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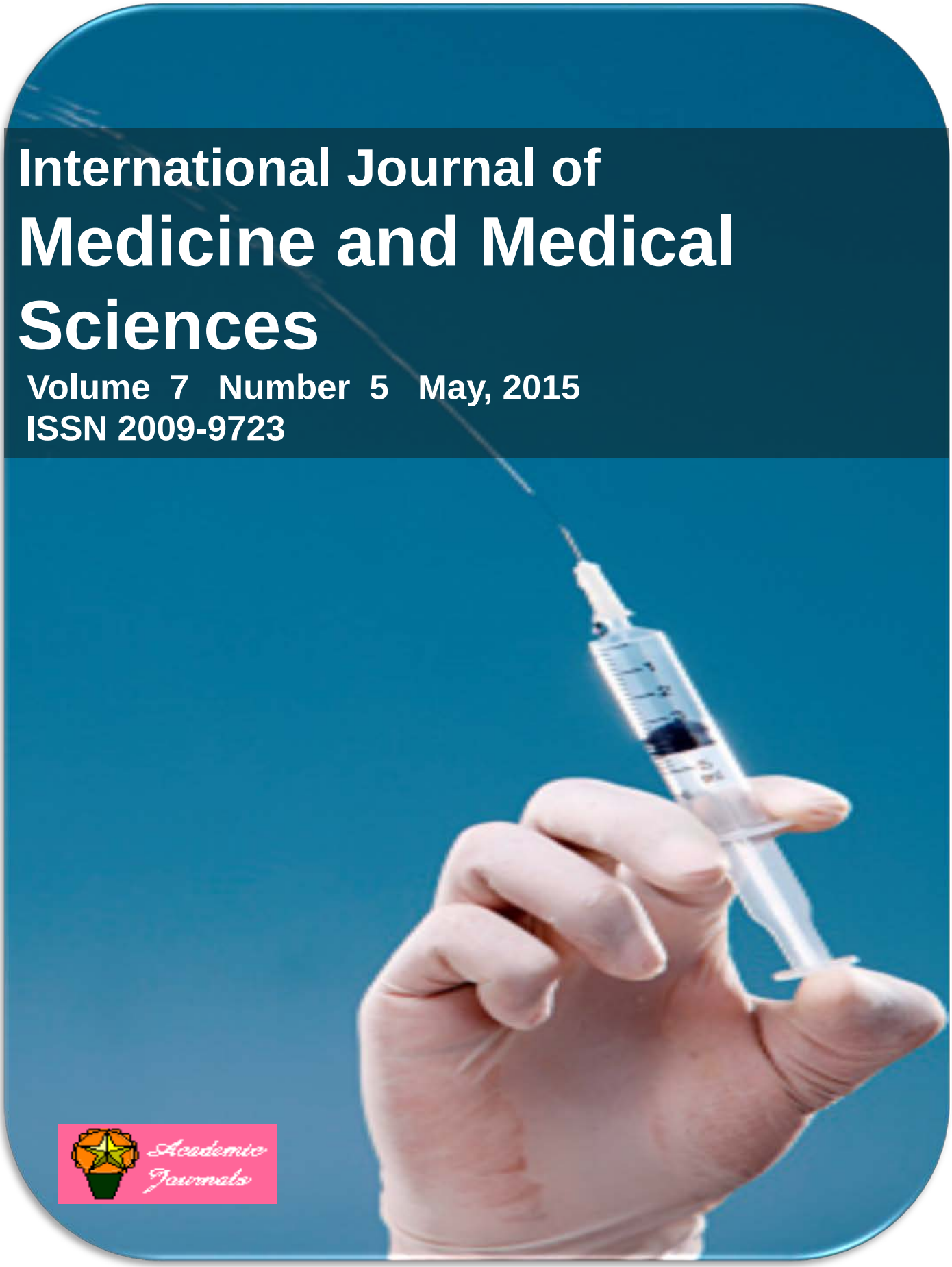

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Nishimura (2000), Agindotan et al. (2003), (Kelebeni, 1983), (Usman and Smith, 2001), (Chege, 1998; Stein, 1987a,b; Tijani, 1993,1995), (Kumasi et al., 2001)

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Mussel RL, De Sa Silva E, Costa AM, Mandarim-De-Lacerda CA (2003). Mast cells in tissue response to dentistry materials: an adhesive resin, a calcium hydroxide and a glass ionomer cement. J. Cell. Mol. Med. 7:171-178.

Booth M, Bundy DA, Albonico P, Chwaya M, Alawi K (1998). Associations among multiple geohelminth infections in school children from Pemba Island. Parasitol. 116: 85-93.0.

Fransiscus RG, Long JC (1991). Variation in human nasal height and breath, Am. J. Phys. Anthropol. 85(4):419-427.

Stanislawski L, Lefeuvre M, Bourd K, Soheili-Majd E, Goldberg M, Perianin A (2003). TEGDMA-induced toxicity in human fibroblasts is associated with early and drastic glutathione depletion with subsequent production of oxygen reactive species. J. Biomed. Res. 66:476-82.

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Full Length Research Paper

Role of body mass index (BMI) on the oxygen saturation and apneic spells in obstructive sleep apnea (OSA)

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Data from the sleep disorders institute (SDI) showed that subjects with similar apnea hypopnea index (AHI) but different body mass index (BMI) had no difference in oxygen saturation in rapid eye movement (REM) or non-rapid eye movement (NREM) sleep. Only 6 pairs of subjects were evaluated in the study and they were not age-matched. The objective of this study was to evaluate, in age-matched subjects, if there were any differences in oxygen saturation and duration of apenic spells in subjects with similar AHI but different BMI. Ninety eight (98) subjects paired for AHI within one event/hour and BMI differences of 5 and above were grouped in 9 groups. Subjects belonged mainly to normal, mild and moderate AHI groups. Diagnostic nocturnal polysomnography (NPSG) inclusion criteria were normal REM sleep and total sleep time of 5 h. Oxygen saturation was continuously assessed throughout the nocturnal polysomnography (NPSG), and was calibrated for each NPSG study, and was visually identified by sleep physician and artifacts were eliminated from the analyses. For all age groups, differences between matched pairs on BMI were regressed on the following factors: baseline oxygen saturation, lowest oxygen saturation, average oxygen saturation difference between pairs, apnea maximum and mean durations. Mean BMI differences between age- and AHI-matched pairs were 10.2 ± 5.7 (range 5.0 to 29.0). Stepwise regression indicated that BMI differences between pairs best predicted minimum oxygen saturation (p = 0.008, 1-tail). One-way analysis of variance (ANOVA) showed that age differences contributed to the robust finding regarding how BMI differences predicted lowest oxygen saturation. Using a very conservative Bonferroni correction for multiple comparisons, lowest saturation differed only between lower age groups [group 1 < group 2 (p = 0.3) < group 3 (p = 0.001) and < group 4 (p = 0.02)]. Difference in BMI (when AHI is matched), especially between ages 25 and 44 years old, predicts differences in minimum oxygen saturation. Caution is warranted as severe apneics were not evaluated in small sample sizes in subject older than 40.

Key words: Obstructive sleep apnea (OSA), apnea hypopnea index (AHI), body mass index (BMI), nocturnal polysomnography (NPSG), oxygen saturation, sleep disorder.

INTRODUCTION

Sleep disordered breathing comprises a spectrum of conditions ranging from simple snoring and upper airway resistance syndrome to obstructive sleep apnea (OSA). OSA is a severe form of sleep-related disorders.

OSA is a chronic disease characterized by sleep apneas, hypopneas, daytime sleepiness, fatigue and disturbed sleep. It is usually diagnosed using a full night in-lab polysomnography study [NPSG] (gold standard), though split night and portable in-home monitoring options are also available. The Apnea-hypopnea index (AHI) and respiratory disturbance index (RDI) are calculated from the NPSG.

