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Bacteria on Mobile Phones of Low-Skilled Migrant Workers in Malaysia: A Preliminary Study

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ABSTRACT

Objective: The mobile phones carried by low skilled migrant workers may serve as a vehicle for pathogen transmission for it warm and hand held, worsen by poor hygiene routine by the workers. This paper aimed to determine the microbial burden on mobile phones of low-skilled migrant workers and the association with their hygiene practices as well as health symptoms.

Method: A group of Nepal security workers (n=40) answered a questionnaire, after which, mobile phone swap samples were collected. Bacteria species were cultured, isolated and determined using blood agar, MacConkey agar and analytical profile index (API) kit.

Result: All of the mobile phones, except one, showed positive for microbial growth. Fifty five percent of the samples isolated beta haemolytic bacteria on blood agar while 82.5% isolated Gram negative non-lactose ferment bacteria on MacConkey agar. The respondents had good general hand hygiene practices (70.9±18.5%), but moderate in hygiene related to mobile phone use (54.4±12.5%). The latter along with hand sanitizer use significantly influenced the pathogenicity of microbes isolated ($p<0.05$). Reduction in mobile phone hygiene practices also significantly increased the onset of skin (-0.321) and gastrointestinal symptoms (-0.447), matched the species isolated of which *Acin. Calcoaceticus, Shigella spp.* and *Tatumella ptyseos* were the most prevalent ones.

Conclusion: Mobile phone may transmit pathogen and disease to mankind, especially when hygiene did not prevail. Thus, hand as well as phone sanitizing measures should be taken up along with education campaigns among low-skilled migrant workers.

Keywords: *Mobile phone; Bacteria; Migrant workers*

1. Introduction

There is a drastic rise in demand for migrants in sectors that are the principal engines of Malaysia's growth like plantations, construction, manufacturing, and services, as many Malaysians are no longer willing to perform jobs that they consider as 3-D (dirty, difficult and dangerous). Today, Malaysia has the 4th highest number of migrants in the world. Most migrant workers in Malaysia, especially for 3-D jobs, came from more than 12 countries in Asia, with majority coming from Indonesia, Nepal and Bangladesh (Table 1). Other countries include India, Pakistan, Vietnam, Cambodia, Thailand, and the Philippines (Robertson, 2008). These are low income countries where poverty prevails while portable water and good sanitation is limited, which in turn promote pathogen growth and infection disease transmission (Sepehri et. al, 2009). Landing in Malaysia,

with prior and continuous ignorance towards hygiene, these workers face several constraints and difficulties related to their health (Karim & Diah, 2015).

Be it social or professional life, mobile phone is the most indispensable accessory in recent years, highly used by everyone regardless of age and social status. In Asia, the growth of mobile phone usage has been steadily increasing (Akinyemi et. al, 2009) and became the fastest growth rate for cellular phone subscribers in the world (Al-Abdalall, 2010). Apart from storing in pockets or bags, mobile phones are also hand-held. Poor hand hygiene practices may transform the electronic gadget into a perfect habitat for microorganism's growth (Al-Abdalall, 2010). Having close contact from hands to mouth, nose, ears, or other areas of body, mobile phones serve as a pathogen carrier and increase the incidence of infectious diseases among the users, and others close by. Hence, this study was undertaken as an initiative to determine the microbial burden on mobile phones of low-skilled migrant workers in Malaysia and associate it with their hand hygiene practices as well as health symptoms.

Table 1 Foreign Workers in Malaysia in 2013, by Country of Origin

Country of Origin	Total (n)	Percentage (%)
Indonesia	835,965	39.2
Bangladesh	282,437	13.2
Thailand	13,547	0.6
Philippine	65,096	3.0
Pakistan	72,931	3.4
Myanmar	145,652	6.8
Nepal	502,596	23.5
India	139,751	6.5
Others	77,060	3.6

Source: Ministry of Internal Affairs, Malaysia (2015)

2. Materials and Method

This was a preliminary study conducted among a group of Nepalese security workers in Shah Alam, Selangor (Figure 1). Permission was sought from employer followed by consent from the workers.

