AJSTD

Vol. 34 No. 1, 2017
ISSN 0217-5460

A Journal of the ASEAN Committee on Science & Technology

ASEAN JOURNAL ON SCIENCE & TECHNOLOGY FOR DEVELOPMENT

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Perniagaan Normahs

Publisher

Academy of Sciences Malaysia

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ASEAN J. Sc. Technol. Dev.
Volume 34(1), 2017

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Nursing Care for a Patient with NSTEMI Admitted to the Coronary Care Unit for Percutaneous Coronary Intervention — A Case Study

M.S. SITI MARYATI[1] AND R. (II) P. DIOSO[2*]

This case study aims to demonstrate clinical nursing skills to a patient with myocardial infarction admitted for percutaneous coronary intervention. Nursing care for this patient started with a physical assessment and laboratory investigation analysis. This evaluation was necessary to develop a nursing care plan. The activities in the ward enumerated the medications provided, and the details of the vital signs monitored hourly. The patient was sent to cardiac catheter laboratory at 1030H. From the cardiac catheter laboratory post-percutaneous coronary intervention to the mid-right coronary artery (1 Drug-Eluting Stent) he was transferred out to Telemetry unit on 11 August 2016 at 1500H with Terumo band hemostatic device through radial approach.

Key words: Case study; myocardial infarction; angioplasty; percutaneous coronary intervention; coronary care unit; nursing care; NSTEMI

This case study aims to demonstrate clinical nursing skills to a patient with myocardial infarction admitted to a private hospital in the Kingdom of Saudi Arabia for percutaneous coronary intervention. This intervention is formerly known as angioplasty with stent (Granato, 2011; Badimon *et al.* 2012); and is a non-surgical procedure that opens up blood vessels in the heart that have been narrowed by atherosclerosis (NSTEMI 2014).

Before commencing with the study, approval from the ward manager of the coronary care unit and the patient was acquired. The hospital used in this case has 700-bed capacity, while the coronary care unit has ten beds, with excellent facilities for patients with heart diseases. Information herewith will be treated with anonymity and confidentiality.

Case Description

Mr. F is a 41-year-old male, who was scheduled for percutaneous coronary intervention on 10 August 2016 due to non-ST-elevation myocardial infarction (NSTEMI). He is a known diabetic, a hypertensive patient who denies of smoking addiction. His latest Troponin I (0.094) and initial electrocardiography (*Appendix 1*) was secured. Mr. F's demographic profile is further enumerated in *Table 1*.

The authors will provide care, management and treatment for the patient at the coronary care unit. However, it is essential to describe the management for the patient that was primarily done at the emergency room.

[1] Sulaiman Al Habib Hospital, Arrayan, Riyadh KSA
[2] Lincoln University College, Jalan SS 6/12, 47301 Petaling Jaya, Malaysia
[*] Corresponding author (e-mail: duke@lincoln.edu.my)

Table 1. Demographic profile.

Age	41
Gender	Male
Marital Status	Married
Nationality	Saudi Arabian
Religion	Muslim
Occupation	Businessman (wholesale trade)
Address	Riyadh, Kingdom Saudi Arabia
Social history	Heavy smoker (2–3 packs/day)
Height	165 cm
Weight	90 kg
Past medical history	Retrosternal compressing type of chest pain with dyspnea and pain unrelated to exertion. Known diabetic and hypertensive
Surgical plan	Percutaneous coronary intervention to mid-right coronary artery

At 0037H, 10 hours before his schedule for admission to the coronary care unit, Mr. F came to the emergency room on wheelchair borne, with complaints of a retrosternal compressing type of chest pain that lasted for two days intermittently with waxing and waning intensity. On 9 August at 1300H, he experienced a sudden onset of pain, and crescendo over the day (10 to 12 hours before arriving at the hospital) and was associated with sweating, fatigue, and dyspnea — important assessments for nurses to recognize as an impending cause of sudden death among patients with heart diseases (Mozarelli *et al.* 2011; Badimon *et al.* 2012). Within the periods of emergency room confinement, vital signs were monitored hourly (*Appendix 2*). The patient was then transferred to the coronary care unit at 0200.

Mr. F was immediately seen by Dr M in the coronary care unit to intuitively decide whether an open heart surgery was necessary or proceed with the previous plan of having a percutaneous coronary intervention. The authors (being the attending nurse-in-charge) secured previous blood investigations (*Table 3*), and echocardiogram results (*Table 4*). Dr M also prescribed oral medications such as *Juspirin* 300 mg and *Plavix* 300 mg per tablet (Table 5) before a decision is finalized. The patient was instructed to rest the whole night.

After 6 hours (at 0800H) at the coronary care unit of medical management at the coronary care unit (*Appendix 3*), the pain subsided. With this assessment cue, the patient can be prepared for a percutaneous coronary intervention.

In preparation for a percutaneous coronary intervention, the patient was instructed to be on NPO (Nil per orem). An intravenous (IV) fluid of 0.9 normal saline solution at 100 milliliters (mls) /hour was started and received an IV infusion of nitroglycerin at 5 mcg/min for his mild chest pain (NSTEMI 2014) at around 0230H, and titrated the nitroglycerine infusion according to his blood pressure to maintain systolic pressure at 100 to 120 mm Hg until 0600H as one time dose. All laboratory results were also secured.

This case can be further understood if the altered physiology is explained and an anatomical animation is illustrated. Analyzing the pathway of the disease process in addition to the anatomical and physiological analysis can be useful to provide nurses an excellent care plan.

Altered Anatomy and Physiology

The NSTEMI of Mr. F is an incomplete heart attack and also one type of myocardial infarction (Granato 2011). An anatomical disturbance of blood supply to a part of his heart (*Figure 1)* was identified by an elevation of cardiac markers (*Table 2*) in the blood (Anderson *et al*. 2011; Granato 2011). The anatomical structure of the heart can have an enlarged dimension (Shehab *et al.* 2013; Al Habib *et al.* 2011).

The absence of ST-segment elevation in NSTEMI is comprehended to implicate less than a full thickness (partial thickness) damage of heart muscle according to Buck (2012). Hence, NSTEMI is a less extreme kind of heart attack in which partial thickness damage of the myocardium (*Figure 1*) develops.

Pathway of the Disease Process of NSTEMI

The disease process starts with the growth form of cell death without ST-segment changes (Granato 2011). *Figure 1* shows a partial closure or blockage of a major coronary artery or a complete blockage of a minor coronary artery heretofore affected by atherosclerosis (Mozarelli *et al.* 2011). The most common mechanism of NSTEMI is rupture or erosion of an atherosclerotic plaque that triggers platelet adhesion, activation, and aggregation, which bring to establishment of a thrombus (*Figure 1*) in a coronary artery, thereby increasing platelet count (Mc Pherson *et al.* 2011).

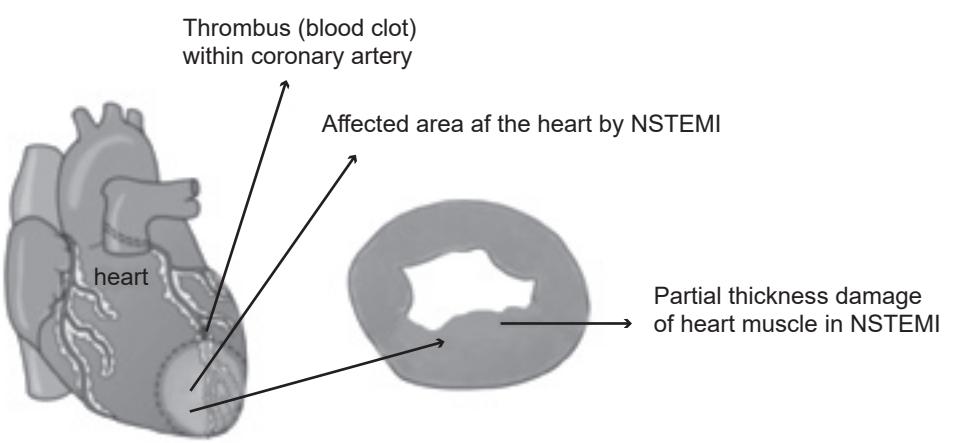

Figure 1. Partial thickness damage of heart muscle in NSTEMI.

Partial thickness damages of the heart muscle will happen (Badimon *et al.* 2012). Mc Pherson *et al.* (2011) agreed that arterial thrombus will develop, and deep changes will take place in the heart that leads to an irreversible change with the death of myocardial cells.

According to Levy *et al.* (1992), plaque will be removed by percutaneous coronary intervention. However, a thorough laboratory investigation is required to identify an occurrence of a disease on the patient concretely.

Laboratory Results

Electrocardiography (ECG) (*Appendix 1*) shows a consistent regular heart rhythm with a total heart rate of 75–85 beats per minute. There were no ST segment elevation seen in leads V1 and V2 validating the diagnosis of NSTEMI; while the small Q inferior waves noted on leads II, III, and AVF describes infarction in the myocardium. The rest of the ECG tracing shows the PR interval to be normal that was followed by a QRS and every QRS complexes is preceded by a P wave. This means that the patient prognosis is good and activities of daily living can be tolerated even on post percutaneous coronary intervention status. The LAA (left atrial abnormality) showing an m-shaped (notched) and widened P wave (≥0.12 second) in a "mitral" lead (I, II, and aVL) were also important to note — a deep negative component to the P wave in lead V1 (P Mitrale) showing the ability of the heart muscle to tolerate surgery. The QT/QTc interval (404/430 milliseconds) were calculated in leads II and V5; while the QRS complex was calculated to be 80 milliseconds which means there were no loss of heart voltage noted, and that the electrical activity of the heart remains rhythmic. The T-wave flattening in amplitude is a sign of an electrolyte imbalance that is why blood specimens need to be sent for serum laboratory investigation (*Table 2*).

The chest X-ray was also done for heart-lung clearances. The result shows that both lung fields were clear and were in costophrenic angles. Mr. F had normal cardiac size and shape and the disease process of NSTEMI that may lead to an enlarged heart did not occur.

The abnormalities found in the serum laboratory results were the delta-dimer, sodium, chloride, white blood cells, platelets, and hemoglobin A1Cs; while the lipid profile such as the cholesterole, triglyceride, and low-density lipoprotein were also altered. This blood / serum investigation would provide a concrete evidence on the patient's disease occurrence. Also medications to maintain physiologic homeostasis of Mr. F was validated by the blood results such as anti-coagulators (due to high platelet count) and anti-cholesterol (due to abnormal lipid profile). Standard results of the hemoglobin and hematocrit are good evidence that is necessary to be investigated before invasive procedures are done.

Howerver, it is also important to perform an echocardiogram (*Table 3*) and a coronary angiogram (*Table 4*) since the chest X-ray and ECG are not able to identify abnormalities (if any) of the heart regions and its chambers in multiple dimensions.

Echocardiography (*Table 3*) has an advantage unlike the ECG as it has 2 to 3-dimensional imaging seen by way of

ultrasonogram without the cardiac cycle (Shehab *et al.* 2013; AlHabib *et al.* 2011). In addition, this procedure also provides information on blood movements inside cardiac structures and on haemodyamics (Vincent *et al.* 2011; Kipshidze *et al.* 2014; Doenges *et al.* 2014). The result of the echocardiography concludes that the percutaneous coronary intervention will hence focus on the left ventricle specifically in the inferio-posterior wall from base to apex of the heart where the blockage was found.

Table 2. Blood serum laboratory investigation.

Serum	Normal value	Result
Serial cardiac enzymes		
• Creatinine	• 62 – 106	• 70
• CPK-MB	• <25	• 15
• CPK	• 20 – 200	• 151
• Troponin I	• < 0.028	• 0.094
• Delta-dimer	• 0.05	• 0.39
Electrolytes		
• Sodium	• 135 – 145	• 180
• Urea	• 2.78 – 8.07	• 3.30
• Potassium	• 3.5 – 5.1	• 4.12
• Creatinine	• 62 – 106	• 70
• Chloride	• 98 – 107	• 70
Complete blood count		
• WBCs	• 4 – 11	• 9.11
• Neutrophils	• 2 – 6.9	• 5.31
• NEUT %	• 37 – 80	• 58.20
• Lymphocytes	• 0.6 – 4	• 2.59
• LYM %	• 10 – 50	• 28.40
• Hemoglobin	• 13 – 17.4	• 15.0
• Hematocrit	• 39 – 52	• 41.1
• MCV	• 78 – 96	• 83.0
• MCH	• 27 – 32	• 30.3
• MCHC	• 29 – 37	• 36.5
• RDW	• 11.6 – 15.5	• 11.7
• Platelets	• 150 – 450	• 300
• Hemoglobin A1C	• 4.8 – 5.9	• 6.96

Table 2. (cont.) Blood serum laboratory investigation.

Serum	Normal value	Result
Lipid profile		
• Cholesterol	• < 5.21	• 5.98
• High density lipoprotein	• 0.9 – 1.45	• 0.91
• Low density lipoprotein	• < 4.12	• 3.90
• Triglycerides	• < 2.0	• 4.5
Liver function test		
• Albumin serum	• 40 – 49	• 40
• Alkaline phosphate	• 40 – 130	• 98
• ALT/GPT	• < 41	• 30
• AST/GOT	• < 40	• 26
• Direct bilirubin	• < 5	• 2.60
• Total bilirubin	• < 21	• 8

Table 3. Echocardiogramresult.

Left ventricle	Regional wall motion abnormality noted in inferoposterior wall (basal to apical). Overall normal systolic function at 56%.
Left atrium	Normal size.
Aortic valve	Structurally normal. No regurgitation or stenosis.
Mitral valve	Structurally normal. No regurgitation or stenosis.
Right ventricle	Dilated with good systolic function.
Right atrium	Normal size.
Tricuspid valve	Structurally normal. No regurgitation or stenosis.
Pulmonic valve	Structurally normal. No regurgitation or stenosis.
Aortic arch	Normal.
Inferior venacava	Normal.

This coronary angiography procedure (*Table 4*) injected the right coronary artery with X-ray contrast dye to show blockage or narrowing of the artery. A minor atheroma was seen distally from the left anterior descending coronary artery while a mid-tubular atheroma was visualized on the 1st diagonal proximal segment of the coronary artery.

METHODOLOGY

The method of nursing care for this patient starts with a physical assessment. This assessment is necessary to develop a nursing care plan to provide care (*Table 5*). The activities in the ward found in the appendices enumerate the medications provided and the details of the vital signs monitored hourly. The method ends with a transfer out of the word.

Physical Assessments

Mr. F's general conditions were assessed to be fully conscious, awake, alert, communicating well and follow commands, able to move all limbs with a total Glasgow Coma Scale (GCS) score of 14/15. Mr. F's initial vital signs are:

- BP: 130/90 mm Hg
- Pulse Rate: 92/min
- Shortness of breath, respiratory rate: 19 / minute
- Chest pain with visual analogue scale (VAS) score of 7/10
- RBS: 139 mmo l; and
- SPO2: 97% on room air.

No complaints of nausea or vomiting noted. Output was at 600 mls of urine for the first 6 hours, while the total intake calculated was 731 mls within 6 hours. Within normal range of respiratory rates, there were no signs of lung atelectasis; while the Sp02 was maintained at 98%.

However, there were anxiety and facial grimacing noted in combination with shortness of breath, fatigue, and fresh and clammy skin when touched. Palpitation, weak pulse, and jugular vein distention were also observed.

Table 4. Coronary angiography results.