AHI is the total number of complete cessations (apnea) and partial obstructions (hypopnea) of breathing occurring per hour of sleep. These apneas and hypopneas must last for at least 10 s and be associated with a decrease in oxygenation of the blood. RDI is the total number of events including apneas, hypopneas, and respiratory effort related arousals (RERAs) per hour of sleep. RDI is usually slightly higher than the AHI, because it also includes the frequency of RERAs.

OSA diagnostic criteria in adults (American Academy of Sleep Medicine, 2005) ≥ 15 apneas, hypopneas, or respiratory effort related arousals per hour of sleep (that is, AHI or RDI ≥15) in an asymptomatic patient with more than 75% of apneas and hypopneas being obstructive. OR ≥ 5 apneas, hypopneas, or respiratory effort related arousals per hour of sleep (that is, AHI or RDI ≥5) in a symptomatic patient with more than 75% of apneas and hypopneas being obstructive.

OSA is further classified on the basis of AHI as mild (AHI 5 to 15), moderate (AHI 15 to 30) and severe (AHI >30). Prevalence of OSA has increased tremendously in the past few decades and this is partly due to the growing of the number of obese population (Young et al., 1993). Moreover, there is evidence that prevalence of OSA increases in patients with morbid obesity (Foster et al., 2009).

In the pathophysiology of OSA in obesity, patients with OSA are able to maintain their airway while awake by increasing the upper airway muscle tone (Schwab et al., 2003); but when asleep the airway muscle tone decreases and hence they fail to maintain their airway patency. This is further complicated in obese patients, in whom the gross enlargement of pharyngeal soft tissue structures (Horner et al., 1989; Shelton et al., 1993) along with increased fatty tissue in the soft palate, uvula, tongue and mandibular structures (Schwab et al., 2003; Stauffer et al.,1989) leading to further narrowing of the airway. In addition to the airway disorder, the lung volume is also additionally affected by the reduction in tracheal tractional and pharyngeal wall tension forces (Isono, 2012). More so, obesity related reduction of leptin responsiveness further interferes with breathing via neuro-anatomical interference (Polotsky et al., 2012).

The clinical significance of identifying patients with OSA lies in the fact that it has been associated with high rates morbidity and mortality, mostly from cardiovascular causes and road traffic accidents (Marin et al., 2005).

The sleep disorders institute (SDI) study shows that subjects with similar AHI but different BMI have no difference in oxygen saturation in rapid eye movement (REM) or non-rapid eye movement (NREM) sleep. This study determines if it remains consistent once the subjects are age and BMI matched (Khan et al., 2009).

MATERIALS AND METHODS

Patient population

A retrospective study was conducted at SDI in New York City. The protocol was approved by the institutional review board (IRB) and ethics committee of the institution. Seven hundred and fifty six (756) charts were reviewed and 203 subjects who were selected met inclusion and exclusion criteria. Of these 203 patients, 98 patients were selected, based on AHI and BMI; and these 98 pairs of patients were compared. Charts were reviewed from January, 2007 to June, 2009. Patients were selected based on the following criteria [inclusion criteria]: age more than 18 years, having received a diagnosis of OSA confirmed through NPSG, total sleep time (TST) of 5 h and normal or within 90% of REM sleep]. Exclusion criteria: REM disorders, parasomnias, insomnia, current smokers or ex-smokers who quit within ≤6 months, lung surgeries [lobectomy, pneumonectomy], neuromuscular diseases, seizure disorders, chronic obstructive lung disease patients, previous cardiovasular accident or transient ischemic attacks, kyphosis, scoliosis, peripheral vascular disease patients (Raynaud's disease), interstitial lung disease (sarcoidosis, idiopathic pulmonary fibrosis) and pregnant women.

Experimental

BMI for each subject was obtained by dividing weight in kilograms by height in meters squared. Subjects were categorized by weight status based on their BMI: normal [between 20 and 24.9 kg/m^2], overweight [BMI between 25 and 29.9 kg/m^2], obese [BMI between 30 and 39.9 kg/m^2] (NIH Publication, 2000).

Polysomnography was performed using the standard method. The standard NPSG montage included measurement of the left and right anterior tibialis muscle electromyography (EMG) lead: two respiratory effort monitoring devices (RIP sensors): one on the abdomen at the navel level or below, and the other on the chest, nipple level or above; 3 chin EMG electrodes; electrocardiogram (ECG) electrodes used for modified Lead II; electroencephalogram (EEG) electrodes F3, F4, C3, C4, O1, and O2 using the international 10 - 20 system; reference electrodes at M1 (left mastoid) and M2 (right mastoid), and a ground electrode at Fpz; electrooculogram (EOG) leads with E1 (left eye) 1 cm below the left outer canthus and E2 (right eye) 1 cm above the right outer canthus; oronasal thermal sensor and nasal air pressure transducer with vibration sensor to detect snoring; and an oximeter probe placed on the patient's finger. The pulse oximeter model used was Ohmeda 3000. Electrode impedances were checked and biocalibrations performed to ensure signal integrity and absence of artifact.

During the data collection process, body position, and snoring

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status were recorded. Oxygen saturation was continuously assessed throughout the NPSG. Unusual movements and behaviors were documented by the technician. In this study, oxygen saturation was continuously assessed throughout the NPSG, and was calibrated for each NPSG study and was visually identified by the sleep physician and artifacts were eliminated from the analyses. Periodic impedance checks were made and documented to ensure signal strength and integrity. Sleep stages were classified according to the American Academy of Sleep Medicine (AASM) Manual for the Scoring of Sleep and Associated Events: Rules, Terminology and Technical Specifications (AASM Manual for the Scoring of Sleep and Associated Events, 2007).

Airflow was measured using a nasal cannula connected to a pressure transducer, and peripheral oxygen saturation (SpO^2) was measured using an Ohmeda 3000 pulse oximeter. Apnea was defined as a reduction in airflow to ≤10% of the baseline value for 10 s or more, and hypopnea was defined as reductions in airflow of ≥30% accompanied by awakening and a ≥4% drop in SpO^2. (AASM Manual for the Scoring of Sleep and Associated Events, 2007). AHI was calculated by dividing the total number of apnea-hypopnea episodes by the number of hours of sleep. Based on the AHI, OSA severity was classified as mild [<15], moderate [15 to 30] or severe [>30] (The Report of American Academy of Sleep Medicine Task Force, 1999).

Statistical analysis

Data were stored and analyzed using the program Statistical Package for Social Sciences (version number 20). Results are expressed as the number of cases, percentages, range, mean and standard deviation. Student's t-test was used for data analysis. Stepwise regression was used to evaluate for BMI differences between matched pairs. Analysis of variance (ANOVA) was used to analyze the differences between the group means for statistical significance. For comparison between multiple groups, Bonferroni correction method was used. Values of $p < 0.05$ were considered statistically significant.

RESULTS

A total of 98 subject pairs were reviewed; data are shown in Table 1. They were divided into 9 groups based on their age, at intervals of 5 years [group 1: 25 to 29 years, group 2: 30 to 34 years, group 3: 35 to 39 years, group 4: 40 to 44 years, group 5: 45 to 49 years, group 6: 50 to 54 years, group 7: 55 to 59 years, group 8: 60 to 64 years, group 9: >65 years].