2.1. Survey

Questionnaire was used to gather relevant information including socio-demographics (age, marital status, educational status and income), migration history (region in country of origin, years of living in Malaysia, working history), living environment (residential area, type of accommodation, amenities, total members in current residency), mobile phone use (mobile phone type, first user or more, years of usage, frequent location of keeping mobile phones, disinfection knowledge and practice), hygiene practices (general hand hygiene, hygiene before/after mobile phone use, hand sanitizer usage) and health symptoms (infectious disease-skin, respiratory and intestinal) in the past one month (Zakai et. al, 2016).

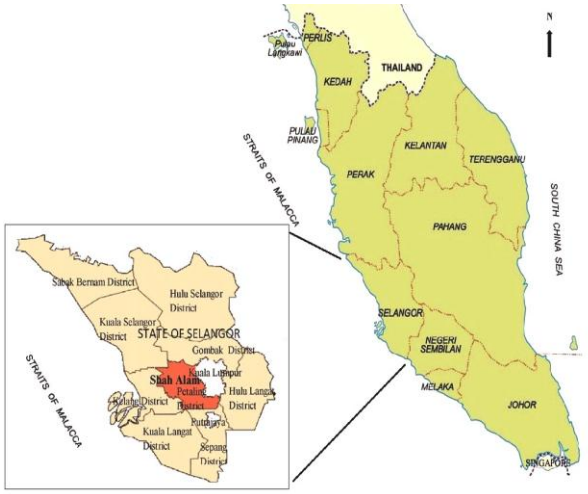

Figure 1. Study location
(Map showing Peninsular Malaysia, Selangor State and Shah Alam)

2.2. Chemical and Reagents

Alcohol-ethanol-(70%), peptone water, immersion oil, API kit reagents (indole reagent, and incubator fluid), gram stain reagents (crystal violet, iodine, alcohol-acetone solution, Safranin reagent), and distilled water were used in this research.

2.3. Microbial Detection

Detection of microbes involved three steps: swabbing, culturing and biochemical test for species identification. Forty swap samples were taken by rotating sterile cotton swabs on the keys, mouthpiece, and ear-piece of mobile phones. The swabs were then transferred into sterilized test tubes containing 5 ml of peptone water, covered with aluminum foil and transferred to an incubator (37°C for 24 hours) to enhance microorganisms' growth (Akinyemi et. al, 2009; Al-Abdalall, 2010).

The incubated swabbed sticks were then cultured into two medias: general (sheep blood agar) and selective (MacConkey agar). Blood agar is a differential and enriched medium for fastidious organisms such as the Streptococcus spp. Bacteria grow on blood agar produce three haemolytic

patterns; alpha (partial haemolysis colonies with green color surrounding these colonies), beta (clear zone grey colonies) and gamma (no change as bacteria don't produce haemolytic enzyme) (Gunn et. al, 1977). On the other hand, MacConkey agar is a selective and differential media used for the isolation and differentiation of non-fastidious gram-negative rods, particularly members of the family *enterobacteriaceae* and genus *Pseudomonas*. Gram negative bacteria that ferment lactose grows in pink colonies while that do not ferment lactose appear colorless on the medium and the agar surrounding remains relatively transparent (March & Ratnam, 1986). Wire loop and burner were used in the culturing method after which, the agar plates were incubated (37°C/48 hours).