Left main stem	Normal
Left anterior descending	Minor atheroma mid-course and mild disease distally
1st diagonal	Mild-tubular disease in the proximal segment
Circumflex	Non-domain a good calibre vessels with mild bifurcation mid-vessel disease
Right coronary artery	Dominant and critical mid-vessel narrowing with further moderate tandem lesion (culprit vessel)

Nursing Care Plan

The goal is to reduce the pain (from 7/10 to 2/10) within 8 hours of nursing care. Therefore, the priority nursing diagnosis would be "acute pain related to decrease in myocardial blood flow" (Doenges *et al.* 2014). Buck (2012) and Doenges *et al.* (2014) stated that severe pain due to the myocardium's infarct impeding blood flow was one of the causes of deaths worldwide due to an ischemic heart disease.

Which is why the primary nursing intervention is to assess the vital signs such as the VAS, the facial grimacing, irritability, hypertension, shortness of breath and palpitations. Noting onset, duration, location and pattern of pain is also necessary. This will differentiate angina pain from other referred pains. The pain was monitored hourly (*Appendix 2*). Secondly, oxygenation was provided to relax the myocardial muscles. It is also important to stay with the patient to decrease the anxiety that may increase myocardial workload. Complete bed rest were instructed and maintained the head of the bed on moderate high back rest at 45° angles to reduce myocardial oxygen demand. Reducing preload and afterload of the heart reduces pain. The rationales for the nursing interventions are enumerated in *Table 5*.

Medications, on the other hand, are dependent nursing actions that require licensed physicians' orders. However, it is also important to methodological plan for the nursing responsibilities before administering the drugs.

Drug Study

Details of drug dosages, frequencies, and side effects are found in *Appendix 3*. Platelet aggregation inhibitors were Juspirin and Clopidogrel Plavix (both orally administered). However, these drugs will only be used after the percutaneous coronary intervention to avoid bleeding during the procedure (Davi's Drug Guide 2000–2016). The nursing responsibility when administering these drugs is to frequently monitor bleeding gums and episodes of hematuria as the patient is ambulatory and performs activities of daily living as he wishes to. It is also important to avoid proton pump inhibitors since it may lead to reinfarction and revascularization (Vera 2013). Besides lung sounds, depth of breathing and respiratory rate may also be monitored to ensure that oxygenation is not compromised if Morphine are given for pain (Vera 2012; Drugs.com 2000–2016).

Heart drugs on the other hand were Concor®, ramipril, and morphine used for chest pain and hypertension (Mays 2013). The significant responsibility indicated for the patient is to monitor electrocardiography, pulse rate and blood pressure (Vera 2013; Vera 2012). These drugs are necessary before commencing with percutaneous coronary intervention as it stabilizes the heart muscles and ensures that the heart remains pumping even after the procedure (Davi's Drug Guide 2000–2016; Drugs.com 2000–2016).

Lastly, the drugs used for cholesterol were Lipitor® and lipantyl. It is important to remove this lipoprotein as it is dangerous for the heart muscles to be covered with lipids (Davi's Drug Guide 2000–2016). Monitoring of blood sugar is also vital since these drugs may induce hypoglycemic episodes to those who are on NPO (Davi's Drug Guide 2000–2016).

Transfer Out of the Word

Transferring patient out of an intensive care unit such as the coronary care unit is an evidence of

a successful nursing care. After the procedure, Mr. F stayed overnight in Coronary Care Unit and was referred to a hospital dietitian, and heart specialists for rehabilitation. The rehabilitation programme will be continued in Telemetry Ward and will be instructed to adhere to the treatments until discharged. Also the nutritional status was assessed prior to ward trans-out. Mr. F was diagnosed at high nutritional risk due to compromised glucose level after NPO and was aggravated by anticoagulants and continuous prescriptions of 3-hydroxy-3-methylglutaryl-coenzyme (HMG-CoA) reductase inhibitors (such as Lipitor). It was suggested that a cardiac Diabetic Mellitus diet is to be taken.

Recent laboratory results (including the percutaneous coronary intervention techniques) were also endorsed to the receiving nurse in charge at the regular ward. The blood investigation results were: Hgb: 12; Mono: 7.90 (high); MPV:11.1(high); Chol: 5.98 (high); CL: 97 (low); HbA1c: 96 (high); HDL: 0.83 (low); TG: 6.6 (high); and Trop-I: 0.423.

Since general conditions and vitall signs were stable, Mr. F was transferred out to Telemetry Unit on 11 August 2016 at 1500H.

Post-discharge Follow-up

Effective communication and therapeutic relationship with the patient and their family increase long-term compliance with lifestyle adapt and prescribed drugs. At discharge, patient should have received details regarding medication, diet, exercise, smoking cessation counseling, referral to cardiac rehabilitation prevention programmes. Low risk and a revascularized patient should given appointment to come back within 2–6 weeks and higher risk within 14 days.

DISCUSSION

This section will discuss the demography of the patient; and will rationalize why such profiles were mainly acquired to study his case.

The patient was a smoker. Smoking is the most risk factor for heart disease (Dioso 2015; Mohan *et al.* 2008; Zubaid *et al.* 2009). Smoking can cause high blood pressure, lipids worsen, and make a very sticky platelets, raising the risk of clots (ACLS Institue 2016). Smoking is often practiced by men than women (Dioso 2015). Meanwhile, heavy cigarette smokers are at substantial risk for a blood vessel influential defect that exposes danger to the heart (McPherson *et al.* 2011; Vincent *et al.* 2011).

The patient was also hyperlipidemic, diabetic and hypertensive. Zubaid *et al.* 2009 explained that myocardial infarction is associated due to the high usualness of cardiovascular risk factors, such as diabetes mellitus, hypertension, smoking, and hyperlipidemia; which resulted from notable changes in the lifestyle behaviors; such as decrease exercise and poor dietary habits. In Saudi Arabia known as the "generation of electronic potatoes", a 1 in 4 people are meant to be possibly afflicted with fatal heart attacks within ten years (Zubaid *et al.* 2009; AlHabib *et al.* 2011). In retrospect, more than 4,900 Saudi, majorities of age between 20 to 40 years old who do not have a history of heart disease and lived in large urban areas like Riyadh, 26% experienced heart attack due to obesity and diabetes complications (Zubaid *et al.* 2009). Dr Adil Soofi explained that the cause of heart attacks is because of the practice of unhealthy lifestyle from an early age. He said, "they like to eat fast food and fried and greasy foods and lacks exercise." Atherosclerosis,

Table 5. Nursing care plan.

Assessment	Planning	Intervention	Rationale	Evaluation
Nursing Diagnosis: Acute pain related to decreased myocardial blood flow				

Subjective:
"My chest is painful" says Mr. F
Objective:
• GCS = 14/15
• Restlessness
• Fatigue
• Facial grimacing
• Jugular vein distention
• Cool and clammy skin
• Retrosternal compressing type of pain while guarding the chest region
• Weak pulse
• Palpitation
• Reluctant to move
• Strength of extremities
  • Left arm 5/5
  • Right arm 5/5
  • Left leg 5/5
  • Right leg 5/5
• Vital signs:
  • BP: 130/90 mm Hg
	After 8 hours of nursing interventions the patient will be able to:
	• Reduce pain from 7 to 3 being 10 as the most painful, to 3/10
	• Maintain stable vital signs
	• Prepare for percutaneous coronary intervention
		• Assess for vital signs and symptoms of pain such as facial grimacing, rubbing of neck or jaw, reluctance to move, increased blood pressure and tachycardia. Noted the onset, duration, location and pattern of pain for myocardial infarction.	• As baseline data.
			• This may also help the nurses to identify referred pain of myocardial infarction.
				After 8 hours of nursing interventions and health teaching, patient verbalized was free from pain with rated pain as 3 in the scale of 10, maintained stable vital signs and prepared for coronary stenting.

		• Provided oxygenation using nasal cannula at 2LPM.	• To promote heart muscle relaxation.	
		• Stayed with the patient during chest pain episodes.	• To decrease anxiety.	
		• Instructed complete bed rest and maintained head of bed on moderate high back rest at 45° angle.	• To decrease myocardial oxygen demand through vasodilation; and preload and afterload reduction decreasing cardiac work load.	

Table 5 cont. Nursing care plan.

• Pulse Rate: 92/min • Shortness of breath • SPO2: 97% on room air • RBS: 139 mmol. • VAS 7/10		• Administered drugs such as Morphine by appropriate route as ordered (*Appendix 3*).	• Potent option analgesic may be used in acute angina because of its effects such as peripheral vasodilation reducing myocardial workload; sedation can produce relaxation; and interruption of flow of catecholamines.	
		• Instructed the patient to notify nurse immediately when experiencing pain.	• To minimize ischemia produced by increased myocardial workload.	
		• Obtained a 12-lead ECG immediately during acute cheat pain.	• To monitor ischemic changes.	
		• Maintained a quiet, comfortable environment; restrict visitors as necessary.	• For mental or emotional stress that increases myocardial workload.	
		• Prepared for potential surgery.	• For percutaneous coronary intervention.	
		• Observed associated symptoms, such as dyspnea, nausea, vomiting, dizziness, palpitation and desire to urinate.	• Decreased cardiac output, which may occur during ischemic myocardial episode, stimulate sympathetic or parasympathetic nervous system, causing a variety of vague sensation that patient may not identified as related to angina like episodes.	

obesity and other risk factors in Saudi have been identified as one of the factors leading to early heart attacks and even death at a young age (Zubaid *et al.* 2009; Richardson 2015). The study done by The Saudi Project for Assessment of Coronary Events from December 2005–2007 found 72% were either overweight or obese. Overweight and obese patients were significantly younger than the normal-weight group (P=0.006). In general, obesity prevails throughout the world which is found that 33.1% and 32.2% of Americans were overweight and obese (McPherson *et al.* 2011).

Meanwhile, men are more at risk of having coronary artery disease because in general, a woman lived longer than men (ACLS Institute 2016; Harris 2006). Men also appear like engaging in stressful behaviour (Mohan *et al.* 2008; Badimon *et al.* 2012). Mobeirek *et al.* 2014; Hersi *et al.* 2013; and Harris 2006 argued that all of the various stress have been relevant with higher fatal risks of coronary heart disease.

CONCLUSION

Mr. F was sent to cardiac catheter laboratory at 1030H. From the cardiac catheter laboratory post-percutaneous coronary intervention to the mid-right coronary artery (1 Drug-Eluting Stent) he was transferred out to Telemetry unit on 11 August 2016 at 1500H with *Terumo* band hemostatic device through radial approach.

In conclusion, the factors that trigger myocardial infarction is the unhealthy lifestyles such as consumption of fatty foods, oily, salty, fast food and so on, which led to Mr. F to suffer from a heart disease. Also other factors are identified that are less encouraged such as stress at work and the possibility of a lazy lifestyle. Mr. F denied that he had diabetes but the RBS (120–139 mmol/l) and HBA1C (6.96%) revealed it. The amount of fat contained is more than ideal body weight of the patient. Therefore dietician was recommended. There are several things in the rehabilitation programme that have also been recommended for Mr. F to take and practice to improve his lifestyle.

RECOMMENDATION

As recommended by NSTEMI (2014) guidelines for the management of patients of NSTEMI is as follow:

1. Adhere to treatment modalities of; and

2. Ensure that the patient is instructed about how to modify cardiac risk factors (as shows below).

Smoking Cessation

Patient should be advised to quit smoking and avoid exposure to environmental tobacco smoke at home, work or at public places. Patient was recommended for counseling and plan development for quitting, including nicotine replacement and referral to special smoking cessation programme. The patient should be referred to smoking cessation programme after one month of hospitalization.

Optimal Weight

Patient should be encouraged to maintain his body mass index at normal range. The initial target is to reduce body weight by approximately 5–10% from baseline. Diet and exercise is a combination that should be done.

Daily Exercise

A month of post-NSTEMI events, should be favourable to perform 30–60 minutes of exercise for seven days a week to improve heart

function, body function, reduce cardiac risk factors, reduce risk of a second heart attack and improve psychological well being. Rigorous exercise and lifting heavy objects are prohibited and taken with caution.

Diet

Low intake of salt and saturated fats, and regular intake of fruits, vegetables and fish would be a perfect recommendation. Mediterranean diet has been taken as a model for optimum mental and physical fitness. However, taking moderate wine and alcohol should not be encouraged.

Blood Pressure Control (<140/90 mm Hg)

Counseling of lifestyle adjustment is needed to create the conditions for optimal blood pressure management. It involves a number of things that need to be practiced such as weight control, increased physical activity, alcohol moderation, salt reduction and greater consumption of fresh fruits, vegetables and low fat dairy products. If the blood pressure exceed the limits, pharmacological therapy with beta blockers and/or angiotensin-converting enzyme inhibitors or angiotensin-receptor blockers should be commence, with the introduction of other drugs such as calcium channel blockers or thiazides diuretics as needed to attain the treatment objective.

Consider Referring an Out Patient Cardiac Rehabilitation Programme

This gives a comprehensive long-term programme that limits physiological and physiological impact of cardiac illness by involving medical evaluation, prescribed exercise, lifestyle and cardiac risk factor modification, education and counseling. Exercise may include bicycle, treadmill, calisthenics, walking and jogging. Patients should be given specific instruction on activities (e.g. lifting, climbing stairs, and household activities) that are allowable and avoided. Particular state should be made of resumption of driving, return to work, and sexual activity.

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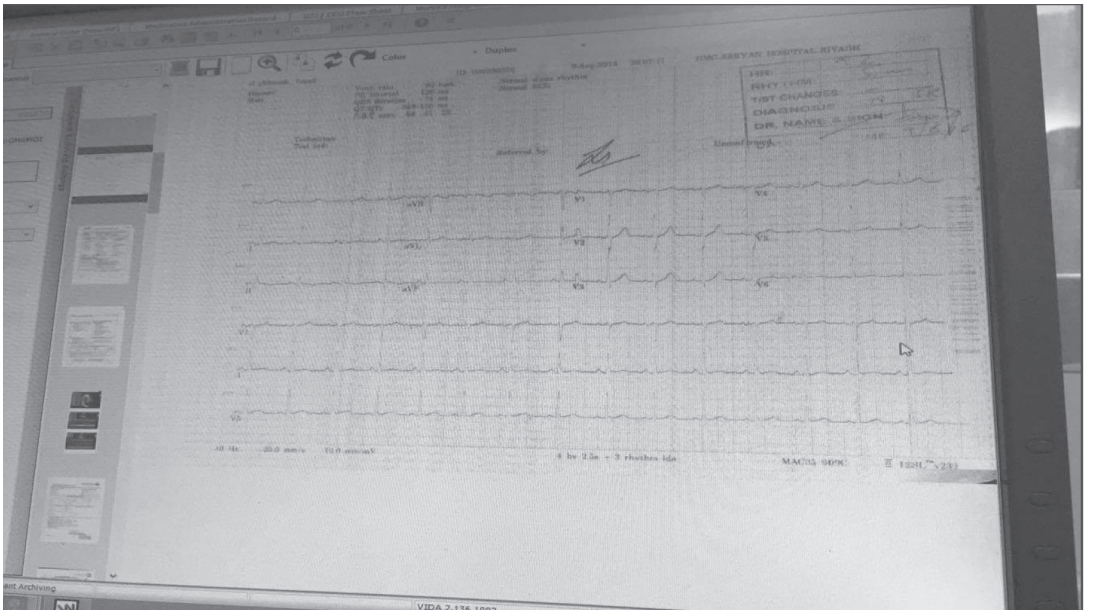
Appendix: Activities done in the ward

