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Renal Function Assessment of Workers Occupationally Exposed to Hair and Nail Care Products in Benin City, Edo State

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Authors' contributions

This work was carried out in collaboration between all authors. Author HBO designed the study, wrote the protocol, draft of the manuscript and supervised the work from the beginning to completion while authors OGI and AFO managed the literature searches, performed the study analysis and the statistical analysis. All authors read and approved the final manuscript.

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ABSTRACT

Cosmetology is a profession with a population of mostly women, who are exposed to a myriad of chemicals of concern every day in their workplaces. Research shows that salon workers are at greater risk for certain health problems compared to other occupations. This study aims at evaluating the renal function of nails and hair care workers in Benin City who are exposed to cosmetic borne toxicants. Blood samples were collected from hair and nail care workers resident in Benin City, Edo state, Nigeria for urea creatinine and electrolyte evaluation. Urea was analyzed by the urease-betherlot process, creatinine was analyzed using modified jaffe-slot technique, sodium and potassium ions were analyzed by flame emission spectrophotometry while chloride and bicarbonate ions were analyzed using Schales and Schales method and acid-base back titration respectively. Plasma levels of urea and creatinine was significantly higher in cosmetologist than heavy cosmetics users and cosmetic nave participants ($p<0.000$). Sodium and Chloride were also

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found to be reduced in cosmetologists than heavy cosmetics users and cosmetic naive participants ($p<0.000$). The results obtained from this study may be suggestive of renal damage. However, it is recommended that salon workers and salon owners should be enlightened so as to improve their awareness of the risks associated with the exposure toxic chemicals in hair and nail care products. And also further studies be carried out on a larger scale in order to further assert these claims.

Keywords: Cosmetics; renal function assessment; hair; nail; Benin City.

1. INTRODUCTION

Cosmetology which include nail and hair care has become a lucrative profession. Cosmetologists typically provide pedicures, manicures, facials, and other beauty treatments [1]. The use and application of cosmetics have shown to have some effects on the human system. There are about 9000 chemicals ingredients found in cosmetic products. Nail and hair care workers have daily contact with cosmetic products and are therefore routinely exposed to a wide range of chemicals by inhalation, skin contact and diffusion of fumes through the pores of the eyes [2].

Hairdressers and nail technicians are predominantly female, and many are of reproductive age [1]. Hairdressers use a wide range of products, including shampoos, hair dyes, hair sprays, straighteners, and bleaches. Hair dyes represent the largest segment of chemical products in the hair market today. As such, they are the main source of chemical exposure among hairdressers [3].

These products may play a positive role in improving quality of life, due to the human desire to improve appearance, however, individual's frequent contact with these products requires the ingredients be safe [4].

Among nail technicians, nail polish is the product most often used and the main potential source of chemical exposure for them. Common nail polish ingredients include toluene, plasticizers (dibutyl phthalate), and formaldehyde [5]. Toluene is a widely used industrial solvent. Toluene inhalation during pregnancy has led to neonatal effects, including intrauterine growth retardation, premature delivery, congenital malformations, and postnatal developmental retardation [6]. Dibutyl phthalate, which keeps polish from becoming brittle and chipping, has been linked to reproductive issues in humans if the mother is exposed while pregnant and has been banned for use by the European Union [7].

Nail technicians handle fewer chemicals than hairdressers, but they frequently share a workspace with hairdressers and sometimes perform some of the same tasks. The shared space and dual roles increase occupational exposures for both groups [1].

Hairdressing has been reported to be associated with a variety of health issues, including dermatitis, cancer, and respiratory problems [3]. In a meta-analysis of 42 studies, a statistically significant increased risk for bladder cancer was found among hairdressers, specifically those who had held the job for more than 10 years [8].

Alternatively, a review conducted by [4] concluded that evidence suggests that occupational exposure to hair dyes poses no carcinogenic or other human health risk.

Exposure to high doses of Diethanolamine (DEA) which is an ingredient found in soaps, cleansers and shampoos has been found associated with liver cancer, and precancerous changes in thyroid as well as mild and eye irritation [9].

Parabens which is used as a preservative in cosmetics has been found to interfere with hormonal function causing endocrine disruption [10].

