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Impact of Oral Health

Mass Diffusive Micro Stretch

Highlights

Dental Caries Experience

Workplace Mentoring Strategies

Discovering Thoughts, Inventing Future

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Dental Caries Experience in 2-15- Year-Olds Living with HIV in Nairobi and Mombasa "Kenya"

By Mariam A. Hussein & Gladys N. Opinya
University of Nairobi

Abstract- *Title of the article:* Dental caries experience in 2-15 year old children living with HIV in Nairobi and Mombasa "Kenya".

Background: Dental caries affects children both healthy and those living with HIV.

Aims: To determine the dental caries prevalence and association with dental parameters, HIV related oral lesions, oral health practices, immune status and use of ARV's.

Methods: This was a cross sectional descriptive study with a sample size of 237 children aged 2-15 years. A specially structured questionnaire captured demographic data, oral health practices, oral complaints. Plaque scores, gingivitis and dental caries were recorded `in a modified WHO form. Data on ARV use and immune suppression state were obtained from the medical records. Data was analysed using the SPSS software version 17.

Results: 237 children confirmed with HIV aged 2-15 years (mean age=7.5 years) were assessed. The deciduous dentition caries prevalence was 84.4% with a mean dmft of 6.38(± SD5.45). Caries prevalence in the permanent dentition was 78.3% and the mean DMFT score was 3.35 (± SD 3.55).Significant associations were also noted when comparing dental caries with oral hygiene status, gingivitis, presence of HIV oral manifestations, immune suppression state and oral complaints of pain($p<0.05$).

Conclusion: High prevalences of dental caries and dmft/DMFT scores were noted. Reduction in their caries experience is important hence the need for Oral health care to be integrated in their primary care to alleviate their pain, improve their nutritional status and quality of life.

Keywords: *children HIV, caries experience prevalence, dmft, DMFT.*

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Mariam A. Hussein [α] & Gladys N. Opinya [σ]

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I. Introduction

There is minimal literature on the oral health of children with HIV including both dental parameters and oral lesions within the country and our neighbours despite more than 90% of HIV infected children living in Sub Saharan Africa[1,2] . Elsewhere, although there are many studies evaluating oral soft tissue manifestations of HIV/AIDS in children, there are relatively few clinical investigations into the prevalence and incidence of dental caries in the primary and permanent dentitions.[3-5] Some authorities in pediatric HIV/AIDS have indicated that there is no substantial difference between pediatric HIV/AIDS children and the general child population; while others have noted increased caries susceptibility. Among the studies conducted, a wide variation in the prevalence of dental caries has been noted. [6-12]

The high prevalence has been associated with nutritional supplements, Cariogenic medications, xerostomia, presence of painful oral lesions.[6,7]

II. Materials and Methods

The study was conducted in two private homes for children living with HIV (Nyumbani and New life childrens homes) and two referral hospital outpatient comprehensive care centers (Kenyatta National Hospital and Coast Province General hospital) running HIV programmes for children, located in Nairobi and Mombasa respectively. Since this was a descriptive cross sectional study the sample size was determined using the formula: $n = Z^2 XP (1-P)$ with P at 85% as the prevalence of gingivitis in HIV infected children [7]

CI- Confidence Interval 95%; d-absolute precision- 5% [α]; $Z^{1-\infty}$standard error of mean: 1.96

A minimum of 237 children were recruited via convenience sampling technique.

The study was conducted over a period of three months and approved by the joint ethical research committee of KNH and University of Nairobi.

The subjects were categorized into three baseline age groups: 2-5 year olds, 6-11 year olds, and 12-15 year olds based on the dentition primary, mixed and permanent dentition stages respectively.

Plaque scores (WHO Plaque index 1999), Gingival scores (Loe and Sillness 1963), Dental caries status (Klein, Palmer and Knutson 1938) and specific HIV related oral manifestations were recorded in a modified WHO Form[13]

A specially structured questionnaire was used to assess the oral health practices of each child, complaints of oral pain and challenges in feeding and maintaining oral hygiene. Data on ARV'S and the immune suppression state based on the CD4counts/% were obtained from the records. Data was analysed using S.P.S.S version 17.0

Author α: B.D.S (Manipal) MDS Paediatric Dent (Nairobi), Department of Paediatric Dentistry & Orthodontics; School of Dental Sciences; College of Health Sciences University of Nairobi, Nairobi, Kenya.
e-mail: husseinmariam@yahoo.com
Author σ: B.D.S (Nairobi) CAGS, MSc. (Boston) PhD. (Nairobi) Professor of Paediatric Dentistry, Department of Paediatric Dentistry & Orthodontics; School of Dental Sciences; College of Health Sciences, University of Nairobi. e-mails: amaniwanjala@yahoo.com, gladys.opinya@uonbi.ac.ke

III. Results

Among the 237children, Six (2.5%) were from NewLife childrens home, 77(32.5%) Nyumbani childrens home, 39(16.5%) from the Comprehensive Care Centre at KNH while 115(48.5%) were from the C.C.C at the CPGH. Children from the homes comprised a total of 83(35%) while those from the outpatient centres completed the remaining study population (154, 65%) as depicted (Fig1).

Among the population examined 112 (47.3%) were males and 115(52.7%) females.

The mean and modal ages were 7.5 and 9 years respectively and age cohorts as shown (Table 1).

The mean dmft was 6.38± SD 5.45, 84.4% had caries while only 15.6% were caries free, 2% had fillings and 7.5% of the children had teeth missing due to caries. The mean DMFT was 3.35 ± SD3.55, 78.3% had decayed teeth, 3.9% missing teeth and only 6.2% had fillings (Table 2).

The mean dmft /DMFT of children from the homes (4.77± SD 4.10/ 2.95±SD3.51) was significantly lower than that of the C.C.C outpatient centres (7.39±SD 6.04/ 3.67±SD3.57): Tables 3 and 4.

Males had a dmft of 6.49±SD 5.84 and DMFT of 3.03± SD 3.13 while females had a dmft of 6.55±SD 5.39 and DMFT of 3.65±SD3.89.The gender differences were not statistically significant: Tables 3 and 4.

The mean dmft of children in the 2-5 yrs , 6-11 yrs and 12-15 year age groups were 7.12 ±SD 6.79, 6.57±SD 4.88 and 3.4±1.844 respectively, though not statistically significant.(Table 3).

Differences in the mean DMFT scores in the 6-11 year (2.41±SD2.944) and 12-15 year (4.98±SD3.964) age groups were found to be statistically significant (Table 4).

Children who reported not brushing (32) had mean dmft of 6.66± 6.225,while those who brushed once (90) had a mean dmft score of 7.84±SD 5.98 and those who brushed twice regularly (77) had the lowest mean dmft of 4.92±SD 4.4. (Table 5 and 6).

Children who complained of pain in the mouth had higher dmft and DMFT's (7.90±6.08 and 4.29±4.21) than those who did not (dmft 5.53±5.04 and DMFT 2.97±3.00) Tables 5 and 6.

Higher dmft and DMFT scores (dmft 8.05±SD 6.03, DMFT 4.3±SD4.26) were recorded in children who reported difficulty in maintaining oral hygiene as opposed to those who did not (dmft 5.45± SD5.04, DMFT 2.82±SD2.97); Tables 5 and 6.

A statistically significant difference was also noted in the caries status of children who reported of difficulty in feeding due to pain in the oral soft tissues and the teeth and those who did not. Children who did not complain of feeding difficulties had dmft scores of 5.47± SD5.041and DMFT of 2.94±SD3.099 whereas children who reported feeding difficulty had dmft scores of 8.05± SD6.048 and DMFT 4.13± SD4.182. , Tables 5 and 6.

Chidren who were on ARV therapy (n=109, N=75) had a mean dmft of 7.03± 5.742 and DMFT 3.41± 3.271.Children who were not on ARV's (n=90, N=54) had a dmft of 5.91± 5.4 and DMFT of 3.28± 3.931 respectively. However, statistical tests were not significant as shown below:

DMFT: Mann U, (Z-0.483); p>0.05 (0.629).
dmft: Mann U(Z-1.385);p>0.05(0.166)

Children with no evidence of immune suppression (n=75, N=50) had a dmft of 5.39±SD4.426 and DMFT of 2.22±SD2.179 while the group with moderate immunosuppression (n=55, N=41) had a dmft of 4.84± SD4.574 and DMFT 4.76± SD4.939. Amongst the severely immunosuppressed (n=56, N=30), the mean dmft was 10.04± SD6.734 and mean DMFT was 3.4± SD2.737 respectively. Statistical tests were highly significant as shown:

DMFT: Kruskal-Wallis, X^2=8.505; 2df; p<0.05(0.014)
dmft: Kruskal-Wallis, X^2=22.213; 2df;p<0.05(0.000)

Children with good oral hygiene scores had a lower mean dmft of 4.29±SD 5.22, and highest dmft scores of 9.43± SD 7.32 were seen in patients with poor oral hygiene. (Table 7).

Children with good OH scores had a mean DMFT of 3.38± SD 3.18, those with fair OH scores had a mean DMFT of 3.07± SD 3.29 while those with poor OH scores presented with the highest scores of 4.35± SD4.55.However no significant differences were noted, Kruskal-Wallis test {X^2=0.593;2df;p=0.101}.

Children who were free of gingivitis had mean dmft of 2.46±SD 3.75 and a mean DMFT of 3.42±SD4.36 and those with mild gingivitis presented with a mean dmft of 6.37±SD 4.67 and mean DMFT of 3.36±SD 3.55, while those who had moderate gingivitis presented with a mean dmft of 8.09±SD 6.41 and mean DMFT of 3.33±SD 3.42 respectively.

Kruskal-Wallis test was statistically significant {X^2=24.065; 2df; p<0.05(0.000)} :Table 7, however, it was not statistically significant in comparison for the mean DMFT scores {X^2=0.784;2df;p>0.05(0.676) } .

The mean DMFT of children who did not present with any HIV related oral manifestation (82) was 3.1±SD3.343, while those with one manifestation (38) had a mean DMFT of 4.08±SD4.207, and those with two or more oral lesions (10) had a mean DMFT of 2.7±SD1.889, however these differences were not statistically significant, Kruskal-Wallis {X^2 =2.900; 2df; p>0.05(0.235)}.

The mean dmft in children who did not present with any HIV related oral manifestations (104) was 5.16± SD4.616 and those who showed presence of one manifestation (81) had mean dmft score of 7.33±SD5.922, while those with more than one

manifestation (14) had dmft scores of 11.31± SD6.408. Kruskal- Wallis was significant {X^2 =16.539, 2df; p<0.05(0.000)}.

IV. Discussion

The overall caries experience in both the deciduous and permanent dentitions was high. The mean dmft was 6.38±SD 5.45 and 84.4% of the children while only 2% had fillings indicating most of the caries were untreated. The mean DMFT was 3.35 ± SD 3.55 and 78.3% of the children had caries while only 6.2% had fillings.

Our study reports dmft and DMFT which are 3.5 and 12.4 times respectively higher than those reported for healthy Kenyan children[14].

The caries prevalence is higher than other studies which report prevalences of 60% and 63.8% respectively. [6,7].

The trend toward increased caries susceptibility in HIV infected children noted may be due to several different factors.

Many of the children experience failure to thrive hence more frequent feedings with carbohydrate and sucrose-rich foods may be necessary to maintain body weight.[3-8] It has been shown that increased frequency of carbohydrate intake in HIV infection is associated with increased caries prevalence and cariogenic microbes. In addition to the increased frequency of carbohydrates, many of the medications essential for antiretroviral therapy and prophylaxis against opportunistic infections contain relatively high sweetener levels or are sucrose based for compliance purposes.[3-11] The fact that these medications need to be taken on a frequent basis increases the child's exposure to cariogenic substances[15].

Lack of effective oral hygiene practices and their late commencement, inadequate oral health education, lack of an adequate referral system resulting in poor dental care for these children may also be factors to consider. Ignorance and fear of the sero-status also prevents these children from seeking dental attention in addition to the high cost of dental treatment which inevitably causes the parents/guardians to prioritize other health needs[6,7].

The adolescent group also had high mean DMFT of 4.92±3.95 (p=0.000), a finding close to what Meless et al. reported (294/407) fifteen-year-olds had a DMFT 4.1± 3.0 [16].This may be attributed to the duration of time the permanent teeth were in the oral cavity. During this period the teeth the erupted permanent teeth are exposed to a cariogenic diet, plaque, gingivitis, and microorganisms or cumulative neglected decay.

In the present study, no record was made of the dietary habits of the children and consumption of snacks.

Significant differences were noted in the mean dmft and DMFT scores among children from the homes(p=0.006) and the C.C.C's (p=0.033). This could be attributed to better and supervised oral hygiene practices incorporated in their care .

The mean dmft scores were also lower in children with good and fair oral hygiene (p=0.03) and mild gingivitis (p=0.008); these findings are in agreement with other studies[10-11].

Among the oral health practices, increased frequency of brushing was significantly associated with lower dmft scores (p=0.007) showing that improved oral hygiene could help slow the decay processes, a finding in agreement with other studies [10-11].

Children with positive complaints of pain and difficulty eating presented with higher dmft scores (7.90± SD 6.08) and DMFT scores (4.29± 4.21) as opposed to those with no such complaints (dmft: 5.38± 5.04, DMFT 2.97± 3.00) once again reflecting on the vicious cycle of oral disease- painful oral lesions- pain – dental disease [18] . Painful gums and pain from oral lesions create a vicious circle where a child who does not brush their teeth because they are in pain, results in plaque accumulation, followed by increased severity of gingivitis and then caries experience resulting in more pain[11,21, 22]. During these periods there is deteriorating health along with the influence of increased use of medications most of which are likely to be sucrose based to combat various opportunistic infections [22, 23].

The mean dmft and DMFT did not vary significantly among children who were on ARV's and those who were not on therapy. These findings are in agreement with other studies which have not associated ARV's with increased caries prevalence. However, it is known that frequent use of medications most of which are sucrose based for compliance purposes may be responsible for the high caries prevalence [15].

Further research may be required to establish any association between duration of ARV therapy, the type of medication, its sucrose content and the caries experience.