1. Electrocardiograph.



2. First eight hours monitoring of vital signs.

Date/Time	Temperature	Pulse	RR*	Blood pressure	SPO2*	Capillary blood glucose	VAS* pain score
10/08/2016 0040H	36.6	92/min	21/min	122/80 mm Hg	97%	139 mmol/l	7/10
0140H	36.5	94/min	20/min	120/75 mm Hg	98%	138 mmol/l	7/10
0230H	36.3	100/min	30/min	140/88 mm Hg	93%	137 mmol/l	7/10
0245H	36.4	98/min	28/min	135/78 mm Hg	94%	136 mmol/l	6/10
0300H	36.5	94/min	26/min	130/80 mm Hg	95%	135 mmol/l	6/10
0330H	36.5	96/min	24/min	132/82 mm Hg	96%	134 mmol/l	Asleep
0400H	36.6	90/min	20/min	128/76 mm Hg	95%	133 mmol/l	Asleep
0430H	36.8	93/min	19/min	136/70 mm Hg	96%	132 mmol/l	Asleep
0500H	36.7	75/min	18/min	118/70 mm Hg	96%	130 mmol/l	Asleep
0530H	36.6	85/min	21/min	120/80 mm Hg	97%	125 mmol/l	Asleep
0600H	36.5	80/min	20/min	122/75 mm Hg	98%	120 mmol/l	Asleep
0700H	36.4	88/min	20/min	110/70 mm Hg	97%	140 mmol/l	3/10

*RR = Respiratory rate; SP02 = Saturated partial oxygenation; VAS = Visual analogue scale

3. Medications

Drug study				
Drugs Names	Dosage	Frequency	Indication	Side effects
Plavix	75 mg/tab	Once a day	Blood clot	Blood-tinged urine
Concor	10 mg/tab	Once a day	Chest pain	Mild headache, and skin rashes
Ramipril	5 mg/tab	Once a day	Hypertension	Dizziness and nausea
Lipitor	40 mg/tab	Once a day	Cholesterol	Dark colored urine; hypoglycemia
Lipantyl	145 mg/tab	Once a day	Triglyceride	Hypoglycemia
Juspirin	81 mg/tab	Once a day	Clotting	Discoloration of urine
Morphine	3 mg intravenous	As necessary	Chest pain	Drowsiness

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Evaluation of Cooking Oil as Processing Addtive for Natural Rubber

Y. M. SYAMIN[1], S. AZEMI[2*] AND K. DZARAINI[3]

It was reported recently that high amount of aromatic ring or number of polycyclic aromatic hydrocarbon compounds found in aromatic oil are carcinogenic. This paper discusses the work to evaluate the Malaysian cooking oil as an alternative option to be used as process oil since cooking oil is safe to use and non-toxic. The performance of cooking oil is compared against aromatic and paraffinic oils. The results showed that rubber compounds containing cooking oil produced almost similar cure characteristics as those produced by aromatic and paraffinic oils indicating that it did not interfere with the vulcanization reaction. The physical properties of the vulcanizates containing cooking oil were almost similar to those of vulcanizates containing aromatic and paraffinic oils, except the rebound resilience. The vulcanizates containing cooking oil gave higher resilience than vulcanizates containing aromatic and paraffinic oils. High resilience is one of the desired features for a low rolling resistance tyre. Cooking oil provided this extra advantage.

Key words: Mooney viscosity; cure time; tensile strength; hardness and resilience

Aromatic oil has been used as rubber processing additive for centuries. The oil aids the mixing process such as to ease the incorporation of filler into the rubber and facilitates dispersion of fillers. In extrusion and calendering processes, the oil reduces heat generation and improves flow. Aromatic oil is known for high levels of aromatics (>65% wt, CA > 35%) (BP 1982), multiple-ring compounds, impart odour, low oxidation stability and high reactivity. The main characteristic of aromatic oil is associated with its excellent compatibility with most of the rubber. Aromatic oil also gives softening characteristic for improving the workability of rubber composition (Hasimoto 2000). However, recently it was reported that carcinogenic chemicals found in the petroleum process oils can be dangerous to human health (Swedish Ntional Chemical Inspectorate 2003; Dasgupta *et al.* 2009). The high aromatic oil contains large quantities of aromatic and polyaromatic hydrocarbons (PAHs), up to 10–30 percent (Swedish Ntional Chemical Inspectorate 2003; Dasgupta *et al.* 2009). Several of the PAHs contained in aromatic oils are classified as carcinogenic. A carcinogen is any substance, radionuclide or radiation that is an agent directly involves in the promotion of cancer or in the increase of its propagation (Wikipedia n.d.). This paper discusses some of the preliminary work to evaluate Malaysian cooking oil (palm oil with a brand name *Minyak Masak Cap Pisau* by Loon) as an alternative process oil for rubber mixing. Cooking oil is harmless

[1] Proreka (M) Sdn Bhd, No. 17 Jalan Industri PBP 3, Taman Industri Pusat Bandar Puchong, 47000 Puchong, Selangor
[2] Iprus Sdn Bhd, C-3-1 Block C, Pacific Place Commercial Centre, Jalan PJU 1A/4, 47301 Ara Damansara, Selangor
[3] Department of Polymer Technology, Faculty of Applied Sciences, Universiti Teknologi MARA, 40450 Shah Alam, Selangor
[*] Corresponding author (e-mail: azemi.sam@gmail.com)

and contains several saturated and unsaturated fats in the forms of lauric (0.1%, saturated), myristic (0.1%, saturated), palmitic (44%, saturated), stearic (5%, saturated), and oleic (39%, monounsaturated). Most of the current commercial processing additives are based on fatty acid soaps.

EXPERIMENTAL

Mix Formulations

Table 1 shows the mix formulations where the variables are the type and quantity of process oil used. Mixing was done in a laboratory Banbury mixer. The total mixing time in the mixer was five minutes. The mix was finalized by mixing with the curatives on a two-roll mill immediately after the mix was discharged.

Cooking Oil

Palm oil with a brand name *Minyak Masak Cap Pisau* by Loon. The density of cooking oil is 0.89 g/cm^3, the fat content of cooking oil is 90 g at every 100 ml (9% fats per 100 ml). The viscosity of cooking oil at 28°C is 6.66 × 10^{-3} Pa.sec.

Aromatic Oil (Tudalen 65)

The specific gravity of the aromatic oil by the *ASTM Test Method (D1250)* is around 0.95 to 1.00 g/cm3, while the molecular weight by *ASTM (D2502)* is around 300 – 700 and the aromatic content *ASTM (D2007)* in terms of percentage (%) is around 65 – 85. In this work, the aromatic oil was Tudalen 65 and the amount varied from 5 pphr to 20 pphr.

Paraffinic Oil

Paraffinic oil is oil distinguished by a molecular structure composed of long chains of hydrocarbons linked in a long linear series similar to a chain. It has high levels of isoparaffinic molecules. Paraffinic oil is more oxidative stability compared to aromatic and naphthenic oil and lower in odour. The level of monoaromatics is similar to those of the aromatic oil, but much lower levels of multi-ring aromatic process oil. The paraffinic oil used here is Nytex 840. The amount varied from 5 pphr to 20 pphr.

Table 1. Formulations.

Mix number	1	2	3	4	5
NR (SMR L)	100	100	100	100	100
Zinc Oxide	5	5	5	5	5
Stearic Acid	2	2	2	2	2
Santoflex 13™	3	3	3	3	3
HAF (N330)	50	50	50	50	50
*Process Oil	-	5	10	15	20
Sulphur	2.5	2.5	2.5	2.5	2.5
**CBS	0.75	0.75	0.75	0.75	0.75

*Process oil – three different types of process oil are being investigated.

Mooney Viscosity

Mooney viscosity measurement was done by using Mooney viscometer at 100°C in accord with *ISO/R289*. The results were expressed as ML (1 + 4), in torque units, indicating a preheat time of 1 minute and a reading time of 4 minutes at test temperature 100°C.

Cure Characteristics

The cure characteristics such as the scorch time t_2 and optimum cure time t_{95} were determined from the oscillating disc cure meter in accord with *ISO 3417*.

Tensile, Hardness, and Resilience Test

Tensile test was done in accord with *ISO 37*. Hardness test was done in accord with *ISO 48* and resilience test was done in accord with *BS 903*.

RESULTS AND DISCUSSIONS

Physical Tests on Unvulcanized Rubber Compound

Mooney viscosity. In the absence of process oil, the Mooney viscosity of the rubber compound was relatively high about 68 Mooney units (MU). In the presence of process oil, the Mooney viscosity decreased progressively as the quantity of oil increased as shown by the histogram in *Figure 1*. This behaviour is attributed to the effect of diluents from the oil softening associated with the swelling of rubber and enhancement of molecular flow associated with the lubrication. All the three process oils produced comparable Mooney viscosity at each oil loading.

Cure Characteristics. The effect of the type and quantity of process oil on scorch time t_2 and cure time t_{95} is shown in *Figures 2* and *3,* respectively. The aromatic oil gave slightly better processing safety i.e. longer scorch time than the other two types of oil. In the case of optimum cure time t_{95}, there was not much difference among these three process oils. The paraffinic oil contributed slightly higher t_{95} than the other two oils at 15 and 20 pphr oil loading. The results showed that cooking oil produced almost similar cure characteristics of the rubber compound as that produced by aromatic process oil.

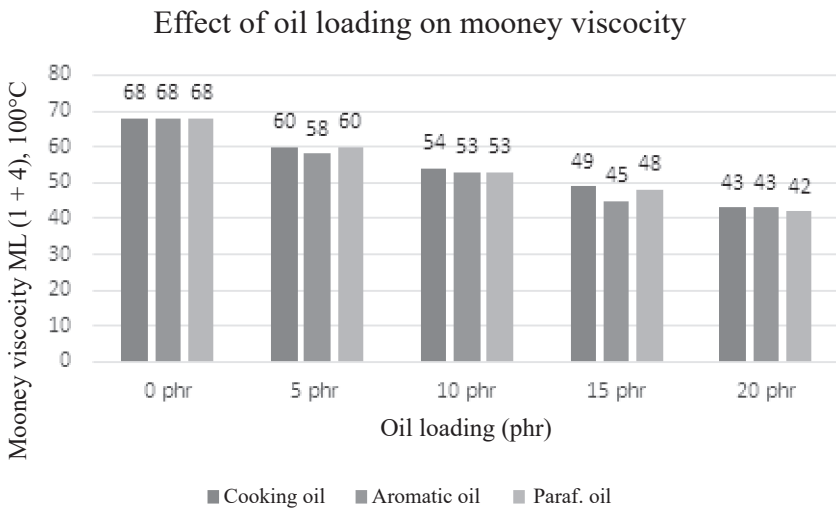

Figure 1. Influence of types of oil and quantity of oil on Mooney viscosity of rubber compound.

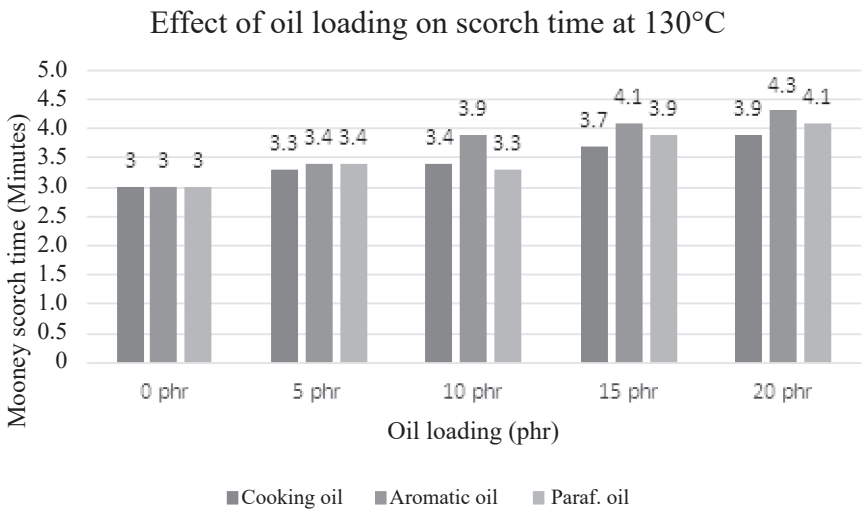

Figure 2. Effect of type and quantity of oil on scorch time t_2 of rubber compound.

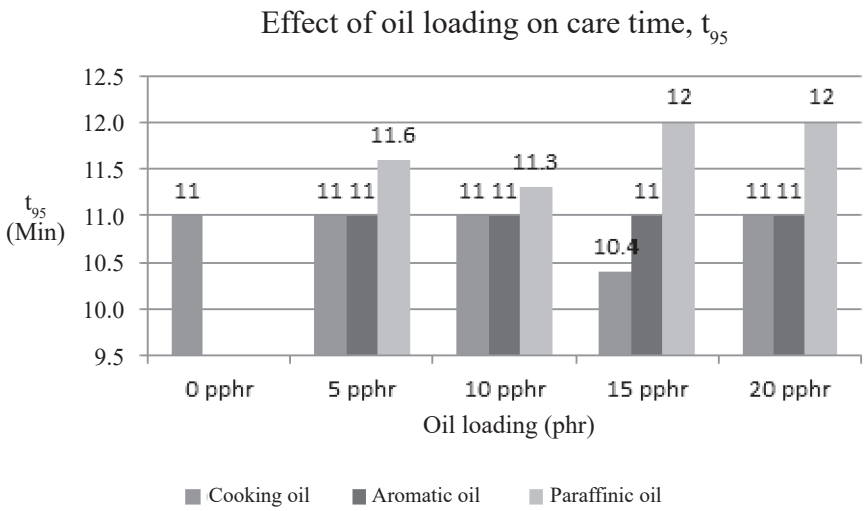

Figure 3. Effect of type and quantity of oil on scorch time t_{95} of rubber compound.

Mechanical and Physical Tests for Hardness and Tensile Strength of Vulcanized Rubber

Hardness. Hardness is defined as the resistance to surface indentation as measured under specified conditions. It is a non-destructive test that measures the reversible deformation when an indenting force is applied on the rubber surface at a specified time. Hardness test is widely used in quality control because hardness is sensitive to filler loading and also the state of cure.

The histogram in *Figure 4* shows that the hardness decreases steadily as the quantity of oil in the vulcanized rubber increases. It is well established that the main function of the oil is to facilitate during processing (such as mixing, calendering and extrusion) by lubricating and

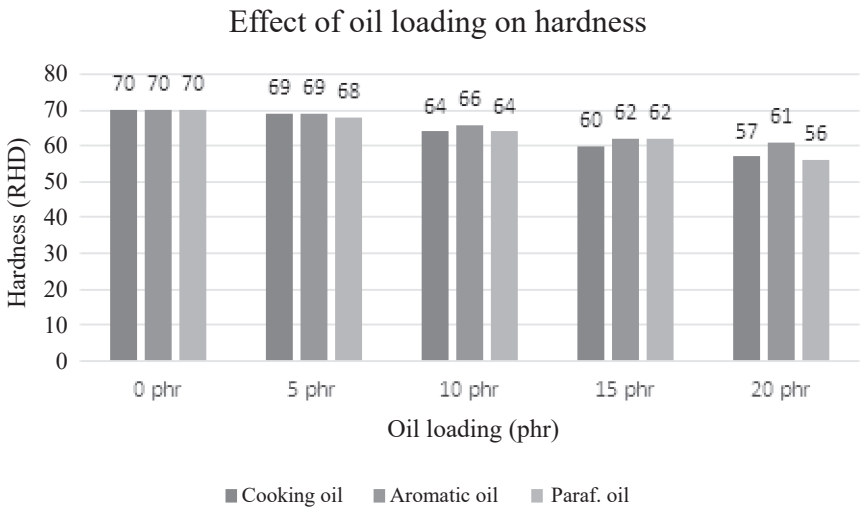

Figure 4. Effect of type and quantity of process oil on hardness of vulcanized rubber.

softening to ease rubber flow. The hardness decreased with increasing quantity of oil because the rubber became softer at higher oil loading than at low oil loading since the plasticizing and swelling effects were more effective at higher oil loading than at low oil loading. This softening was consistent with the results shown in *Figure 1* where the Mooney viscosity decreased with increasing quantity of oil. Thus, this indicates that, apart from filler and crosslink concentration, the quantity of oil also affected the hardness markedly. The type of oil did not cause much difference in hardness especially at 5 pphr of oil. At 20 pphr of oil, the aromatic oil contributed slightly higher hardness than paraffinic and cooking oils.