Long term exposure of high doses of BHT (Butylated hydroxytoluene) used as preservative in moisturizers has been found toxic in mice and rat causing kidney, liver and thyroid problems [11].

According to the US FDA, cosmetic products and their ingredients are not subject to regulation prior to their release on the market. Also in Nigeria, government policy regarding cosmetics ingredients is poorly regulated.

Therefore, toxicological and biochemical studies of these exposed subjects is necessary for proper knowledge of the effects of constant exposure to nail and hair care products associated with the work, hence ensuring

adequate handling of these products by nail and hair care workers, thereby improving working conditions and reducing hazards associated with working in this industry.

There is increasing repertoire of cosmetic products into the Nigeria market legally or illegally without ascertainment of the level of their toxicity, the use of protective materials by nail and hair care workers in Nigeria has been found to be on an occasional basis. Also, the ventilation system of most saloons is not given due consideration neglecting the fact that they handle volatile chemicals. Therefore, this research is aimed at ascertaining if hair and nail care workers with over 3 years of working experience are at risk of renal impairment due to long term exposure to cosmetic borne toxicants and compare with unexposed individuals using blood urea, creatinine and electrolytes as biomarkers.

2. MATERIALS AND METHODS

2.1 Materials

2.1.1 Study area

This study was conducted in Benin City, Edo state, Nigeria. Benin City is the capital of the defunct Bendel state and the current capital of Edo state which in turn is located in the south southern region of Nigeria. She shares boundaries with Ondo State (West), Delta State (South), Anambra State (East) and Kogi State to the North [12]. She has an estimated population of over 1147188 in the 2006 national general census [13].

2.1.2 Sample size

Fifty (50) cosmetologists between the ages of 18 and 35 years of age were recruited for the study. The sample size was obtained using the formula below:

$$N = \frac{Z^2 P (1 - P)}{D^2}$$

N = required sample size
Z = confidence level at 95% (standard value of 1.96)
P = estimated prevalence of cosmetic products toxicity (4.3%)
D = margin of error at 5% (standard value = 0.05)

Therefore, approximately 50 participants would be recruited alongside over 50 unexposed control subjects in Benin City.

2.1.3 Study population

2.1.3.1 Exposed group and non-exposed group

In this study, fifty (50) age-matched female cosmetologists and twenty-five (25) heavy comestic users working and living in Benin City, formed the exposed group. Subjects recruited into this study were 18 years and above, with a minimum of 3 years of occupational exposure to toxic substances in cosmetics products, no serious health challenges in recent years and willing to participate in the study. Twenty-five (25) age-matched apparently healthy female subjects recruited from the Ugbowo Campus Community of the University of Benin formed the non-exposed group in this study. The non-exposed group consisted of subjects with minimal or no occupational exposure to toxic substances in cosmetics products or from other sources and they willingly participated in the study.

2.1.4 Sample separation

Materials for sample separation include: centrifuge, plastic Pasteur pipettes, sterile plain containers. The samples in Li/heparin bottle were spun for five minutes at 5000 g. The plasma from each sample was dispensed into sterile plain container with the same bottle number. The clotted samples in plain container were dislodged and spun in the same way. The serum from each sample was dispensed into new plain containers with corresponding identification number.

2.1.5 Ethical approval and informed consent

Ethical approval was sought and received from the Edo state ministry of health since the study cuts across the state. All participants recruited into this were adequately informed of the reasons for the study viz-a-viz the benefits to both cosmetics users and those who carry out the occupation. Where necessary, interpreters were used to pass the message to them due to the illiterate members of the recruits. Only those who willingly indicated interest and gave their consent were finally recruited.

2.2 Methods

2.2.1 Renal function tests

The parameters analysed for renal function include: Urea, creatinine, sodium, potassium, chloride and bicarbonate ions.

2.2.2 Urea estimation

Urea was analysed using the urease Berthelot method [14].

Principle: Urea is broken down by urease yielding ammonia. Ammonia reacts with phenol in the presence of hypochlorite to form indophenols which produces a blue colour in an alkaline medium. The intensity of the colour developed is directly proportional to the concentration of urea in the sample.

Reference range: 10-50 mg/dl

2.2.3 Creatinine estimation

Creatinine was analysed using Jaffe reaction [15].