Of the 98 pairs that were compared, there were 62 men and 44 patients were non-Caucasians. Each of the age groups were matched for AHI. The mean difference in BMI between age- and AHI- matched pairs were 10.2 ± 5.7 (range 5.0 to 29.0); data are shown in Table 2. Stepwise regression analysis indicated that BMI differences between the age and AHI matched pairs best predicted minimum oxygen saturation (p=0.008). One-way ANOVA showed that age differences contributed to how the BMI differences predicted lowest oxygen saturation. On further analysis using Bonferroni correction for multiple comparisons, the lowest saturation differed only between lower age groups [group 1 < group2 (p = 0.3) < group 3 (p = 0.001) and < group 4 (p = 0.02)]. These differences were not apparent at group 5 and above [age 45 and above].

DISCUSSION

In this retrospective study with OSA subjects, the effects of BMI on the disease were compared. This study suggests an inverse association between BMI and minimum nocturnal oxygen saturation in OSA patients. But the contribution of BMI (when age and AHI were matched) in predicting minimum oxygen saturation was seen only in subjects with OSA under 45 years of age. The BMI did not predict degree of nocturnal oxygen desaturation in OSA patients > 45 years.

Katz et al. (1990) noted that external neck circumference correlated with OSA but observed the need for further work to establish a strong co-relation with BMI. In a study by Knorst et al. (2008), the degree of obesity [assessed by BMI] had the greatest impact on the severity of OSA [AHI, percentage of total sleep time spent in apnea and minimum SPO^2]. This study not only confirms the findings of the aforementioned study, but also pointed out a lesser-known contribution of age to this effect. In other words, the directly proportional effect of BMI on worsening nocturnal oxygen desaturation on OSA subjects is limited to young subjects only [< 45 years of age]. In this study, groups were matched for age, AHI and other baseline characteristics; thus ensuring no confounding factors. Though the reason for this observation is not fully established, there is a possibility of craniofacial abnormality in the young adults being more severe (Johns et al., 1998). These anatomical abnormalities can become more pronounced with obesity. It can be hypothesized that with aging and associated changes in pharyngeal anatomy in the elderly, the degree of desaturation (thus the severity of OSA) can be low as compared to the young. Whether other age related factors in subjects > 45 years are contributing and compounding, the effect needs to be further studied.

Previous study noted as basis of our study: Dreher et al., 2012, A German study showed that in OSA patients with an equal AHI, the obese have fewer apneas, but more hypopneas, and a lower minimal oxygen saturation than normal weighted patients. Thirty two (32) normal weighted OSA patients (BMI ≤ 25 kg/m^2) were compared with 32 obese patients (BMI >25 kg/m^2). The patients had almost equivalent AHI. The mean AHI in both groups was 27.9 (BMI ≤ 25 kg/m^2) and 28.0 (BMI ≥ 25 kg/m^2), respectively. Sleep efficiency, relative percentages of sleep phases S1-S4 and REM, mean, minimal and maximal heart rates were not significantly different in statistic analysis in normal weighted and obese patients. Normal weighted OSA patients had a higher apnea index (11.4 versus 6.4, p=0.040), a higher minimal oxygen saturation (81.3% versus 71.7, p = 0.003) and mean (94.9% vs. 92.8%, p=0.007) oxygen saturation, but a

Table 1. Ninety-eight pairs of subjects' BMI, AHI and saturation difference.

Age (Years)	pairs	BMI difference	AHI difference	Saturation baseline difference	Saturation minimum difference	Saturation average difference	AHI maximum difference	AHI average difference
	1	6.0	0.8	2.0	6.0	4.0	29.6	2.5
	2	5.0	0.7	1.0	6.0	7.0	11.9	11.9
	3	5.0	0.4	1.0	9.0	8	5.9	5.2
	4	21.0	0.1	0.0	16.0	16	13.1	4.9
	5	5.0	1.0	3.0	5.0	2	7	2.6
25-29	6	16.0	1.0	1.0	22.0	21	6.5	5.5
	7	6.0	0.2	1.0	1.0	0	19.6	17.4
	8	16.0	0.9	3.0	21.0	18	6.1	2.3
	9	17.0	0.0	0.0	21.0	21	14.6	6.5
	10	6.0	0.1	3.0	0.0	3	19.2	14.2
	11	7.0	0.8	0.0	0.0	0	27.7	18.4
	12	13.0	0.2	1.0	23.0	24	35.3	12.8
	13	11.0	0.4	1.0	0.0	1	51.5	15.9
	14	22.0	0.6	5.0	7.0	2	18.8	8
	15	16.0	0.6	3.0	1.0	2	7.6	5.7
	16	10.0	0.4	4.0	9.0	5	4.3	1.7
	17	16.0	0.2	3.0	7.0	4	17.7	4.3
	18	8.0	0.9	0.0	7.0	7	8.9	2.2
	19	17.0	0.1	1.0	4.7	3.7	12.6	5.1
	20	17.0	0.6	0.0	0.0	0	4	1.1
	21	10.0	0.4	0.0	6.0	6	25.1	6.4
	22	7.0	0.2	2.0	1.0	1	19.9	18.2
	23	6.0	0.6	6.0	0.0	6	10.2	9
	24	13.0	0.7	1.0	4.0	5	25.1	22
	25	5.0	0.9	3.0	2.0	1	14.4	12.4
	26	24.0	0.5	1.0	6.0	7	2.4	2
	27	11.0	0.8	1.0	2.0	1	14.4	12.4
	28	5.0	1.0	2.0	2.0	4	14.4	12.4
	29	25.0	0.8	1.0	1.0	2	0.1	2.2
	30	5.0	0.9	6.0	1.0	5	2	1.2
	31	12.0	1.0	1.0	3.0	4	16.9	14.2
	32	29.0	0.1	2.0	8.0	6	16.8	14.4
	33	7.0	0.0	3.0	2.0	1	14.8	14.3
	34	6.0	0.0	2.0	6.0	4	11.2	2.3
30-34	35	12.0	1.0	1.0	2.0	3	14.5	6.3
	36	6.0	0.4	2.0	0.0	2	2.1	3.7
	37	7.0	0.3	1.0	10.7	10	12.5	1.3
	38	7.0	1.0	0.0	6.0	6	21.1	5.3
	39	5.0	0.0	0.0	5.0	5	21.1	15.6
	40	22.0	0.1	1.0	6.0	7	2	0.1
	41	29.0	0.0	1.0	8.0	7	16.8	14.4
	42	6.0	1.0	1.0	8.0	7	2.8	4
	43	7.0	0.1	5.0	4.0	1	14.9	13
	44	7.0	0.1	2.0	2.0	4	14.8	14.3
	45	6.0	0.6	1.0	2.0	1	12.9	2.6
	46	19.0	0.2	2.0	5.0	3	36.1	13.4
	47	11.0	0.3	0.0	2.0	1	49.4	5
	48	12.0	0.7	1.0	3.0	2	2	0.2
	49	11.0	0.8	2.0	1.0	3	2.4	1.8
	50	5.0	0.2	1.0	2.0	1	1.2	2.6
	51	15.0	0.3	0.0	0.0	0	6	0.9
	52	6.0	0.2	1.0	5.0	5	10.9	10.8
	53	9.0	1.0	1.0	3.0	2	22	22
	54	6.0	0.1	1.0	4.0	5	1.9	4.1
	55	7.0	0.9	0.0	1.0	1	0.6	2.4
	56	12.0	0.6	2.0	3.0	1	2	2.2
	57	6.0	0.5	1.0	2.0	3	16.6	2.1
	58	16.0	0.5	0.0	1.0	1	1.3	1.3