Tensile strength. The histogram in *Figure 5* shows that the tensile strength of vulcanized black-filled NR is not markedly affected by

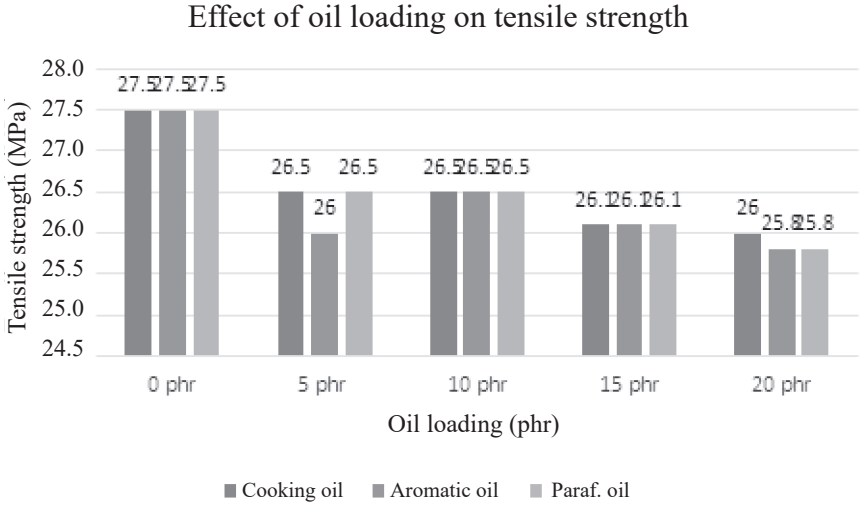

Figure 5. Effect of oil on tensile strength (unaged).

the type of oil. There is a marginal decrease of tensile strength as the quantity of oil increases. This decrease is associated with the dilution effect (Azemi 2012; Azemi 2014). Apart from the dilution effect, tensile strength also decreased when the molecular interaction between rubber chains was reduced because the rubber molecules were further apart since the rubber was in the swollen state. The decrease in the molecular interaction also responsible for the increase in elongation at break as shown in *Figure 6*. Here, the cooking oil gave slightly higher elongation at break than aromatic and paraffinic oil probably because the former contributed higher lubricating effect since the former had lower viscosity than the latter.

Physical Tests for Tensile Strength After Heat Aging

Tensile Strength. However, the type of oil affects the tensile strength after accelerated heat aging. *Figures 7, 8* and *9* showed the plot of tensile strength after accelerated heat aging for 7 days at 70°C, 14 days at 70°C and 1 day at 100°C, respectively. The results showed that the tensile strength was higher in samples with oils than the control sample (without process oil). Azemi (2012 & 2014) attributed this behaviour to the phenomenon known as supercoiled network. The presence of oil in the rubber compound causes the rubber molecules to be pushed apart as if they are extended (as a consequence of swelling). During vulcanization, crosslinks are formed between these extended rubber molecules. When the diluent (oil or solvent) is then removed by extraction (or by evaporation) (Azemi 2012) the network collapses (disappearance of swelling) and forms supercoiled network. The aromatic and the paraffinic oils give higher tensile strength than that of vulcanizates containing cooking oil. The longer the aging period and the higher is the temperature of heat aging the lower is the tensile strength.

Resilience. *Figure 10* showed an impressive result where cooking oil gave higher resilience than the other two process oils especially at oil loading more than 10 pphr. There was a general trend where the rebound resilience decreased progressively with increased oil loading.

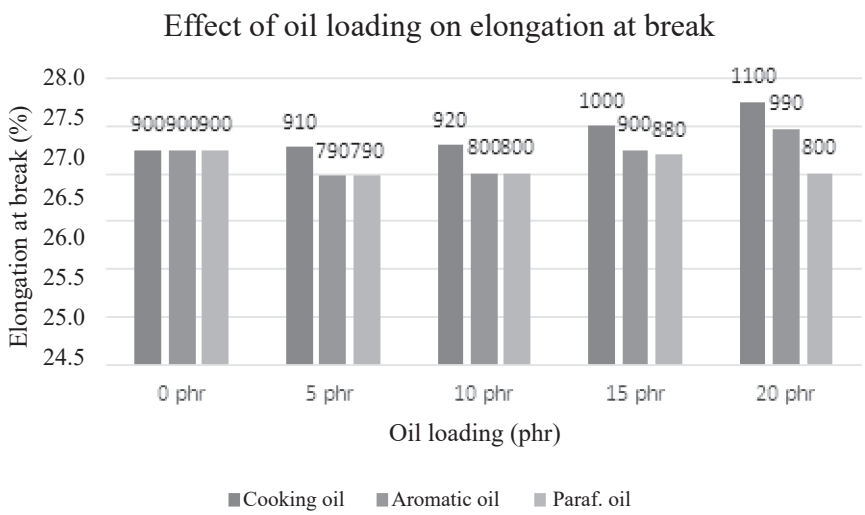

Figure 6. Effect of oil on elongation at break (unaged).

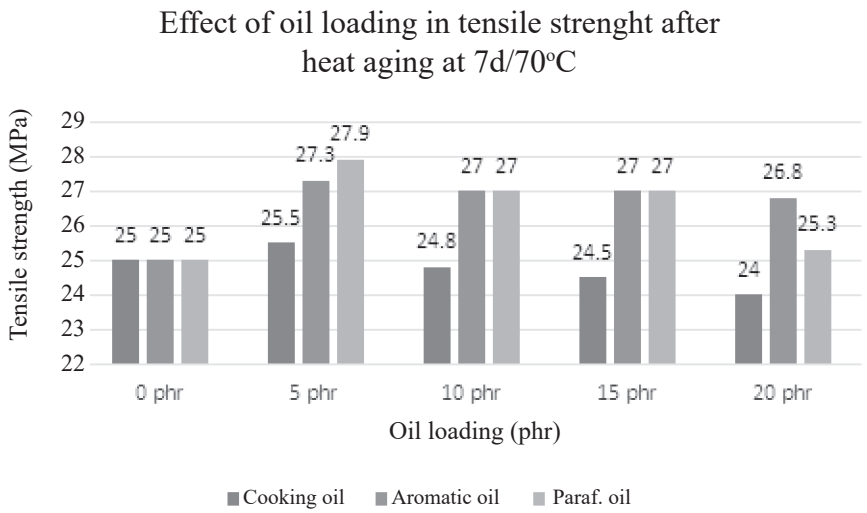

Figure 7. Influence of types of oil on tensile strength after accelerated heat aging at 70°C for 7 days.

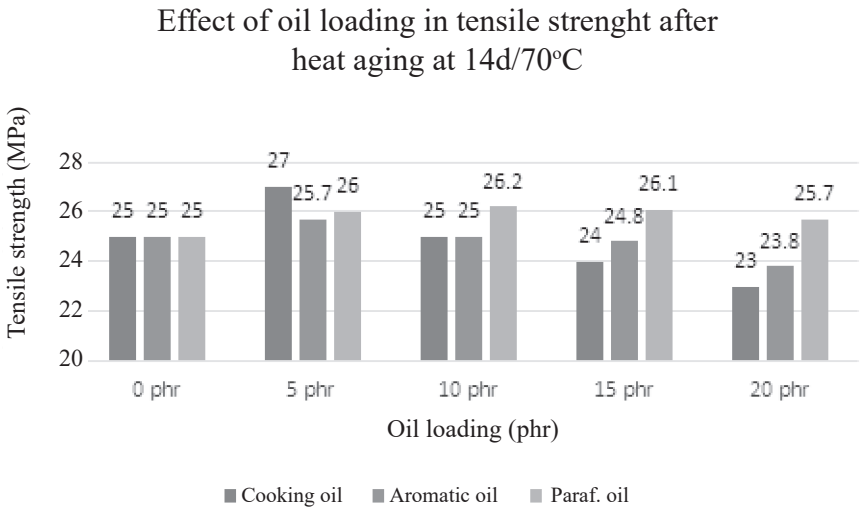

Figure 8. Influence of types of oil on tensile strength after accelerated heat aging at 70°C for 14 days.

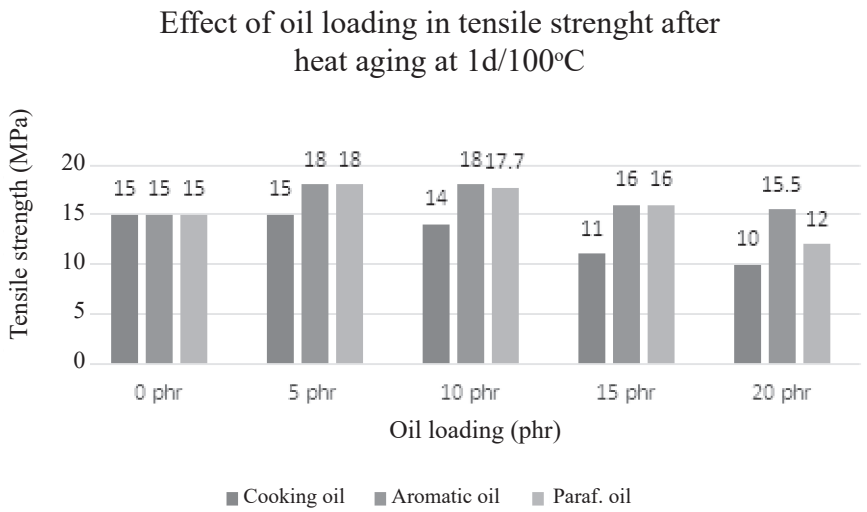

Figure 9. Influence of types of oil on tensile strength after accelerated heat aging at 100°C for 1 day.

The rebound resilience was greatly influenced by the glass-transition temperature T_g, crosslink concentration and filler loading. *Table 2* shows the T_g of the vulcanized rubber reproduced from the work published by Azemi (2012). The aromatic oil gives higher T_g by 2°C to 3°C at 5 and 10 pphr of oil, and a difference of about 8°C at oil loading higher than 25 pphr. The results indicate that process oil is not a true plasticizer, but a softener or lubricant since the reduction in T_g is not substantial. The fact that the resilience decreases with increase oil content suggests that the oil acts as a damper.

Indeed the high quantity of aromatic oil is incorporated into highly filled NR to give high damping for compounding of natural rubber for seismic rubber bearings. The cooking oil exhibited higher resilience than aromatic and paraffinic oils because the viscosity of the former was lower than the latter. The low damping characteristic of cooking oil (high resilience) was one of the desired features for a low rolling resistance tyre. Cooking oil provided this extra advantage.

Table 2. Glass transition temperature T_g of unfilled NR vulcanizate.

Oil (pphr)		Raw SMR L Standard	0	5	10	25	35	40
T_g°C	(Aromatic)	−72	−69.3	−68.9	−69.3	−69.3	−69.1	−69.6
T_g°C	(Paraffinic)	−72	−69.3	−71.3	−72.3	−77.3	−78.0	−78.6

(Note: T_g was determined using DSC heating from –100°C to 0°C at 20°C per minute. Calibration was by cyclohexane. Also standard raw NR T_gs were measured before and after the sample series. The sample T_gs were then corrected).

CONCLUSION

Cooking oil was suitable to be used as process oil for rubber compounds. It showed almost similar behaviour with the commonly used process oils such as aromatic and paraffinic types. Cooking oil possessed further advantages of having low damping characteristics and being non-toxic.

AKNOWLEDGEMENT

The authors would like to express their thanks to the Dean of the Faculty of Applied Sciences for the consent to present this work at the *International Polymer Technology Conference and Exhibition 2013*.

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Increasing Serum Cholesterol Level among Sri Lankan Adult Obese Patients Admitted to Medical Wards: A Cross-sectional Study

R. (II) P. DIOSO[1*], K. SHALINA[2] AND K. JUDENIMAL[3]

This research identified the factors affecting the widespread of the level of serum cholesterol among adult obese patients admitted to government hospitals in the eastern part of Sri Lanka, and identified the number of adults obese patients with increasing serum cholesterol level. A descriptive cross-sectional study design was used. Convenience sampling technique helped select 150 patients in medical wards and clinics of two government hospitals in the eastern province of Sri Lanka, and Questionnaires were distributed for data analysis. Overall findings of 150 obese patients regarding increasing serum cholesterol level admitted in the medical wards and follow-up at medical clinics had 59% in moderate risk, 36% with high risk, and 2% with a minimal risk of increasing serum cholesterol level. Gender was a factor, which brings about 49.3% (n = 74) of the respondents were female and 50.7% (n = 76) were male. About 59% of participants had 130–159 mg/dl of total cholesterol level while 36% had 160–189 mg/dl and 1% had lower than 100 mg/dl. It was also identified that age and co-morbidities of obesity are factors that affect an increasing serum cholesterol level.

Key words: Cross-sectional study; increasing serum cholesterol; obesity; medical nursing

This study is the first observational study report on an increasing serum cholesterol level among adult obese patients admitted to two government hospitals in the eastern part of Sri Lanka.

One of the most essential functions of the serum cholesterol is to serve as the primary raw material from which your body makes many major steroid hormones, including testosterone, estrogen, progesterone, cortisone, and aldosterone (Basavanthappa, 2005; Roberta *et al*. 2006). Without cortisone your body could not cope with stress, and without aldosterone, your body could not properly balance your sodium and water levels (Basavanthappa 2005; Roberta *et al.* 2006).

Age, gender, and genetics are the factors that cannot control the elevating serum cholesterol level but, diet and lifestyle can control the elevating serum cholesterol level (Cordelia & Milliard 1995). Also lack of proper knowledge regarding the importance of maintaining optimal serum cholesterol level, negligence of health advice and no willingness to change their life style and diet patterns are the reasons for increasing their serum cholesterol level (Office of Medicine Application Research 1985).

[1] Faculty of Nursing, Lincoln University College, Jalan SS 6/12, 47301 Petaling Jaya, Malaysia
[2] Ashraff Memorial Hospital, Sri Lanka
[3] Batticaloa Teaching Hospital, Sri Lanka
[*] Corresponding author (e-mail: duke@lincoln.edu.my)

Most obese patients perceive that anti-cholesterol drugs can reduce the serum cholesterol level rather the dietary control and lifestyle modification (Cordelia & Milliard 1995; Roberta *et al.* 2006). When patients are affected by increasing serum cholesterol level, they are admitted to hospitals and get complications such as cardiovascular diseases, stress, and neurological disorders which are co-morbidities of obesity (Turley & Dietschy 1988; Cordelia & Milliard 1995).

Problem Statements

Elevating serum cholesterol level is one of the main causes of mortality in Sri Lanka. In spite of many awareness programs and free health services for the public, hospital statistics reported that a number of admission with high serum cholesterol and its complications are getting high.

Hypotheses

There are significant evidence of an increased serum cholesterol level among adult obese patients admitted to medical wards in the eastern part of Sri Lanka.

Variables

The cause variable is obesity, and the effect variable is the increasing serum cholesterol level. The variables will answer the question, "Are there statistical evidences on the increasing serum cholesterol level among adult obese patients admitted to government hospital in the eastern part of Sri Lanka?"

Objectives

At the end of this research, it is hoped to:

(1) Identify the factors that affect an increasing level of serum cholesterol among adult obese patients admitted to medical wards; and

(2) Distinguish the prevalence of adult obese patients with increasing serum cholesterol level.

