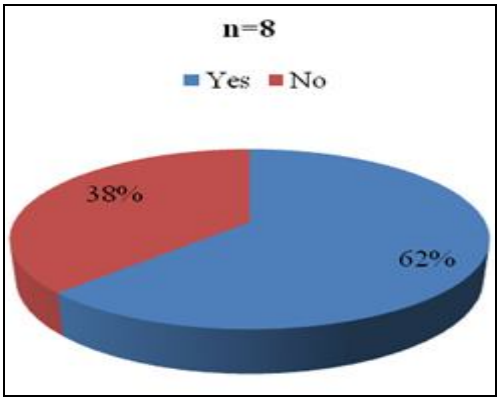

Figure 4: Whether training in 3D/4D was structured or not
The majority, (62%) of those trained 3D/4D had undergone structured training

Respondents who practice 3D/4D		
Response	**Frequency (f)**	**Percentage (%)**
Yes	8	32
No	17	68
Total (n=25)	25	100

Table 6: Whether practiced 3D/4D
Majority, 68% (n=17) did not practice 3D/4D

Regular access to 3D/4D equipment		
Response	**Frequency (f)**	**Percentage (%)**
Yes	13	52
No	10	40
No. response	2	8
Total	25	100

Table 7: Regular access to 3D/4D equipment
Majority, (52 % (n=13) had regular access to 3D/4D equipment

Engagement in continuing education in 3D/4D		
Answers	**Frequency (f)**	**Percentage (%)**
Yes	9	36
No	16	64
Total	25	100

Table 8: Whether engaged in continuing education in 3D/4D
Majority, 64 %(n=16) did not engage in continuing education in 3D/4D imaging

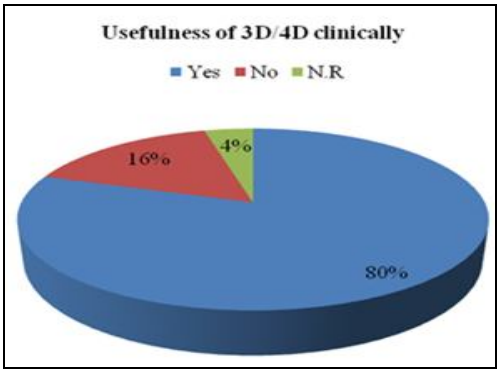

Figure 5: whether 3D/4D is clinically useful
Majority, (80%) said 3D/4D is useful clinically.

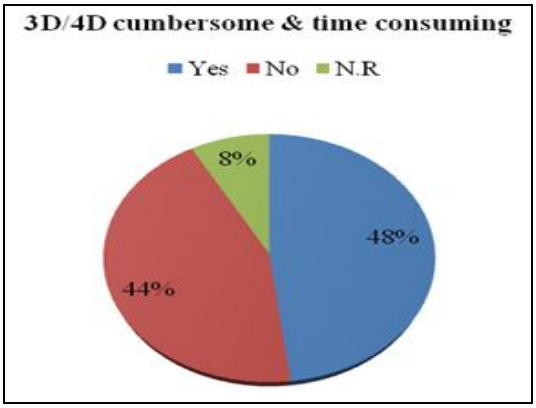

Figure 6: Whether 3D/4D is cumbersome and time consuming

Majority, 48 % thought that 3D/4D was cumbersome and time consuming. Close to the same number (44%) thought it was not.

Is 3D/4D good for entertainment and commercial gimmick		
Responses	**Frequency (f)**	**Percentage (%)**
Yes	17	68
No	7	28
N.R	1	4
Total	25	100

Table 9: Whether 3D/4D is good for patient entertainment and commercial gimmick

Majority, 68 %(n=17) responded that 3D/4D was good for patient entertainment and commercial gimmick.

Recommend 3D/4D to clinicians		
Responses	**Frequency (f)**	**Percentage (%)**
Yes	9	36
No	16	64
Total	25	100

Table 10: Whether ever recommended 3D/4D to clinicians

The majority, 64 % (n=16) had never recommended 3D/4D to clinicians.