Table 1. Cont'd

	59	5.0	0.5	2.0	3.0	1	1.2	2
	60	6.0	1.0	1.0	1.0	0	14.3	14.3
	61	6.0	0.6	2.0	3.0	1	14.3	14.3
	62	6.0	0.1	0.0	2.0	8	46.8	22.9
	63	7.0	0.8	3.0	5.0	8	2.4	0.5
	64	17.0	0.5	1.0	8.0	7	3.4	2
	65	11.0	0.4	2.0	7.0	9	7.2	4
	66	21.0	0.0	0.0	5.0	5	15.9	11.1
	67	12.0	0.9	0.0	1.0	1	28	21.1
	68	15.0	0.6	2.0	1.0	1	8.2	6.7
	69	9.0	0.9	0.0	4.0	4	11.9	11.2
	70	6.0	0.6	2.0	6.0	4	8.1	2.2
	71	12.0	0.4	1.0	2.0	1	0	0
	72	5.0	0.9	1.0	0.0	1	6.1	3.9
	73	7.0	0.9	0.0	1.3	4.3	31.6	25.5
40-44	74	5.0	0.8	1.0	3.0	2	17.8	17.8
	75	7.0	0.8	0.0	1.0	1	3.4	2.9
	76	5.0	0.7	1.0	2.0	1	19.9	15
	77	11.0	0.9	4.0	3.0	0.7	0.4	2.1
	78	13.0	0.6	2.0	1.0	3	2.2	4.4
45-49	79	8.0	0.7	0.0	6.0	6	2.2	5.1
	80	6.0	1.0	0.0	2.0	2	16.5	10
	81	9.0	0.6	1.0	8.0	9	9.5	4
	82	6.0	0.4	1.0	4.0	10	3.9	0.1
	83	8.0	0.5	4.0	3.0	7	20.8	1.3
50-54	84	13.0	0.3	2.0	2.0	0	5.4	3.9
	85	7.0	0.1	1.0	2.0	3	19.3	10.9
	86	5.0	0.2	2.0	5.0	7	15.4	9.9
	87	10.0	0.9	3.0	5.0	8	0.9	5.9
50-59	88	6.0	0.3	1.0	2.0	7	15.9	12.5
	89	9.0	0.7	2.0	2.0	4	8.5	9.4
	90	9.0	0.8	1.0	7.0	2	0.7	1.4
	91	5.0	0.2	2.0	1.0	3	23	0.2
60-64	92	5.0	0.9	2.0	8.0	6	9	5.2
	93	8.0	1.0	0.0	4.0	4	18.3	1.9
	94	5.0	0.3	4.0	6.0	2	13.2	11.9
	95	11.0	0.5	2.0	7.0	9	1.5	5.6
65+	96	7.0	0.9	2.0	2.0	0	11.1	6.8
	97	16.0	0.4	0.0	1.0	1	9.6	4.8
	98	7.0	0.1	1.0	1.0	2	3.8	0.1

smaller hypopnea index (16.5 vs. 21.6, $p = 0.047$) and a lower index of snoring (175.2 versus 394.1, $p < 0.001$) than their obese counterparts.

The major limitations of this study were the lack of control group, severe apneics and absence of patients with BMI > 40 who fit the inclusion criteria. Also, the sample size for patients more than 40 years of age was small.

Previous studies have emphasized the need for OSA screening in subjects with obesity and the metabolic syndrome. It is important to keep in mind that traditional risk factors for OSA such as excessive daytime somnolence may not be present in a significant proportion of the patients (Resta et al., 2001). Although, there is a strong correlation between obesity and OSA, it is not clear why a significant proportion of obese patients, including severe forms of obesity, do not develop OSA. Comprehensive genetic studies with anatomic and functional upper airway assessment should be undertaken to elucidate protective mechanisms (Patel et al., 2008). Researchers have pointed out previously that though there is clear interaction between obesity and

Table 2. Patient groups according to age range and corresponding AHI range.

Group No.	No. of patients	Age range	Mean AHI ± SD	AHI range
1	11	25 - 29	4.1 ± 2.3	0.2 − 10.2
2	34	30 - 34	8.8 ± 8.7	1.1 − 35.9
3	26	35 - 39	5.0 ± 3.6	0.6 − 16.6
4	5	40 - 44	5.3 ± 3.8	1.7 − 12.6
5	5	45 - 49	12.3 ± 2.5	8.4 − 16.4
6	5	50 - 54	13.0 ± 0.2	12.8 − 13.3
7	4	55 - 59	7.7 ± 2.4	5.7 − 11.9
8	4	60 - 64	14.8 ± 11.4	3.5 − 25.8
9	4	65+	6.7 ± 3.8	4.2 − 13.1

OSA there are several gaps in the present knowledge (Ong et al., 2013).

Conclusion

In conclusion, this study shows that oxygen desaturation during sleep is correlated with BMI in younger subjects (< 45 years) when they are matched for AHI.

There is need for more studies to further explore the correlation of BMI in the elderly population (> 45 years).

It is of clinical significance both from a diagnostic and management perspective to keep in mind that BMI plays a more important role in the severity of OSA for younger population and one should be cautious when interpreting the significance of BMI in the elderly population.

Conflict of interest

Authors have none to declare.

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Health care providers' satisfaction with the clinical laboratory service of Nekemte Referral Hospital, Western Ethiopia

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The objective of this study was to assess health care providers' satisfaction with the service provided by the clinical laboratory personnel at Nekemte Referral Hospital, Western Ethiopia to determine the level of satisfaction of health care providers on clinical laboratory services. A cross sectional study was conducted from March to April, 2014 at Nekemte Referral Hospital. The data was collected from 105 randomly selected health professionals. The collected data was analysed using Statistical Package for Social Sciences (SPSS) version 20 statistical software. Bivariate and multivariate logistic regression analyses were used to assess the association between treatment outcomes and predictor variables. The overall satisfaction for all health care professionals on clinical laboratory services was 62.86%, while specific professional level of satisfaction was 51.2% for nurses, 65.0% for physicians, 75.0% for health officer (Assistant physician) and 85.7% for midwifes. Lack of adequacy of laboratory materials, absence of a timely report of critical values, lack of getting urgent results on time, and inadequacy of test menu on laboratory request forms were areas mentioned as sources of dissatisfaction. The overall degree of customers' satisfaction with laboratory services was good. But the study showed room for improvement. In addition to taking intervention, the root causes of dissatisfaction need to be investigated and means of improving the satisfaction level should be designed and implemented.

Key words: Satisfaction, health care providers, clinical laboratory services, Nekemte Referral Hospital.

INTRODUCTION

Clinical laboratories are part of the health institution team which produces important information for patient care (Salkie, 1994; Hassemer, 2003). Laboratory services are given in all health care level, except in health posts in Ethiopia (Tegbaru et al., 2004).

Client satisfaction reflects provider's ability to successfully deliver care or laboratory services that meets clients' expectations and needs (Sitzia and Wood,