LITERATURE REVIEW

Articles were extracted from Google Scholar, and PubMed search engines using the combination of following key words: "increasing serum cholesterol level, adult obese patients and obesity".

Sources

Sources of literature usually used in research studies are of scientific researches (Turnock 2004; Burns & Grove 2007; Indrani 2005). There were adequate research articles related to this topic but not in the Sri Lankan context. The researchers found literature from other countries related to this subject. There were few research articles available during the past five years. Therefore, articles up to ten years back were used.

Critical Appraisal

Arai *et al.* (1994) investigated the "Increased plasma cholesterol ester transfer protein in obese subjects". In this research the mechanism for this reduction has not been fully clarified. Cholesteryl ester transports protein (CETP) transfers cholesterol ester from HDL to apolipoprotein B-containing lipoproteins and plays a major role in regulating the concentration and composition of HDL. The CETP, and postheparin lipoprotein lipase (LPL) and hepatic triglyceride lipase (HTGL) investigated activities in 30 obese subjects (17 women and 13 men, age 44±14 years, mean±SD). The average body mass index

of the obese subjects was 33.1±4.8 kg/ m^2 (range, 26.4 to 43.8 kg/m2). The obese subjects showed significantly lower serum HDL cholesterol levels than control subjects (1.04±0.28 versus 1.50±0.34 mmol/l, P<0.01). In the obese subjects, both activities and protein mass of CETP and postheparin HTGL activities were significantly increased,whereas postheparin LPL activities were significantly decreased. CETP activities, independent of postheparin HTGL and LPL activities, were correlated negatively with HDL-cholesterol (r= –0.39, P<0.05). And the cholesteryl ester to triglyceride ratio of HDL2 and HDLj (r= –0.36, P<0.05; r= –M, P<0.05, respectively). CETP activities were correlated positively with body mass index (r=0.38, P<0.05), body fat ratio (r=0.42, P<0.05), and subcutaneous fat area determined by abdominal CT scan imaging (r=0.49, P<0.05) and negatively with visceral fat/subcutaneous fat ratio (r= –0.52, P<0.01). After body weight reduction by caloric restriction, both activities and protein mass of CETP were reduced. These results suggest that high levels of plasma CETP may partly explain the decrease of serum HDL cholesterol in obese subjects and that plasma CETP levels may be regulated by the degree of total body fat accumulation.

Hill and Peters (2010) evaluated the current epidemic of obesity that is caused largely by an environment that promotes excessive food intake and discourages physical activity. Although humans have evolved excellent physiological mechanisms to protect against body weight loss, they have only weak physiological mechanisms to defend against body weight gain when food is abundant. Control of portion size, consumption of a diet low in fat and energy density, and regular physical activity are behaviours that protect against obesity, but it is becoming difficult to adopt and maintain these behaviours in the current environment. On account of obesity is difficult to treat, public health efforts need to be directed toward prevention. According to the Hill and Peters (2010), the relationship between certain diets and serum cholesterol levels, are the effect of obesity. Thus, a lot of obese patients have high serum cholesterol levels and risk of heart diseases.

Analysis

While all these studies were carried out in other countries, Sri Lankan literature was not available to bring definitions to obesity. The articles above are appropriate. From 1994 to 2010, the difference between the years would give the foundation to the operational definitions in this study.

According to the literatures reviewed, obese patients are defined as, persons who are more than overweight or are undergoing treatment for high cholesterol (Aria *et al.* 1994; Hill & Peters 2010). On the other hand, cholesterol is defined as, a byproduct of obesity made by the liver and acquired through diet (Hill & Peters 2010; Aria *et al.* 1994). The body uses cholesterol to produce bile, some hormones, vitamin D, cell membrane and myelin (Aria *et al.* 1994; Hill and Peters, 2010). High blood cholesterol has been linked to a lot of diseases and is believed to be the cause of mortality over 10 years' time (Aria *et al.* 1994; Hill & Peters 2010). An increasing serum cholesterol level among adult obese patients must be observed.

METHODOLOGY

Research methodology is a way to solve the research problem systematically. It may be understood as a science of studying how

research is done scientifically (Polit & Beck 2013). This section will describe the design, sampling techniques, and the method of data collection.

Research Design

This study planned to conduct using a descriptive cross-sectional design since two government hospitals will be used to select the respondents. It is more appropriate to investigate two hospitals admitting adult obese patients with increasing serum cholesterol level to identify prevalences from two sections.

Research Setting

Specifically, the researchers conducted their study at Ashraff memorial hospital and Kalmunai base hospital.

Population and Sampling

Convenience sampling technique was used to select the respondents. The accessible populations were patients who had more than 240 mg/dl serum cholesterol level between the age group 35 years to 60 years. This study used 150 patients with increasing serum cholesterol level during the month of April to October 2016.

The sample size was calculated using this formula:

$$n = \frac{Z^2 .P(1 - P)}{d}$$

where n = Population;
z = Confidence;
p = Prevalence;
d = Precision.

Data Collection

All adequate information were given to all the participants regarding the study and,invited them to participate. Data collection in this study was done using a questionnaire. A questionnaire was in a printed paper to elicit information that can be obtained through written response of the patients. The close-ended questionnaire became appropriate as an umbrella to answer the objectives and hypotheses set (Cormack 1996).

Distributing the questionnaires was conducted from April to September 2016. Data was collected from 150 of patients with high serum cholesterol. Questionnaire completed at the same place. The questionnaire was initially developed in English and it was translated in to both Tamil and Sinhala language to cover up all ethnic groups to ensure that all participants understood the questionnaire without any difficulty. The rate of response of this study was 100%. Questions were sets of multiple choices, and the respondents would only tick one answer from the given selections.

Data Analysis

Data processing and analysis were done using descriptive statistics and software summarized data were presented in appropriate charts and tables using manual and SPSS version 21. This study analyzed all responses made by patients, with the help of computer guided graphs and charts to understand their perception on increasing serum cholesterol level.

The population and estimated prevalence are set at 20% because the margin of error was at 5% precision with the confidence of 95%. Central tendencies with probability findings were used to mathematically analyze the data collected.

Ethical Permission

Ethics refers to the quality of research procedures to their adherence to professional,

legal and social obligations to research subjects (Polit & Beck 2013). We obtained permission from the medical superintendents of the hospital to conduct this study. The ethical committee of Lincoln University College then gave permission to commence the research. Lastly, the Ministry of Health Sri Lanka gave the letter of approval to use the government hospitals to use patients for this research.

Written consent was explained to provide sufficient understanding of the study among patients who cannot understand English. Voluntary participation was encouraged among the selected patients.

RESULTS AND FINDINGS

Of the 150 adult obese patients it was identified that 76 (50.7%) were the male and 74 (49.3%) were female who were confined at the Ashraff Memorial Hospital in Kalmunai and Kalmunai Base Hospital, with increase cholesterol (*Figure 1*). The prevalence of these participants also identified the male gender to be more obese as compared with the females.

According to the study sample, participants' socio-economic statuses were identified under following characteristics such as education, economical status to be factors affecting increasing serum cholesterol among obese patients (*Figure 2*). Most of the participants were high in serum cholesterol level of the advanced education level of knowledge. Lower socio-economic participants were in low serum cholesterol level. Overall findings of low ordinary education attainment and lower socio-economic patients were in low risk of serum cholesterol level.

Of the 150 obese patients admitted to medical wards and followed-up at medical clinics 59% were in moderate risk of serum cholesterol level, and 36% were in high risk, and 2% were in minimal risk (*Figure 3*).

Table 1 identified that the age bracket of 30 to 40 years old obese Sri Lankan patients with a high probability ($p = 0.061$) correlated with cholesterol. Factors affecting cholesterol is more likely correlated with gender having the female ($p = 0.026$) to be higher than male ($p = 0.025$) even though men are more obese than women.

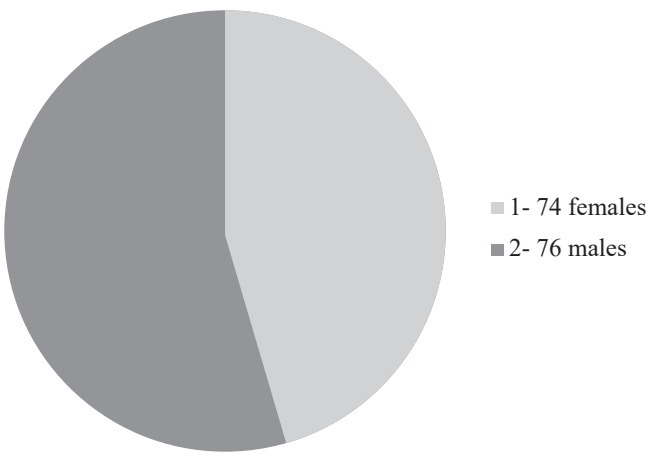

Figure 1. Gender factor affecting increase serum cholesterol level.

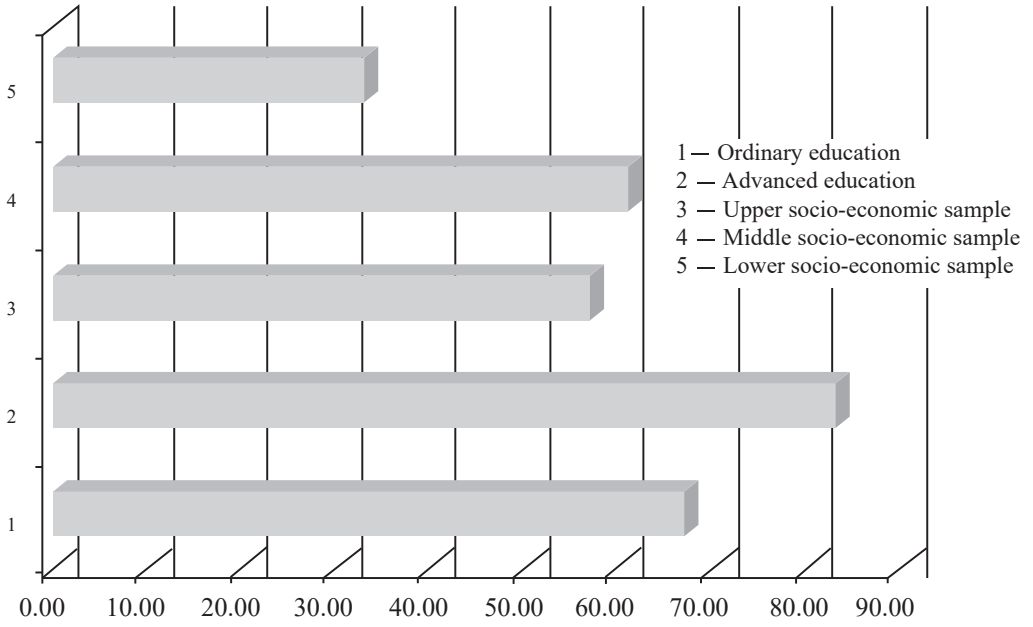

Figure 2. Socio-economic and educational demography.

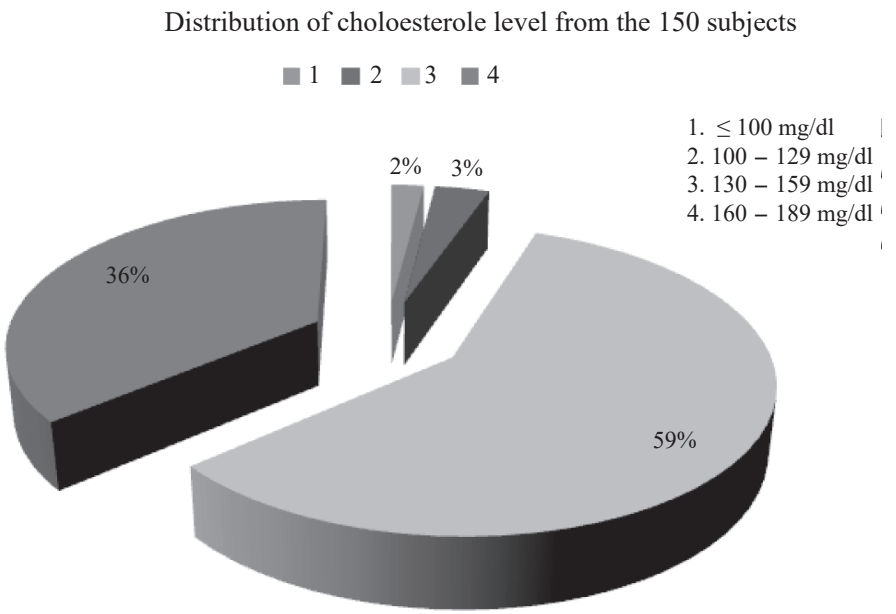

Figure 3. Serum cholesterol prevalence.

Table 1. Factors affecting increasing cholesterol.

	100 mg/dl	100–129 mg/dl	130–159 mg/dl	160–189 mg/dl	Mean	Standard deviation	Probability
Male	2	5	38	28	18.25	1	0.025
Female	1	0	49	26	19.25	1	0.026
Diabetes	2	2	20	18	10.5	8	0.054
Hypertension	1	2	25	24	13	11.5	0.041
Respiratory	0	1	29	7	9.25	1	0.049
30–40 years	1	2	14	13	7.5	6	0.061
41–50 years	1	0	36	21	14.5	1	0.033
51–60 years	1	3	37	21	14.5	1	0.031

Table 2. Correlation of consultations to total cholesterol.

	Total = 150	
	N	%
100 mg to dl* when I have complications on severity	2	1.3%
100 mg to dl* No regular consultations	1	0.7%
100 to 129 mg/dl* Regularly	3	2.0%
100 to 129 mg/dl* When I have complications on severity	1	0.7%
100 to 129 mg/dl* No not regularly	1	0.7%
130 to 159 mg/dl* Regularly	43	28.7%
130 to 159 mg/dl* Once in a while	23	15.3%
130 to 159 mg/dl* When I have complications on severity	11	7.3%
130 to 159 mg/dl* No not regularly	14	9.3%
160 to 189 mg/dl* Regularly	33	22.0%
160 to 189 mg/dl* Once in a while	12	8.0%
160 to 189 mg/dl* When I have complications on severity	5	3.3%
160 to 189 mg/dl* No not regularly	4	2.7%

Co-morbidities of obesity such as diabetes mellitus ($p = 0.054$), hypertension ($p = 0.041$) and respiratory diseases ($p = 0.049$) were identified as factors to affect an increase in serum cholesterol.

Gender was also identified as factors such as male ($p = 0.025$) and female ($p = 0.026$) but are not very likely among Sri Lankan adults to affect their cholesterol level.

The age bracket 41 to 50 years old ($p = 0.033$) was also identified to have affected increase cholesterol and are more probable as compared to the age bracket of 51 to 60 years of age ($p = 0.031$) to influence the increase in serum cholesterol.

Also it was investigated that correlations of cholesterol was due to consultations such as when patients had complications, if consultations were not regular and only once in a while, or if consultations were constantly done.

CONCLUSION

There was significant evidence of an increased serum cholesterol level among adult obese patients admitted to government hospitals in the eastern part of Sri Lanka.

Overall findings of 150 obese patients regarding increasing serum cholesterol level admitted in the medical wards and the follow-up at medical clinics had 59% in moderate risk, 36% with high risk, and 2% with a minimal danger of increasing serum cholesterol level. About 74 (49.3%) of the respondents were female, and 76 (50.7%) were male. About 59% had 130–159 mg/dl of total cholesterol level range while 36% had 160–189 mg/dl, and 1% had lower than 100 mg/dl cholesterol level range. It was also identified that gender and co-morbidities affected an increasing serum cholesterol level including the age bracket of 41–50 and 51–60 years old.