Both dmft and DMFT scores were notably higher in children with evidence of moderate and severe immunosuppression (p=0.000, 0.014), a finding in agreement with various studies in the literature to assess the relation between caries and CD4 status [11, 19].

The mean dmft scores were lower in children with good and fair oral hygiene (p=0.03) and mild gingivitis (p=0.008), a finding in line with, Hicks et al[11], Riberio et al[12] and Chen et al[20].

High dmft scores were noted among children with HIV related oral manifestations (p=0.000). Reports have cited it as the next common manifestations following candidiasis and concluded an increase in caries prevalence among the pediatric HIV population[2,3,4].

Chen et al reported fungal infections were associated with an increased caries rate.[20]

The high prevalence of dental caries observed in the children in this study may be associated with increased levels of streptococcus mutans in the saliva of children living with HIV[21].

Children suffering from HIV infections have been reported to have xerostomia. Combined with pain, on chewing food salivary flow would be reduced hence the cleansing lubricating effect from the saliva reduces resulting in dryness of the oral cavity leading to increased severity of gingivitis and decay.[21].

Low et al[22] studied the effect of severe caries on the quality of life in children .Tooth-associated pain, difficulty with nutrition, hampered growth as noted by body height and weight, and sleep patterns are adversely altered by severe dental caries in children. HIV infected children do have growth retardation and failure to thrive. This may be further complicated by the presence of severe dental caries.

V. Conclusion

This study had a high prevalence of dental caries in both primary and permanent dentition with high mean dmft /DMFT scores. The oral health of HIV-infected children and a reduction in the caries experience are quite important. In pediatric HIV patients, many factors play a role in caries development and attention should be directed toward establishment of a caries prevention regimen.

It is advisable for oral health care to be integrated in the primary care for these children in order to alleviate their pain and improve their nutritional status and quality of life.

Challenges and limitations of the study

This study was institution based and conducted over a short period. Hence, the results may not be a representative of the caries experience and prevalence of children living with HIV in Kenya as a whole.

Without the aid of radiographs, only 35% of the decay may have been reported.

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This study had Ethical clearance of the Kenyatta National Hospital Ethical Research Committee(Ref no: KNH –ERC/01/2407).

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Table 1: Gender and age distribution of the study population (n=237)

Age Group	Male		Female		TOTAL	
	N	%	N	%	N	%
2-5	36	32	40	32	76	32
6-10	55	49	58	46	113	48
11-15	21	19	27	22	48	20
TOTAL	112	100	125	100	237	100

Table 2: Dental caries experience in the study population

Descriptive	Mean	SD	%
Decayed deciduous	6.38	5.45	84.4%
Missing deciduos	0.15	0.59	7.5%
Filled deciduous	0.05	0.289	2%
Dmft (n=199)	6.38	5.45	
Decayed perm	3.19	3.44	78.3%
Missing perm	0.05	0.29	3.9%
Filled perm	0.16	0.69	6.2%
DMFT (n=130)	3.35	3.55	

Table 3: Caries experience dmft scores in the study population, n=199

Variable	N	dmft	± SD	Statistical test
Study Center				
• Children homes	66	4.77	4.10	Mann U(Z- .761);p=0.006
• Outpatient centre	133	7.39	6.04	
Age				
• 2-5yrs	76	7.12	6.79	Kruskal-Wallis Chi-square
• 6-11yrs	107	6.57	4.88	4.502;2df;p=0.105
• 12-15yrs	15	3.40	1.84	
Gender				
• Male	99	6.49	5.84	
• Female	100	6.55	5.39	Mann U(Z-.394);p=0.693

dmft d-decayed m-missing f-filled in deciduous dentition; ±- plus or minus, SD- standard deviation

Table 4: Caries experience DMFT scores in the study population, n=130

Variable	N	DMFT ± SD		Statistical test
Study Center				
• Children homes	57	2.95	3.51	Mann U (Z-2.132) P=0.033
• Outpatient Centres	73	3.67	3.57	
AGE				
• 6-11YRS	82	2.42	2.96	Kruskal-Wallis Chi-square
• 12-15YRS	48	4.92	3.95	16.89;2df; = 0.000 (P≤0.01)
Gender				
• Male	62	3.03	3.13	Mann U Z-.82 p=0.412 (p≤ 0.05)
• Female	68	3.64	.89	

D- Decayed permanent teeth, M- Missing permanent teeth. F- Filled in permanent dentition, T- Teeth permanent, ±- plus or minus, SD- standard deviation

Table 5: Association between dmft scores and oral complaints, n=199

Variable	N	dmft	± SD	Statistical test
Pain in the Mouth				
• Yes	85	7.9	6.08	Mann U(Z-2.781);p=0.005
• No	114	5.53	5.04	
Challenges in Oral Hygiene				
• Yes	82	8.05	6.03	Mann U(Z- 3.094);p=0.002
• No	117	5.45	5.04	
Difficulties in Feeding				
• Yes	79	8.05	6.05	Mann U(Z-3.060);p=0.002
• No	120	5.47	5.04	

Table 6: Association between DMFT scores and oral complaints, n=130

Variable	N	DMFT	± SD	Statistical test
Pain in the Mouth				
• Yes	48	4.3	4.2	Mann U(Z-2.649);p=0.008
• No	81	2.8	3.0	
Challenges in Oral Hygiene				
• Yes	47	4.30	4.26	
• No	83	2.82	2.97	Mann U(Z-2.490);p=0.013
Difficulties in Feeding				
• Yes	44	4.13	4.2	Mann U(Z-2.092);p=0.036
• No	86	2.94	3.1	

Table 7: Association of dmft scores with oral hygiene and gingivitis

Variable	N	dmft	± SD	Statistical Test
Oral Hygiene				
• Good	24	4.29	5.22	Kruskal-Wallis Chi-square
• Fair	131	5.95	4.60	11.382;2df;P=0.03
• Poor	44	9.43	7.32	
Gingivitis				
• No	30	2.46	3.75	Kruskal-Wallis Chi-square
• Mild	99	6.37	4.67	24.065;2df;P=0.000
• Moderate	77	8.09	6.41	

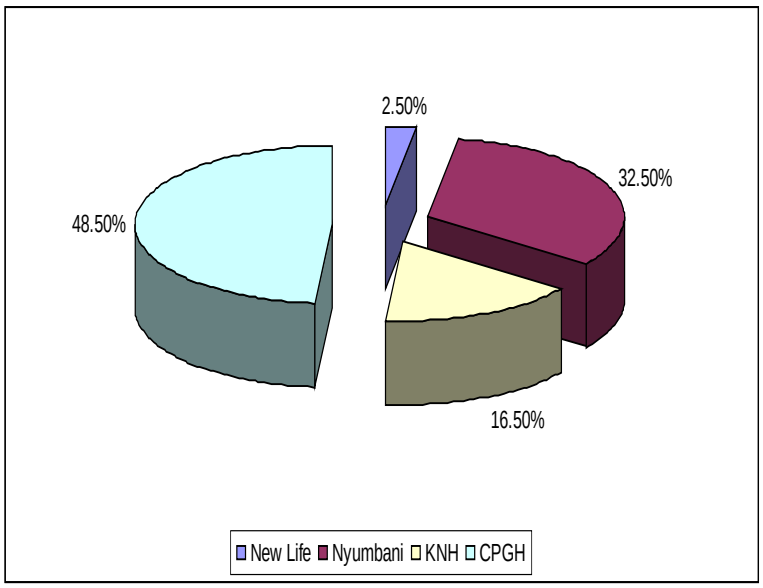

Figure 1: Percent distribution of the children by home and center, n=237

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Thermodynamical Behavior of Laser Irradiated Mass Diffusive Micro Stretch Thermoelastic Medium

By Arvind Kumar
Punjab Technical University

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I. Introduction

Eringen [1] developed the theory of thermo-micro stretch elastic solids. Micro stretch continuum is a model for Bravais lattice with basis on the atomic level and two-phase dipolar solids with a core on the macroscopic level. Composite materials reinforced with chopped elastic fibers, porous media with pores containing gas or in viscid liquid, asphalt or other elastic inclusions and solid-liquid crystals etc. are examples of micro stretch solids. Ezzat et al. [2, 3] discussed the concept of thermal relaxation. Marin [4, 5] investigated various problems in micropolar thermoelasticity and micro stretch thermoelasticity.

Diffusion is the spontaneous movement of the particles from a high concentration region to the low-concentration region, and it occurs in response to a concentration gradient expressed as the change in the concentration due to change in position. Thermal diffusion utilizes the transfer of heat across a thin liquid or gas to accomplish isotope separation. Simply concentration is calculated using Fick's law. This law does not consider the mutual interaction between the inclusion substance and the medium. The thermo diffusion in elasticity is result of the coupling of temperature, mass diffusion and that of strain in addition to heat and mass exchange with the environment. Nowacki [6-9] developed the theory of thermoelastic diffusion by using coupled thermoelastic model. Dudziak and Kowalski [10] and Olesiak and Pyryev [11], respectively, discussed the theory of thermo diffusion and coupled quasi-stationary problems of thermal diffusion for an elastic layer.

Thermal shock due to exposure to an ultra-short laser pulse is interesting from the point of thermo elasticity since they require a coupled analysis of the temperature and deformation fields. A thermal shock induces very rapid movement in the structural elements, giving rise to very significant inertial forces, and thereby, an increase in vibration. In irradiation of ultra-short pulsed laser, the high-intensity energy flux and ultra-short duration lead to a very high thermal gradient. So, in these cases, Fourier law of heating is no longer valid. Scruby et al. [12] and Rose [13] considered the point source model of lasers. Later McDonald [14] and Spicer [15] proposed a new model known as laser-generated ultrasound model by introducing the thermal diffusion effect. Dubois [16] experimentally demonstrated that penetration depth plays an important role in the laser-ultrasound generation process. The thermoelastic response of laser in context of four theories was discussed by Youssef and Al-Bary [17]. A problem for a thick plate under the effect of laser pulse thermal heating was studied by Elhagary [18]. Kumar et al. [19] studied the thermo-mechanical interactions of a laser pulse with the micro stretch thermoelastic medium.

This present research deals with the disturbance in a homogeneous micro stretch thermoelastic medium with mass diffusion due to the effect of an ultra-laser heat source. The normal mode analysis technique is used to obtain the expressions for the displacement components, couple stress, temperature, mass concentration and micro stress distribution due to various sources.

II. Basic Equations

Following Eringen [20] and Al-Qahtani and Datta [21], the basic equations for homogeneous micro stretch thermoelastic mass diffusion medium in the absence of body force, body couple with laser heat source are given by:

Author: Department of Mathematics, Punjab Technical University, Jalandhar, Punjab (India). Department of Secondary Education Haryana, at Hissar (Haryana), India. e-mail: arvi.math@gmail.com

a) Stress equation of motion

$$(\lambda+\mu)\nabla(\nabla.u)+(\mu+K)\nabla^2u+K\nabla\times\phi+\lambda_0\nabla\phi^*-\beta_1\left(1+\tau_1\frac{\partial}{\partial t}\right)\nabla T-\beta_2\left(1+\tau^1\frac{\partial}{\partial t}\right)\nabla C=\rho\ddot{u} \quad (1)$$

b) Couple stress equation of motion

$$(\gamma\nabla^2-2K)\phi+(\alpha+\beta)\nabla(\nabla.\phi)+K\nabla\times u=\rho j\ddot{\phi} \quad (2)$$

c) The equation of balance of stress moments

$$(\alpha_0\nabla^2-\lambda_1)\phi^*-\lambda_0\nabla.u+\nu_1\left(1+\tau_1\frac{\partial}{\partial t}\right)T+\nu_2\left(1+\tau^1\frac{\partial}{\partial t}\right)C=\frac{\rho j_0}{2}\ddot{\phi}^* \quad (3)$$

d) The equation of heat conduction

$$K^*\nabla^2T=\rho c^*\left(\frac{\partial}{\partial t}+\tau_0\frac{\partial^2}{\partial t^2}\right)T+\beta_1T_0\left(\frac{\partial}{\partial t}+\varepsilon\tau_0\frac{\partial^2}{\partial t^2}\right)(\nabla.u-Q)+\nu_1T_0\left(\frac{\partial}{\partial t}+\varepsilon\tau_0\frac{\partial^2}{\partial t^2}\right)\phi^*+aT_0\left(\frac{\partial}{\partial t}+\gamma_1\frac{\partial^2}{\partial t^2}\right)C \quad (4)$$

e) The equation of mass diffusion is

$$D\beta_2\nabla^2(\nabla.u)+Da\left(1+\tau_1\frac{\partial}{\partial t}\right)\nabla^2T+\left(\frac{\partial}{\partial t}+\varepsilon\tau^0\frac{\partial^2}{\partial t^2}\right)C-Db\left(1+\tau^1\frac{\partial}{\partial t}\right)\nabla^2C=0 \quad (5)$$

f) The constitutive relations are

$$t_{ij}=\left(\lambda_0\phi^*+\lambda u_{r,r}\right)\delta_{ij}+\mu\left(u_{i,j}+u_{j,i}\right)+K\left(u_{j,i}-\epsilon_{ijk}\phi_k\right)-\beta_1\left(1+\tau_1\frac{\partial}{\partial t}\right)\delta_{ij}T-\beta_2\left(1+\tau^1\frac{\partial}{\partial t}\right)\delta_{ij}C \quad (6)$$

$$m_{ij}=\alpha\phi_{r,r}\delta_{ij}+\beta\phi_{i,j}+\gamma\phi_{j,i}+b_0\epsilon_{mji}\phi^*_{,m} \quad (7)$$

$$\lambda^*_i=\alpha_0\phi^*_{,i}+b_0\epsilon_{ijm}\phi_{j,m} \quad (8)$$

The plate surface is illuminated by laser pulse given by the heat input

$$Q=I_0f(t)g(x_1)h(x_3) \quad (9)$$

Where I_0 is the energy absorbed. The temporal profile $f(t)$ is represented as,

$$f(t)=\frac{t}{t_0^2}e^{-\left(\frac{t}{t_0}\right)} \quad (10)$$

Here t_0 is the pulse rise time. The pulse is also assumed to have a Gaussian spatial profile in x_1

$$g(x_1)=\frac{1}{2\pi r^2}e^{-\left(\frac{x_1^2}{r^2}\right)} \quad (11)$$

Where r is the beam radius, and as a function of the depth x_3 the heat deposition due to the laser pulse is assumed to decay exponentially within the solid,

$$h(x_3)=\gamma^*e^{-\gamma^*x_3} \quad (12)$$

Equation (9) with the aid of (10-11) and (12) takes the form:

$$Q=\frac{I_0\gamma^*}{2\pi r^2t_0^2}te^{-\left(\frac{t}{t_0}\right)}e^{-\left(\frac{x_1^2}{r^2}\right)}e^{-\gamma^*x_3}, \quad (13)$$

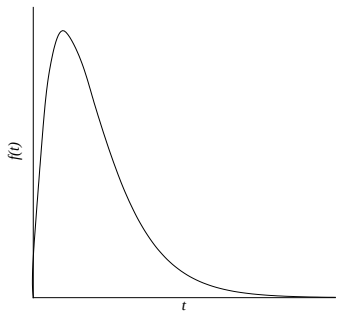

Fig. 1: Temporal profile of $f(t)$.

