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Full Length Research Paper

Knowledge of food borne infection and food safety practices among local food handlers in Ijebu-Ode Local Government Area of Ogun State

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Increase in food borne infection has been linked with the lack of knowledge of food borne infection (FBI) and poor food safety practice (FSP) of food handlers. This is a major determinant of the kind of patronage received by local restaurants and fast food restaurants. This study was carried out to assess the knowledge of FBI and FSP of local food handlers in Ijebu-Ode Local Government Area of Ogun State. Four hundred and seventy three local food handlers (snacks and cooked food handlers) were recruited for the study. Interviewer's administered questionnaire was used to gather information on knowledge and practice and a score index was then created. Data was analyzed using SPSS version 15. Frequencies, percentages, Chi square and correlations were done. The results revealed that majority (66.4%) of the respondents were female and 17.0% food handlers had no formal education. Majority (84.5%) of the respondents earned below ₦30,000. About 41.6% food handlers had poor knowledge FBI. Only 7.6% respondents had adequate knowledge. Also, 31.5% respondents had poor FSP. Educational qualification of respondents had a significant relationship with their knowledge of FBI (P=0.001) and it also significantly affected their FSP (P=0.0011). Furthermore, monthly income of respondents did not affect the practice of FSP (P=0.216) and the type of outlet of respondents had no significant effect on FSP (P=0.654). Knowledge of FBI and FSP of food handlers have a poor correlation coefficient (r<0.24). The knowledge of FBI among food handlers is adequate, but this does not translate into practice.

Key words: Food vendors, food borne infection, food safety practices, knowledge score, disease outbreak, hygiene, micro-organism.

INTRODUCTION

Food borne infections (FBI) are infections caused by the ingestion of food containing pathogenic microorganisms which multiplies within the gastrointestinal tract, producing widespread inflammation and is a significant

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public health problem with major economic and social effects (Altekruse and Swerdlow, 1996). Microorganisms commonly implicated are species of *Salmonella*, *Shigella*, *Escherichia coli* (pathogenic strains), *Bacillus* species, *Clostridium botulinum*, and *Listeria monocytogens*, viruses such as hepatitis A and E*;* Norovirus, molds, fungi and yeasts (Oranusi et al., 2011). FBI have incubation periods usually from 6 to 24 h or longer after ingestion and the causative organism may be identified by laboratory examination of the vomits, feaces, or blood of the infected individual and the suspected food (Sudershan et al., 2014). FBI includes salmonellosis, shigellosis typhoid fever, amoebic dysentery, gastroenteritis among many others.

FBI is usually characterized by diarrhea (which may be sometimes bloody) and vomiting. Symptoms may include fever and cold, headache, nausea, abdominal pain and cramps, distress, and weakness which in some instances may lead to respiratory arrest; other symptoms include signs of shock which include weak or rapid pulse or shallow breathing, confusion or difficulty reasoning (Mead et al., 1999).

Foodborne illness is a growing public health problem in developing as well as developed countries, causing morbidity and mortality in the general population, especially in vulnerable groups, such as infants, young children, elderly and the immunocompromised (Nyenje and Ndip, 2013; Fleury et al., 2008). Despite the efforts made on food safety and environment, 2.1 million adults and three million children, including two million in developing countries, die each year from water consumption or contaminated food (Sabir et al., 2013). Also, the World Health Organization (2007) estimated up to 1.5 billion episodes of diarrhoea and more than three million deaths occur in children every year as a result of food and water contamination.

It has been reported that an estimated 47.8 million, 2 million and 750,000 people become ill as a result of consumption of food containing pathogens or disease causing substances in the United States, United Kingdom and France, respectively while 5.4 million cases of food-borne illness was estimated to occur yearly in Australia, causing 18,000 hospitalizations, 120 deaths, keeping 21 million people away from work, 1.2 million people receiving medical consultations and 300,000 people receiving antibiotics prescriptions (Ifenkwe, 2012; Akintaro, 2012).

In developing countries, an estimated 70% of diarrheal episodes are associated with the ingestion of contaminated foods (WHO, 2008). Approximately 10 to 20% of food-borne disease outbreaks result from contamination of foods by the food handler (Gizaw et al., 2014; Zain and Naing, 2002). In African region, several devastating outbreaks of food borne diseases have been reported, including acute aflatoxicosis in Kenya in 2004 that was attributed to maize (Nyikal et al., 2004) and bromide poisoning in Angola in 2007 associated with the use of sodium bromide as cooking salt (Mensah et al., 2012).

Inadequate food safety laws, weak regulatory systems, lack of financial resources to invest in safer equipment, inadequate knowledge of food borne diseases and their causes, improper handling of food and unhygienic environments among others have been identified as some of the causes of FBI (Haileselassie et al., 2013).

The changing patterns of food consumption have had a major influence in the increasing incidence of FBI. In the past, foods were produced and consumed locally (Fowora, 2012). A trend towards eating fresh unprocessed foods and processed foods without preservatives permits the growth of food borne pathogens (Altekruse and Swerdlow, 1996). Minimally processed and extended shelf life food also carries inherent risks for increased contamination.

Food handling personnel plays important role in ensuring food safety throughout the chain of food production and storage (Adewunmi et al., 2014; Green et al., 2006). Mishandling and disregard of hygienic measures on the part of the food vendors may enable pathogenic organisms gain entry and in some cases survive and multiply insufficient numbers to cause illness in the consumer (Tivadar, 2003). It has been observed that most of the vendors who sell both raw and cooked food items are not regulated. They operate haphazardly without any monitoring of what they prepare and how they prepare it (Adewunmi et al., 2014; Green et al., 2006).

The knowledge of food handlers about the food borne infections and their safety practices is an important issue in the outbreaks of food borne infection (Fowora, 2012). It has been revealed that in Nigeria, 27.7% of food handlers do not wash their hands before preparing food and 28.1% use only water to wash hands after using the toilet. It was also revealed that 90% of food handlers have heard about typhoid fever out of which only 15.6% of them know how it is contracted (Smith et al., 2010). Furthermore, large quantity of food produced and distributed gets to the consumers in an unwholesome condition due to poor handling methods, inefficient processing equipment and storage practices, high ambient tropical temperature and humidity conditions (Akintaro, 2012). In order to reduce or eliminate these outbreaks of infection through food, proper handling of food and food materials by vendors or food handlers cannot be over emphasized. Therefore, this study aims to assess the knowledge of food handlers on FBI and their safety practices.

MATERIALS AND METHODS

This study is cross sectional and descriptive in design and it was carried out in 8 out of the 11 wards in Ijebu-Ode Local Government Area where 473 food handlers were randomly selected for this study. A validated structured interviewer's administered questionnaire was used to obtain information on the socio-demographic and socio-economic characteristics of the respon-

Table 1. Gender, ethnicity and educational qualification of food handlers.

Variable	N	%
Gender		
Male	159	33.6
Female	314	66.4
Total	473	100
Ethnicity		
Hausa	47	10
Igbo	162	34.4
Yoruba	241	51.2
Others	21	4.5
Total	471	100
Educational qualification		
No formal education	80	17
Primary school education	105	22.3
Secondary school education	145	30.9
Tertiary education	140	29.8
Total	470	100

dents. Knowledge of food borne infection was assessed on a scale of 12 questions. A score of 1 to 4 was categorized as poor knowledge, 5 to 8 as average knowledge and 9 to 12 as adequate knowledge. Food safety practices of the respondents was also assessed on a scale of 10 questions and a score of 1 to 4 was categorized as poor food safety practice, 5 to 6 as average food safety practice and 7 to 10 as adequate food safety practices. Observation was also made on the cooking environment. Data was analyzed using Statistical Package for Social Sciences SPSS 16.

RESULTS AND DISCUSSION

The results of this study (Table 1) show that more females are involved in the food business. Adewunmi et al. (2014) reported that 100% of food handlers were females in a study among food vendors in selected secondary schools in Ogun State, Nigeria. Other studies in Nigeria also reported the same (Afolaranmi et al., 2015; Isara and Isah, 2009; Chukuezi, 2010; Musa and Akande, 2003). However, Kasturwar and Shafee (2011) reported that 62.7% of food handlers assessed in a Rural Private Medical College in India were males. About 31% of the food handlers in this study had only secondary school education. Some other studies reported similar findings (Thidarat et al., 2011; Oridota et al., 2014). Just about a quarter of the respondents in this study had tertiary education. As a result, they may have little or no knowledge on proper handling and hygienic practices of food and food materials, hence, contributing immensely to food contamination by pathogenic microorganisms.

About 40% of the food handlers had a monthly income below ₦15,000 (75 US dollar) and more than 50% of them are involved with snacks production (Table 2). Since snacks production does not require huge amount of money, the monthly income of respondents may be a major determinant of the type of food sold by the food handlers.

Knowledge of FBI

Figure 1 shows that about half of the respondents (50.7%) had average knowledge of food borne infection; 41.6% had poor knowledge and only 7.6% had adequate knowledge. This result disagree with the report of Labib et al. (2013) where majority of food handlers had excellent knowledge of FBI. More than one-third (41.6%) of the food handlers in this study had poor knowledge of FBI and this implies respondents are not likely to put in place the food safety measures required to prevent food borne infection and ensure food safety. This result is similar to some reports which show that a large number of food handlers had poor knowledge of FBI (Zain and Naing, 2002) and food safety (Gizaw et al., 2014).

Factors affecting the knowledge of FBI

Though research has shown that female food handlers maintain better personal and food hygiene than male food handlers (Kasturwar and Shafee, 2011), gender, the type of food sold and ethnicity did not have a significant relationship with the knowledge of FBI among the food handlers ($P = 0.858$, 0.654, and 0.417, respectively). Factors identified to contribute to the knowledge of FBI

Table 2. Type of food sold and monthly income of respondents.

Variable	N	%
Types of food sold		
Snacks	263	55.7
Cooked food	209	44.3
Total	472	100
Monthly income (₦)		
Below 5000	106	22.5
5000 – 14,999	186	39.5
15,000 – 29,999	106	22.5
30,000 and above	73	15.5
Total	471	100

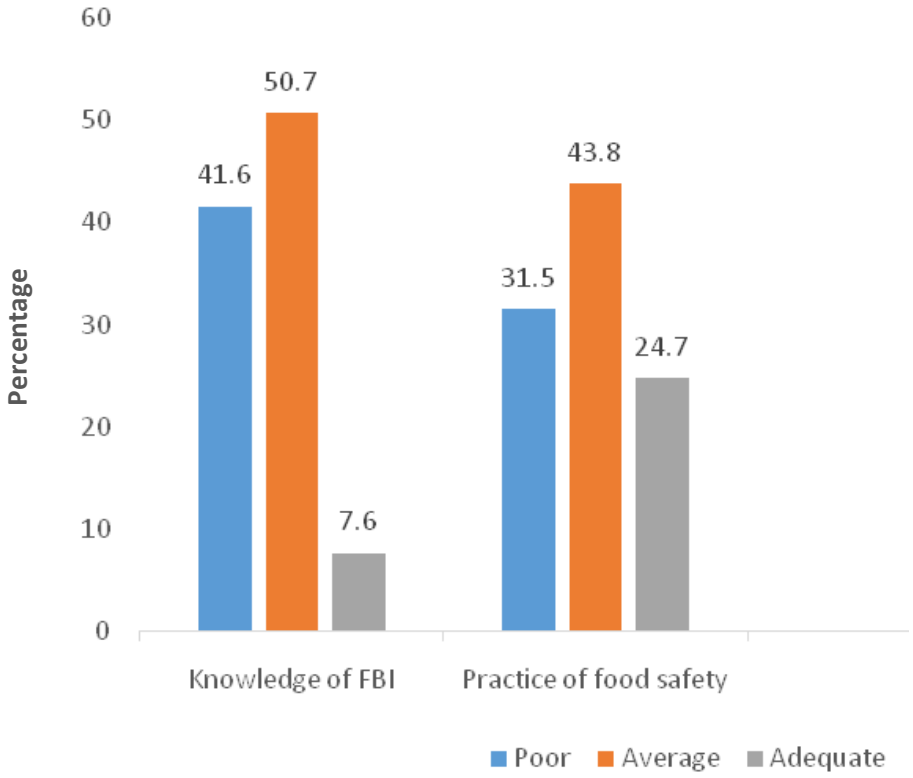

Figure 1. Knowledge of FBI and food safety practices.

include income and educational level of the food handlers. It was observed from this study that the higher the educational level of the respondents the higher their knowledge of food borne infection (P = 0.001). A study in India (Kasturwar and Shafee, 2011), Jordan (Labib et al., 2013) as well as a study in Northwest Ethiopia (Labib et al., 2013) established that poor knowledge of food borne infections was due to low educational level. Another study in Malaysia (Mizanur et al., 2012), however identified ethnicity and age as important factors for good knowledge of food safety (Table 3).

Food safety practices

About one-third (31.5%) of the respondents had poor food safety practices as observed in Figure 1. This study is similar to the report of Gizaw (2014) where 22.10% food handlers had poor food safety practices. It has been reported that food handlers do observe food safety practice like personal hygiene and hand washing, food separation, sickness leave from work, vaccination or deworming, use of gloves, mask and cap (Anuradha and Dandekar, 2014). It was also observed in this study also

Table 3. Knowledge of FBI by educational qualification and monthly income.

Variable	Poor knowledge [N (%)]	Average knowledge [N (%)]	Adequate knowledge [N (%)]	Total [N (%)]	P-value
Educational qualifications					
No formal education	55 (11.7)	23 (4.9)	2 (0.4)	80 (17)	0.001
Primary education	54 (11.5)	45 (9.6)	6 (1.3)	105 (22.3)	
Secondary education	54 (11.5)	79 (16.8)	12 (2.6)	145 (30.9)	
Tertiary education	33 (7.0)	91 (19.4)	16 (3.4)	104 (29.8)	
Total	196 (41.7)	238 (50.6)	36 (7.7)	471 (100)	
Monthly income					
Below 5000	52 (11)	42 (8.9)	12 (2.5)	106 (22.5)	0.006
5000 – 14,999	83 (17.6)	97 (20.6)	6 (1.3)	186 (39.5)	
15,000 – 29,999	40 (8.5)	58 (12.3)	8 (1.7)	106 (22.5)	
30,000 and above	21 (4.5)	43 (9.1)	9 (1.9)	73 (15.5)	
Total	196 (41.6)	240 (51)	35 (7.4)	471 (100)	

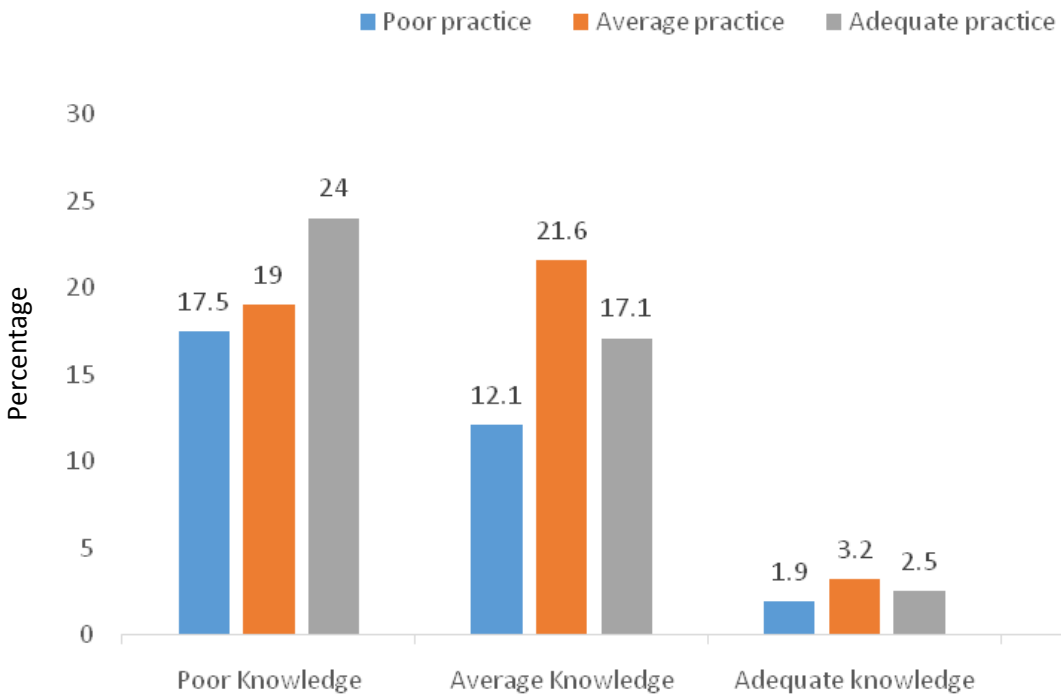

Figure 2. Relationship between knowledge of FBI and food safety practice.

that about half (43.8%) of the food handlers interviewed had moderate food safety practice, although the specific practices observed by these food handlers were not assessed.

From this study, food safety practice score was significantly different among the gender group. Female food handlers had better practice score than the male (P = 0.011). A study by Kasturwar and Shafee (2011) reported that female employees maintain proper personal and food hygiene and they are more careful in safe food handling than men. The level of education of the respondent was another factor that contributed to food safety practice (P = 0.001). A study by Mizanur et al. (2012) showed that training in food safety significantly increased food safety practice among food handlers in Kuching city in Malaysia. Although training in food safety was not assessed in this study, it is evident that the level of education of respondent is a major contributing factor to both the knowledge of FBI and food safety practice. Monthly income, type of food sold, and ethnicity did not significantly relate with food safety practice (P = 0.216, 0.654, and 0.777, respectively) (Figure 2).

Several studies have observed that adequate knowledge of FBI and knowledge of food safety do not necessarily translate into adequate food safety practice (Pragle et al., 2007; Clayton and Griffith, 2004). The findings of this study were not completely different. Knowledge of FBI in this study was poorly correlated to food safety practice (r = 0.24). Knowledge of FBI alone cannot be used to predict good safety practice. Other explanatory variables such as training of food handlers, environmental hygiene of food outlets, food control monitoring and food borne disease surveillance not assessed in this study may also contribute to good safety practice.

Observational report

During the data collection and interview of respondents, the following were observed:

(1) Most of the food handlers prepared cooked food in uncovered space while some prepared cooked food under wooden structures. A study carried out in Ghana showed that there are variations in food hygiene standards among food handlers in different set ups (Tomlins et al., 2002).
(2) Some of the outlets are either located close to a refuse dump, water way or are on the highway.
(3) For cooked food handlers, water used in washing and rinsing plates often gets very dirty before they are changed while some do not allow water used in rinsing plates to drain before the plates are used to serve food.

Conclusion

More than 40% of the respondents have poor knowledge of FBI and about one-third indulges in poor food safety practices. The level of education of the respondents was identified as the major contributing factor to good knowledge of FBI and practice of food safety. Knowledge of FBI was poorly correlated to good safety practice. It could only predict about 20% good safety practice.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations were made:

(1) Since education is a major contributing factor to good knowledge of FBI, training of food handlers on prevention of food contamination, personal hygiene and how to ensure food safety should be encouraged.
(2) A regular food control monitoring and evaluation of food handlers on their food safety practice and hygiene should be encouraged.
(3) A routine inspection of environmental hygiene of the food outlets should be carried out.

Conflicts of interest

Authors have none to declare.

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Medicine pricing: Impact on accessibility and affordability of medicines vis a vis the product origin as pharmaco-economic drivers in Comoros

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This paper highlights the availability, pricing and affordability of popular medicines in Comoros. We used the standardized survey methodology developed by the World Health Organization and Health Action International to conduct a cross sectional survey for collecting data on availability and patient prices of medicines in public, private and mission sector medicines outlets from April 1 to June 30, 2014. Median availability of medicines in Comoros across all sectors was particularly low at 31.11% for all product types. The median price ratios of procurement prices for original brands, most sold generics and lowest-priced generics in the public sector, were 11.60, 4.74 and 3, respectively. These were 83 times higher than the international reference prices; and the median price ratios of retail prices to patients for lowest priced generics in the private sector were 29.49% higher than those in the public sector. For most of the population, the medicine prices are unaffordable particularly in the islands Ndzuwani and Mwali, where many people earn less 1$ per day. The survey revealed higher procurement prices and poor availability in the public sector. Various policy adjustments could increase the availability of essential medicines and reduce their prices for the low income population.

Key words: Affordability, availability, Comoros, islands, prices.