RECOMMENDATION

For the Sri Lankan community, it was important to seek consultations more often. This is because most of the people in Sri Lanka were busy with their jobs and only sought consultations once co-morbidities of obesity occured with such symptoms of diabetes mellitus, hypertension, and respiratory disorders. If the practice of regular medical consultation was done, increasing serum cholesterol might be identified before symptoms of co-morbidities worsen.

Date of receipt: January 2017
Date of acceptance: June 2017

ACKNOWLEDEMENT

The authors would like to express our appreciation and gratitude to: the Ministry of Health of Sri Lanka; the Medical Superintendents of Ashraff Memorial Hospital and the Batticaloa Teaching Hospital of Sri Lanka; and the Ethical Committee of the Lincoln University College, for granting the permission to commence this study.

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ASEAN J. Sci. Technol. Dev., **34(1)**: 35 – 50

Hydrocarbons as Refrigerants—A Review

J.H. KOH[1], Z. ZAKARIA[1] AND D. VEERASAMY[2*]

Refrigerants used in air conditioning and refrigeration (AC&R) industries have come full circle since the beginning of the industrial revolution. With concern on issues relating to the environment such as the global warming and climate change issues, we should find a better alternative than to continue using these refrigerants that cause global warming and ozone depletion. AC&R industry players have blended in by introducing some new equipment and components that are specifically designed for hydrocarbon (HC) use. Most new refrigerators sold in Malaysia are already equipped with isobutane [a hydrocarbon designated as R-600a by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standards] as refrigerants. Malaysia has ratified the Montreal Protocol and targetted a 10% reduction in hydrochlorofluorocarbon (HCFC) consumption, beginning 2016 with the banning of 2.5 horsepower (hp) and below in air-conditioning (AC) equipment to be used. Instead, hydrofluorocarbon (HFC) R-410a was introduced as a replacement for HCFC- 22, whereas in other countries this HFC has been phased down. This article was initiated because of the difficulty in finding a replacement for HCFC. Also, the possibilities of using HC as an alternative to replace HCFC instead of using HFC as a transitional refrigerant in place of HCFC is reviewed in this article. The performance of HC is very similar to HCFC and flammability issues could be easily overcome with the use of an effective design. Their use could be facilitated with the adaptation of specific standards and properly enacted legislation.

Key words: Refrigerants; hydrocarbon; hydrochlorofluorocarbons; hydrofluorocarbon; flammability hydrofluorocarbon

Malaysia has committed to the reduction in the consumption of hydrochlorofluorocarbons (HCFC) and other ozone depleting substances following the ratification of the Montreal Protocol on 29 of August 1989. The Department of Environment (DOE) Malaysia, has devised the HCFC Phase-out Management Plan by gradually reducing the dependency, starting with the reduction of 10%, 35%, 67.5 % and total phase out for the year, 2015, 2020, 2030 and 2040, respectively with only minimal quantities usage for servicing purposes (DOE 2010).

With this implementation, the local air conditioning and refrigeration (AC&R) industry is subjected to a plan and imposed restriction by DOE to ban the manufacture, importation and installation of split type air conditioner units of 2.5 horse power (hp) (cooling capacities of 24 000 British thermal units per hour (BTU/h) and below) as of 31 December 2015 (DOE 2015).

The AC&R players have also resorted to converting the manufacturing, importation, and installation of AC&R equipment from HCFC 22

[1] Faculty of Chemical and Energy Engineering, Universiti Teknologi Malaysia, Skudai, Johor, Malaysia
[2] Suraaj Mahir Consultancy, 19, Jalan KE 4/9, Kota Emerald, 48000 Rawang, Selangor, Malaysia
[*] Corresponding author (e-mail: veerasamydevaraj199@gmail.com)

to hydrofluorocarbon (HFC) 410a, citing the "0" ozone depletion potential (ODP), as its distinct advantage. The HFC 410a equipment was often being labelled as eco-friendly despite having a Global Warming Potential (GWP) of 2090 as compared to HCFC 22, which is at 1810.

At least one major AC&R equipment manufacturer has introduced HFC 32 or R 32 (difluoromethane), a mildly flammable refrigerant as the answer to the replacement refrigerant to HCFC 22. The advantages HFC 32 has over the HFC 410a is the low GWP (675) and lower volume needed to produce the same refrigeration effect as HFC 410a. However, the cost of the new equipment, higher operating pressures, and the mild flammability will be of significant concern to the end users. Beside these R 32 has an atmospheric lifespan of 5.2 years and when leaked to the environment has long effect of 675 times more potent than CO2 has, as a global warming gas.

Most domestic refrigerators sold in Malaysia these days consist of hydrocarbon (HC) refrigerants with isobutane (HC 600a) as a clear choice due to similar thermodynamic properties it had with the HFC 134a refrigerant which it replaces. In the refrigerators, the insulation materials also consist of cyclopentane as its blowing agent. *Figure 1* shows the Japanese branded refrigerator currently being sold in a local Malaysian departmental store using isobutane (R 600a) as a refrigerant and cyclopentane ($C_5 H_{10}$) as its insulation blowing agent. It has the highest energy efficiency ratings of "5 Stars" awarded by the Energy Commission of Malaysia. Fire hazard warning labels are found throughout the back of the refrigerator to inform owners and handlers of the potential risk of fire when using or to repairing the fridge.

However, in the air conditioning sectors, the use of HC refrigerants is at the minimal as there is no equipment manufactured or imported suited for use. The Fire and Rescue Department of Malaysia only allows equipment that is manufactured specifically to use HC and prohibits any form of HC "drop in" to replace HCFC 22. Any modification to existing equipment that uses other than HC shall only be allowed to operate if professional engineers certified the safety aspect.

In the European Union (EU), HFC is currently being phased down due to its high GWP values. The fluorinated gas regulation (Regulation EU No 517/2014 or commonly addressed as the F-gas regulation) was introduced in 2014 to reduce the EU's consumption of fluorinated gases gradually, members of the EU have started using natural refrigerants in replacement of HFC. Ammonia, carbon dioxide, water, air and hydrocarbons which are known as "the natural five" have been a much sought-after replacement for the HCFC and HFC they replace. In Malaysia, ammonia (NH_3) refrigeration have long existed in refrigeration systems in the ice making industries. CO_2 would not be efficient in high ambient temperature tropical climates (Lorentzen 1995). Water-lithium bromide ($Li\ Br_2$) absorption refrigeration systems are only viable in areas or building which have an abundance of waste heat as it is also not economical and inefficient to supply heat to generators. There are cases of modification and drop in use of HC refrigerants in small scales throughout Malaysia but its impact is minimal to the majority of AC&R players. HC refrigerants are currently being imported from Australia, Korea, and the USA and these products are sold under different trade names. These HC refrigerants are marketed as pure

(a) (c)

(b) (d)

Figure 1. (a) Two door Japanese brand refrigerator available locally; (b) fire hazard label with refrigerant identity displayed on the compressor unit; (c) '5 star' rating label awarded by Energy Commission and (d) fire hazard labelling on the back of the refrigerator.

refrigerant grade propane and butane which as claimed by importers are made to suite ACR equipment. There are no local manufacturers of ACR equipment using commercially available HC such as liquefied petroleum gas (LPG) as refrigerants, even though the LPG is produced locally.

Elsewhere in China, Yang and Wu (2013) reported that HC (R 290) split ACs produced by a major manufacturer branded as 'GREE' are already being certified by VDA (Verband Deutscher Elektrotechniker). As of September 2010, and ten months later the ACs manufactured by GREE has obtained the TUV (Technisher Uberwachungs Verein) safety certifications. These ACs were slated for export to the European countries especially to Germany. This shows the acceptance of use the of HC based refrigerants in developed countries.

In India, Rajadhyaksha *et al.* (2015) reported that since 2012, Indian ACR equipment manufacturer Godrej and Boyce has launched

its first R 290 based split air conditioners and have since sold and installed around 100 000 units of dedicated R 290 split ACs within the Indian market. The percentage of complaints of insufficient cooling were same as the split ACs using R22 units sold. Complaints of HC leaking from outdoor units was about 0.3%, and no leakage was ever found in the indoor. It was reported that the leaks were mainly from the service valves, condenser and compressor piping.

Developing countries had until now transited from HCFCs to HFCs because of the ratification of the Montreal protocol. This transition of using a refrigerant that contains higher GWP values as compared to the one it replaces has been phase down by countries in the EU caucus when the F-gas regulations were enforced thus gradually reduces the use of HFCs. In the case of Malaysia, it allows new AC&R equipment to use HFC 410a as a replacement for HCFC 22 since there are no alternatives.

Developed nations and most recently the 'Significant New Alternative Policy' (SNAP) of the U.S. Environmental Protection Agency (EPA) on March of 2015 has approved low GWPs refrigerants ranging from 3 to 675 to replace existing refrigerants with GWPs ranges of 1400 to 4000. HC refrigerants are included in these categories of refrigerants (US EPA 2015). The question now is, when will the developing nations, like Malaysia follow suite?

Malaysia has the potential to use HC as refrigerants as HCs are currently being produced locally, and the cost will be a non-issue if safety concerns are rectified by adopting safety standards and regulations practiced in several developed countries.

It is the objective of this paper to report on the availability of HCs as replacements for the transitional HFC currently being promoted by the authorities for use in small split type household air conditioners. This paper focuses on the use of HCs as an alternative replacement refrigerants to be used in residential air conditioners and refrigerators.

A Brief History of Refrigerants

Stored ice was probably the very first attempt to provide refrigeration to prevent food from turning rancid. Perkins was the first person credited to create a vapour compression cycle using ethyl ether (Calm & Didion 1998). Other earlier refrigerants in vapour compression cycles include, methyl ether, carbon dioxide, carbon tetrachloride, ammonia, isobutene, propane, dielene, and petrol (gasoline). Without the invention of a hermetic system at that period, industrial accidents were prone due to leaks from refrigeration circuits. (Calm & Didion 1998).

Due to the combustibility and toxicity of early refrigerants, Thomas Midley Junior and Albert Leon successfully synthesized "dichlorodifluoromethane' the world's first chlorofluorocarbon (CFC) in the 1930s and marketed it through Fridgaire, a division of General Motors. It was known as Freon-12 (Designated as refrigerant R 12 by ASHRAE).

Then 40 years later when Molina and Rowland (1974) reported in the *Journal of Nature* that depletion of the stratospheric ozone due to the use of CFC. (Calm & Didion 1998). Ozone Deletion Factor (ODP) of Freon-12 (CFC 12) is 1, and all other refrigerants use CFC 12 as a reference point to the determine its potential towards ozone depletion.

The quest for alternatives to CFC and hydrofluorochlorocarbon (HCFC) thus begins with the impeding phaseout of these refrigerants through the ratification of the Montreal Protocol in 1989 by all countries that are members of the United Nations.

Chemical companies tried providing solutions in the form of hydrofluorocarbons (HFC) but were later curtailed due to the high GWP values and will also be banned by the ratification of the Kyoto Protocol (1997) and in the European Union, where the commonly known F-Gas regulation prohibits the use of refrigerant with high GWPs. Given the restrictions imposed by the F- Gas regulations, chemical companies tried to blend HFC/HFO mixture to provide alternatives to R 134a, R 404a and R 410a. (Babiloni et al. 2016). Blends like 'XP-10' which consists of 44% mass of R 134a and 56 % of R 1234yf is to replace R 134a mainly used in refrigerators and mobile air conditioners. Honeywell proposes blend 'L 41' which is 3.5 % mass of R 125, 60% R 32 and 28.5% R 1234ze as a replacement for R 410a currently being used by most split air conditioners (Babioloni *et al.* 2016).

The quest for low GWP and 0 ODP refrigerants has pushed chemical companies to synthesised a new type of hydrofluoroolefins (HFO). HFO 1234 yf (GWP =4) is to replace the high GWP HFC 134a (GWP =1430) in all vehicles manufactured in European Union (EU) as of 1st January 2017 (EU Mobile Air Conditioning Directive 2006/40/EC). Others tried to blend existing HFC and HFO to overcome the directive of using low GWP and 0 ODP refrigerants in equipment. "Daikin" a major AC&R equipment manufacturer of Japan has encouraged the use of HFC 32 (difluoromethane) which has a GWP of 675 as the main refrigerant to replace HCFC 22. HFC 32 is 50% of HFC 410a which consist of 50% HFC 125 and 50% HFC 32. HFC 32 is a mildly flammable refrigerant as categorised by ASHRAE *Standard 34* and *ISO 817* as 'A2L'.

On another note, most Scandinavian countries had begun using natural refrigerants to replace synthesised refrigerants in the early 1990s. Ammonia (R 717) has all the while being used in ice making plants and water (R 718) is widely used as a refrigerant in absorption chillers. The use of CO_2 (ASHRAE designated refrigerant no. R 744) in transcritical cycles was conceptualised by Lorentzen (1994), and now more refrigeration units in supermarkets in Europe had adopted this system. Lorentzen (1995) also predicted the re-introduction of natural refrigerants correctly in the foreseeable future to replace all synthesised substances. Hydrocarbon refrigerants which include HC 290 (propane), HC 600a (isobutane), HC 1270 (propylene) and HC 170 (ethane) have now made an impact as an efficient alternative to replace HCFCs and HFCs. HCs are categorised as "A3" by ASHRAE *Standard 34* and *ISO Standard 817* because of inherent flammability.

The use of refrigerants in the ACR industries had witnessed an about turn when in the early 1930s natural refrigerants were widely used before the introduction of CFC, HCFC, HFC, HFO were re-introduced due to climate change. *Figure 2* illustrates the cycle of refrigerant usage from naturals to synthetics and possibly back to natural refrigerants again shortly. The limit of its use back in the 1930s was due to unavailable equipment, knowledge, standards and legislation that made these substances dangerous to operators,

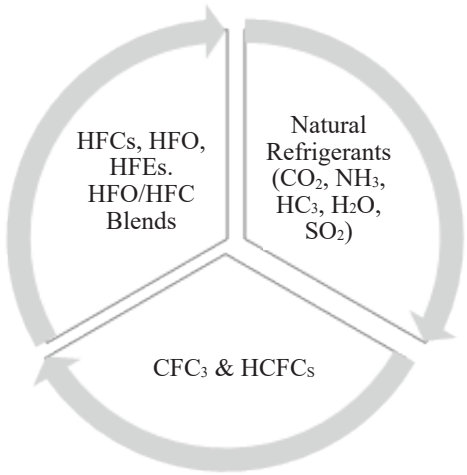

Figure 2. Cycle of refrigerant usage.

building, owners and occupiers. Today we have 'ATEX' certified hermetically sealed compressors {ATEX certified is the French term for equipment for use in the explosive environment. (*Appareils destinés à être utilisés en **AT**mosphères **EX**plosibles*)}, combustible gas leak detectors, standards and guides to provide a safer environment to use these flammable gasses. The use of refrigerants has witnessed a complete cycle of events that began with using naturally available substances to using synthesised ones and back to natural refrigerants. Calm (2008), provided a historical review of the use of refrigerants from 1st generation utilized in the 1830s right up to the current period as illustrated in *Figure 3*. The quest for suitable refrigerants that are efficient, have low GWP, zero ODP and short atmospheric lifespan is still ongoing. The US National Institute of Standards and Technology (NIST) have until recently look into close to 60 million chemicals and found only 27 suitable efficient substance to replace R 410a. All 27 candidates are 'slightly flammable' (Rose 2017). Flammability is one of the concerns when hydrocarbons (HCs) are used in AC & R applications, and many parts of the world prohibit its use due to this inherent property.