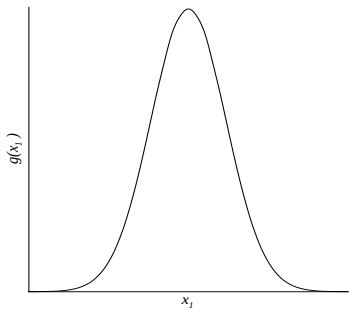

Fig. 2: Profile of $g(x_1)$.

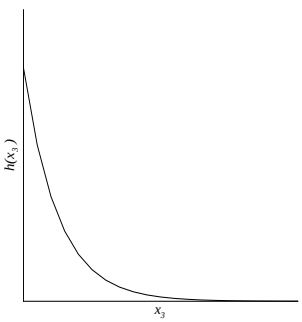

Fig. 3: Profile of $h(x_3)$.

Here λ, μ, α, β, γ, $K, \lambda_0, \lambda_1, \alpha_0, b_0$, are material constants, ρ is mass density, $u = (u_1, u_2, u_3)$is the displacement vector and $\phi = (\phi_1, \phi_2, \phi_3)$is the microrotation vector, $\phi^*$is the scalar micro stretch function, T is temperature and T_0 is the reference temperature of the body chosen,C is the concentration of the diffusion material in the elastic body,K^* is the coefficient of the thermal conductivity,c^* is the specific heat at constant strain, D is the thermoelastic diffusion constant, a is the coefficient describing the measure of thermo diffusion and b is the coefficient describing the measure of mass diffusion effects, j is the microinertia, $\beta_1 = (3\lambda + 2\mu + K)\alpha_{t1}$, $\beta_2 = (3\lambda + 2\mu + K)\alpha_{c1}$, $\nu_1 = (3\lambda + 2\mu + K)\alpha_{t2}$, $\nu_2 = (3\lambda + 2\mu + K)\alpha_{c2}$, α_{t1}, α_{t2} are coefficients of linear thermal expansion and α_{c1}, α_{c2} are coefficients of linear diffusion expansion, j_0 is the microinertia for the microelements,t_{ij} are components of stress, m_{ij} are components of couple stress, λ_i^* is the micro stress tensor, e_{ij} are components of strain, e_{kk} is the dilatation,δ_{ij} is Kroneker delta function, τ^0, τ^1 are the diffusion relaxation times and $\tau_0, \tau_1$are thermal relaxation times with $\tau_0 \geq \tau_1 \geq 0$.

In the above equations symbol (",") followed by a suffix denotes differentiation with respect to spatial coordinates and a superposed dot (" $\dot{}$ ") denotes the derivative with respect to time respectively.

III. Formulation of the Problem

We consider a micro stretch thermoelastic mass diffusion medium with rectangular Cartesian coordinate system $OX_1X_2X_3$ with x_3-axis pointing vertically downward the medium.

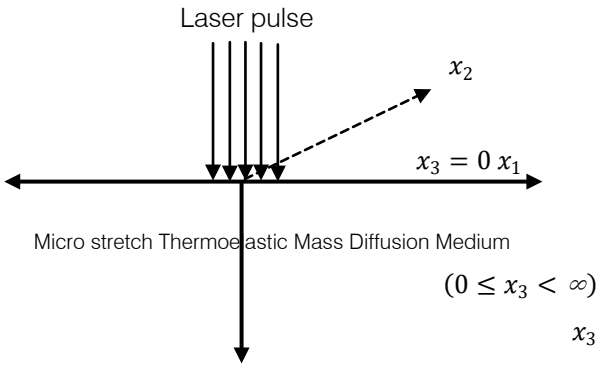

Fig. 4: Geometry of the Problem

For two dimensional problems, we take the displacement vector and micro rotation vector as:

$$u = (u_1, 0, u_3), \phi = (0, \phi_2, 0), \tag{14}$$

For further consideration it is convenient to introduce in equations (1)-(5) the dimensionless quantities defined by:

$$u_i' = \frac{\rho\omega^* c_1}{\beta_1 T_0} u_i \ , \ x_i' = \frac{\omega^*}{c_1} x_i \ , \ t' = \omega^* t \ , \ T' = \frac{T}{T_0} \ , \ \tau_1' = \omega^* \tau_1 \ , \ \tau_0' = \omega^* \tau_0 \ , \gamma_1' = \omega^* \gamma_1, \ t_{ij}' = \frac{1}{\beta_1 T_0} t_{ij} \ , \ \omega^* = \frac{\rho c^* c_1^2}{K^*} , \phi_i' = \frac{\rho c_1^2}{\beta_1 T_0} \phi_i \ ,$$
$$\tau^{1'} = \omega^* \tau^1 \ , \ c_1^2 = \frac{\lambda + 2\mu + k}{\rho} \ , \ c_2^2 = \frac{\mu + k}{\rho} \ , \ c_3^2 = \frac{\gamma}{\rho j} \ , \ c_4^2 = \frac{2\alpha_0}{\rho j_0} \ , \ \varepsilon = \frac{\gamma^2 T_0}{\rho^2 c^* c_1} \ , m_{ij}^* = \frac{\omega^*}{c\beta_1 T_0} m_{ij} \ , \ C' = \frac{\beta_2}{\rho c_1^2} C \ , \ Q = \frac{K^* \omega^{*2}}{C^*} Q' , \phi^{*'} = \frac{\rho c_1^2}{\beta_1 T_0} \phi^* \tag{15}$$

By Helmholtz representation of a vector into scaler and vector potentials the displacement components u_1 and u_3 are related to non- dimensional potential functions ϕ and ψ as:

$$u_1 = \frac{\partial \phi}{\partial x_1} - \frac{\partial \psi}{\partial x_3} \ , \quad u_3 = \frac{\partial \phi}{\partial x_3} + \frac{\partial \psi}{\partial x_1} \tag{16}$$

Substituting the values of $u_1 \& u_3$ from (16) in (1)-(5) and with the aid of (14) & (15), after suppressing the primes, we obtain:

$$\nabla^2 \phi - \ddot{\phi} + a_4 \phi^* - \left(1 + \tau_1 \frac{\partial}{\partial t}\right) T - a_5 \left(1 + \tau^1 \frac{\partial}{\partial t}\right) C = 0, \tag{17}$$

$$\left(\nabla^2 - a_8 - a_{12} \frac{\partial^2}{\partial t^2}\right) \phi^* - a_9 \nabla^2 \phi + a_{10} \left(1 + \tau_1 \frac{\partial}{\partial t}\right) T + a_{11} \left(1 + \tau^1 \frac{\partial}{\partial t}\right) C = 0, \tag{18}$$

$$\left(\frac{\partial}{\partial t} + \tau_0 \frac{\partial^2}{\partial t^2} - \nabla^2\right) T + \left(1 + \varepsilon \tau_0 \frac{\partial}{\partial t}\right) \left(a_{13} \nabla^2 \phi + \dot{a}_{14} \dot{\phi}^*\right) + a_{15} \left(1 + \gamma_1 \frac{\partial}{\partial t}\right) \dot{C} = Q_0 f^*(x_1, t) e^{-\gamma^* x_3}, \tag{19}$$

$$\nabla^4 \phi + a_{16} \left(1 + \tau_1 \frac{\partial}{\partial t}\right) \nabla^2 T + a_{17} \left(\frac{\partial}{\partial t} + \varepsilon \tau^0 \frac{\partial^2}{\partial t^2}\right) C - a_{18} \left(1 + \tau^1 \frac{\partial}{\partial t}\right) \nabla^2 C = 0 \tag{20}$$

$$a_2 \nabla^2 \psi - \ddot{\psi} + a_3 \phi_2 = 0, \tag{21}$$

$$\nabla^2 \phi_2 - 2a_6 \phi_2 - a_6 \nabla^2 \psi = a_7 \ddot{\phi}_2, \tag{22}$$

Here $\nabla^2 = \frac{\partial^2}{\partial x_1^2} + \frac{\partial^2}{\partial x_3^2}$ is Laplacian operator, $f(x_1, t) = \left[t + \epsilon\tau_0 \left(1 - \frac{t}{t_0}\right)\right] e^{-\left(\frac{x_1^2}{r^2} + \frac{t}{t_0}\right)}$ and $Q_0 = \frac{Q_{20} I_0 \gamma^*}{2\pi r^2 t_0^2}$

IV. Solution of the Problem

The solution of the considered physical variables can be decomposed in terms of the normal modes as in the following form:

$$\{\phi,\psi,T,\phi_2,\phi^*,C\}(x_1,x_3,t)=\{\bar{\phi},\bar{\psi},\bar{T},\overline{\phi_2},\overline{\phi^*},\bar{C}\}(x_3)e^{i(kx_1-\omega t)} \tag{23}$$

Here ω is the angular frequency and k is wave number.

Making use of (23), equations (17)-(22) after some simplifications yield:

$$[AD^8+BD^6+CD^4+ED^2+F]\bar{\phi}=f_1(\gamma^*,x_1,t)e^{-\gamma^* x_3} \tag{24}$$

$$[AD^8+BD^6+CD^4+ED^2+F]\overline{\phi^*}=f_2(\gamma^*,x_1,t)e^{-\gamma^* x_3} \tag{25}$$

$$[AD^8+BD^6+CD^4+ED^2+F]\bar{T}=f_3(\gamma^*,x_1,t)e^{-\gamma^* x_3} \tag{26}$$

$$[AD^8+BD^6+CD^4+ED^2+F]\bar{C}=f_4(\gamma^*,x_1,t)e^{-\gamma^* x_3} \tag{27}$$

$$[D^4+GD^2+H]\bar{\psi}=0 \tag{28}$$

Where $D=\frac{d}{dx_3}$, $A=a_{21}-a_{33}, B=a_{37}-2k^2a_{21}-a_{31}a_{39}+-a_{34},$

$$C=a_{38}+a_{21}k^4-2k^2a_{37}-a_{32}a_{39}-a_{31}a_{40}+a_{33}a_{43}+a_{34}a_{42}\ , H=-(k^2a_3a_6+a_{35}a_{36})/a_2$$

$$E=a_{37}k^4-2k^2a_{38}-a_{32}a_{40}-a_{31}a_{41}, F=a_{38}k^4-a_{32}a_{41}+a_{34}a_{44}, G=a_{35}+a_3a_6-a_2a_{36}/a_2,$$

Also, a_i , $i=19,\ldots.,44$ are defined in appendix A.

The solution of the above system of equations (24)-(28) satisfying the radiation conditions that $(\bar{\phi},\bar{\psi},\bar{T},\overline{\phi_2},\bar{C})\to 0$ as $x_3\to\infty$ are given as following:

$$\bar{\phi}=\sum_{i=1}^{4}c_ie^{-m_ix_3}+\frac{f_1}{f_5}e^{-\gamma^* x_3} \tag{29}$$

$$\overline{\phi^*}=\sum_{i=1}^{4}\alpha_{1i}c_ie^{-m_ix_3}+\frac{f_2}{f_5}e^{-\gamma^* x_3} \tag{30}$$

$$\bar{T}=\sum_{i=1}^{4}\alpha_{2i}c_ie^{-m_ix_3}+\frac{f_3}{f_5}e^{-\gamma^* x_3} \tag{31}$$

$$\bar{C}=\sum_{i=1}^{4}\alpha_{3i}c_ie^{-m_ix_3}+\frac{f_4}{f_5}e^{-\gamma^* x_3}, \tag{32}$$

$$(\bar{\psi},\overline{\phi_2})=\sum_{i=5}^{6}(1,\delta_i)c_ie^{-m_ix_3}\ , \tag{33}$$

Where$m_i^2(i=1,2,3,4)$ are the roots of the equation (24) and $m_i^2(i=5,6)$ are the roots of characteristic equation of equation (28) and

$$\alpha_{1i}=-\frac{\Delta_{2i}}{\Delta_{1i}}, \alpha_{2i}=\frac{\Delta_{3i}}{\Delta_{1i}}\ , \alpha_{3i}=-\frac{\Delta_{4i}}{\Delta_{1i}}\ ,\ i=1,2,3,4\&\delta_i=\frac{a_3}{(a_2m_i^2+a_{35})}\ , i=5,6$$

Here, $\Delta_{1i},\Delta_{2i},\Delta_{3i},\Delta_{4i}$ are defined in Appendix B.

Substituting the values of $\bar{\phi},\overline{\phi^*},\bar{T},\bar{\psi},\bar{\phi}_2,\bar{C}$ from the equations (29)-(33) in the (6)-(8), and using (14)-(16) & (23) and then solving the resulting equations, we obtain:

$$\bar{t}_{33}=\sum_{i=1}^{6}G_{1i}e^{-m_ix_3}-M_1e^{-\gamma^* x_3} \tag{34}$$

$$\bar{t}_{31}=\sum_{i=1}^{6}G_{2i}e^{-m_ix_3}-M_2e^{-\gamma^* x_3}, \tag{35}$$

$$\bar{m}_{32}=\sum_{i=1}^{6}G_{3i}e^{-m_ix_3}-M_3e^{-\gamma^* x_3} \tag{36}$$

$$\lambda_3^*=\sum_{i=1}^{6}G_{4i}e^{-m_ix_3}-M_4e^{-\gamma^* x_3}, \tag{37}$$

$$\bar{T}=\sum_{i=1}^{6}G_{5i}e^{-m_ix_3}-M_5e^{-\gamma^* x_3}, \tag{38}$$

$$\bar{C}=\sum_{i=1}^{5}G_{6i}e^{-m_ix_3}-M_6e^{-\gamma^* x_3}, \tag{39}$$

$G_{mi}=g_{mi}C_i$, $i,m=1,2,\ldots,6$. G_{rs} , $(r,s=1,2,\ldots,6)$,M_r , $(r=1,2,\ldots,6)$ are described in Appendix C.