Species confirmation was done using the Analytical Profile Index (API) kit; REMEL's RapIDTM ONE System. The system is a qualitative micro method employing conventional and chromogenic substrates for the identification of medically important *Enterobacteriaceae* and other selected oxidase-negative, Gram-negative bacilli isolated from human clinical specimens. Inoculating loop was used to collect 2-3 colonies from MacConkey agar and subsequently inserted into 2ml of rapid inoculation fluid. Then, suspensions were mixed thoroughly (suspension was required to be used within 15 minutes of preparation). The suspension was gently transferred into API panel and incubated at 35-37°C in non-CO_2 incubator for 4hours. After incubation of the panel, each test cavity was examined for reactivity by the development of a color. A numerical procedure described species identification procedure served as an aid to decide the types of bacterial growth on mobile phones (Zhou et. al, 2016).

2.4. Data Analysis

All statistical analysis was computed using SPSS version 22. Spearman's rank correlation and Mann-Whitney U-test were utilized. For all tests, statistical significance was defined by a $p \leq 0.05$.

3. Results

All of the respondents were male. As given in Table 2, they aged 32 years (SD=7.5) on average, lived in Malaysia approximately two years (SD=1.0) and mostly were married (72.5%). They were staying in accommodation provided by their employer and more than half lived in a crowded environment, exceeding ten members (52.5%). Back in their homeland, majority have attended secondary school (40%) and earning between RM1000-1500 (57.5%) in Malaysia.

3.1. Mobile Phone Use

All of the workers disclosed of having at least one mobile phone, mostly a brand-new one (57.5%). The phone is being used for one year or less (60.0%). Majority respondents did not use mobile phone while on duty (47.5%), instead, used in their hostel (Table 2).

Table 2. Socio-demographics, mobile phone usage and health symptoms among the respondents (n=40)

Factors	
Socio demographics	
Age (years), mean±SD	32.2±7.36
Living in Malaysia, (years), mean±SD	2.1±1.0
Marital status, n(%)	
Single	11(27.5)
Married	29(72.5)
Education level, n(%)	
None	8(20)
Primary	8(20)
Secondary	16(40)
Tertiary and above	8(20)
Number of people in house	
≤ 10 people	19 (47.5)
> 10 people	21 (52.5)
Income (RM/month), n (%)	
RM500-RM1000	3(7.5)
RM1000-RM1500	23(57.5)
RM1500-RM2000	14(35.0)
Mobile phone usage	
Duration using current phone (years), median (IQR)	1.0 ±1.0
Duration using current phone (years), n (%)	
≤ 1 Year	24 (60.0)
> 1 Year	16 (40.0)
Mobile phone user, n (%)	
First user	23 (57.5)
Second hand user and more	17 (42.5)
Use phone while on duty, n (%)	
Never	19 (47.5)
Seldom	13 (32.5)
Often	8 (20.0)
Health Symptoms*	
Skin allergy, mean±SD	1.6±0.7
Respiratory illness, mean±SD	1.6±0.8
Gastrointestinal disease, mean±SD	1.5±0.9

* *Score range: 0 (never), 1 (seldom), 2 (often)*

3.2. Health Symptoms

Among the health symptoms included were flu, rashes, stomachache, fever, diarrhea and headaches. Scores of these

symptoms were totaled and averaged based on categories (skin / respiratory / GIT). All the three types of health symptoms were often occurring, with skin allergy and respiratory illness slightly leading (Table 2). Specifically, flu or running nose and rashes were the prominent ones indicating possible exposure to respiratory allergens. The prominent symptoms in descending order of occurrence was flu > rashes > stomachache > fever > diarrhea > headaches.

3.3. Hygiene Practices

There were two types of hygiene practices enquired; general hygiene and hygiene related to mobile phones (Table 3). Example of general hygiene practices is hand wash sequences. Hygiene related to mobile phone usage described the practices lead to phone contamination; higher scores reflect poor mobile phone hygiene practices.