Hydrocarbon Refrigerants

Greenpeace has categorised HC as one of the 'gentle five' which include carbon dioxide (R-744), water (R-718), air (R-729) and ammonia (R 717). The most commonly used HC refrigerants are ethane (R 170), propane (R-290), iso-butane (R-600a), and propylene (R-1270). HC refrigerants are categorised as A3 by ASHRAE *Standard 34* and *ISO 817* which means that these refrigerants are highly combustible with a lower flammability limit (LFL) of less or equal to 0.10kg m^{-3} and a heat of combustion of greater than or equal to 19,000 kJ kg^{-1}. *Table 1* shows some properties of four of the most commonly used HC refrigerants. Figure 4 shows HC refrigerants being marketed differently across different countries. *Figure 4* (a) shows a white cylinder (U.S. Department of Transportation Standard 39 – Non-Refillable Cylinder) containing primarily of propane and is marketed as "HC 22a", imported to Malaysia from the U.S.A. The photo in *Figure 4* (b) shows an orange coloured cylinder which also contained propane being branded simply as "Refrigerant 290" and is imported from China. The material safety data sheets (MSDS) of both the HC refrigerants indicates that the contents are more than 98% propane.

Flammability of HCs when used as refrigerants, must be investigated in depth for its successful adoption as possible replacements to HCFC, HFC, and even HFO.

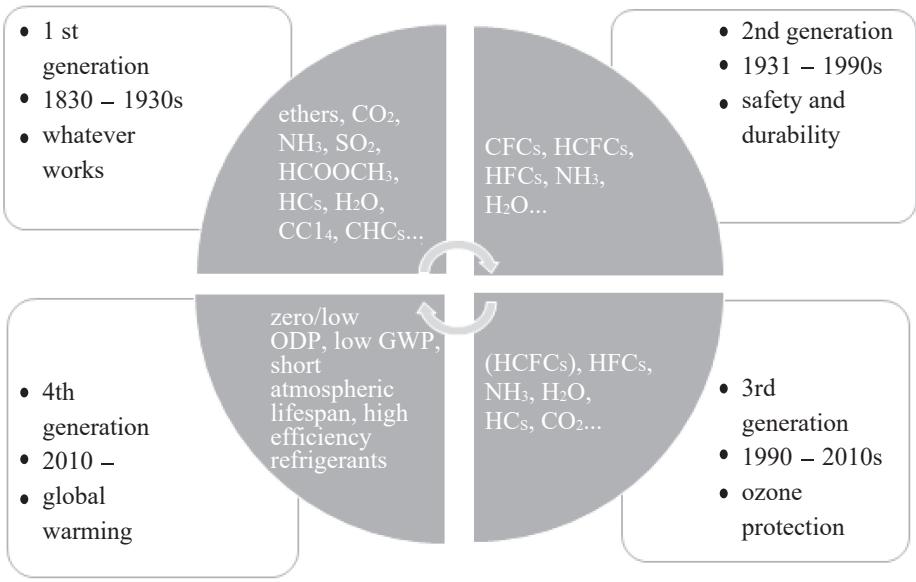

Figure 3. Development and progression of refrigerants (adapted from Calm 2008).

Table 1. Properties of Common HC Refrigerants (ASHRAE Handbook- Fundamentals 2013).

Refrigerant	Molecular mass M, (g mol^{-1})	Critical temperature, t_{cr} (°C)	Critical pressure, P_{cr} (MPa)	Boiling point, T_{bp}(°C)	Atmospheric Lifetime, Years	ODP	GWP
R 290	44.0	96.740	3.80	– 42.2	0.041	0	20
R 600a	58.1	134.660	3.64	– 0.5	0.016	0	20
R 1270	42.1	91.061	4.67	– 47.7	0.001	0	20
R 170	30.1	32.200	4.87	– 88.6	0.167	0	20

Figure 4. (a) Propane marketed as HC 22a (b) Propane marketed as refrigerant 290.

Flammability Issues and Classification of Hydrocarbon Refrigerants

Flammability qualities inherent with HC refrigerants is one of the major factors in preventing its extersive usage in ACR industries, despite its extremely low GWP values. However, it must be noted that for HC to combust, it must meet three conditions and these are firstly, HC and air mixture ratio, must be within its flammability ranges of lower flammability limit (LFL) and upper flammability limit (UFL), secondly ignition temperature must be high enough to start the combustion and finally, oxygen that air contains must be within the correct fuel/air mixture for combustion to occur. *Figure 5* shows the common typical 'Fire Triangle' requirements for combustion to happen. For HC refrigerants to combust, they must meet the demands of the Fire Triangle which are (1) The availability of oxygen as the oxidizer, (2) The ignition temperature and the fuel in the correct mixture. For propane to be able to combust, the proper ratio of propane and air is between 2% –10% of propane mixed with 98% – 90% of the air in the presence of an ignition source that reaches 493ºC.

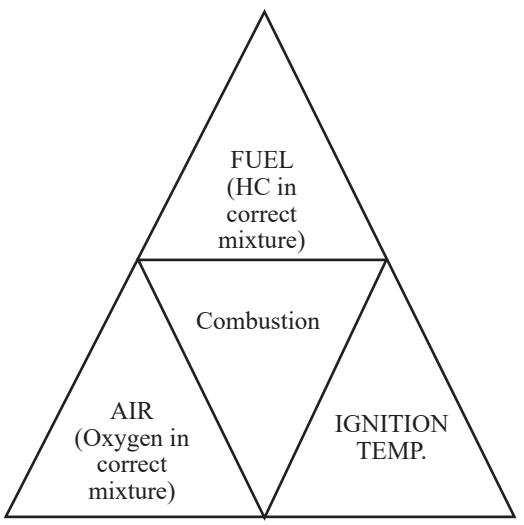

Figure 5. The Fire Triangle.

Due to this inherent factor, many researchers have conducted experiments on the flammability issues of HC refrigerants used in vapour compression cycles. Some have conducted using simulation with a number using actual equipment in test chambers.

Coulbourne and Suen (2003) simulated the leaking scenario of HCs in an enclosed chamber and concluded that smaller amount HCs is mixed with the surrounding air the safety aspects of using HC refrigerants will be enhanced. Coulbourne and Espersen (2013), using the quantitative risk assessment (QRA) technique have established that ignition frequencies (IF) in ice cream cabinets that uses R 290 placed in different room sizes and position to be in a range of 2×10^{-13} to about 1×10^{-8} per year as compared to a typical frequency of fire in household refrigerator of 1×10^{-5} per year. Coulbourne and Suen (2015) studied and evaluated the risk of split air conditioners and refrigerator using hydrocarbon refrigerants and concluded that ignition frequency (IF) of both refrigerators and split air conditioner being extremely small. In refrigerators, it was found that only one ignition event per million units of refrigerators in a 10 years period and in the split air conditioners, one event per 100 million of split air conditioners in 10 years was reported.

Li (2014), uses gas detectors set up at various locations to detect leaking R 290 from a split type air conditioner and established that in an enclosed room concentrations of leaking HC is around 1/3 of LFL and HC will reach LFL at a region directly below the indoor unit. Zhang *et al.* (2013), ignited leaking refrigerants from a split unit air conditioner in a controlled environment and established that R 290 will ignite within a very close range of the indoor unit and combustion of R 290 leaking in an enclosed space will create a pressure of 6.5 kPa above atmospheric pressure. There will be secondary smoke generated from the burning indoor unit.

Li *et al.* (2013) and Nagaosa (2014) conducted simulation with mathematical modelling and computational fluid dynamics (CFD) to ascertain the effects of leaking HC from a source in an enclosed space.

All the above was conducted to allay the fear of the flammable properties of the HC refrigerants. Someways can be employed by users of HC to avoid the incidents of explosions or fire from leaking HCs from air conditioning equipment. One of the methods that can ensure the safe use of HC refrigerants is to minimise the charge allowed into the air conditioner unit to levels well below the LFL. This can be done by establishing set of rules, regulations, and standards to minimise charge and adopt passive and active safety measures when using HC refrigerants.

Due to concerns on the flammability of HC refrigerants, standards and guides were already being developed and used as a basis to use these refrigerants safely. These standards and guides are comprehensive documents to allow HC refrigerants to be used in correct locations and amount of refrigerant allowed to be charged into a system.

Standards and Guides for Safe Operation of Hydrocarbon Refrigerants

Good and safe design can overcome flammability issues of HC refrigerants based on standards and safety guides that are widely available today. Some of the more popular adopted standards on refrigerants and in particular HC refrigerants are published by authoritative bodies that are involved with the AC&R industries and national standard bodies.

The American Society of Heating Refrigerating and Air Conditioning Engineers (ASHRAE), which has published several well adopted and authoritative standards which deal solely with the safe use of refrigerants and include the following standards:

(1) Standard 15, Safety Standard for Refrigeration Systems
(2) Standard 34, Designation and Safety Classification of Refrigerants; and
(3) Standard 147, Reducing the Release of Halogenated Refrigerants from Refrigerating and Air Conditioning Equipment.

Other than ASHRAE, the International Organisation for Standardization (ISO) also publishes standards that concern the safe use of refrigerants. The *ISO 5149: 2014* Refrigeration and Systems and Heat Pumps- Safety and Environmental Requirements which comprise three parts and are as follows:

(1) Part 1 — Definitions, classification and selection criteria.
(2) Part 2 — Design, construction, testing, marking and documentation; and
(3) Part 3 — Installation site.

The *ISO 817:2014* is a standard that deals with 'Refrigerants—Designation and Safety Classification'. On the issues of refrigerant flammability, the ASHRAE 34 and *ISO 817*, both have a similar use of the flammability and toxicity levels classifications, as shown in *Table 2*. These existing standards about to refrigerants safety and compatibility are available and widely adopted in most industrialised nations.

Apart from the American and international standards, the European Union (E.U) having actively promoting environmentally friendly policies have published the EN 378 which deals with "Refrigeration Systems and Heat Pumps– Safety and Environmental Requirements". This

Table 2. Classification of refrigerant.

Classifications	Explanations
Class A	Refrigerants that have an occupational exposure limit (OEL) of 400 ppm or greater
Class B	Refrigerants that have an OEL of less than 400 ppm, where the numeral 1, 2 and 3 denotes the following:
Class 1	No flame propagation in air at 60°C and 101·325 kPa
Class 2	Exhibits flame propagation in air at 60°C and 101.3 kPa, lower flammability limit (LFL) greater than 0.10 kg/m^3 at 23ºC and 101·3 kPa, and heat of combustion less than 19 000kJ/kg
Class 2L	Class 2 refrigerants may be classified as 2L if they exhibit maximum burning capacity of no more than 100 mm/s at 23°C and 101·325 kPa
Class 3	Exhibits flame propagation in air at 60°C and 101·325 kPa and lower flammability limits (LFL) less than or equal to 0.10 kg/m^3 at 23°C and 101·325 kPa or heat of combustion greater than or equal 19 000 kJ/kg

standard comprises four parts which are:

(1) Part 1— Basic requirements, definitions, classification and selection criteria
(2) Part 2—Design, construction, testing, marking and documentation
(3) Part 3—Instalation site and personal protection
(4) Part 3—Operation, maintenance, repair and recovery

With the four parts of the EN 378, this standard is a much better and comprehensive which can ensure that the equipment which uses the refrigerant can be designed, installed, operated and maintained properly. It deals with flammable, toxic and high-pressure refrigerants currently being chosen as a replacement for the environmentally damaging substances.

Annex C is useful for the calculation of maximum charge allowable for the HC used in various locations of the building. Under the subtitle, C.3.1 Annex C, factory-sealed refrigeration systems with less than 150 g of A2 and A3 (flammable refrigerants) have "no location classification constraints" which means that most household refrigerators having less than 150 g of HC refrigerants or blends could be placed anywhere in a building.

The maximum charge allowable for air conditioning, heat pump and refrigeration equipment that does not comply to the factory sealed and charge HC of 150 grams and below shall be according to the following equations (*ISO 5149-1:2014* and *EN 378-1:2013*). Maximum charge allowable in human occupied spaces is estimated through Equation (1).

$$M_{max} = 2.5 \times LFL^{5/4} \times h_0 \times A^{1/2} \quad (1)$$

When the refrigerant charge is known or ascertained than the minimum allowable area

that the equipment is allowed to be installed in human occupied areas shall be determined using Equation (2).

$$A_{min} = m^2 \times (2{\cdot}5 \times LFL^{5/4} \times h_0)^2 \qquad (2)$$

where, M_{max} = Allowable maximum charge in a room in kg
m = Refrigerant charge amount in the system in kg
A_{min} = Required room area in m^2
A = Room area in m^2
LFL = Lower Flammable Limit in kg m^{-3}
h_0 = Height factor of appliance as shown in *Table 3*.

Table 3. Height factor of appliance.

Appliance installation	Height factor
Floor	0.6
Wall mounted	1.8
Window mounted	1.0
Ceiling mounted	2.2

Some of the useful guides published to ensure safe application of HC refrigerants are already available online and can be downloaded freely. One of the more useful one that provides much comprehensive guide to operate split unit air conditioners using HC refrigerants is published by German International Cooperation (Programme Proklima) on behalf of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety of the Federal Republic of Germany. This guide provides the information to convert existing split type air conditioners that use HCFC to HC refrigerants.

The British Refrigeration Association (BRA) have also published a 'Guide to Flammable Refrigerants' which contains useful information for safe use of HC from regulations and code of practices, transportation, applications and design to procedures in servicing and training. (BRA 2012) The Australian Institute of Refrigeration Air conditioning and Heating (AIRAH), first published the 'Refrigerant Selection Guide' in August 1994, updated in 2003 which includes a section on HC refrigerant. In 2013, AIRAH published an industry safety guide dedicated solely to flammable refrigerants. The latest guide is fully comprehensive as it consisted legislation, safety and risk requirements, emergency planning, service and maintenance, training and even a dedicated chapter on proper storage of flammable refrigerants. (AIRAH 2013).

Guides and standards are used to ensure that minimal amount of HC refrigerant is charged into systems to minimise the occurrence of the mixture of HC and air meeting the LFL levels when HC leaks from the AC. Guides and standards do not provide the information needed to properly design systems that use HC efficiently. The use of HC refrigerants must be safe and efficient as inefficient HC systems contribute more CO_2 emissions than conventional HCFC or HFC refrigerants as 90% of emissions are from indirect emissions. The energy efficiency ratios or coefficient of performances of HC must be considered together with safety when designing and installing air conditioning or refrigeration systems that utilises HC refrigerants.

Performance of Hydrocarbon Refrigerants

The coefficient of Performance (COP) or Energy Efficiency Ratio (EER) is the description of the performance of the refrigeration cycle.

$$COP = \frac{\text{Useful refrigeration effect}}{\text{Net energy supplied by external sources}}$$

Apart from this, the compression ratios, mass flow rate and temperature glides of the HC refrigerants must be taken into consideration in evaluating the full comparative analysis of the HC refrigerants. (AIRAH 2003). An example would be the molecular mass of R 290 (propane) is about half of that of HCFC 22 to have similar refrigeration effect. *Table 1* is adopted from the 2013 ASHRAE Fundamentals Handbook compares the refrigerant performance per kilowatt of refrigeration based on theoretical calculations. It was stated that actual results might differ significantly if other factors such as compressor efficiency and transport properties are taken into consideration. However, *Table 4* shows the similarities in performances between R 290 and R 22 except the net refrigeration effect of R 290 which is almost 77% higher than that of R 22 and compressor displacement of R 290 is 17% higher than R 22. The comparison between R 600a and R 134a it replaces netted comparable results, where R 600a has 82% higher net refrigerating effect as compared to R 134a. However, the compressor displacement of R 600a is also much higher to that of R 134a by 86%.

Current AC&R systems that use R 22 and R 134a as refrigerants must take into consideration of changes in charge volume and compressor displacement if R 290 and R 600a are used as replacement refrigerants.