INTRODUCTION

Medicines accessibility and affordability depends on various factors that include purchaser variables such as individual, household, community, private insurer, national health system or international donor and even product specificities. Different approaches therefore have been employed to measure accessibility and affordability including benchmarking medicine prices against per capita gross national income (GNI), setting prices against "catastrophic" household health expenditure levels, or converting prices to working days based on government salaries as a proxy for average income (Cameron et al., 2009; Niens and Brouwer, 2009; Niens et al., 2010;

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Table 1. Facility sample distribution.

Island	Region	District	Public sector Hospital/Health Center	Private sector Pharmacies/retails	Mission sector/NGOs	Total
Ngazidja	North	Mitsamuhouli, Mbeni	2	4	0	6
	Central	Moroni, Mitsoudje	6	12	2	20
	South	Foumboni, Ouziouani	2	4	0	6
Ndzuwani	North	Domoni	1	2		3
	Central	Mutsamudou, Ouani	3	6	2	11
	South	Pomoni, Sima	2	2		4
Mwali	North	None selected				
	Central	Fomboni, Djando	3	5	2	10
	South	None selected				
Comoros	7	14	19	35	6	60

Wagstaff and van Doorslaer, 2003). These methods may however not account for all the widely varying levels of income inequality in different countries (Xu et al., 2003).

The Islamic Federal Republic of the Comoros is an insular, discontinued territory. The signing of the Fomboni Framework Agreement in 2001 for Reconciliation in the Comoros opened the way to the resolution of a number of crises and led to the creation of the Union of Comoros (François, 2008; Chrysantus, 2008; Thierry, 2007; Union of Comoros and United of Nations, 2007). Hence the ensuing constitution extends considerable autonomy to the three islands of Ngazidja (Grande Comore), Ndzuwani (Anjouan), and Mwali (Moheli), each having its own government. Collaboration between the central Government and the islands' local administration is difficult and jurisdiction is frequently disputed, including health delivery (WHO, 2014). Malaria is the leading cause of morbidity, the most vulnerable groups being children under five and pregnant women. The rate of HIV/AIDS prevalence is still low despite steady increase of the pandemic disease (WHO, 2014; Ouledi et al., 2012). Maternal and child mortality rates are alarming (Graham et al., 2013).

Despite efforts to develop national policies, delivery of health services is highly constrained: access to health facilities that are up to within 5 km varies from 45 to 74% from one island to the next, while use of health facilities varies between 9 and 20% (WHO, 2006). An encouraging increase in health staff has occurred but staff distribution is unequal and overall, motivation is rather poor (Ouledi et al., 2012). Qualified staff is insufficient, especially in the public sector; there is a general lack of mentoring, retraining and resources for management. A large proportion of staff is trained abroad and most do not return (WHO, 2002). Despite a national supply policy, shortage of essential drugs occurs frequently. There is no national quality control laboratory. Illegal markets are thriving and prices of drugs vary from one facility to another. The country lacks a coordinated and integrated system for health information collection, analysis, and use (Union of Comoros, 2005 and 2010). The private sector is expanding; however, it is uncontrolled, which adversely impacts quality of care and contributes to high and non-standardized costs of health care.

This paper reporting on the prices and availability of essential medicines in Comoros is one of the important initial baseline information summarizing the results of medicine price and availability surveys carried out around the globe using a standard survey methodology developed by the World Health Organization (WHO) and Health Action International (HAI) (WHO/HAI, 2009).

METHODOLOGY

A total of 20 medicines from the WHO/HAI core list of medicines were surveyed between the months of April 1 and June 30, 2014, selecting representation from the pre-set dosage forms, strengths and recommended pack sizes (WHO/HAI, 2003 and 2008; WHO, 2013). Prices and availability were recorded for the original/innovator brand product (OB) determined at the national level; and for both most sold (MSGs) and lowest priced generics (LPGs) equivalent which was determined at facilities in each of the three islands of Ngazidja (Grande Comore), Ndzuwani (Anjouan), and Mwali (Moheli). Data was collected from a total of 19 public sector facilities, 35 private pharmacies or private retail facilities and 6 Mission or Non-Governmental Organizations (NGO) across the Islands (Table 1). Pharmacies in government health facilities were surveyed for the availability of the selected medicines and frequency of utilization. In all three sectors, and in the three Islands surveyed, the medicine price data collection form was used to enter the price and availability of the medicines at the time of data collection.

Price information

As per the WHO/HAI survey methodology, prices were presented in

Table 2. Median percentage availability of all medicines on the day of survey across 3 sectors.

Product type	Mean availability (%)			Average product type for 3 sectors
	Public sector (N= 19 outlets)	Private sector (N=35 outlets)	Mission sectors (N=6)	
Original brand (n=20 medicines)	4.73	7.86	0	6.29
Most sold generic (n=20 medicines)	12.63	52.19	15	26.61
Lowest price generic (n=20 medicines)	54.21	49	55.83	53.01
Average of mean availability for all medicines on the day of the survey across three sectors				31.11

local currency and as median price ratios (MPR). The MPR was calculated by dividing the local price by an international reference price (converted to local currency). An MPR of 1 was regarded as the local price being equivalent to the reference price whereas an MPR of 2 means the local price is twice the reference price. To facilitate international comparisons, the international reference prices used for this study were taken from the Management Sciences for Health (MSH) reference prices - the International Drug Price Indicator Guide, 2013 (WHO, 2013).

Affordability

Affordability was calculated as the number of days the lowest paid unskilled government worker would have to work to pay for medicines for one month's treatment for medicines for a course of treatment for acute conditions. At the time of the survey, the lowest paid government worker earned KMF 1000 per day (equivalent to US$ 2.75 per day at the time of the survey) (The World Bank, 2013). Having to spend more than 1 day's income per month on family medical needs was considered to be unaffordable. All prices were converted to US dollars using the exchange rate (buying rate) of April 1st 2014, the first day of data collection that is, US$ 1 = 362.72783 KM. The cost of treatment and affordability for pre-selected clinical conditions was calculated in the public and the private sectors. Like many low income developing countries, a large proportion of the population in Comoros, earns less than the lowest paid government worker. It should be noted that nearly half the population (44.8%) live below the poverty line and have no access to essential medicines (MDGs Report, Comoros, 2013).

International comparisons

In every WHO/HAI survey, data is collected on the same global list of medicines with the same dosage forms and strengths, which allows for comparisons to be made across countries. A list of 5 countries from the reference of African Low income countries (2013) were selected for international comparisons of availability, medicine prices ratio and affordability were then established in this survey. Countries were selected based on similarity in terms of economic wealth and development. Country data was extracted from the global database of survey results available on the HAI website.

Data collection

The participating institutions were selected based on geographical locations and population size. Ethical clearance/permission was granted and sought through the Pharmaceutical Association of Comoros from the Ministry of Health for the survey to be conducted. All survey personnel received training in the standard survey methodology and data collection /data entry procedures at a workshop held on March 10, 2014 to March 17, 2014. As part of the workshop, a data collection pilot test was conducted at public and private medicine outlets which did not form part of the survey sample. In Comoros, there is only one central purchasing medical store (CAMUC) which represents the public procurement agency following the bankruptcy and liquidation of the National Autonomous Pharmacy of Comoros (PNAC) in 2012. This provided the prices that the government pays to procure medicines and the public facilities. At private pharmacies, availability and the prices on the medicine strips/containers were surveyed at each selected facility.

Data analyses

For data analyses, the data entry was done by a single operator in the predesigned computerized WHO/HAI medicine prices workbook designed in the Microsoft Excel software and cross-checking done, with actual double data entry, on different dates. Descriptive statistics mainly in the form of percentages and mean (average) were used.

RESULTS

Availability of medicines in the public, private and mission sectors

In Comoros, the mean availability of surveyed medicines at all facilities in public, private and mission was 53.01, 26.61 and 6.29% for LPGs, MSGs and OBs, respectively with an overall percentage availability of surveyed medicines at 31.11% (Table 2). In the public sector, the median availability for all 20 medicines surveyed was 54.21 and 12.63% for both LPGs and MSGs, respectively, and only 4.73% of innovator brands were available in this sector. Six medicines: Clotrimazole, Co-trimoxazole, Erythromycin, Ibuprofen, Mebendazole and Paracetamol were available in public facilities as both innovator brands and generics equivalent. In the private sector, MSGs were the predominant product type available, with average availability at 52.19% for all medicines. For OBs, average availability was low at 7.86 and 49% for LPGs. The medicine availability was higher in private sector than that of the public sector. Availability in the mission sector for LPGs was higher at 55.83 and only 15% for MSGs. None of the OBs were available. The mean availability of surveyed medicines across sectors in Ngazidja, Ndzuwani and Mwali are depicted in Figure 1a. This Figure also shows the mean availability of surveyed

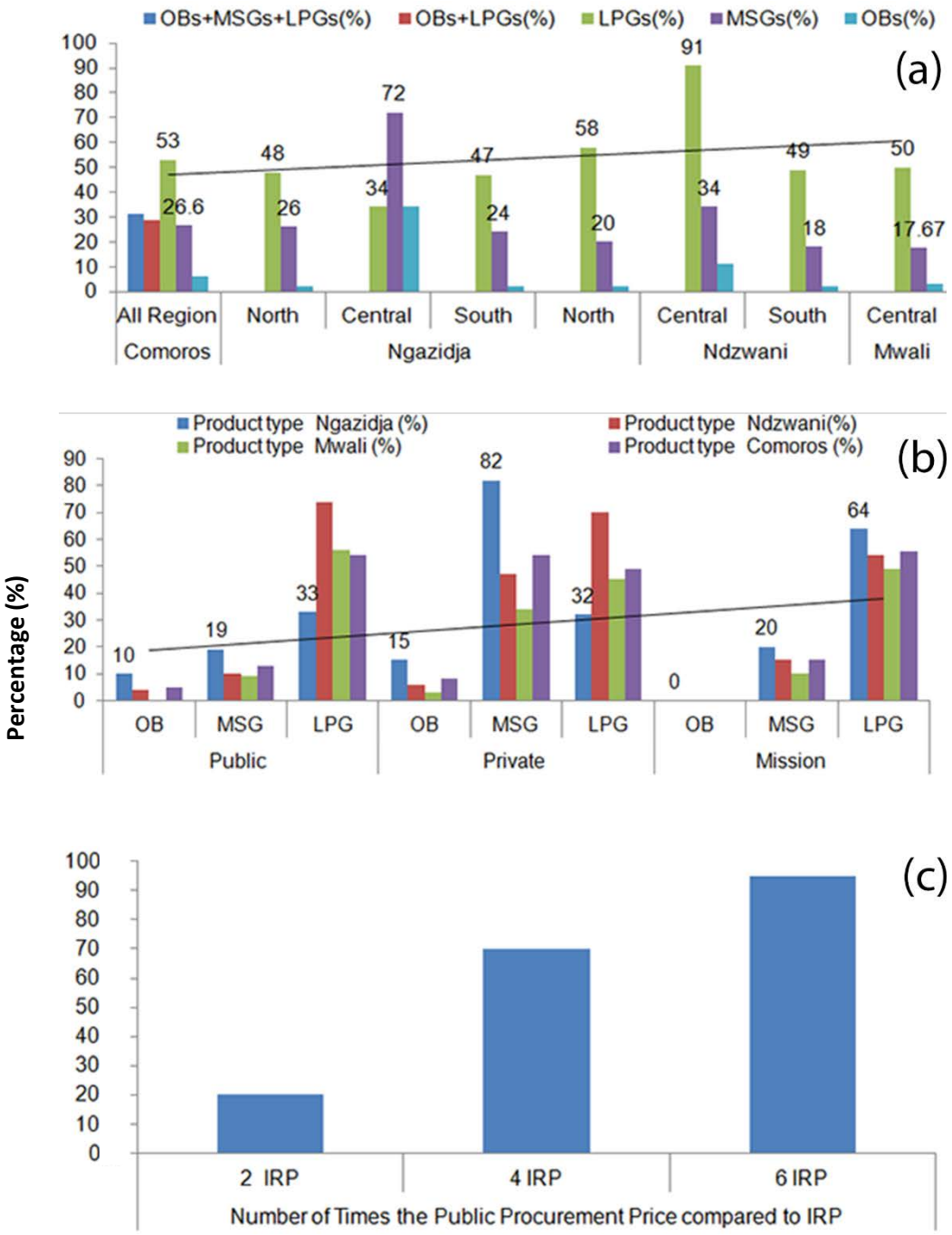

Figure 1. (a) Mean availability of surveyed medicines in various areas across 3 sectors; (b) Mean availability of any product type across 3 sectors and by Island; (c) Percentage availability of Medicines procured compared to the international reference prices (IRP).

medicines in 7 regions of Comoros across private, public and mission sectors in each Island.

From Figure 1a, it can be noted that the Central region for each Island had the highest mean availability of all medicines surveyed, indicating that some patients from other regions usually purchase their medicines in the Central Region. As shown in Table 3, in Ngazidja, the mean availability of both MSGs and LPGs was between 40.33 and 43% for all medicine surveyed. For OBs it was higher at 12.5% than in the other islands. The average availability of all medicine was 32% with the most available being MSGs and OBs than other the surveyed areas. In Ndzuwani, the mean availability of both MSGs and LPGs was between 24 and 66%. For OBs only 5%

Table 3. Mean availability of product type for all sector across Islands

Product type	Average mean availability (%)			
	Ngazidja	Ndzuwani	Mwali	Comoros
Original brand	12.5	5	3	6.3
Most sold generic	40.33	24	17.67	26.6
Lowest price generic	43	66	50	53
Average for all product type	32	32	24	31.11

Table 4. Mean availability across islands in public sector

Product type	Mean availability (%)		
	Ngazidja (Grande Comore)	Ndzuwani (Anjouan)	Mwali (Moheli)
Original brand	10	4	0
Most sold generic	19	10	9
Lowest price generic	33	74	56

Table 5. Mean availability across Islands in private sector.

Product type	Mean availability %		
	Ngazidja (Grande Comore)	Ndzuwani (Anjouan)	Mwali (Moheli)
Original brand	15	6	3
Most sold generic	82	47	34
Lowest price generic	32	70	45

mean availability was realized. Ndzuwani has the highest mean availability of LPGs than Ngazidja and Mwali. In Mwali, availability of both MSGs and LPGs was between 17.67 and 50%, with only 3% of innovator brands. In this Island, many patients often purchase medicines from other places, usually outside the Island.

Regional analysis

Comparison of availability in public sectors across the islands surveyed

As shown in Table 4, the mean availability of survey medicines in the public sector ranged from 33% in Ngazidja to 74% in Ndzuwani for LPGs equivalents. For MSGs, mean availability was lowest in Mwali (9%) and highest in Ngazidja (19%) while for OBs, mean availability was lowest in Mwali (0%) and highest in Ngazidja (10%).

Comparison of availability in private sectors across the islands surveyed

The mean availability of surveyed medicines in the private sector ranged from 32% in Ngazidja to 70% in Ndzuwani for the LPGs equivalents. For MSGs, mean availability was lowest in Mwali (34%) and highest in Ngazidja (82%) while for OBs, mean availability was lowest in Mwali (3%) and highest in Ngazidja (15%) (Table 5).

Comparison of availability in mission sectors across the islands surveyed

Mean availability of surveyed medicines in the Mission sector ranged from 49% in Mwali to 64 % in Ngazidja for the LPGs equivalents (Table 6). MSGs showed the lowest mean availability in Mwali (10%) and the highest in Ngazidja (20%). None of the OBs was found in the mission sector. The mission sector had predominantly LPGs as compared to other product types. As shown in this Fig.1b, in both public and private sector, Ndzuwani is procuring predominantly generic products and in Ngazidja both MSGs and OBs were substantially available.

Price information

The results from the survey were not presented in actual

Table 6. Mean availability across Islands in mission sector.

Product Type	Mean availability (%)		
	Ngazidja (Grande Comore)	Ndzuwani (Anjouan)	Mwali (Moheli)
Original brand	0	0	0
Most sold generic	20	15	10
Lowest price generic	64	54	49

Table 7. Summary of the mean of median price ratio in the public procurement sector for all medicines found

Product Type	MPR	25th percentile	75th percentile	Number of medicines found
Original brand	11.60	11.60	11.60	6
Most sold generic	4.74	4.74	4.74	9
Lowest price generic	3.83	3.83	3.83	18

N = 1 Public procurement; (n = 20 medicines).

Table 8. Summary of the Median Price Ratio (MPR) in the public sector patient prices for all medicines found.

Product Type	MPR	25th percentile	75th percentile	Number of medicines found
Original brand	13.69	13.23	14.40	6
Most sold generic	5.62	5.22	5.74	9
Lowest price generic	4.45	4.20	4.62	18

N= 19 facilities; (n = 20 medicines).

currency units but, rather, expressed as MPRs calculated using international reference prices.

MPR = median local unit price / reference unit price (both expressed in the same currency)

Public sector procurement prices

In the public sector, the national procurement agency CAMUC procures drugs through the public facilities and some local private sectors. All the regional hospitals and facilities are, in turn, expected to procure from their respective Regional CAMUC store. Public sector procurement prices were substantially higher than the international reference prices, for both MSGs and LPGs, the procurement prices were up to 4 and 5 times their IRP (Table 7). Only six (6) medicines of OBs were found in the public procurement with their prices about 12 times their IRP, indicating a poor level of purchasing efficiently. Only four (4) medicines (Metformin 500 mg, Mebendazole 100 mg, Ibuprofen 100 mg/5 ml, Cotrimoxazole 200 + 40 mg) were procured for less than twice the international reference price (Figure 1c).

Public sector patient price

At public sector facilities, patient prices for both LPGs and MSGs generic medicines were found to be 4 and 6 times their IRP, respectively. Patient prices ranged from 1.23 times (or 23% higher than) the IRP for Mebendazole to 13.27 times the IRP for Diclofenac. Six OBs were found and their generic equivalents were also found at lower prices. This is summarized in the Table 8.

Private sector patient prices

In the private sector, there is no procurement agency. Medicines are purchased by private wholesalers from importers and then wholesalers sell to pharmacies. Out of the 20 medicines surveyed, OBs were found for 14 of them in private retail pharmacies. At the private retail pharmacies, patient prices for both MSGs and LPGs were found to be 5.96 and 6.34 times higher than their IRP. And OBs in this sector are about 11.28 times higher than IRP (Table 6). When OBs are prescribed /dispensed in the private sector, patients pay about 111.23% more than they would for generics. Generic medicines were

Table 9. Summary of the MPR in the Private Sector for all medicines found.

Product Type	MPR	25th percentile	75th percentile	Number of medicines found
Original brand	11.28	11.16	12.02	14
Most sold generic	5.96	5.73	6.34	20
Lowest price generic	5.34	5.13	5.56	19

N= 35 retail pharmacies; (n = 20 medicines)

Table 10. Summary of the MPR in the Mission Sector for all medicines found.

Product type	MPR	25th percentile	75th percentile	Number of medicines found
Original brand	-	-	-	0
Most sold generic	4.31	4.23	4.38	7
Lowest priced generic	3.55	3.48	3.73	15

N= 6 Mission facilities; (n = 20 medicines).

Table 11. Comparison of the prices of original brands and generically equivalent products: MPRs for medicines found as both product types, in the case of public procurement

Product type (n = 5 medicines found)	MPR	25th percentile	75th percentile	Difference of OBs to LPGs (%)
Original brand	11.87	11.87	11.87	310.73
Lowest priced generic	2.89	2.89	2.89	

N=1 Public Procurement; (n= 20 medicines).

priced 20% higher in the private sector than in the public sector and 50 % higher in the private than in the mission sector. In the private sector, the prices patients are charged for medicines varied from pharmacy to pharmacy (Table 9).

Mission sector patient prices

In the non-governmental sector, the price charged to patient for LPGs was found to be 3.55 times than IRP. In the mission sector, no OBs was found. For both LPGs and MSGs generic medicines prices were found to be 3.55 and 4.31 times higher than their IRP, indicating a good level of purchasing efficiency compared to both public and private sectors. Generic medicines were priced 25.35 and 50.42% higher, respectively in the public and private sector than in the mission sector (Table 10).

Comparative median price ratio across sectors for a selection of interested medicines

The patient prices of some medicines across sectors for both MSGs and LPGs were, respectively exactly the same or almost the same in all sectors. Figure 2a illustrates this for 7 medicines. Interestingly a number of these medicines had a marked higher than average difference between patient's prices and procurement prices in public sector and lower than average difference of patient prices in mission sector.