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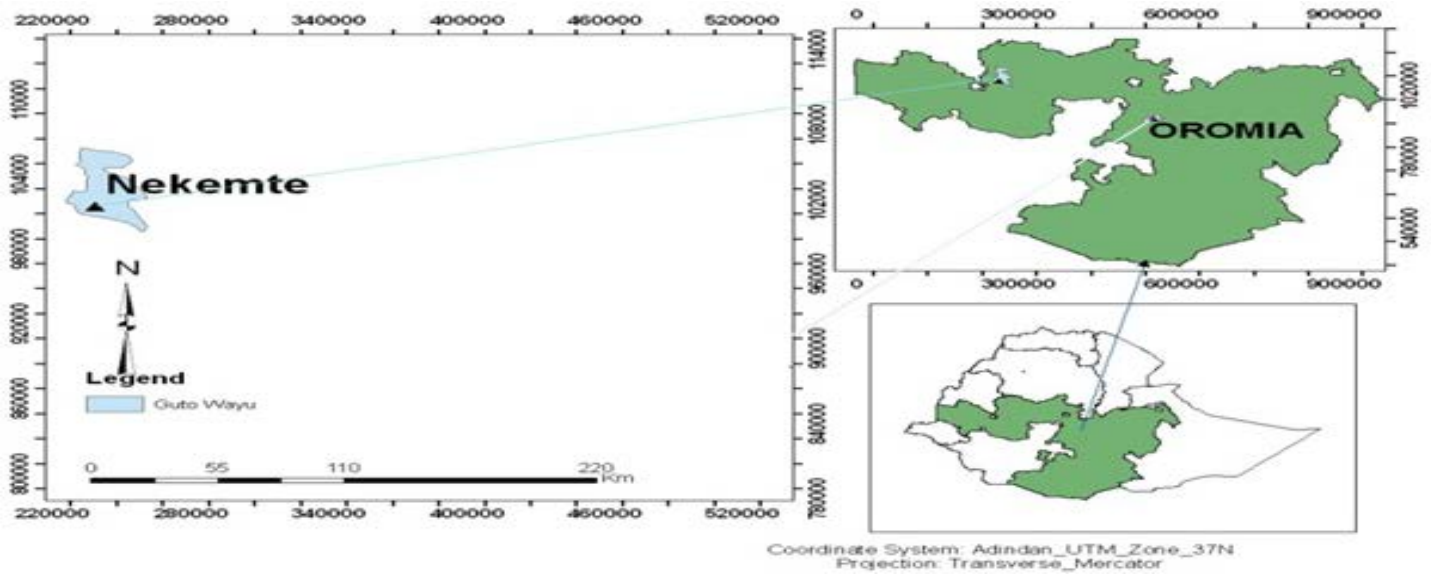

Figure 1. Map of the study area. Source: Nekemte LED strategy, 2010.

1997; Thiedke, 2007). A number of factors have been shown to influence clients' satisfaction with health care services including clients' socio-demographic characters, physical appearance of the hospital, general environment of the premises, clients' personal understanding and expectations from various health care services (Muula et al., 2007; Tsasis et al., 2002; Muhondwa et al., 2008).

Assessing customer satisfaction with laboratory services is considered as an important component of laboratory quality assurance program and is required for accreditation in United State by the College of American Pathologists (CAP) and The Joint Commission on Accreditation for Healthcare Organizations (Laboratory General Checklist 2006; Comprehensive Accreditation Manual for Laboratory and Point-of-Care Testing (2005, 2006). The implementation of quality standards, such as ISO 15189 (ISO, 2003) and ISO 17025 (ISO/IEC, 2005), and the use of management systems like Balanced Scorecard (Salkie 1994) in clinical laboratories have also further emphasized the customer perspective in the improvement of laboratory service. Health care providers are the primary customers of laboratory services, and their feedback provides laboratory managers with opportunities to identify areas for improvement.

Some previous studies have assessed the laboratories quality in Ethiopia based on patients satisfactions (Teklemariam et al., 2013; Addis et al., 2013; Mindaye and Taye, 2012). Periodic reassessment of group performance provides an opportunity to identify and characterize industry changes in service performance and customer attitudes. However, customer's satisfaction by healthcare provides' on clinical laboratory services has not yet been studied in Ethiopia. Therefore, this study assessed health care providers' satisfaction with the clinical laboratory service at Nekmete Referral Hospital, Western Ethiopia.

METHODOLOGY

Study design and setting

A cross sectional study was conducted in Nekemte Referral Hospital from April to May, 2014. The Nekemte Referral Hospital was constructed in 1932 by Sweden Missionary and intended to serve 2.1 million peoples annually. The hospital is the only referral hospital in the western part of Ethiopia and services as referral center for the patients from other hospitals, health centers and private practitioners. The hospital offers comprehensive general and referral health care service for western part of Ethiopia, and currently staffed by senior physicians, general practitioners, laboratory technologists or technicians, pharmacists, dentist, nurses, midwifes, heath officer and other health professionals. The hospital is located at Nekemte Town. Nekemte is a historic town of 328 km away from Addis Ababa, capital city of Ethiopia (Figure 1). The town has a total population of about 110,688 according to the 2012 census.

Study subject, sample size and sampling procedure

The study population was all health professionals who work in Nekemte Referral Hospital. The hospital had 164 health care providers during data collection. All (105) health professionals who work in Nekemte Referral Hospital for the last six months or longer, willing to participant in the study, and on duty during the study period were included in the study.

Methods of data collection and measurement

A self-administered pre-tested questionnaire was given to health care providers' and then collected at the end of each day. The questionnaire contained the socio-demographic characteristic,

courtesy of the laboratory staff, critical value notification, courier service, reliability of test results, and others.

Data quality assurance

The structured questionnaires were validated by pre-testing at Nekemte Health Center using 5% of the total population. Based on the pretest finding, some modifications were made to the questionnaire and terminologies. The data were collected by trained data collector under supervision of investigators to ensure the completeness of data and monitored the overall quality of the data collection.

Data processing and statistical analysis

The collected data were coded, entered and checked for missing values and outliers, and analyzed using SPSS version 20.0 statistical software. A 5 point Likert scale rating of very dissatisfied (1-point), dissatisfied (2-points), neutral (3-points), satisfied (4-points) and very satisfied (5-point) were used. To identify associated factors, first a bivariate logistic regression was performed for each independent variable with the outcome of interest (general/overall satisfaction). Finally, multivariable logistic regression was done to determine independent predictors of overall satisfaction. A two sided test was used and $p < 0.05$ was considered statistically significant. Very dissatisfied, dissatisfied and neutral responses were considered as dissatisfied, whereas satisfied and very satisfied were considered as satisfied. The percentage satisfaction or dissatisfaction was calculated by dividing the number of satisfied or dissatisfied responses by the total number responses, respectively.

The overall rate of satisfaction by Likert scale was calculated as: (No. of very satisfied rating × 5) + (No. of satisfied rating × 4) + (No. of neutral rating × 3) + (No. of dissatisfied rating × 2) + (No. of very dissatisfied rating × 1) divided by the total number of ratings (1–5) for the specific laboratory service. While the percentage of very dissatisfied, dissatisfied, neutral, satisfied and very satisfied rating was calculated by dividing the number of very dissatisfied, dissatisfied, neutral, satisfied and very satisfied rating by the total number of ratings (1–5) for specific laboratory service, respectively.

Ethical consideration

The study was ethically approved from Wollega University Ethical Review Committee and Official permission to conduct the study was obtained from the Nekemte Referral Hospital. After the purpose of the study explained to the clients, written and signed informed consent was obtained; the survey was conducted. The obtained data from each client were kept confidential.

RESULTS

Socio demographic character of the study participants

A total of 105 health professionals were enrolled in the study making the response rate to be 64%, of which 54 (51.4%) were male and 51 (48.6%) were female. The health professionals had a mean, standard deviation and median age of 33.5, 8.20 and 31.00, respectively. Majority of the respondent were between the 20 and 29 (43.8%) age groups followed with 30 and 39 (33.3%). Concerning professionals of the study participants, 41.0 were nurse, 19.0% were physician, 19.0% were health officer and 13.3% were midwifes. Majority of the respondents had 6 to 10 year (44.8%) of work experiences while 32.4% had less than or equal to five year. Regarding their working unit/ward, 29 (27.6%) worked at outpatient department (OPD) and 72.4% worked in other unites of the institution, namely, antenatal care and postnatal care center, gynecology, neonatology ward, pediatrics ward, tuberculosis ward, medical ward, surgical ward, antiretroviral treatment unit, emergency ward, voluntary HIV/AIDS counseling and testing center (Table 1).