Table 4. Comparative refrigerant between R 22 and R 290 and R 134a and R 600a performance per KW of refrigeration (based on evaporator of 7.2°C and condenser of 30°C for R22 and R 290 and evaporator of −6.7°C and condenser of 30°C for R 134a and R 600a).

Refrigerant number and chemical name	EP MPa	CP MPa	CR	NRE kj/kg	RC g/s	LC L/s	SV of SC m^3 /kg	CD L/s	PC kW	COP	CDT °C
R22 chlorodifluoromethane	0.626	1.192	1.9	171.0	5.85	0.0050	0.0377	0.2205	0.0918	10.885	40.3
R 290 propane	0.588	1.079	1.84	303.9	3.29	0.0068	0.0787	0.2580	0.0931	10.743	32.6
R 134a tetrafluoroethane	0.228	0.770	3.37	153.0	6.54	0.0055	0.0880	0.5745	0.1650	6.063	34.8
R 600a isobutane	0.123	0.405	3.29	278.0	3.60	0.0066	0.2984	1.0723	0.1620	6.171	30.0

EP-Evaporator Pressure, CP-Condenser Pressure, CR-Compression Ratio, NRE-Net Refrigerating Effect, RC-Refrigerant Circulated, LC-Liquid Circulated, SV- Specific Volume, SC- Suction Gas, CD-Compressor Displacement, PC- Power Consumption, COP- Coefficient of Performance, CDT-Compressor Discharge Temperature.

In actual experiments, numerous authors have reported different results in comparing HC refrigerants with HCFC and HFC refrigerants. Halimic *et al.* (2003) examined R 290 with R 12 and R 410a in refrigeration cycles. It was conclusive that R 290 had highest cooling capacity and COP of R 290 equals that of R 12. Al Amir and Joudi (2014) reported the highest COP for R 290 as compared to R 22, R 407c and R 410a in ambient temperature of between 35°C to 55°C. Devotta *et al.* (2005) tested a window type air conditioner according to Indian Standard 1391 which resulted in COP of R 290 higher that of R22 in ranges of 2.8 – 7.9%. He *et al.* (2014) experimented using chest freezer concluded that COP of R 290 is lower by 1.8% as compared to R 134a. Hatamipour *et al.* (2014) uses blends of R 290/R 600a in mass ratio of 56:44% in a domestic refrigerator resulting in reduction of energy consumption of 5.34% as compared to R 134a. Hwang *et al.* (2006) researched R 290 with R 404 and R 410a, where results indicated R 290 had COP improvements between 4% – 12%. Jayaraj and Muraleedharan (2007), indicated that COP of R 290/ R 600 in ratio of 45.2/54.8% is 3.6% higher than R 134a. Kim *et al.* (1998), uses the Korean Standard 9305 to compare R 600a and R 12 in domestic refrigerator. COP of R 600a had 6% improvements over R 12. Teng *et al.* (2012) reported that COP of R 290 is higher than R 22 at 50% of R 22 charge. Wongwises and Chimres (2005) blended R 290/ R 600 at a rate of 60/40% in a domestic refrigerator which results in reduced energy consumption of 4.86% compared to R 134a. Yang *et al.* (2012) concluded that a 20% increase in compressor displacement will enhance the performance of split unit ACs.

d'Angelo *et al.* (2016) simulated the use of a mixture of R 290/ R 600a in a vapour injection refrigeration system. The best COP for a simulated vapour injection refrigeration system is when 40 wt% of R 290 and 60 wt% of R 600a is used.

It is conclusive that HCs have better performance than HCFC and HFC refrigerants as HCs were the first to be used as refrigerant in the early 1900s and were replaced by the synthesised refrigerants to overcome the flammability issues of HCs. CFCs, HCFCs and HFCs were manufactured to mimic performances of natural refrigerants without the need to worry about toxicities and combustibility issues.

CONCLUSIONS

With the impeding phaseout and phasedown of ozone depleting and global warming refrigerants, Malaysia listed as 'article 5' group of the Montreal Protocol agreements has started to impose a targeted reduction of HCFC in industries beginning of 2016. The AC&R industries were most affected in particular the residential air conditioners markets when the DOE of Malaysia has imposed restrictions on the manufacture, importation, and installation of domestic AC of 2.5 hp and below to use HCFC 22. Manufacturers and importers switched to HFC 410a as replacements for R 22. This proves to be a wrong move as GWP of R 410a is higher than R 22. Besides, components and oil used in the ACs are incompatible. R 410a had 50% higher operating pressures and uses polyolester oil (POE) as opposed to mineral oil in R 22. Further to this two significant incompatibilities R 410a is not the long-term solution and is touted as a "transitional" refrigerant until a suitable replacement is found. R 410a will be banned in the European Union in a couple of years (1January 2025) (EU Regulation No

517/2014). The recently concluded meeting of parties to the Montreal Protocol on 15 October 2016 in Kigali, Rwanda (Kigali Amendment) added HFC in the original Montreal Protocol list of banned substance and targeted to be phased down. The Kigali Amendment will enter into force on 1 January 2019 when it is ratified by at least 20 parties of the original Montreal Protocol (UNEP 2016).

Standards, guides, legislation, and equipment (ATEX certified components) are already available for a safe and efficient use of HC based AC&R equipment in developed countries. It is about time that legislation on the use of HC is enacted in Malaysia as to enhance its safe and efficient use in AC&R industries considering the widely available international and regional standards and guides available for the adoption of HC and other natural refrigerants.

Regarding of performance of HCs, many researchers had unanimously concluded on the improved performances of HC and its blends compared to HCFC and HFC. These results should further prove that HCs are the best option for the replacement for HCFC instead of HFCs.

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ASEAN J. Sci. Technol. Dev., **34(1)**: 51 – 55

Prevalence of Diarrhoeal Diseases Among Children under Five Years in East African Countries from 2012–2017

O.E. ELMI[1*] AND R. (II) P. DIOSO[2]

This meta-analysis analyzed the prevalence of diarrheoal diseases among children less than five years in three selected East African countries from 2012–2017. Search engines used Google Scholar, Proquest, and PubMed. Primarily, 300 studies were selected; hence 297 were eliminated using inclusion and exclusion criteria. The PICO (population, intervention, comparison, and outcome) guide helped in the analysis of the three selected studies. The prevalence of diarrhoea among children less than five years in the three selected East African countries from 2012 to 2017, averaged to 27% range from a minimum of 11% to a maximum of 54% of the 5478 total respondents (OR 2.07). The five-year prevalence escalated extensively at Kenya, Ethiopia, and Somalia. There is a 207% risk of further escalation.

Key words: Diarrhoea; East Africa; meta-analysis; nursing; public health

Diarrhoeal diseases are the most major health problems in the world which cause highest mortality and morbidity in children especially in children less than five years, and they can also affect children's growth and development (World Health Organization 2001). Diarrhoea becomes the primary burden of all water and sanitation related diseases.

Globally about 4 million cases of diarrhea are recorded annually, and this causes about 2.2 million deaths, mostly among children under the age five (United Nations Children's Fund/World Health Organization 2009).

About 50% of deaths are due to acute watery stool, 35% are due to persistent diarrhoea, and 15% are due to dysentery (United Nations Children's Fund/World Health Organization 1999). According to World Health Organization, in developing countries, diarrhoea is the major cause of child death when children are less than five years old (World Health Organization 2000). Diarrhoea mortality is mainly due to dehydration which is the first direct consequence (United Nations Children's Fund/World Health Organization 1999). Diarrhoea morbidity is one of the major health burdens among infants and young children in low-income countries (Cunliffe *et al.* 1999).

An incidence of 3.2 episodes of diarrhoea per child per year among children below five years old was estimated between 1990 and 2000 within 20 countries (World Health Organization 1996). The immediate impact of diarrhoeal infant diseases regarding morbidity, hospitalization and death has been proved in several studies (United Nations Children's Fund/World Health Organization 1999).

[1] East Africa University, Somalia
[2] Lincoln University College, Jalan SS 6/12, 47301 Petaling Jaya, Malaysia
[*] Corresponding author (e-mail: elmiomar11@gmail.com)

In developing countries, diarrhoeal diseases represent one-third of the hospitalizations (World Health Organization 1996). Children who were not looked after by their mothers, and those were partially breastfed or weaned children are at risk for diarrhoeal morbidity (Jensen *et al.* 2002). The long-term consequence is under-nutrition when episodes are repeated and prolonged (Cairncross & Feachem 1993). Poor socio-economic status, sanitation and living conditions, nutrition and hygiene behaviour are the health determinants for diarrhoea prevalence (Jensen *et al.* 2002).

In Africa and especially Sub-Saharan Africa, diarrhoeal diseases account for over 90% of deaths in children below five years old (World Health Organization 2007). This has been attributed to lack of safe drinking water, sanitation and hygiene as well as poor nutrition (World Health Organization 2005). Accordingly, improved water sources reduce diarrhoea morbidity by 21%, improved sanitation by 37.5% and hand washing by as much as 35% (Roberts *et al.* 2001; World Health Organization 2007).

METHODS

Literature Searches

Google Scholar, Proquest and PubMed were searched from similar research articles related to the prevalence of diarrhoeal diseases in East African countries. Search strategy started with using keywords entered on search engines on the internet as English text words.

Study Selection

The inclusion criteria were: a population-based study with participants under five years children; random sampling of a defined population or studies involving entire; studies involving African participants living in East African countries. Data extracted from each paper included country where research was conducted.

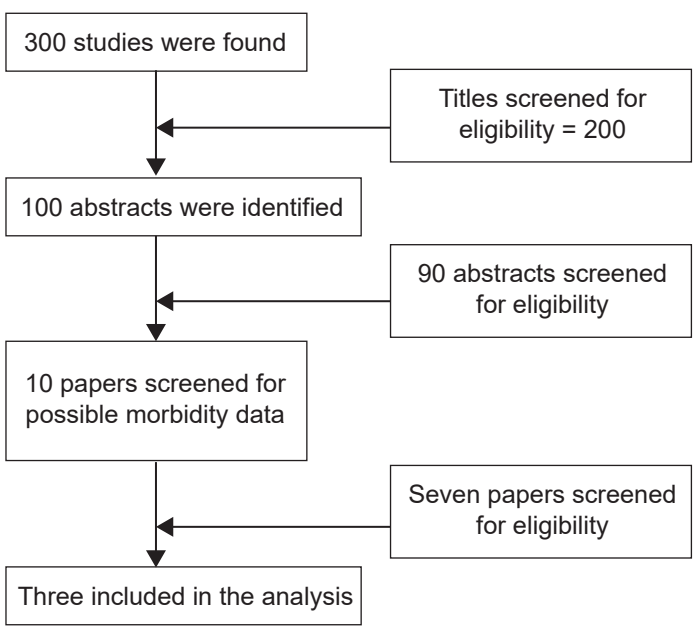

Figure 1. Data extraction.

Data Extraction

Extracted data were collected using the PICO (population, intervention, comparison, outcome) guide. Of the 300 studies found on search engines, only three were selected (*Figure 1*). The study design method, sample size, and reported prevalence rate was analyzed by comparing factors related to occurrences of diarrhoea.

RESULTS

A total of three studies that fulfilled the inclusion criteria were used for the meta-analysis as shown in *Table 1*. All the studies adopted a cross-sectional design method. In the majority of the studies, diarrhoea was measured in a single visit of the children's caregivers by asking incidences of diarrhoea among their children in last two weeks. All the studies used children less than 5 years old. Prevalence of diarrhoea varied extensively between studies, ranging from a minimum of 11% to a maximum of 54%.

Furthermore, this study summarized prevalence of diarrhoea in 3 East African countries for a five years period (2012 to 2017). The prevalence of diarrhoea from the three counties was 11% in Somalia, 16% in Kenya and 54% in Ethiopia. The total population was 1480 of the 5478 (27%).

In Kenya, according to Kawakatsu *et al.* (2017), a total of 278 mothers were participated in the study. Of the 278 participants, 150 (54%) children had acute diarrhoea. Only family income and current breast feeding status of the children were significantly associated with diarrhoea [AOR at 95% CI, 0.59 (0.21–1.65)] and [AOR at 95% CI, 0.36 (0.16–0.80), respectively].

In Somalia according to Mohamed *et al.* (2016), a total of 245 under-five children were identified from Bosaso city, to be a total of 23 (9.4%) children with diarrhoeal diseases who had a watery type of diarrhoea. The north-eastern regions of Somalia on the southern coast of the Gulf of Aden have caregivers to report children in the month before the day of the interview, having only 26 (11%) diarrhoeal cases. About 7.34% reported 1 episode and only 2.85% reported 2 episodes and 0.4% reported 3. Diarrhoea also occurred more often in children who were not exclusively breastfed (OR 3.9).

In Ethiopia, according to Mengistie *et al.* (2013), 4955 children under five and their family members living in Nyanza Province had diarrhoea. This Sample was used to determine the prevalence of childhood diarrhoea in Kenya at about 16% from the total respondents.

Table 1. The PICO Guide.

Comparison	Intervention	Population		Outcome
Mohamed *et al*. (2016)	Determined the prevalence of diarrhoea	Somalia	245	11%
Mengistie *et al.* (2014)	Determined the prevalence of diarrhoea	Ethiopia	4955	16%
Kawakatsu *et al*. (2017)	Assessed the prevalence of diarrhoea	Kenya	278	54%

DISCUSSION

Three important studies were extracted from search engines that address the risk factors associated with the prevalence of diarrhoea in the East Africa. The biases on selecting the studies are called selection biases. But considering the implications of diarrhoea and how harmful it will be is enough to ignore the biases implied.

In addition, occurrences of diarrhoea in this meta-analysis found 3 associated factors affecting it – (1) caregivers (2) age (3) surroundings.

Caregivers who are not mothers of the children are a factor associated with the occurrence of diarrhoeal diseases (OR 3.5) (Kawakatsu *et al.* 2017). The education level of the caregivers had an association with the occurrence of diarrhoea (Kawakatsu *et al.* 2017). Illiterate caregivers usually do not understand that milk can expire fast after diluted with water especially in warm climates (OR 1.6) (Mohamed, *et al.* 2016). Lastly, caregivers who are not giving enough time caring for children end up ignoring their dirty hands, that is usually sucked by children (OR 5.4) (Mengistie *et al.* 2013).

Children between 1 to 2 years old addressed the age as a factor associated with diarrhoeal diseases (OR 5.8) (Kawakatsu *et al.* 2017). Also, children who received other milk during the first six months of life (bottle feeding) also had occurrence of diarrhoea (OR 3.4) (Mohamed, *et al.* 2016). Similarly, Children who did not receive colostrums from breast milk had diarrhoea as well (OR 3.7873) (Mohamed *et al.* 2016).

Children living in unhygienic conditions addressed the surroundings as a factor associated with the occurrence of diarrhoeal diseases (OR 2.4) Mengistie *et al.* 2013. Those who were prematurely born without latrines had association diarrhoea (OR 1.04) (Mohamed *et al.* 2016). Similarly, those who have no separated drinking water storage had diarrhoea (OR 1.3) Mengistie *et al.* 2013.

CONCLUSION

The three studies from different east African countries revealed that children have the occurrence of diarrhoeal diseases less than five years of age that was 27% of the 5,478 total respondents (OR 2.07) from 2012 to 2017. Therefore, there is a 207% risk of further escalation of prevalence in East Africa.

Even though poor environmental conditions were believed to increase the risk of diarrhoeal disease, the majority of the environmental variables included in this study showed significant association with diarrhoea. Secondly, children who are 1 to 5 years old must be given breast milk (not exactly breastfed) to develop intestinal resistance to diarrhoea. Low family income per month may have no other choice but hire unintelligent caregivers who sometimes are uneducated and illiterate.

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