Comparison of the prices of OBs and generically equivalent products

Only those medicines for which both the OBs and a generically equivalent products were available, were included in the analysis to allow for the comparison of prices between the two product types. Results showed that in the public procurement, OBs cost 310.73% more, on average, than their generic equivalents (Table 11). Table 12 shows those medicines for which both the innovator brand and a generically equivalent product were found, that were included in the analysis to allow for the comparison of price. Results showed that in the public sector patient prices, OBs cost 294.35% more, on average, than their generic equivalents. Table 13 shows the medicines for which both the OBs and generically equivalent products were found, allowing for the comparison of prices between the two product types. Results indicated that in the private sector, OBs cost 110.45% more, on average, than their generic equivalents. While public sector patient prices for LPGs were more than 20% the public procurement prices, the

Table 12. Comparison of the prices of original brands and generically equivalent products: MPRs for medicines found as both product types, in the case of Public sector patient prices

Product type (n = 5 medicines found)	MPR	25th percentile	75th percentile	Difference of OBs to LPGs (%)
Original brand	13.96	13.55	14.57	294.35
Lowest priced generic	3.54	3.38	3.65	

N= 19 Public facilities; (n = 20 medicines)

Table 13. Comparison of the prices of original brands and generically equivalent products: MPRs for medicines found as both product types, in the case of Private sector patient prices

Product type (n = 14 medicines found)	MPR	25th percentile	75th percentile	Difference of OBs to LPGs (%)
Original brand	11.28	11.15	12.02	110.45
Lowest priced generic	5.36	5.15	5.58	

N= 35 retail pharmacies; (n = 20 medicines).

Table 14. MPRs for medicines found in both public and private sectors.

Product type	MPR Public sector patient prices (n= 19 outlets)	MPR Private sector patient Prices (n=35 outlets)	Difference of private To public (%)
Original brand (n=3 medicines)	11.83	13.67	15.55
Most sold generic (n=9 medicines)	5.62	6.31	12.28
Lowest priced generic (n=17 medicines)	4.25	5.50	29.49

public sector patient price of some medicines was as much as 2 times the public procurement price; this may relate to items being sourced from the private sector instead of the public sector procurement sources. In the public sector, OBs were found to be 2.94 times more expensive than the LPGs (n=5) and in the private sector, OBs were found to be 1.1 times than the LPGs (n=14) (see Figure 2b).

Comparison of patient prices in the public and private sectors

In the Table 14, those medicines found in both public and private sector medicine outlets were compared in terms of prices between the two sectors. Results revealed that final patient prices charged in the private sector were 15.55% higher than in the public sector for originator/innovator brands. For both MSGs and LPGs patient prices charged in private sector was 12.28 and 29.49% higher than the public sector, respectively. On average in both sectors in Comoros, the patient prices in the private sector were generally 12% more than those in public sector, some medicines were up to 16 times more expensive than IRP; however most of MSGs medicines were the same or lower in both the public and private sector.

Regional analysis

Comparison of prices in public sectors across the islands surveyed

As shown in the Table 15, the MPR for OBs and generics in the public sector differed significantly across the 3 islands surveyed.

Comparison of prices in private sectors across the islands surveyed

The MPR for OBs in the private sector differed significantly across the 3 Islands surveyed (Table 16). This is explained by the fact that in Comoros most of the private licensed retail medicine outlets (Pharmacies) are located in Ngazidja and it is the highest medicines purchasing Island. However both MSGs and LPGs in the private sector seemed the same across the 3 Islands surveyed.

Comparison of MPR prices in mission sectors across the islands surveyed

As shown in the Table 17, the MPR for OBs and generics in the private sector differed significantly across the 3

Table 15: MPRs per survey area, public sector

Product type	Median MPR		
	Ngazidja (Grande Comore)	Ndzuwani (Anjouan)	Mwali (Moheli)
Originator brand	13.69 (n=6)	11.83 (n=3)	
Most sold generic	5.62 (n=9)	4.55 (n=5)	4.46 (n=4)
Lowest price generic	4.35 (n=19)	4.35 (n=19)	4.35 (n=19)

Table 16. MPRs across islands in private sector.

Product type	MPR		
	Ngazidja (Grande Comore)	Ndzuwani (Anjouan)	Mwali (Moheli)
Original brand	11.28 (n=14)	10.65 (n=10)	9.85 (n=5)
Most sold generic	5.96 (n=20)	4.96 (n=20)	5.45 (n=20)
Lowest priced generic	5.34 (n=19)	4.80 (n=19)	5.12 (n=19)

Table 17. MPRs across Islands in mission sector.

Product type	MPR		
	Ngazidja (Grande Comore)	Ndzuwani (Anjouan)	Mwali (Moheli)
Original brand	(n = 0)	(n = 0)	(n = 0)
Most sold generic	4.31 (n = 7)	4.44 (n = 5)	5.09 (n = 3)
Lowest priced generic	3.55 (n = 15)	3.55 (n =15)	3.55 (n =15)

Islands surveyed. The MPRs of product type (OBs, MSGs and LPGs) of selected individual medicines were compared across the 3 Islands. In the public sector, the average price were the same in all regions with little difference between Islands, across sectors, the median price of all medicines for all product type were highest in Ngazidja. This variation could be explained by several factors specific to Ngazidja.

Affordability of standard treatment regimens

The affordability of treatment for 11 common conditions (Table 18) was estimated as the number of days' wages of the lowest-paid unskilled government worker needed to purchase medicines prescribed at a standard dose. Table 18 illustrates how many days this worker would have to work to purchase various treatments.

Comparisons with other countries

Comparisons with other countries' public sector procurement

Results for basket of medicines in Figure 2c showed that government procurement prices in Comoros (2014) were higher than those in Burundi (August, 2013), Mauritius (2008), Mongolia (October, 2012), Sudan (February, 2013) and 7 other Africa low income countries (April, 2013). Moreover the Comoros' public sector appears to be purchasing medicines less efficiently than other countries.

Comparisons with other countries' private sector prices

From Figure 3a, the basket of medicines selected to make comparison between Comoros and other countries; Amoxicillin, Co-trimoxazole and Nystatin both OBs and LPGs prices in Comoros were higher than other countries. However the median MPR innovator brand of Glibenclamide was less in Comoros than others, but for LPG of Glibenclamide in Comoros was higher than in the other low income countries in Africa.

Comparisons with other countries' public sector availability

Results for basket medicines in Figure 3b indicate that the availability of OBs of all medicines was less in Comoros than other countries. However the median

Table 18. Number of days' wages of the lowest paid government worker needed to purchase standard treatments.

Disease condition and 'standard' treatment			Day's wages to pay for treatment					
Condition	Drug name, strength, dosage form	Treatment schedule	Public patient prices			Private patient prices		
			OB	MSG	LPG	OB	MSG	LPG
Asthma duration = 30 days Number of units per treatment = 60	Salbutamol 0.5 mg/ml ampoule	1 ampoule×2×30 days=60	-	12.66	7.08	21.20	12.46	11.85
Diabetes duration = 30 days Number of units per treatment = 60	Glibenclamide 5 mg Cap/tab	1 cap/tab×2×30 days=60	-	-	0.73	1.78	0.81	0.78
Diabetes duration = 30 days Number of units per treatment = 90 days	Metformin 500 mg cap/tab	1 cap/tab×3×30 days=90 days	-	-	1.23	8.76	2.82	2.45
Hypertension duration = 30 days Number of units per treatment = 60	Nifedipine 20 mg cap/tab	1 cap/tab×2×30 days=60	-	-	1.96	5.86	2.89	2.83
Adult.Resp.infection duration = 7 days number of units per treatment =21	Mebendazole 100 mg tab-cap	1 cap/tab×3×7days=21	6.52	1.71	0.67	6.95	2.38	1.32
Adult.Resp.infection duration = 7 days Number of units per treatment=21	Amoxicillin 500 mg cap/tab	1 cap/tab×3 for7days=21	-	1.26	1.25	3.18	1.56	1.45
Paediatric.Resp.infection duration = 7 days Number of units per treatment =70	Co-trimoxazole (200+40 mg/5 ml) suspension	5 ml×2 for 7 days=70	9.42	-	2.72	9.21	4.11	2.64
Paediatric.Resp.infection Duration = 7 days Number of units per treatment =105	Erythromycin125 mg/5 ml suspension	5 ml×3 for 7 days = 105	29.15	-	9.22	-	11.91	10.90
Arthritis duration = 30 days number of units per treatment = 60	Diclofenac 25 mg cap/tab	1 cap/tab×2×30 days= 60	-	1.64	1.56	1.88	1.75	1.68
Arthritis duration = 4 days number of units per treatment = 60	Ibuprofen 100mg/5ml suspension	5 ml×3×4days=60	12.01	-	1.76	15.05	5.20	4.98
Pain/inflammation duration = 3 days Number of units per treatment= 45	Paracetamol 500 mg, 50 ml vial	5 ml ×3×3 days=45	10.01	-	3.42	-	4.43	3.76
Pyelonephritis duration = 10 days number of units per treatment = 40	Ampicillin 500 mg cap/tab	2 cap/tab×2×10 days= 40	-	2.39	1.96	4.79	2.52	2.23
Anxiety duration = 7 days Number of units per treatment = 7	Diazepam 5mg cap/tab	1 cap/tab×1×7 days=7	-	0.1	0.09	0.20	0.10	0.1

Table 18. Cont'd

Gastro intestinal health duration = 7 days Number of units per treatment = 21	Metoclopramide Hcl 10 mg tab-cap	1 cap/tab×3×7 days=21	-	0.26	0.23	-	0.25	0.22
Tropical fungal infection Duration = 7 days Number of units per treatment =21	Clotrimazole 1% cream	1 g ×3 times × for 7 days=21	0.61	-	0.18	-	0.25	0.21

availability of LPGs of Amoxicillin, Co-trimoxazole, Diazepam and Nystatin was higher than African low income countries. The LPGs of Glibenclamide and Nifedipine were less in Comoros than in other African low income countries and Sudan.

Comparisons with other countries' private sector availability

Results for basket medicines in Figure 3c showed that the availability of OBs of all the basket medicines was lower in Comoros than the other countries. The LPGs of Amoxicillin, Co-trimoxazole, Glibenclamide and Nifedipine, the median availability was lower in Comoros than in Africa low income countries and most of other countries under study. LPGs of Metformin had a median availability that was lower in Comoros than in Sudan and Mauritius and higher than in Mongolia and Burundi. The LPGs of Nystatin availability was lower in Comoros than in Burundi and Mauritius and almost the same in African low income countries.

Comparisons with other countries' public and private sector affordability

Comparisons of chronic medical condition treatment across public and private sector in terms of affordability: Figure 4a and b illustrate that in the selected countries, treatment of diabetes using Glibenclamide costs between 0.4 and 1.1 days' wages when LPGs are purchased from both private and public sector. In Comoros, the lowest paid government worker would need to spend 0.73 or 0.78 days wages to purchase the LPGs in both sectors, which shows a better affordability compared with Burundi but less affordability with other countries. When the OB is purchased, the affordability ranges from 1.3 to 6.7days' wages across the selected countries in both sectors.

Comparisons of acute medical condition treatment across public and private sector in term of affordability: Figure 4c and 5a indicate that in the selected countries, treatment of adult respiratory infection using Amoxicillin costs between 0.3 and 1.45 days' wages when LPGs are purchased from both the private and public sectors. In Comoros, the lowest paid government worker would need to spend 1.25 or 1.45 days' wages to purchase the LPGs in both sectors, which shows a lower affordability compared with other the countries. When the OBs are purchased, the affordability ranges from 1.7 to 3.18 days' wages across the selected countries in both sectors.

DISCUSSION

The present survey was done in Comoros according to the methodology described in the WHO/HAI manual for measuring medicine price. The provision for supplementary medicines allowed local morbidity patterns to be better presented. A total of 20 medicines were surveyed for the price and availability in the public, private and mission sectors in Comoros. The results of this study can be compared with a previous survey performed in Comoros (2001) in order to obtain a more precise evaluation of the availability of medicines before the reconciliation (Fomboni Agreement, 2001). This study chiefly compared the prices, availability and affordability of medicines, and also aggregated selected medicines for valid comparisons. One particularly important aspect of this study is that it included a comparison analysis of the health situation before the political conflict between Islands and the markup cost from the old procurement prices and the new one to health facilities in public sector.

Availability of all medicines survey across the sector

Results indicate that in the public sector, the procurement of medicines is inefficient, as shown by purchase prices being higher than international reference prices. By the time these medicines are sold to patients, prices have increased by 18% as a result of add on costs in the public sector distribution chain. Availability of generic medicines in public sector is noted to be poor. The average availability across all surveyed medicines was

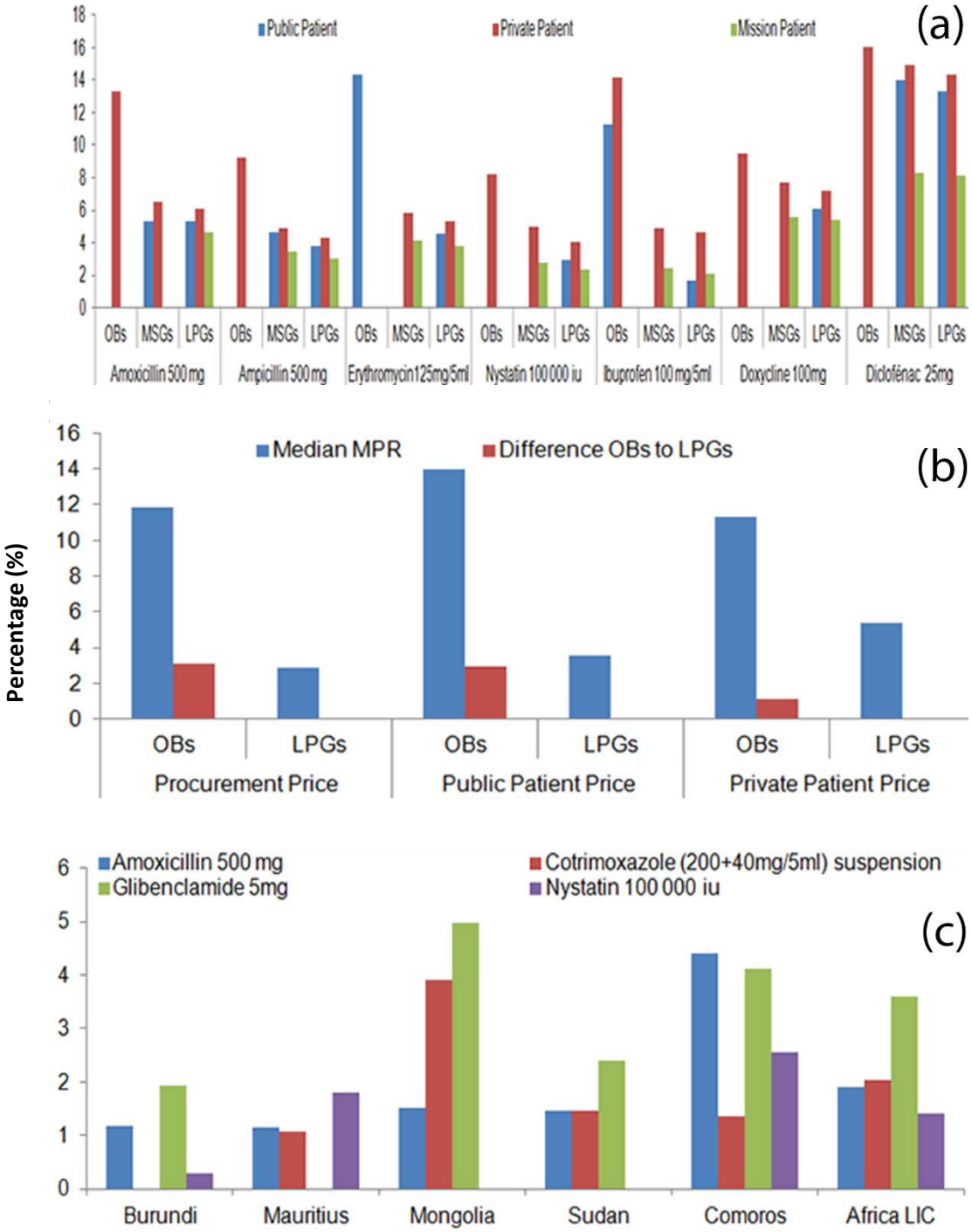

Figure 2. (a) Comparison of medicine product types MPR prices across 3 Sectors; (b) Comparison of both originator/innovator brands and generically equivalent MPR across public and private patient prices; (c) MPR comparison of a basket of medicines in Comoros and others selected countries for the public procurement price.

31.11%. The availability of the LPGs was mostly available in public sector, and the mean availability was 54.21%. Given this median availability of medicines in public sector, it can be concluded that many patients have to purchase medicines from the private sector. This difference of availability could be explained by many reasons but the most important is financial constraints. It should be noted that the availability of both MSGs and OBs medicines are rarely or not available in the public sector, with an average availability, respectively 12.63 and

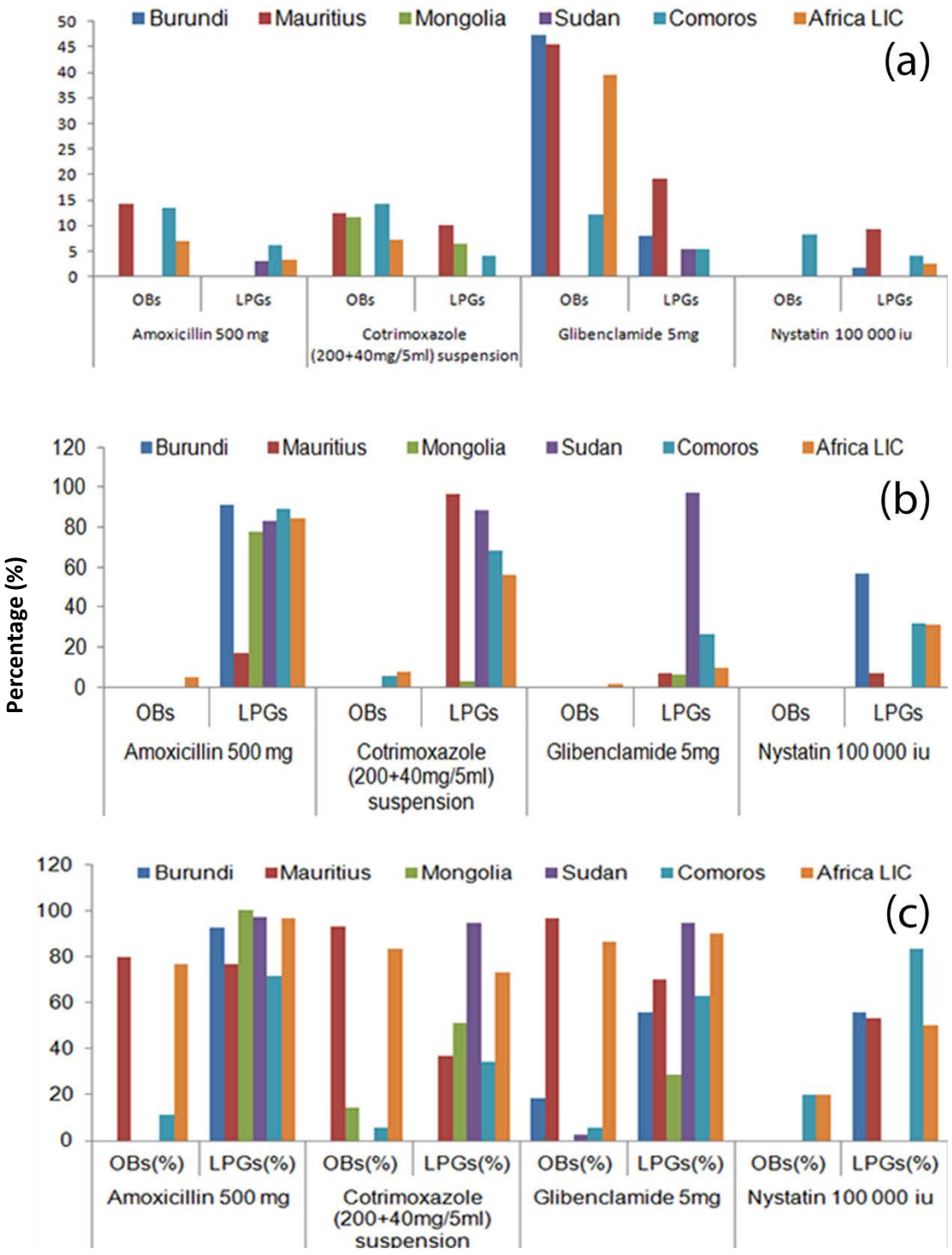

Figure 3. (a) MPR Comparison of private sector prices of a basket Medicines in Comoros and other selected countries; (b) Mean (%) Availability of basket of Medicines in Comoros in the Public Sector in Comparison with Other selected Countries; (c) Mean (%) Availability of a basket of Medicines in the Private Sector in Comoros in comparison with other Countries.