Magnitude of satisfaction and its association with socio-demographic variables

The overall satisfaction for all professional on clinical laboratory services was 62.86%, while 30% of the respondents were neutral and 8% were dissatisfied (Figure 2). The professional specific level of satisfaction was 51.2% for nurses, 65.0% for physicians, 75.0% for health officer and 85.7% for midwifery. Female (50.8%) were more satisfied than male (39.1%). In addition, more experienced and older professional were more satisfied than their counterpart (Table 2).

In bivariate analysis, age range between 20 and 29 years, being midwifery professional and having equal or less than 5 years work experiences were significantly more satisfied with the clinical laboratory services. However, controlling the confounding factors, professional in age range between 20 and 29 years were [AOR = 8.611 (2.35 to 31.54)] less likely to be satisfied with the services of clinical laboratory (Table 2).

Degree of satisfaction of health professionals on the clinical laboratory services

Table 3 showed the rates of satisfaction for the different aspects of the laboratory service using Likert scale. The overall mean rate of satisfaction was 3.58. The higher satisfaction was observed on the location of the laboratory in the hospital, cleanness of room, staff courtesy and improvement of laboratory service with mean rating of 3.82, 3.84, 3.81 3.76 and 3.76, respectively. However, they were less satisfied with critical value notification, adequacy of laboratory of materials, getting urgent/STAT results on time and adequacy of test menu on laboratory request format with the main rating of 3.36, 3.46, 3.33 and 3.27, respectively.

Concerning department specific satisfaction of health professionals, they were relatively more satisfied with the department of anti-retroviral treatment laboratory (ART) services with mean satisfaction rate of 3.65 followed with

Table 1. Socio demographic characteristics of the health care providers' in Nekemte Referal Hospital Western Ethiopia, 2014.

Variable		Frequency	Percentage
Sex	Male	54	51.4
	Female	51	48.6
Age	20-29	46	43.8
	30-39	35	33.3
	≥40	24	22.9
Department	OPD	29	27.6
	Other	76	72.4
Profession	Nurse	43	41.0
	Midwifery	14	13.3
	Health officer (HO)	20	19.0
	Physician	20	19.0
	Other**	8	7.6
Experience	≤5 years	34	32.4
	6-10 years	47	44.8
	≥11 years	24	22.9

**Other: dentists, clinical pharmacist.

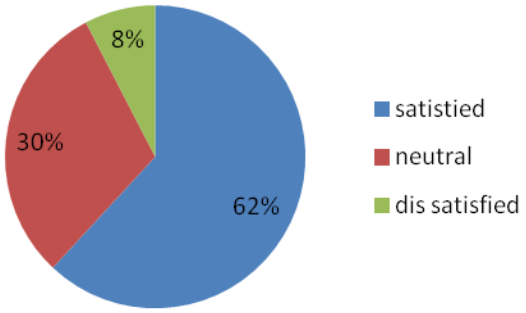

Figure 2. The general level of satisfaction on laboratory services at Nekemte Referral Hospital Western Ethiopia, from April to May, 2014.

hematology and serology laboratories department services with mean satisfaction of 3.61 and 3.6, respectively. They were comparably less satisfied with the services of clinical chemistry and bacteriology departments (Table 4).

DISCUSSION

Measurement of customer satisfaction brings customer preferences into the quality assessment process and corrects false assumptions about particular aspects of service, which customers value most. Today, assessing customer satisfaction with laboratory services is considered as an important component for improving the identified areas. The health care providers are the primary customers of clinical laboratory and their satisfaction is considered an important factor that indicates the quality of health care system.

In present study, the overall level of satisfaction of health care providers' on clinical laboratory services was 62.8%. The finding was lower than studies conducted in selected government hospitals in Eastern Ethiopia (80%) (Teklemariam et al., 2013). The observed difference is caused by institutional services difference. The professional specific satisfaction was 51.2, 85.7, 75 and 65% for nurse, midwifes, health officer and physician, respectively. This result is similar for nurse satisfaction but higher for physician satisfaction with the study conducted in Gondar University Hospital, Northwest Ethiopia where 51.1% of nurses and 51.5% of physicians were satisfied (Addis et al., 2013).

In this study, professional between 20 and 29 years age ranges had statistically significant difference with the satisfaction of clinical laboratory services in which 39.1% are satisfied with the services. This lower satisfaction in this age group partly observed because of lower experiences of the age group which was shown by having less than or equal to five years experiences had negative association with the level of satisfaction in Bivariate analysis in the study.

The overall mean rate of satisfaction among clinical service providers was 3.58 which is not far from the

Table 2. Univariate and multivariate analysis to assess predicator socio-demographic variables for satisfaction of health care providers' on the clinical laboratory services at Nekemte Referal Hospital Western Ethiopia, 2014.

Variable		General satisfaction		Total (%)	COR (95% CI)	AOR (95%CI)
		Satisfied (%)	Dissatisfied (%)			
Sex	Male	32 (39.1)	22 (60.9)	54 (43.8)	1.26 (0.57-0.77)	-
	Female	33 (50.8)	18 (45.0)	51 (48.6)	1	-
Age	20-29	18 (39.1)	28 (60.9)	46 (43.8)	4.813 (1.45-0.90)*	8.61 (2.35-1.54)*
	30-39	27 (77.1)	8 (22.9)	35 (33.3)	1.96 (0.618-6.226)	1.687 (0.42-6.74)
	≥40	20 (83.3)	4 (16.7)	24 (22.9)	1	1
Department	OPD	19 (65.5)	10 (34.5)	29 (27.6)	0.807 (0.33-1.97)	-
	Other	46 (60.5)	30 (39.5)	76 (72.4)	1	-
Profession	Nurse	22 (51.2)	21 (48.8)	43 (41.0)	0.573 (0.12-2.702)	0.87 (0.158-4.82)
	Midwifery	12 (85.7)	2 (14.3)	14 (13.3)	0.10 (0.013-0.79)*	0.129 (0.014-0.17)
	Health officer (HO)	15 (75.0)	5 (25.0)	20 (19.0)	0.20 (0.035-1.15)	0.31 (0.04-0.115)
	Physician	13 (65.0)	7 (35.0)	20 (19.0)	0.323 (0.059-1.77)	0.68 (0.103-0.56)
	Other**	3 (37.5)	5 (62.5)	8 (7.6)	1	1
Experience	≤5 years	15 (44.1)	19 (55.9)	34 (32.4)	4.813 (1.45-5.90)*	0.714 (0.12-0.36)
	6-10 years	31 (66.0)	16 (34.0)	47 (44.8)	1.96 (0.618-6.226)	0.86 (0.186-4.01)
	≥11 years	19 (79.2)	5 (20.8)	24 (22.9)	1	1

*Statistical significance (P<0.05), 1: Reference group, COR: Crude odd ratio, 95% CI: 95% confidence interval.

studies conducted in selected government hospitals in Eastern Ethiopia (3.49 ± 1.27) (Teklemariam et al., 2013), and specialized hospital in Alexandria, Egypt **(**3.46 ± 0.49) (Elhoseeny and Mohammad, 2013). However, this result is lower than 3 studies in the USA which measure the physician satisfaction and reported a mean satisfaction score between 4.0 and 4.1 (Elhoseeny and Mohammad, 2013; Howanitz, 2002; Jones and Bekeris, 2009). This could be due to differences in the physical arrangements of the laboratories, available resources and quality and expectation of the clinical laboratory services in different countries.