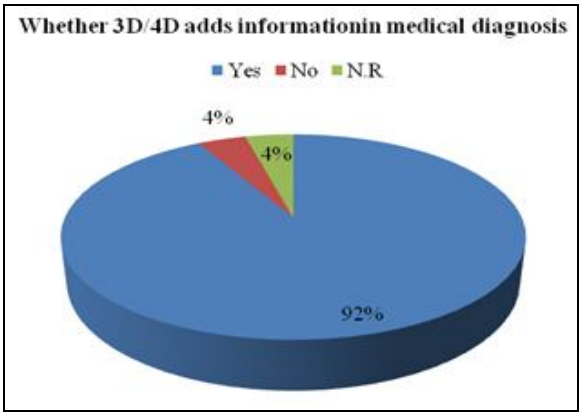

Figure 7: Whether 3D/4D adds information in medical diagnosis

The majority, 92% held that 3D/4D was useful for medical diagnosis.

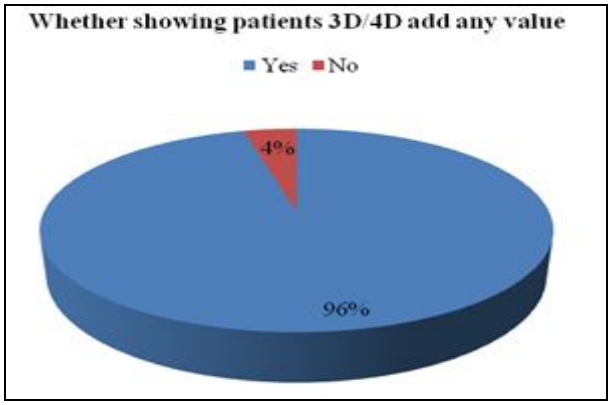

Figure 8: whether showing 3D/4D images to patients adds any value
Majority, 96% answered that showing 3D/4D images to patients adds value.

CHAPTER 5

5. Discussion, Conclusions and Recommendations

5.1. Response Rate

Out of 75 questionnaires distributed, 25 were filled and returned. This constitutes 33.3 % of the target population, which was deemed adequate and representative.

5.2. Discussion of Findings

Table 1 show the nature of health facility where the respondents in this study worked. It can be seen that the majority, 60 %(n=15) of participants worked in private healthcare facility.

Figure 3 shows the gender distribution. Majority of participants, 52% were male. This represents a near gender equity.

Table 2 shows the professional inclination of participants. The majority, 60%(n=15) of the respondents had a radiography/ imaging inclination. None of the participant had a radiology inclination while one respondent (4%) had an obstetrics inclination. However, it is noted that 32 %(n=8) of the respondents did not respond to this particular question. It is probable that those participants could be respondents not comfortable with the question.

Table 3 shows experience of respondents in sonography. The majority, 76 %(n=19) had an experience of between zero and four years. It can be deduced that the majority of practicing sonographers are in their formative years in sonography, hence the low levels of knowledge and skills in 3D/4D ultrasound imaging. The level of competency in 3D/4D in Nairobi County is very low and this may be the reason of underutilization of the application. The lack of professional experiences in the range of 10-19 years among the respondents meant that there was a general low level of ultrasound experience with expected low innovativeness.

Table 4 shows the highest professional qualification of the respondents. It can be seen that on 8% (n=2) of participants had a bachelor's degree and above. This represents a high level of inadequate knowledge base.

Table 5 shows the training of the respondents in 3D/4D. It can be seen that 68 %(n=17) of the repondents did not have training in 3D/4D ultrasound imaging. This could partly explain the low levels of competency in 3D/4D.

Figure 4 represents the nature of training for those who had 3D/4D training. It can be seen that the majority, 62 % of the respondents had structured training.