Close to half or greater number of the respondents often performed general hygiene practices. Top in the list were washing hand after washing dishes, cleaning home, doing laundry and after waking up in the morning (>70%). However mobile phone related hygiene practices were never or seldom exercised. The most often mobile phone related hygiene practices were not exchanging phone with friends and colleagues (62.5%), not using phone during works (60.0%) and not using mobile phones while eating (57.5%). As tabulated in Table 4, the total hygiene practices scores computed showed that the respondents demonstrated a good general hand hygiene practices (mean±SD=70.9±18.5%) but a moderate hygiene practices related to mobile phones (mean±SD=54.4±12.5%). In addition, hand sanitizer using habits were seldom exercised too (mean±SD=1.1±1.9 times/day).

3.4. Microbial Burden on Mobile Phones

Almost all of the mobile phone swap samples, except one (2.5%), showed positive for microbial growth (n=39). In sheep blood agar, 55% of microorganisms grew in beta haemolysis pattern while 42.5% grew in alpha haemolysis pattern. In MacConkey agar, 82.5% (n=33) microorganisms were Gram negative non-lactose ferment. Overall, the swap samples had the highest number of beta haemolytic, non-lactose fermenter negative > alpha haemolytic, non-lactose fermenter negative > alpha haemolytic, lactose fermenter positive > beta haemolytic, lactose fermenter positive (Figure 2).

Microbial species identification showed that half of the swap samples isolated four bacteria species (n=20), followed by 30% isolated one species (n=12), 12.5% isolated two species (n=5) and 5.0% isolated three species (n=2). There were 11 types of species identified from the swap samples cultures (Figure 3). The most associated species was *Acinetobacter calcoaceticus* (77.5%, 31/40), followed by *Shigella spp.* (62.5%), *Tatumella ptyseos* (52.5%), *Shigella sonnei* (52.5%), *Klebsiella pneumonia* (7.5%), *Escherichia vulneris* (5%) and *Moellerella wisconsensis, Enterobacter aerogenes, Citrobacter freundii, Burkholderia cepacia* as well as *Klebsiella pneumoniae subsp. Rhinoscleromatis* (2.5% each).

3.5. Interrelations between Hygiene Practices-Microbial Burden-Health Symptoms

The three components of hygiene practice; general hand hygiene, hygiene related to mobile phone and hand sanitizer usage was tested against isolation of microbes (Table 4). Independent sample t-tests showed significantly lower scores of mobile phones hygiene among respondents whose phone isolated beta haemolytic (mean±SD=50.6±11.6% versus 58.9±12.3%, $t(38)=2.189$, $p=0.035$) as well as Gram negative non-lactose ferment (mean±SD=51.2±10.4% versus 72.6±5.4%, $t(38)=4.906$, $p<0.001$) species. Similarly, there were significantly lower hand sanitizer usage among respondents whose mobile phone isolated beta haemolytic (mean±SD=0.4±0.9 versus 1.4±1.6, $t(38)=2.451$, $p=0.022$) as well as Gram negative non-lactose ferment species (mean±SD=0.5±0.9 versus 3.2±1.3, $t(38)= 6.504$, $p<0.001$).

As for the health symptoms, mobile phone hygiene practice scores had a moderate but negative and significant correlation with skin and GIT symptoms. These indicates that increasing mobile phone related hygiene practices and hand sanitizer usage may reduce the growth of pathogen on mobile phones and thus the transmission of infectious diseases.

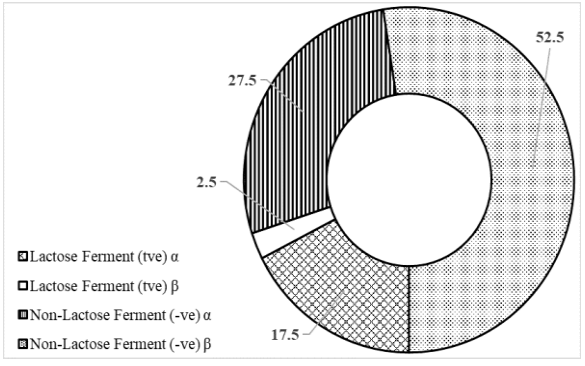

Figure 2. Percentage of samples in cultured media (Alpha/beta haemolytic bacteria on sheep blood agar and Gram negative/positive; lactose/non-lactose ferment bacteria on MacConkey agar)