The higher satisfaction was observed on the staff courtesy (71.42%) which is consistent with the study conducted in specialized hospital in Alexandria, Egypt (Elhoseeny and Mohammad, 2013). Also higher satisfaction was observed in location of the laboratory in the hospital (74.28%), cleanness of room (71.43%), and improvement of laboratory service (66.6%). This is observed because of the hospital is under World Health Organization Regional Office for Africa (WHO-AFRO) Stepwise Laboratory (Quality) Improvement Process Towards Accreditation (SLIPTA) to strengthen laboratory systems of its member states which is a framework for improving quality of public health laboratories in developing countries to achieve ISO 15189 standards.

The lowest rate of satisfaction was observed on critical value notification, getting urgent/STAT results on time and adequacy of test menu on laboratory request format which is almost similar with the finding from studies conducted in selected government hospitals in Eastern Ethiopia (Teklemariam et al., 2013), Gondar University Hospital, Northwest Ethiopia (Addis et al., 2013), Tanzania (Mfinanga et al., 2008), and specialized hospital in Alexandria, Egypt (Elhoseeny and Mohammad, 2013). This implies the need for improving laboratory services in terms of quality management system to ensure proper reporting and critical value notification.

The higher satisfaction was observed in the department of anti-retroviral treatment laboratory (ART) services. This finding is similar with a report from selected government hospitals in Eastern Ethiopia study. The underlying reasons for the higher satisfaction were the attention given from the Ethiopian government and many donors. The government gives more emphasis on the monitoring, reporting, together with the fact that the implementation of policies and guidelines are functional for ART services and donors are investing large amount of resources and giving technical supports to the program (Mindaye and Taye 2012).

Lower satisfaction was observed with the clinical chemistry and bacteriology departments services in the present study. This result may be partly explained by inadequacy of clinical chemistry materials and lack of culture and sensitivity test facility for bacteriology, which

Table 3. Rate of health care providers' satisfaction by different measuring item of laboratory services at Nekemte Referral Hospital Western Ethiopia, 2014.

Variable	Level of satisfaction, No. (%)					Mean satisfaction score	Satisfaction percentage
	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied		
Location of the laboratory in the hospital	3 (2.9)	6 (5.7)	18 (17.1)	58 (55.2)	20 (19.0)	3.82	74.28
Avoiding of missing result	1 (1.0)	14 (13.3)	31 (29.5)	50 (47.6)	9 (8.6)	3.49	56.19
Respect	0	10 (9.5)	31 (29.5)	43 (41.0)	21 (20)	3.71	60.95
Cleanness of room	2 (1.9)	3 (2.9)	25 (23.8)	55 (52.4)	20 (19)	3.84	71.43
Staff courtesy	0	8 (7.6)	22 (21.0)	57 (54.3)	18 (17.1)	3.81	71.42
Getting urgent/STAT results on time	2 (1.9)	19 (18.1)	35 (33.3)	40 (38.1)	9 (8.6)	3.33	46.66
Adequacy of test menu on laboratory request format	2 (1.9)	24 (22.9)	31 (29.5)	39 (37.1)	9 (8.6)	3.27	45.71
Availability of laboratory staff on working hours	0 (0)	16 (15.2)	25 (23.8)	43 (41.0)	21 (20)	3.66	60.95
Adequacy of laboratory valuable of materials	2 (1.9)	18 (17.1)	34 (32.4)	32 (30.5)	19 (18.1)	3.46	48.57
Quality/reliability of laboratory test results	4 (3.8)	8 (7.6)	30 (28.6)	52 (49.5)	11 (10.5)	3.55	60
Reporting of complete test result	2 (1.9)	11 (10.5)	32 (30.5)	48 (45.7)	12 (11.4)	3.54	57.14
Critical value notification	1 (1.0)	18 (17.1)	37 (35.2)	40 (38.1)	9 (8.6)	3.36	46.66
Improvement of laboratory service	3 (2.9)	5 (4.8)	27 (25.7)	49 (46.7)	21 (20.0)	3.76	66.66
*General satisfaction on the overall laboratory services	3 (2.9)	4 (3.8)	32 (30.5)	40 (38.1)	26 (24.7)	3.78	62.86

*It was calculated from single question.

Table 4. Rate of health care providers' satisfaction by department laboratory services at Nekemte Referral Hospital Western Ethiopia, 2014.

Variable	Level of satisfaction, No. (%)					Mean Satisfaction score	Satisfaction percentage
	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied		
Satisfaction in hematology laboratory department	2 (1.9)	6 (5.9)	36 (34.3)	48 (45.7)	13 (12.4)	3.61	58.09
Satisfaction in serology laboratory department	1 (1.0)	10 (9.5)	35 (33.3)	43 (41.0)	16 (15.23)	3.6	56.19
Satisfaction in bacteriology laboratory department	1 (1.0)	13 (12.4)	36 (34.3)	38 (36.2)	17 (15.3)	3.54	52.38
Satisfaction in clinical chemistry laboratory department	1 (1.0)	13 (12.4)	36 (34.3)	38 (36.2)	17 (16.2)	3.54	52.38
Satisfaction in urine and parasitology laboratory department	3 (2.9)	15 (14.3)	30 (28.6)	41 (39.0)	16 (15.2)	3.49	54.28
Satisfaction in ART laboratory department	3 (2.9)	7 (6.7)	31 (29.5)	47 (44.8)	17 (16.2)	3.65	60.95

is the most important method for monitoring drug resistance profile, which was only available in 1 (2.9%) of the hospitals assessed in Ethiopia (Tegbaru et al., 2004). This may lead to prescription of drugs without knowing their status, which makes them not effective against the etiologies. Furthermore, it will increase drug resistance in the country for different pathogenic microbes. These, elucidation are supported by low

satisfaction on the adequacy of available laboratory material in the study institution in this study.

Conclusion

The overall degree of customers' satisfaction with laboratory services was good. This study showed wide room for improvement on critical value notification, adequacy of laboratory materials, getting urgent/STAT results on time and adequacy of test menu on laboratory request format which were the cause of dissatisfaction. Thus, improvement strategies for the satisfaction level should be designed and implemented by the hospital administrations and the laboratory departments' head.

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Conflict of interests

All authors declare that they have no conflict of interests associated with the publication of this manuscript.

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Effect of radiation on pregnancy

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The present study was carried out to evaluate the effect of radiation on pregnancy. 20 experimental animals (rabbits) were exposed to X-ray (10 random exposure to represent patients' dose and 10 continuous to represent radiation workers dose). Each sample was exposed to X-ray and this dose measured with thermo luminous dosimeter (MGP instruments DMC 2000X) in the first, second and third trimester then the dose accumulative was observed and recorded together with its effect on pregnancy during these periods.

Key words: Radiation, pregnancy, Saudi Arabia.

INTRODUCTION

Radiation exposure during pregnancy has been debated for years, but various experiences are continuing to show that there are increasingly negative effects on the growing fetus as well as effects later in life. While the exact effects are unknown due to inability for testing, there are a variety of speculations and proven patterns that suggest that pregnant women should not exceedingly expose themselves to radiation during pregnancy (Charissa, 2006).

Females are at high risk of exposure to ionizing radiation resulting from medical procedures, workplace exposure, and diagnostic or therapeutic interventions before the pregnancy. Such waves are known as electromagnetic waves. In utero exposure to non-ionizing radiation is not associated with significant risks; therefore, ultrasonography is safe to perform during pregnancy. Ionizing radiation includes particles and electromagnetic radiation (for example x-rays). In utero exposure to ionizing radiation can be teratogenic, carcinogenic or mutagenic. The effects are directly related to the level of exposure and stage of fetal development. The fetus is most susceptible to radiation during organogenesis .Non-cancer health effects have not been detected at any stage of gestation after exposure to ionizing radiation of less than 0.05 Gy (5 rad). Spontaneous abortion, growth restriction may occur at higher exposure levels. The risk of cancer is increased regardless of the dose (Pamela and Stacy, 2010).