V. Boundary Conditions

We consider normal force and thermal and mass concentration sources are acting at the surface $x_3 = 0$ along with vanishing of couple stress in addition to thermal and mass concentration boundaries considered at$x_3 = 0$ and$I_0 = 0$. Mathematically this can be written as:

$$t_{33} = -F_1 e^{i(kx_1-\omega t)},\ t_{31} = 0,\ m_{32} = 0,\ \lambda_3^* = 0,\ \frac{\partial T}{\partial x_3} = F_2 e^{i(kx_1-\omega t)},\ \frac{\partial C}{\partial x_3} = F_3 e^{i(kx_1-\omega t)} \tag{40}$$

Where F_1 and F_2 are the magnitude of the applied force.

Substituting the expression of the variables considered into these boundary conditions, we can obtain the following system of equations:

$$\sum_{i=1}^{6}(G_{1i}, G_{2i}, G_{3i}, G_{4i}, m_i G_{5i}, m_i G_{6i})c_i = (-F_1, 0,0,0, -F_2, -F_3) \tag{41}$$

The system of equations (41) is solved by using the matrix method as follows:

$$\begin{bmatrix} c_1 \\ c_2 \\ c_3 \\ c_4 \\ c_5 \\ c_6 \end{bmatrix} = \begin{bmatrix} g_{11} & g_{12} & g_{13} & g_{14} & g_{15} & g_{16} \\ g_{21} & g_{22} & g_{23} & g_{24} & g_{25} & g_{26} \\ g_{31} & g_{32} & g_{33} & g_{34} & g_{35} & g_{36} \\ g_{41} & g_{42} & g_{43} & g_{44} & g_{45} & g_{46} \\ m_1 g_{51} & m_2 g_{52} & m_3 g_{53} & m_4 g_{54} & m_5 g_{55} & m_6 g_{56} \\ m_1 g_{61} & m_2 g_{62} & m_3 g_{63} & m_4 g_{64} & m_5 g_{65} & m_6 g_{66} \end{bmatrix}^{-1} \begin{bmatrix} -F_1 \\ 0 \\ 0 \\ 0 \\ -F_2 \\ -F_3 \end{bmatrix} \tag{42}$$

VI. Special Cases

a) Micro stretch Thermoelastic Solid

If we neglect the diffusion effect in (41), we obtain the corresponding expressions of stresses, displacements and temperature for micro stretch thermoelastic solid.

b) Micropolar Thermoelastic Diffusive Solid

If we neglect the micro stretch effect in (41), we obtain the corresponding expressions of stresses, displacements and temperature for micropolar thermoelastic diffusive solid.

VII. Numerical Results and Discussions

The analysis is conducted for a magnesium crystal-like material. The values of constants are as:

$$\lambda = 9.4 \times 10^{10} Nm^{-2}, \mu = 4.0 \times 10^{10} Nm^{-2},\ K = 1.0 \times 10^{10} Nm^{-2},\ \rho = 1.74 \times 10^{3} Kgm^{-3}, j = 0.2 \times 10^{-19} m^2,\ \gamma = 0.779 \times 10^{-9} N$$

Thermal, diffusion and micro stretch parameters are given by:

$$c^* = 1.04 \times 10^{3} JKg^{-1}K^{-1},$$
$$K^* = 1.7 \times 10^{6} Jm^{-1}s^{-1}K^{-1}, \alpha_{t1} = 2.33 \times 10^{-5} K^{-1}, \alpha_{t2} = 2.48 \times 10^{-5} K^{-1}, T_0 = 0.298 \times 10^{3} K, \tau_0 = 0.02, \tau_1 = 0.01, \alpha_{c1} = 2.65 \times 10^{-4} m^3 Kg^{-1}, \alpha_{c2} = 2.83 \times 10^{-4} m^3 Kg^{-1}, a = 2.9 \times 10^{4} m^2 s^{-2} K^{-1}, b = 32 \times 10^{5} Kg^{-1} m^5 s^{-2}, \tau^1 = 0.04, \tau^0 = 0.03, D = 0.85 \times 10^{-8} Kgm^{-3} s,$$
$$j_0 = 0.19 \times 10^{-19} m^2,\ \alpha_0 = 0.779 \times 10^{-9} N,\ b_0 = 0.5 \times 10^{-9} N,\ \lambda_0 = 0.5 \times 10^{10} Nm^{-2}, \lambda_1 = 0.5 \times 10^{10} Nm^{-2}$$

A comparison of the dimensionless form of the field variables for the cases of micro stretch thermoelastic mass diffusion medium with a laser pulse (MTMDL), micro stretch thermoelastic mass diffusion medium without a laser pulse (MTMD) subjected to normal force is presented in Figures 5-13. The values of all physical quantities for both cases are shown in the range $0 \le x_3 \le 5$.

Solid lines, dash lines corresponds to micro stretch thermoelastic mass diffusion medium with laser pulse (MTMDL) and micro stretch thermoelastic mass diffusion medium without laser pulse (MTMD) respectively. The computations were carried out in the absence and presence of laser pulse ($I_0 = 10^5, 0$) and on the surface of plane $x_1 = 1, t = 0.1$

Fig. 5 shows the variation of normal stress t_{33} with the distance x_3. It is noticed that for MTMDL and MTMD, the normal stress t_{33} show similar behavior. The normal stress in both the cases initially increases and then monotonically decreases. The value of t_{33} increases near the application of the normal force due to the stretch effect and then decreases.

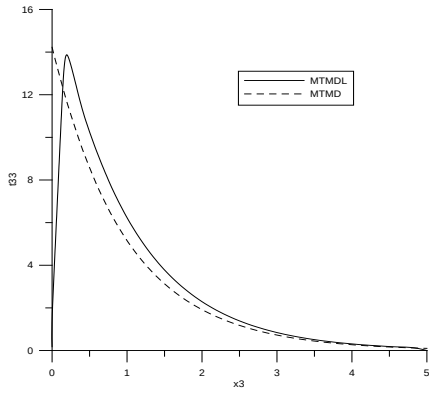

Fig. 5: Variation of normal stress

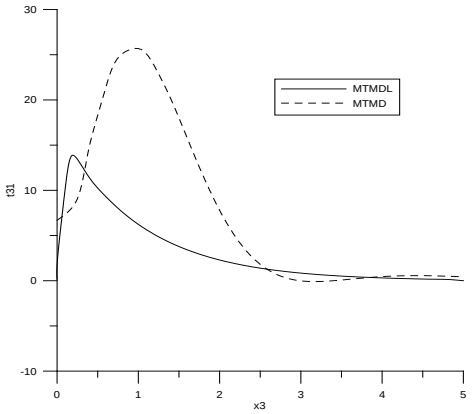

Fig. 6: Variation of tangential stress

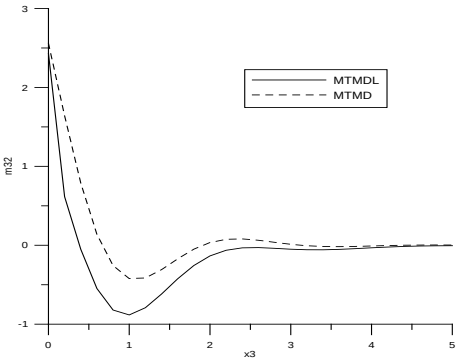

Fig. 7: Variation of coupled tangential stress

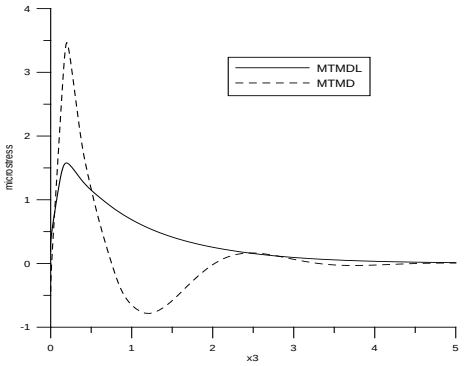

Fig. 8: Variation of micro stress

Fig. 6 displays the variation of tangential stress t_{31} with the distancex_3. It is noticed that initially the behavior of t_{31} for MTMDL and MTMD is similar. Initially t_{31} increases monotonically for MTMDL and MTMD and then approaches to the boundary surface away from the point of application of normal force.

Fig. 7 shows the variation of couple stress m_{32} with distance x_3 for MTMDL and MTMD. The variation of m_{32} for (MTMDL, MTMD) is monotonically decreasing in region $0 \leq x_3 \leq 1$ and monotonically increasing after that. The m_{32} approaches to zero away from the point of application of source. It is clear from figure 3 that laser source has a significant effect on the value ofm_{32}.

Fig. 8 depicts the variation of micro stress λ_3^* with distance. The variation of λ_3^* is similar for both the cases in the beginning and in the last, however λ_3^* for MTMD show oscillatory behavior in range$1 \leq x_3 \leq 4$

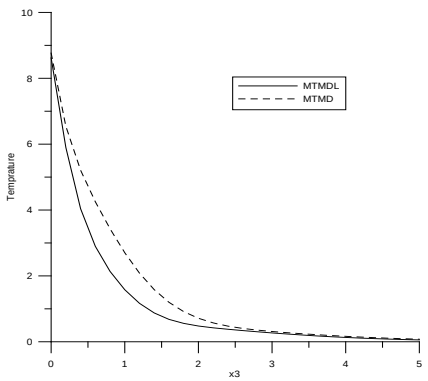

Fig. 9: Variation of temperature distribution

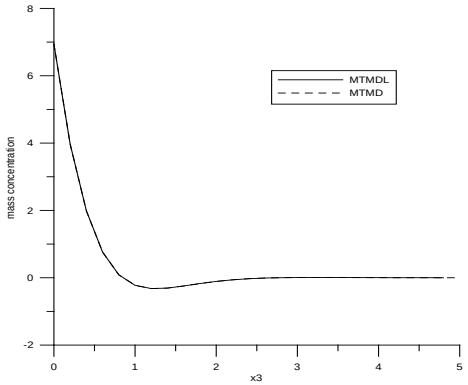

Fig. 10: Variation of mass concentration

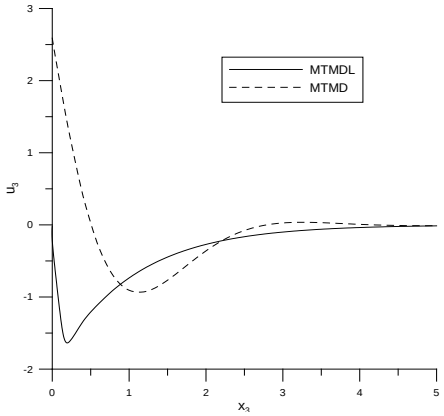

Fig.11: Variation of u_1 w.r.t. x_3.

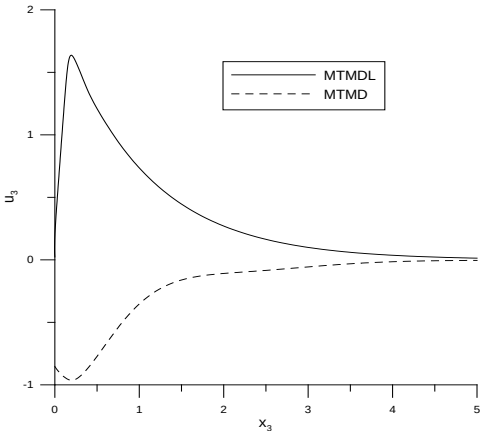

Fig. 12: Variation of u_3 w.r.t. x_3.

Fig. 9 displays the variation of temperature T with distancex_3. The values of temperature change for MTMDL and MTMD show monotonically decreasing behavior in the range $0 \leq x_3 \leq 5$. In case of MTMDL the temperature decreases more rapidly in comparison to MTMD due to the presence of input ultra-short laser heat source.

Fig. 10 show variation of mass concentration w.r.t. distancex_3. Mass concentration monotonically decreases with increasing distance from application of source. The laser source seems to have no significant effect on variation of mass concentration.

Fig. 11 and Fig.12 exhibits the behavior of displacement components u_1 and u_3w.r.t. x_3. Both the displacement components approaches to boundary surface away from the application of normal force which is in agreement to the generalized theory of thermoelasticity.

VIII. Variation of Temperature with Respect to Time

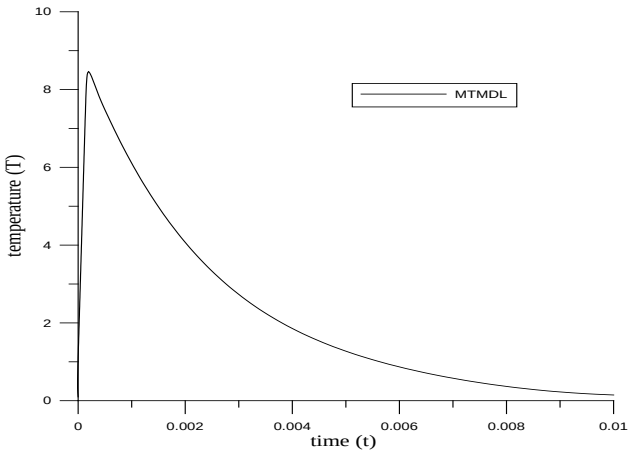

Fig. 13: Variation of temperature w.r.t. time

Fig. 13 represent the variation of temperature distribution w.r.t. time. As the laser is irradiated the temperature increases rapidly. The temperature decreases uniformly after reaching a peak value.