4.73%. The results of this survey indicate that the mean availability differed in public sector from Island to Island. It will be noted that in the big Island Ngazidja, most of public facilities presented all product types in contrast to

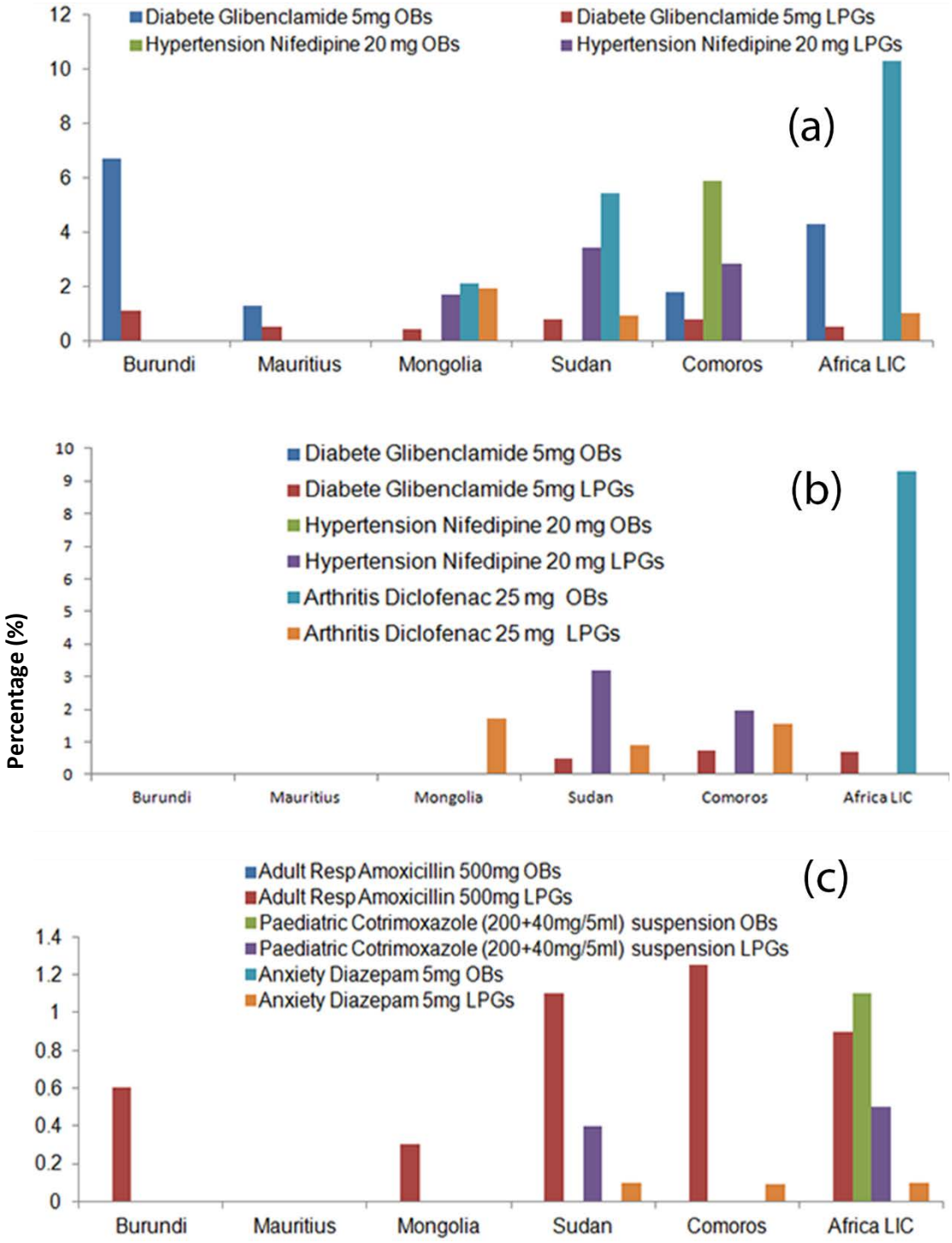

Figure 4. (a) Private Sector affordability Comparison of Chronic conditions in Comoros and other countries; (b) Public sector affordability Comparison of Chronic condition in Comoros and others countries; (c) Public sector affordability Comparison of Acute conditions in Comoros and others countries.

the smallest Island Mwali where only two kind of product type were found. In Ndzuwani, the mean availability of LPGs was higher than others. This situation of low availability of medicines in Mwali public facilities forces many patients to seek treatment from other Islands.

In the private sector, generic equivalents were the predominant product type found. Mean availability in the private sector for MSGs and LPGs was 52.19 and 49%,

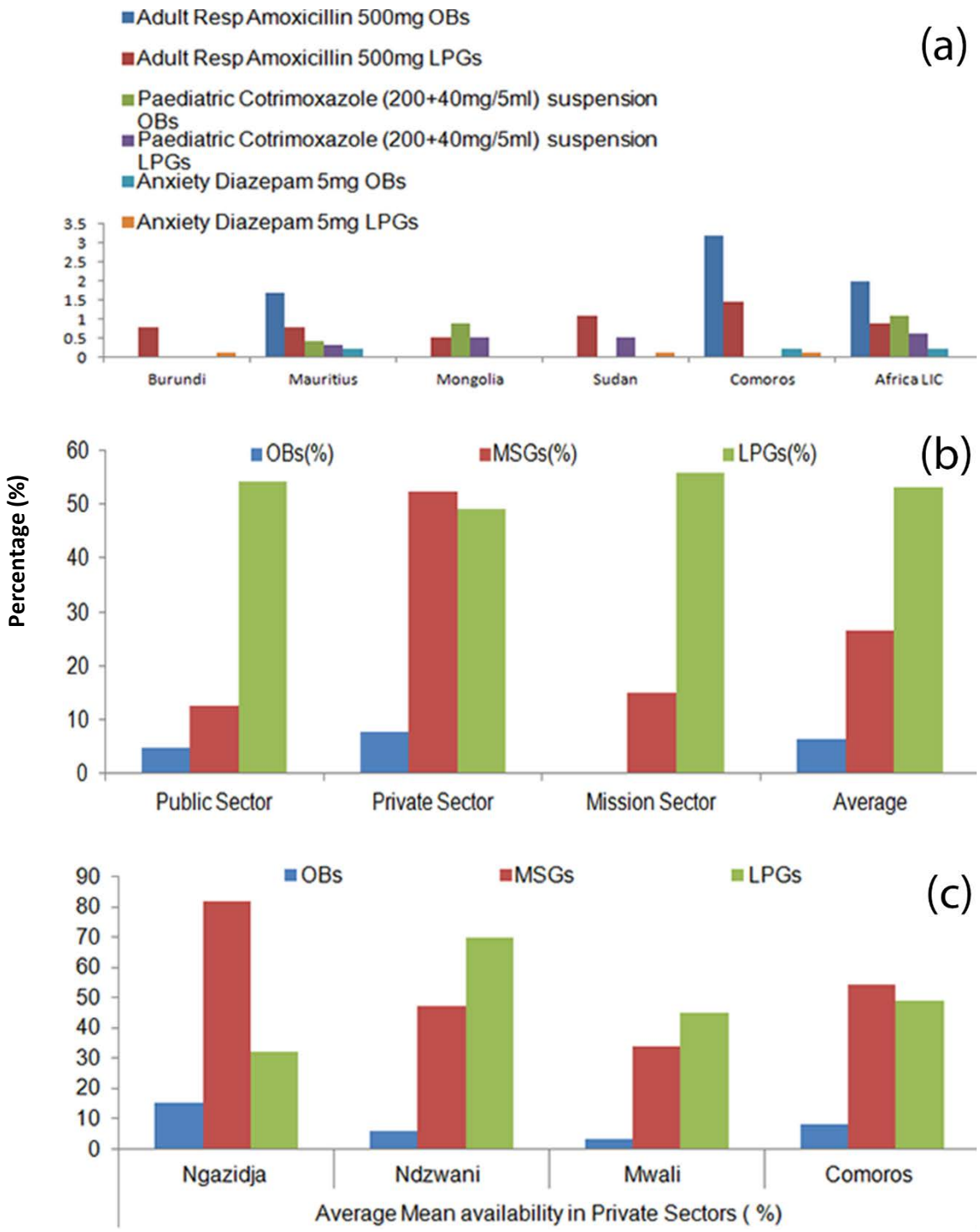

Figure 5. (a) Private sector affordability comparison of acute conditions in Comoros and others countries; (b) Mean (%) Availability Comparison of a basket medicine in Comoros and others countries; (c) Mean (%) Availability Comparison per surveyed areas in public sector.

respectively. For the OBs, mean availability in private sector was 7.86%. The mean availability however differed from island to island. Availability of medicines in private sector was higher in the three Islands for both OBs and generic equivalents (Figures 5 and 6).

In conclusion in both public and private sectors in Comoros, availability of medicines remained low. And this low availability created many disparities and inequalities

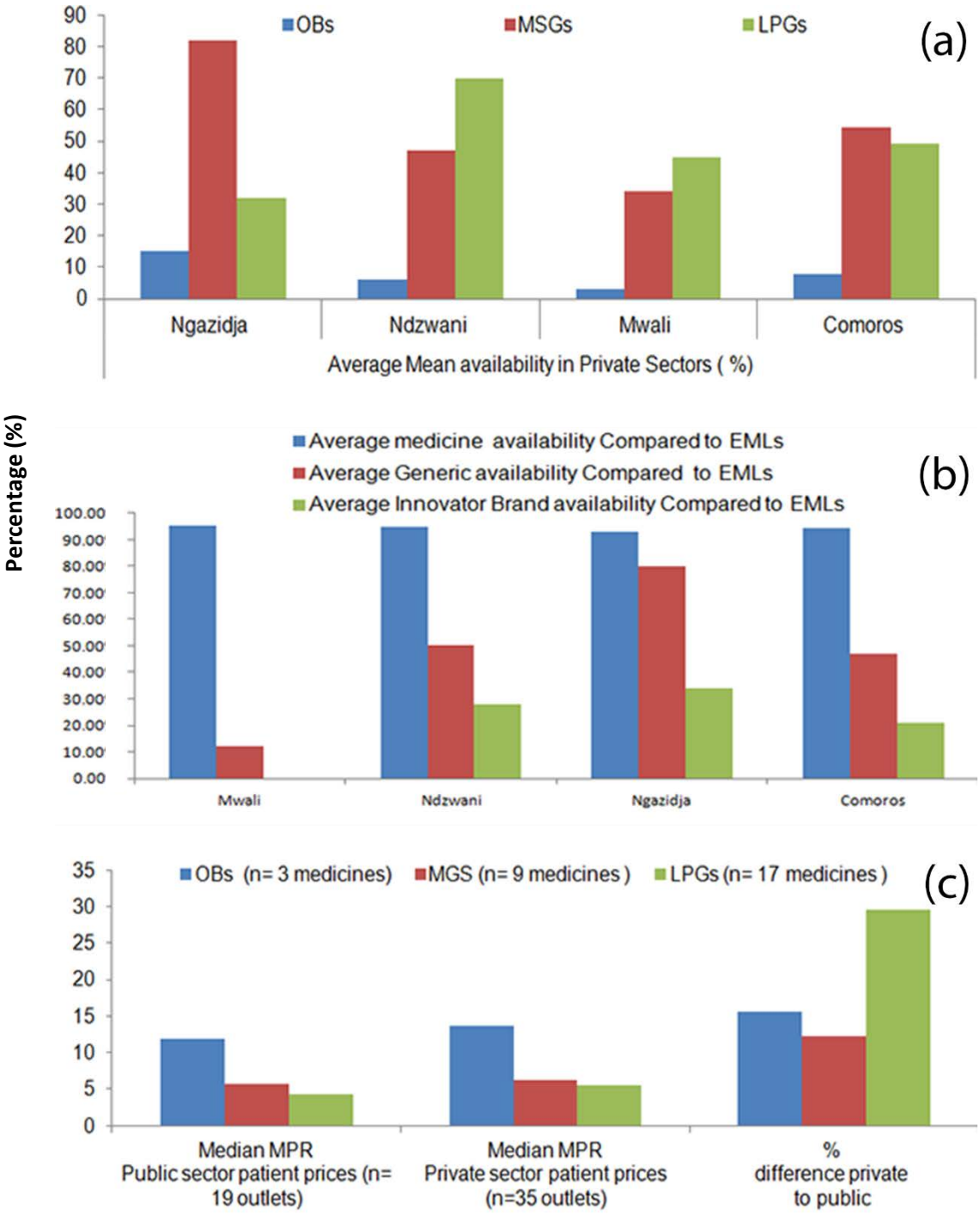

Figure 6. (a) Mean (%) availability per surveyed areas in private sector; (b) Mean Availability (%) per surveyed areas in public sector 2001; (c) Comparison of Medicine price in both private and public sectors.

between islands and also between districts. Comparing to the previous surveys conducted by the Ministry of Health and financed by World Health Organization (projet santé III, October 2001) in Comoros, the differences of availability could be explained by the political disputes and jurisdiction issues on health matters between the central government and the regional administration resulting immediately after adoption of Fomboni (2001) Union des Comores and United of Nations. (2008).

This study noted an improvement in that more than94% of most of the medicines recommended in the Essential Medicines List (EML) was now available in the health

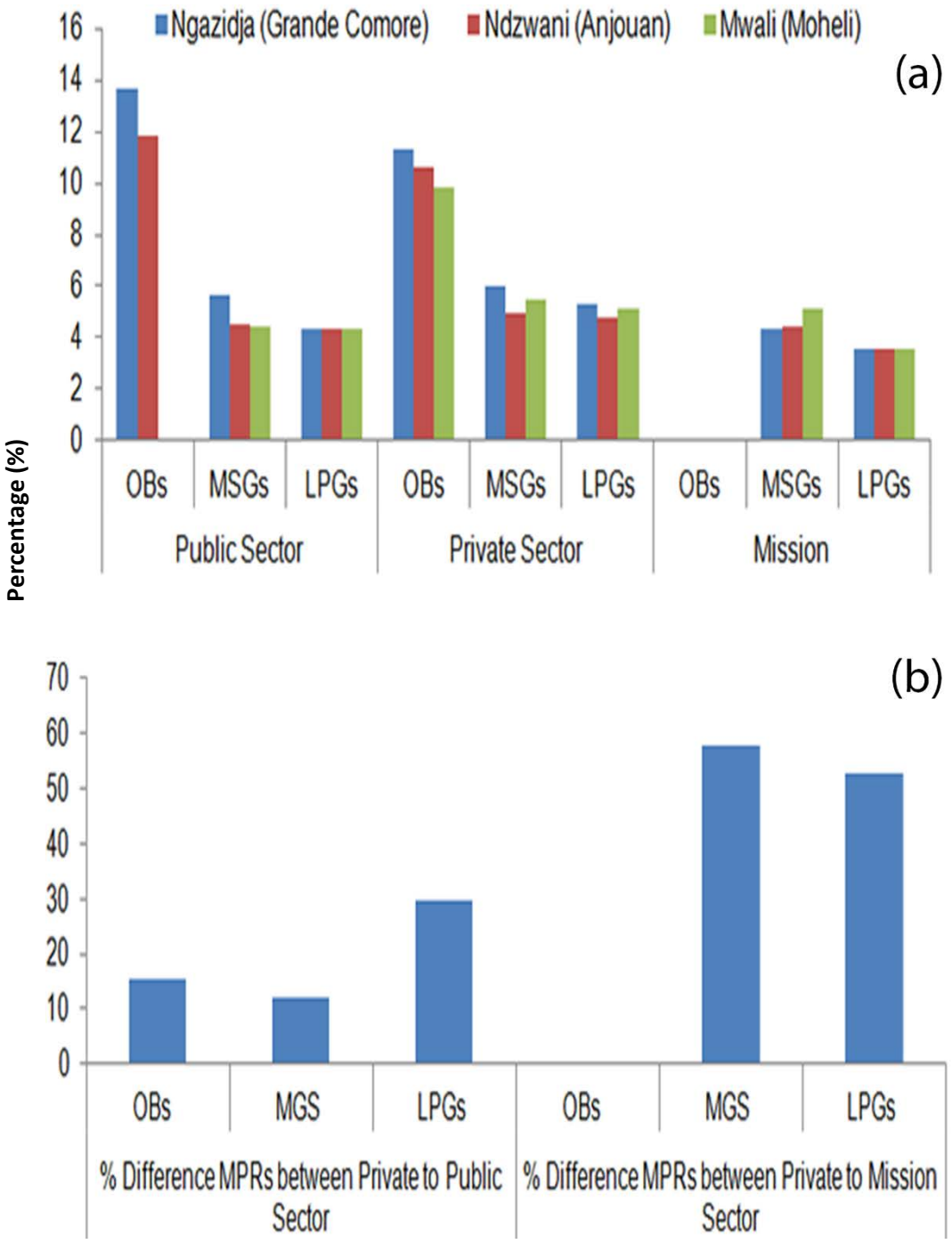

Figure 7. (a) Variation of MPRs per survey area and by sector; (b) Variation of MPR by product type between private sector and others.

health facilities. And also it was realized that more the 30% of them were innovator brands (Figure 7).

Prices

Compared to international prices it was established that the public sector procured drugs were also priced at up to 11.60, 4.74 and 3.83 times the international price for OBs, MSG and LPGs, respectively. Although the overall purchasing efficiency is indicated to be poor it was noted that the government procurement agency is purchasing a little bit efficiently when buying generics but not OBs which overall were very highly priced. The inter quartile

range does not show substantial variation in median price ratios across individual medicines. In public sector patient pricing, the MSGs were generally sold at 5.62 times their international reference prices. It should be noted the variation in MPRs across individual MSGs in public sector of the inter quartile ranged from 5.22 to 5.74. LPGs were generally sold at 4.45 times their IRP. Half of the LPGs were priced at 4.20 to 4.62 times their international reference prices; similarly therefore minimal variation in MPRs across individual generic medicines in the public sector. For OBs, the MPRs were at 13.69 times than IRP. The inter quartile variation was between 13.23 to 14.40 times than IRP.

Several reasons might explain this variation of MPRs in public facilities; first there are no national guidelines on how medicines prices are fixed in the public sector. This is why the prices patients are charged for medicines varied from facility to facility in the public sector. The medicines were higher multiples of the international reference price in both MSGs and LPGs, indicating the influence of the fact that all medicines are imported and none is manufactured within the country or region, since the liquidation of National Autonomous Comoros Pharmacy (PNAC). In the private sector, prices were a bit higher than or same in public sector. Compared with the public sector, for the medicines found in both public and private sector medicines outlets a specific analysis to allow for the comparison of prices between the two sectors was carried out and results showed that final patient prices in the private sector were higher for all the medicines individually varying as differences, private patient charged at 15.55, 12.28 and 29.49% higher for OBs, MSGs and LPGs, respectively for all medicines found. However, the average MPR patients' prices in the private sector were lower at 17.60% than in the public sector for all OBs found in both sectors. Both MSGs and LPGs, the average MPRs in private price was at 5.96 and 5.34 higher than the MSH international reference price, indicating higher mark-up rates but the study could not reveal whether the variation was related to high procurement pricing or high add-on costs, or a combination (lack of information from private sector).