Fetal death

Very early exposure to even 10 rad of radiation in the first trimester of pregnancy carries a high risk of fetal death,

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according to perinatology.com. Since the embryo at this stage consists of just a few cells, damage to even one cell can be lethal. Normal x-rays deliver far less radiation than 10 rad; however, treatment for cancer or hyperthyroidism may occur before a woman knows she is pregnant. Since the dose of radiation received in these procedures is very high, in the thousands of rads, according to a Health Physics Society article by Robert Brent, M.D., there is a high chance of fetal damage. Barium studies also deliver more than 10 rad, according to perinatology.com. After 2nd trimester, the fetus is no more susceptible to radiation than a newborn would be, but doses of 100 rad or more leads to an increased risk of still birth.

Fetal deformities

The first trimester of pregnancy is crucial for embryonic growth and development. According to Brent, the average dose of radiation in a typical diagnostic procedure is 5 rad. Studies show that an increased risk of fetal deformity does not occur until radiation exposure reaches 20 rad up to week 8 and 30 rad between weeks 8 to 15. Brent states that fetal deformities do not occur from radiation exposure after week 20, since the fetus is fully formed at that point (International Commission on Radiological Protection, 2003)

Cancer risks later in life

Exposure to radiation before birth in high amounts can increase the chance that a fetus will develop cancer later in life; however, according to the Centers for Disease Control (CDC), the risk for those exposed to equal to 500 chest x-rays or less have only two percent more chance overall of developing cancer than a person without prenatal radiation exposure (according to perinatology.com) this risk is not dependent on the stage of pregnancy when radiation exposure occurred. (Bushong, 2001).

Aim of work

The study aims to observe and detect the effect of radiation on pregnancy.

MATERIALS AND METHODS

A total of 20 animals were collected from September to December, 2012. Samples were collected in healthy condition and transported to the Diagnostic Radiology Department, Faculty of Applied Medical Science, Hail University. Each sample was examined by the following methods.

Advanced x-ray machine

Two groups of samples were exposed to x- rays. The first group was exposed randomly as all population when they need to be exposed to radiation on emergency or medical examination. The second group of samples was exposed to x- rays continuously as radiation workers, they are exposed to radiation or they do not use the protections tools from radiation (www.radiologyinfo.org/en/safety/index.cfm?pg=sfty_xray#part6).

Thermo luminous dosimeter (TLD)

This was employed to measure the accumulative radiation dose (National Council on Radiation Protection and Measurements, 1998).

RESULTS

A total of 20 samples were examined. Out of them, 10 animals (50%) were sensitive for radiation as observed by the different exposure stages in pregnancies. The effects of low-dose, long term irradiation *in utero* can include:

1. Death of fetus, congenital deformity, cancers, impairment of growth and genetic effect. After maturity, radio-sensitivity increases with age. It begins to decrease with age at the end of child bearing age.
2. Within the first two weeks after fertilization the most pronounced effect of a high radiation dose is fetal death which is manifested as a spontaneous abortion.
3. During the 2nd to 10th weeks two effects may occur. Early in this period, skeletal and organ abnormalities can be induced. As organs continue to develop, central nervous system abnormalities may develop. If the abnormalities are severe enough, the effect will be fetal death.
4. After a dose of 200 rad, nearly 100% of the fetuses suffered significant abnormalities. In 80%, it was sufficient to cause death.
5. A dose of 10 rad during organogenesis is expected to induce congenital abnormalities by 1% above natural occurrence.

In utero irradiation has been associated with childhood malignancy. Fetal death when the abnormalities are severe enough.

DISCUSSION

Everyone is exposed to radiation every day. People are continuously exposed to low-level radiation found in food, soils, building materials, and the air and from outer space. All of this radiation originates from naturally

occurring sources. For example, bananas contain naturally occurring radioactive potassium-40 and air contains radon, a radioactive gas. The average natural background radiation dose is about 3.0 mSv (300 mrem) each year, in comparison with the study of Kevin et al. (1999).

Maternal illness during pregnancy is not uncommon and sometimes requires radiographic imaging for proper diagnosis and treatment. The patient and her physician may be concerned about potential harm to the fetus from radiation exposure. In reality, however, the risks to the developing fetus are quite small. The accepted cumulative dose of ionizing radiation during pregnancy is 5 rad, and no single diagnostic study exceeds this maximum. For example, the amount of exposure to the fetus from a two-view chest x-ray of the mother is only 0.00007 rad. The most sensitive time period for central nervous system teratogenesis is between 10 and 17 weeks of gestation. Non-urgent radiologic testing should be avoided during this time. Rare consequences of prenatal radiation exposure include a slight increase in the incidence of childhood leukemia and, possibly, a very small change in the frequency of genetic mutations. Such exposure is not an indication for pregnancy termination. Appropriate counseling of patients before radiologic studies are performed is critical. Observed in atomic bomb survivors has been an increase in mental retardation. This involved very high exposure rates. It is known that radiation does retard growth. Irradiation particularly during organogenesis has been associated with microcephaly (small head) and retardation. Human data from atom bomb survivors and residents of the Marshall Islands exposed to fall out from atom bomb tests demonstrated impaired growth in children. In addition to natural background radiation, the Pt may be exposed to radiation from medical x-rays and medical radiation tests or treatments, if the Pt think, or there is a possibility, that the female may be pregnant and need a medical x-ray or radiation procedure.

Radiation effects vary depending on the fetal stage of development and the magnitude of the doses that indicates that there is a threshold below which negative effects are not observed. According to the American College of Radiology (2010), routine x-rays of a mother's abdomen, back, hips, and pelvis are not likely to pose a serious risk to the child. However, certain procedures (such as a computerized tomography [CT scan]) or a lower GI fluoroscope exam) to the mother's stomach or hips may give higher doses. Most standard radiological tests and treatments produce radiation doses below 50 mSv (5,000 millirem). The National Council on Radiation Protection and Measurements (1998) and the American College of Obstetricians and Gynecologists (2013, 2014) both agree that the potential health risks to the fetus are not increased from most standard medical tests with a radiation dose below 50 mSv. Potential health risks, however, may increase for a few medical tests or combinations of tests that result in radiation doses that exceed 50 mSv, depending on the dose and on the stage of pregnancy.

The sensitivity of a developing fetus to radiation can vary with the stage of development, the magnitude of the dose, and the length of time of the total exposure (minutes, hours, days, or weeks). The most radio sensitive period appears to be between 8 and 15 weeks after conception.

CONCLUSION

The effects of low-dose, long term irradiation *in utero* can include: death of fetus, congenital deformity, cancers, impairment of growth and genetic effect. These abnormalities are based upon exposure of greater than 10 rad in animal experiments (rabbits). There is no evidence that diagnostic levels of radiation exposure currently experienced occupationally or medically are responsible for any such effects on fetal growth or development. Ultrasonography is safe to perform during pregnancy.

RECOMMENDATIONS

1. Keep the time of exposure to radiation as short as possible.
2. Maintain a large distance as possible between the source of radiation and the exposed object.
3. Insert shielding material between the radiation source and the exposed person.
4. ALARA stands for "As low as reasonably achievable" and is the corner stone of radiation safety policies and procedures.
5. During pregnancy we should be considering having an abdominal/pelvic x-ray or medical test.
6. Determine if the procedures can be delayed until after birth or whether another medical procedure, such as an ultra-sound or MRI, could be used instead.
7. When pregnancy and abdominal x-rays are scheduled without consultation with doctor, we should inform the person performing the exam of our pregnant state. As a precaution, you should inform a person performing any type of x-ray or radiation procedure that you are pregnant. Ultrasonography is safe to perform during pregnancy.

Conflict of interest

Authors have none to declare.

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