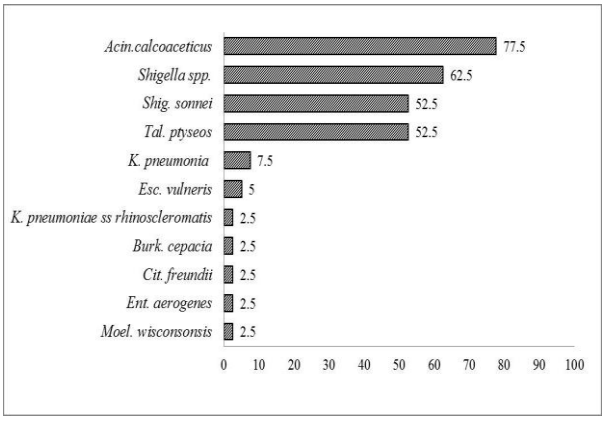

Figure 3. Enterobacteriaceae species identified
(A sum of all the species identified using API kit)

4. Discussion

In less than 20 years, mobile phones have gone from being rare and expensive pieces of equipment used primarily by the business elite, to a common low-cost personal item (Dave & Shende, 2015). Constant handling and heat generated by the phones creates a prime breeding ground and habitat for many microorganisms on each square inch of the phone (Ekrakene & Igeleke, 2007; Al-Abdalall, 2010), worsen by Malaysian climate (hot and humid). In the present study, except one, all of the mobile phones had bacterial growth, similar to numerous studies that have demonstrated the device as a potential bacteria transmission mode (Ekrakene & Igeleke, 2007; Akinyemi et. al, 2009; Sepehri et. al, 2009; Al-Abdalall, 2010; Dave & Shende, 2015) in more than 90% of the samples tested (Brady et. al, 2007; Jeske et. al, 2007; Karabay, Kocoglu & Tahtaci, 2007; Tambekar et. al, 2008; Ulger et. al, 2009; Elkholy & Ewees, 2010; Singh et. al, 2010; Mohammadi-Sichani & Karbasizadeh, 2011). These also includes various nosocomial pathogens (Brady et. al, 2007; Karabay, Kocoglu & Tahtaci, 2007; Ulger et. al, 2009).

Not maintaining proper hygiene and health lead to the manifestations of heath symptoms such as vomiting, diarrhea, rashes and flu; implicated by the bacteria species isolated. For instance, the most prevailing *Acinetobacter spp.* is widely distributed in the environment and frequently found on many skin regions of human (Wilson, 2005) whereas *Shigella spp.* is the most leading cause of diarrhoea known as shigellosis (Niesel et. al, 1986) and *Shig. sonnei* is the leading cause of food poisoning (Kolavic et. al, 1997). Identification of *Ent. aerogenes* and *Cit. freundii* indicates the presence of fecal contamination on the mobile phones since these species are generally found in the human GIT (Al-Abdalall, 2010; Bai et. al, 2012). Some isolates of *Cit. freundii* have acquired virulence traits and caused diarrhea and other infections (Bai et. al, 2012) similar to *Esc. vulneris* (Jain et. al, 2016) and *Moel. Wisconsonsis* (Abbott & Janda, 2011). *Tal. ptyseos, K. pneumonia, K. pneumoniae ss rhinoscleromatis* and *Burk. cepacia* are pathogens connected to respiratory illness such as tracheobronchial / pulmonary infections (Karabay, Kocoglu & Tahtaci, 2007; Fevre et. al, 2011; Vial et. al, 2011). *K. pneumoniae ss rhinoscleromatis* produces rhinoscleroma, a rare granulomatous infiltration of the mucosa of the nose and upper respiratory system which is endemic in tropical and subtropical areas (Fevre et. al, 2011).