Principle: Creatinine reacts with picric acid in an alkaline medium to yield an orange-coloured complex which is measured spectro-photometrically. The intensity of this complex is directly proportional to the conce ntration of creatinine in the sample.

Reference range: Male: 0.9 – 1.3 mg/dl
Female: 0.6 – 1.2 mg/dl

2.2.4 Sodium ion estimation

Sodium was analyzed using flame emission photometry [16].

Principle: Flame emission spectrophotometry is based on the characteristic emission of light by atoms of metallic elements when given sufficient energy, such as that supplied by a hot flame. When elements in their ground state are heated, they move to an excited state; they are unstable in this excited state and thus have a tendency to return to a more stable ground state. When these atoms return to ground state under constant and controlled conditions, the light intensity of the characteristic wavelength produced by each of these atoms is directly proportional to the number of atoms that are emitting energy, which is in turn directly proportional to the concentration of the substance in the sample.

Reference range: 135-145 mmol/L

2.2.5 Potassium ion estimation

Potassium was analyzed using flame emission photometry [17].

Principle: Flame emission spectrophotometry is based on the characteristic emission of light by atoms of metallic elements when given sufficient energy, such as that supplied by a hot flame. When elements in their ground state are heated, they move to an excited state; they are unstable in this excited state and thus have a tendency to return to a more stable ground state. When these atoms return to ground state under constant and controlled conditions, the light intensity of the characteristic wavelength produced by each of these atoms is directly proportional to the number of atoms that are emitting energy, which is in turn directly proportional to the concentration of the substance in the sample.

Reference range: 3.5 – 5.0 mmol/L

2.2.6 Chloride ion estimation

Chloride was analyzed using Schales and Schales method [18].

Principle: When mercuric nitrate is added to a solution containing chloride ions, unionised but soluble mercuric chloride is formed. Excess mercuric ions (Hg^{+}) combine with the indicator diphenylcarbazone to give a violet coloured complex which indicated the end point of the reaction.

Reference range: 20-30 mmol/L

2.2.7 Bicarbonate ion estimation

Bicarbonate was analyzed using Acid/base back titration method [19].

Principle: HCl is treated with bicarbonate in serum until all carbon (II) oxide is released. Excess HCl left is titrated against standard sodium hydroxide using methyl red indicator.

Reference range: 97-107 mmol/L

2.3 Statistical Analysis

Statistical analyses including descriptive statistics was carried out using the Statistical Package for Social Scientists (SPSS) version 16.0. All values were expressed as Mean ± Standard Error of the Mean. The Independent t-test was used to determine significant differences in test parameters in the test and control groups. Confidence limit was set at 95%; level of significance ($p < 0.05$).

3. RESULTS

Results presented below represent serum levels of biomarkers of renal functions and electrolyte levels were estimated for occupationally exposed participants, user exposed participants, unexposed participants, cosmetic naïve participants and heavy cosmetic users.

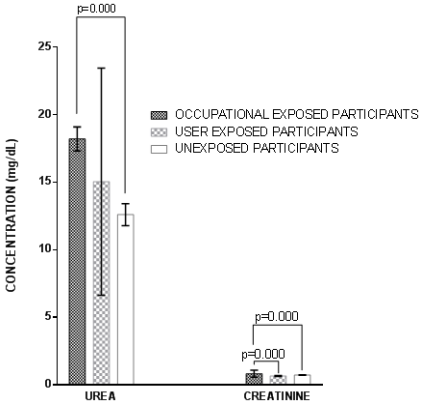

Fig. 1. Biomarkers of renal function among participants

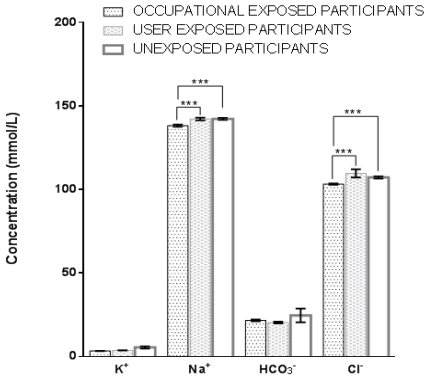

Fig. 2. Body electrolytes among participants *(***p=0.000)*

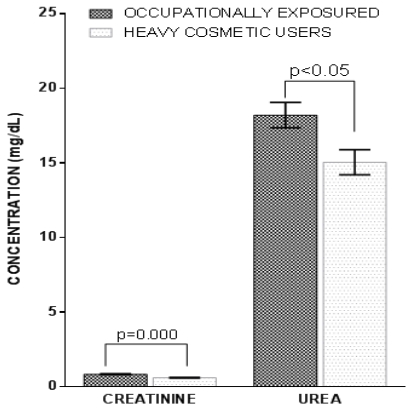

Fig. 3. Plasma levels of creatinine and urea in occupationally exposed participants and heavy cosmetic users