IX. Conclusions

The problem consists of investigating displacement components, scalar micro stretch, temperature distribution and stress components in a micro stretch thermoelastic mass diffusion medium subjected to input laser heat source. Normal mode analysis is employed to express the results. Theoretically obtained field variables are also depicted graphically.

The analysis of results permits some concluding remarks:

1) It is clear from the figures that all the field variables have nonzero values only in the bounded region of space indicating that all the results are in agreement with the various theories of thermoelasticity.
2) The effect of the input laser heat source is much pronounced in normal stress, tangential stress, micro stress, temperature distribution and displacement components. Change in the value of I_0 cause significant changes in all these simulated resulting quantities.
3) It is noticed from the figures that the laser heat source has no significant role on mass concentration.
4) The trend of variation of physical quantities show similarity with Elhagary [18] although diffusion effect is included.

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Appendix A

$$a_1=\frac{\lambda+\mu}{\beta_1 T_0}, a_2=\frac{\mu+K}{\beta_1 T_0}, a_3=\frac{K}{\rho c_1^2}, a_4=\frac{\lambda_0}{\rho c_1^2}, a_5=\frac{\rho c_1^2}{\beta_1 T_0}, a_6=\frac{K c_1^2}{\gamma\omega^{*2}}, a_7=\frac{\rho j c_1^2}{\gamma}, a_8=\frac{\lambda_1 c_1^2}{\alpha_0\omega^{*2}}, a_9=\frac{\lambda_0\rho c_1^4}{\beta_1 T_0\alpha_0\omega^{*2}}, a_{10}=\frac{\upsilon_1\rho c_1^4}{\beta_1\alpha_0\omega^{*2}}, a_{11}=\frac{\nu_2\rho^2 c_1^6}{\beta_1\beta_2 T_0\alpha_0\omega^{*2}}, a_{12}=\frac{\rho c_1^2 j_0}{2\alpha_0}, a_{13}=\frac{T_0\beta_1^2}{\rho\omega^* K^*}, a_{14}=\frac{\upsilon_1\beta_1 T_0}{\rho\omega^* K^*}, a_{15}=\frac{a\rho c_1^4}{\omega^*\beta_2 K^*}, a_{16}=\frac{a\rho c_1^2}{\beta_1\beta_2}, a_{17}=\frac{\rho c_1^4}{\omega^* D\beta_2^2}, a_{18}=\frac{b\rho c_1^2}{\beta_2^2}, Q_{20}=\frac{\rho c_1^4}{\omega^{*2}\beta_1 K^*}, a_{19}=\omega^2-k^2,$$

$$a_{20}=1-i\omega\tau_1, a_{21}=a_5(1-i\omega\tau), a_{22}=k^2 a_9, a_{23}=\omega^2 a_{12}-a_8-k^2, a_{24}=a_{10}(1-i\omega\tau_1), a_{25}=a_{11}(1-i\omega\tau'), a_{26}=-a_{13}(i\omega+\omega^2\varepsilon\tau_0), a_{27}=k^2 a_{26}, a_{32}=-k^2 a_{31}, a_{28}=-a_{14}(i\omega+\omega^2\varepsilon\tau_0), a_{29}=k^2-i\omega-\omega^2\tau_0, a_{30}=-a_{15}(i\omega+\omega^2\gamma_1), a_{31}=a_{16}(1-i\omega\tau_1), a_{33}=-a_{18}(1-i\omega\tau'), a_{34}=a_{17}(i\omega-\omega^2\varepsilon\tau^0), a_{35}=\omega^2-k^2 a_2, a_{36}=\omega^2 a_7-k^2-2a_6, a_{37}=a_4 a_{25}+a_{20}a_{30}-a_{29}+a_{23}, a_{38}=a_4(a_{24}a_{30}-a_{29}a_{25})+a_4(a_{24}a_{30}-a_{29}a_{25})-a_4(a_{24}a_{30}-a_{29}a_{25}), a_{39}=a_{21}a_{26}+a_{30}, a_{40}=a_{21}(a_{26}a_{33}-a_{27})+a_{30}(a_{23}-a_{19})+a_4 a_{25}a_{26}-a_9 a_{21}a_{28}-a_4 a_9 a_{30}-a_{25}a_{28}, a_{41}=-a_{21}(a_{22}a_{28}+a_{23}a_{27})-a_{25}(a_{24}a_{27}-a_{19}a_{28})-a_{30}(a_{19}a_{23}-a_4 a_{22}), a_{42}=a_{29}-a_{23}+a_{19}+a_4 a_9+a_{20}a_{26}, a_{43}=a_{23}a_{29}-a_{24}a_{28}-a_{19}(a_{29}-a_{23})-a_4(a_{29}a_9-a_{22}-a_{24}a_{26})+a_{20}(a_{23}a_{26}+a_{27}-a_9 a_{28}), a_{44}=a_{19}(a_{24}a_{28}-a_{23}a_{29})-a_4(a_{22}a_{29}+a_{24}a_{27})-a_{20}(a_{27}a_{23}+a_{28}a_{22}),$$

Appendix B

$$\Delta_{1i}=\begin{vmatrix} m_i^2+a_{23} & a_{24} & a_{25} \\ a_{28} & a_{29}-m_i^2 & a_{30} \\ 0 & a_{31}m_i^2+a_{32} & a_{33}m_i^2+a_{34} \end{vmatrix}, \Delta_{2i}=\begin{vmatrix} a_9 m_i^2+a_{22} & a_{24} & a_{25} \\ a_{26}m_i^2-a_{27} & a_{29}-m_i^2 & a_{30} \\ (m_i^2-k^2)^2 & a_{31}m_i^2+a_{32} & a_{33}m_i^2+a_{34} \end{vmatrix},$$

$$\Delta_{3i}=\begin{vmatrix} a_9 m_i^2+a_{22} & m_i^2+a_{23} & a_{25} \\ a_{26}m_i^2-a_{27} & a_{28} & a_{30} \\ (m_i^2-k^2)^2 & 0 & a_{33}m_i^2+a_{34} \end{vmatrix}, \Delta_{4i}=\begin{vmatrix} a_9 m_i^2+a_{22} & m_i^2+a_{23} & a_{24} \\ a_{26}m_i^2-a_{27} & a_{28} & a_{29}-m_i^2 \\ (m_i^2-k^2)^2 & 0 & a_{31}m_i^2+a_{32} \end{vmatrix},$$

Appendix C

$$b_1=\frac{\lambda_0}{\rho c_1^2}, b_2=\frac{\lambda}{\rho c_1^2}, b_3=\frac{2\mu+K}{\rho c_1^2}, b_5=\frac{\mu+K}{\rho c_1^2}, b_6=\frac{\mu}{\rho c_1^2}, b_7=\frac{K}{\rho c_1^2}, b_8=\frac{\omega^{*2}\gamma}{\rho c_1^4}, b_9=\frac{\omega^{*2}b_0}{\rho c_1^4}, b_{10}=\frac{\omega^{*2}}{\rho c_1^4}$$

$$g_{1i}=\alpha_{1i}+(m_i^2-b_2k^2)-\alpha_{2i}+b_{11}\alpha_{3i}, g_{2i}=-\iota b_3 k m_i, g_{3i}=\iota b_9 k\alpha_{1i},$$
$$g_{4i}=-\alpha_0 b_{10}m_i\alpha_{1i}, g_{5i}=\alpha_{2i}, g_{6i}=\alpha_{3i}, \quad i=1,2,3,4$$
$$g_{1i}=\iota b_3 k m_i, g_{2i}=(b_6 m_i^2+b_5 k^2)-b_7\alpha_{4i}, g_{3i}=-b_8\alpha_{4i}m_i,$$
$$g_{4i}=-ikb_0 b_{10}\alpha_{4i}, g_{5i}=0, g_{6i}=0, \quad i=5,6$$

$$M_1=\left(\frac{b_1 f_2+\left(\gamma^{*2}-b_2k^2\right)f_1-f_3+b_{11}f_4}{f_5}\right), M_2=\frac{-\iota b_3 k\gamma^* f_1}{f_5}, M_3=\frac{\iota b_9 k f_2}{f_5}, M_4=\frac{-\alpha_0 b_{10}\gamma^* f_2}{f_5}, M_5=\frac{f_3}{f_5}, M_6=\frac{f_4}{f_5}$$

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A Survey of Impact of Oral Health on Quality of Life and its Determinants among Healthcare Workers in a Tertiary Hospital

By Dr. Paul Ikhodaro Idon, Dr. Ibrahim Kayode Suleiman, Dr. Yusuf Halidu Bako, Dr. Faith Nonyelun Ngene, Mercy Ibhade Idon & Dr. Janada Yusuf

University of Maiduguri Teaching Hospital

Abstract- *Purpose:* To assess the OHRQoL of healthcare workers in a teaching hospital in northeastern Nigeria and how it is influenced by sociodemographic factors and dental clinic visits.

Methods: A cross-sectional study was performed among doctors and nurses in the teaching hospital using the English version of the short form of the oral health impact profile questionnaire (OHIP-14) to obtain information on their perception of their oral health.

Results: The mean overall OHIP-14 score (4.30 ± 0.29(SEM)), and the prevalence of impact (13.2%) were relatively low. The highest domain scores were recorded in the psychological discomfort (1.16 ± 0.07(SEM)) and physical pain (1.06 ± 0.07(SEM)) domains. Significantly higher OHIP-14 scores were seen with those who had visited the dental clinic ($p = 0.01$) and for visits due to emergency reasons ($p = 0.00$), with no significant differences in the impact for age, gender and profession. Multiple regression model variables statistically significantly ($p < 0.005$) predicted about 16.9% of the variations in the OHIP-14 scores.

Conclusions: Oral disorders did have an impact on the quality of life of the healthcare workers. Being female, younger in age, previous visit to the dentist and visits due to emergency reasons were associated with poorer OHRQoL.

Keywords: *oral health, quality of life, oral health related quality of life, healthcare worker.*

GJMR-K Classification: *NLMC Code: WU 113*

Strictly as per the compliance and regulations of:

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I. Introduction

Oral health related quality of life (OHRQoL) is a relatively new but rapidly growing phenomenon[1] that appeared in the literature in the early 1980s.[2] Its dimensions include areas of concern to individual patients.[3] It is therefore multidimensional and among other things reflects on people's comfort while eating, sleeping, as well as the effect of oral health on social interactions and self-esteem in everyday life.[4,5] Slade[6] and others[7,8] identified the shift in the perception of health from merely the absence of disease and infirmity to complete physical, mental and social well-being, from the definition of health given by the World Health Organization (WHO),[9] as the key issue in the conception of health related Quality of life (HRQoL) and, subsequently OHRQoL.This definition of health by the WHO thus included quality of life (QoL) within the broader definition of health[10] unlike the biomedical model. Consequently, any measure of health needs to assess social and emotional aspects of health as well as assessing presence or absence of disease.[11]

Until recently, the psycho-social consequences of oral conditions have received little attention. Also, the oral cavity has historically been dissociated from the rest of the body when considering general health status. It is however established that oral health is an integral part of general health and is one of the determinants of quality of life.[7] Thus the need to conceptualize oral health as an integral part of overall health and to consider its contribution to overall health related quality of life (HRQoL) has been stressed.[12] This is supported by recent research which highlighted that oral disorders have emotional and psycho-social consequences as serious as other disorders.[11,13] Furthermore, Reisine[14] and Gift *et al* [15] indicated that approximately 160 million work hours a year are lost due to oral disorders. With the growing interest in the QoL, several studies have been conducted to assess QoL among working adults in different occupations.[16-19] Most of these research has primarily focused on HRQoL, the quality of work life (QWL), and effort-reward imbalance. There is paucity of data on the impact of oral health on QoL among workers and especially among healthcare workers (HCW).

The working lives of HCW like doctors and nurses is associated with a high level of work-related stress and these HCWs often do not pay a sufficient amount of attention to their own health.[20] High levels of both physical and psychological ill health was identified among HCW in the UK.[21] The literature focusing on the OHRQoL of healthcare personnel is scarce. It is important to understand healthcare personnel's

Author α: Department of dental Surgery University of Maiduguri Teaching Hospital Maiduguri Nigeria. e-mails: idonp85@gmail.com, kaysuleiman@yahoo.com
Author σ: Department of Dental Surgery Abubakar Tafawa Balewa University Teaching Hospital Bauchi Nigeria.
e-mail: bako_yusuf@yahoo.com
Author ρ: Department of Dental Surgery University of Maiduguri Teaching Hospital Maiduguri Nigeria.
e-mail: ngene.faithevans@gmail.com
Author ω: Department of Community Medicine, Irrua Specialist Teaching Hospital, Edo, Nigeria.
Author ¥: Faculty of Dentistry University of Maiduguri Maiduguri Borno Nigeria. e-mail: janalassa1@gmail.com

characteristics and explore their pattern of clinic attendance due to oral health problems and how these impact on their daily lives. This will optimize the use of support and interventional measures and help to reduce negative effects on their lives. Minimizing the burden on healthcare personnel will possibly improve the quality of life and medical outcomes of their patients and the relationships with their private life. Based on: the importance of oral health to psychological well-being; the paucity of data on the impact of oral health on QoL among populations in sub-Saharan Africa and in Nigeria; and the lack of data on OHRQoL among HCWs in Nigeria, this study aimed to determine the OHRQoL among doctors and nurses; explore the association between the OHRQoL and the use of dental services by the HCWs in a teaching hospital in Nigeria.

II. Materials and Methods

a) Study design and data collection

This study was conducted as a cross-sectional study assessing the OHRQoL of HCW at the University of Maiduguri Teaching Hospital, Maiduguri, in northeastern Nigeria. The approval for the study was granted by the Research and Ethics Committee of the hospital before commencement. The study population comprised of all doctors and nurses in the various hospital departments that agreed to participate in the study. Thus a total population survey was carried out, but excluded doctors and nurses who were on leave from work during the study as well as doctors sent out for clinical rotations to other hospitals. Consent was sought from each participant following an explanation of the study objectives, procedure for the collection of data, the benefits of the research, and the confidentiality of the data collected. A copy of the self-administered questionnaire was given to each participant and retrieved after completion at the end of the working day. The survey used a short demographic questionnaire constructed to collect information such as the participant's gender, age, profession, and dental visits. The remaining part of the questionnaire contained the short form of the oral health impact profile (OHIP–14) used to collect information on oral health impact on QoL.