The mission sector mainly gets its medicine supply and other public health services by humanitarian non-governmental organizations. From the survey it was noted that OBs were not availed by these organizations and but their generic products were priced at lower prices than both the public and private sectors. For instance the MPR values were at 4.31 and 3.55 for MSGs and LPGs, respectively than the international reference price. Compared to public and private sector, the average median MPRs prices for MSGs were at 27.68 and 23.31% lower than private and public sector, respectively. For LPGs in mission sector, the MPRs price was at 33.52 and 20.22% lower than LPGs in both sectors. This is opposite to the expectation since the mission sector is presumed to be largely sponsored by international bodies hence expectation of their pricing to be at the same level with international prices. In addition, a high variation of MPRs price medicines from Islands to Island is noted. This wide variation of MPRs might be attributed more to licensed pharmacies being located in Ngazidja than other Islands and also Ngazidja had the highest average purchasing power in Comoros.

In Comoros, the price charged to patients for both LPGs and MSGs was found to be on average 3.55 and 5.96 times higher than the international reference prices across sectors, and OBs was found to be 11.28 and 13.69 times higher than international reference. Unlike the patients in the 7 African Low Income countries (2013), the price charged to patients in both public or private sectors are higher than neighboring countries. This is therefore an indication of lack of relevant policies for price control in Comoros which are here witnessed to have direct impact on medicines and hence accessibility. It is illustrated that the price charged to patients in both Public and Mission sector for any products were found at 5 to 50% lower than the private sector.

Affordability of standard treatment regimens

In the public sector, the affordability of lowest priced generics proved adequate for some conditions, with standard treatment costing 2 days' wage or less. For instance in the treatment of diabetes, Glibenclamide 5 mg capsule/tablet or Metformin 500 mg cap/tab, the lowest government wage earner spends 0.73 or 1.23 days' wage for paying for the treatment. For adult respiratory infection with Mebendazole or Amoxicillin 500 mg cap/tab, the lowest paid government worker purchasing the lowest price generic would invest 0.67 or 1.25 days' wages. However, in the treatment for asthma using Salbutamol 0.5 mg when lowest priced generic is used, the cost is equivalent to 7.08 days' wage for the lowest paid government worker.

For the treatment of paediatric respiratory infection using Co-trimoxazole (200+40 mg/5 ml) suspension or Erythromycin for 7 days, when lowest priced generics are used, the cost incurred would be equivalent to 2.72 or 9.22 days' wage of the lowest paid government worker. These high treatment costs for the lowest paid government worker, could be a reason for high rate of mortality in children under 5 years from 122/1000 live births in 1990 to 50/ 1000 live births in 2012. In other words, in Comoros, about one in twenty births dies before reaching the age 5 (Union of Comoros, National Health Development Plan 2010/2014).

The pharmaceutical business in Comoros is still being considered like any other business, the Comorian government applies the *laissez aller* of the market (uncontrolled market), which explains the raising of medicines prices to mark up for both sectors. Like most of the developing countries the poor people in Comoros

cannot afford the drugs that could improve, extend, or save their lives. Price is not the only reason why people do not get the medicines they need, but it is a major barrier, as was indicated by Médecins Sans Frontières (MSF), in most developing countries (Pecoul et al., 1999). Secondly, in private pharmacies, often the MSG was the most generic available (54%) so it was also the LPG in that particular facility. Generally, the domestic market has many other generic equivalents that are less expensive than the MSGs. Often the retailers do not sell these lower priced generics, possibly because health care practitioners prescribe only MSGs and/or profit margins are higher.

The study has also shown differences in prices of OBs and generic equivalent medicines. In public procurement, the difference in MPR of OBs and LPGs was 310.73%. For patient prices in the public sector, the MPR difference between OBs and LPGs was 294.35%, compared to 110.45% between OBs and LPGs in private sector. This implies that the public procurement purchased inefficiently OBs. This article should be useful to government health policy makers in providing a broad picture of the present situation regarding essential medicines and suggesting ways to strengthen the national essential medicines scheme and hence bring benefits to patients. For example, a price monitoring system would be useful for supervising and controlling the availability and price of essential medicines for the population.

Limitations of the study

The main limitation is with the number of medicines selected for the study. The study was also based on the epidemiological profile of Union of Comoros, thus the essential medicines list. This could differ from one country to another.

CONCLUSION AND RECOMMENDATIONS

This survey has shown poor availability (31.11%) and high MPRs price at more than 4 times than IRP of all medicines surveyed across sectors. So even if patients visit public facility they end up buying medicines from private retail pharmacies. The disparity of availability and high pricing of medicines between Islands created some inequality in the populace of Comoros. Many people in Comoros lose their lives trying to cross 70 km of sea to Mayotte to getting free treatment (The World Bank, Comoros, 2014; Ellen, 2013). Such situation is a call on the Government to develop policies that allow for generic substitution and generic prescribing. Regular training workshops in generic substitution should also be conducted for doctors, pharmacists and patients and for awareness on the cost-effective medicines in the same therapeutic class and for the same molecule in order to achieve the lowest possible price for essential medicines (Ghislandi, 2011; Kaiser et al., 2014).

A multifaceted approach is required for medicine price regulation in the market, the first step being establishment of transparency in the supply chain. A regular publication of medicine prices of different generics by some reputed NGO/research team will increase public awareness and empowerment of consumers. Consumer consciousness about medicine price will be helpful in bringing down the prices of medicines in the market. The Government can decrease medicines prices by decreasing the margins (profits) of all actors of supply chain, by abolishing taxes on essential medicines and by promoting generics. The prices and availability of medicines in the public and private sectors should be regularly monitored, and price data published so that people are informed about medicines prices.

Competing interests

The authors declare that there are no competing interests regarding this study.

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Full Length Research Paper

Geomedical study of thyroid disorders in the foot hill settlements of Pir Panjal Range

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The present study is an, attempt to find out the concentration of Iodine (I) in soil and water phases of the natural environment, and its relationship with the human health in the foot hill settlements of Pir Panjal Range in Anantnag district of Kashmir valley. Also, socio-economic determinants of health were taken into due account. Firstly, the area was divided into altitudinal zones and soils classes. Then, the soil and water samples were taken from each soil type in each altitudinal zone and were analyzed by Atomic Absorption Spectrophotometer. The socio-economic character of the area was analyzed through surveying the area by using structured household schedules. In this area, people rely mostly on locally cultivated food items because of their economic condition. The study highlights that about 19.5, 42.9 and 37.6% households in the study area have low (Rs. <5, 000 month^{-1}), medium (Rs. 5, 000-10, 000 month^{-1}) and high (Rs. >10, 000 month^{-1}) income status respectively. The study reveals that iodine content in all the soil (0.970 to 1.230 mg kg^{-1}) and water (1.6 to 4.2 µg L^{-1}) samples in all the altitudinal zones is less than the average values in the world soils (2.8 mg kg^{-1}) and fresh waters (8.7 µg L^{-1}). About 17.6% of the population in sample villages suffers from Iodine Deficiency Disorders (IDDs). These IDDs can be ascribed to the scarcity of iodine in soils, drinking waters (and hence diet) and lifestyle. Attempts have been made to suggest certain remedial measures to minimize the magnitude of IDD sufferers in the study area.

Key words: Iodine, thyroid disorders, foot hills, cooking methods.

INTRODUCTION

Trace elements are the elements present in the earth's crust in concentrations less than 0.1% (<1000 mg kg^{-1}) or those elements that are ordinarily present in plant or animal including human beings tissues in concentrations less than 0.01% (<100 mg kg^{-1}) of the organism's dry weight (Adriano, 2001). Trace elements are necessary for life in small amounts. They are components of haemoglobin, Deoxyribonucleic acid, Ribonucleic acid, and various enzymes (Warren, 1991). Trace metals play an important role in the synthesis of both proteins and nucleic acids. There is a standard requirement of each trace element for human health (WHO, 1996). All essential trace elements either in excess states or in deficit states are known to create serious health problems particularly in the areas where these are regionally deficit (Hunter and Akhtar, 1991) or surplus. The

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concentration of trace elements in soil, water or food items is mainly determined by the geological conditions of the area (Keller, 1999; Pyle, 1979).

The human body does not make its own iodine and is dependent on dietary sources, and thus making it an essential part of our diet. The healthy adult human body contains 15 to 20 mgs of iodine, of which about 70 to 80% is in the thyroid gland. The normal intake and requirement of iodine is 100 to 150 µg d^{-1} (Masoodi, 2012; Fuge, 2005).

It is an essential element that is critical for the normal growth and development, and well being of all humans. Iodine deficiency is associated with reduced thyroid hormone synthesis, leading to increased thyroid stimulating hormone levels, which stimulates thyroid over growth and goiter (Jamescon and Weetman, 2005). The distribution of iodine is uneven in the biosphere. Its deficiency does not cause a mere enlargement of thyroid gland (endemic goiter), it can cause a variety of disorders called iodine deficiency disorders (IDDs) or thyroid disorders consisting of hypothyroidism, endemic cretinism, still-births, mental retardation, defects in vision, hearing and speech, and neuromuscular weakness.

These disorders are mainly found in those people who live away from coastal areas, in mountainous areas, previously glaciated areas and the like. Even people living in coastal areas and on islands suffer from IDDs because sea salt does not contain iodine content as much as required by the people and due to their unsuitable habits (UNICEF, 2002). World health organisation estimated that about 20 to 60% of the world's population is iodine deficient (Zimmermann, 2009) with most of the burden in developing countries. Mayer while working out the goiter incidence in Kashmir Valley during 2004 to 2005 found that Anantnag district (a part of foot hills) has the highest incidence of goiter, and he suggested that nature of bedrock and soils is responsible for the variable goiter incidence in the valley.

According to a recent research conducted on school children of Kulgam district which is a part of the foot hills of Pir Panjal range, it was found that 18.9% suffer from Total Goiter Rate (TGR); 21.2% boys and 16.7% girls (Khan et al., 2014). Since, the incidence/prevalence of thyroid disorders is a significant health problem covering an appreciable section of the society in the foot hills of Pir Panjal range, the present study was attempted to investigate its the possible causes and factors of both geochemical and socio-economic origins in the area.

Study area

The area taken in this study is a part of the Kashmir region located roughly between the elevations of 1,800 meters to 3,000 meters above the mean sea level (m AMSL). The area lies between 33°23´ 08" N to 332°65´90" N latitudes and 74° 55 75° 10' 05'' to 75° 35′ 20'' E longitudes**,** covering an area of about 547.04 km^2 (Figure 1) with a population of about 1, 88,055 (Census, 2011). The soils of the concerned area vary in origin from alluvial to lacustrine and glacial (Figure 2 and Table 1).

METHODOLOGY

A comprehensive methodology has been adopted to carry out the present study. Figure 3 shows the general data base and methodological scheme divided into many related steps in order to accomplish the objectives of the present work.

GIS techniques

The study area was delineated from Survey of India (SOI) toposheets of 1:50,000 scale of 1971 with numbers as 43 O/2, 43 O/3, 43 O/6 and 43 O/7 with the help of Arc View 3.2a software. The base contour was taken as 1,800th m AMSL and top one as 3,000th m AMSL (Raza et al., 1978). These two contours were connected on the lateral sides by taking the watershed limits through digitization.

By digitizing 2,400th m contour, the area under study was divided into two altitudinal zones, namely, Lower Foot Hills (LFHs) and Upper Foot Hills (UFHs) varying in altitude from 1,800th-2,400th m and 2,400th-3,000th m respectively. The LFHs are characterized by good permanent human occupancy, while as the UFHs experience mostly seasonal human inhabitations. By digitizing 2,100th m contour, the LFHs were further sub-divided into two sub-zones namely, LFHs-1 and LFHs-2 varying in elevation from 1,800th-2,100th m and 2,100th-2,400th m (Figure 4a) for comparative analysis.

Stratified random sampling technique was used for the selection of sample sites (sample villages, soil and water sample sites), and sample households as shown in Tables 2 and 3 and Figures 4b, 5a and 5b.

Field Work

The soil samples were collected in clean unused polythene bags and were labeled properly. A clean spade was used to take the soil samples. In order to reduce variability, a composite sample was obtained from each sample site. A composite sample comprised of five sub-samples taken from each sample site in 10 m × 10 m grid format. Four sub-samples were taken from four corners of the square and one from the center. Soil samples were taken from depths of 0 to 20, 0 to 40 and 0 to 60 cm in relation to different major land uses that is, agricultural, horticultural and forest respectively (Brady, 1991; Pennock et al., 2008). Water samples were collected in clean unused plastic bottles from the selected sample sites and were labeled properly, and were taken to the lab within 24 h. Both types of samples were analyzed in Research Centre for Residue and Quality Analysis Lab, SKUAST, Shalimar. The socio-economic survey was done through the structured schedules to give the socio-economic picture of the area and to assess the dependence of people on local food items, income status, methods of cooking, households using iodized salt and boiled drinking water and percentage of households purchasing food from the market. The data regarding the prevalence of IDDs was collected from the prescriptions given by the registered practitioners.

Lab work

The soil samples were air-dried, crushed with a wooden roller,

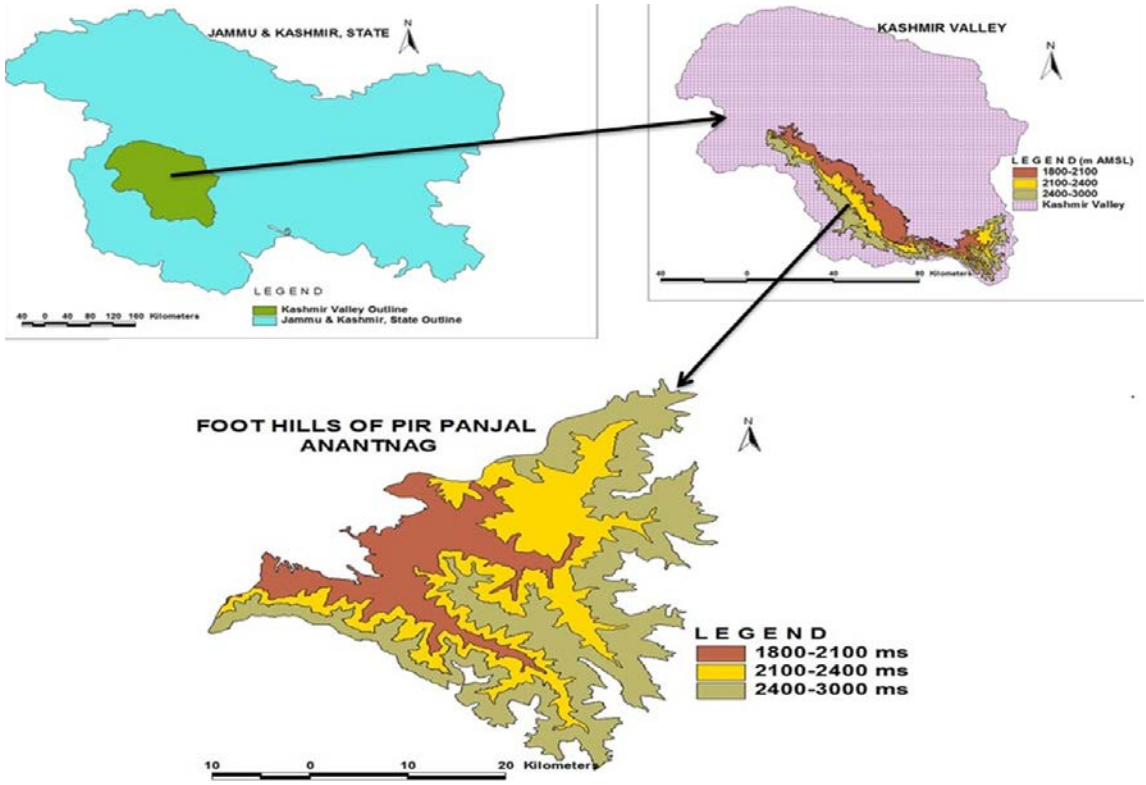

Figure 1. Location map of foot hills of Pir Panjal range in Anantnag (Generated from SOI toposheets, 1971).

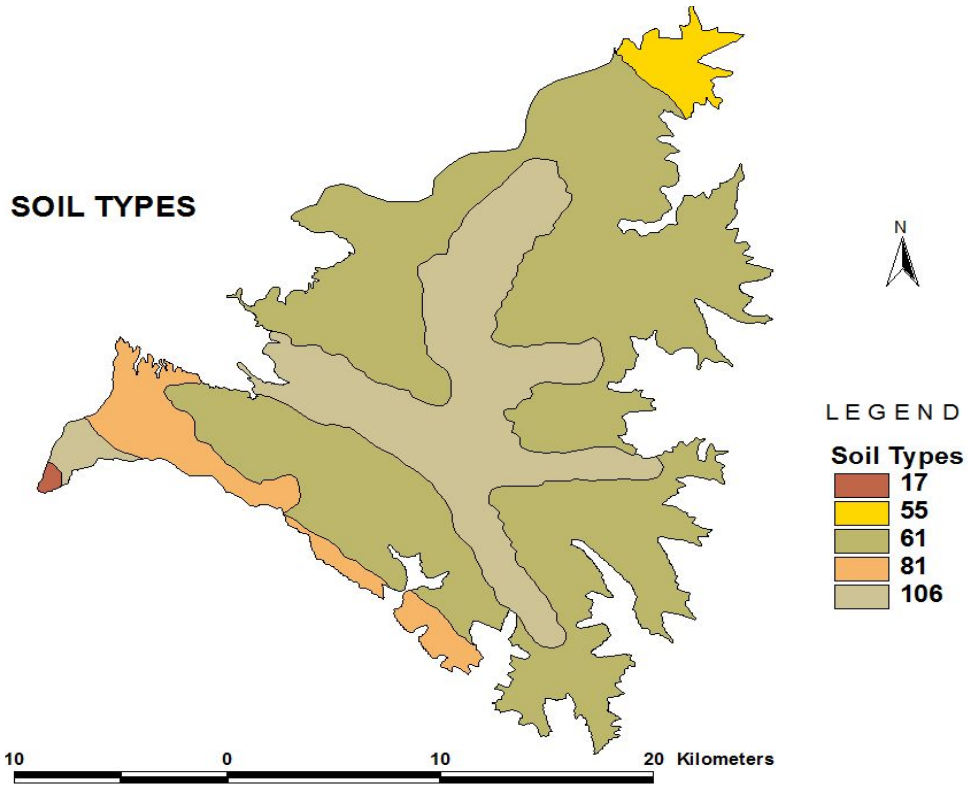

Figure 2. Soil map of the study area (Generated from Soil Map of J & K, ICAR, Nagpur-2010).

Table 1. Soil types with codes and description.

Code	Description	Soil type
17	Dominantly rock outcrops; associated with shallow, loamy, calcareous soils on steep to very steep slopes with loamy surface, strong stoniness and severe erosion	Lithic. Cryorthents
55	Deep, well drained coarse-loamy soils on gentle slopes with loamy surface, moderate erosion and slight gravelliness; associated with deep, well drained, coarse loamy, calcareous soils with loamy surface, moderate erosion and slight gravelliness	Typic Cryofluvents
61	Medium deep, well drained, loamy-skeletal soils on moderate slopes with loamy surface, severe erosion and strong stoniness; associated with medium deep, well drained, fine-loamy soils with loamy surface, moderate erosion and moderate stonniness.	Typic Udorthents/ Dystric Eutrochrepts
81	Deep, moderately well drained, fine soils on very gentle slopes with loamy surface; associated with deep, well drained, fine-loamy soils with loamy surface	Typic Hapludalfs/ Dystric Eutrochrepts
106	Medium deep, well drained, fine loamy soils on moderate slopes with loamy surface and moderate erosion; associated with shallow, excessively drained, loamy soils with loamy surface, moderate erosion and strong stonniness	Dystric Eutrochrepts/ Lithic Udorthents

Source: Modified from Soil Map of J & K, ICAR, Nagpur-2010.