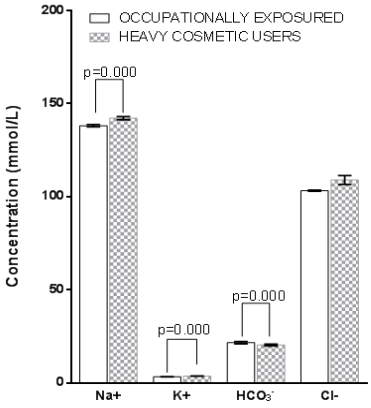

Fig. 4. Plasma levels of sodium, potassium, bicarbonate and chloride in occupationally exposed participants and heavy cosmetic users

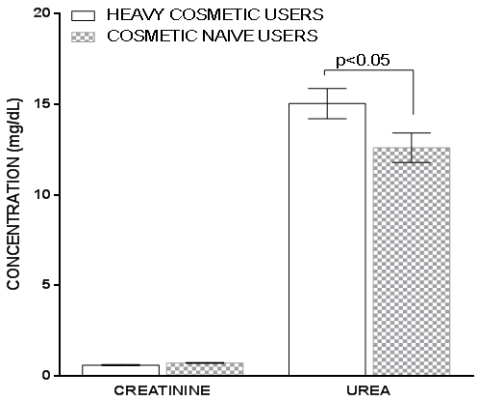

Fig. 5. Plasma levels of creatinine and urea in heavy cosmetic users and cosmetic naive participants

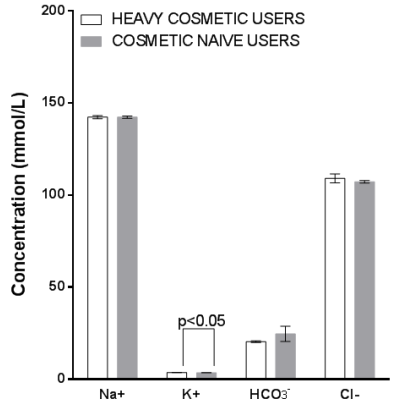

Fig. 6. Plasma levels of sodium, potassium, bicarbonate and chloride in heavy cosmetic users and cosmetic naive participants

Table 1. Basic health and demographic indices of cosmetologists, heavy cosmetic users and cosmetic naive participants

Observations	Cosmetologists (occupationally exposed) (n=50)	Heavy cosmetics users(n=25)	Cosmetics naive (unexposed) participants (n=25)	p- value/ level of significance
Sex of participants	Females=100%	Females=100%	Females=100%	Not applicable
Mean age nationality state of origin	25.49±0.709 Nigerian (100%) Akwa-Ibom = 8.0% Anambra = 4.0% Delta = 22.0% Edo state = 58.0% Enugu = 2.0% Imo = 2.0% Kogi = 2.0% Ondo = 2.0% Osun = 6.0%	23.68±0.415 Nigerian (100%) Akwa-Ibom = 4.0% Anambra = 8.0% Delta = 24.0% Edo state = 48.0% Imo = 4.0% Rivers = 4.0% Ondo = 4.0% Osun = 4.0%	20.00±0..416 Nigerian (100%) Akwa-Ibom = 4.0% Anambra = 8.0% Delta = 24.0% Edo state = 40.0% Osun = 4.0% Ondo= 12.0	(p<0.001) NA NA
Marital status	Single= 70% Married= 30% Divorced= 0.0%	Single= 100% Married=0.0% Divorced= 0.0%	Single= 100% Married= 0.0% Divorced= 0.0%	NA
Number of children	N=1=3% N=2=4% N=3=5% N=4=2%	Nil	Nil	NA
Use of tobacco	None=86% Occasional=0.0% Frequent=0.0%	Occasional=0.0% Frequent=0.0%	Occasional=0.0% Frequent=0.0%	NA
Use of alcohol	Passive users=100% Occasional=26% Frequent=0.0% Non-users= 74%	Passive users =100% Occasional=0.0% Frequent=0.0% Non-users=100%	Passive users=100% Occasional=0.0% Frequent=0.0% Non-users=100%	NA
Medical history (current medical challenges).	Malaria= 1% Typhoid= 0.0% Headache=1% Cough=1% None= 97%	Malaria= 0.0% Typhoid =0.0% Headache=0.0% Cough =0.0% None = 100%.	Malaria = 0.0% Typhoid =0.0% Headache=0.0% Cough=0.0% None= 100%.	NA
Conditions noted by beauticians to be associated with saloon care products.	Skin burns, nasal and eye irritation, catarrh.	Not applicable	Not applicable	NA
Mean BP(mmHg)	Systolic=114 Diastolic=77	Systolic=108 Diastolic=71	Systolic=111 Diastolic=72	(p>0.264) (p>0.032)
Mean BMI Use of multivitamins	23 Yes=7% Occasional=10% No=83% Multivite Tab=96% Omega H_3=2% Trehor=2%	21 Nil	20 Nil	(p<0.008) NA