The OHIP-14 is one of the OHRQoL instruments that have been widely used in several cross-sectional and longitudinal studies.[19,20] It consists of self-reported measurements of the adverse impacts of oral conditions on daily life.[20] The questionnaire has 14 items organized into seven domains namely functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability and handicap. Each domain has two questions.The responses to these questions are to be scored on a 5-point Likert scale: 0, 1, 2, 3, and 4 for "never", "hardly ever", "occasionally", "fairly often", and "very often" respectively. A more negative impact of oral health on the person's life is indicated by the answers "fairly often" and "very often". One response per question reveals how often the impact is felt in the last one year. The questions have already been pre-weighed to reflect population judgments about the relative unpleasantness of each impact.[22] The coded responses are multiplied by their weights and the sum of the products within each domain represents subscale scores, and summation of the subscale scores will produce an overall OHIP-14 score for each participant. Subscale scores for each domain and an overall OHIP-14 score range from 0 to 4 for the subscales and 0 to 28 for the overall OHIP-14 score for the participant. A high score represents a greater impact and thus a low OHRQoL, and a low score represents a lesser impact and a higher OHRQoL.

b) Data Analysis

Analysis of the data obtained was performed using Statistical Package for Social Sciences (SPSS) for windows (version 20.0 SPSS inc., Chicago, IL, USA). Data was subjected to descriptive statistics in the form of frequencies, percentages, means, and standard error of mean. Comparison of domain and OHIP-14 scores between and among the variables were done with Student's t test and ANOVA statistics. Statistical significance was inferred at $p < 0.05$ for both tests and $p < 0.005$ for test of fit of the regression model in the multiple regression analysis performed.

III. Results

A total of 250 questionnaires were distributed and 236 were completed and returned, a response rate of 94.4%. Their ages ranged between 20 and 58 years with mean age of 33.1 ± 7.1. The age range 25 – 34 accounted for the majority of the study population. (Table 1) One hundred and sixty six of the participants had visited the dentist at least once, 79 (47.6%) of which had been in the last one year. Majority of the participants visited the dentist for check-up and/or prophylaxis. No significant difference was seen between the genders, professions and among the age groups for visit to the dentist ($p = 0.19$).

Table 1: Demographic distribution and dental visits among the participants

Variable	Frequency (%)
Age group	
18 - 24	27 (11.4)
25 - 34	143 (60.6)
>35	66 (28.0)
Gender	
Male	130 (55.1)
Female	106 (44.9)
Profession	
Doctors	107 (45.3)
Nurses	129 (54.7)
Prior dental visit	
Yes	166 (70.3)
No	70 (29.7)
Total	236 (100.0)
Reason for dental visit	
Check-up/prophylaxis	96 (57.8)
Routine treatment/review	46 (27.7)
Emergency treatment	24 (14.5)
Total	166 (100.0)

a) The Prevalence of Impact

The prevalence of impact of oral health on the subjects is expressed as the percentage of the participants that responded with "very often" or "fairly often" to all the items in the OHIP-14 questionnaire. Table 2 shows the percentage of participants that responded with "very often" or "fairly often" to all items in each domain and to all the items in the OHIP-14 questionnaire, expressed as a percentage of the total number of respondents. The highest prevalence of impact (27.9%) was noted in the physical pain domain with item number 4, "Have you found it uncomfortable to eat any foods because of the problem with your teeth or mouth?"

Table 2: Percentage of respondents who expressed frequency of impact of oral health on QoL as "fairly often" or "very often" based on the 14 items

Domains	Items		%
Functional limitation	P1	Trouble pronouncing any words	2.5
	P2	Worsened sense of taste	10.6
Physical pain	P3	Painful aching in the mouth	10.2
	P4	Found it Uncomfortable to eat any foods	27.9
Psychological discomfort	P5	Been self-conscious	8.5
	P6	Felt tense	4.6
Physical disability	P7	Diet has been unsatisfactory	6.0
	P8	Has had to interrupt meals	5.1
Psychological disability	P9	Found it difficult to relax	4.7
	P10	Been a bit embarrassed	5.0
Social disability	P11	Been a bit irritable with other people	3.8
	P12	Had difficulty doing usual jobs	6.7
Handicap	P13	Life in general was less satisfying	1.7
	P14	Been totally unable to function	3.8
Total			13.2

b) Severity of Impact

The severity of impact calculated as the mean value of the responses to the OHIP-14 items in the domains and overall was lowest in the functional limitation domain (0.30±0.04(S.E.M)) and highest in the psychological discomfort domain (1.16±0.07(S.E.M)) [Figure 1]. No statistical significant difference between the genders in all the domains and overall OHIP scores $p>0.05$, except in the social disability domain ("Have you been a bit irritable with other people because of the problem with your teeth or mouth? And "Have you had difficulty doing your usual jobs because of the problem with your teeth?"), where the females expressed a higher severity of impact ($p = 0.04$) [Table 3].

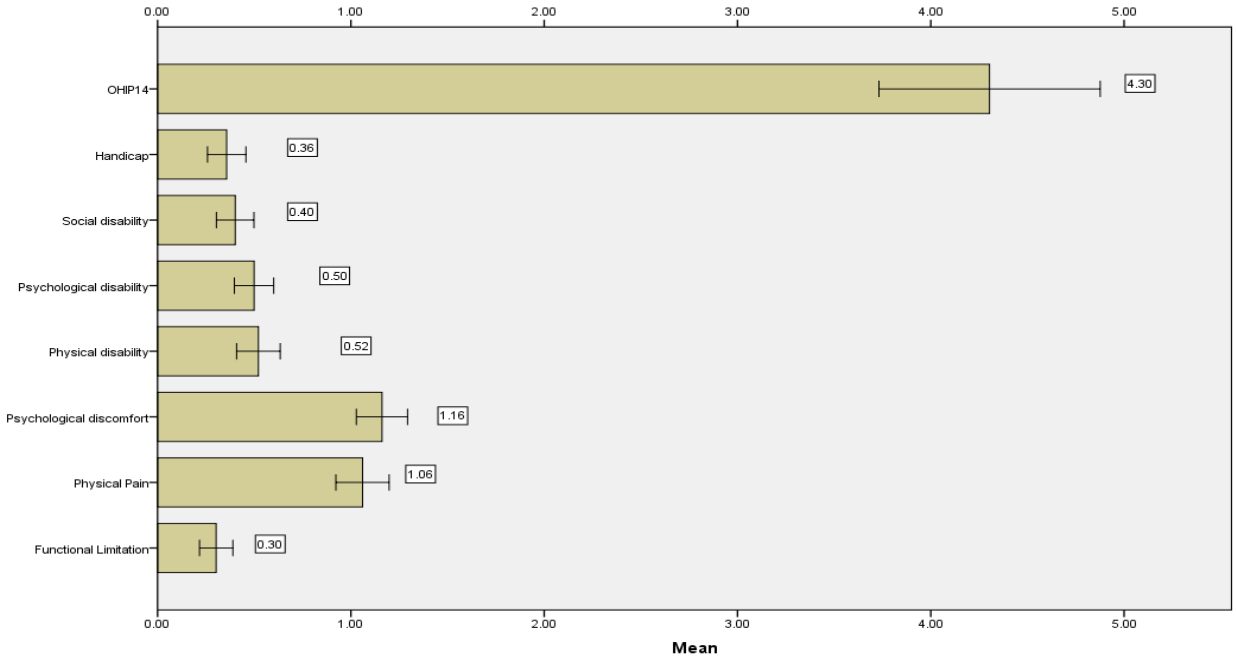

Figure 1: Mean domain and OHIP-14 scores

Table 3: Comparison of domain and OHIP-14 scores between the genders

Domain (N = 236)	Mean scores ± SEM		t	p
	Male	Female		
Functional Limitation	0.28±0.05	0.33±0.07	-0.47	0.64
Physical Pain	1.11±0.09	0.99±0.11	0.84	0.40
Psychological Discomfort	1.15±0.08	1.17±0.11	-0.11	0.91
Physical Disability	0.46±0.07	0.59±0.10	-1.09	0.28
Psychological Disability	0.45±0.06	0.56±0.09	-0.98	0.33
Social Disability	0.31±0.05	0.52±0.09	-2.09	0.04
Handicap	0.27±0.05	0.47±0.09	-1.96	0.05
OHIP-14	4.04±0.31	4.63±0.52	-0.97	0.33

The 18 – 24 years age group reported higher impact in all the domains and overall OHIP-14 except in the psychological discomfort domain. These differences were not statistically significant (Table 4).

Table 4: Comparison of domain and OHIP-14 scores among the age groups

Domain (N = 236)	Mean score ± S.E.M.			F	p
	18 -24	25 - 34	35 - 44		
Functional Limitation	0.59±0.17	0.25±0.05	0.30±0.10	2.98	0.05
Physical Pain	1.36±0.23	1.00±0.08	1.08±0.14	1.31	0.27
Psychological Discomfort	1.11±0.26	1.24±0.09	1.00±0.12	1.29	0.28
Physical Disability	0.70±0.17	0.48±0.07	0.54±0.12	0.75	0.48
Psychological Disability	0.73±0.19	0.51 ±0.06	0.38±0.09	2.02	0.14
Social Disability	0.64±0.20	0.39±0.06	0.33±0.09	1.71	0.18
Handicap	0.65±0.22	0.30±0.06	0.36±0.09	2.36	0.10
OHIP-14	5.80±1.03	4.17±0.35	3.98±0.57	1.76	0.18

The nurses had significantly higher domain scores in the functional limitation (0.40±0.07, p=0.01) and handicap domains (0.47±0.08, p=0.01). They also reported higher overall impact scores though not significant (4.58±0.43, p=0.28).

The participants who had visited the dentist at least once in the past had significantly higher overall OHIP-14 severity of impact score when compared to those who had never been to the dentist (Table 5). This trend was noted in all the domain scores except in the functional limitation (p=0.43) and handicap (p=0.33) domains. Comparison of the severity scores based on reason for clinic attendance showed that participants who visited the dentist for emergency reasons had a significantly higher OHIP-14 score (p <0.05) (Table 5) and domain scores except in the functional limitation domain (p=0.30). Post hoc analysis (Bonferoni) revealed the significant differences to be due to differences in the severity scores for check-up versus emergency visits in all domains and overall OHIP (p=0.00) and the OHIP-14 scores between check-up and routine visit scores (p=0.01). There was no significant difference in domain and overall OHIP-14 scores between routine and emergency visits (p=0.48), as well as between checkup and routine scores in the psychological disability (p=0.12), social disability (p=0.40) and handicap (p=1.00) domains.

Table 5: Comparison of OHIP-14 scores by dental attendance and reason for attendance

Variable	Mean score ± S.E.M.	t	p
Dental clinic attendance			
Yes	4.04±0.31	-2.74	0.01
No	4.63±0.52		
Reason for clinic attendance		F	p
Check-up/prophylaxis	3.42±0.31		
Routine treatment/review	5.77±0.80	13.81	0.00
Emergency treatment	8.55±1.19		

A multiple regression analysis was run to evaluate the relationship between the OHIP-14 score and the variables, age, gender, profession, prior visit to the dentist and reason for last visit. These variables were statistically significantly related to the variations in the OHIP-14 score, F (5, 230) = 10.542, p = .000 (i.e. < .005), R^2 = .186, R = .432 and adjusted R^2 = .169. Where F is the test of fit of the regression model, 5 and 230 are the degrees of freedom for the regression and residual models. R-squared gives the percentage of explained variation in the OHIP-14 scores assuming all variables in the model affect it, and the adjusted R-squared gives the percentage of variation explained by only those independent variables that in reality affect the OHIP-14 score. In this regression model, however, only age, prior visit to the dentist and reason for last visit added statistically significantly to the prediction of OHIP-14 score, p < .05 (Table 6).

Table 6: Relationship between participants' characteristics and OHIP-14 scores

Variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-4.308	1.480		-2.911	.004
Gender	.712	.547	.079	1.301	.194
Age	-1.142	.451	-.155	-2.531	.012*
Profession	.295	.550	.033	.536	.592
Visit to the dentist	8.508	1.226	.873	6.938	.000*
Reason for last visit	2.699	.445	.770	6.065	.000*

*$p < 0.05$

IV. Discussion

A relatively small proportion of the participants had their daily life affected negatively by the oral conditions that they suffer from as seen from the reported prevalence of impact (13.2%) in this study. The interpretation of this is that the frequency of the impact of oral disorders on the daily lives of these proportion of the participants is higher than in the rest of the participants. Within the domains, items 2, 3, 4 and 5 in the functional limitation (item 2), physical pain (items 3 and 4) and psychological discomfort (item 5) domains had the most prevalent impacts on QoL. The highest, as expected, is item 4 since it reflects level of comfort while eating. This is expected since the most common oral disorder still remain dental caries and its sequelae and periodontal disease, both of which would result in pain while eating. It would have been enlightening to compare these prevalence values to that of the general population but for lack of such data. However, a study of OHRQoL among patients with dentine hypersensitivity in Nigeria also reported the highest prevalence of impact (64.7%) on QoL with item 4.[23] Pain from oral disorders while eating or drinking therefore appears to have a major effect on QoL. This stand was corroborated again by the calculated mean value of the responses to the items of the OHIP-14, that is, the severity of impact, where the physical pain domain mean score was second only to that of the psychological domain.

In conjunction, both the prevalence and severity of impact showed that oral disorders among the participants did have an impact on their QoL. The severity of impact was noted to be highest in the domain of psychological discomfort followed by physical pain as is also seen for the domain scores for both genders in the study. This is consistent with results reported by Locker and Quinonez[24] and Batista *et al.*[25] The mean OHIP-14 score was however lower than that reported in other studies: 4.55 among Technical Administrative Workers in Portugal;[26] 9.60 among healthy Spanish workers;[27] and 12.0 among dental patients in Ibadan, Nigeria.[28] It is important to stress that these comparisons should be interpreted with caution as differences in perception of impact among populations depends on several factors. The perception of QoL itself is highly subjective, therefore individual perceptions vary with social, cultural, and political conditions.[29] The values reported therefore make meaning to the individuals in the setting where the study was conducted. However, the low severity of impact for the HCWs in this study may still be explained by their high level of education, and probably awareness of oral health. Similarly, Mesquita and Vieira[30] reported lower impact of oral health on QoL among subjects with higher income and education and suggested that this may be due to higher income and information about oral health and dental services.