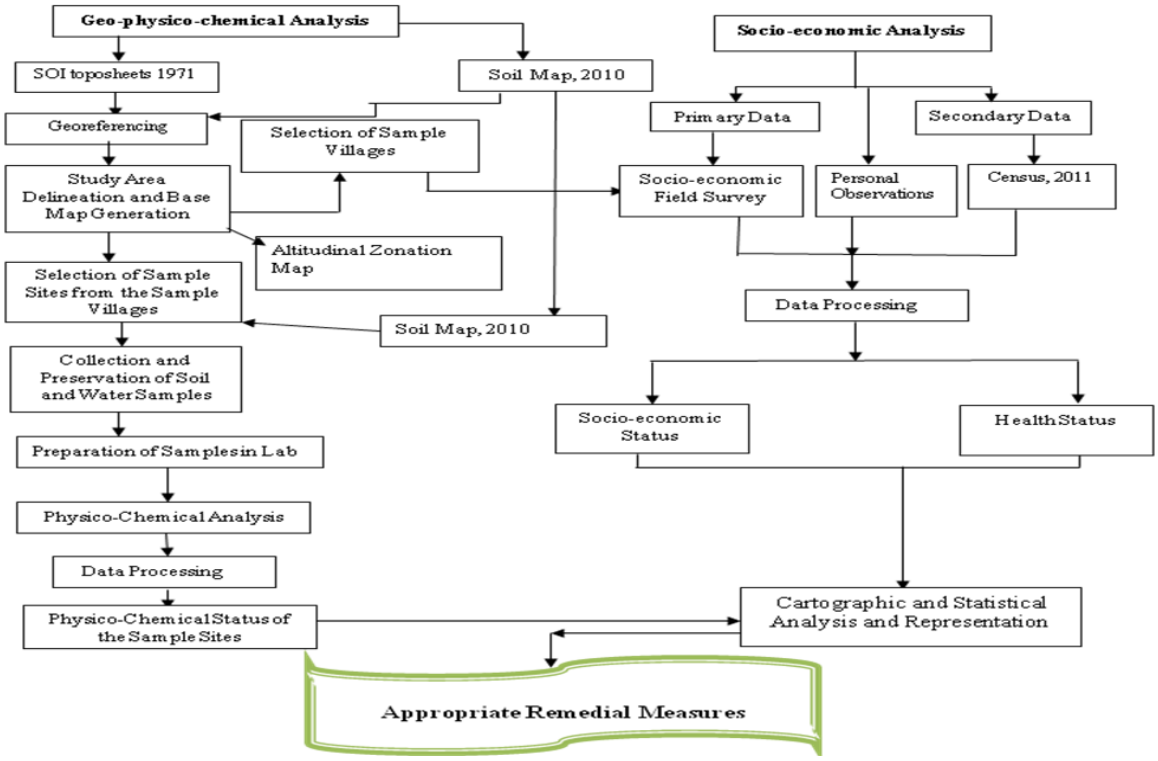

Figure 3. Flow chart of methodology.

passed through a 10 mesh (<2 mm) sieve, and then ground in an agate mortar. The recovered <63 µm particles were separated for chemical analysis. The samples were analyzed under Atomic Absorption Spectrophotometer (AAS-4141, Electronic Corporation

Table 2. Sample frame.

Macro regions (Altitudinal zones in meters AMSL)	Micro regions (Sub-altitudinal zones in meters AMSL)	Sample villages	Total No. of households in the sample villages	Number of households Surveyed	Percentage of surveyed Households to total Households	Soil type (Codes)	Number of samples taken	Main water source	No. of samples taken
Lower foot hills (LFHS)-1,800-2,400	LFHs-1 (1,800-2,100)	Bidder Hayat Pora	77	08	>10	61	01	TSg	01
		Bindoo Zalan Gam	519	52	>10	106	01	TSm	01
	LFHs-2 (2,100-2,400)	Hala Pora	292	29	<10	61	01	TSm	01
		Gaw Ran	252	25	<10	106	01	TSg	01
Upper foot hills (UFHs)-2,400-3,000	UFHs (2,400-3,000)	Raing Mandoo	143	14	<10	61	01	Sg	01
		Chuntwar	00	00	00	106	01	00	00
Total	-	-	1,283	128	10	-	06	-	05

Source: Generated by the authors.

Table 3. Sample villages and sample sites with codes and geo-coordinates.

Macro regions (Altitudinal zones in meters AMSL)	Micro regions (Sub-altitudinal zones in meters AMSL)	Sample villages/sites	Sample village/site (Codes)	Geo-coordinates (Lat./Long.)
Lower Foot Hills (LFHs)-1,800-2,400	LFHs-1 1,800-2,100	Bidder Hayat Pora	SS1-ANG	33°36'23° N & 75° 17'54"E
		Bindoo Zalan Gam	SS2-ANG	33° 34'45°N & 75° 18'17"E
	LFHs-2 2,100-2,400	Hala Pora	SS3-ANG	33° 30'40°N & 75° 21'07"E
		Gaw Ran	SS4-ANG	33°35'24°N & 75° 21'26"E
Upper Foot Hills (UFHs)-2,400-3,000	UFHs 2,400-3,000	Raing Mandoo	SS5-ANG	33° 26'38°N & 75° 22'24"E
		Chuntwar	SS6-ANG	33°34'15°N & 75° 24'08"E

Source: SOI toposheets, 1971.

Limited, India). A total concentration of I was determined after 4-acid digestion (HF, HClO4, HNO3 and HCl) by AAS. The samples were analyzed for iodine, pH and organic matter (OM).

RESULTS AND DISCUSSIONS

Concentration of Iodine in the soil and drinking water sources

The study showed that the soils and drinking water sources of the foot hills of Pir Panjal range in Anantnag district are deficient in iodine content in all the altitudinal zones (Tables 4 and 5), and have iodine content less than the world averages.

From Table 4, it is obvious that the soils are iodine deficient at all the elevation levels in the study area. The organic matter and pH influence the concentration of iodine in the soils. In soil type-61, iodine content first increases with altitude because of increase in OM in the soil, and then slightly decreases with altitude due to increasing slope and coarser texture of soil. OM binds up iodine ions in the soil but the increasing slope and coarser texture cause iodine ions flow and translocate easily during rainfalls. In soil type-106, iodine content first decreases with altitude because of increase in the acidity of the soil and then increases with altitude. The acidic pH in soil catalyzes the loss of iodine ions in soil through leaching.

Likewise, Table 5 shows the concentration of iodine in drinking water sources in the area. Iodine content in drinking water sources first increases with altitude and then decreases. It shows affinity

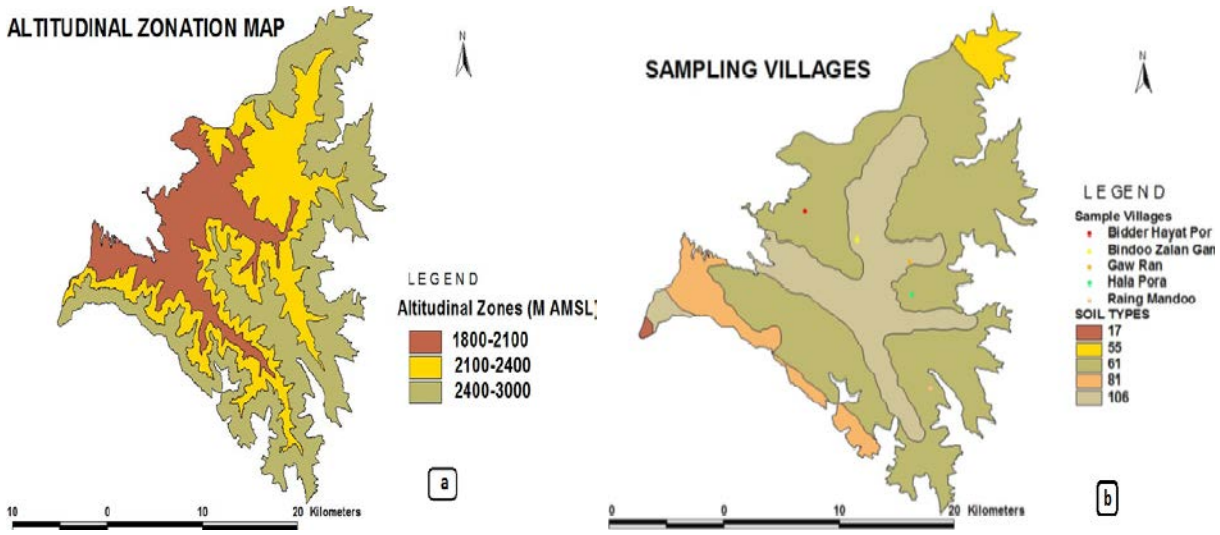

Figure 4. (a) Altitudinal zonation map and (b) Sampling villages.

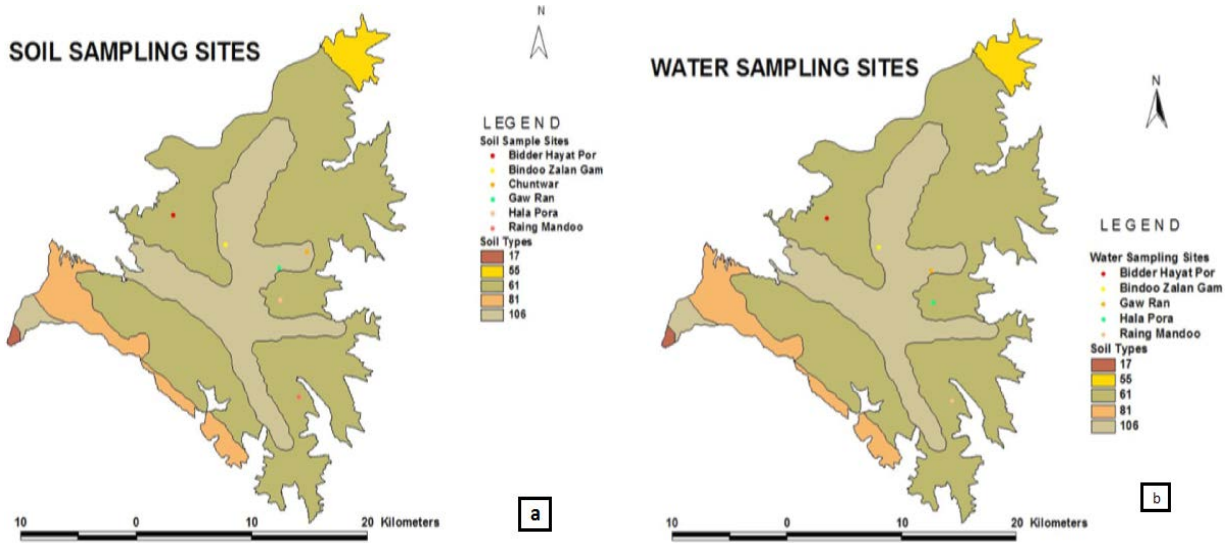

Figure 5. (a) Soil Sampling Sites and (b) Drinking water sampling sites.

to the surrounding soils and their physico-chemical character.

Prevalence of Iodine deficiency diseases

The study revealed that about 17.6% people suffer from different IDDs in all the age-sex groups (Table 6). These people have greater (66.89%) dependence on locally cultivated food items because of their disadvantaged economic condition. More than 62.4% households comprising low and medium income status households fall below poverty line as per international standards of income-based poverty lines (Rs. 2371.5 month^{-1} person^{-1}). They also have inadequate income as per the local economic scenario is concerned.

It is evident from the Table 6 that in the sample village of UFH region, about 30.2% people suffer from IDDs as compared to 24.0% of LFH region. This variation can be attributed to the greater dependence of people on locally cultivated iodine deficit food items, and less use of iodized salt in UFHs than the people in LFHs (Table 7). In the sample village in UFHs, about 92.9% households fall in low and medium income groups (Table 8) which forces them to rely on whatever food items they cultivate locally. About 92.85% households have >50% dependence on

Table 4. Iodine content, pH and organic matter of soil types.

Macro regions	Micro regions	Sample sites	Soil type	Iodine conc. (mg kg^{-1})	pH	Organic matter (OM in %)
Lower foot hills	LFHs-1 (1,800-2,100 m AMSL)	SS1-ANG	61	0.980	6.42	2.15
		SS2-ANG	106	1.000	6.51	3.76
	LFHs-2 (2,100-2,400 m AMSL)	SS3-ANG	61	1.230	6.28	3.76
		SS4-ANG	106	0.970	5.88	3.42
Mean				1.05	6.27	3.27
Upper foot hills	UFHs (2,400-3,000 m AMSL)	SS5-ANG	61	1.050	6.42	4.90
		SS6-ANG	106	1.000	6.56	1.34
Mean	-	-	-	1.03	6.49	3.12
Mean	-	-	-	1.04	6.35	3.22
Standard deviation	-	-	-	0.0893mg kg^{-1}	-	-
Coefficient of SD	-	-	-	0.0859	-	-
Coefficient of variation	-	-	-	8.6003%	-	-

Source: Based on soil sample analysis done by the authors, 2013.

Table 5. Iodine content and pH of water sources.

Macro regions	Micro regions	Sample sites	Water source	Iodine Conc. (µg L^{-1})	pH
Lower foot hills	LFHs-1 (1,800-2,100 m AMSL)	SS1-ANG	TSg	1.6	7.53
		SS2-ANG	TSm	2.5	7.85
	LFHs-2 (2,100-2,400 m AMSL)	SS3-ANG	TSm	3.9	7.87
		SS4-ANG	TSg	4.2	7.54
Mean				3.05	7.70
Upper foot hills	UFHs (2,400-3,000 m AMSL)	SS5-ANG	Sg	4.1	7.75
Mean	-	-	-	4.1	7.75
Mean	-	-	-	3.26	7.71
Standard Deviation	-	-	-	1.6600 µg L^{-1}	-
Coefficient of SD	-	-	-	0.5092	-
Coefficient of Variation	-	-	-	50.920%	-

Source: Based on water sample analysis done by the authors, 2013, Note: TSg=Tap fed by a spring, TSm=Tap fed by a stream, Sg=Spring.

local iodine deficit foods, and 42.8% people used iodized salt in UFHs as compared to the LFHs in which about 81.76% households in the sample villages have >50% reliance on local foods and 75.4% people use iodized salt (Table 7).

The prevalence of IDDs in LFHs shows a decline from LFHs-1 to LFHs-2. About 17.4% people suffer from IDDs in LFHs-1 as compared to 16.4% in LFHs-2 (Table 6). This variation seems to be outcome of the differential lifestyles especially the food cooking methods. In LFHs-1, about 96.7% households surveyed are accustomed to inappropriate cooking methods such as long period boiling, braising, blanching and frying as compared to LFHs-2 in which the value is 83.4% (Table 7).

The prevalence of IDDs in the sample villages in the sub-zones decreases with altitude with respect to changing iodine, pH and OM content in the respective soil types and socio-economic conditions with the exception of SS5-ANG. In the LFHs-1, SS1-ANG (soil type-61) records 21.4% and SS2-ANG (soil type-106) records 16.9% of patients and in LFHs-2, SS3-ANG (soil type-61) records 16.4% and SS4-ANG (soil type-106) records 16.5% of patients and in UFH sub-zone, SS5-ANG (soil type-61) experiences 22.2% of patients to its

Table 6. Prevalence of IDDs in different altitudinal zones (by age and sex).

Macro region	Micro region	Sample villages	Number of persons surveyed (100%)	Age groups	Sex	Number of persons suffering from IDDs (% cases to total)	
						Person suffering from IDD (Thyroid)	Person suffering from no IDD
LFH	LFHs-1	SS1-ANG	6	Children (1-14)	M	1 (16.6)	5 (83.4)
			4		F	1 (25)	3 (75)
			8	Adults (15-50)	M	2 (25)	6 (75)
			8		F	2 (25)	6 (75)
			1	Olds (>50)	M	0 (0)	1 (100)
			1		F	0 (0)	1 (100)
		Total	28	-	-	6 (21.4)	22 (79.6)
		SS2-ANG	36	Children (1-14)	M	7 (19.4)	29 (80.6)
			40		F	8 (20.0)	32 (80.0)
			52	Adults (15-50)	M	7 (13.5)	45 (86.5)
			52		F	9 (17.3)	43 (82.7)
			27	Olds (>50)	M	3 (13.1)	20 (86.9)
			23		F	5 (18.5)	22 (81.5)
		Total	230	-	-	39 (16.9)	191 (83.1)
	Total	-	258	-	-	45 (17.4)	213 (82.6)
	LFHs-2	SS3-ANG	14	Children (1-14)	M	3 (21.4)	11 (78.6)
			9		F	1 (11.1)	8 (88.9)
			29	Adults (15-50)	M	5 (17.2)	24 (81.8)
			28		F	5 (17.8)	23 (82.2)
			15	Olds (>50)	M	2 (13.4)	13 (85.6)
			15		F	2 (13.4)	13 (85.6)
		Total	110	-	-	18 (16.4)	92 (83.6)
		SS4-ANG	16	Children (1-14)	M	3 (18.7)	13 (81.3)
			12		F	1 (8.4)	11 (91.6)
			25	Adults (15-50)	M	4 (16.0)	21 (84.0)
			24		F	5 (20.8)	19 (79.2)
			7	Olds (>50)	M	1 (14.3)	6 (85.7)
			7		F	1 (14.3)	6 (85.7)
		Total	91	-	-	15 (16.5)	76 (83.5)
	Total	-	201	-	-	33 (16.4)	168 (83.6)
Total	-	-	459	-	-	78 (17.0)	381 (83.0)
UFHs	UFHs	SS5-ANG	14	Children (1-14)	M	3 (21.4)	11 (78.6)
			11		F	2 (18.2)	9 (81.8)
			14	Adults (15-50)	M	4 (28.6)	10 (71.4)
			14		F	2 (14.3)	12 (85.7)
			5	Olds (>50)	M	2 (40)	3 (60.0)
			5		F	1 (20)	4 (80.0)
Total			63	-		14 (22.2)	49 (77.8)
Grand total			522	-		92 (17.6)	430 (82.4)

Source: Sample survey, 2013.

Table 7. Showing households drinking boiled water, households using iodized salt, dependence of people on locally cultivated food items and methods of cooking.

Macro region	Micro region	Sample villages	Number of households surveyed (100%)	Households drinking boiled water (%)	Households using iodized salt (%)	Dependence on local food items (%)		Food purchased from market (%)	Methods of cooking foods (%)	
						<50%	>50%		Deep[1]	Light[2]
LFHs	LFHs-1	SS1-ANG	8	6 (75)	6 (75.0)	37.5	62.5	37.8	8 (100)	0 (0)
		SS2-ANG	52	35 (67.3)	40 (76.9)	00	100	23.85	50 (96.2)	2 (3.8)
	Total	-	60	41 (68.3)	46 (76.7)	18.75	81.25	30.83	58 (96.7)	2 (3.3)
	LFHs-2	SS3-ANG	29	14 (48.3)	19 (65.5)	3.45	96.55	30.17	25 (86.2)	4 (13.8)
		SS4-ANG	25	10 (40)	21 (84.0)	32	68	43.00	20 (80.0)	5 (20.0)
	Total	-	54	24 (44.4)	40 (74.1)	17.73	82.27	36.58	45 (83.4)	9 (16.6)
Total		-	114	65 (57.02)	86 (75.4)	18.24	81.76	33.71	103 (90.4)	11 (9.6)
UFHs	UFHs	SS5-ANG	14	0 (00)	6 (42.8)	7.14	92.85	32.5	12 (85.7)	2 (14.3)
Grand total		-	128	65 (50.7)	92 (71.8)	12.69	87.31	33.11	107 (93.8)	13 (6.2)

Source: Sample survey, 2013; Note: Deep[1]=Long period Boiling/Braising/Blanching/Frying, Light[2]=Short period Boiling/Braising/Blanching/Frying.

Table 8. Income levels of households surveyed (Rs. %).

Macro region	Micro region	Sample villages	Number of households surveyed (100%)	Average family size (numbers)	Income levels of households surveyed (Rs.%)		
					Low (<5, 000)	Medium (5, 000-10, 000)	High (>10, 000)
LFHs	LFHs-1	SS1-ANG	8	6	2 (25.0)	2 (25.0)	4 (50.0)
		SS2-ANG	52	7	8 (15.4)	24 (46.1)	20 (38.5)
		Total	60	6.5	10 (16.7)	26 (43.3)	24 (46.0)
	LFHs-2	SS3-ANG	29	7	6 (20.7)	10 (34.4)	13 (44.9)
		SS4-ANG	25	6.5	5 (20.0)	10 (40.0)	10 (40.0)
		Total	54	6.75	11 (20.4)	20 (37.0)	23 (42.6)
Total			114	6.63	21 (18.4)	46 (40.4)	47 (41.2)
UFHs	UFHs	SS5-ANG	14	7.3	4 (28.6)	9 (64.3)	1 (7.10)
Grand total			128	6.96	25 (19.5)	55 (42.9)	48 (37.6)

Source: Sample survey, 2013.

total surveyed population. The increase in the percentage of patients suffering from IDDs in SS5 -ANG is due to high (4.90%) OM in soil (Table 4).