Table 2. Pattern of occupational exposure and risk awareness level among participants

Observations	Cosmetologists (occupationally exposed participants) (n=50)	Heavy cosmetic users (n=25)	Cosmetic naive (unexposed participants) (n=25)
Occupational description	Hair stylist=36.2% Nail care=6.9% Both=56.9%	Not applicable	Not applicable
Duration of occupational exposure	≥3.0 years	Life style exposure	No occupational/ life style exposure

Observations	Cosmetologists (occupationally exposed participants) (n=50)	Heavy cosmetic users (n=25)	Cosmetic naive (unexposed participants) (n=25)
Days of exposure per week	≥6 days per week	Nil	Nil
Route of exposure	Hands, Dermal contact, nasal cavity, eyes, oral cavity.	Skin, oral cavity, nasal cavity, eyes	Minimal (environmental)
Level of awareness of exposure risk	Yes=Basic awareness (4.5%)		
	No=No basic awareness (95.5%)	No response	No response
Personal protective device	Frequent=4%	Not applicable	Not applicable
	Occasional=32%		
	Non-users= 64%	Not applicable	Not applicable
	Gloves only=55.5%		
Personal protective devices used	Gloves and apron=33.3%		
	Apron only=5.6%		
	Nose mask=5.6%		

Increased significant levels were observed for urea, creatinine, sodium and chloride levels when occupationally exposed participants were compared with user exposed participants and unexposed participants ($p<0.000$). On comparison of occupationally exposed participants with heavy cosmetic user, increased significant level ($p<0.05$) was observed for creatinine, urea, sodium, potassium and bicarbonate. When occupationally exposed participants were compared with cosmetic naïve participants, increased significant levels ($p<0.05$) was observed for all parameters assayed except bicarbonate levels. Increased significant levels was noticed for urea and potassium ($p<0.05$) when heavy cosmetic users were compared with cosmetic naïve participants. Error bars indicate SEM.

- Occupational description showed Hair Stylist been 36.2%, Nail care and those doing both to be 6.9% and 56.9% respectively
- Only 4.5% of cosmetologist showed awareness of possible exposure risk, 4% frequently used PPD, 32% occasionally and 64% have never used PPD.
- PPD used included, gloves only 55.5%, gloves and apron 33.3%, apron only 5.6% and nose mask 5.6%.
- Skin burns, nasal and eye irritation as well as catarrh were reported by cosmetologist to be associated with salon care products.

4. DISCUSSION

Cosmetics have considered more harmful than good by many dermatologist [20]. They are known to contain over 10,000 ingredients linked to many diseases including cancer, birth defects, development and reproductive harm [1]. Toxic chemicals found in cosmetics include coal tar, formaldehyde, glycol ethers, lead, mercury, parabens, phenylenediamine, and phthalates among others.