Concerning the association between sociodemographic variables among the participants and OHRQoL, age and gender had minimal influence. This is similar to reports by Bombarda-Nunesi *et al.*[31] and Batista *et al.*[25] for age range and gender respectively. Although minimal, the influence of age was seen as a higher impact of oral disorders on QoL in all the domains and overall OHIP-14 score except the psychological domain among the younger age groups. In contrast, a greater impact was reported among older individuals by Guerra *et al.*[26] and Mesquita and Vieira.[30] The female HCWs in this study only had a significantly greater severity of impact on their daily social life as seen from their score in the social disability domain, but not in the mean OHIP-14 score. The reason for this finding is unknown, but may be due to differing subjective perceptions of social demands between the genders. It may also not be unrelated to the female gender having an emotion-focused approach to coping with health problems.[32] This may therefore explain why they may be a bit irritable with other people as well as having difficulty doing their usual jobs because of the oral disorders. Greater impact in females, that is, lower OHRQoL, has also been reported in other studies.[25,30,33]

Participants with a history of use of dental care facilities reported significantly lower OHRQoL. It is known that pain is the most frequent reason why adults visit the dental clinic, resulting in attendance that is sporadic and spurred by onset and persistence of symptoms.[34,35] This was supported by the results of this study by the significantly greater severity of impact reported by those who visited the dentist for emergency reasons when compared to routine visits and check-up. Emergency reasons here refers primarily to visits due to pain and discomfort such as endodontic emergencies

and trauma. This is consistent with reports on the association between reason for dental appointment and significance of impact from other studies.[25,26,30,31]

Based on the results of multiple regression analysis, all five variables considered in the study added statistically significantly to the prediction of the participants OHIP-14 score and hence their OHRQoL. However, these variables could only account for 16.9% of the variations of the OHIP-14 scores. This mean that there are other factors which may be responsible for the remaining variations. As suggested by Turrel *et al.*,[29] these unexplained variations in the perception of QoL among populations may be due to social, cultural and political differences.

V. Conclusion

The present study revealed that the impact of oral disorders on the OHRQoL among the HCW was relatively low. All the variables and factors included can however be used as predictors of this impact. Physical pain, functional limitation and psychological discomfort were the most prevalent impacts while psychological discomfort was reported as the most severe impact. The various factors assessed in this study influenced the perception of OHRQoL. Being female, being younger in age, a nursing staff, and having attended a dental clinic for treatment and attendance due to emergency reasons were associated with poorer OHRQoL.

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Workplace Mentoring Strategies and Sustainable Commitment of University Teaching Hospital Staff in South-South Region of Nigeria

By Akpan, James Williams, Owhor, A. Grace & Nsikan, E. John

University of Uyo

Abstract- Mentoring employees in healthcare institutions is essential: it helps to elicit enduring commitment in the delivery of efficient and effective medical services. This study aims at determining the effect of employee mentoring on sustainable commitment of workers towards achieving the goals of healthcare delivery. The research adopted a correlational survey design. For the purpose of this study, three university teaching hospitals in the south-south region of Nigeria were randomly selected. Purposive sampling was used to select 131 participants for the study. Primary data was collected through pretested structured questionnaire. The study reveals that employee mentoring has a strong impact on commitment of healthcare workers towards efficient service delivery. The study suggests the need for managers of healthcare personnel to attach more importance/interest to group/team, one-protégé-one mentor, and informal mentoring because it has been found to significantly contribute to overall workers commitment.

Keywords: *employee mentoring, workers commitment, learning culture, mentor, mentee.*

GJMR-K Classification: *NLMC Code: W 84*

WORKPLACEMENTORINGSTRATEGIESANDSUSTAINABLECOMMITMENTOFUNIVERSITYTEACHINGHOSPITALSTAFFINSOUTH-SOUTHREGIONOFNIGERIA

Strictly as per the compliance and regulations of:

Workplace Mentoring Strategies and Sustainable Commitment of University Teaching Hospital Staff in South-South Region of Nigeria

Akpan, James Williams [α], Owhor, A. Grace [σ] & Nsikan, E. John [ρ]

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I. Introduction

A hospital is a unique, dynamic, multispecialty environment, with many systems, all working to deliver superior quality service to the patient. In order for Healthcare providers to perform at optimal, it may be necessary for them to have a systems-perspective of their activities. They should know that their action or inaction affects the goals and objectives of the hospital.

For hospital management to become the kind of employer that attracts and retains talents who understand and are willing to ensure the successful functioning of the hospital, they need to create a high-impact learning culture (Tsai, 2014). According to Bell and Robbinson, (2013), introducing a learning culture in health care organisation could improve the quality of professional practice, commitment, satisfaction, lifelong learning, and patient care, while also lowering cost. Learning culture has been believed to take different forms such as training, mentoring and coaching (Johnson and Ridley, 2004). But for the purpose of this study employee mentoring will be considered a practice for learning and a process of bringing into existence and passing on a professional legacy.

Workplace mentoring has been conceptualized by different researchers. According to Greene and Puetzer (2002) workplace mentoring incorporates support, guidance, socialization, well-being, empowerment, education, and career progression. For the purpose of this study workplace mentoring is defined as an advisory role in which an experienced professional guides another individual in their professional development (Council of University Teaching Hospital, 2003). Through best possible use and application of employee mentoring programs in the healthcare organisation, commitment may be improved.

According to Rayton, (2006), understanding employee commitment as an employee attitude is important because it has an important effect on organizational performance. Organizations value commitment among their employees as it is typically assumed to reduce withdrawal behaviour, such as lateness, absenteeism, complacency and turnover (Fahad Al-Mailam, 2005). It is therefore important for hospital management to know the aspects that play important role or have big impact in boosting the commitment of their employees. And also help reduce the risk of potential loss due to unproductive work behaviours occurring within the workplace. Hence the researcher's intent to find out if employee mentoring has any influence on the commitment level of healthcare providers becomes the main thrust of the study.

With today's complex, dynamic, and fast-paced healthcare work environment, the role of developing talent and, specifically, of developing committed employees is critical to success. Healthcare organizations rely upon effective knowledge transfer to sustain a competitive advantage. And when they do not have processes to promote effective knowledge transfer, productivity may suffer and the survival of these healthcare organisations may be threatened. Nigerian hospitals like their counterparts in other parts of the world is facing an unprecedented ''passing of the torch'' from experienced and proven senior healthcare professionals to the younger generation (doctors and nurses), who may be less experienced in carrying out their responsibilities both to the hospitals and their intended patients.

Author α σ ρ: Department of Business Management, Faculty of Business Administration, University of Uyo, Uyo, Akwa Ibom State.
e-mails: bsbngwilliams@gmail.com, amabelgrace@gmail.com, nsikiboy5000@yahoo.com

This reality has brought to the fore the need to investigate what strategies could be employed to ensure that younger employees are well guided and prepared for the great task of knowing that their individual actions and in-actions contribute to the success of the hospital while also saving lives. Thus, it is necessary to extend research in this area to find out if employee mentoring is best adopted in grooming committed employees and how these practices can be successfully implemented to yield optimum result.

II. Objectives of the Study

This study aims to investigate the effect of employee mentoring on sustainable commitment in hospitals. The study was designed to achieve some specific objectives. These objectives were to:

1. Examine the level of prominence accorded mentoring by public hospitals in South –South Nigeria.
2. Identify the strategies used by healthcare institutions in South-south Nigeria to implement mentoring process.
3. Evaluate the influence of the identified mentoring strategies on workers commitment in south- south public hospitals.

III. Research Questions

The following research questions were raised considering the foregoing.

1. What level of prominence do public hospitals in South-South Nigeria accord to mentoring?
2. What strategies are used by healthcare institutions in implementing mentoring process in South-South Nigeria?
3. Do the identified mentoring strategies have any influence on workers commitment?

IV. Literature Review

a) *Importance Attached to Mentoring Roles in Public Hospitals*

Workplace mentoring, amongst the many programs introduced and integrated in the healthcare practice, has not been maximally utilized. This is very unfortunate, considering that the healthcare sector amongst the many areas of business has seen an upward growth. And without mentoring, many practices and important methods and procedures involved in healthcare may not be maximized at all. According to General Medical Council (2012), the importance of mentoring as a tool in fostering career development in all areas of the medical profession, including non-technical skills is increasingly being recognized. Healthcare management is becoming aware of the need to introduce mentoring programs into the hospital system and also set up channels to ensure that this program is functional.

Mentoring has been a tool used in most hospitals to assist in many levels of nursing which varies from skill training to leadership development to behaviour/attitude building. As a result of the foregoing, the importance of healthcare institutions in having a culture that accords value to workers mentoring can never be underestimated.

b) *Strategies Developed to Mentor Protégées in Healthcare Institutions*

Many strategies for mentoring relationships exist, and it is necessary to understand the differences and nuance before initiating any mentoring program. These relationships vary from formal or informal to group or individual etc. According to Metros and Yang (2006), one of the most important distinctions is whether the mentoring relationship is considered formal or informal. Most mentoring relationships sit somewhere in-between these two extremes.

Informal mentoring model is one in which more experienced clinicians guide and support their juniors in developing clinical skills. Although the number of formalized schemes in healthcare are increasing (Pololi, Knight, Dennis, et al, 2002), Formal mentoring relationships are often mandatory. This exist where the hospital management assigns mentors (consultants) to new hires (Doctors and Nurses) or promising healthcare service providers for promotion. The meetings are often scheduled, tracked, documented, and evaluated based on clearly articulated goals and milestones. Studies have found that properly implemented formal and informal mentoring program activities (friendship, social support, role modeling, acceptance and participation) had been a determinant of individuals' advancement, such as career development and psychosocial support (Okurame and Balogun, 2005).

Group mentoring is a form of mentoring that matches up mentors with multiple mentees in a hospital. This form of mentoring is ideal for public hospital because they have a greater amount of mentees than mentors. One advantage of group mentoring are that it allows mentors to pass on information to a lot of people at once and it allows mentees who are uncomfortable meeting one-on-one the opportunity to meet in a group setting. On the other hand, it is not conducive to the development of a one on one relationship where the mentor and mentee really get to know one another and identify personalized developmental goals and opportunities for the mentee.

In some cases, mentoring is needed to overcome specific hurdles or challenges. In situational mentoring, the relationship between mentor and mentee is established for the purpose of addressing specific challenge, issue or opportunity. The mentor may be on hand to assist the mentee more frequently, but the duration of the mentoring period is typically short.

c) Effect of Employee Mentoring Strategies on Sustainability of Workers Commitment

Workplace mentoring strategies outcome may seem difficult to measure but that does not make it in any way a less important undertaking. Workplace mentoring is an acknowledged process that may help in improving processes within the hospital and may lead to better staff results in their efforts, particularly in today's knowledge-based institutions. The mentor may not usually be specifically trained for his mentorship role, but simply has a head-start in terms of experience and knowledge. His motivation stems from his interest in mentoring, and the satisfaction derived from passing on experience to younger professionals.

Tourigny and Pulich, (2005) in their study focuses on how mentoring among nurses can help them to better serve their profession and health care organizations to more successfully achieve their goals. They further addresses how formal and informal mentoring can yield benefits to both the nursing profession and health care organizations by listing their advantages and disadvantages. The researchers finally concluded by accruing more importance to formal mentoring and that important consideration should be observed before establishing a formal program.

According to Cotton and Ragins, (1999) informal organizational mentoring is more beneficial than formal mentoring. Informal mentors provided higher amounts of several types of career development functions, including coaching, providing challenging assignments, or increasing protégés exposure and visibility. The researcher also went further to say that informal mentors are more likely to engage in positive psychosocial activities such as counseling, facilitating social interactions, role modeling, and providing friendship.

One result of informal mentoring is that protégés were much more satisfied with their mentors than protégés were with formal mentors. These differences may be attributed to the underlying differences in the structure of the relationships. Informal mentoring relationships develop because protégés and mentors readily identify with each other. The mentor may see one's self in the protégé and the protégé may wish to emulate the mentor's qualities. Finally, in informal mentoring the protégé and mentor are selective about whom they wish to approach for a mentoring relationship; it can last for years (Nemanick, 2000). Informal mentoring is a strong and valuable tool for developing an employee. It occurs in a relationship that is voluntarily formed by both persons. It is friendship first, learning and career second and third.

d) Sustainable Employee Commitment

Amidst today's competitive economic world every organisation is facing new challenges regarding sustained productivity and creating committed workforce. It may be considered that organisation can perform at peak levels unless each employee is committed to the organisations goals and objectives.

According to Greenberg (2005), Robbins and Coulter, (2003) employee commitment can be defined as an employee's drive to continually take active participation in the organisational activities at present and in the future that is borne out of a sincere desire to contribute efficiently to the general sustainability of the organisation. To Akintayo (2010) employee commitment can be defined as the degree to which the employee feels devoted to their organization. Meyer and Allen (1997) identified three dimensional forms of employee's commitment which are:

1. Affective commitment: This form of commitment basically reveals the employee's desire to remain with the organisation as its base on a perceived emotional personal attachment to the organisational goals and objectives. That is, employment with the organization will continue because the employee wants to do so.
2. Continuance commitment: This is where the employee perceives it is dependent on the organisation to achieve certain economic benefit. It is borne out of the sentiment or fear of not belonging to anywhere or losing by not been part of the organisation.
3. Normative commitment: This form of commitment is based on the perception that the employee's hold to the organisation. Thus, employees remain with the organization because they feel that they ought to do so.

e) Workplace Mentoring and Workers Commitment

There exists a strong link between workplace mentoring and positive workers outcomes (Kammeyer-Mueller and Judge, 2008), including employee commitment, job involvement, and reduced turnover intention (Joiner et al., 2004; Kraimer Seibert, Wayne, Liden, and Bravo, 2010). In a comparison of those employees who had mentors and those that did not, the employees with mentors often have more positive subjective outcomes including career satisfaction, job satisfaction, career commitment, and intention to stay at their organization (Allen, Eby, Poteet, Lentz and Lima, 2002). Donaldson, Ensher, and Grant-Vallone, (2000) in his study found that high quality mentoring relationship correlated with workers commitment.