Although most studies related to microbial burden on mobile phones focused on healthcare workers, the present study focused on low-skilled migrant worker group, originating from poor country with limited hygienic practices. While the microbial burden on mobile phones among healthcare workers rely on patient handling, contact with biological agent and disinfection practices, the extent of microbial growth on mobile phones of low skilled workers rely mainly on personal hygiene factors. Hand served as a major vehicle of transmission of various microbes including the enteric species (Al-Abdalall, 2010) and in transmission of some diseases such as diarrhoea, pneumonia, boils, and abases (Badr, Ibrahim Badr & Ali, 2012). Improper washing of hands and using the mobile phone during working hours can lead to infection (Sepehri et. al, 2009). The accompanying poor mobile phone related hygiene practices worsen the condition. Bacteria could be easily transmitted from mobile phones to hands, and then from hands to other parts of the body such as mouth, nose and ears. Evidently, the present study found a relationship between hygiene practices related to mobile phones and the pathogenicity of microbes isolated as well as health symptoms.

Notwithstanding, awareness on sanitation and disinfection is of concern too which reflect the importance given for hygienic lifestyle. Akinyemi et al. (2009) who took 400 swab samples from mobile phones of food vendors, lecturers/students, public servant and healthcare workers found that food vendors had mobile phone with the highest bacteria contamination level. This could be attributed to poor hygienic and sanitary practices associated with a relatively lower level of education among marketers and food vendors. On the other hand, hand sanitizer usage was found to be a significant for pathogenicity of microbial species isolated. Compared to the hand washing-only control group, respondents using alcohol-free instant hand sanitizer had fewer illness-related absence days, and a drop in GIT as well as respiratory-related illnesses (Masitah, 2008).

Table 3. General hygiene practices and hygiene related to mobile phone usage

		n (%)		
	Mean±SD	**Never**	**Seldom**	**Often**
General Hygiene				
Wash hands before meals	1.2±0.9	12 (30.0)	7 (17.5)	21 (52.5)
Wash hands after meals	1.5±0.8	6 (15.0)	9 (22.5)	25 (62.5)
Wash hands before using restroom	1.3±0.9	11 (27.5)	7 (17.5)	22 (55.0)
Wash hands after using restroom	1.4±0.8	7 (17.5)	10 (25.0)	23 (57.5)
Wash hands when come home	1.3±0.8	8 (20.0)	11 (27.5)	21 (52.5)
Wash hands after handshaking	1.2±0.9	12 (30.0)	9 (22.5)	19 (47.5)
Wash hands before going to bed	1.5±0.8	8 (20.0)	5 (12.5)	27 (67.5)
Wash hands after using public transportation	1.2±0.8	11 (27.5)	11 (27.5)	18 (45.0)
Wash hands after waking up in the morning	1.7±0.6	3 (7.5)	8 (20.0)	29 (72.5)
Wash hands after touching animals	1.6±0.7	4 (10.0)	10 (25.0)	26 (65.0)
Wash hands before preparing meals	1.5±0.8	6 (15.0)	8 (20.0)	26 (65.0)
Wash hands after money exchange	1.3±0.8	9 (22.5)	10 (25.0)	21 (52.5)
Wash hands after blowing the nose	1.5±0.8	7 (17.5)	6 (15.0)	27 (67.5)
Wash hands after touching garbage	1.6±0.7	5 (12.5)	8 (20.0)	27 (67.5)
Wash hands after combing hair	1.4±0.7	6 (15.0)	12 (30.0)	22 (55.0)
Wash hands after cleaning home	1.6±0.7	4 (10.0)	7 (17.5)	29 (72.5)
Wash hands after washing dishes	1.7±0.6	2 (5.0)	8 (20.0)	30 (75.0)
Wash hands after doing laundry	1.7±0.6	3 (7.5)	8 (20.0)	29 (72.5)
Hand sanitizer use	1.1±1.9		-	
Hygiene in using Mobile Phone				
Use mobile phones during work hours	0.6±0.8	24 (60.0)	9 (22.5)	7 (17.5)
Use mobile phones while eating	0.5±0.7	23 (57.5)	13 (32.5)	4 (10.0)
Wash hand before using mobile phone	1.3±0.9	10 (25.0)	8 (20.0)	22 (55.0)
Clean mobile phones	1.2±0.8	9 (22.5)	15 (37.5)	16 (40.0)
Clean hands after using phone	1.5±0.6	3 (7.5)	14 (35.0)	23 (57.5)
Exchange phone with friends/ colleagues	0.5±0.7	25 (62.5)	9 (22.5)	6 (15.0)
Use headsets while using phones	0.5±0.7	23 (57.5)	13 (32.5)	4 (10.0)
Bring mobile phones to the rest room	0.8±0.8	17 (42.5)	15 (37.5)	8 (20.0)