On individual notes, Phthalates have been associated with renal cysts, reduced creatinine clearance and transitional cell carcinoma [21], Toluene causes kidney and liver damage [22], while Coal tar has been associated with bladder and kidney cancers [23]. Information on the effect of exposures to mixtures of chemicals such as those found in salon have been unknown [24].

This study has shown possible renal impairment and electrolyte imbalance resulting from exposure to mixtures of these heavy metals as found in cosmetic products through dermal contact, inhalation and diffusion through eye pores of cosmetologist. Although significant increases of renal markers levels and electrolytes did not exceed physiological ranges considering the period of exposure, longer exposures may result in impaired renal function and incompetence of the kidney in maintaining electrolyte balance.

5. CONCLUSION

The use of cosmetic has become an integral part of human daily lives especially women giving rise to the need of better quality products and cosmetologist as well. Daily exposures to toxic chemicals and heavy metals which constitutes salon products can only be reduced not completely avoided by cosmetologist. Renal damage could arise following persistent

exposure over long periods of time to cosmetic and other salon products as a result of heavy metal toxicity and toxic chemicals contained in them. Cosmetologist are advised to use PPD and ensure proper handling, storage and disposal of salon products for safety purposes. Production of homemade cosmetic products with reduced concentrations of toxic chemicals and heavy metals should be encouraged with accompanied regulation of imported cosmetic products and their constituents.

6. RECOMMENDATION

Evidence from this research work has shown that persistent exposure to cosmetics products may cause renal damage in the long run; thus, cosmetologists should minimize direct contact with some of these toxic chemicals.

However, it is recommended that cosmetologists should ensure proper handling, storage, and disposal of salon products. The use proper protective devices for the nose, eyes, skin and hands when working should be of paramount. Use less toxic products in the hair and nail salon when possible. Ensure adequate ventilation in the salon.

Cosmetologists should also be enlightened so as to improve their awareness of the risks associated with the exposure toxic chemicals in hair and nail care products. They should inculcate the attitude of personal hygiene and cleanliness; as some do eat at work without proper washing of hands after working, Government should prevent or at least regulate by legislation the use of toxic cosmetic products in the country.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX I

Toxicological and Biochemical studies in nails and hair care workers in Benin City, Edo State

This is a project work by ONYEOGALU AMARACHI FAVOUR, Department of Medical LABORATORY Science, School of Basic Medical Sciences, University of Benin, Benin City. This questionnaire is aimed at evaluating the health risk associated with occupational exposure of nails and hail care workers to toxicants in Cosmetics in Benin City, Edo State, Nigeria.

The information obtained from this research will be used only for the purpose of the research and will be kept **confidentially**.

Please kindly help complete the questionnaire, **your name will not be required**. Tick appropriate boxes and thanks for your anticipated cooperation.

A, Personal Information

Sex: Male ☐ Female ☐

Age (Years): .....

State of Origin: .....

Level of formal Education: None ☐ Primary ☐ Secondary ☐ Tertiary ☐

Do you Smoke: Yes ☐ No ☐ Occasionally ☐

Do you drink Alcohol: Yes ☐ No ☐ Occasionally ☐

B, Occupational History

How many years have you being in the job? 0-2 ☐ 3-5 ☐ 6-8 ☐ ≥9 ☐

What is your role in the Job? Nail Care ☐ Hair Stylist ☐ Both ☐

Others (please specify).....

Are you aware of health risk(s) associated with your work? Yes ☐ No ☐

If yes, please specify.....

Do you use of wear protective devise(s) when working? Yes ☐ No ☐

If yes, please specify.....

C, Medical History

Any current medical challenge(s): Yes ☐ No ☐
If yes, what is (are) the challenge(s).....

Are you currently on drug(s)? Yes ☐ No ☐
If yes, please specify.....

How often do you eat fruits? Yes ☐ No ☐ Occasionally ☐

Do you take multivitamins? Yes ☐ No ☐ Often ☐
If yes, please specify.....

D, Family Information

Marital Status: Married ☐ Single ☐ Divorced ☐

Number of Children: 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ N None ☐

Thanks for your cooperation, God bless.

Medical Examination

Blood Pressure (BP): Systolic..... (mmHg) Diastolic..... (mmHg).
Height ..... (Cm) Body Weight ..... (Kg)
BMI ..... (Kg/m^2)

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http://sciencedomain.org/review-history/13831