An empirical work by Rhay-Hug *et al.*, (2010) in their study on "The impact of mentoring on job satisfaction and employee commitment of new staff nurse", explores if employee mentoring has any significance on the satisfaction and commitment of employees. Questionnaire was used to collect research data from 306 nurses sampled from three regional hospitals in Taiwan. Multiple regression analysis was used to testing the variable. The findings of the study

revealed that employee mentoring have a positive effect on employee commitment.

Roshen and Siby (2015) carried out study on "Employee Mentoring and Affective Commitment: A Study among New Generation Private Sector Bank Employees in Kerala", adopted convenience sampling to select 36 employees working in Axis bank, ICICI bank and HDFC bank. The instrument used was questionnaire and all items were measured using a 5-poin Likert type scale (1= strongly disagree to 5= strongly agree). The data of this study is analyzed using SPSS 21.0. The findings proved that there exists a positive effect of employee mentoring on employee commitment.

Payne and Huffman, (2005), in his findings from a longitudinal study suggest that mentoring fosters organizational retention in part because the emotional bond established between a mentor and a protégé may contribute to higher levels of employee commitment. In other words, mentoring relationships may operate, thus, to impact healthcare workers service quality by assisting in the transfer of organizational knowledge while simultaneously developing the high interpersonal relationships that strengthen a protégé's commitment to the hospital.

Lankua and Scandura, (2002) posits that employee mentoring relationships in hospital organizations provides strong evidence that employees with mentors are much more likely to experience a range of positive outcomes, including enhanced job performance, greater promotions and compensation, employee commitment and job satisfaction, personal learning, and reduced turnover intentions. A mentor demonstrates through role modeling the behavior, attitudes, and/or values that a protégé wants to emulate. The protégé observes the mentor's example, identifies with aspects of it, and learns from these observations.

V. Research Design

a) *Population & Sampling*

This research was undertaken at three university teaching hospitals in South-South region of Nigeria. The population in this study consisted of all doctors and nurses from the three public hospitals totaling 1400 as reflected on the personnel list obtained from the HR department of the hospitals. As a result of the large population size, the sample size was 10% of the total population (140) and consisted of purposively selected nurses and doctors who were currently in a mentor-protégée relationship. From the 140 participants administered with copies of questionnaire, 131 responded accordingly on schedule yielding 93.6% response rate.

b) *Data Collection Instrument*

In order to evaluate workers commitment from the perspective of mentoring, a close-ended structured survey questionnaire was used as instrument for data collection. The mentoring construct of the questionnaire was self-designed, taking inputs from relevant literature and pre-study discussion held with healthcare practitioners. Items that measure sustainable commitment were taken from the famous "Organisational Commitment Questionnaire" (OCQ) originally designed by Meyer and Allen (1997). Organizational commitment questionnaire in this study was categorized into three dimensions, namely: affective, continuance and normative commitment. The questionnaire contains twenty-four items divided into sections A and B. Sections A contains four items on the demographic variables of the respondents and section B has five closed-ended items on thematic variables on workplace mentoring and workers commitment designed based on a 5-point Likert scale of Strongly Agree (SA), Agree (A), Undecided (UD), Disagree (D), and Strongly Disagree (SD).

c) *Data Analysis Technique*

Descriptive statistics (percentage count, mean and standard deviation) were used to analyse data generated to answer the research questions. Multiple regression analysis was used to estimate the effects of mentoring variables on measures of commitment.

VI. The Findings and Discussion

a) *Importance attach to mentoring by hospitals*

Table 1 present descriptive result showing the extent of importance given mentoring in the studied organisations. The mean responses of the distribution ranges between 4.23- 3.20, while the standard deviation lies between (0.89-1.34) suggesting that the variables are normally distributed. Data also exhibit relatively high values in four of the six dimensions measured. This implies that organization under survey attached high level of prominence to staff mentoring as a strategy for heightening organizational commitment. The organization appears to accord importance to assigning protégées to mentors with similar career interest (Mean=4.23, SD=0.89), developing and encouraging good mentoring knowledge and skill (Mean=4.13, SD=0.88), assigning one employee per time to a mentor (Mean=4.02, SD=1.06), and demonstrating positive perception towards mentoring (Mean=3.97, SD=1.19). On the other hand, less prominent is given to issues such as: regular evaluation of mentoring relationship (Mean= 2.53, SD= 1.35), and provision of special training to mentees (Mean= 2.14, SD=1.83) as their mean scores are below the benchmark of midpoint of 3.0

Table 1: Priority accorded mentoring (N=131)

Item description	Mean	Std. Dev
"To what extent does the following reflect the importance attached to mentoring by your organsation?"		
Assigning protégées to mentors with similar career interest	4.23	0.89
Encouraging individuals with mentoring skills	4.13	0.88
Assigning one employee per time to a mentor	4.02	1.06
Positive perception towards mentoring	3.97	1.19
Regular evaluation of mentoring relationship	2.53	1.35
Provision of special training to mentees	2.14	1.83

Note: 5= very high extent, 1= not at all Source: Field Survey, 2016

b) Mentoring approaches in Nigerian hospitals

This section explores the approaches used by respondents to implement mentoring in hospitals. Respondents were asked to identify most adopted mentoring strategies in their hospital. Though several methods were identified, it was necessary to classify these measures into seven key approaches such as: situational (need-driven) mentoring, formal mentoring, informal mentoring, multiple mentoring, group or team mentoring, e-mentoring and one protégé-one mentor strategy. Respondents place much premium on approaches that appear sustainable and enduring. In their judgment, they ranked having just one mentor to a protégée per time as the most adopted (and probably the best) mentoring approach, and that allowing mentoring relationship develops naturally through informal processes is a credible practice. Respondents also highlight situational mentoring (which is targeted at specific task, and ceases to exist after task completion), and group or team mentoring (where mentee serves as team leader) as sound mentoring methods. They were however confident that having many mentors (multiple mentoring) at any one time could breed conflict and unnecessary distraction. Formal mentoring also appears not to receive popular support from respondents, and e-mentoring (uses electronic means as primary channel of communication), ranked least by respondents is still at its infancy. These results are summarized in Table 2.

Table 2: Strategies for Mentoring Protegees (N=131)

Item Description	SA	A	U	D	SD	% of Agreement	Rank
What strategy is mostly adopted by your hospital to facilitate mentoring?							
Group or team mentoring	58 [A](44.3)	37 (28.2)	6 (4.6)	19 (14.5)	11 (8.4)	72.5	4
Situational mentoring	64 (48.9)	31 (23.7)	10 (7.6)	12 (9.2)	14 (10.6)	72.6	3
Informal mentoring	53 (40.5)	44 (33.6)	7 (5.3)	9 (6.9)	18 (13.7)	74.1	2
Multiple mentoring	50 (38.2)	39 (29.8)	18 (13.7)	14 (10.6)	10 (7.6)	68.0	5
One protégé-one mentor	41 (31.3)	62 (47.3)	9 (6.9)	12 (9.2)	7 (5.3)	78.6	1
Formal mentoring	39 (29.8)	25 (19.1)	16 (12.2)	30 (22.9)	21 (16.0)	48.9	6
E-mentoring	23 (17.6)	26 (19.8)	9 (6.9)	36 (27.5)	37 (28.2)	37.4	7

Source: Field Survey, 2016.

[A] Figures in parenthesis are percentage scores
[B] Where 5= strongly agree, 4= agree, 3= neutral, 2= disagree, 1=strongly disagree

c) Effects of mentoring on commitment

In order to estimate the effects of these mentoring variables on measures of organizational commitment, multiple regression analysis was performed. We employed the ordinary least square technique. Regression models were developed separately to study and explain the extent to which each of the dimensions of commitment- affective, continuance, and normative are affected by series of mentoring approaches identified by respondents.

Results in Table 3 summarize the findings from the multiple regression analysis.

The standardised Beta estimates (β) and t-scores are used in order to compare and determine the impact of mentoring approaches on the three measures of commitment. Table 3 summarizes the findings for the three regression model. Note that three of the seven mentoring approaches (group/team, one protégé-one mentor, and informal mentoring) contribute in a positive and significant way to affective, continuance and normative commitment. Thus, managers of healthcare personnel could achieve high commitment using a combination of the three key mentoring approaches found to significantly contribute to overall organizational commitment.

It is equally interesting to note that all the seven dimensions of mentoring made significant predicting effect on normative commitment (Table 3). By implication, respondents may have felt obliged to stay and contribute to organization's success given the huge investment in mentoring and other support programmes. This finding support the notion of commitment and organizational support put forward by Payne and Huffman, (2005) that mentoring fosters organizational retention because the emotional bond established between a mentor and a protégé may contribute to higher levels of employee commitment. Certainly, workers that have undergone fruitful period of mentorship are expected to consider it morally wise not to quit the company but rather, to stay and contribute to its success. Thus, mentoring facilitates positive work outcome (including enhanced job performance, greater promotions and compensation, employee commitment and job satisfaction, personal learning, and reduced turnover intentions) as reported in the works of Roshen and Siby (2015); Lankua and Scandura, (2002).

As result on Table 3 further indicates, the coefficient of determination (adjusted R^2) with values: 0.735, 0.783, and 0.833 implies that the fitted model explains about 73.5% of variation in affective commitment (Model I), 78.3% of variation in increased continuance commitment (Model II), and 83.3% variation in normative commitment of hospital employees (Model II). As indicated, the overall fit of the regression model is robust since the ANOVA (F-value) for model 1(84.948), model 2 (114.684), model 3 and (82.747), and model 4 (180.22) are significant at 0.05level of significance.

Some implications can be drawn from these sets of results. First, facilitating high commitment among healthcare workers can be achieved. Depending on the nature of commitment desired, healthcare managers have ample opportunities of planning commitment strategies around selected mix of mentoring approaches identified in the study. Second, managers that expect to derive higher normative commitment outcome through high performance work practices could consider a portfolio of the seven mentoring approaches as important strategy. More specifically, healthcare managers are advised that investing organizational support and resources into a "one protégé-one-mentor", informal mentoring, and situational mentoring has propensity of yielding higher continuance commitment. This may results in positive commitment outcomes such as those reported by Ilesanmi and Lasisi, (2015) -increased staff retention, reduced role ambiguity, good professional identity, increased task performance skills, increased job satisfaction, and reduced role ambiguity.

Table 4.4: Multiple regression analysis showing mentoring approaches contributing to organizational commitment

	Dependent Variable		
Independent variable	Model I	Model II	Model III
	Affective Commitment	Continuance commitment	Normative commitment
Group or team mentoring	0.452** (3.771) [0.063]	0.302** (2.492) [0.062]	0.213** (5.317) [0.045]
One protégé-one mentor	0.456** (6.100) [0.056]	-0.181** (-2.681) [0.046]	0.410** (6.918) [0.040]
Informal mentoring	0.539** (7.907) [0.045]	0.930** (11.958) [0.052]	0.466** (5.002) [0.056]
Situational mentoring	0.107 (1.679) [0.016]	0.209 (1.008) [0.011]	0.380** (3.064) [0.014]
Formal Mentoring	0.410** (6.918) [0.040]	0.102 (1.492) [0.062]	0.456** (6.100) [0.056]

Multiple mentoring	0.152 (1.771) [0.063]	0.102 (1.492) [0.062]	0.339** (7.907) [0.045]
E-mentoring	0.102 (1.492) [0.062]	0.230 (1.958) [0.052]	0.207** (7.679) [0.016]
F-value	84.948**	114.681**	82.747**
R^2	0.743	0.790	0.839
Adjusted R^2	0.735	0.783	0.833
N	131	131	131

Source: Field Survey, 2016.

Note: ** $p < 0.01$, numbers in the first parenthesis are t-scores; standard errors are in the second parenthesis.

VII. Conclusion

Studying to understand the nature and approaches to mentoring in healthcare is important as a means of tackling poor quality service delivery by healthcare personnel. Thus, a number of conclusions can be drawn from this study: First, though healthcare practitioners in public hospitals actually accord high prominence to workplace mentoring, they were selective in their choice of mentoring approach to implement. Among the strategies implemented include: group or team mentoring, situational mentoring, informal mentoring, multiple mentoring, one protégé-one mentor, formal mentoring and e-mentoring. Second, three of the seven mentoring approaches (group/team, one protégé-one mentor, and informal mentoring) contribute in a positive and significant way to affective, continuance and normative commitment. Third, it is also established that mentoring facilitates positive work outcome such as: enhanced job performance, greater promotions and compensation, employee commitment and job satisfaction, personal learning, and reduced turnover intentions. Finally, this study concludes therefore that high commitment of welfare workers to delivering quality services can be achieved through a combination of mentoring strategies. This can be achieved with the use of workplace mentoring which has a significant effect on workers commitment in university teaching hospital staff in south-south region of Nigeria.

Given this conclusion, it is recommended that managers of healthcare personnel should attach more importance/interest to group/team, one protégé-one mentor, and informal mentoring because it has been found to significantly contribute to overall workers commitment. In situations where hospital managers desire normative commitment from her employees, the study suggest that all seven dimensions of mentoring would serve as an optimum strategy for the desired outcome. In course of the study, the E-mentoring, though still in its infancy in Nigeria, was found to be significant in predicting commitment of healthcare personnel. Hence, a call is hereby made for this mentoring approach to be given attention by scholars and industry practitioners.

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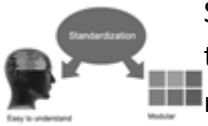

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Note :

"

- In future, if the board feels the necessity to change any board member, the same can be done with the consent of the chairperson along with anyone board member without our approval.
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"

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2. Ethical Guidelines,

3. Submission of Manuscripts,

4. Manuscript's Category,

5. Structure and Format of Manuscript,

6. After Acceptance.

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Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.

Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.

- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

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- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

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Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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