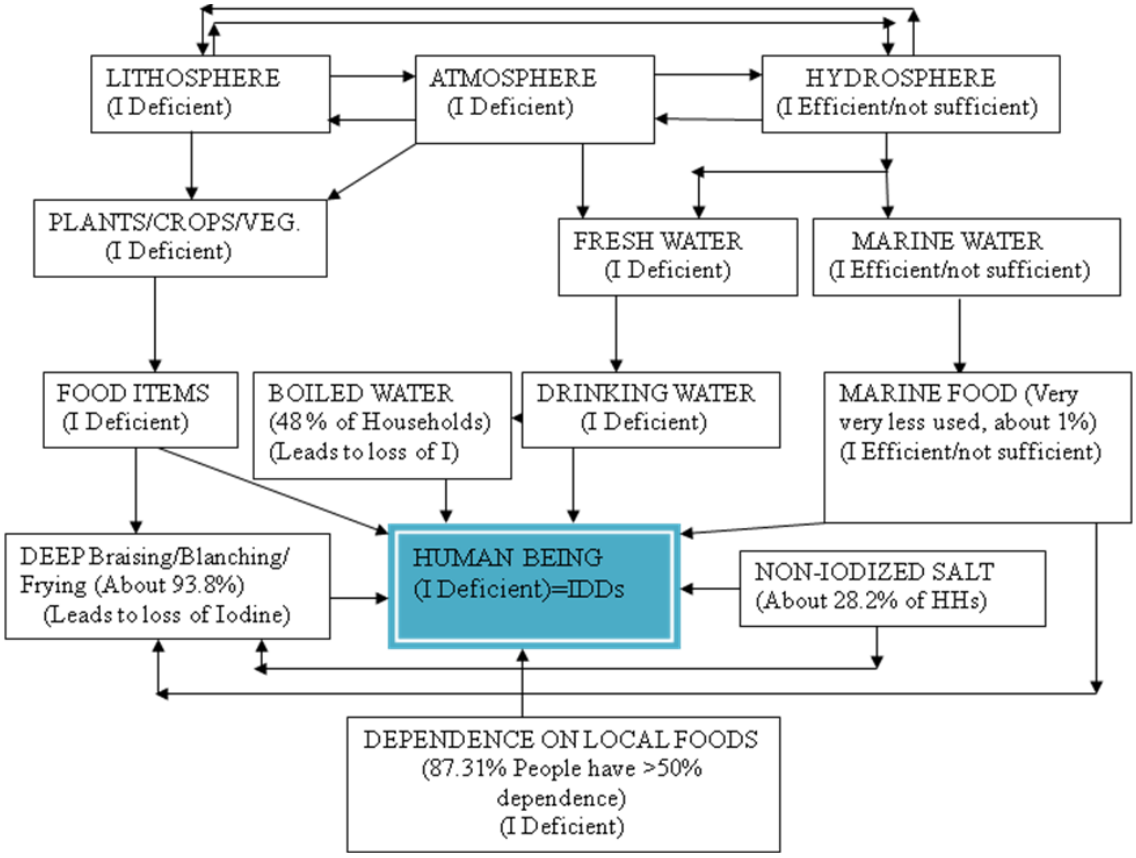

Figure 6. Schematic diagram showing transfer and loss of iodine at different stages of iodine transfer and the consequent results in human beings (Developed by the authors).

Though the concentration of iodine at SS5-ANG is relatively greater than some of the other sites, it has the disadvantage of having high OM. The OM decreases the bioavailability of iodine for the plants/crops resulting in iodine deficient foods. It may also be attributed to the greater dependence of the people on local foods (Table 7). Difference in the percentage prevalence of IDDs with respect to age and sex groups can be attributed to the relative differences in the life styles.

A diagrammatic model (Figure 6) has been developed related to the present study that shows cyclic movement of the iodine in the different phases of environment, the pathways on how iodine reaches the human body, its losses at different stages of movement at the dual hands of nature and humankind and the consequent results that is, IDDs. The diagram also highlights the role of natural pools of iodine transfer and the life style of the people of the area under study in contributing the causation of the different IDDs. The lithospheric and atmospheric pools of natural environment are iodine deficient while as the hydrospheric pool is efficient in iodine content but not sufficient to save human beings from IDDs. So, the food derived from the soil is deficient in iodine. An individual human being derives only about 0.5 µg d^{-1} of iodine from inhalation (Nordic Project Group, 1995). The marine food is rich in iodine but unfortunately people make less use of marine foods perhaps because of their low income status and high price of the food. The problem of iodine deficiency and loss from whatsoever food and water is used is further coupled by the unsuitable and unhealthy cooking methods and other lifestyles.

CONCLUSION

In all the altitudinal zones, the iodine content in the soil (0.970 to 1.230 mg kg^{-1}) and fresh (drinking) water (1.6-4.2 µg L^{-1}) sample sites is less than the world level averages in soils (2.8 mg kg^{-1}) and drinking water (8.7 µg L^{-1}) sources. The iodine content in soils showed a close association with OM and pH. Iodine in soils has direct relationship with OM and inverse relationship with pH. Iodine content in water samples showed a relationship with iodine content in surrounding soils. Leaching and run-off play an important role in the transfer of iodine from surroundings soils to water bodies. About 17.6% people surveyed suffer from thyroid disorders. There is decrease in the prevalence of IDDs from LFHs to UFHs and from LFHs-1 to UFHs-2 because of the lifestyle of people. At sample village level, there is also a decrease in the

percentage prevalence of IDDs with altitude in respective soil types except SS5-ANG of UFH region. This is due to high (4.90%) OM in soil at SS5-ANG and dependence on vegetarian food.

RECOMMENDATION

Certain simple and low cost suggestions to minimize the magnitude of IDD sufferers in the area under study are needed for the area is rural in character. The people of the area should make 100% use of iodized salt by the whole population. Special care should be taken of pregnant and nursing mothers after consulting a registered medical practitioner. They should avoid long period boiling, braising, blanching and frying of foods to avoid the loss of nutrients especially iodine. Iodine should be added to drinking water and the irrigational water through fertigation to increase the content of iodine in the natural systems of soil and water. More and more sea foods, eggs, dairy products, watercresses, iodized salt, grains and fruits should be used. The people should also avoid drinking of boiled water in coliform risk free areas.

Conflict of interest

Authors have none to declare.

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Full Length Research Paper

Study of ABO and Rh-D blood group among the common people of Chittagong city corporation area of Bangladesh

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This study was aimed to identify the distribution patterns of ABO and Rh-D blood group among the population of Chittagong city corporation area in Chittagong city of Bangladesh in order to promote social awareness, and safe blood transfusion among the population. A cross sectional, analytical study was carried out on a total of 937 people in three different area of Chittagong City Corporation (that is, Central railway building area, District commissioner hill area and Patenga sea beach area). The ABO blood group system in the total sample showed the same trend of prevalence with that of the general Indian subcontinent (B > O > A > AB). The same trend was found among males, but among females the order of prevalence was different (O > A > B > AB). Rh-D positive were 90.72% and Rh-D negative were 9.28%. Study of blood grouping is not only generating a simple database but also create a great social awareness about self-blood grouping and safe blood transfusion among the population of a country.

Key words: ABO, Rh-D, social awareness, agglutination method, Bangladesh.

INTRODUCTION

ABO blood groups were discovered by Landsteiner in 1901 (Landsteiner and Wiener, 1940). Later on in 1939, Rhesus blood groups were discovered by Landsteiner and Wiener in 1940. Since 1901, more than 20 distinct blood group systems have been identified but the ABO and Rhesus blood groups remain clinically the most important. Furthermore, they are also well defined genetic markers employed in population genetics (Amin-ud-Din et al., 2004; Sigmon, 1992). Blood group or blood type is based on the presence or absence of inherited antigenic substance on the surface of red blood cells that can be determined by specific antibodies (Garg et al., 2014). The importance of blood group discovery lies in the transfusion of blood amongst different populations irrespective of their ethnic origin, in organ transplantation and in the development of legal medicine, genetic research and anthropology (Storry, 2003).

The major ABO blood group system is divided into four blood types on the basis of presence or absence of A and B surface antigens. The blood groups are A, B, O and AB. The frequency of four main ABO blood groups varies in the population throughout the world. ABO blood group system derives its importance from the fact that A and B are strongly antigenic and anti A and anti B naturally

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Table 1. Distribution of ABO blood group among the male and female volunteers of Chittagong city corporation area.

Sex	A	B	AB	O	Total
Male	223	298	81	249	851 (90.82%)
Female	26	22	9	29	86 (9.18%)
Total	249 (26.57%)	320 (34.15%)	90 (9.61%)	278 (29.67%)	937

occurring antibodies present in the serum of persons lacking the corresponding antigen, and these antibodies are capable of producing intravascular hemolysis in case of incompatible transfusion (Harmening and Firestone, 2005). Blood group investigations in this subcontinent started during 1st World War with Hirschfled in 1919 who determined blood groups in large number of soldiers including Indians, and found high frequency of blood group B. Though records were not maintained separately for endogamous population groups, the studies revealed large regional and ethnic differences in blood group frequencies (Nydegger et al., 2007). The distribution of ABO and Rhesus blood group systems in Bangladeshis was studied in South East zone of the country during 1984 to 1988; the predominant blood group was O followed by B group (Majumder and Roy, 1982). In Eastern part of Bangladesh, O group was predominant and distribution of O and B was almost same in Western part (Nandy, 1986).

The present study was conducted among the common population of Chittagong city corporation area with the objective to observe the distribution pattern of ABO and Rhesus blood group system among them. This study will document a blood group data base as well as create social awareness among them, allow safe blood transfusion and prevent hemolytic disease of new born and fetus by knowing ABO and Rh typing.

MATERIALS AND METHODS

This cross sectional study was conducted in three different places and those were at District commissioner hill area on 21st February, at Chittagong railway building area on 1st April and at Patenga sea beach on 16th December. The duration of the study was 8 months from February, 2013 to December, 2013. A total sample of 937 participants irrespective of age and sex were included in the study. Samples were determined using random sampling technique.

Collection of specimens

After aseptic washing with 70% ethyl alcohol, blood samples were collected on grease free clean slide from left ring finger tip with the help of a sterile lancet. Blood groups were determined in a single slide to minimize any errors.

Laboratory investigations

The determination of ABO blood group and Rh (D) blood group was done according to the principle of slide method (Sultana et al., 2013). A drop of blood from each volunteer was placed on a glass slide in three places. A drop of each of the antisera A, B and D was added and mixed with each blood sample, with the aid of glass rods. Then, the mixture was rocked gently for 60 seconds to observe for agglutination. The results of agglutination were recorded immediately after mixing. The agglutination in blood drop A was considered as group A, and agglutination in blood drop B as group B. The agglutination in both drops was considered as group AB, and if both blood drops were not agglutinated, it was considered as group O. The agglutination in rhesus blood drop was considered as rhesus positive and non-agglutination as rhesus negative.

Data collection

All the participants were told about the aims and objectives of the study, and the blood grouping procedures were briefed to them. Written consent was taken from the participants aged more than 18 years, and parents' consent was taken for those who were less than 18 years old. Particulars of the each participant were taken in a data collection sheet.

Statistical analysis

All statistical analyses were done by Microsoft Office Excel 2007. The result was calculated as frequency of each blood group expressed as percentage.

RESULTS

Out of 937 participants, 90.82% were male and 9.18% were female. Table 1 shows the distribution of ABO blood group among the male and female volunteers. ABO blood grouping data revealed that group 'B' was predominant with 34.15%, followed by group O with 29.67%, group A with 26.57% and group AB with 9.61%. Figure 1 shows the distribution of ABO blood groups among the total participants (for both male and female). The frequency distribution of Rhesus blood group among the participants is shown in Figures 2 and 3. The Rhesus-negative blood group distribution is 2.45% for group A, 2.99% for both group B and O, 0.85% for group AB. In the rhesus-positive blood group distribution, blood group A has percentage frequency of 24.12%; blood group B 31.16%; blood group AB 8.75% and blood group O 26.68%. Blood group B had the highest frequency followed by blood groups O and then A. Blood group AB had the least. The Rhesus-positive and Rhesus-negative

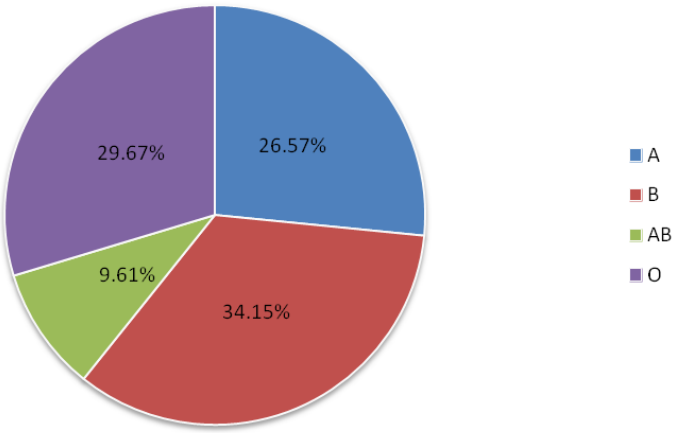

Figure 1. ABO blood group distribution among the population of Chittagong city corporation area.

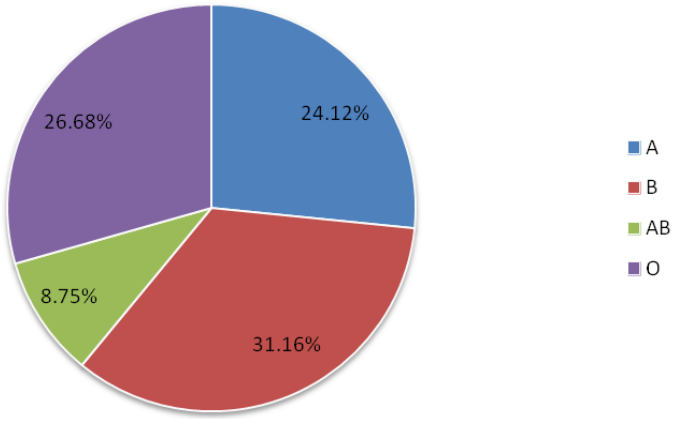

Figure 3. Rhesus-positive blood group distribution among the total volunteers.

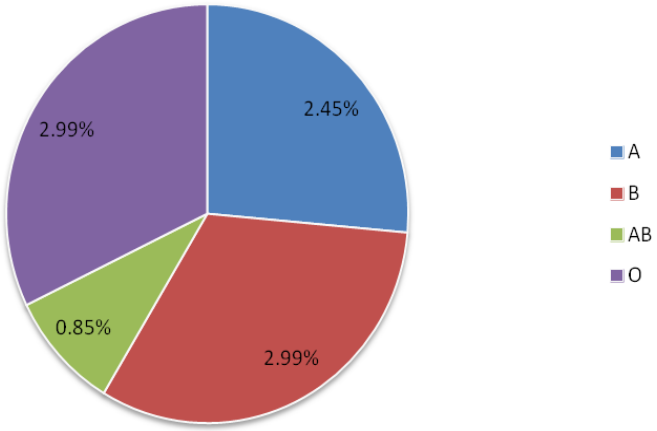

Figure 2. Rhesus-negative blood group distribution among the total volunteers.

vary among the ABO blood group. Rhesus positive has the highest frequency (90.72%) while Rhesus negative has the lowest frequency (9.28%). Table 2 shows the distribution of Rhesus blood groups by sex among the participants. The frequency distributions of ABO blood group based on Rhesus blood group is also shown in Figure 4. The percentages of the ABO blood group and Rhesus blood group varies significantly.

DISCUSSION

The present study has been carried out to determine the distribution pattern of ABO and Rh-D blood groups in common people of Chittagong City Corporation. The knowledge of the blood groups and Rhesus factor is important in evolution, related to diseases and environment, essential in blood transfusion, organ transplantation, forensic pathology, anthropology and training ancestral relation of human (Khurshid et al, 1992), and also helps to prevent complications due to Rhesus incompatibility (Bamidele et al., 2013).

This study showed that among the common people of Chittagong city corporation area, blood group B was the commonest followed by O. The distribution pattern of A, B, O, and AB were 26.57, 34.15, 29.67 and 9.61% respectively. The study regarding the distribution of ABO and Rhesus Blood Group systems among the people of central part of Bangladesh was first done in 1975 by Rahman (1975) where blood group B was found most predominant among the population. Another study (Pathan et al., 2008) conducted in the rural and urban areas of Bangladesh showed the similar results of predominant blood group B (35.54%) followed by blood group O (32.57%). These findings are almost similar to that of common people in the current study. However, study in South East and Western part of Bangladesh demonstrated the most frequent blood group was O (Majumder and Roy, 1982; Hussain et al., 1990).

There are several factors such as genetic and environmental factors on variation of blood group frequency in different parts of the world. Comparative study on data among the different studies in the Indo-Pak sub-continent revealed that there was an equal dominance of group B and O (Khan et al., 2004). Studies in Pakistan explored that B blood group predominated in many regions of Punjab and Multan, Swat, Gilgit, and Rawalpindi/Islamabad, while in Sindh and in Baluchistan, group O was predominated (Sultana et al., 2013; Khattak et al., 2008). Study in India showed group O is the predominant followed by B, A and AB (Das et al., 2001; Reddy and Sudha, 2009; Periyavan et al., 2010). However, in contrast, other studies showed group B is the most prevalent followed by group O, A, and AB (Chandra and Gupta, 2012; Nanu and Thapliyal, 1997).

Table 2. Distribution of Rhesus blood groups by sex among the participants.

Gender	Rh-positive	Rh-negative	Number of volunteers
Male	772	79	851
Female	78	8	86

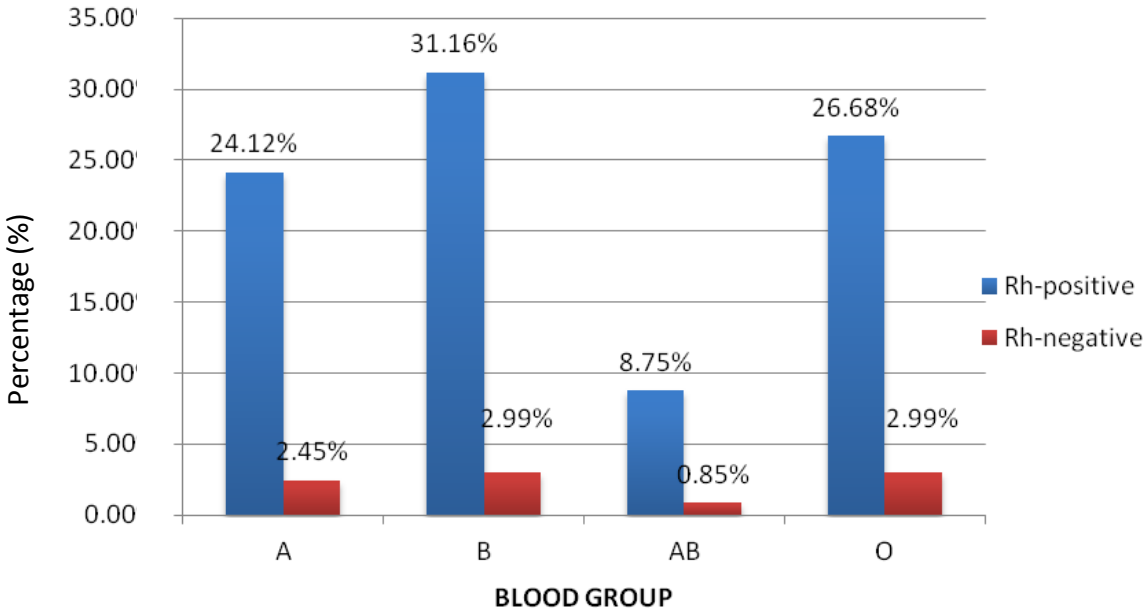

Figure 4. Distribution of ABO blood group among total volunteers based on rhesus blood group.

Data from neighboring country Nepal, revealed different structure of higher frequency of group A (Pramanik and Praminic, 2000). In Australia (Australian Red Cross Blood service, 2013), Britain (Frances, 2002), and USA (Mourant et al., 1976), group 'O' and 'A' were the commonest followed by B and 'AB'. In African subcontinent phenotypic frequency order is as follows; O>A>B>AB. The phenotypic frequency order is quite similar in Europe and Africa (Table 3).