Table 6 shows the practice of the respondents in 3D/4D. It can be seen that the majority, 68 % did not practice 3D/4D ultrasound imaging. It can be deduced that majority of sonographers have low skills of 3D/4D or negative attitude towards the technology.

Table 7 shows the access of the respondents to 3D/4D equipment. It can be seen that the majority, 52% had regular access to 3D/4D equipment. The low levels of non-practice of 3D/4D could therefore stem from lack of knowledge and skills.

Figure 8 shows the engagement of the respondents in continuing medical education in 3D/4D. It can be seen that the majority, 64% did not undergo continuing education in 3D/4D, suggestive of low levels of knowledge, skills and attitudes in 3D/4D ultrasound imaging.

Figure 5 shows the participants response on whether the 3D/4D is clinically useful. The majority of respondents, 80% thought that 3D/4D is clinically useful. This represents an overwhelming consensus on the usefulness of 3D/4D applications. Most respondents believe that 3D/4D is clinically useful. Majority of respondents ascribed 3D/4D to obstetrics, suggesting a skewed knowledge base in 3D/4D applications in a wide range of clinical presentations.

Figure 6 shows the response of participants on whether 3D/4D was cumbersome and time consuming. The majority, 48 % of the respondents thought that performing 3D/4D examinations was cumbersome and time consuming.

Table 9 shows the response of participants on whether 3D/4D was good for patient entertainment and commercial gimmick. The majority, 68% thought that 3D/4D was good for patient entertainment and as a commercial gimmick. This attitude negates the positive

clinical applications of 3D/4D and may point to low levels of utilization of 3D/4D. Alternatively, it may be an appreciation of how 3D/4D can be misused for commercial reasons by enterprising practitioners as well as vendor driven purchases.

Table 10 shows recommendation of 3D/4D to clinicians by the respondents. Majority of the respondents, 64 % did had not recommended 3D/4D to a clinician. This could be attributable to the low levels of training in 3D/4D among respondents.

Figure 7 represents an assessment of whether 3D/4D adds information in medical diagnosis. The majority, 92 % held that 3D/4D added information in medical diagnosis. This correlates well with the participants' majority opinion that 3D/4D was useful (figure 5).

Figure 8 shows whether showing 3D/4D images to patients adds any value. It can be seen that the majority, 96 % of respondents were of the opinion that showing 3D/ 4D images to patients added value. Some participants said that seeing 3D/4D obstetric image would re-assure the patient that all was well, that what they were being told is true and enhances patient's confidence in the sonographer. Since 3D/4D are like real life pictures, the patients are able to appreciate if there are abnormalities and get delighted when they see detailed pictures of their normal intra-uterine babies. This generally, according to respondents, increases the patient satisfaction in the ultrasound services. Some participants also opined that 3D/4D gives detailed images, as one is able to project images in several dimensions.

Some participants recommended routine use of 3D/4D and that user application training is necessary to enhance competence in the same. Others cautioned that 3D/4D be utilized for only specific clinical purposes since there is no absolute proof that over use of the technology does not hold potential harm to the fetus.

5.3. Conclusion

There is a generally low level of knowledge in 3D/4D ultrasound imaging among sonographers in Nairobi County and much equipment with 3D/4D functionalities remain under-utilized despite the fact that use of 3D/4D options adds value in ultrasound imaging.

A number of participants thought that 3D/4D was for patient entertainment or simply a commercial gimmick. This suggests precedence of the push factors that vendors use to achieve a sale of new equipment while neglecting the clinical supremacy of the clinical application.

5.4. Recommendations

Purchase of equipment should be strategic rather than passive so that equipment are not purchased expensively with in-built state of art technology like 3D/4D that is left to lie idle while other priorities are denied funding. In case there is purchase of equipment with 3D/4D capability, there should be regular continuing medical education workshops or seminars by the dealers on user application training in order to achieve optimal utilization of the functionalities. The curriculum for training of sonographers should incorporate aspects of 3D/4D imaging in order to harness the benefits of using this technology as an adjunct to the routine 2D imaging.

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