Score: 0=Never; 1=Seldom; 2=Often

Table 4. Factors Associated with Microbial Burden on Mobile Phones and Health Symptoms

		Health Symptoms			Microbial Burden	
		r			t	
	Mean±SD	Skin	Respiratory	Gastrointestinal	MacConkey	Sheep Blood
Hand Hygiene Score, %	70.9±18.5	-0.217	-0.041	-0.013	0.381	0.008
Phone Hygiene Score, %	54.4±12.5	-0.321*	-0.292	-0.447*	4.906*	2.189*
Hand Sanitizer, times/day	1.1±1.9	-0.147	-0.214	-0.153	6.504*	2.451*

** Significant at p-value< 0.05*

This affirms the need for frequent hand sanitizer usage. Besides, antibacterial wipes (Akinyemi et. al, 2009) or alcohol disinfectant wipes (Ulger et. al, 2009) make mobile phones germ free and a simple cleaning with 70% isopropyl alcohol (IPA) decreased the bacterial load on mobile phone and hand (Badr, Ibrahim Badr & Ali, 2012; Dave & Shende, 2015).

Poor hygiene practices related to phones and lower usage of hand sanitizer among the respondents could possibly due to education and awareness level, which may vary from person to person depends on cultural and social differences. Besides, restricted hospital visits may prolong and promote the prevalence of infectious diseases. The migrants are not fond of visiting the public hospitals due to fear of work permit non-renewal or deporting back to homeland, language barriers, cultural attitudes for seeking health care facilities and social exclusion (Karim & Diah, 2015). For example, despite of initiating Malaria Eradication Program (ERD) in 1967, malaria infection has been increasing rapidly among migrant workers in Malaysia (Masitah, 2008).

Hence, education campaign on medical benefits, infection control programs and decontamination practices is pertinent balanced with the need or ideas to prevent damage to the device. Some manufacturers' advice against the use of cleaning fluids on mobile phones (Brady et. al, 2009), whereas the use of hands-free mobile phones (Sepehri et. al, 2009; Dave & Shende, 2015) or antimicrobial additive materials (Brady et. al, 2006) and silicon cell phone covers (Tekerekoglu et. al, 2011) are effective in reducing the risk of cross-contamination.

5. Conclusion

If proper care and personal hygiene is not taken care of, mobile phones that ease communication could be vehicles for the transmission of bio-hazard. Though hand hygiene plays an important role, hygiene related to mobile phone and frequent use of hand sanitizers should be observed. This study provides an insight to further investigate microbial transmission from mobile phones of low skilled migrant workers from various industries in Malaysia. Higher emphasis should be given to those in food and beverage industries. In addition, as awareness plays a vital role, it is imperative to engage employers and healthcare providers to spread information on the risk of unhygienic behaviours especially those related to mobile phones and medical facilities for migrant workers in Malaysia as well as improve their participation in health campaigns.

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CONFLICT OF INTEREST

None declared.

ETHICAL ISSUES

Approval from the Human Ethics Committee of the Management and Science University was attained [Reference No: HE-MSU-014].

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