This study suggests blood group order similar to the reports of other Indian subcontinent countries. But it differs from the reports of the middle-east countries (Table 3). The present investigation demonstrated similarities with the findings of previous research done in Bangladesh. The implication of this study finding is that Blood group B and O are readily available among the population of Bangladesh, and it is advantageous for the population in the event of blood transfusion. The higher proportion of blood group B and O is also advantageous from the point of pancreatic cancer. Previous studies have shown that the frequency of blood group A was significantly higher among people suffering from pancreatic cancer (Greer et al., 2010). It also indicates that one out of five of the studied population is probably at elevated risk of pancreatic and other types of cancer. For instance, early independent studies showed association of rectal, cervical, leukemia, pancreatic, breast, ovarian, gastric cancers among individuals with blood groups A, AB, or B more likely to have elevated risk of pancreatic cancer than individual belonging to blood group O (Wolpin et al., 2009; Greer et al., 2010; Amundadottir et al., 2009)

This study also found that, Rh (+ve) blood group is dominant in Chittagong which is consistent with the available data from previous reports of other population in Bangladesh. Moreover, Rh (+ve) group remains higher than Rh (-ve) group throughout the world (Table 4).

Conclusion

This study showed higher frequency of group B followed by group O, A and AB which reflects the same blood group pattern with the previous studies conducted in Bangladesh. Rh blood group system is also similar to other previous studies. Study of blood grouping not only generates a simple database but also create a great social awareness about self-blood grouping and safe

Table 3. Order of blood groups (ABO) studied in different populations across the world.

Population		Blood group order	Reference
Asia	Swat (Pakistan)	B>O>A>AB	Khattak et al. (2008)
	India	O>B>A>AB	Khattak et al. (2008)
	Gujrat (Pakistan)	O>B>A>AB	Anees and Shabir (2005)
	Bangladesh	B>O>A>AB	Rahman (1975)
Middle-East	Kuwait	O>A>B>AB	Al-Bustan et al. (2002)
	Saudi Arabia	O>A>B>AB	Khattak et al. (2008)
Africa	Kenya	O>A>B>AB	Lyko et al. (1992)
	Sudan	O>A>B>AB	Khalil et al. (1989)
	Nigeria	O>A>B>AB	Falusi et al. (2000)
Europe	Britain	O>A>B>AB	Frances (2002)
	Hungry	O>A>B>AB	Tuaszik (1995)
	Turkey	O>A>B>AB	Akbas et al. (2003)
Asia	This study	B>O>A>AB	-

Table 4. Frequency of Rh blood groups studied in different populations across the world.

Population	Rh+ (%)	Rh- (%)	Reference
Pakistan	91.40	8.60	Anees et al. (2007)
India	94.45	5.50	Khattak et al. (2008)
Bangladesh	97.4	2.6	Haque et al. (2013)
Saudi Arabia	93.00	7.00	Khattak et al. (2008)
Nigeria	94.30	5.70	Falusi et al. (2000)
USA	85.00	15.00	Khattak et al. (2008)
Britain	83.00	17.00	Khattak et al. (2008)
Germany	95.00	5.00	Akbas et al. (2003)
This study	90.72	9.28	-

blood transfusion among the population of a country. This study will serve as a reference for other studies particularly to the geneticists and to the clinicians especially in the planning of blood transfusion programs since they play integral role of the genetic profile of the Bangladeshi population.

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Conflict of interest

The authors declare that there are no conflicts of interest.

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Full Length Research Paper

Viral and bacterial acute lower respiratory tract infections in Khartoum children emergency hospital in 2012

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Acute lower respiratory tract infections (ALRI) including severe pneumonia are among the leading causes of morbidity and mortality in children under five years of age worldwide especially in developing countries. There is little information on the viral and bacterial etiology of severe pneumonia in Sudan where the disease burden is particularly high. The objectives of this study were to identify causative bacteriological and virological agents of ALRI among children attending Khartoum Pediatrics Emergency Hospital and to assess association between selected factors and ALRI. Investigations included an extensive etiological workup on nasopharyngeal aspirates. Immunofluorescence technique was used to detect the viral pathogens. Descriptive statistic was done and associations of variables were tested by Chi squire test. 123 patients were included in the study. Bacterial pathogens were detected in 49 patients (40%). Seventy three patients were tested for viral agents and 49 patients (67%) of them were detected. Mixed infection was found in 27%. Respiratory syncytial virus (RSV) was found to be the predominant causative agent (32.8%). *Streptococcus pneumoniae* was detected in 11.4% of ALRI. Low birth weight, prematurity, congenital anomalies and malnutrition were found to be highly associated with viral infection.

Key words: Lower respiratory infections, viral respiratory disease, child emergency, pneumonia, Sudan child morbidities.

INTRODUCTION

Pediatric respiratory tract infection is one of the common reasons for physician's visits and hospitalization resulting in significant morbidity and mortality (Nair et al., 2010). The incidence of acute respiratory infections (ARIs) in children aged less than 5 years is estimated to be 0.29 and 0.05 episodes per child-year in developing and industrialized countries, respectively; 151 and 5 million new episodes each year, respectively. Pneumonia is responsible for about 21% of all deaths in children aged less than 5 years, leading to an estimate of 12 to 20

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deaths per 1,000 live birth (Nair et al., 2010; Duke, 2005).

ARIs in children are classified as upper respiratory tract infections (URIs) and lower respiratory tract infections (LRIs). Most URIs resolve spontaneously within 3 to 10 days with symptomatic therapy alone. Frequent hand washing remains the most important preventive measure for most URIs (Killingley et al., 2011). On the other hand, about 20% of all deaths in children under 5 years are due to Acute lower respiratory tract infections (ALRIs) (pneumonia, bronchiolitis and bronchitis); 90% of these deaths are due to pneumonia. Every year, pneumonia contributes to 750,000 to 1.2 million neonatal deaths worldwide (Duke, 2005; World Health Organisation (WHO), 2010). Early detection and prompt treatment of pneumonia is lifesaving.

In infants aged up to three months, pneumonia is mostly of a bacteriological etiology and *Streptococcus pneumoniae* is the most common isolated pathogen. In infants older than four months and preschool-aged children, viruses are the most contributing agents. Bacterial infections can occur at any time throughout the year in preschool/school-aged children and adolescents (Ostapchuk et al., 2004). Generally, *S. pneumoniae* is the most common bacterial cause of pneumonia; less common bacterial etiologies include *Haemophilus influenzae* serotype b, *Moraxella catarrhalis,* and *Staphylococcus aureus*. While *Mycoplasma pneumoniae* and *Chlamydia pneumonia* are more associated with pneumonia in pre-school-aged children*. Mycobacterium tuberculosis* may cause community acquired pneumonia (CAP) in exposed children. Co-infection of two or more microbial agents is not uncommon with a rate up to 41% in hospitalized patients (Bradley, 2002; Ostapchuk et al., 2004).

In the same regards, the most important viral groups that cause pneumonia as a primary manifestation of a disease include influenza virus types A and B, respiratory syncytial virus (RSV), adenovirus, parainfluenza virus, rhinovirus, Hantavirus, severe acute respiratory syndrome (SARS) and cytomegalovirus (CMV). While the ones that cause pneumonia as part of a multisystem syndrome include Paramyxovirus species (measles), varicella-zoster virus, and Epstein-Barr virus, cytomegalo virus and herpes simplex virus (Mackie, 2003). According to the WHO, Sudan is one of the fifteen countries that bears the highest burden of child ALRI in the East Mediterranean Region (EMR). The estimated new cases of pneumonia is around two million and 0.48 episode per child per year (Rudan et al., 2008).

This study aims to identify causative bacteriological and virological agents of ALRI among children attending Khartoum Pediatrics Emergency Hospital and to assess association between selected factors and ALRI.

Ethical approval was obtained from the ethical review committee in Sudan National Board of Medical Specialization and Sudan Federal Ministry of Health (FMOH); informed consent was obtained from parents of all study participants.

MATERIALS AND METHODS

Study design

The study design was a cross sectional, descriptive hospital based study. The study was carried out in Children Emergency Hospital in Khartoum which is a referral pediatrics hospital in Sudan and serving almost the whole population of Khartoum state. Sample collection was done from the period of November, 2011 to February, 2012.

Study population

All children younger than 5 years old who were diagnosed with acute lower respiratory tract infection were considered to be the target study population. The presence of respiratory symptoms for ≤5 days and parental written consent to participate in the study were the study inclusion criteria. Children with contraindications to respiratory specimens sampling were excluded.

Sample size

A total convenient sample of 123 participants who agreed to undergo blood and nasopharyngeal laboratory sampling were included and tested for bacteriological tests. While only 73 of them were successfully tested for both bacteriological and virological examinations. Shortage of the testing reagents and samples shipment restriction were the major constraint that prevented full samples analysis.

Data collection and processing

Data was collected through a structured questionnaire. Blood samples and nasopharyngeal samples were collected applying the recommended infection control precautions. Specimens were processed at the National Public Health Laboratory and private virological laboratory in Khartoum. Statistical Package for the Social Sciences (SPSS-19) was used to analyze the data. Descriptive statistics was done in addition to Chi square test to assess association between selected variables and the outcome.

Outcome determination and quality assurance

Children with ALRTI were diagnosed clinically by senior pediatricians based on presenting symptoms and signs. Severity of pneumonia was classified depending on the WHO classification of pneumonia. Direct immunofluorescence techniques and culture methods were used to identify etiological agents for respiratory infections (Murray et al., 1990). For virology, the study used IMAGENTM reagent from Oxoid (UK); its sensitivity ranges between 87 and 100% and specificity ranges between 98 and 100 % (according to the manufacturer). These reagents include monoclonal antibodies conjugated to fluorescein isothiocyanate (FITC) and Evans blue dye as a counter stain. The monoclonal antibodies are targeted against matrix protein of influenza A, nucleoprotein of influenza B, Fusion protein of RSV and parainfluenza 1, heamaglutinin protein of parainfluenza 2 and 3 and against the hexon protein of the adenovirus.

For bacteriology, chocolate agar, blood agar and MacConkey agar were used for primary isolation. Cultures were incubated at 35°C, for 24 to 48 h. Blood and chocolate plates were incubated in 5 to 7% Co_2. Colonial morphology was observed and gram stain and relevant chemical tests were done for identification (Duke, 2005). For mixed growth, purification was attempted, identification

Table 1. Main individual characteristics of study participants.

Characteristic	Frequency	Percent
Age groups (in month)		
<2-12	4	3
13-36	113	92
37-60	6	5
Gender		
Male	69	56
Female	54	44
Smoker father	66	54
Education of mother		
Illiterates	17	14
Primary	41	33
High school	44	36
University	21	17
Exclusive breast feeding	44	38
High TWBCs	49	40
Low birth weight	16	13
Premature	9	7
Malnourished	4	3
Congenital abnormalities	12	10
Clinical diagnosis of study participants		
Bronchiolitis	49	40
Pneumonia	47	38
Sever pneumonia	27	22

methods were chosen according to the colonial morphology and gram stain results.To identify gram positive cocci, catalase positive, bacitracin, coagulase, and mannitol fermentation tests were used. While for catalase negative, optochin susceptibility and pattern of blood hemolysis were used. To identify gram negative cocci/coccobacilli and short bacilli, ability to grow on MacConkey agar, oxidase, catalase, requirement for X and V factors, penicillin disc test, acid production from glucose and lactose and DNAse tests were used.

RESULTS

Overall

This study involved 123 children, 69 (56%) of them were males. Median participant's age is 9 months (range: 1 to 60 months), with 60% of them ≤1 year of age. Sixteen children had low birth weight (13.7%) and 9 were born prematurely (7%). Sixty six fathers were smokers, while all mothers have denied a history of tobacco smoking. 14% of the mothers were found to be illiterate, 33% had primary education, 36% completed high school and 17% had university education. All 123 patients were tested for bacterial pathogens and seventy three of them were tested for viral etiology as well. One or more viral pathogens were detected in 49 (67%) patients. Bacterial pathogens were detected in 49 (40%) patients. Co-infection by both viral and bacterial agents was detected in 20 (27.5%) patients. Table 1 summarizes the study participant's characteristics while Table 2 describes the results of microbiological testing.

Virology

Among 73 tested samples for virology, RSV was found to be the most prevalent virus (21 patients, 29%), followed by Influenza A (9 patients, 12%), then Parainfluenza 3 (7 patients, 10%), Influenza B (6 patients, 8%) and Adenovirus (3 patients, 4%). Parainfluenza 1 and 2 viruses were not detected in any of these samples. Concomitant infection and presence of more than one virus at a time was detected in three patients (4%); in all of them RSV was present along with either Influenza B or Influenza A.

Bronchiolitis was the commonest clinical diagnosis among study participants (49 patients, 40%), followed by pneumonia (47 patients, 38%) and the rest patients (27

Table 2. Results of microbiological testing for study participants.

Organism	Samples tested	Samples positive	%
One bacterial agent	123	49	39.8
More than one bacterial agent	123	0	0
One viral agent	73	46	63
More than one viral agent	73	3	4
Mixed bacterial and viral agent	73	20	27.3
Breakdown of common organisms isolated			
Bacteriological			
S. pneumoniae	123	14	11
M. catarrhalis	123	11	9
K. pneumoniae	123	9	7
P. aeruginosa	123	7	6
H. influenzae	123	2	2
S. aureus	123	5	4
E. coli	123	1	1
Virological			
RSV	73	21	29
Influenza A	73	9	12
Influenza B	73	6	8
Para Influenza 3	73	7	10
Adenoviruses	73	3	4
RSV + Influenza A	73	1	1
RSV + Influenza B	73	2	3
Mixed bacterial and viral infection			
RSV+ *S. pneumoniae*	73	7	9.6
RSV+ *M. catarrhalis*	73	4	5.5
RSV+ *P. aeruginosa*	73	3	4
Influenza A+ *S. pneumonia*	73	6	8

patients, 22%) were diagnosed with severe pneumonia and viral agents were found predominantly in all of these.

In patients with a documented respiratory virus infection, Bronchiolitis was caused predominantly by RSV (31%), and it was also the most frequently detected virus in pneumonic cases (34.5%). RSV is found to be a causative agent responsible of around 13% of severe pneumonia along with Adenovirus and Influenza B virus.

Bacteriology

Among 123 tested samples for bacteriology, bacterial pathogens were detected in 39.8% of the children. *Streptococcus pneumoniae* was detected in 14 patients (11.4%). *M. catarrhalis* was isolated from 11 patients (8.9%). *Klebsiella pneumoniae* was isolated from 9 patients (7.3%). *Pseudomonas aeruginosa* was isolated from seven patients (5.7%). *H. influenzae* was isolated in pure culture from 2 patients (1.6%). *S. aureus* was also isolated from five patients (4.1%). *Escherichia coli* was isolated as a sole organism from one patient (0.8%). Combined bacterial and viral infections were found in 20 patients (27.4%). RSV infection was accompanied by *S. pneumonia* in 7 patients, with *M. catarrhalis* in 4 patients and with *P. aeruginosa* in 3 patients. Six Influenza A cases were found mixed with *S. pneumoniae*. Table 2 summarizes the common isolated organisms in the study.

Associated factors

There was statistically significant difference between males and females in susceptibility for acquiring viral respiratory infections in χ^2 test ($p = 0.03$). Males showed higher prevalence of viral infections (77.5%). There was no significant difference in gender regarding bacterial pathogen ($p = 0.2$).

Children age group between 2 and 12 months showed a higher prevalence of viral agents (44%) of the overall positive viral agents. RSV virus was the most prevalent virus among all age groups except the oldest group (37 to 60 months). Older age group has a similar incidence of RSV, Influenza B and Parainfluenza 3. Age had no statistical significance association with bacterial infections in this study (p = 0.5). Congenital anomalies were observed in 12 participants and bacterial pathogens (*K. pneumoniae* and *P. aeruginosa*) were detected in 4 (33%) of them. A chest deformity patient was found to be positive for both viral and bacterial pathogens (*S. pneumoniae* + Influenza B virus). History of low birth weight (<2 kg) was detected in 16 patients (13%) including 9 premature cases (7%), 10 of them were positive for bacterial pathogens. In addition they were found to be predominantly infected by RSV; while only one patient had a co-infection of RSV and Influenza B (p = 0.01). Four malnourished infants (3%) were encountered during the study; all of them were co-infected by viral and bacterial agents. Parental smoking was found to be strongly correlated with viral infection (p = 0.004). Variables that did not show any statistical association with child ALRI includes maternal education level, high mean leukocyte or lymphocytes counts, family history of asthma and exclusive child breast feeding in the first six months of life.

DISCUSSION

Proper diagnosis, recognition of complications, and appropriate management of patients with ALRIs is a crucial (Michelow et al., 2004). In this study, ALRI was found to be caused mostly by viruses, this findingis in a coherence with most of the studies worldwide (Michelow et al., 2004; Padilla et al., 2010; Debiaggi et al., 2012; Berkley et al., 2010; Niang et al., 2010). On the other hand, this finding contradicts another Sudanese study that concluded the reverse (viral agents were found to be less prevalent) (Salih et al., 1994). Contradiction between the mentioned study and current one could be due to difference of participants' age groups.

RSV proved to be the most prevalent respiratory virus among children in Sudan; also concluded from previously mentioned Sudanese study in 1994, matches with most similar studies in developing and developed countries (Chen et al., 2014; Zurawski et al., 2011; Salih et al., 1994; Berkley et al., 2010). Importantly, Rhinovirus and human Bocavirus were detected as the most common pathogens in some other studies and unfortunately these tests could not be performed in the current study due to unavailability of their reagents in Sudan during the study period. This study confirmed the existence of dual infections by bacterial and viral agents at a time, this fact established from several similar studies (Cevey et al., 2009; da Silva et al., 2013; Mameli and Zuccotti, 2013).

Bacteriologically, this study proved that *S. pneumoniae* is the common circulating bacterial pathogen in child respiratory infections in Sudan. This finding was concluded as well by similar studies around the world (Cevey et al., 2009; Honkinen et al., 2012; Zurawski et al., 2011). Only two cases of *H. influenzae* were detected in the study participants and this would intellectually be explained by the introduction of *H. influenzae* type b (Hib) vaccine to the routine immunization program scheduled in Sudan with sustained coverage above 90% since 2009.

Regarding the associated factors, that prevalence of viral infection was found to be higher among infants (2 to 12 months) which is consistent with the previous study in Sudan (Salih et al., 1994). Male children showed higher susceptibility to viral infection. Although this correlation was found in other studies (Sovero et al., 2011), but currentlycould be confounded by other predisposing factors (age, prematurity, low birth weight and congenital anomalies) since no statistical adjustments was done. A strong relationship was demonstrated between viral infection and congenital anomalies, low birth weight, prematurity and under-nutrition. This result matches with the result of a global study done by the WHO (Rudan et al., 2011). The same global study attributed higher incidence of pneumonia to the lack of exclusive breast feeding in the first few months of life, while this study failed to demonstrate such a link. In accordance with another study, white blood cell count and differential was not found to be beneficial in discriminating between viral and bacterial etiologies (Don et al., 2009). Household overcrowding seems to have a great effect on acquisition of viral respiratory infections. The risk increases when more than three persons share one room at bed time. Exposure to tobacco smoking showed strong correlation with viral infection among study participants. This agrees with the Sudanese study which found a direct link between parental smoking and susceptibility to pneumonia (Salih et al., 2011).

This study has some limitations that could be addressed in future similar investigations. The sampling technique compromised the study and made it more descriptive. It would have been better if all 123 samples were tested for both bacteriological and virological agents. In addition, there is a possibility of result distortion by a cofounding effect of some other variables regarding assessing association with outcomes. This could be avoided by proper sampling technique, adequate sample size and applying advance statistical models.

Conclusion

Viral pathogens are more common than bacterial ones in young children attending Khartoum National Pediatrics Emergency Hospital. Confirmation of a viral etiology for

respiratory infection is important, since currently more antiviral therapies become available as well as prophylaxis for critical patients such as the premature and those with congenital anomalies. In addition, national ARI surveillance system should be strengthened to provide the evidence for EPI department to include further vaccines in the national EPI schedule.

Conflict of interest

Authors disclose that there are no financial or other relevant competing interests.

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